Proposal to

County of Siskiyou

Box Canyon Hydroelectric Project FERC Nineth Part12D Comprehensive Assessment

P/076977

April 24, 2024

HATCH

April 24, 2024

Ms. Joy Hall
Project Coordinator
County of Siskiyou
190 Greenhorn Road
Yreka, CA 96097

Dear Ms. Hall:

Subject: Box Canyon Dam FERC Nineth Part12D Comprehensive Assessment

Hatch pleased to submit this proposal in response to the Comprehensive Assessment Consultant Services for the Box Canyon Hydroelectric Project on the Sacramento River Request for Proposal. The proposed IC Team is passionate about solving Siskiyou County's toughest challenges, and together our team brings global risk assessment experience and personnel with unique expertise in performing PFMA workshops incorporating a risk prioritization component, semi-quantitative or Level 2 Risk Analyses (L2RA), comprehensive seismic hazard and consequence analysis services.

Of great importance is the fact that our team members have hands-on experience in the design, construction, rehabilitation, and assessment of dams and levees of all types and bearings on a wide variety of foundations, allowing our team to undertake a thorough and comprehensive assessment of our client's dams, understanding what key indicators signify potential problems. Our team possesses the expertise and experience to efficiently conduct the first comprehensive assessment of the Box Canyon Development.

We are a team that you can rely on, consistently. Our long tradition of supporting our clients' operations with world class engineering skills sets us apart. Building on this long tradition of excellence in sustaining capital and major projects, we look forward to a future relationship with you. Together, we can create a longstanding rapport based on trust and a common appreciation of value; let's work together to improve the safety and longevity of your facility.

If you would like to meet with me to clarify and further discuss any aspect of this proposal, please call me at 716-221-4581.

Regards,

Allison Lunde, PE (MN)
Midwest Regional Manager, Hydropower & Dams

County of Siskiyou –
Box Canyon Hydroelectric Project FERC Nineth Part12D
Comprehensive Assessment

Contact:
Allison Lunde, P.E.
Hydropower & Dams Midwest Regional Manager USA

Address:
1999 Harrison Street, Suite 620
Oakland, CA 94612
Tel: +1 415 520 8850
www.hatch.com

April 24, 2024

Table of Contents

1. Introduction ... 1

1.1 Summary of Project Features ... 1

2. Box Canyon Hydroelectric Project IC Team ... 2

3. IC Project Team ... 2

4. Team Experience ... 8

4.1 Risk Assessments Experience ... 8

5. Key Components for a Successful Assessment ... 11

5.1 Quality Assurance/Quality Control Plan ... 11

6. Scope of Work ... 12

6.1 Task 1: Project Coordination ... 12
6.2 Task 2: Document Review ... 12
6.3 Task 3: Comprehensive Assessment Pre-Inspection Preparation Report ... 14
6.4 Task 4: Field Inspection ... 15
6.5 Task 5: Potential Failure Mode Analysis (PFMA) ... 16
6.6 Task 6: Risk Assessment (L2RA) ... 18
6.7 Task 7: Comprehensive Assessment Report (CAR) ... 24
6.8 Task 8: Comprehensive Assessment (CA) Review Meeting ... 24
6.9 Task 9: Project Management ... 25

7. Schedule ... 25

8. Exclusions and Assumptions ... 26

9. Items Required from Siskiyou ... 27

10. Commercial Offer ... 28

10.1 Overview ... 28
10.2 Estimated Cost of Services ... 28
10.3 Basis of Compensation ... 29
10.4 Schedule of Rates ... 29
10.5 Travel and Related ... 29
10.6 Subconsultants ... 29
10.7 Invoicing & Payment ... 29
10.8 Additional Services ... 29
10.9 Contract Terms and Conditions ... 29
10.10 Validity ... 29

Appendices

Appendix A : Terms and Conditions

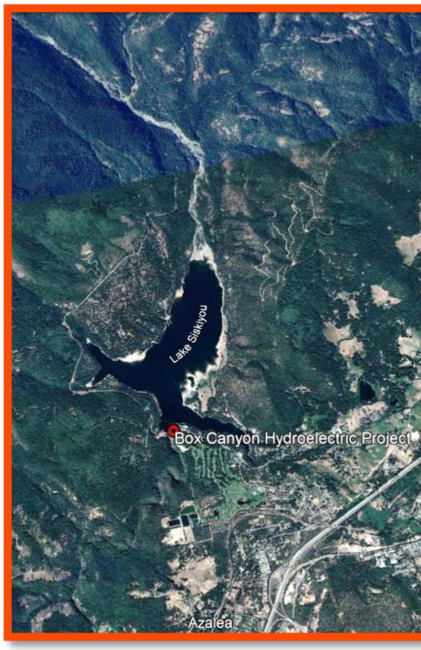
Appendix B : Schedule of Rates

Appendix C : Resumes

1. Introduction

County of Siskiyou (Siskiyou) has requested Hatch Associates Consultants, Inc. (Hatch) to provide a proposal for the Federal Energy Regulatory Commission (FERC) Independent Consultant (IC) Part 12D Comprehensive Assessment Report (CAR) including a Level 2 Risk Analysis (L2RA) for the Box Canyon Hydroelectric Project (FERC No. P-2796-01-01) (the Project).

1.1 Summary of Project Features



The Box Canyon Hydroelectric Project (a.k.a. Lake Siskiyou Power Project) (Project) is located on the headwaters of the Sacramento River in Siskiyou County, California. The Project consists of a 360 ft long and maximum height of 220 ft concrete gravity dam, with both a section of ungated overflow spillway and non-overflow sections, rolled earth embankments on both the right and left sides of the concrete dam, outlet works, and a powerhouse. The Lake Siskiyou impoundment has a 26,000 acre-ft storage capacity with a normal pond elevation of 3,181 ft.

The left embankment spans 590 ft, is up to 55 ft tall, and is zoned earth consisting of clay silt and sandy clay with silt central core and a sandy gravel shell. The right embankment is 150 ft long and a maximum 18 ft tall and was constructed as a homogeneous section comprising of clayey silts and sandy-clayey silts with a 3-ft-thick riprap protection layer. The 151 ft long spillway has an ogee-shaped crest and has a maximum discharge (without overtopping) of about 56,000 cfs. The intake ports have trashracks, and the spillway structure houses a hydraulically-operated, 50-ft diameter butterfly valve that controls flow through the 5-ft diameter steel conduit conveyance (which includes two bifurcations). The powerhouse houses two horizontal-shaft Francis turbines (2,500 kW each) with maximum flow capacities of 251 cfs each.

A brief review of the available project information identifies the major project components as:

- Main Dam
- Drainage Gallery
- Left and Right Earthen Embankments
- Spillway Structure
- Intake Ports, Trashracks, and Butterfly Valve
- Steel Conveyance Conduit and Bifurcations
- Powerhouse (Francis Turbines)
- Low-Level Outlet

The major components list is considered preliminary for the purposes of this proposal. Historic design and construction documents will be more thoroughly reviewed, and additional components will be considered during the course of this work.

2. Box Canyon Hydroelectric Project IC Team

Understanding the FERC Comprehensive Assessment (CA) scope requirements, Hatch has assembled an IC Team with the SMEs being selected based on their depth of experience and expertise in dam design, construction, risk analyses, and safety assessments. All have multiple, relevant, and applicable, projects within their respective areas of expertise. The proposed SME's have experience with complex dam sites across the world which lends to providing practical expert analysis to evaluate risk and support the analysis during the PFMA and L2RA across the following disciplines:

- Structural
- Seismicity
- Geotechnical/Geology
- Consequence
- Hydrology
- Hydraulics
- Mechanical

3. IC Project Team

Team members will primarily include the following individuals. Resumes for the proposed Independent Consultants and IC Team Subject Matter Experts can be found in Appendix C.

- Ryan Berg, P.E. (NY) – Project Sponsor. The Project Sponsor will sign contract documents and will assist with other project commercial needs (as necessary)
- Allison Lunde, P.E. (MN) – Independent Consultant / Project Manager / Structural and Dam Safety Subject Matter Expert
- Peter Haug, P.E. (WI) - PFMA and L2RA Facilitator
- Bill Kussmann, P.E. (MN) – Co-Independent Consultant / Geotechnical and Geology Subject Matter Expert
- TBD – Recorder, the recorder will be appointed by the Facilitator
- Nicholas Agnoli, P.E. (NJ) – Hydrology & Hydraulics and Consequence Subject Matter Expert
- Val Kovalishyn, P.E. (WA) – Mechanical Subject Matter Expert

The staff proposed for this project have availability throughout 2024 and 2025 to complete the necessary components of the Part 12D scope of work for the Project.

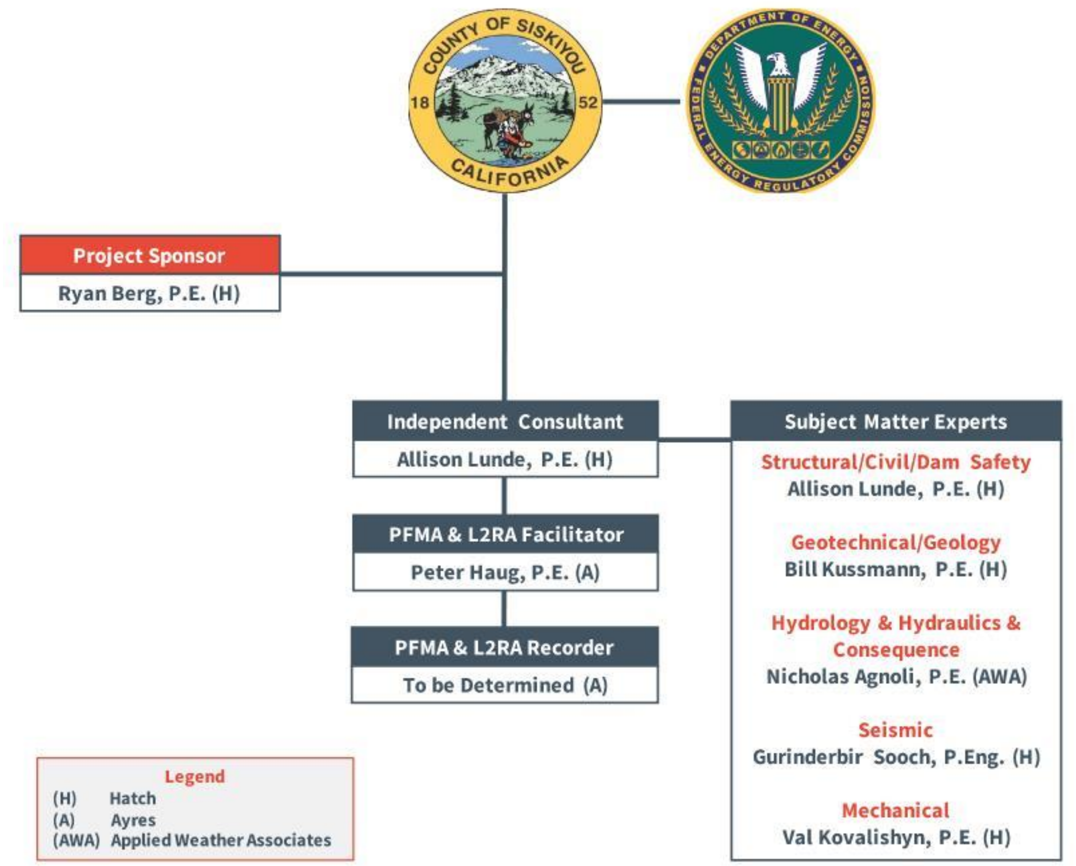


Figure 3-1: Proposed IC Team

Ryan Berg, P.E., P.Eng.

Role: *Primary Sponsor* - Ryan will interface with Siskiyou on all commercial and technical issues.

Experience: +18 years of experience (currently Regional Manager of USA Hydropower & Dams and a Senior Project Manager).

Qualifications: Ryan is currently a regional manager of U.S. Water Power for Hatch and a senior project manager with more than 20 years of experience. He has extensive experience with mergers and acquisitions and performing due diligence activities on facilities ranging from 1 MW to 2000 MW for investment companies. His professional background includes design, analysis, layout, evaluation and management of various projects in the hydroelectric sectors. His experience includes assignments in various countries in North America, Central America and South America. Ryan has been responsible for the successful completion of a variety of projects, including feasibility studies, rehabilitation works, dam safety, due diligence assessments, and design/layout of both tender level and construction level greenfield hydroelectric facilities. Ryan recently served as Facilitator for the Boundary Dam spillway focused construction PFMA.

Allison Lunde, P.E. (NY)

Role: *Independent Consultant (IC), Project Manager, and Structural/Civil/Dam Safety Subject Matter Expert-* Allison will lead portions of the Part 12D activities and coordinate with Siskiyou on project activities.

Experience: over 13 years of experience in dam safety industry, including FERC projects, along with expertise in the design, rehabilitation, and construction management of refurbishment projects at hydroelectric facilities. Currently a co-IC on the Solomon Gulch Hydroelectric Project Part 12D in 2022.

Qualifications: Allison is currently a Senior Structural Engineer with over 13 years of civil and structural engineering experience in heavy industrial, wind energy and hydroelectric facilities. She is currently the Midwest Regional Manager – Hydropower & Dams USA where she guides structural, geotechnical and hydrologic engineers. She has experience in the dam safety industry, including FERC projects, along with expertise in the design, rehabilitation, and construction management of refurbishment projects at numerous hydroelectric facilities.

She is currently a licensed professional engineer in Alaska, Colorado, Louisiana, Maine, Massachusetts, Michigan, Minnesota, New York, New Hampshire, Nevada, North Dakota, South Dakota, Tennessee, Washington, West Virginia and Wisconsin. Allison's professional background includes dam safety; design, analysis, and inspection of reinforced concrete, reinforced masonry, structural steel, and timber structural systems; feasibility studies; and construction management. Much of Allison's dam work has been completed on sites regulated by the Federal Energy Regulatory Commission (FERC) and US Army Corps of Engineers (USACE).

Allison's involvement in the FERC Part 12D dam safety inspections at numerous hydroelectric projects as summarized below.

- FERC External ODSP Auditor for the Elevate Power hydroelectric portfolio in 2024.
- FERC External ODSP Auditor for the Copper Valley Electric Association hydroelectric portfolio in 2023.
- Project Manager and co-IC in the Part 12D Inspection at the Solomon Gulch Hydroelectric Project in 2022. Drafted the CSIR, reviewed and assessed PFMs, STID and DSSMP, made recommendations, reviewed structural analyses and synthesized survey and monitoring data.
- Structural Engineer in Construction PFMA for the Upriver Hydroelectric Project Phase III Rehabilitation Project in 2021. Participated in workshop and construction PFMA report.
- Project Manager and assisted IC in the Part 12D Inspection at the Castle Rock Hydroelectric Project and Petenwell Hydroelectric Project in 2018. Oversaw the underwater dive inspections, drafted the CSIR for IC review and approval, reviewed and assessed PFMs, STID and DSSMP and made recommendations, reviewed structural analyses, and synthesized survey and monitoring data.
- Assisted IC in the Part 12D Inspection at the Victoria Hydroelectric Project and Bond Falls Hydroelectric Project in 2017. Work focused on review and assessment of STID, review of structural analyses, and synthesized survey and monitoring data. Wrote up CSIR sections pertinent to reviewed information for IC review and approval.
- Assisted IC in the Part 12D Inspection at the Otter Hydroelectric Project and Alexander Hydroelectric Project in 2017. Work focused on structural analyses review and comment.

- Project Manager and assisted IC in the Part 12D Inspection at the St. Cloud Hydroelectric Project in 2016. Drafted CSIR for IC review and approval, assisted with field inspection, reviewed, and assessed PFMs, STID and DSSMP and made recommendations, reviewed structural analyses, and synthesized survey and monitoring data.
- Assisted IC on the Part 12D Inspection at the Thief River Falls Hydroelectric Project in 2014. Work focused on review of structural analyses and monitoring data review.
- Assisted IC on the Part 12D Inspection at the Fish Lake Hydroelectric Project in 2013. Work focus was on structural analyses review and assessment.
- Assisted IC on the Part 12D Inspection at the Chippewa Falls Hydroelectric Project in 2012. Focus on the hands on tainter gate inspection and summary report.

Bill Kussmann, P.E.

Role: *Geotechnical and Geology Subject Matter Expert* - Bill will provide subject matter expert services regarding embankment dams for the Project, as needed.

Experience: +25 years of experience as a geotechnical engineer with emphasis on dam safety projects.

Qualifications: Bill Kussmann is an engineer and geologist with over 25 years of experience in geological and geotechnical investigations, engineering evaluations, and design for a variety of hydroelectric, renewable energy, and commercial/industrial projects. Most of Bill's career has been devoted to hydropower, flood control, and renewable energy projects. Bill has also taken part in numerous dam safety reviews including seepage analyses, stability analyses, hazard analysis, embankment armoring, and emergency responses for numerous operational hydropower dams and existing and proposed levee embankments. Some of his designs have included embankment buttresses, embankment reinforcement, filter blankets, under seepage collection systems, cut-off walls, and grouting programs to improve levee and dam stability on numerous FERC-regulated and USACE projects. Bill has also designed construction support features such as cofferdams, sheet pile walls, soldier pile walls, dewatering systems, and OSHA-regulated deep excavations.

Bill is currently serving as the design manager for the diversion channel and levees at the Fargo-Moorhead Metropolitan Flood Diversion Project, a first of its kind USACE/flood authority sponsored Public-Private-Partnership (P3), $1B flood control project consisting of 30 miles of diversion channel, levee, local drainage, aqueduct, road/rail crossings, drain inlets, and outlet structure. Bill's involvement in the FERC Part 12D dam safety inspections at numerous hydroelectric projects is summarized below.

- Performed emergency response for depressions forming on the FERC-regulated Big Falls Dam earthen embankment in 2010. Designed embankment repair and oversaw execution in 2011. Assisted IC with subsequent Part 12D safety inspections and reviewed and assessed PFMs, STID and DSSMP.
- Assisted IC in the Part 12D Inspection at the FERC-regulated Cornell Hydroelectric Project in 2017. Work focused on review and assessment of STID, review of earthen embankments, and slope stability assessments. Identified need to increase embankment stability to meet FERC requirements and performed embankment improvement design. Provided subsequent embankment stability evaluation for STID.
- Assisted IC in the Part 12D Inspection at the FERC-regulated Wissota Hydroelectric Project in 2017. Work focused on review and assessment of STID, review of earthen embankments, and review of existing embankment seepage. Identified earthen dike which required tree removal and further

assessment. Provided improvement design concepts for owner's consideration to improve the embankment to meet FERC requirements.

- Assisted IC in the Part 12D Inspection at the FERC-regulated Holcombe Hydroelectric Project in 2014. Work focused on review and assessment of STID, review of earthen embankments, and review of existing embankment seepage. Also performed piezometer assessment and installation, seepage review and inspection program development, and assessment of animal burrows on the earthen embankments for the project.
- Performed geotechnical assessment and foundation design recommendations for the spillway replacement project at FERC-regulated Bond Falls Dam in 2009. Assisted with construction oversight in 2010. Provided follow-up embankment stability and seepage calculations for inclusion in the post-construction STID and provided follow-up inspections for the facilities minor embankment/dike systems. Devised monitoring plan for continued dam seepage at the facility following construction for use in subsequent Part 12D evaluations.
- Performed slope stability assessments, dam structure foundation assessments, seepage assessments, embankment inspections, piezometer rehabilitation and monitoring, embankment depression evaluations, grout plan designs, and erosion assessments in support of Part 12D dam safety inspections and improvement projects at numerous FERC-regulated facilities from 2009 to 2021.

Peter Haug, P.E. (WI)

Role: *PFMA & L2RA Facilitator*

Experience: 25 years of experience

Qualifications: Pete serves as manager of Ayres' Water Resources with a primary focus on hydraulic structures and dam inspections. For more than 11 years, prior to joining Ayres in 2010, he worked on dam safety studies for the Columbia River and Snake River dams and focused on physical models of spillway forces, structural pressure (lift joints, cavitation, uplift), tailrace erosion (bedrock erodibility, ball milling, and flip jet deflectors), and high velocity conveyances.

His career with Ayres and the Midwestern dams has expanded to bedrock spillway assessments, bedrock grouting, arch dam design, structural stability, powerhouse design, and Part 12D dam safety inspections. His design experience includes concrete arch dams, concrete spillways, unlined bedrock spillways, new gate installations, gate refurbishments, new powerhouse structures, and analysis of existing dams for stability and hydraulic sufficiency.

From his work on the 1,185 MW Wanapum Dam in Washington to the 330-foothigh Hells Canyon spillway in Idaho and from the 163-foot-high Kingsley Dam embankment to the 34,000-foot-long Sutherland embankment, Pete has been widely exposed to geotechnical, hydraulic, structural, and regulatory challenges. He has helped multiple FERC licensees improve their advanced dam monitoring practices for scour, movement, and other stability failure modes. He has participated in numerous potential failure mode analysis meetings, both as the engineer-of-record and also as an independent consultant including:

- FERC P-9951, French Landing Comprehensive Assessment, Wayne County, MI. FERC-approved facilitator for Comprehensive Assessment with Level 2 Risk Assessment.

- FERC P-2181 Menomonie Dam Comprehensive Assessment, Menomonie, WI. Co-independent consultant and hydraulic structures subject matter expert.
- FERC P-2595 High Falls Comprehensive Assessment, Crivitz, WI. Project manager and note taker for Level 2 Risk Assessment.

Mr. Haug brings his experience of having participated in several comprehensive assessments; he understands the steps that can be taken to ensure that the PMFA and L2RA workshops run efficiently.

Nicholas Agnoli, P.E. (NJ)

Role: *Subject Matter Expert Hydraulics and Hydrology and Consequence/Hazard Classification*

Experience: +26 years of experience

Qualifications: Nicholas is a water resources engineer and hazard specialist with over two decades of experience. Mr. Agnoli served as the branch chief with the federal energy regulatory commission for 14 years where he was responsible for the civil engineering staff that performed safety inspections and technical review on studies related to approximately 243 FERC-regulated hydropower projects in the northeastern United States. He performed technical reviews including construction/rehabilitation drawings, Part 12D Safety Inspection Reports and supplemental studies, Emergency Action Plans and associated dam failure studies, inflow design flood determination studies, hazard classification studies, and Probable Maximum Precipitation (PMP) / Probable Maximum Flood (PMF) studies. He's expertise is in the development and review of cold season (rain-on-snow) and all season site-specific PMP studies and 2D dam failure modeling in HEC-RAS. Nicholas is the founder and chairman of the NY Hydrology and Hydraulics Technical Resource Group (NYRO H&HTRG) and served as the advisor of the national FERC H&HTRG.

Recent projects included the conversion of gridded precipitation data with a variety of temporal and spatial distributions to runoff with the use of ArcMap and HEC-RAS. The 2D runoff models included calibration of hydrologic inputs and the evaluation of mitigation strategies.

He has considerable experience with many numerical hydrologic and hydraulic modelling programs and GIS programs for hydraulic and hydrologic applications such as HEC-RAS 2D, HEC-HMS, ArcMap 10.x, HEC-FIA, USGS PeaKFQ (17C), HEC-SSP, HEC-DSSVue, FLOW3D, and legacy software, including FLDWAV, DAMBRK and HEC-1.

Gurinderbir Sooch, P.Eng.

Role: *Seismic Subject Matter Expert*

Experience: +28 years of experience

Qualifications: Gurinderbir is an experienced structural engineer (FEA and seismic specialist) with fifteen years' experience in hydropower industry and academia. His experience includes advanced structural analysis/ design of 35+ hydropower projects. He also has performed numerous nonlinear finite element analysis of hydroelectric projects and locks for seismic, flood and AAR induced concrete growth loads. He has extensive experience in FEA programs (LS DYNA, ABAQUS, ANSYS, FLAC and 3DEC) and computer programming (MATLAB, FORTRAN, Python, C++, MathCAD).

Gurinderbir' s recent project experience includes lead structural engineer role for the detail structural design of BatterSea Dam and dam safety evaluations (seismic and AAR analysis) of Cushman 1 & 2 Arch

Dams; Long Lake Dam; Powell River Dam; Lower Baker Dam; Upper Baker Dam; Mactaquac Dam; Fontana Dam; Wanapum Dam; Mossyrock Arch Dam; and Seaway Lock 3. He has also performed structural evaluations of numerous spillway gates and hoist towers (e.g., Powell River Dam, Mossyrock Dam and Waneta Dam). His experience includes the development of site-specific earthquake ground motions for Ocoee and Wheeler Dams. Gurinderbir has also evaluated field investigation program and concrete laboratory test results for eight Tennessee Valley Authority dams.

His recent experience also includes being a review board member for seismicity review of Ituango Dam (Columbia, 225 m high earth core rock fill dam). The detail dam analysis work performed by Gurinderbir using LS-DYNA and other FEA programs for numerous projects owned by Tennessee Valley Authority, Tacoma power, Grant PUD etc. has been reviewed by the Federal Energy Regulatory Commission (FERC) and Nuclear Regulatory Commission (NRC). Also, he has presented and published numerous papers at various dam engineering conferences i.e., ICOLD, USSD and CDA.

Val Kovalishyn, P.E. (WA)

Role: *Mechanical Subject Matter Expert*

Experience: 23+ years of experience

Qualifications: Val is a senior mechanical engineer with 23 years of experience in a variety of hydro projects, including detailed design of hydraulic gates/hoists, trashracks/cleaners, penstocks, and balance of plant equipment. Val has performed detailed design and inspection tasks on a number of intakes, which included trashracks and rakers, hydraulic gates and hoists, and penstock/units connections. Also, Val has designed a number of buried and exposed penstocks with diameters up to 12 feet and static pressures up to 2,000 feet. Val's expertise in the area of hydraulic machinery, pressure vessels and pipelines, hydraulic gates and hoists, and energy dissipating systems makes him a valuable addition to a multi-disciplinary design team. Val has also coordinated multi-disciplinary engineering teams on hydropower projects that included geotechnical, civil/structural, mechanical and electrical disciplines.

4. Team Experience

Below is a sample of recently completed projects, similar to the requested services, that are representative of Hatch's expertise in this type of dam safety work including a narrative of any unusual problems overcome or novel approached utilized.

4.1 Risk Assessments Experience

Risk assessment has become mainstream across the United States when evaluating sites and the associated potential failure modes. Hatch has experience across the globe completing risk assessments for clients. We take a practical and efficient approach to prepare, execute, and finalize risk assessment work from PFMAs, SQRA/QRA and facilitation. Hatch understands the USACE, FERC and USBR approaches to risk assessment for dam facilities. We are able to develop a program that best meets the needs of the project while following current industry standards.

4.1.1 Quantitative Risk Assessments (QRA)

The IC Team is well versed and capable of performing quantitative risk assessments if it were to become necessary as a follow-up to the L2RA. First step in quantitative risk assessment (QRA) is a

Potential Failure Mode Analysis (PFMA). Various PFMs are developed into event tree (or fault trees) to arrive at the probabilities of branch sequences.

The probabilistic modelling of the PFM(s) relies on the information provided in PFMA workshops. The probability bounds are typically elicited with the PFMA workshop for:

- Important variables governing the mechanics of the failure mechanism
- Uncertain events which cannot be defined through failure mechanisms
- Potential losses, and consequences (financial or otherwise)

The event tree model is then developed to consider the probability bounds around the underlying failure mechanisms and physics of the PFM events. They typically rely on the Hatch PFM database and Hatch experts for arriving at the engineering assumptions to augment the elicited probability bounds.

Risk analysis is typically performed by either an in-house risk analysis program (developed using python and MATLAB programing languages) or DAMRAE (USACE, 2022). The DAMRAE program was developed by the Risk Management Center for the US Army Corps of Engineers. DAMRAE provides a graphical interface for building, modifying, and computing the event tree model. A summary of DAMRAE features is as follows:

- A user interface to interactively build the event tree model and assign the branch inputs.
- Functionality to construct the risk model for a dam in its existing condition and to readily adapt this base case to consider risk reduction alternatives and staged risk reduction measures.
- A generalized event tree algorithm to perform the calculations of risk estimates using the user-drawn event tree structure and assigned branch inputs.
- Options for a common-cause adjustment, system response probability (SRP) and consequences freezing, sub-event trees and sensitivity runs.
- Graphical and tabular outputs of risk estimates, including estimates of risk reduction and their economic justification for risk reduction measures (RRMs) with options for evaluating risk reduction alternatives, and staged implementation of RRMs or calculation of incremental benefits for each RRM within a risk reduction plan.
- Graphical output of USACE tolerable risk guidelines charts.
- Options for incorporating uncertainty using Monte Carlo analysis, including a feature to disaggregate components of knowledge (epistemic) uncertainty and variability (aleatory uncertainty) using a logic tree in addition to an event tree.

As an output, the Hatch Team, using the DAMRAE or in-house program, will provide the following annual breach risk estimates: Annual Probability of Failure (APF); Average Annual Incremental Life Loss (AALL); Average Annual Incremental Economic Consequences (EC); and similar estimates for non-breach. Failure is normally defined as the case of an uncontrolled release of reservoir contents.

The tolerable risk guidelines for dam safety, as described in ER 1110-2-1156 (USACE 2014), could be used to evaluate the significance of the risk estimates for the base case and for the risk reduction measures. The USACE (2014) guidelines have a two-part evaluation process. The first part compares the total risk estimate against the USACE tolerable risk limits, and the second part evaluates the risk estimates from the 'as low as reasonably practicable' (ALARP) consideration.

Also, the Hatch Team can perform post-processing of risk analysis results to estimate the following:

- Contribution of ground motion and magnitude to risk.

- Disaggregation of contribution of sources of uncertainty to risk (Tornado plots, variance in inputs and respective contribution to variance in risk analysis results).
- Review and evaluation of risk analysis results and their effects on decision making about retrofit options. The effects on decision making about retrofit option is estimated based on the (ALARP) considerations. Also, various decision variables for retrofit options, such as benefit cost ratio, cost per statistical life saved and disproportionality ratio, can be calculated from the risk analysis.

4.1.2 Semi-Quantitative Risk Assessment (SQRA)

Hatch team has extensive experience with facilitating and participating in SQRAs. SQRA is a process to evaluate the PFMs from a risk perspective. The SQRA method provides a risk categorization system that is a useful and quick means to prioritize dam safety activities, especially to determine if higher level studies would be beneficial for a specific potential failure model (USACE 2019). The Hatch Team has supported or participated in QRA and SQRA for the projects listed in Table 4-1 below.

Table 4-1: Experience in Risk Assessments

Project Name	Quantitative Risk Assmt. (QRA)	Semi-Quantitative Risk Assmt. (SQRA)	SQRA Facilitation or Subject Matter Expert Support	Remarks
Bigelow Dam (Alberta Environment Parks)	✓	✓	✓	
Coal Lake Dam (Alberta Environment Parks)	✓	✓	✓	
Wilson Dam (TVA)			✓	Participated in SQRA's and provided Subject Matter Expert Support
Boone Dam (TVA)			✓	
Beech Dam (TVA)			✓	
Nolichucky Dam (TVA)			✓	
Cherokee Dam (TVA)			✓	
Douglas Dam (TVA)			✓	
Rock Island Dam (Chelan County Public Utility District)			✓	Participated as a FERC Co-Independent Consultant
Mactaquac Dam (NB Power)	✓		✓	Performed structural analysis to support the QRA and participated in Risk Elicitation workshops

5. Key Components for a Successful Assessment

Based on the IC Team's extensive dam safety experience, we have developed a table of the key components critical to achieving a thorough and efficient dam safety review. These components translate to the comprehensive review process and therefore, the IC Team will stive to achieve these objectives during the Box Canyon Comprehensive Assessment work.

Table 5-1: Key Components for a Successful Assessment

Communication	Regular communication needs to be maintained throughout the review process between the project leadership, operations staff and discipline leads. This helps to ensure that the report that is eventually presented will meet the approval of client dam safety leadership to ensure timely completion of the Comprehensive Assessment.
Data Review	All data needs to be reviewed at the outset of the Comprehensive Assessment, prior to the site inspections. This includes construction documents and photographs as well as any technical reports and papers, government reports, monitoring logs or other information that might assist in assessing the condition of the structures. To facilitate this process, the IC Team makes use of our SharePoint database system that allows for real-time access to all information, including the most up-to- date versions of our reports throughout the project.
Site inspection	The site inspection needs to be documented during and immediately following the completion of the visit. The visit needs to establish a current snapshot of the structures and any defects documented through photographs, standard forms and our own e-inspection tools. Efficient and thorough interviews with dam operations staff are also an essential part of this task. To expedite this process, Hatch prepares and issues an Operator Dam Safety Questionnaire prior to the visit that assists in facilitating the discussions.
Data Collection	Invariably, it is the data you did not collect that becomes the information you need. Throughout the process, it is essential to collect and assess all of the data that is available from documents and observations made during the site inspection. Often it is the shear resistance at the concrete-to-bedrock contact that can dictate the need for remedial repairs. Particular attention to this interface is needed to be performed by experienced and knowledgeable professionals.
Deficiencies	It is essential that any dam safety defects that are observed are communicated immediately.
QA/QC	See Section 5.1 below

5.1 Quality Assurance/Quality Control Plan

Hatch's Quality Management System (HQMS), compliant with the requirements of ISO 9001:2008, is delivered to projects through the Hatch Project Lifecycle Process (PLP) and will be used in all aspects of the work Hatch performs. This toolkit contains the procedures, functional guidelines and associated tools needed to execute quality projects. It contains documentation for all functional groups and engineering disciplines.

Quality in project management will be achieved through:

- A formal kick-off meeting to ensure that everyone is aware of project requirements.
- Development of a Project Execution Plan (PEP). The scope of the PEP covers all policies, plans and procedures necessary to implement, execute and close out the project. The plan defines the

specific technical procedures to be followed and the technical checking and project reporting requirements. This plan will be reviewed with Siskiyou to ensure any specific project requirements and input/approval processes are reflected. The plan will formalize quality assurance procedures and controls.

- Proper planning throughout all functions within the project.
- Regular progress reporting to Siskiyou and Hatch management to identify issues in a timely fashion.
- Regular communication of project status throughout all levels of the project organization.

Quality in engineering will be achieved through:

- Internal and external deliverables will be reviewed and signed off by independent reviewers before issue.
- Quality audits will be undertaken by a qualified internal auditor on a routine basis. The results of these audits will be presented to the project team along with documentation in HQMS.

6. Scope of Work

The proposed IC Team will complete the work in accordance with this developed Scope of Work. The scope of services constitutes the engineering services necessary to perform the Ninth Part 12D Inspection and CAR including a Level 2 Risk Analysis (L2RA) for the Box Canyon Hydroelectric Project (FERC No. P-2796-01-01-CA) in accordance with FERC regulations, guidelines, and conditions described in the January 9, 2024, letter from the FERC to Siskiyou. Specifically, the Hatch team will follow FERC Engineering Guidelines Chapter 16 Part 12D Program. Additionally, Potential Failure Mode Analysis (PFMA) will be completed following FERC Engineering Guidelines Chapter 17 and Level 2 Risk Analysis (L2RA) in accordance with FERC Engineering Guidelines Chapter 18.

It is assumed that Siskiyou will develop and provide a Supporting Technical Information Document (STID) in accordance with FERC Engineering Guidelines Chapter 15 prior to beginning work. Siskiyou will be responsible for the STID.

6.1 Task 1: Project Coordination

6.1.1 Kickoff and FERC Coordination Meeting (Virtual)

A project kickoff and coordination meeting via conference call will be held with Siskiyou to review existing data, deliverables, and project schedule. Strategies for a successful CA and L2RA to meet the FERC requirements listed in 18 CFR 12.37 will be discussed. Dates for key meetings, such as the field inspection, PFMA, and L2RA will be identified. The meeting will discuss project communication protocols, scope of services, roles and responsibilities, project schedule, and the overall project execution plan to be reviewed and adapted to address any additional requirements. Minutes from the kickoff meeting will be prepared by Hatch and distributed to meeting participants.

Deliverable: Meeting Minutes (pdf)

6.2 Task 2: Document Review

The IC Team will complete a thorough review all the reference data provided by Siskiyou. The documents will be reviewed to determine any missing or gaps in information before completing all necessary pre-inspection documentation, field inspection, and final reporting. The findings of the reviewed documents will be summarized in the Comprehensive Assessment Pre-Inspection Preparation Report (CA-PIPR).

Documents that are assumed to be reviewed, but are not limited to, the following:

- Supporting Technical Information Document (STID);
- Owner's Dam Safety Program (OSDP);
- Dam Safety Surveillance Monitoring Plan (DSSMP);
- Last five years of Dam Safety Surveillance Monitoring Reports (DSSMR);
- Emergency Action Plan;
- Public Safety Plan;
- Pertinent FERC correspondence for the last five years for the Project;
- All prior FERC Dam Safety Inspection Reports and FERC's review letter dated for the Project;
- Recent field inspection(s), underwater survey(s) and LiDAR survey report(s) for the Project;
- Project drawings, technical specifications, and construction reports for the Project; and
- Analyses such as but not limited to stability analyses, dam break analysis, seismic analysis, etc.

During the review of existing documents, a summary table of the stability analyses performed for the Project features will be developed. The objective of this table is to be able review relevant and previously-performed analyses and be able to compare results as to where there may be information missing. The table will also summarize sources of the information with reference to analysis reports and communications, assumed analysis plane locations, headwater and tailwater elevations, load case, strength parameter assumptions, and analysis results. Analysis results of interest for concrete gravity structures usually include factors of safety against sliding and cracking. Table 6-1 shows an example table with the key variables that will be entered as part of this documentation. Hatch will expand stability analyses to include a parametric review that allows the IC Team to better use their professional judgement to assess the likelihood of specific PFMs and often, based on the type of failure, the downstream consequence. Table 6-1 below shows an example of a comprehensive analysis summary for a specific structure and the range of strength parameters and loading that might be considered.

Table 6-1: Example Table Summarizing Stability Analyses Performed for Project Features

Example Project HATCH

Stability Analysis Data Summary

Features:
LA = Left Abutment
PH = Powerhouse
SW = Spillway
RA = Right Abutment

Analysis Plane
F = foundation
LJ = Lift Joint
CRI = Concrete Rock Interface

Sub-features:
LAE = Left Abutment Embankment
LAW = Left Abutment Wall
SW1 through SW8 = Spillway Monoliths 1 thru 8
RAE = Right Abutment Embankment
RAG = Right Abutment Gravity Seciton

Load Cases:
N = normal static load (1.5 limit)
H - Hydrologic/flood, unusual load (1.3 limit)
EQ = seismic (1.1 limit) 1/10,000 AEP
P-EQ = Post-seismic (1.3 limit)

Definistions
HW, TW = headwater, tailwater (ft)
T = crack length (ft)
phi = friction angle assuming no cohesion (degrees)
PT = post-tension load (k)
DE = drain efficiency (%)

Key HW and TW Data per XYX Analysis report for N and EQ

	HW (ft.)	TW (ft.)
N	430	307
N (min.)	416	307
H	455	350
EQ	430	307

Sources
XYZ Consultants 2021: Green Field Hydroelectric Project, FERC Project No. xxx, "Dam Stability Analysis, February 2020
XXX Consultant 2020: Embankment Stability Analysis
XXX Consultant 2019: "Geotechnical Investigation and Embankment Stability Analysis, Green Field Hydoelectric Project,

No.	Feature	Sub-feature	Load Case	Analysis Plane	Failure Mech.	Source	Yr	Section and Table Nos.	FS	AP El.	HW	TW	Assumptions T	phi	PT	DE	Notes
1	LA	LAE	EQ		Liquifaction	XXX	2019, 2020	3.2, Table 3-4	2.2	n/a	430	307	n/a	n/a	n/a	n/a	Analysis approach - see report.
2	LA	LAE	H		Downstream slope	XXX	2019, 2021	3.3, Table 3-12	3	n/a	455	350					Slope x analysis program used.
3	LA	LAE	EQ		Downstream slope	XXX	2019, 2022	3.3, Table 3-14	3.7	n/a	430	307					Slope x analysis program used.
4	LA	LAE	EQ		Upstream slope	XXX	2019, 2023	3.4, Table 3-17	1.9	n/a	430	307					Slope x analysis program used.
5	LA	LAW	N	CRI	Sliding	XYZ	2020	4.1, Table 4-3	3.2	312	430	307	3.5	45	2,500	0%	No LJ drains
6	LA	LAW	H	CRI	El. 312	XYZ	2021, 2022	4.1, Table 4-5	2.1	312	455	350	5.7	45	2,500	0%	No LJ drains
7	LA	LAW	EQ	CRI	El. 312	XYZ	2021, 2022	4.1, Table 4-7	n/a	312	430	307	3.5	45	2,500	0%	No LJ drains
8	LA	LAW	Post-EQ	CRI	El. 312	XYZ		4.1, Table 4-8	1.6	312	430	307	12.5	45	2,500	0%	No LJ drains
9	SW	SW1, SW8	N	LJ	El. 320	XYZ	2020	5.2, Table 5-7	2.5	320	430	307	0.00	45	0	0%	No LJ drains
10	SW	SW1, SW8	N	LJ	El. 320	XYZ	2020	5.2, Table 5-7	2.0	320	430	307	0.00	45	0	0%	No LJ drains
11	SW	SW2 - SW7	N	LJ	El. 312	XYZ	2020	5.2, Table 5-8	5.1	312	430	307	0.00	45	0	0%	No LJ drains
12	SW	SW2 - SW7	H	LJ	El. 312	XYZ	2020	5.2, Table 5-9	3.0	312	455	350	0.00	45	0	0%	No LJ drains
13	SW	SW2 - SW7	H	LJ	El. 312	XYZ	2020	5.2, Table 5-9	2.0	312	455	350	0.00	45	0	0%	No LJ drains
14	SW	SW2 - SW7	H	LJ	El. 312	XYZ	2020	5.2, Table 5-11	2.3	312	455	350	0.00	45	0	0%	No LJ drains
15	SW	SW2 - SW7	EQ	LJ	El. 312	XYZ	2020	5.2, Table 5-12	2.6	312	430	307	5.50	45	0	0%	No LJ drains
16	SW	SW2-SW7	Post-EQ	LJ	E. 312	XYS	2020	5.2, Table 5-12	1.3	312	430	307	6	45	0	0%	No LJ drains

The IC Team will complete independent calculations of the stability analyses of records prior to completing Task 3. This will be done to verify the need for updated or additional analyses prior to completing the field inspection, PFMA, and L2RA. The independent calculations will be simple hand calculations and included in the CAR as an appendix.

The IC Team will review the existing hydrology modeling (performed by others) and assesses if the flood inundation and other assessments are adequate to rely upon the results during later tasks. This proposal assumes no additional hydrology and hydraulic modeling will be required; however, if deemed necessary, the IC Team will provide recommendations for additional analysis, which can be performed at an additional cost.

No additional detailed analysis is assumed to be performed or included in this scope of work to complete the Part12D CA with L2RA.

6.3 Task 3: Comprehensive Assessment Pre-Inspection Preparation Report

6.3.1 Comprehensive Assessment (CA) Pre-Inspection Preparation Report (CA-PIPR)

The IC Team will prepare a CA-PIPR in accordance with 18 CFR Part 12.42 and FERC Engineering Guidelines Chapter 16, Appendix E. To improve efficiency, the CA-PIPR will be prepared concurrent with the project document review. The IC Team understands that the CAPIPR is a comprehensive summary of the project documents to identify data gaps and to identify critical features to observe during the field inspections. During the document review, the IC Team will begin populating the CA-PIPR report sections, which will include:

- Description of project features and operations;
- Summary and assessment of the original design considerations and construction ;
- Summary and assessment of previous analyses ;
- Summary of the project modifications, previous Part12D recommendations, completed studies, outstanding/on-going studies, and operation and maintenance program(s);
- Summary and interpretation of historic instrumentation data; and

- Summary and assessment of the dam and public safety programs.

Preliminary conclusions will be developed based on the review of the available information.

Upon development of the CA-PIPR, it will be submitted to Siskiyou for review and comment (approximately six weeks prior to conducting the field inspection). The Team will incorporate comments and submit a final CA-PIPR to Siskiyou for submittal to FERC for their review and approval.

The evaluations and conclusions in the CA-PIPR are considered preliminary.

Deliverable: Draft CA-PIRP (pdf)
Final CA-PIRP (pdf)

6.4 Task 4: Field Inspection

6.4.1 Part12D Inspection Plan

A Part12D Inspection Plan is required by FERC to be submitted a minimum of 180 days prior to completing the field inspection and other IC Team activities. The Part12D Inspection Plan is to be developed in accordance with 18 CFR Part 12.34 and the FERC Engineering Guidelines Sections 6-2.3 and 6-3 and Appendix A. This document includes a description of the project information, FERC inspection type, detailed list of project features to be inspected and how, IC Team proposal, and project schedule.

The Part12D Inspection Plan will include the IC Team members provided in Table 3. The site inspection participants include the ICs, recorder, facilitator, and representative of the relevant technical disciplines.

Hatch will develop the Part12D Inspection Plan for Siskiyou's review and submittal to FERC. We have assumed one draft comment period from Siskiyou. We have assumed that FERC will accept the submitted Part12D Inspection Plan without comment.

Deliverable: Draft Part12D Inspection Plan (pdf)
Final Part12D Inspection Plan (pdf)

We assume one round of Siskiyou comments will be addressed before issuing the final inspection plan to Siskiyou for FERC submittal. We have assumed that FERC may request updates to the plan upon their review. We have included one revision to the plan that addresses simple, editorial changes and clarifications.

6.4.2 Field Inspection

A physical field inspection will be performed at the Project. Hatch's IC Team will review and assess all relevant data including but not limited to settlement, movement, erosion, piping, seepage, leakage, cracking, deterioration, seismicity, internal stress, and hydrostatic pressure in the project structures, their foundations, and abutments, functioning of foundation drains and relief walls, stability of critical slopes adjacent to the reservoir or project works, and regional and site geological conditions. Additionally, specific evaluation of the adequacy of spillways, effects of overtopping of non-overflow structures, structural adequacy and stability of structures under all credible loading conditions, relevant hydrological data accumulated since the project was constructed or the last Part 12D inspection, history of the performance of the project works through analysis of data from monitoring instruments, and quality and adequacy of maintenance, surveillance, and methods of project operations for the protection of public safety will also be reviewed.

Hatch's IC Team will conduct the field inspection in compliance with the FERC Engineering Guidelines Chapter 16 Part 12D Program. The field inspection will include all dams and all principal works for the Projects.

Hatch anticipates performing the field inspection in one day. It is anticipated that one full day of site time (eight hours) will be needed. The IC Team will plan inspection activities and physically participate during the field inspections at the Project. The IC Team is anticipated to include five individuals (the IC, Facilitator, Recorder, and two subject matter experts that will participate in the workshops) for the field inspection. We propose the following individuals attend the site inspection:

- Allison Lunde, PE (IC)
- Pete Haug, P.E. (Facilitator)
- TBD, as Appointed by the Facilitator (Recorder)
- Bill Kussmann, PE (Geotechnical/Geology SME)
- Nicholas Agnoli, P.E. (H&H SME)

The site inspection SME team representation is subject to change based on the finding during Task 2.

Hatch will complete detailed notes and include photographs in the FERC CAR. It is assumed that the site inspection will take place the Monday of the PFMA workshop week.

Any areas requiring non-traditional means of access or additional safety coordination, as determined during document review or on the second coordination call, will be discussed with Siskiyou at least 60 days prior to the field inspection.

6.5 Task 5: Potential Failure Mode Analysis (PFMA)

6.5.1 Potential Failure Mode Analysis (PFMA) Training

Prior to travelling to the site, the Facilitator will conduct a one-hour virtual meeting to familiarize the team with the elicitation software and discuss expectations for the PFMA workshop.

6.5.2 *Potential Failure Mode Analysis (PFMA) Workshop*

The PFMA will be completed in conjunction with the Part 12D inspection. Based on the number of facility components, the PFMA is assumed to be completed immediately after the field inspection and last four full days (32 hours). Mr. Peter Haug will serve as the Hatch team's Facilitator for the PFMA workshop. We have assumed that the IC, the Facilitator, the Recorder, and two subject matter experts will participate in the PFMA workshop full time. As required, the IC Team (Facilitator, Recorder, IC, and two SMEs) has budgeted up to 12-hours for virtual continuation of the PFMA.

The PFMA will be completed in accordance with FERC Engineering Guidelines Chapter 17 and Chapter 16 Section 16-6.6.2. The following is Hatch's approach to completing a PFMA that follows FERC's updated guidelines.

The IC Team will prepare a detailed workshop agenda to provide meeting structure to improve efficiency and help eliminate redundancy. The agenda will include a proposed SME participation schedule in order to limit individual SME participation on applicable days and/or session sections. Hatch will also develop and present a project summary and overview to the PFMA Team including an understanding of the project's design, construction, physical features, operation, loading conditions, and instrumentation. We will provide a draft of the presentation to Siskiyou at least two weeks prior to the workshop for review. Once approved by Siskiyou, the IC Team will present this presentation at the PFMA workshop.

The PFMA will kick-off the after the site inspection concludes and will start with a brainstorming session to identify candidate PFMs. Candidate PFMs will be identified for all project features and components using the expanded definition of failure in Chapter 17 of the FERC guidelines. Hatch's Team will participate in the brainstorms of PFMs and collaborate in developing and detailing the PFM.

Each PFM will be screened as either urgent, credible, financial/damage state, asset management, insufficient information, clearly negligible, or ruled out. Urgent, credible, financial/damage state, and insufficient information PFMs that are found to be potential risk drivers based on the initial risk screen described above will be carried forward to the risk analysis. Note that urgent PFMs must be followed up on with FERC within seven days of identification. FERC recommends that asset management PFMs be carried forward into the risk analysis; however, these PFMs will be discussed with Siskiyou prior to a decision. Any additional studies or additional information will be identified during the workshop. At the end of the workshop, the IC Team will participate in developing the major findings and understandings (MFUs).

We assume Siskiyou will provide suitable (one table per person, private, limited noise, well lit, etc.) meeting room accommodations (projection systems, Wi-Fi, tables, chairs, electrical power outlets, etc.). The IC Team will coordinate with Siskiyou to confirm the meeting room selection and provided accommodations.

Hatch will develop the draft PFMA report that will be provided to the participants for review and comment. The guidelines state that the PFMA summary can be included within the CAR. Upon incorporation of comments from participants, the final PFMA report will be incorporated in the PFMA section of the daft and final will be included in the CAR. We assume one round of comments from Siskiyou on the draft.

Deliverable: Draft Potential Failure Mode Analysis Report (pdf and Word)
Final Potential Failure Mode Analysis Report (pdf) – *included in the CAR*

6.6 Task 6: Risk Assessment (L2RA)

6.6.1 L2RA Preparation

Following the PFMA workshop and prior to kick-off of the L2RA workshop, the Facilitator will assign the IC Team homework items that can be conducted in small groups without a Facilitator. This will allow the IC to arrive to the L2RA prepared and ready to discuss the homework findings with the Facilitator. The IC Team will participate in a one-hour virtual teleconference training session. The training session will provide a list of the PFMAs determined to be brought forward to the L2RA from the PFMA workshop and provide education on the L2RA process and expectations of the participants. The Facilitator, Recorder, and ICs will participate in this call.

6.6.2 L2RA Workshop and Report

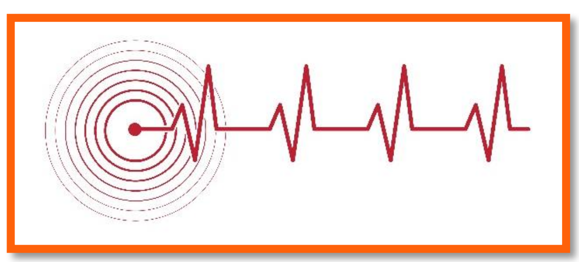
The L2RA IC Team will consist of the Facilitator, the Recorder, the IC, and appropriate Subject Matter Experts as described in Section 3.

Mr. Peter Haug will serve as the IC Team's Facilitator for the L2RA workshop. The IC Team and Risk Facilitator will complete a L2RA in accordance with 18 CFR Part 16-6.6.4 and FERC Engineering Guidelines Chapter 18. The L2RA process includes a refined screening and characterization of risk for specific PFMs. As described in this guideline, the primary purposes of a L2RA are to:

- Evaluate the project potential failure modes and associated risks.
- Identify the need for additional studies and determine the priority for those studies.
- Identify and prioritize any data collection and analyses.
- Identify operations and maintenance, monitoring, emergency action plan, training, and other recurrent needs.
- Provide a better understanding of potential failure modes and a basis for future dam safety inspections and activities.
- Provide support to inform dam safety decisions for taking action (or not) to better define risks through higher level studies or reduce risks.

6.6.2.1 Seismic Hazard Analysis

The IC Team will develop the seismic hazard probabilistic estimate for the Project. An estimate of the seismic hazard at the Project will be to assess the probability of ground shaking caused by earthquakes that could lead to an adverse response of the dam, appurtenances, and components. It is assumed that a site-specific seismic analysis hazard analysis is not available for the Project.



FERC provides an alternative approach when no probabilistic seismic hazard study is available for a site. FERC allows a simplified seismic hazard that is available from USGS to be used. The IC Team proposes that the USGS simplified seismic hazard curve be utilized for this project.

Development of the probabilistic seismic hazard curves will rely on a simplified approach in which the published values from the USGS 2018 NSHM are utilized without modification. The 2018 NSHM provides seismic hazard curves, which display the annual frequency of exceedance for a range of ground-shaking intensity levels, for Peak Ground Acceleration (PGA) and 21 periods between 0.01 and 10.0 seconds.

If no shear-wave velocity measurements have been made at the site, we will use descriptions of the site geology to characterize the materials beneath the dam and estimate the shear-wave velocity for the foundation conditions. The shear-wave velocity for the foundation conditions of the dam will be used to extract seismic hazard curves for the 2018 NSHM for an appropriate reference site condition.

To document the USGS simplified seismic hazard curve, Hatch will develop a short technical memo, which may be referenced during the L2RA workshop and later included in the CAR.

Deliverable: Draft and Final Seismic Hazard Curve Memo (pdf)

6.6.2.2 Flood Hazard Analysis

Per Chapter 18 of the Guidelines, the IC Team will investigate the hydrologic loading conditions. Specifically, we will develop hydrologic hazard curves (reservoir elevation vs. annual chance exceedance or (AEP) or review the curves currently on record for the project and prepare a white paper. If adequate curves do not currently exist on record for the project, AWA will develop the site-specific AEP that will be used to develop the hydrologic hazard curves. Our hydrologic hazard curves (HHC) will extend far enough out to a frequency that captures the full range of response and project risk. This may require the portrayal of the hydrologic hazard curve at frequencies less than what is represented by the Probable Maximum Flood (PMF) – in other words, events more remote than the PMF.

There are various ways in which such curves can be developed. They typically rely on statistical evaluation of historical information and some method to estimate loading levels for more extreme flood events, possibly performing some limited flood routing using reservoir operating rule curves.

For qualitative assessments, flood loading is typically limited to existing information or information that can be easily obtained from sources such as the US Geological Survey websites (although data from the USGS websites will be limited to a flood with an AEP of about 1/500). However, the IC Team has a large library of rainfall data across the United States and, when coupled with hydrologic models on record, there is the potential for more accurate curve values. The IC Team will use Best Practices in Dam and Levee Safety Risk Analysis Chapter B-1 Hydrologic Hazard Analysis (BOR/USACE, 2019) as recommended by FERC. It is assumed due to the cost and complexity that paleo-flood evaluation is beyond the scope of this proposal.

Together, these models calculate the statistical frequency of extreme floods, a flood hydrograph shape, and a peak reservoir flood stage that can be used for L2RA.

6.6.2.3 Flood-Frequency Analysis

RMC-BestFit is the model used to complete statistical analysis to estimate the magnitude, probability, and uncertainty surrounding extreme floods. It is a Bayesian estimation and fitting software, meaning the model uses data (e.g., river flow data) as well as priors (expectations about the data) to compute the expected flood frequency curve (peak flows vs. probability of occurrence) as well as the range of uncertainty of extreme floods.

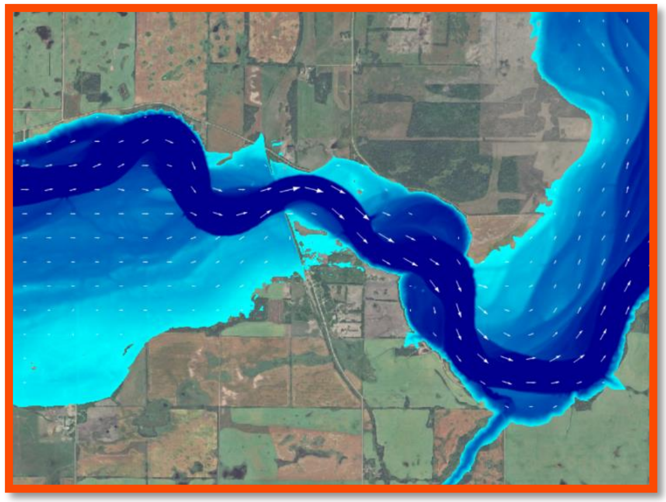


Figure 6-1: Flood Analysis Graphic

RMC-BestFit uses up to three types of input data to complete a flood-frequency analysis. These types of data and our approach to gathering this data are listed below:

1. Inflow data (referred to in RMC-BestFit as "Systematic Data"). Inflow to the reservoir comes from two sources: precipitation falling on the reservoir surface and water pumped from the Connecticut River. Daily precipitation gauge and pumping data will be entered into RMC-BestFit as volumetric flow data based on the critical duration, which Hatch will calculate based on the duration of past flood events. The pumping data is regulated and lacks natural variability, and it will be used with the knowledge that the resulting flood frequency curve is subject to change based on operating procedures.
2. Historical flood data (referred to in RMC-BestFit as "Interval Data"). This type of data does not apply because the stage elevation in the source of the reservoir, the Housatonic River, does not directly correlate with the stage in the reservoir because flow is controlled by pumping.
3. Inferred data (referred to in RMC-BestFit as "Threshold Data" or "Perception Thresholds"). This type of data also does not apply due to the same reasons as listed above.

In addition to known data, RMC-BestFit can also include up to two types of ***priors*** (expectations) about extreme floods to use in calculating the flood-frequency:

1. Regional skew, which is a numerical statistical measure of the behavior of floods within a similar geography. Because the flood, in this case, would be the result of precipitation primarily on the surface of the reservoir itself, regional skew is not expected to provide an accurate representation and will not be used.
2. Hydrologic model results based on precipitation-frequency estimates. If a hydrologic model is already available, Hatch will add information from the hydrologic model to the RMC-BestFit . The hydrologic model must be appropriate for modeling extreme storms, as Hatch has not scoped for modification of the hydrologic model.

We will then run a Bayesian simulation using the data and priors described above and complete a test on the extreme value goodness-of-fit of the statistical plotting method (e.g., Log-Pearson Type III, Log-Normal, Generalized Extreme Value, Gumbel, etc.) to determine the most appropriate flood-frequency curve.

We will also complete a sensitivity analysis on the flood-frequency curve by varying the regional skew, assessing the critical duration, and, if applicable, modifying the uncertainty bounds of the historical flood data.

6.6.2.3.1 Reservoir Frequency Analysis

The flood-frequency curve computed by RMC-BestFit will be imported into the RMC-RFA model. RMC-RFA is the model used to complete statistical analysis to estimate the peak reservoir stage (water level) frequency curve and uncertainty surrounding extreme floods.

The input data to RMC-RFA is comprised of four categories:

1. Volume frequency curve computed by RMC-BestFit.
2. Discharge data from the unmodified flow record (without critical duration) is also entered into the dataset.
3. Historical flood hydrographs (referred to RMC-RFA as “Inflow Hydrographs:”
   a. Flood hydrographs of past major floods will be entered into the model. Hatch will follow USACE guidance and use between three and five historical floods. Equal weighting (probability) will be applied to all historical flood hydrographs unless event-specific conditions (e.g., upstream dam or levee breach) may have altered the flood hydrograph.
4. Stage Data:
   a. Historical reservoir stage data will be entered from data/operational logs.

Next, RMC-RFA requires analysis of event conditions before the final simulations. To do this, we will analyze the:

- Seasonality of differing types of floods and magnitudes of floods that occur on the basin;
- Initial (pre-event) water level of the reservoir; and
- Annualized stage-frequency curve (peak annual stage).

Finally, the input data coupled with the analysis of event conditions and the reservoir models will be simulated to develop a stage-frequency curve for both reservoir conditions.

A sensitivity analysis on the RMC-RFA model will be completed by modifying seasonality assumptions, consideration of alternative historical flood hydrographs, and varying the initial water level in the reservoir.

Deliverable: Draft and Final Flood Hazard Analysis Report (pdf) with assumed one round of comments from Siskiyou the draft report and one round of comments from the FERC on the final report.

6.6.2.3.2 Hazards Evaluation

Mr. Nicholas Agnoli will lead the consequences analysis in support of the PFMA and L2RA workshops. The analysis includes the estimation of direct life loss and direct property damages using two publications by the Bureau of Reclamation: *Reclamation Consequence Estimating Methodology* and *A Procedure for Estimating Loss of Life Caused by Dam Failure.*

The impacts of dam failure will be assessed for each scenario, including an assessment of the potential for loss of life (RCEM, 2014 and Graham, 1999 are the primary sources used by the IC Team to determine potential LOL) and for economic and environmental damage. As part of the assessment of impacts, Hatch will identify and classify areas of concern in the downstream floodplain including buildings, bridges, roads, towns, etc. This will be done through the data gathered during the data gathering phase and by inspection of the most recent aerial photography, analysis of available mapping, contacts through local municipal governments and emergency measures organizations. Reasonable estimates of property/ infrastructure value will be made using available information and past experiences.

Reasonable estimates of third-party losses including property, infrastructure, agricultural and water supply value will be made using available information and past experiences. Incidental costs such as legal costs and/or compensation to affected parties, secondary impacts such as interruption of business/services, provincial/federal fines related to environmental damages, environmental cleanup, potential damages to the river to bank/slope failures, damages and costs to replace third party hydro-meteorological equipment and intangible impacts such as evacuation costs, stress and discomfort will also be accounted for, as a markup on the capital costs assessed. The first party loss including the cost to repair the dam itself following failure will be evaluated separately.

A basic qualitative evaluation of the types and severity of incremental environmental impacts that may result in the event of a breach of the dam will be made.

The following assumptions were made regarding the analysis:

- Output from the existing dam breach analysis completed using the USACE's Hydrologic Engineering Center River Analysis System (HEC-RAS) will be used to complete the consequence analysis.
- Consequence analysis will be completed for up to four hydraulic scenarios.
- One structure inventory using the USACE National Structure Inventory database, Microsoft Buildings, or other open-source buildings layers (such as Mapillary).
- Two alternatives, one for minimal warning and one for ample warning, will be developed for each hydraulic breach scenario. Hazard identification time and hazard communication delay for each alternative will be defined following the USACE Modeling, Mapping, and Consequence Center Technical Manual Dams.

Both daytime and nighttime hazard occurrence times will be simulated.

The results of the consequence will be summarized in a short technical memo. We assume consequence analysis only related to the L2RA will be performed. If requested, additional modelling to confirm the existing IDF could be performed as an additional service.

6.6.3 *L2RA Workshop*

The IC Team Facilitator will guide the group through the FERC process described in the referenced engineering guidelines. Hatch will provide the Facilitator, Recorder, ICs, and Subject Matter Experts for the workshop.

The L2RA workshop is assumed to be completed in person at a Siskiyou-provided facility with suitable amenities (one table per person, private, limited noise, well lit, etc.) meeting room accommodations (projection systems, Wi-Fi, tables, chairs, electrical power outlets, etc.). The facilitator will work with dam owner to confirm the meeting room selection and provided accommodations are suitable. Some subject matter expert participants may be virtual for cost efficiency. It is expected that Siskiyou is able to provide staff members that are appropriate for the workshop, such as but not limited to, chief dam safety engineer, technical engineers, and operator(s). A working lunch is expected with the owner organizing the lunches.

Each team member will make an individual estimate of the failure likelihood following initial group discussions. Then the group will discuss the reasoning behind each individual's estimate until a consensus is reached. If a consensus cannot be reached, the range of descriptors will be captured along with the reasons for each. Confidence ratings are also selected by the group and recorded for each likelihood and consequence ranking. FERC provides failure, life safety, economic and environmental consequences likelihood descriptors that are broken down into the annual failure probability levels for more frequent (1/10) to remote (1/10,000) will be used. Upon completing the L2RA for the selected PFMA, a report will be developed to document the process.

The L2RA Report will be developed in accordance with the outline provided in FERC Engineering Guidelines Chapter 18 Appendix B. The report will include the following sections:

- Section 1.0: Introduction (including Introduction, Scope of Work and Project Team)
- Section 2.0: Description of Dam and Other Key Features
- Section 3.0: Previous Studies
- Section 4.0: Hydraulic Loading (including Subsection General, Background Information, Reservoir Elevation Frequency, Methodology/Approach, Results and Non-Breach Scenario)
- Section 5.0: Seismic Loading (including subsections General, Background Information, Methodology/Approach, and Results)
- Section 6.0: Consequences (including subsections General, Approach, Inundation Scenarios, Description of Inundation Area, Breach Assumptions, Life Loss Estimates, Economic Loss Estimates, and Other Consequences)
- Section 7.0: Potential Failure Modes (including subsections Potential Failure Mode Analysis, Identification of Candidate Potential Failure Modes, Evaluation and Screening of Potential Failure Modes, and Potential Failure Modes Carried Forward into Risk Analysis)
- Section 8.0: Risk Analysis (including subsections General, Methodology/Approach, PFM Summary, and Summary and Evaluation of Risk Estimates)
- Section 9.0: Major Findings and Understandings
- Section 10.0: Conclusions and Recommendations
- Appendix A: Risk Analysis PFM Worksheets (which will be formatted similar to the template projected in FERC Engineering Guidelines Chapter 18 Appendix C)

It is assumed that the in-person L2RA workshop will take place over three 10-hours days and one partial day (up to 37 hours). After the L2RA, up to 12 hours of additional time is budgeted for virtual L2RA sessions to accommodate facilitated discussions of economic risk and minor dispositions (damage states) by the core IC Team (facilitator, recorder, IC, and two SMEs). The L2RA will be complete after the PFMA workshop and draft development of the PFMA report.

The IC Team will develop the L2RA report that will be provided to the participants for review and comment. Upon incorporation of comments from participants, Hatch will provide a signed final L2RA report to include in the CAR.

Deliverable: Draft Level 2 Risks Analysis Report (pdf and Word)
Final Level 2 Risks Analysis Report (pdf) – *to be included in the CAR*

6.7 Task 7: Comprehensive Assessment Report (CAR)

The following sections describe the final report, CAR, and findings presentation, CAR Review Meeting, that will provide the details of the work completed for the Part 12D.

6.7.1 Part 12D Comprehensive Assessment Report

The ICs will prepare the Part12D CAR in accordance with 18 CFR Part 12.38 and FERC Engineering Guidelines Chapter 16 Appendix D. The CA-PIPR will be expanded to include the findings, conclusions, and recommendations stemming from the PFMA and L2RA; the observations and findings made during the field inspection; any necessary updates to the CA-PIPR sections as additional information becomes available to prepare the CAR.

Upon development of the CAR, it will be submitted to Siskiyou for review and comment. The Team will incorporate comments and submit a final CAR to Siskiyou for submittal to FERC for review and approval. It has been assumed that one draft CAR will be provided to Siskiyou for review and comment.

The final CAR will be provided upon completion of the CA Review meeting. The pdf of the CAR will be a searchable file that will have high resolution printing capabilities and copying of text and graphics.

Deliverable: Draft Part 12D Comprehensive Assessment Report (pdf and Word)
Final Part 12D Comprehensive Assessment Report (pdf)

6.8 Task 8: Comprehensive Assessment (CA) Review Meeting

The IC Team will prepare a PowerPoint presentation to be used in the CA Review Meeting. The presentation will cover the findings, conclusions, and recommendations from the CAR. The Team will provide a draft PowerPoint to Siskiyou for review and comment, at a minimum, one week prior to the meeting. Siskiyou's comments will be incorporated into a final presentation. The final presentation will be provided to Siskiyou. The CA Review Meeting (anticipated to be a four-hour teleconference meeting) will be held between the IC Team, Siskiyou, and FERC. We anticipate the CAR Review meeting will be virtually attended by the two ICs and the Recorder. Meeting minutes from the meeting will be developed by Hatch and distributed to Siskiyou.

The CA Review Meeting will be completed in accordance with FERC Engineering Guidelines Chapter 16 Section 7.5 and Appendix F. The following is the proposed general format for the presentation.

- Title Slide (including but not limited to Project Name, Location, FERC Office, Licensee Name, and Photograph)
- Project Location Map
- Project Team (including the Names and Roles of the IC Team and Facilitators)
- Project Description (including Key Drawings)
- Summary of Review of Design, Construction and Analysis
- Review of STID
- Key Field Inspection Findings
- Review of Dam Safety Surveillance and Monitoring Report
- Summary of PFMA and Overall Summary of PFMs
- Loading Curves for Hydrologic and Seismic
- Consequence Summary (including Life Loss, Economic, etc.)

- Risk Analysis Summary (including Risk Plot, Discussion of Risk-Driving PFMs)
- Review of Dam and Project Safety Programs (ODSP, DSSMP, EAP, PSP, O&M, etc.)
- Summary of Findings and Recommendations (including Key Findings, Status of Outstanding Recommendations, and Summary of New Recommendations)

Deliverable: Draft CA PowerPoint (.pdf)
Final CA PowerPoint (.pdf)
Meeting minutes (.pdf)

6.9 Task 9: Project Management

Hatch's Quality Management System (HQMS), compliant with the requirements of ISO 9001:2008, is delivered to projects through the Hatch Project Lifecycle Process (PLP) and will be used in all aspects of the work Hatch performs. This toolkit contains the procedures, functional guidelines and associated tools needed to execute quality projects. It contains documentation for all functional groups and engineering disciplines.

Quality in project management will be achieved through:

- Development of a Project Execution Plan (PEP). The scope of the PEP covers all policies, plans and procedures necessary to implement, execute and close out the project. The plan defines the specific technical procedures to be followed and the technical checking and project reporting requirements.
- Proper planning throughout all functions within the project.
- Regular progress reporting to Siskiyou and Hatch management to identify issues in a timely fashion.
- Regular communication of project status throughout all levels of the project organization .

Quality in engineering will be achieved through:

- Internal and external deliverables will be reviewed and signed off by independent reviewers before issue.
- Quality audits will be undertaken by a qualified internal auditor on a routine basis. The results of these audits will be presented to the project team along with documentation in HQMS.

7. Schedule

The services described herein shall be completed by August 19, 2025. Below is a preliminary project schedule. Note, the timing of the field inspection of the Project will be critical to meet the project deadline. Upon award, Hatch will work with Siskiyou to develop a detailed project schedule.

Note, the Part12D Inspection Plan is required to be submitted to FERC 180 days prior to the inspection. With an inspection tentatively planned for end of October 2024, this would require the Inspection Plan to be submitted to FERC May 1, 2024. Due to the timing to execute the contract and provide Notice to Proceed, we recommend that Siskiyou County should request a 60-day extension to submit the Inspection Plan with all other dates remaining the same to meet the final submittal date of June 20, 2025. This would still allow for approximately four months of review and comment by FERC on the Inspection Plan.

Table 7-1: Critical Project Schedule Dates

Task	Date
Notice to Proceed / Award	May 1, 2024
Draft Part12D Inspection Plan	June 17, 2024 (TBD)*
Final Part12D Inspection Plan	June 28, 2024 (TBD)*
Second Coordination Call	within 6 weeks of IC Team Approval/Conditional Approval (tentatively before August 9, 2024)
Draft CA-PIPR	September 16, 2024 (TBD)
Final CA-PIPR	September 27, 2024
PFMA Training Call	Week of October 21st
Field Inspection	Monday October 28, 2024
PFMA Workshop (On-site)	October 29 to November 1, 2024
Draft PFMA Report	4 weeks following PFMA Workshop
L2RA Workshop (Onsite)	January 28 to 31, 2025
Draft L2RA Report	May 9, 2025
Draft CAR	May 23, 2025
Final CAR	June 20, 2025
CAR Review Meeting	Before August 19, 2025 (within 60 days after CAR submittal)

8. Exclusions and Assumptions

- STID will be updated by Siskiyou or others using the FERC Engineering Guidelines Chapter 15 Supporting Technical Information Document.
- Part 12D work will be based on the FERC Engineering Guidelines Chapter 16 Part 12D Program.
- PFMA will be based on the FERC Engineering Guidelines Chapter 17 Potential Failure Modes Analysis.
- Level 2 Risk Analysis will be based on the FERC Engineering Guidelines Chapter 18 Level 2 Risk Analysis.
- Siskiyou will provide owner's staff during inspection and workshops.
- Semi-quantitative risk analysis (SQRA) will not be completed.
- Hatch has not included the service to perform or subcontract for services related to underwater dive inspection for the Project.
- Hatch has not included the service to perform or subcontract for services related to detailed inspection of the penstock nor inspections requiring no confined space entry.
- Hatch has not included the service to perform or subcontract for services related to underwater sonar or remote vehicle inspection for the Project.
- AWA does not intend to complete any field sampling or field survey.
- The inundation mapping for the site is of sufficient quality to verify the PAR of the purposes of the PFMA and L2RA/ SQRA.

- Field Inspection will be completed in person with the IC Team (assumed five individuals of Allison Lunde, Bill Kussmann, Nickolas Agnoli, Peter Haug and the recorder). Field Inspection will be one full day (eight hours per day).
- Field inspection does not include entrance into confined space entry, such as the penstock and turbines.
- PFMA and L2RA workshops will be completed in person at a Siskiyou facility that has adequate internet and conference room space.
  - It is assumed that the onsite PFMA is assumed to take up to four full days (32 hours), and additional 12-hours virtual PFMA sessions are included for the five core IC team members.
  - It is assumed that the L2RA will take up to three long days and one partial day (37 hours) in person and additional 12-hours virtual L2RA sessions are included for the five core IC team members.
- Updates to the STID following this Part 12D are not included in our scope of work as the full scope is not currently known.
- Consequence analysis only related to the L2RA will be performed. If requested, additional modelling to confirm the existing IDF could be performed as an additional service.
- Bathymetric survey and reservoir rim survey are not included in the scope of work.
- All field inspection work is anticipated to be completed from the ground or by watercraft that is provided and operated by Siskiyou. Hatch has assumed any access for confined space will not be permitted and not included in the scope of work (i.e., roped access, confined space entry).
- Hatch's independent analysis of project features will not investigate effects due to alternate codes and standards such as but not limited to USACE EM 1110-2-2104 vs. ACI 318 and ACI 350, AWS vs. ASME, USACE ETL 1110-2-584 vs. AISC, AWWA M11 vs. ASCE No. 79, and general USACE vs. FERC vs. USBR.
- Hatch's independent analysis of project features scope of work will be limited to established failure modes only and used to determine whether additionally study(s) are warranted. Additional analysis study(s) are not within the scope of work of this proposal. Additional analyses determined to be necessary to complete the CA / PFMA / L2RA are not included in this scope of work but, if determined necessary, can be developed as an additional service.

9. Items Required from Siskiyou

- Interface and coordination with Siskiyou.
- Access to the Project.
- Previous reports and relevant information.
- Provide project reference documents for the Project.
- Provide latest project figures for the Project.
- Provide pertinent FERC correspondence for the last five years for the Project.
- Provide the FERC Letter Requiring Part 12D Inspection (letter dated May 19, 2022) (Part 12D Report Appendix A).
- Provide the FERC Letter Approving Consultant (Part 12D Report Appendix B).
- Provide all prior FERC Safety Inspection Report.

- Provide recent underwater survey and LiDAR survey reports for the Project.
- Provide all analyses for the Project.
- Review and comment on draft deliverables within two weeks of being provided documentation.

10. Commercial Offer

10.1 Overview

Hatch is pleased to provide the following commercial offer to Siskiyou for the professional services (the "Services") detailed herein.

10.2 Estimated Cost of Services

The overall cost is estimated to be USD $434,999 on a reimbursable cost basis, exclusive of adjustment for variations.

A summary of the cost reimbursable estimate is provided Table 10-1 below.

Table 10-1: Estimated Breakdown of the Cost Estimate

Task	Level of Effort (hrs)	Estimated Expenses ($)	Total Estimated Cost (including Expenses) ($)
Task 1 – Project Coordination	6	-	$1,670
Task 2 – Document Review	32	-	$8,765
Task 3 – Inspection Plan & CA-PIPR	80	-	$19,340
Task 4- Field Inspection & Potential Failure Mode Analysis	182	$5,215	$54,450
Task 5 – Level 2 Risk Assessment	241	$4,230	$69,660
Task 6 – CAR	58		$15,020
Task 7 – Summary Tables and Recommendations	12	-	$2,875
Task 8 – CAR Review Meeting	20	-	$4,980
Task 9 – Project Management	28	-	$7,240
Subtotal HATCH estimated Cost:	**659**	**$9,445**	**$184,000**
Ayres Subconsultant Fee	432	$4,810	$109,560
Applied Weather Services Subconsultant Fee	434	$8,965	$141,439
Total Subconsultant Expenses	**866**	**$13,775**	**$250,999**
TOTAL ESTIMATED COST:	**1,525**	**$23,220**	**$434,999**

The fee breakdown is provided for indicative purpose only. Depending on type, quantity, format and completeness of information/data available for Hatch's review, as well as on actual findings or specific requirements from the Client during the assignment, fees may vary. In the case required additional budget beyond the herein presented initial total fees estimate is needed, it will be timely submitted to County of Siskiyou for review and approval.

10.3 Basis of Compensation

As full compensation for the services, Hatch will be paid the sum of labor billings and reimbursable expenses incurred.

10.4 Schedule of Rates

The applicable Schedule of Rates for reimbursable personnel labor and Project expenses incurred in performing Services is set out in Appendix B attached hereto.

The Schedule of Rates attached is applicable for 2024. To account for inflation, the rates shall be adjusted each January 1st according to Hatch's annual economic adjustments for the jurisdiction in which such Schedule of Rates applies. Notwithstanding the foregoing, applicable increases (if any) will not be Project specific but will be based on actual increases to the national rate schedule for the jurisdiction as applicable to all of Hatch's clients for similar Services.

The estimated cost in Section 10.2 above has been calculated to reflect for increased rates for services performed after January 1, 2025.

10.5 Travel and Related

Compensation to Hatch for chargeable expenses incurred by Hatch in the interests of the project and not provided for within the charge-out rates, such as travel and related costs including out-of-pocket disbursements, will be charged at Hatch's cost, plus 5%.

10.6 Subconsultants

Hatch has included the estimated cost for the proposed services of Subconsultants in Table 10-1. These Subconsultants will be charged to the Client at cost, plus an additional markup of 10% to cover administration services.

10.7 Invoicing & Payment

Invoices for reimbursable time and expenses will be invoiced on a monthly basis in arrears with payments due NET 30 days from the date of each invoice.

10.8 Additional Services

When a Scope Change is proposed or required, Hatch shall present to Siskiyou for its approval of the Hatch request for an adjustment in the Scope of Work supported by appropriate documentation. When approved by Siskiyou, a Contract Change Order shall be issued to Hatch amending the Scope of Work and the price accordingly. All Change Orders to be processed within twenty-one (21) calendar days.

10.9 Contract Terms and Conditions

Hatch will perform the Services detailed in this offer in accordance with the Professional Services Terms and Conditions included in Appendix A, on which this proposal has been expressly based.

10.10 Validity

This offer remains valid for County of Siskiyou's written acceptance for a period of 30 days from the date of this letter.

Acceptance of Offer

County of Siskiyou accepts this proposal and requests Hatch to undertake the assignment as detailed above. This letter, the enclosed proposal including the Statement of Services and attached Professional Services Terms and Conditions and Hatch Schedule of Rates form the whole agreement between County of Siskiyou and Hatch notwithstanding anything to the contrary in any purchase orders issued for administrative convenience.

Signed on behalf of Hatch Associates Consultants, Inc. by:	Signed on behalf of County of Siskiyou by:
______________________	______________________
Name: ______________	**Name:** ______________
Title: ______________	**Title:** ______________
Date: ______________	**Date:** ______________

Appendix A:
Terms and Conditions

CLAUSE 1 AGREEMENT

1.1 Unless a written agreement is entered into, Client's acceptance of a proposal (the "*Proposal*") from the Hatch company submitting the Proposal ("*Hatch*") or a request by Client for some or all of the services included in the Proposal, constitutes a binding contract between Client and Hatch (the "*Agreement*"). The Agreement incorporates and is subject to these Terms and Conditions and the terms and conditions included in the Proposal, including the description of the services to be provided by Hatch (the "*Services*"). If there is any conflict between the Proposal and these Terms and Conditions, these Terms and Conditions will govern. Any terms appearing on any orders or other documents produced by or on behalf of Client are excluded unless they have been specifically accepted in writing by Hatch.

CLAUSE 2 HATCH SERVICES AND RESPONSIBILITIES

2.1 Hatch will (a) perform the Services with due care, skill and diligence in accordance with the standard of care normally exercised by professionals providing similar services under similar circumstances, and (b) reperform at its cost any Services that fail to comply with this standard, provided that Hatch may instead opt to refund to Client all amounts paid in respect of such Services if it determines that reperformance is not practicable.

2.2 Hatch will comply with all applicable laws and site policies and procedures, including those relating to safety and security; but, unless otherwise agreed, Hatch is not responsible for overall site safety or security at any Client premises or the project site.

2.3 Unless otherwise agreed, Hatch can rely without verification on all information provided by Client or by third parties on behalf of Client.

2.4 Hatch will have in effect for the duration of the Services (a) workers compensation coverage in accordance with statutory requirements, (b) commercial general (or public) liability insurance ($5,000,000 per occurrence); and (c) automobile liability insurance ($5,000,000 per occurrence).

CLAUSE 3 CLIENT RESPONSIBILITIES

Client will (a) make available to Hatch all information, documents and assistance required in connection with the Services, (b) make decisions and provide approvals in a timely manner and obtain all necessary project authorisations and permits, (c) notify Hatch if it becomes aware of any matter that may change the scope, timing or complexity of the Services, (d) act reasonably and in good faith, (e) comply with applicable laws, and (f) maintain insurance to limits which are normal and customary in the circumstances and Client, on behalf of itself and its insurers, waives all rights of subrogation against Hatch for, and releases Hatch from any liability for damage to Client's property to the extent that Client is compensated for such damage under an insurance policy.

CLAUSE 4 INVOICING, PAYMENT AND TAXES

4.1 Unless otherwise provided in the Proposal and subject to Clause 4.2, (a) Services (including any additional services provided at the request of Client or pursuant to Clause 4.5) and related costs incurred by Hatch in connection with the Services will be charged to Client in accordance with Hatch's schedule of rates or the amount agreed in the Change Order, (b) amounts invoiced to Client by Hatch are due and payable within the period stated in Hatch's schedule of rates or, if not so stated, within 30 days of receipt of invoice by Client, and (c) interest will be paid on past due amounts at the rate stated in Hatch's schedule of rates.

4.2 If an advance payment or security deposit amount is specified in the Proposal, such amount will be paid by Client prior to Hatch commencing the Services and will be held by Hatch as security for payment. Hatch may apply these funds against any amounts owing by Client to Hatch and will return any remaining amounts to Client upon receiving full payment for the Services.

4.3 Hatch's rates are exclusive of all taxes, duties, royalties, levies and other governmental or regulatory charges, other than taxes on payroll and Hatch's net income in the Jurisdiction. If any such taxes, duties, royalties, levies or charges are levied on or applicable to amounts payable to Hatch, they will be borne by Client and (a) if Hatch is required to pay any such taxes, duties, royalties, levies or charges, the amount of such payments will be reimbursed to Hatch by Client, and (b) if they are required to be withheld or deducted from amounts payable to Hatch, the amounts payable will be grossed up so that Hatch receives the entire amount that is due pursuant to the terms of the Agreement.

4.4 If Client disputes any portion of an invoice, it will pay those amounts that are not in dispute and notify Hatch in writing of the reasons for the dispute within 10 days of receiving the invoice. Failure to notify Hatch of the dispute within the required time will be treated as acceptance of the invoice. If it is determined that any amounts in dispute should have been paid at the time it was invoiced, then Client will promptly pay such amount, together with interest at the rate set out in Clause 4.1.

4.5 Hatch shall be entitled to a Change Order in the event of any Scope Changes and shall not be required to proceed with any change to the Services in advance of the execution by both parties of the relevant Change Order.

CLAUSE 5 LIABILITY AND INDEMNITY

5.1 To the maximum extent permitted by law and notwithstanding and superseding anything to the contrary in the Agreement:

(a) Clause 2.1(a) sets out Hatch's sole warranty respecting the Services and Clause 2.1(b) sets out Hatch's sole obligation and Client's sole remedy in connection with any breach of Clause 2.1(a) (and Client will not otherwise have any recourse against Hatch in connection with any errors or omissions in the Services);

(b) subject to Section 5.2, the aggregate liability of Hatch arising in connection with the Agreement is limited to (i) the amount of the professional fees paid to Hatch pursuant to the Agreement up to $100,000, plus (ii) 10% of such fees paid in excess of $100,000; provided that in no event will Hatch's aggregate liability exceed $1,000,000;

(c) Hatch has no liability to Client for any losses, damages or costs that can be construed as an indirect, special, punitive or consequential losses, damages or costs; and

(d) any claim, action or proceeding against Hatch in connection with the Agreement, including any warranty claims under Clause 2.1, must be made within 12 months of the earlier of completion of the Services and termination of the Agreement.

5.2 Hatch's liability for claims or losses covered by the insurance policies referred to in Clause 2.4 is limited to the proceeds of insurance up to the amounts specified in Clause 2.4.

5.3 Client indemnifies, defends and holds harmless Hatch for any claims, actions, proceedings, liabilities, losses, damages or costs that Hatch suffers or incurs (a) in connection with the Services and which result other than from a breach of the Agreement by Hatch, (b) as a result of any breach of the Agreement by Client, (c) as a result of site conditions that were unknown to Hatch at the time of entering into the Agreement, or (d) as a result of third party use of, or reliance on, any information or deliverable provided by Hatch to Client in connection with the Services.

CLAUSE 6 USE AND OWNERSHIP OF INFORMATION

6.1 Each party retains title to all intellectual property (including all patents, trademarks, copyright, trade secrets and know how) owned or possessed by it or any of its affiliates and used by it in fulfilling its obligations under the Agreement, including any modifications or improvements made thereto ("*Background IP*"). All new and original intellectual property created by Hatch during the course of performing the Services ("*Project IP*") is the property of Hatch. Hatch grants Client a non-exclusive, non-transferable and, unless otherwise agreed, royalty-free license to use (a) any Hatch Background IP used in the performance of the Services but only to the extent required to use any deliverables provided by Hatch for the purpose for which they have been provided and (b) Project IP for any purpose whatsoever; provided that Client has no right to receive or use proprietary information or coding that is embedded in Hatch's project systems, software or electronic copies of deliverables and Client will not modify any Hatch deliverables unless it has first removed Hatch's name and logo from the deliverable.

6.2 Upon receipt of full payment for the related Services and subject to the other provisions of this Clause 6, all reports, drawings and other deliverables provided to Client by Hatch will become the property of Client.

6.3 Any information or deliverable provided by Hatch to Client in connection with the Services is provided solely for Client's use and for the specific purpose for which the Services were engaged. Unless otherwise agreed by Hatch in writing, in no case will (a) any such information or deliverable be made publicly available or used in connection with any financing, sale or investment transactions, or (b) Hatch's name be used in any of Client's public disclosure or filings.

6.4 Each party will keep confidential all Confidential Information disclosed to it by the other party; provided that (a) Hatch is able to disclose Client's Confidential Information to those persons who need to know such information for purposes that relate to the performance of the Services, (b) Client is able to disclose Hatch's Confidential Information to the extent required in connection with the purpose for which the information was disclosed, and (c) either party is able to disclose Confidential Information where it is required to be disclosed by law, provided that the receiving party immediately notified the disclosing party of the requirement to disclose and allowed the disclosing party to take reasonable steps to lawfully resist or narrow the requirement to disclose the Confidential Information. Except as specifically provided herein, neither party will acquire any right, title or interest in or to the Confidential Information of the other party.

6.5 "*Confidential Information*" means any information in any form disclosed by or on behalf of one party to the other party at any time before or after the execution of the Agreement in connection with the Services; excluding only information which (a) was at the time of disclosure or thereafter became part of the public domain through no act or omission of the receiving party, (b) became available to the receiving party from a third party who did not acquire such confidential information under an obligation of confidentiality either directly or indirectly to the disclosing party, or (c) was known to the receiving party at the time of disclosure by the disclosing party and such knowledge can be demonstrated by written records that were in existence at the time of disclosure.

CLAUSE 7 TERMINATION AND SUSPENSION

7.1 Client may suspend the Services or terminate the Agreement for its convenience on 30 days prior written notice to Hatch; provided that, if the aggregate duration of all suspensions under the Agreement exceeds 60 days, Hatch will have the right to terminate the Agreement.

7.2 Either party may terminate the Agreement immediately if anything happens to the other party that reasonably indicates that there is a significant risk that the other party is or will become unable to pay its debts generally as they come due.

7.3 Either party is entitled to terminate the Agreement on 14 days prior written notice to the other party in the event that the other party is in substantial default under the Agreement and such default has not been corrected or reasonably commenced to be corrected within 14 days following notice of such default. Hatch may, by providing 5 days prior notice to Client, suspend Services if Client is in breach of Clauses 3 or 4.

7.4 In the case of any suspension or termination of the Agreement, Client will pay Hatch for all Services provided and costs incurred up to the effective date of suspension or termination, including all reasonable demobilization costs.

7.5 Hatch makes no warranty and has no continuing obligations in respect of any deliverables that are incomplete as of the date of any termination or suspension.

CLAUSE 8 NON-SOLICITATION

Neither party will, during the term of the Agreement or for 12 months thereafter, either directly or indirectly on its own behalf or jointly with or on behalf of any other person, solicit, engage or employ any employee or independent contractor of the other party (or any of its affiliates) that has been involved in the provision of Services or with whom the party has otherwise had contact in connection with the Agreement.

CLAUSE 9 DEFINITIONS AND INTERPRETATION

9.1 Reference to (a) "*affiliate*" means with respect to a party, one or more entities that control, are controlled by, or are under common control with, the party, (b) "*Change Order*" means a written agreement between the parties amending the terms of the Agreement, including price and schedule, to the extent fair and reasonable in the circumstances as a result of a Scope Change, (c) "*costs*" means any and all costs and expenses, including reasonable legal fees, (d) "*force majeure*" means acts of God, strikes, lockout, other industrial action, war or civil disturbance, terrorism, unusually inclement weather, storm, flood, earthquake, lightning, fire, explosion, nuclear or radioactive contamination, epidemics or pandemics, governmental action or inaction, extraordinary market conditions affecting the availability of labour, late or inadequate execution of work or supply of goods by third persons and any other event beyond the reasonable control of the affected party, (e) "*Hatch's schedule of rates*" means Hatch's standard hourly rates and reimbursable charges as notified by Hatch from time to time, provided that any changes to the schedule of rates will be communicated to Client before they take effect and will not occur more than once every six months, (f) "*liability*" includes any and all liability whatsoever, whether arising under the law of contract, tort (including negligence), equity, statute or otherwise, whether arising in connection with the performance or non-performance of the Services or otherwise in connection with the Agreement and whether to Client or other persons, and "*liable*" has a corresponding meaning, (g) "*Scope Changes*" means (i) any change to the Services, or (ii) any other event or circumstance that is outside of Hatch's control and impacts the timing or sequencing of, or work effort required by Hatch to complete, the Services (typically by requiring rework or by preventing Hatch from performing Services in the manner or sequence originally planned), (h) "*site conditions*" means any conditions in, on, under or around the project site that affect the project or the performance of Services, including any plant and subsurface conditions and any hazardous substances, waste or materials, (i) "*Jurisdiction*" means the jurisdiction in which Hatch's contracting office is located, and (j) "*$*" means the currency of the Jurisdiction where it is in Canada or Australia and, in all other cases, it is a reference to US dollars.

9.2 If any provision of the Agreement is held to be void, illegal or unenforceable, then (a) it is severed and the rest of the Agreement remains in force, and (b) the parties will replace the provision with one that is in accordance with applicable law and as close as possible to the parties' original intent. Any rules of contract interpretation that result in the Agreement being construed contrary to the interests of either party do not apply in the interpretation of the Agreement.

CLAUSE 10 GENERAL

10.1 The Agreement will be governed by and construed in accordance with the laws of the Jurisdiction, without giving effect to conflict of law considerations. All disputes will be submitted to senior management for discussion. If the parties are unable to resolve a dispute through such discussions, either party may submit the dispute to the International Chamber of Commerce ("ICC") for resolution in accordance with its rules then in force. The arbitration will be held in English and at the location of Hatch's contracting office. The arbitration panel will consist of one arbitrator selected by the ICC in accordance with its rules. Any arbitration award will be final and binding on the parties without any right of appeal. The unsuccessful party will bear the costs of arbitration. No legal proceedings may be commenced by either party in connection with the Agreement or the Services other than in accordance with this Clause; provided that either party may apply to a court of competent jurisdiction for interlocutory relief during the course of such proceedings or to enforce any order or award obtained in accordance with this Clause.

10.2 The Agreement represents the entire agreement between the parties regarding the subject matter hereof and supersedes all prior representations, understandings or agreements; provided that, if the parties have previously entered into a confidentiality (or similar) agreement regarding the subject matter hereof, such agreement will survive and Clauses 6.4 and 6.5 will be of no force and effect. Amendments to the Agreement are effective only if executed in writing by authorized representatives of both parties.

10.3 Neither party may assign (other than to its affiliate) the Agreement or any interest therein, in whole or part, without the prior consent of the other party. The Agreement will enure to the benefit of and be binding upon the parties and their respective successors and permitted assigns.

10.4 Neither party will be considered to be in breach of its obligations under the Agreement, except obligations to make payment, to the extent that performance is prevented or delayed by force majeure. Each party will use best efforts to overcome any force majeure as soon as possible.

10.5 The limitations and exclusions on liability expressed in the Agreement will apply even in the case of the fault, negligence or strict liability of the party who is the beneficiary of the clause, and will extend to the officers, directors, employees, agents, representatives, subconsultants and affiliates of such parties.

10.6 Any notice, consent or other communication given hereunder will only be deemed to have been given if it is in English, in writing and is sent to the recipient's authorized representative at the usual business address of the recipient by (a) registered mail, (b) fax, (c) e-mail (but only when receipt is confirmed in writing by reply e-mail or otherwise) or (d) personal delivery for which a receipt is obtained. Notice given by fax, personal delivery or e-mail will be deemed to have been given on the business day following delivery. Notice given by mail will be deemed to have been given on the fifth business day after mailing.

10.7 No waiver by either party of any breach of the Agreement will be binding unless made in writing and any such waiver will extend only to the specific breach waived and not to any future breach.

10.8 Hatch is an independent contractor in performing the Services. Nothing in the Agreement will create or will be construed so as to create the relationship of principal and agent between Client and Hatch.

10.9 The provisions of Clauses 1, 4, 5, 6, 7.4, 8 and 10 survive the termination of the Agreement.

Appendix B: Schedule of Rates

Schedule of Rates
Energy - USA

	Per Hour
Principals	316
Senior Consultants	316
Engineering, Project, and Construction Managers	288
Consultants	264
Specialists and Supervisors	240
Senior Engineers and Technologists	217
Engineers	188
Intermediate Engineers	168
Junior Engineers	151
Technologists	183
Senior Designers and Technicians	168
Designers and Technicians	151
Intermediate Designers and Technicians	133
Junior Designers and Technicians	107
Purchasing Agents and Senior Expediters	132
Technical Assistants	114
Buyers and Expediters	102
Administrative Specialists	107
Project Support Coordinators	96
Project Support Technicians	82
Students	60

Currency: United States Dollars

Time Charges:
All time expended on the assignment, whether in our office, at the client's premises, in transit, or elsewhere, is chargeable, including the time of staff engaged in the preparation of documents such as reports and specifications.

Systems Expense Recovery:
Secure global cloud-based systems, encompassing platform charges, IT infrastructure, network connectivity, hardware, system licence fees, design and analysis tools are included in the above rates.

Expenses and Disbursements:
Travel, living expenses, personal protective equipment, site office costs for resident staff and project expenses will be charged at cost plus 5%. Project expenses include capital procured equipment, project delivery software (at individual daily rates) and other items not otherwise listed. Sub-consultant expenses will be charged at cost plus 10%.
Reimbursement for general expenses on assignments including telecommunications, reproductions, printing, office supplies and courier charges are included in the above rates.

Invoicing and Payment:
Fees and expenses are invoiced monthly and are due and payable within 14 days or other agreed duration. The above rates are exclusive of all taxes and other regulatory charges, which will be added to the invoice when applicable. Interest will be charged on any past due amounts at the lower of: (a) the highest permissible rate, or (b) 12% per annum, charged at 1% per month from the due date to the date of payment. Client usage of portals for submission of invoices with mandated supporting documents and details will result in a processing fee charge equivalent to 2% of the invoiced fee value.

Industry Leading Technical & Project Management Specialists:
Industry Leading Technical & Project Management Specialists are charged at specific individual rates.

Overtime: Overtime will be charged at 1.5 times the above rates.

Terms and Conditions: The above rates are based on Hatch standard terms and conditions.

Scheduled Revision: The next revision of this Schedule of Rates will be effective July 1st, 2024.

Appendix C: Resumes

Ninth Part12D Safety Inspection Report & Comprehensive Assessment

Ryan D. Berg, P.E. (NB, CA, OR), MSc., ASCE

Project Sponsor

Education & Qualifications
M.S., Civil and Environmental Engineering, Utah State University
B.S., Civil and Environmental Engineering, Utah State University

Professional Affiliations
Oregon P.E. – No. 84631PE
California P.E. – No. C78565
New York P.E. – No. 100358-1

Experience
15+ years

Specialties
River Hydraulics, Public Water Safety Around Dams, Risk Assessments and Management Plan, Operations and Maintenance Planning

Ryan is currently a Regional Manager of U.S.A. Hydropower & Dams for Hatch and a Senior Project Manager with more than 16 years of experience. He has extensive experience in mergers and acquisitions and performing due diligence activities on facilities ranging from 1 MW to 2000 MW for investment companies. Ryan also has experience with hydro operations and maintenance planning working for a private power producer. His professional background includes design, analysis, layout, evaluation and management of various projects in the hydroelectric sectors. His experience includes assignments in various countries in North America, Central America and South America. Ryan has been responsible for the successful completion of a variety of projects, including feasibility studies, rehabilitation works, dam safety, due diligence assessments, and design/layout of both tender level and construction level greenfield hydroelectric facilities.

RELEVANT PROJECT EXPERIENCE

Hydro Portfolio Due Diligence, Brazil, Project Manager.

- Responsible for an operational concession due diligence review of a portfolio of four existing operational hydroelectric projects located in the country of Brazil with a total capacity of 2,000 MW.
- Assessed potential generation versus historical generation, reviewed licensing conditions, environmental permitting and compliance, evaluated the potential of generation upgrades and/operational improvements and assessed life extension work and future capital improvements for the portfolio.
- Developed annual capital improvement costs and operational costs for the portfolio for a period of 50 years. Worked in conjunction with internal business development and mergers and acquisitions groups to formulate business proposals and financial analysis to present to the company board of directors for acquisition authorization.

Refinancing Hydro Portfolio Due Diligence, USA., Senior Project Manager.

- Responsible for a refinancing review of an existing pump storage hydroelectric facility located in the USA with a total capacity of 1000 MW.
- Assessed potential generation versus historical generation, reviewed licensing conditions, environmental permitting and compliance, evaluated the potential of generation upgrades and/operational improvements and assessed life extension work and future capital improvements for the portfolio.
- Developed annual capital improvement costs and operational costs for the portfolio for a period of 50 years.
- Worked in conjunction with external financiers to formulate business needs and financial analysis to present to the client's board of directors.

Hydro Portfolio Due Diligence, USA, Senior Project Manager.

- Responsible for an acquisition due diligence review of an existing pump storage hydroelectric facility located in the USA with a total capacity of 800 MW.
- Assessed potential generation versus historical generation, reviewed licensing conditions, environmental permitting and compliance, evaluated the potential of generation upgrades and/operational improvements and assessed life extension work and future capital improvements for the portfolio.
- Developed annual capital improvement costs and operational costs for the portfolio for a period of 50 years.
- Worked in conjunction with external business development and mergers and acquisitions groups to formulate business proposals and financial analysis to present to the client's board of directors for acquisition authorization.

Santa Maria 82 Hydroelectric Project, Panama, Project Manager.

- Greenfield development of 28 MW along the Santa Maria River.
- Projects consisted of pre-feasibility, feasibility, final design, and detailed construction design and tender bidding documentation.

- Project included a hybrid 24-meter-high earthen embankment and RCC concrete dams, diversion canal, 7 tainter gates, intake, tailrace, and powerhouse with three new vertical Kaplan turbines and reservoir operations protocols and 18.5 km of high voltage transmission lines.
- Responsibilities also included environmental analyses, consultation with resource agencies and transmission line planning.

Buenavista Hydroelectric Complex Project, Columbia, Project Manager.

- Greenfield development of a 160 MW project along the Rio Margua. This project is currently in the early design stages.
- The project consisted of two projects in series (50 MW and 110 MW) and included 10 km of tunnels and necessary diversion works and 15 km of high voltage transmission lines.
- Responsibilities included environmental analyses consultation with resource agencies and transmission line planning.

Boott Hydro Pneumatic Crest Gate Project, Lowell, MA, Project Manager.

- Responsible for the detailed construction design and construction of 970 feet of Obermeyer type pneumatic gates. System compromised of five operable zones without the use of intermediate piers for support.
- Pawtucket Dam is one of the oldest operating masonry block dams in North America and is a vital diversion structure for power generation.
- Detailed analyses included the stability of the 150-year-old dam, design of new Obermeyer bladder system without intermediate piers for support and gate sealing and the development of special cofferdams to aid in the construction of the gates.
- Project currently under construction and is expected to be complete by the end of 2017.

Hydro Portfolio Due Diligence, Panama, Project Manager.

- Responsible for a due diligence review of a portfolio of one existing operational hydroelectric project located in the country of Panama with a total capacity of 14 MW.
- Assessed potential generation versus historical generation, reviewed licensing conditions, environmental permitting and compliance, evaluated the potential of generation upgrades and/operational improvements and assessed life extension work and future capital improvements for the portfolio.
- Developed annual capital improvement costs and operational costs for the portfolio for a period of 50 years.
- Worked in conjunction with internal business development and mergers and acquisitions groups to formulate business proposals and financial analysis to present to the company board of directors for acquisition authorization.

Hydro Portfolio Due Diligence, Columbia, Project Manager.

- Responsible for a due diligence review of a portfolio of four greenfield hydroelectric projects located in the country of Columbia with a total capacity of 69 MW.
- Assessed potential generation, reviewed licensing conditions, environmental compliance and potential generation limitations.
- Developed annual capital improvement costs and operations and maintenance costs for a period of 50 years for the portfolio.

Hydro Portfolio Due Diligence, New York, USA, Project Manager.

- Responsible for a due diligence review of a portfolio of hydro two projects located in NY State with a total capacity of 16.6 MW.
- Assessed potential generation versus historical generation, reviewed licensing conditions, environmental permitting and compliance, evaluated the potential of generation upgrades and/operational improvements and assessed life extension work and future capital improvements for the portfolio.
- Developed annual capital improvement costs and operational costs for the portfolio for a period of 50 years.
- Worked in conjunction with internal business development and mergers and acquisitions groups to formulate business proposals and financial analysis to present to the company board of directors for acquisition authorization.

Hydro Portfolio Due Diligence, Eastern United States, USA, Project Manager.

- Responsible for a due diligence review of a portfolio of hydro 10 projects located in the Eastern United States with a total capacity of 86 MW.
- Assessed potential generation versus historical generation, reviewed licensing conditions, environmental permitting and compliance, evaluated the potential of generation upgrades and/operational improvements and assessed life extension work and future capital improvements for the portfolio.
- Developed annual capital improvement costs and operational costs for the portfolio for a period of 50 years.
- Worked in conjunction with internal business development and mergers and acquisitions groups to formulate business proposals and financial analysis to present to the company board of directors for acquisition authorization.

Ninth Part12D Safety Inspection Report & Comprehensive Assessment

Allison Lunde

INDEPENDENT CONSULTANT/SENIOR STRUCTURAL ENGINEER

Education & Qualifications

MS, Civil Engineering (structural engineering focus), Iowa State University

MBA, Iowa State University

BS, Civil Engineering (structural engineering focus), Iowa State University

Professional Affiliations

Registered Professional Engineer – AK, CO, LA, MA, ME, MI, MN, NH, NY, ND, SD, TN, WA, WV, WI

Experience

12+

Allison is currently a senior structural engineer with over twelve years of civil and structural engineering experience in heavy industrial, wind energy and hydroelectric facilities. Her professional background includes dam safety; design, analysis, and inspection of reinforced concrete, reinforced masonry, structural steel, and timber structural systems; feasibility studies; and construction management. Much of Allison's dam work has been completed on sites regulated by the Federal Energy Regulatory Commission (FERC) and US Army Corps of Engineers (USACE).

RELEVANT PROJECT EXPERIENCE

Robert Moses Niagara Power Plant, New York, Project Manager/Engineer of Record (2022-present). Project manager and engineer of record for development of the penstock inspection programs typical repairs and coating replacement technical specifications for a 13-year program.

Solomon Gulch Hydroelectric Project, Alaska, Project Manager/ Co-IC (2022-present). Project manager and Co-IC for the Part12D inspection and CSIR at the Solomon Gulch Hydroelectric Project in Valdez, Alaska.

Confidential Project, Project Manager/Structural Engineer (2022). Project manager and structural engineer providing Owner's Engineering services in the replacement of tailrace slot concrete and reinforcement for the bulkhead system that had failed due to inadequate prior structural detailing and construction quality during original construction.

Long Sault Hydroelectric Project, New York, Project Manager/Structural Engineer (2021-2022). Project manager and engineer of record for the installation of the largest ice and safety boom in the United States. Installation included 10 in river bedrock anchors, spillway anchor and short anchor.

Watts Bar Hydroelectric Project, Tennessee, Project Manager/Structural Engineer (2021-2022). Project manager and engineer of record for the installation of a debris boom.

Slave Falls Hydroelectric Project, Winnipeg, Canada, Structural Engineer (2021-2022). Structural engineer responsible for the oversight of condition assessment, stability analysis and rehabilitation recommendations to improve the overall stability of multiple spillways for extend useful life to 2040.

Summersville Hydroelectric Project, West Virginia, Project Manager/Structural Engineer (2021-2022). Project manager and structural engineer to complete inspection and analysis of the penstock for submittal to FERC.

Confidential Project, Project Manager/Structural Engineer (2021-2022). Project manager and structural engineer that led the extensive root cause analysis including laboratory testing to determine the likely failure mode of Tainter gate chains at two facilities in the United States.

Martin Power Plant, Florida, Project Manager/Dam Safety Specialist (2020-present). Project manager and dam safety specialist responsible for the developed and implementation of the dam safety monitoring program for the dismantlement of a power plant facility (two 500 MW 2-on-1 combined cycle units). Oversee full time on-site dam safety specialists that complete daily dam monitoring inspections and activities. Project manager responsible for the vibration analysis to determine the maximum concrete panel drop size when dismantling 500 ft concrete chimney in close proximity to piles, buried concrete pipes and embankment where long term damage and potential break of dam are leading concerns.

Sidney Murray Jr. Hydroelectric Project, Louisiana, Dam Safety Specialist/Project Manager (2020). Dam Safety Specialist that completed the site inspection and dam safety review for the project in accordance with Brookfield's internal dam safety program.

Much Valley Hydroelectric Project, California, Dam Safety Specialist/Project Manager (2020). Dam Safety Specialist that completed the site inspection and dam safety review for the project in coordinate with Brookfield's internal dam safety program.

Morrow Hydroelectric Project, Michigan, Project Manager/Structural Engineer (2020). Project manager and structural engineer responsible for new design of radial gate with flap gate on top, design of structural steel dewatering system, existing hoist and chain analysis, civil site layout and access, global and local stability for dewatered conditions, crane pad design and analysis. Responsibilities also included preparation of design drawings, technical specifications, design report and additional documentation such as Quality Control Inspection Program (QCIP) and Temporary Construction Emergency Action Plan (TCEAP) for the FERC approval.

Chippewa Falls Hydroelectric Project, Wisconsin, Project Manager (2020). Project manager responsible for the design of a new concrete trash sluice pier between the powerhouse and trash sluiceway and new sluice gate, structural steel cofferdam, new concrete bridge deck, and stability analysis. Work included design report, drawings, technical specifications, TCEAP and QCIP. Work completed in accordance with FERC and USACE guidelines.

Mio Hydroelectric Project, Michigan, Project Manager/Structural Engineer (2019-2020). Project manager and structural engineer responsible for option study, design of new tailrace concrete retaining wall system and associated dewatering cofferdam, design report, design drawings, review and construction implications of Potential Failure Modes (PFMs) and supporting documentation for FERC approval.

Newell Dam Spillway Replacement, South Dakota, Project Manager/Structural Engineer (2019). Project manager and structural engineer lead that was responsible for the conceptual design of a new spillway dam to replaced failed conduct spillway. Work included options evaluations, hydraulic modelling, geotechnical site investigations, spillway configuration evaluations, preliminary civil and structural design. Work was completed in accordance with FEMA, USBR, FERC and USACE guidelines.

City of St. Cloud Hydroelectric Project, Minnesota, Project Manager/Structural Engineer (2013 – 2020)

- **FERC Relicensing:** Project manager responsible in developing the FERC licensing documents on behalf of the owner, coordination with the FERC, interested tribes, agencies, and stakeholders.
- **Turbine and SCADA Upgrades:** Project manager responsible for technical oversight of turbine modifications and SCADA upgrades to the facility. Work including overseeing the SCADA drawings and specifications.
- **Part 12D Inspection (2016):** Project manager that was responsible for drafting CSIR for IC review and approval, assisted with field inspection, reviewed and assessed PFMs, STID, and DSSMP and provided recommendations, reviewed structural analyses, and synthesized survey and monitoring data.
- **Overflow Spillway Modifications:** Project manager and structural engineer that completed multiple spillway configuration options, lifecycle cost analysis, and risk management assessment. Engineer of Record for the design of new overflow spillway gates and associated support equipment and coordination with mechanical and electrical upgrades. Work included design report, design drawings, technical specifications, EJCDC documents, TCEAP, QCIP, FERC license amendment, final construction report for FERC submittal. Provide construction observation and oversight.
- **Dam Break Analysis:** Project manager responsible for the execution of the FERC required dam break analysis and resulting inflow design flood determined for the facility in accordance with FERC engineering guidelines.
- **Dam Safety Projects:** Structural engineer and project manager that oversaw the spillway manometer evaluation which included sensitivity stability analysis to determine the need of new manometers in relation to PFMs, detailing of a powerhouse downstream apron scour repair, evaluated bend waler on training wall, evaluated waler tie-rod replacement options, provided EAP updates, provided STID updates, and provided DSSMP updates.
- **Miscellaneous Projects:** structural engineer that designed bulkhead dewatering system for Tainter gates. Structural engineer responsible for the details for turbine bulkhead refurbishment. Oversaw the turbine rehabilitation inspection services.

Wausau Hydroelectric Project, Wisconsin, Project Manager/Structural Engineer (2017-2020). Project manager and structural engineer responsible for design of new radial gate, spillway dewatering system, new equipment room, new spillway deck design, site coordination and layout, construction hydraulics evaluation, design report, design drawings, technical specifications, QCIP, TCEAP, construction management and oversight, FERC construction reporting.

St. Anthony Falls Hydroelectric Project, Minnesota, Project Manager/Structural Engineer (2012-2019).

- Structural engineer responsible for the design of a spillway lifeline system to improve operator personnel safety when accessing the spillway for flashboard repair and replacement.
- Project manager and structural engineer responsible for the conceptual option evaluation to replace the flashboards on the horseshoe dam spillway. Work included conceptual design drawings, design report, FERC license amendment evaluation and historical preservation evaluation and permitting.

Project manager for the computation fluid dynamic (CFD) modelling of different river flows events to evaluation horseshoe dam

Victoria Hydroelectric Project, Michigan, Structural Engineer (2017). Structural engineering that assisted Independent Consultant in review of existing structural analyses and review of survey and monitoring dated. Evaluated relevance of PFMs to structural analyses, survey and monitoring data. Provided findings and recommendations within the CSIR as part of the FERC Part 12D.

Bond Falls Hydroelectric Project, Michigan, Structural Engineer (2017). Structural engineering that assisted Independent Consultant in review of existing structural analyses and review of survey and monitoring dated. Evaluated relevance of PFMs to structural analyses, survey and monitoring data. Provided findings and recommendations within the CSIR as part of the FERC Part 12D.

Winton Hydroelectric Project, Minnesota, Project Manager/Structural Engineer (2014-2017). Managed and served as structural engineering lead for the Head Gate Replacement Project. Work included a site visit to evaluate the intake structure's existing concrete condition, design recommendations based on site visit observations, stop log design to dewater the structure during construction, global and local stability analysis for construction conditions, development of stainless-steel head gate performance specification, review of head gate manufacturer's bid documents, and development and execution of a concrete core plan.

USACE Lock and Dam 21 Cofferdam Design, Illinois, Structural Engineer (2016). Structural Engineering that complete structural design for a 3-sided structural steel cofferdam for contractor to complete localized concrete repairs to concrete wall of USACE lock using USACE guidelines.

Oxbow-Hickson-Bakke (OHB) Ring-Dike-Levee, North Dakota, Structural Engineer (2014-2019). Structural engineer responsible for the design of the pump station. Lead coordination between hydraulics, civil, geotechnical, mechanical, electrical and structural for the layout of the pump station. Complete stability analyses and detailed structural analysis calculations in accordance with USACE guidelines. Wrote the design documentation report and technical specifications and developed design drawings. Provided construction support services including on site observation, request for information responses and contractor submittal review.

Alcona Hydroelectric Project, Michigan, Structural Engineer (2014-2017). Structural Engineering that provided QA/QC of structural analyses computations of powerhouse stability for the FERC Risk Informed Decision Making (RIDM) study.

Thief River Falls Hydroelectric Project, Minnesota, Structural Engineer (2014-2017). Structural engineer responsible for the structural analysis review of STID and review of monitoring data for CSIR recommendations Structural engineer responsible for the structural analysis review of STID for CSIR recommendations as part of FERC Part 12D. Assisted in development of tabletop exercise documents.

Little Falls Hydroelectric Project, Minnesota Structural Engineer (2014-2015). Structural engineer responsible for the design of a new spillway Tainter gate. Work included analytical modeling, calculations, design report, design drawings, TCEAP and QCIP. Work was completed in accordance with FERC and USACE guidelines.

Thomson Hydroelectric Project, Minnesota, Structural Engineer (2013-2014). Structural engineer that designed multiple items at the project site's upper and lower gate houses and powerhouse. Both gatehouses involved the development of a performance specification for stainless- steel head gates, an electric operator to replace existing systems, and sill modifications for the new head gates. Work involved reviewing all submittals from the gate manufacturer prior to FERC submittal and overseeing construction. For the lower gatehouse, designed a bulkhead column to replace the existing corroded column in Unit #5. The powerhouse work included design of height extensions for a lifting system to remove a portion of the penstock flange and design of a new lifting system for a penstock flange.

Blanchard Hydroelectric Project, Minnesota Structural Engineer (2016-2017). Structural engineer responsible for analytical modeling of the historic shop building to determine building's wall movement that supports the upstream embankment need to be repaired to reduce the probability of embankment failure and lose of reservoir. Work included geotechnical investigation, complex modeling and load distribution, and review of historical structural code standards. Developed a design report that documented complex analytical modeling of the structure and recommendations for rehabilitation of the historical building.

Blanchard Hydroelectric Project, Minnesota Structural Engineer (2013-2015). Structural engineer that provided construction management and oversight for tainter gate upgrades, which included those to structural steel members to meet current code standards, upgrade of the existing trunnion bearing to a greaseless system, installation of new side and bottom seals, lead abatement of existing coating, coating application, and installation of sacrificial anodes for corrosion protection.

Island Lake Hydroelectric Project, Minnesota, Structural Engineer (2012-2016). Structural Engineer that complete three-dimensional modeling of concrete pier extensions (30 ft extension) to allow for gate replacement without dewatering reservoir. Completed analytical modeling, concrete design calculations, bulkhead design, stability analysis, design report, design drawings, technical specification, and construction sequencing. Work was completed in accordance with FERC and USACE engineering guidelines. Project was an American Council of Engineering Companies (ACEC) of Minnesota 2020-2021 Grand Award Winner.

Oslo Flood Control System Design, Minnesota, Structural Engineer (2011-2015). Structural engineer that completed stability analysis of pre-cast concrete inlet and outlet structures as part of the flood control system. Provide stability evaluations for design modifications during construction phase services. Utilized USACE design guidelines for analysis.

William Kussmann, P.E.

INDEPENDENT CONSULTANT/SENIOR GEOTECHNICAL ENGINEER

Education & Qualifications

BScE, Geotechnical, University of Minnesota, MN

BSc, Geology, University of Minnesota, MN

Professional Affiliations

Registered Professional Engineer – IA, ID, IL, IN, MI, MN, MO, NC, ND, NE, OH, SD, WI

Experience

20+

Bill is currently a senior geotechnical engineer with over 20 years of geotechnical engineering experience specializing in water retention structures and renewable energy projects.

RELEVANT PROJECT EXPERIENCE

Fargo-Moorhead Metropolitan Flood Diversion Authority, Fargo-Moorhead Metropolitan Flood Diversion Project, Fargo, ND, United States, Design Manager - Diversion Channel. Design Manager and Geotechnical Engineer of Record for Diversion Channel design. Included assessments of slope stability, seepage/piping, settlement, rebound/basal heave, and levee design to USACE standards. Also coordinated and oversaw geotechnical explorations consisting of soil borings, CPT, and vibrating wire piezometers.

Brookfield Renewable Energy, Medway Dam Downstream Training Wall, Medway, Maine, United States, Geotechnical Engineer. Performed analysis and design of a permanent soldier pile and lagging wall to replace a failed concrete retaining wall along the dam tailrace. Performed site- review and verification of design elements during construction.

New York Power Authority, Long Sault Dam Safety Barrier, Massena, New York, United States, Geotechnical Engineer. Performed construction observation of safety barrier anchors, including verification of adequate rock socket. Observed soil and rock socket drilling, casing installation, anchor chain installation, and tremie grouting methods.

Brookfield, GLHA Storage Reservoir Due Diligence, Various Locations in Maine, United States, Geotechnical Engineer. Performed site review of earthen embankments for storage reservoirs at nine sites in Maine. Reviewed embankment conditions, flow control structures, and seepage. Provided findings for due diligence report.

Xcel Energy, Wissota Hydropower Dam Hydro Lane Embankment, Chippewa Falls, Wisconsin, United States, Geotechnical Engineer/Consultant. Assisted with Part-12 inspection and identification of improvements required for the Hydro Lane Embankment at the FERC-regulated Wissota Dam. Developed embankment improvement options consisting of graded filter design, embankment regrading, and sheet pile core wall installation.

Xcel Energy, Hayward Dam, Hayward, Wisconsin, United States, Geotechnical Engineer/Consultant. Performed site inspections related to earthen embankment abutment seepage for the FERC-regulated Hayward Dam. Seepage mitigation design included a drainage gallery, sheet pile cutoff wall concept design, and spillway apron grouting design.

Xcel Energy, Cedar Falls Dam, Dunn County, Wisconsin, Geotechnical Engineer/Consultant. Provided design review for stilling basin construction plans including rock excavation, grout curtain design and specifications, and excavation stability for the FERC-regulated Cedar Falls Dam.

Xcel Energy, Chippewa Falls Dam, Chippewa Falls, Wisconsin, United States, Geotechnical Engineer. Coordinated geotechnical investigations for the earthen embankment abutments for the FERC-Regulated Chippewa Falls Dam. Provided stability analyses following geotechnical investigations and testing.

City of Des Moines, Levee C Flood Control Project, Des Moines, Iowa, United States, Lead Geotechnical Engineer. Served as lead geotechnical engineer for the Levee C portion of the City of Des Moines flood control project. Determined soil stratigraphy from explorations and performed seepage, stability, and settlement analyses for proposed levee raises. Evaluated under levee and through levee seepage concerns and evaluated mitigation strategies for design consideration. Alternatives consisted of sheet piling, slurry cut-off walls, seepage collection trenches, grout curtains, and zoned embankments.

Mouse River Flood Control Project, Minot/Burlington, North Dakota, United States, Lead Geotechnical Engineer. Served as lead geotechnical engineer for four phases of the Mouse River Enhanced Flood Control Project. Determined soil stratigraphy from explorations and performed seepage, stability, and settlement analyses for the proposed levees, closure structures, flood walls, pump stations, and gate wells. Design elements included seepage collection/pressure relief trenches, slurry cut-off walls, seepage blanket, slope stability improvements, graded filter design, and settlement mitigation using surcharge with wick drains. Assisted with construction observations and recommendations.

City of Thief River Falls, Thief River Falls Dam, Thief River Falls, Minnesota, United States, Geotechnical Engineer. Performed piezometer analysis/rehabilitation and retaining wall analysis for powerhouse at the FERC-regulated Thief River Falls Dam. Provided updated embankment stability analysis based on the piezometer observations and construction recommendations for rehabilitation of the downstream concrete retaining wall.

Xcel Energy, Cornell Dam Embankment Stability, Cornell, Wisconsin, United States, Geotechnical Engineer. Assisted with Part-12 inspections at the site and identified a slope stability failure mode for the right embankment/abutment at the FERC-regulated Cornell Dam. Oversaw site investigations and developed improvement options. Provided stability analysis and design for final buttress improvement.

Xcel Energy, St. Anthony Falls Depression Evaluation, Minneapolis, Minnesota, United States, Geotechnical Engineer. Performed an emergency response for apparent depressions on the FERC-regulated St. Anthony Falls Hydropower Dam. Conducted two separate phases of explorations and performed void-fill grouting design for large limestone block fill below earthen embankment. Observed the grouting program for conformance with design and project specifications. Evaluated post-grouting piezometer results and embankment stability.

Ames Construction, Olmsted Hydropower Powerhouse Replacement, Orem, Utah, United States, Geotechnical Engineer. Developed and observed pump test to design construction dewatering for the deep excavation at the Olmsted Hydropower facility along the Provo River.

Minnesota Power, Fish Lake Dam Embankment Evaluation, St. Louis County, Minnesota, United States, Lead Geotechnical Engineer. Reviewed previous embankment stability analysis and provided options to improve embankment stability for new Probable Maximum Flood (PMF) event for the FERC-regulated Fish Lake Dam near Duluth, Minnesota. Oversaw additional phase of CPT testing, performed updated seepage and stability analyses, and designed a buttress to increase embankment stability. Performed quality control inspections and assistance during buttress construction.

Xcel Energy, Cedar Falls Dam Retaining Wall, Menomonie, Wisconsin, United States, Geotechnical Engineer. Evaluated apparent downstream retaining wall movement at the FERC-regulated Cedar Falls Dam. Reviewed data/site conditions and developed a monitoring program for the wall and embankment to assess magnitude and direction of wall movement. Provided stability analysis and options for repair/stabilization of the retaining wall.

Xcel Energy, Wissota Hydropower Dam, Chippewa Falls, Wisconsin, United States, Geotechnical Engineer. Performed hand auger investigations and coordinated topographical survey for the Rod and Gun Dike at the FERC-regulated Wissota Hydropower Dam. Evaluated stability of the embankment. Assisted with subsequent Part-12 evaluation and limited PFMA for the facility. Additional design of a modification to the dike was not required.

Oxbow-Hickson-Bakke Ring Levee (Fargo Moorhead Diversion), Oxbow, North Dakota, United States, Lead Geotechnical Engineer. Served as lead geotechnical engineer for a portion of the Oxbow-Hickson-Bakke Ring Levee (portion of the Fargo-Moorhead Diversion Project). Determined soil stratigraphy from explorations and performed seepage, stability, bearing capacity, and settlement evaluations for the pump station, gate well, and portion of the earthen levee. Design elements included settlement mitigation using surcharge with wick drains. Assisted with construction observations and recommendations.

Park Nicollet Hospital, Park Nicollet Hospital Flood Control Wall, Golden Valley, Minnesota, United States, Geotechnical Engineer. Coordinated and observed geotechnical investigations and provided analysis and design of a cantilever sheet pile flood control wall to accommodate the existing facility along Bassett Creek. Performed sheet pile driving verification during construction.

UPPCo, Escanaba Dam No. 3, Escanaba, Michigan, United States, Geotechnical Engineer. Observed soil borings and performed seepage and stability analyses for the FERC-regulated Escanaba Dam No.3 facility. Reviewed potential failure modes from previous inspections. Based on the analysis, additional design elements were not required.

Xcel Energy, Dells Dam, Eau Clair, Wisconsin, United States, Geotechnical Engineer. Performed emergency response for a rockslide event near the right abutment of the FERC-regulated Dells Dam. Assisted with a soldier pile and lagging wall design to buttress rock slope at the abutment.

Xcel Energy, Trego Dam, Washburn County, Wisconsin, United States, Geotechnical Engineer. Performed analysis of seepage from the right embankment at the FERC-regulated Trego Dam. Provided seepage control improvement options and designed upgrades to the drainage and site access systems, including a cable concrete mat with underlying granular filter which will also serve as a canoe portage.

UPPCo, Boney Falls Spillway Stability, Delta County, Michigan, United States, Geotechnical Engineer. Performed drilling/coring analysis to assess potential lift-joint instability of the existing FERC-regulated Boney Falls spillway. Pressurized upward seepage was observed, and subsequent analyses and remediation options were provided in an investigation report.

Minnesota Power, Sylvan Dam Evaluation, Cass County, Minnesota, United States, Geotechnical Engineer. Coordinated and observed a detailed subsurface investigation for abutments, foundation soils, and potential lift-joints for the FERC-regulated Sylvan Dam. Soil borings and CPT investigations were performed both on the embankments and on a barge in the reservoir to assess soil conditions. Coring of the dam and vibrating wire piezometer installation was performed to assess uplift pressures below the concrete spillway sections.

Xcel Energy, Holcombe Dam Piezometers/Seepage, Holcombe, Wisconsin, United States, Geotechnical Engineer. Evaluated existing piezometer data and installed replacement piezometers for the right earthen embankment at the FERC-regulated Holcombe Dam. Evaluated toe drain flow and embankment seepage and designed a system of weirs to assess seepage and potential migration of soils. Assisted with the site review and PFMA for the Part-12 evaluation.

Xcel Energy, Chippewa Falls Dam, Chippewa Falls, Wisconsin, United States, Geotechnical Engineer. Evaluated existing conditions to raise right embankment of the FERC-regulated Chippewa Falls Dam for new maximum flow conditions. Designed additional fill materials and geotextile separator covered with rip rap and performed stability analysis for post-construction conditions.

UPPCo, Bond Falls Spillway Replacement Project, Ontonagon County, Michigan, United States, Geotechnical Engineer. Performed subsurface exploration, testing, analyses, and reporting for the FERC-regulated Bond Falls Spillway Replacement project. Design included a sheet pile cofferdam, OSHA deep excavation for spillway removal and construction, bedrock seepage evaluation from packer testing, graded filter, spillway overflow lining, and building foundation support. During construction, performed bedrock evaluation/mapping, review of OSHA excavations and seepage, and general spillway construction. Following construction, prepared the reservoir refill plan and performed additional monitoring of seepage on embankments for 3 years following construction.

Xcel Energy, Menomonie Dam, Menomonie, Wisconsin, United States, Geotechnical Engineer. Performed site review of left abutment conditions and right abutment drain at the FERC-regulated Menomonie Dam. Provided an assessment of the need for improvement and remediation options for the left abutment drain system.

Moore Engineering, Wild River Flood Control Dam, Richland County, North Dakota, Bahamas, Geotechnical Engineer. Served as the supervising geotechnical engineer for a potential flood control dam for the Red River of the North River system. Coordinated and observed geotechnical investigations, assigned laboratory testing, and performed preliminary seepage, stability, and settlement analysis for conceptual embankment design options.

City of Clarkson, Levee Recertification, Clarkson, Nebraska, United States, Geotechnical Engineer. Served as the geotechnical engineer for levee recertification for the city of Clarkson, Nebraska. Determined soil stratigraphy from explorations and performed seepage and stability evaluations for the levee recertification process.

Associated Constructors, Tourist Park Reconstruction Cofferdam, Marquette, Michigan, United States, Design Geotechnical Engineer. Performed analysis of site conditions and earthen cofferdam design for reconstruction of the FERC-regulated Tourist Park Dam. Observed cofferdam construction, monitoring and performed analysis for evaluation of extension of the usage-life of the structure to a second construction season.

FHR Terminals, St. Paul Terminal Flood Control Berm, St. Paul, Minnesota, United States, Geotechnical Engineer. Performed soil explorations and provided a design for a combination soil berm and sheet pile flood control structure to accommodate existing facilities along the Mississippi River. Performed under-seepage analysis, cantilever sheet pile wall design, and robotic total station monitoring of pile driving adjacent to large above-ground storage tanks during construction.

City of Redwood Falls, Redwood Falls Dam Powerhouse Reconstruction, Redwood Falls, Minnesota, United States, Geotechnical Engineer. Coordinated and observed soil borings and rock coring and provided geotechnical recommendations for the powerhouse and turbine reconstruction at the FERC-regulated Redwood Falls Dam.

Xcel Energy, Big Falls Dam Depression Evaluation, Rusk County, Wisconsin, United States, Geotechnical Engineer. Performed emergency response for apparent depressions forming on the main earthen embankment of the FERC-regulated Big Falls Dam. Performed two separate phases of investigations to evaluate depressions and existing rock-filled toe drain. Design included a drilled and backfilled repair for the depressions. During construction, the drilling and backfill placement was observed, and relative compaction was tested. Assisted with the Part-12 site review and limited PFMA following repair work.

Ames Construction, Devils Lake Levees as Roads Project, Devils Lake, North Dakota, United States, Geotechnical Engineer. Utilized existing USACE soil boring and lab testing information to design levees which would serve both as earthen cofferdam during construction and permanent roadways following construction. Observed final cofferdam construction and conditions following winter season to verify use during spring construction.

UPPCo, McClure Dam Penstock Replacement, Marquette County, Michigan, Lead Geotechnical Engineer. Performed subsurface explorations, analyses, and reporting for soil conditions for the penstock replacement at the FERC-regulated McClure Dam. Design recommendations included penstock bedding and backfill recommendations, sheet pile retaining wall design for earthen embankment, pipe supports through wetland areas, and railroad pipe jacking recommendations. During construction, performed observation of sheet piling installation, sheet pile deflection monitoring, piezometer monitoring, embankment seepage monitoring, excavation/rock removal evaluations, and general penstock construction.

Total Experience

25 Years (14 at Ayres)

Registrations

Registered Professional Engineer, MI, MN, WI, IA, MT, OH, WA, ID, NE, CO

Education

MS, Civil and Environmental Engineering, University of Iowa

BS, Civil Engineering, Rose-Hulman Institute of Technology

Memberships

United States Society on Dams, Hydraulics Committee

United States Society on Dams, Dam Decommissioning Committee, committee chair

American Concrete Institute

Association of State Dam Safety Officials

American Society of Civil Engineers (state, national, and local)

National Society of Professional Engineers (Wisconsin chapter)

Pete Haug, PE

Facilitator

Pete serves as manager of Ayres' Water Resources with a primary focus on hydraulic structures and dam inspections. For more than 11 years, prior to joining Ayres in 2010, he worked on dam safety studies for the Columbia River and Snake River dams and focused on physical models of spillway forces, structural pressure (lift joints, cavitation, uplift), tailrace erosion (bedrock erodibility, ball milling, and flip jet deflectors), and high velocity conveyances. His career with Ayres and the Midwestern dams has expanded to bedrock spillway assessments, bedrock grouting, arch dam design, structural stability, powerhouse design, and Part 12D dam safety inspections. His design experience includes concrete arch dams, concrete spillways, unlined bedrock spillways, new gate installations, gate refurbishments, new powerhouse structures, and analysis of existing dams for stability and hydraulic sufficiency.

IN-PERSON CLASS	TITLE	TRAINER	DATE
DLS 102A	Intro to FERC SQRA Process and Guidelines	FERC/USACE	July 2022
DLS 103	Leveraging PFMA to Perform SQRA	USSD	October 2020
DLS 214	Hydrologic Hazard Analysis Training for L2RA	FERC/USACE	October 2022
DLS 113	SQRA Facilitator Training	USSD	October 2022
ONLINE TRAINING	**TITLE**	**TRAINER**	**DATE**
DLS 104	Best Practices in Dam & Levee Safety Risk Analysis	USACE	October-November 2022
RMC-2018-13	Annotated Readings in History of Risk Analysis in Dam Safety	USACE	October 2022

Required Training Completed to Date

From his work on the 1,185 MW Wanapum Dam in Washington to the 330-foot-high Hells Canyon spillway in Idaho and from the 163-foot-high Kingsley Dam embankment to the 34,000-foot-long Sutherland embankment, Pete has been widely exposed to geotechnical, hydraulic, structural, and regulatory challenges. He has helped multiple FERC licensees improve their advanced dam monitoring practices for scour, movement, and other stability failure modes. He has participated in numerous potential failure mode analysis meetings, both as the engineer-of-record and also as an independent consultant.

Recent Training

Internal Erosion in Unsaturated Slopes (1.7 hours), 2023

Recent Developments in Risk Informed Approaches and PMP (4 hours), 2023

Understanding Static Liquefaction (2 hours), 2023

Spillway Gates and Dewatering Systems (2 hours), 2023

USSD's Properties of Mine Tailings for Static Liquefaction Assessment (2 hours), 2022

USSD's Static Liquefaction Workshop, (8 hours), 2022

ASDSO's Drilling Plans and Hazard Evaluations for Dams and Levees (2 hours), 2022

Filters and Drainage Systems for Embankment Dams (2 hours), 2020.

Rock Scour Assessment for Dams, Spillways, and Water Conveyance Structures (2 hours), 2020

ASDSO Relearning how to do Piezometric Data Seepage Evaluation (2 hours), 2019

FERC's 18 CFR Part 12D High Hazard Federally Regulated Inspections Conference (7 hours), 2015

Why People Die During Flood Events and Options for Reducing Future Flood

References

Chris Lemke, Nebraska Public Power District | 308.535.2682

Ryan Schoolmeesters, Eagle Creek Renewable Energy | 303.842.1424

Ryan Grondin, WEC Energy Group | 906.779.4008

FERC Risk and Part 12 Experience

FERC P-9951, French Landing Comprehensive Assessment, Wayne County, MI. FERC-approved facilitator for Comprehensive Assessment with Level 2 Risk Assessment.

- Two 33-foot wide bear trap spillway gates, a masonry powerhouse, and a 181 multiple arch concrete overflow spillway. The foundation is silty clay over hardpan, and clay tile drains are in the 35-foot-tall embankment.

FERC P-2394. Chalk Hill Comprehensive Assessment, WI/MI border. Subject matter expert in hydraulic structures and hydrologic hazard assessment.

- 43-foot-tall concrete dam with 11 tainter gates and three powerhouse units, all founded on igneous bedrock. 3,321-square-mile drainage basin with complex upper basin storage dams. Embankment contains clay tile drains. 560 kip stranded post-tensioned anchors in spillway.

FERC P-2595 High Falls Comprehensive Assessment, Crivitz, WI. Project manager and note taker for Level 2 Risk Assessment.

- Multiple concrete gravity dams and earthen embankments on mostly plutonic bedrock foundation. Net head is 83 feet on 7.5MW powerhouse. Dam contains both 1953-era and 2008-era post-tensioned anchors. The 1910-era dam has both filtered and unfiltered embankments, upstream paving on embankments, and multiple rim overtopping points.

FERC P-1984 Castle Rock Comprehensive Assessment, Mauston, WI. Project manager and subject matter expert in hydraulic structures and hydrologic hazard assessment.

- The 31-foot-high dam impounds 12,900 acres and has 140,600 acre feet of storage. Most of the dam is founded on alluvial sands, with 18 tainter gates, five powerhouse units, and 3.5 miles of embankments. Embankment contains pushed fill foundation without compaction, and population at risk exceeds 3,500. Foundation of concrete spillway consists of 35-foot driven steel sheetpile, stainless 1950's screened foundation drains, and a complex uplift reduction system. Ayres has completed the full CA report and final presentation.

FERC P-2181 Menomonie Dam Comprehensive Assessment, Menomonie, WI. Co-independent consultant and hydraulic structures subject matter expert.

- The 55-foot-high dam is overtopped by 9 feet during the inflow design flood, and the powerhouse and spillway are retrofitted to allow overtopping. The dam is post-tensioned with original 1950s anchors into sandstone bedrock, and the five spillway gates are operated uniformly to reduce bedrock scour risk. The dam is in a narrow valley with mainly recreational user consequences (ice fishing and kayakers). Ayres has completed the full CA report and final presentation.

FERC P-2536 ECRE Little Quinnesec Falls Part 12D Inspection, Niagara, WI

- Independent consultant for the 2022 Part 12D inspection and potential failure modes analysis review.

FERC P-2523 ECRE Oconto Falls Upper Part 12D Inspection, Oconto Falls, WI

- Independent consultant for the 2022 Part 12D inspection and potential failure modes analysis review.

FERC P-1417 Central Nebraska Public Power and Irrigation District Part 12D Inspection, Holdrege, NE

- Independent consultant for the Kingsley Dam, Jeffrey Dam, Johnson Dam, and 75-mile-long supply canal Part 12D inspections in September 2022. Project includes a 28-foot-diameter morning glory spillway with 80-feet-per-second velocities, an unlined rock cut spillway, and 163-feet-high zoned earthfill dam.

FERC P-1835 Keystone Diversion and Sutherland/Maloney Part 12D Inspection, North Platte, NE

- Completed the dewatered inspection and Paxton Siphon (14-foot diameter, 7,000 feet long) inspection in 2021. Completed the Part 12D Inspections for Maloney Dam, Sutherland Dam, Keystone Dam, and Korty Dam along with 63 miles of canal structures. Complex foundation of loess soils on coarse gravel with suffusion and suffosion potential.

FERC P-10855 Dead River Part 12D Inspection, Marquette, MI

- Independent consultant for the Hoist Dam, McClure Dam, and Silver Lake Dam Part 12D inspection. Project included a 70-foot-tall intake tower and gravity arch spillway, hydraulic fill embankments with filter blankets and stabilization measures, and 13,000-foot-long penstock with 400 feet of head. Project has category I seepage PFM for high sand embankments.

FERC P-10856 Au Train Part 12D Inspection, Au Train, MI

- Independent consultant for the Au Train and Whitefish Rivers Part 12D inspection. Project included a 4,500-foot-long loose sand overlying peat embankment across the Whitefish River, a 1,500-foot-long embankment over timber crib with filter blankets and stabilization measures, and a 2,500-foot-long penstock with 134 feet of head.

FERC P-1960 Flambeau Hydro Station Consultant's Safety Inspection Report 2017 and Tainter Gate Bridge Inspection and Analysis 2019, Ladysmith, WI

- Independent consultant with five-year follow-up commitment. Was also the project manager for tainter gate hoist bridge analysis after two buckled members found. 92-foot-tall and nearly one-mile-long embankment dam with 1950s concrete gated spillway and powerhouse on bedrock foundation.

FERC P-6299, Byllesby Dam Part 12D Inspection, and Part 12 CSIR Supplement, Cannon Falls, MN

- Independent consultant for Ambursen Dam with very low reinforcement on dolomitic limestone foundation. Was also the engineer of record for the two new 65-foot-wide and 14-foot-long crest gates (2013 completion) and new 4 MW powerhouse (2024 completion). Dam has 57 feet of head and has a population at risk greater than 700.

FERC P-2587, Xcel 2018 Superior Falls CSIR, and Xcel Energy - Superior Falls New Right Embankment, Saxon, WI

- Independent consultant. Found rim overtopping issues and submitted design report for embankment raise. Concrete gravity dam diverts water into a 1800 foot long by 7-foot diameter steel penstock.

Xcel 2018 Saxon Falls CSIR, Saxon, WI

- Independent consultant for a dam with Holland Ackerman Holland clay tile drains. Concrete gravity dam diverts water into a 1,400-foot-long by 6-foot-diameter steel penstock.

Xcel 2018 Dells CSIR, and Xcel - Dells Hydro - Apron Scour Investigation, Eau Claire, WI

- Assisted Part 12D inspector with apron scour analysis, including a 3-D computational fluid dynamics model of the entire dam.

FERC P-1981, Stiles Hydro 10th CSIR Updates, and Stiles Hydro 11th CSIR Updates, Oconto, WI

- Project manager for Part 12D inspection. Assisted Part 12D inspector with review of findings, including rim overtopping locations, spillway apron scour, uplift analysis, and powerhouse stability review.

FERC P-2663, Minnesota Power Pillager 2014 Part 12, Pillager, MN

- Assisted Jim Bakken, Independent Consultant, with Part 12D inspection of timber crib on timber pile dam converted to concrete gravity structure.

FERC P-2567, Xcel Wissota CSIR, Chippewa County, WI

- Assisted Jim Bakken, independent consultant, with Part 12D inspection.

FERC P-8315, Sartell Dam Part 12D Inspection, Sartell, MN

- Led a semi-quantitative risk assessment for potential failure modes analysis and assisted with the Part 12D inspection. Included development of hydrologic hazard curve for semi-quantitative risk assessment screening for client. Dam founded on grouted timber crib and piles. Dam included two long bascule spillway gates, three small tainter gates, a grouted timber crib gravity dam on alluvial foundation, extensive sheetpile cutoff walls, and challenges of Mississippi River ice and debris passage.

FERC P-6228, Cascade Dam Part 12D Inspection, Grand Rapids, MI

- Subject matter expert for hydraulic structures and hydraulic performance. Independent consultant for Part 12D inspection and assisted with the semi-quantitative risk assessment for potential failure modes analysis. Included development of hydrologic hazard curve for semi-quantitative risk assessment screening for client. Dam included a barrel arch concrete spillway with tainter gates, tailrace erosion concerns, and an embankment with corewall. Powerhouse included a future unit bay that was used for extra spill capacity (wicket gates, no turbine).

FERC P-3071 Rapidan Dam Part 12D Inspection, Mankato, MN

- Subject matter expert for hydraulic structures and hydraulic performance. Independent Consultant for Part 12D inspection and assisted with a screening level semi-quantitative risk assessment. Included development of hydrologic hazard curve for semi-quantitative risk assessment screening for client. Dam included an Ambursen slab on buttress gravity spillway with small tainter gates, debris and ice plugging issues, and a tailwater flood that damaged the powerhouse units.

FERC Design and Construction Experience

FERC P-2114, Wanapum Dam Modifications, Public Utility District No. 2 of Grant County, WA

- Lead project engineer for bedrock erodibility study for Wanapum's spillway during the probable maximum flood. Tested multiple gate operation patterns and flowrates to confirm expected scour profiles for the 12 gates (each 50 feet wide by 75 feet tall) on this 185-foot-tall and 1,185 MW project.
- Assistant engineer for cavitation and pressure distribution study for Wanapum's Future Unit Fish Bypass chute spillway.
- Lead project engineer for spillway gate rating and hydraulic capacity study for Wanapum's spillway.

FERC P-1971, Hells Canyon Dam Spillway, Idaho Power Company, Boise, ID

- Assistant project engineer for spillway scour assessment of this 330-foot-tall spillway.
- Lead project engineer for apron ball-milling study for spillway during various gate operations.

FERC P-1940, WPS Tomahawk Detached Dike Stability, Tomahawk, WI

- Designed Type I and Type II filters for 1,200-foot-long, 18-foot-high rim dike.

FERC P-10856, Au Train Spillway Gates and Levee Raise, Au Train, MI

- Engineer of Record for storage reservoir dike stability and seepage improvements. 5,000-foot-long, 25-foot-high dike required flatter slopes and a two-stage engineered filter. Dam owner has since applied for license surrender for economic reasons. Construction on hold, pending state and federal permits

FERC P-6299, Byllesby Turbine and Powerhouse Upgrades, Construction Phase Services, Cannon Falls, MN

- Project manager on aspect of project involving construction phase support services. Broader project involves study and design for upgrades to powerhouse and equipment at Dakota County's Byllesby Dam. Study includes turbine management, historical river flow rates, historical power production data, and current turbine information. Team is designing improvements to accommodate two SAXO turbines within century-old powerhouse building shell. Services include prequalifying potential equipment suppliers; preparing technical specifications for turbine equipment; collecting HD laser scan of existing powerhouse interior, and analyzing costs involved in various scenarios for placement of cranes, penstock configuration, vertical Kaplan units, and generation control equipment. Team will provide 3D Revit models for up to three alternatives. Design provided for concrete repairs, roof design, raceways, control room, repairs and enhancements for two buttresses, and structural supports and modifications needed to accommodate staged installation of turbine machinery on this $24 million project.

FERC P-2561, TRC Sho-Me Scour Hole Repair and Aquatic Organism Passage, Niangua River, MO

- Designed scour hole repairs and supervised stability analysis.

FERC P-6299, Byllesby Dam Existing Facility Capital Improvements, Grouting Design, Cannon Falls, MN

- Responsible for project management. Project involved engineering services for 18 improvement projects at Byllesby Dam. Primary design tasks included designing bedrock spillway grouting plans, planning 8,000 square feet of spillway ogee resurfacing, evaluating structural cause and solution for north powerhouse buttress wall cracks, developing solutions for various dam leaks and minor cracking, evaluating entrance bridge load capacity, and inspecting trip gate mechanisms for damage. About 1,600 cubic feet of grout was placed at various thicknesses and injection patterns to seal voids in spillway's sandy dolomite. Original concrete on highest spillway section needed replacement, involving removal of 5,000-plus cubic feet of concrete. Spillway resurfacing involved double-layer resurfacing with less costly shotcrete over woven wire mesh, filling all but the top 2 inches of ogee, followed by 2-inch-thick layer of polymer-modified high strength shotcrete for final top wearing layer. Innovative design saved County more than $100,000. Facility is high-hazard FERC dam, and project included preliminary design, final design, and FERC submittal for construction authorization.

FERC P-10805, Black River Partners Hatfield Hydro Canal Construction, Hatfield, WI

- Assisted with design and construction engineering of stability improvements to canal embankments. Project involved providing construction phase services for repairs to three sections of Power Canal. Three-year construction project required multiple iterations of submittals, including revisions to material lists, borrow pits, and construction methods. Construction administration tasks included reviewing contractor submittals and FERC requirements as a variety of FERC inspectors ordered changes throughout this project.

FERC P-1984, WRPCO Castle Rock Tailrace Evaluation, Adams, WI

- Reviewer for tailrace degradation evaluation.

FERC P-1835, Gerald Gentlemen Station Sutherland Cooling Pond, Sutherland, NE

- Reviewer of the 2-D and 3-D Computational Fluid Dynamics model analyses for the Sutherland pond baffle performance.

FERC P-9003, Xcel Riverdale Gate Replacement, Riverdale, WI

- Reviewer of the 3-D Computational Fluid Dynamics model analysis for the apron endsill modifications for energy dissipation.

(not FERC licensed currently) Melrose Mill Pond Dam Preliminary and Final Design and Construction Services, Melrose, WI

- This project is still in negotiations. The dam has not been rebuilt and the Village's desire to produce power through the 36-inch penstock has not been implemented as of 2024. Responsible for project management. Project began with conducting geotechnical explorations at Village of Melrose's old mill pond dam to determine design parameters for bedrock shear and bearing capacity. Ayres designed a 50-foot-tall concrete arch dam and low-level gated outlet works. Construction for $1.8 million project is expected to start after final permits are approved by the Wisconsin Department of Natural Resources (WDNR).

FERC P-0710, Balsam Row Dam Fish Passage Design, Shawano County, WI

- Water resources engineer. Upper Wolf River was historically some of the best spawning grounds for sturgeon, but Balsam Row Hydroelectric Plant and Shawano Mill dam prevent sturgeon from freely navigating upriver to spawn on the rocky shoals near Keshena Falls. Project required extensive coordination with WDNR, F&WS, FERC, MITW, and licensee. Ayres designed 400-foot-long nature-like fishway (pool and riffle), full trap and sort facility for checking fish health, dam safety improvements (cutoff walls, drain filters, and isolating head gate), and owner access improvements (culvert, parking lot). Construction is estimated at $1.5 million, but the project owner is awaiting final funding from state and federal agencies.

Qualifications for Pete Haug

See Section 5 of Relevant Risk Assessment and Facilitation Experience That Support Facilitating and Participating in USACE, FERC, and TVA Risk Assessments, (Reference RMC-TR-2021-01)

Pete's resume follows for further consideration and proof of his qualifications to be a facilitator in multiple areas of dam engineering and risk assessment.

Dam and Levee Safety Experience

Minimum number of years of dam or levee experience

Pete has more than 25 years which exceeds the minimum requirement of 10 years.

- Pete served twelve years with the IIHR-Hydroscience & Engineering research laboratories at the University of Iowa as both a research engineer and the physical shop manager for hydraulic model studies. Studies included gate rating analyses for Grant County, Idaho Power, Chelan County; apron ball milling and spillway erosion studies for dams from 50 to 330 feet high; chute pressure and emergency stoplog closure studies for the Wanapum Future Unit Fish Bypass chute; channel stability assessments for sand scour near multiple nuclear plant intakes; vorticity studies of pump intakes and spillway gates; and soil/sand erosion studies for multiple river and riverbank structures.
- Pete has served 14 years at Ayres and is the senior project manager for hydraulic structures. He has designed concrete arch dams, concrete spillways, energy dissipation systems; analyzed bedrock and sand erodibility below dams (channel stability assessments); supervised cementitious grouting of voids under multiple dams; computed uplift profiles and stability for multiple structures; completed Part 12 inspections for some of the largest Midwest dams (Kingsley, Sutherland, Hoist, Byllesby); and overseen the design and construction of multiple seepage mitigation measures for sand embankment dams. Pete is the technical lead for Ayres' Flow-3D numerical modeling group and has completed pressure assessment studies for ogees and apron blocks, riverbed erosion potential studies, hydraulic jump stability assessments, and more.

Primary author on dam or levee analysis, design or construction

A selected sample of papers/publications follows. This exceeds the minimum requirement of 5.

1) Haug and Weber. "Removal of Rock from Wanapum Dam Spillway Apron." University of Iowa. Limited Distribution Report. June 2006.
2) Haug and Weber. "Probable Maximum Flood Scour Study for Wanapum Dam." University of Iowa. Limited Distribution Report. January 2006.
3) Lyons, Haug, Carrica, and Weber. "Model Studies of a Future Unit Fish Bypass for Wanapum Dam." University of Iowa. Limited Distribution Report. May 2005.
4) Haug and Weber. "Wanapum Dam Gate Rating." University of Iowa. Limited Distribution Report. March 2005.
5) Haug and Odgaard. "Hydraulic Model Studies for Fish Passage through an Overflow-Underflow Gate Combination at Rock Island Dam." University of Iowa. Limited Distribution Report. July 2004.
6) Haug and Odgaard. "Sedimentation Study for Nebraska Public Power District's Cooper Nuclear Station." University of Iowa. Limited Distribution Report. April 2004.
7) Haug, Li, and Weber. "Summary of Hydraulic and CFD Models for Wanapum Dam." January 2003.
8) Haug and Weber. "Hydraulic Modeling for Hells Canyon Dam Spillway Deflector Design: Phase Two – Three-Dimensional Model." University of Iowa. Limited Distribution Report. March 2002.
9) Jain and Haug. "Hydraulic Model Studies of Circulating-Water System for New Madrid Power Plant." University of Iowa. Limited Distribution Report. March 2001.
10) Weber, Young, and Haug. "Hydraulic Model Testing of ESBS Perforated Plate Vibrations" (USACE McNary and Lower Granite Dams). University of Iowa. Limited Distribution Report. May 2000.
11) Haug. "Wanapum Dam Spillway Deflectors." University of Iowa. Masters Thesis. May 2000.

12) Haug, Aadland, and Cox. “Balancing Ecosystem Objectives in Design of a Lake Sturgeon Passage Facility.” Hydrovision 2016 Presentation Delivered by Haug.
13) Haug. “Managing Uncertainties During Hydropower Dam Removals.” USSD Accepted Conference Paper and Presentation Delivered by Haug. April 2015.
14) Haug. “Spillway Capacity and Discharge Uncertainty – Why Do Rating Curves Rarely Agree with Flow Measurement Records?” Hydrovision 2012 Accepted Conference Paper and Presentation Delivered by Haug.
15) Haug and Peterson. “Legal Challenges to Permitting Low Hazard Dam Removals.” ASDSO 2012 Dam Safety Conference Accepted Paper and Presentation Delivered by Haug.

Presentation on Case Study of Dam Failure Incident

1) Presented “Lessons learned on the Byllesby Dam Shotcrete Failure” – presentation to 40 engineers in Eau Claire WI 4/14/2021
2) Silver Lake Dam failure – presented erodibility research for grassed and non-grassed channels below spillways to legal team
3) Also attended these presentations:
    a. Ethics: The St. Francis Dam Failures – Mary McElroy – February 2020
    b. Review of the 1938 Construction Slide at Fort Peck Dam – ASDSO – August 2019
    c. Findings of Oroville Dam Spillway Forensic Investigation – January 2018

Lead technical role for one or more technical disciplines for dam or levee analyses

A selected sample of projects as lead technical role follows. This exceeds the minimum of 5.

Pete was the Engineer of Record for these selected sand embankment dam projects:
1) Tomahawk Dam (WI) Left Detached Dike rehabilitation – 2020, slope stability modeling and seepage mitigation filter design and was onsite/oncall engineer for evaluation of boils found during construction
2) Byllesby Dam Perimeter Dike (MN) – 2012, raised about 1000 feet of perimeter dike, flattened the downstream slope, added two stage filter, and designed piezometer monitoring program 3) Upper and Lower Camelot Dams (WI) – 2012, added two stage toe filters to safety convey groin and toe seepage for 24-foot high homogenous sand embankments in Adams County, WI
4) Sherwood Dam (WI) Two stage blanket filter on sand embankment – 2011, added 3000 CY of two stage toe filters to safety convey groin and toe seepage for 34-foot high, 500-foot long homogenous sand embankment in Adams County, WI
5) Straight Lake Dam (WI) Sheet pile core wall addition – 2010, added embankment corewall to poorly compacted earthfill dam that was part of sensitive Ice Age Trail corridor

Pete was the Engineer of Record for these selected riverbed erodibility studies:
6) Grand Rapids Energy Center / Blandin (MN) – 2021, Flow3D modeling of hydrodynamic fluctuations on alluvial Mississippi River to assess performance improvements for adding apron and chute blocks to spillway
7) Dells Hydro (WI) – 2020, Flow3D modeling of hydrodynamic fluctuations on partly sandstone/partly alluvial riverbed below dam with non-conventional stilling basin (partially collapsed) to assess options for reducing erosion potential
8) Duane Arnold Energy Center (IA), 2004-2019, annual and post-flood hydrosurveys and walking channel stability analysis of sand riverbed near nuclear plant’s cooling water intake, including assessment of channel control vanes, riprap revetment and spur dikes, and sheetpile control weir functionality
9) Minong Dam (WI) – 2013, apron ball milling lead to large voids under spillway founded on alluvial (glacial) substrate, so led project to grout foundation with sand-cement, enlarge spillway 50%, add energy dissipation blocks and convert old ogee to stepped spillway

10) Byllesby Dam (MN) Bedrock erodibility grouting program – 2013, led project and field observation for 1600 cubic feet of cementitious grouting in soluble foundation near spillway apron
11) Superior Falls Dam (MI) Spillway apron and scour repairs – 2014, during part 12 inspection found scour hole nearly as deep as dam is tall, led project to repair scour hole

Pete was the Engineer of Record for these selected concrete dam projects:

12) Byllesby Dam (MN) Powerhouse replacement – 2017-2024, still being constructed, extensive concrete demolition and bedrock excavation below Ambursen Dam, multiple global stability analyses for each phase of construction, piezometric and accelerometer movement monitoring
13) Boney Falls Dam (MI) Spillway ogee replacement – 2020-2024, Shotcrete overlay of spillway ogees and evaluation of profile smoothness in relation to hydraulic performance
14) Stiles Dam (WI) Future unit floor beam supports – 2012, retrofit design for concrete beam under powerhouse floor with excessive spalling and insufficient reinforcement
15) Galesville Mill Dam (WI) Right gravity dam section replacement – 2020, complex stability analysis for retaining wall with high equipment surcharge, multiple internal mill dam remnants
16) Fawn Lake Dam (WI) Outlet works replacement – 2017, replaced 48-inch discharge pipe and control structure for clay core dam with sand shell, onsite engineer for liquefiable sand foundation conditions discovered during construction

Pete was the Engineer of Record for these selected spillway analysis projects:

17) Lake Chelan Dam (WA) – 2022, complete gate rating curve and project hydraulic capacity curve extending well above probable maximum flood
18) Byllesby Dam (MN) New spillway construction with large gates – 2013, added 36000 cfs in spillway capacity, including erodibility analyses, gate rating for entire dam, earth embankment raise and filter blankets for perimeter dike, new piezometer and movement monitoring system
19) Petenwell Dam and Castle Rock Dam (WI) Gate rating curves – 2011, completed comparison of spillway coefficients with literature and model studies for dams of similar ogee conditions
20) Melrose Dam (WI) Timber arch dam replacement with concrete arch dam – 2014, completed multiple 3D finite element models for thermal / ice / water loads for 2 to 8 feet thick single curved 50-foot tall arch dam, completed Flow3D modeling of crest and apron pressures, designed gated outlet works for 1000-year flood
21) Superior Falls Dam (MI) New Right Embankment – 2019, did rating curve and resolved rim overtopping issues by adding new right embankment
22) Wanapum Dam (WA) Spillway gate rating and uncertainty analysis – 2005, did the physical modeling, analytical research, and full uncertainty analysis for a spillway gate rating on a large Columbia River dam.

More projects and details about the above projects are listed on Pete's resume.

Risk Analysis Experience

Pete is the FERC-approved facilitator for French Landing Dam's comprehensive assessment in 2024.

Pete is the project manager and subject matter expert for Castle Rock Dam's Comprehensive Assessment, completed December 2023.

Pete is the co-independent consultant for Menomonie Dam's Comprehensive Assessment, due December 2023.

Pete facilitated Eagle Creek Renewable Energy's Sartell Dam (MN) risk analysis session as part of ECRE's portfolio risk assessment in 2021. Pete participated in two other risk analysis sessions for Cascade Dam (MI) and Rapidan Dam (MN). in 2021. Sartell Dam is on the alluvial Mississippi River and underseepage leading to internal erosion and tailrace erosion leading to stability were two of the investigated risk drivers.

Pete has been an approved Part 12 inspector and conducted PFMA reviews for multiple dams where risk of seepage was heightened (163-foot tall Kingsley Dam, 92-foot tall Flambeau Dam, 70-foot tall Hoist Dam, 67-foot tall Sutherland Dam) and erodible tailraces (40-foot tall Cascade Dam, 37-foot tall Silver Lake Dam, 18-foot tall Keystone Dam). Pete participated in pre-construction risk reduction PFMA sessions for Byllesby Dam and Au Train Dam (sessions held at FERC-CRO).

More details about projects are listed on Pete's resume.

Training Courses

Training (Per RMC-TR-2021-01)

Pete attended DLS-102A Introduction to FERC SQRA Process and Guidelines, lead by Nate Snorteland, Eric Gross, and others in July 2022 in Sacramento. (1 day)

Pete attended DLS-103 Leveraging PFMA to Perform SQRA, lead by USSD's trainers and delivered by interactive online training in October 2020. (21.5 hours delivered in a week long live online training)

Pete attended DLS-214 RMC-RFA and RMC-Bestfit, lead by Eric Gross and Sharon Schultz in October 2022 at USACE-RMC in Denver. (2.5 days)

Pete attended DLS-113 Facilitator Training, lead by USSD's trainers in October 2022 in Denver. (2 days)

Pete has watched the online video series for DLS-104 Best Practices in Dam & Levee Safety Risk Analysis, which is available online as a recorded presentation. The session videos were viewed from: https://www.youtube.com/channel/UCTcud9Y9CQALy_m519tnW2A/videos. Pete also read the Best Practices pdfs available online at: https://www.usbr.gov/damsafety/risk/methodology.html

Also, Pete has read "Annotated Readings in the History of Risk Analysis in Dam Safety" RMC-2018-13

Training (Per Table 2-2 of FERC March 2016 RIDM Guidelines)

Pete has attended the following:

1) Additional report writing and Part 12 seminars:
    a. Expectations of Semi-Quantitative Risk Analysis – ASDSO Doug Boyer – March 2021
    b. How to Conduct a Successful PFMA – ASDSO Doug Boyer – December 2018
    c. Effective Technical Writing, Parts 1 and 3 – Hurley Write – February and March 2016
    d. FERC's 18 CFR Part 12D Inspections Conference – 7hrs – May 2015
2) Geotechnical Review Classes
    a. Filters and Drainage Systems for Embankment Dams – ASDSO John France – Jan 2020
    b. Introduction to Rock Mechanics – ASCE Fulvio Tonon –January 2017
    c. Introduction to Grouting in Rock – ASCE Michael Byle –August 2016
    d. Strength Selection for Static Slope Analysis – ASDSO John France – May 2016
    e. Foundation Preparation and Treatment for Dam Construction – ASDSO John France – October 2014
    f. Internal Erosion and Piping Consideration. Part 2 – ASDSO – June 2010

g. Geotechnical Review of Embankment, Part 1 and 2 – ASDSO – May 2010

3) Structural Review Classes

a. Cold Weather Concreting Practical Approach – American Concrete Institute – November 2018

b. Failures due to Concrete Volume Change and Restraint – American Concrete Institute – October 2017

c. Approach to Design, Placing, and Protecting Concrete – June 2017

d. Overview of Chemical Admixtures for Concrete – American Concrete Institute – April 2017

4) Hydraulics Review Classes

a. Advanced Culvert Hydraulics with HECRAS – ASCE Matthew Zeve – March 2020

b. Rock Scour Assessment for Dams, Spillways, and other Water Conveyance Structures – ASDSO George Annondale – February 2020

c. Introduction to Cavitation in Chutes and Spillways – ASDSO – March 2018

d. Introduction to Design of Erosion Control Measures Using Riprap – January 2017

e. Erosion and Debris Control – July 2013

5) Instrumentation Review Classes

a. Use of Remote Sensing in Dam Safety – ASDSO – July 2021

b. Satellite Data Analytics: A New Tool in Risk Management for Reservoir Safety – Rezatec Katie Whittington – June 2020

c. Libby Dam Slope Stability Radar System – USACE Sharon Gelinas – May 2020

d. Relearn Piezometric Data Seepage Evaluation – ASDSO Richard Olsen – May 2019

e. Drones and Unmanned Aerial Systems – March 2015

Licensure

Pete holds an active Professional Engineering license in ten states.

NICHOLAS W. AGNOLI, P.E., P.P.

10 Virginia Road | Montville | New Jersey | 07045
201-424-5821 (cell) | nagnoli@appliedweatherassociates.com

Education:

M.S., Civil and Environmental Engineering, Option: Water Resources, January 1999.
Rutgers, The State University of New Jersey, Piscataway, NJ 08855.

B.S., Environmental Science, Minors: Biology/Chemistry, May 1996.
Virginia Polytechnic Institute and State University, Blacksburg, VA 24060.

Certifications:

Professional Engineer, Licensed in New Jersey (GE 04580300)
Professional Planner, Licensed in New Jersey (LI 00601900)
Hazardous Materials Awareness Level I, Level II, and Incident Analysis
Confined Space Entry (29 CFR 1910.146)

Software Experience:

HEC-RAS 2D, HEC-HMS, ArcMap 10.x, HEC-FIA, USGS PeaKFQ (17C), HEC-SSP, HEC-DSSVue, FLOW3D, and legacy software, including FLDWAV, DAMBRK and HEC-1

Work Experience:

Position: Senior Hazard Mitigation Analyst, April 2023 – Current
Applied Weather Associates, Monument, CO

Responsible for the development of risk analyses related to regulatory and extreme natural hazards with a focus on rainfall and flooding. Recent projects included the conversion of gridded precipitation data with a variety of temporal and spatial distributions to runoff with the use of ArcMap and HEC-RAS. The 2D runoff models included calibration of hydrologic inputs and the evaluation of mitigation strategies.

Position: Branch Chief, July 2009 - April 2023
Federal Energy Regulatory Commission: Office of Energy Projects, New York, NY

Responsible for the civil engineering staff that performs safety inspections and technical review on studies related to approximately 243 FERC-regulated hydropower projects in the northeastern United States. Technical reviews included construction/rehabilitation drawings, Part 12D Safety Inspection Reports and supplemental studies, Emergency Action Plans and associated dam failure studies, inflow design flood determination studies, hazard classification studies, and Probable Maximum Precipitation (PMP) / Probable Maximum Flood (PMF) studies. Specific expertise in the development and review of cold season (rain-on-snow) and all season site-specific PMP studies and 2D dam failure modeling in HEC-RAS. The founder and chairman of the NY Hydrology and Hydraulics Technical Resource

Group (NYRO H&HTRG) and served as the advisor of the national FERC H&HTRG.

Position: Deputy Director and Chief Engineer, March 2008 – July 2009
Position: Project Engineer, June 2004 – March 2008
New Jersey Meadowlands Commission, Lyndhurst, NJ.

Responsible for the development and execution of the Hackensack Meadowlands Floodplain Management Plan in coordination with the Federal Emergency Management Agency (FEMA) and 14 municipalities as well as the Bergen County Multi-Jurisdictional Natural Hazard Mitigation Plan in coordination with FEMA, NJ-OEM and all 70 County municipalities. Also charged with the regulatory review of all flood control measures associated with large-scale redevelopment projects within the Meadowlands District. Reviews also include structural and geotechnical analyses. Responsible for the revision and expansion of the District's stormwater management zoning regulations and the collaboration of the rule change with the NJDEP. Also responsible for the development and execution of the Five-Year Strategic Plan for area-wide flood control, a 25.4-million-dollar initiative for reducing the impacts of extreme tidal surges and rainfall events (2005-2009). Work included pump stations, levees and tide gates. On a daily basis, employed the use of hydrologic and hydraulic models as well as GIS software to analyze the potential for, and remediation of, local flooding. Supervised 35 staff.

Position: Client Manager, Water Resources Division, February 2003 – 2006 (Part-Time 2004-2006)
Garden State Engineering, LLC, Maywood, NJ.

Directly responsible for development and oversight of all water resources projects, including regional and municipal stormwater management plans. Other major projects have included the design of a Federal Superfund groundwater remediation project in Montgomery Township, NJ; inundation mapping for Lindy's Lake Dam, NJ; hazard re-classification of Shadow Lake Dam, NJ; failure analysis of Lake Wanda Dam, NJ; as well as State and Federal environmental permitting on a number of industrial redevelopment projects throughout Essex and Hudson County, NJ. Personally responsible for the training of all staff engineers in hydrologic and hydraulic analysis, including watershed and stream flow routing using the latest GIS-based software. Speaker at NJDEP-sponsored training seminars regarding the hydrologic and hydraulic analyses dictated by the new NJ Stormwater Management Rules. Supervised 6 employees.

Position: Project Engineer, February 2001 - January 2003
Civil Dynamics, Inc., Stockholm, NJ.

Lead engineer on the study, design, and construction of numerous publicly- and privately-owned dams throughout New York and New Jersey. Responsible for the determination of stormwater inflow magnitudes, hydraulic routing through outlets and spillways, dynamics routing through downstream channels, the design of scour protection, flood hazard assessment, project management and construction inspection. Management experience includes the submission of proposals, running pre-bid construction meetings, overseeing the selection of contractors and managing budgets on State and private projects. Completed Visual Inspection Reports (Regular and Formal) for over 25 NJ dams, Emergency Action Plans with associated inundation mapping and Operation and Maintenance Manuals for submission to the NJDEP Dam Safety Section. The following dams were evaluated for their appropriate Spillway Design Flood (SDF) and hazard classification in NJ alone: Lake Fred Dam, Thundergut Pond Dam, Harrisonville Dam, Willow Crest Dam, Maskells Mill Pond Dam, Twin Lakes Dam, Whites Pond Dam, Pompton Dam, Pequannock Dam, Pinecliff Lake Dam, Lake Hartung Dam, Lake Niwauna Dam, Lake Ocquittunk Dam, Robert Rooke Dam, Swartswood Lake Dam, Skillman Dam, Seneca Lake Dam and Preston Lake Dam. Following acceptance of these studies by the NJDEP, responsible for the preparation of preliminary and final repair designs. This work was all completed in-house, using current and cost-effective design methodologies.

Position: Principal Civil Engineer, September 1998 - February 2001.
NJ Department of Environmental Protection: Bureau of Dam Safety & Flood Control, Trenton, NJ.

Position: Geotechnical/Environmental Engineering Intern, June 1997 - August 1997.
Langan Engineering, Elmwood Park, NJ.

Position: Teaching Assistant, August 1997- December 1998.
Rutgers University, Civil and Environmental Engineering, Piscataway, NJ.

Position: Graduate Research Assistant, May 1996 - May 1997.
Rutgers University, Civil and Environmental Engineering, Piscataway, NJ.

Position: Project Planning Intern, *June* - August 1995.
New Jersey Transit Corporation, Newark, NJ.

Position: Environmental Engineering Intern, January - May 1995.
Hoechst Celanese Corporation, Narrows, VA.

Papers: Guo, Q., N. Agnoli, N. Zhang, and B. Hayes. "Hydraulic and Water Quality Performance of Urban Storm Water Detention Basin Before and After Outlet Modification," *Proceedings of 2000 Joint Conference on Water Resources Engineering and Water Resources Planning & Management.* R.H. Hotchkiss and M. Glade, Editors. Minneapolis, MN. July 30-August 2, 2000.

Thesis: Agnoli, N. 1998. *Modifying Existing Dry Detention Basins to Improve Non-Point Source Pollutant Removal.* Prepared to fulfill the requirements for the degree of Master of Science, Civil and Environmental Engineering, under the guidance of Dr. Q. Guo, P.E.

Honors & Activities:	Chair:	Passaic Valley Regional Flood Board (Appointed by Little Falls Town Council)
	Member:	Montville Township Planning Board, Liaison to Open Space Committee, U.S. Society on Dams (USSD), Little Falls Flood Board, NJ Association for Floodplain Management, American Society of Civil Engineers, Chi Epsilon National Civil Engineering Honor Society, Association of State Dam Safety Officials, Central Passaic River Basin Task Force
	Awards:	Governor's Outstanding Service Award (NJ), 2000. Lampros and Eleni L. Bourodimos Award (Excellence in Water Resources Engineering), 1998.
	Languages:	English, Fluent; Italian, Intermediate; German, Intermediate
Citizenship:	United States of America	

TVA Dam Safety Program and Engineering Support

Gurinderbir Sooch, MASc, P.Eng.

PROJECT MANAGER/ SENIOR STRUCTURAL ANALYST/CO-FACILITATOR

Education & Qualifications

MASc, Civil Engineering, Concordia University, Montreal (Quebec), Canada, 2011

BTech, Civil Engineering, Dr B R Ambedkar National Institute of Technology, Jalandhar (Punjab), India, 2008

Certificate, Course: Seismic Hazard Analysis and Design Ground Motions, University of California Berkeley, Berkeley, United States, 2021

Professional Affiliations

USSD Concrete Committee - Member

EGBC - Engineers and Geoscientists of British Columbia, Canada - Member (Registration Number: 53946)

PEO - Professional Engineers of Ontario - Member (Licence Number: 100203261)

Experience

15 Years

Engineering Services Capabilities

AAR, FEA and seismic specialist, Structural assessment, Structural design, Dam safety, Evaluation of field investigation programs and concrete laboratory test results specifically for TVA.

Gurinderbir is an experienced structural engineer (FEA and seismic specialist) with fourteen years' experience in hydropower industry and academia. His experience includes advanced structural analysis/ design of 35+ hydropower projects. He also has performed numerous nonlinear finite element analysis of hydroelectric projects and locks for seismic, flood and AAR induced concrete growth loads. He has extensive experience in FEA programs (LS DYNA, ABAQUS, ANSYS, FLAC and 3DEC) and computer programming (MATLAB, FORTRAN, Python, C++, MathCAD).

Gurinderbir' s recent project experience includes lead structural engineer role for the detail structural design of BatterSea Dam and dam safety evaluations (seismic and AAR analysis) of Cushman 1 & 2 Arch Dams; Long Lake Dam; Powell River Dam; Lower Baker Dam; Upper Baker Dam; Mactaquac Dam; Fontana Dam; Wanapum Dam; Mossyrock Arch Dam; and Seaway Lock 3. He has also performed structural evaluations of numerous spillway gates and hoist towers (e.g., Powell River Dam, Mossyrock Dam and Waneta Dam). His experience includes the development of site-specific earthquake ground motions for Ocoee and Wheeler Dams. Gurinderbir has also evaluated field investigation program and concrete laboratory test results for eight Tennessee Valley Authority dams.

His recent experience also includes being a review board member for seismicity review of Ituango Dam (Columbia, 225 m high earth core rock fill dam). The detail dam analysis work performed by Gurinderbir using LS-DYNA and other FEA programs for numerous projects owned by Tennessee Valley Authority, Tacoma power, Grant PUD etc. has been reviewed by the Federal Energy Regulatory Commission (FERC) and Nuclear Regulatory Commission (NRC). Also, he has presented and published numerous papers at various dam engineering conferences i.e., ICOLD, USSD and CDA.

RELEVANT PROJECT EXPERIENCE

Experience on Tennessee Valley Authority Projects

Tennessee Valley Authority, Boone Dam 3D Finite Element Analysis (FEA), United States, Project Manager. Supervised the development of 3D FE analysis of Boone Dam. The objective of the analysis was to evaluate the seismic performance of dam, piers, trunnion anchorage and their associated embedment's and tainter gates. The nonlinear finite element analysis includes the effects of AAR growth.

Tennessee Valley Authority, Stability Analysis for Wilson, Pickwick and Kentucky Dams, Tennessee, United States, Structural Engineer. Performed 2D stability analysis for Wilson, Pickwick and Kentucky Dams. Various sections such as Spillway, Powerhouse, Non-Overflow Blocks and Lock etc. of these three projects were analyzed with a range of input values (concrete-rock friction angle, cohesion, concrete density, intact rock shear strength, earthquake site specific amplification factor etc.). The objective of the analyses was to support the field investigations i.e., based on the results from stability analysis total number of boreholes and laboratory tests were decided. During the course of this project Hatch's original stability sheet was modified and upgraded.

Tennessee Valley Authority, Ground Motion Attenuation for Wheeler Dam, Tennessee, Seismic Analysis Specialist. A site response analysis of horizontal layered deposits at Wheeler Dam site was performed to attenuate the site-specific earthquake ground records. Computer Program PROSHAKE was used for the site response analysis. During the course of the work a new methodology was developed for the attenuation of site-specific vertical ground motions, since current state of practice have very limited recommendations on the attenuation of vertical ground motions.

Tennessee Valley Authority, Field Investigation and Laboratory Testing Report for Wheeler and Ocoee Dams, Tennessee, United States, Structural Analyst. Prepared the laboratory test results section for the Field Investigation and Laboratory Testing Report for Wheeler and Ocoee Dams. Evaluated the laboratory test results for concrete material properties.

Tennessee Valley Authority, Ground Motion Attenuation for Ocoee Dam, Tennessee, United States, Seismic Analysis Specialist. A site response analysis of horizontal layered deposits at Ocoee Dam site was performed to attenuate the site-specific earthquake ground records.

Tennessee Valley Authority, Stability Analysis of Fontana Dam, Tennessee, United States, Finite Element Analysis Specialist. Stability analysis of Fontana Dam was performed using 3D finite element model. First an AAR analysis was performed to calibrate the concrete stress induced due to the concrete growth. Thereafter, stability assessment was performed using hydrostatic and seismic loads. The performance of major cracks in Blocks 33,34 and 35 was also evaluated with different loading conditions.

Tennessee Valley Authority, Stability Analysis of Cherokee, Douglas and Hiwassee Dams, Tennessee, United States, Structural Analyst. Developed the technical evaluation criteria for the stability analysis of Cherokee, Douglas and Hiwassee Dams.

Tennessee Valley Authority, Field Investigation and Laboratory Testing Report for Fontana and Hiwassee Dam, Tennessee, United States, Structural Analyst. Prepared the laboratory test results section for the Field Investigation and Laboratory Testing Report for Fontana and Hiwassee Dams. Evaluated the laboratory test results for concrete material properties.

Tennessee Valley Authority, Field Investigation and Laboratory Testing Report for Cherokee and Douglas Dams, Tennessee, United States, Structural Analyst. Prepared the laboratory test results section for the Field Investigation and Laboratory Testing Report for Cherokee and Douglas Dams. Evaluated the laboratory test results for concrete material properties.

Further Projects

BC Hydro, Strathcona Dam, Structural Engineer. Performed topographic seismic amplification study at the Strathcona Dam site. A model in FLAC 2D was developed to estimate on the seismic amplification at the rock pillars. The estimated response was used for the design of control building and rock anchors. The input ground motion included both crustal and subduction ground motions.

NB Power, Mactaquac Dam Risk Elicitation, Canada, Subject Matter Expert. As a subject matter expert (SME), provided system response probability estimates to the Mactaquac Dam Risk Elicitation. Also, supervised the evaluations of various potential failure modes with numerous loading and material property assumptions. The outputs from the evaluations of various potential failure modes were used as input to the quantitative risk assessment.

PSE, Seismic Analysis of Lower Baker Dam, Structural Engineer. Performed nonlinear seismic analysis of Lower Baker Arch Dam using LS-DYNA program. Dam-foundation-reservoir interaction was included in the analysis. Also, supervised Performance based test at dam site was performed to determine the natural frequencies of the dam. The finite element was then successfully calibrated to match first 10 natural frequencies determined the natural frequencies of the dam.

Tacoma Power, Non-linear Seismic Analysis of Cushman 1& 2 Arch Dams, United States, Project Engineer. Performed non-linear finite element analysis of Cushman 1 & 2 Arch Dams using LS-DYNA Program. Dam-foundation-reservoir interactions were included in the analysis. Non-linear concrete material model was used to realistically simulate the cracking of concrete. The peak ground acceleration for these projects was about 0.9g. Also, sliding of foundation rock wedges during a seismic event for both Cushman 1 & 2 Arch Dams was also simulated.

Puget Sound Energy, Structural Stability Analysis of Upper Baker Dam Blocks 18 and 19, Whitcomb County, Washington, United States, Finite Element Analysis Specialist. A three-dimensional model of Blocks 17 to 20 was constructed in LS DYNA. The movement of rock layers at depth below the Blocks 18 and 19 have caused the rotation of Block 18. The main concern with Blocks 18/19 is that rotation of Block 18 may have caused relatively high stresses in the concrete, and this could affect the stability of these blocks. The objective of the analysis is to simulate the cracks in Block 18 caused by its rotation and access the concrete stresses in the dam. State of the art concrete nonlinear material model was used to simulate the cracking in the concrete.

NB Power, AAR analysis of Mactaquac Intake structures, New Brunswick, Canada, Finite Element Analysis Specialist. Performed AAR analysis of the Mactaquac Intake structures. The objective of the analysis was to minimize the number of slot cuts in the intake structure. GROW3D is a proprietary program of HATCH for AAR analysis of Hydro Structures. During the course of work the subroutines of GROW3D were updated to match with the recently available experimental data. This modification resulted in close match between the simulated and observed movements at Mactaquac site. The new slot cut scheme proposed as part the work resulted in reduction proposed slot cuts, i.e., a total 6 less slots were required.

Grant County, Seismic Assessment of Wanapum Dam, Grant County (Washington), United States, Finite Element Analysis Specialist. The Stability of the infilled Wanapum Future Unit intake was investigated considering the static and dynamic conditions. The finite difference model was created using the FLAC program for this purpose. The original 13 anchors were gradually removed in order to investigate the loss of the anchors due to corrosion. The model was analyzed with 1/1000 year returned period hazard earthquake records.

BC Hydro, Seismic Analysis of Ladore Dam, Structural Engineer. Performed nonlinear seismic analysis of Ladore Dam using EAGD SLIDE program.

Val Kovalishyn

Electro/Mechanical Subject Matter Expert

Education & Qualifications

BASc, Mechanical Engineering, University of British Columbia, Vancouver, BC, Canada, 2000

MEng, Mechanical Engineering, University of British Columbia, Vancouver, BC, Canada, 2001

Professional Affiliations

Washington and Alaska Licensing Board - Professional Engineer - Member

Association of Professional Engineers and Geoscientists of Alberta and British Columbia - Member

Experience

23 years

Val Kovalishyn is a senior mechanical engineer with 23 years of experience in a variety of hydro projects, including detailed design of hydraulic gates, hoists, and penstocks. Val has performed detailed design and inspection tasks on a number of hydraulic gates and hoists including selection of gate types, structural analysis of new and existing gates (including effects of corrosion), computation of gate operating forces and selection of materials for gate and hoist components. Also, Val has designed a number of buried and exposed penstocks with diameters up to 3.8 m and static pressures up to 700 m. Val's expertise in the area of hydraulic machinery, pressure vessels and pipelines, hydraulic gates and hoists, and energy dissipating systems makes him a valuable addition to a multi-disciplinary design team. Val has also coordinated multi-disciplinary engineering teams on hydropower projects that included geotechnical, civil/structural, mechanical and electrical disciplines.

RELEVANT PROJECT EXPERIENCE

Seattle Public Utilities, Tolt Ring Gate Refurbishment, Seattle, WA, United States, Project Engineer.

- Project involved rehabilitation of a 37-foot diameter overflow ring gate's lifting and seismic restraint systems.
- Responsible for design for repair of hydraulic cylinder based lifting system and passive seismic restraint system.
- Project included planning for in situ recoating and specification of coating system. Project challenges include working with limited space, existing hydraulic equipment, and environmental restrictions on a drinking water reservoir.

Metro Vancouver, Cleveland Dam Safety Review, West Vancouver, BC, Canada, Mechanical Engineer.

- Dam Safety review of gates and mechanical equipment for Extreme consequence dam (per Canadian Dam Association).
- Cleveland Dam is a concrete gravity dam approximately 640 ft long and 302 ft high. Discharge facilities include 70' W x 23' H drum gate, two 54" Howell Bunger valves, and 5' W x 6' H m slide gates.

City of Spokane, Upriver Dam Gate Friction Measurement and Rehabilitation, Spokane, WA, United States, Mechanical Engineer.

- Analysed existing radial gates (built in 1935) for strength under normal, flood and seismic conditions to determine what structural modifications are required to bring the gate in compliance with modern standards.
- Missing dimensions and member sizes were obtained by wire rope access technicians and were compared against steel members produced during that time period. Relatively minor required structural modifications were identified and recommended for implementation.
- Estimated in-service friction in the tainter gate trunnion bearings by comparing field deflection results with those back-calculated using FEA model of the gate with assumed trunnion friction. Trunnions with higher-than-expected friction were identified.

Cascade Water Alliance, Lake Tapps Headgate Improvement, Buckley, WA, United States, Mechanical Engineer.

- Detailed design of screw stem hoist for rehabilitation of a 4.3 m W x 4.0 m H slide gate. Detailed design work included replacement of sliding surfacex, rehabilitated headgate leaf, and new tandem screw stem hoist.

US Bureau of Reclamation (USBR), Kachess Drought Relief Pumping Plant Project, Near Yakima, WA, United States, Mechanical Engineer.

- Performed feasibility-level design of an underground pumping plant with a capacity of 1,000 cfs (28.3 m3/s).
- Estimated dimensions of the vertical turbine, steel volute, and split case pumps, and performed layout of the pumping units and associated mechanical equipment. Interfaced with suppliers of large pumps, valves and ancillary systems.
- Coordinated mechanical/electrical requirements with civil and structural disciplines.
- Evaluated requirements for variable frequency drives and pump control/bypass valves.

US Bureau of Reclamation (USBR), Wymer Reservoir Fill System Project, Near Yakima, WA, United States, Mechanical Engineer.

- Feasibility level design for the relocated 400-cfs (11.3 m^3/s) pumping plant to fill Wymer Reservoir.
- Performed mechanical/hydraulic design for the intake piping, fish screen bypass piping, discharge conduit and outlet concrete chute.
- Performed mechanical layout of the pumping station considering the size of the pumping units, accessibility requirements at the pumping floor and service bay, and overall project layout.
- Coordinated electrical interconnection study with mechanical design of the pumping plant.

National Parks Service, Elwha River Temporary Diversion Pumping Facility, Port Angeles, WA, United States, Mechanical Engineer.

- Removal of two upstream dams caused extremely heavy sediment load in the river and existing pumping system pumps were not capable of operation without causing premature wearing and eventual failure of the pumps.

- New 40,000 gpm facility was designed with extremely robust pumps, high velocity suction and discharge piping, and expanded electrical/controls systems.
- Responsible for the selection and setting of pumping units, sizing of suction and discharge piping to maintain minimum scour velocities for actual sediments, and design of oil-water separator and sump pumps.
- Coordinated structural, civil, electrical/controls design to ensure that the project meets tight design schedule while delivering quality product for National Park Service.

Puget Sound Energy, Snoqualmie Falls Hydroelectric Project, Snoqualmie, WA, United States, Mechanical Engineer.

- Detailed design of the trashracks for 48 MW project. Project included intake flow modeling to establish velocity distribution and frequency analysis of the system to ensure potentially harmful flow induced vibrations are avoided.
- Prepared requests for proposal, reviewed vendor submittals and coordinated design for a sleeve valve flow bypass system, trashrack cleaning machines and elevator for a seven-unit redevelopment project.
- Independent design check for wheeled gates.

BC Hydro, Ladore Spillway Gates, Campbell River, BC, Canada, Mechanical Engineer.

- Existing spillway gates are 30 ft wide by 30 ft high vertical lift gates operated by dedicated screw stem hoists.
- Conceptual design included analysis of existing gates under normal and seismic conditions, determination of hoist capacities, and recommendations on upgrades.
- Upgrade options were considered which included replacement vs rehabilitation of the gates, upgrade of the screw stem hoists vs replacement with wire rope hoists, and upgrade vs replacement of existing towers.
- Detailed cost estimates were prepared for each option to enable comparison based on cost, schedule, risk, and impacts.

Kiewit/BC Hydro, Buntzen Gates Refurbishment, Near Coquitlam, BC, Canada, Project Engineer.

- Design to provide a new isolation gate and replace the two existing low-level outlet gates at their current locations in the tunnel. while maintaining the current discharge capacity of 40 m3/s and the head of approximately 25 meters.
- Scope of work included upgrade for the electrical and control system to enable full remote control of the facility via satellite. Refurbishment work to be accomplished during 4 major outages with outage 3 recently completed.

Alberta Environment and Parks, Dam Safety Inspection and FMEA for Travers/Little Bow, AB, Canada, Mechanical/Electrical Lead.

- DSI and semi-quantitative Failure Modes and Effects assessment for the Travers and Little Bow dams.

Alberta Environment and Parks, Multiple Systems, Failure Modes and Effects Analysis, AB, Canada, Mechanical/Electrical Lead.

- DSI and semi-quantitative Failure Modes and Effects assessments/ Val provided mechanical/electrical expertise on multiple systems operated by Alberta Environment.

BC Hydro, GM Shrum Spillway Gates, GM Shrum, BC, Canada, Mechanical.

- GMS spillway radial gates are 45 ft m wide by 56 ft high. The gates are operated by a 165-tonne wire rope hoist.
- Design work included analysis of gate hoist loads under normal and overload conditions, check of existing hoist drivetrain components, selection of fluid coupling for limiting overload loads, detailed specifications for upgrades, as well as specific items required prior to inspection/upgrades.
- Detailed design of a system to enable replacement of components in the primary gearbox for spillway gates. Design work included implementation of a blocking device to carry full gate weight. The design work included 100-ton hydraulic jack with locking collar to be able to unload gearbox components in the event of a failure. Connection of the blocking device to the hoist relied of slip-critical friction connection.
- Procedure for gearbox component swap was prepared as part of this project.
- Project was implemented with limited interruptions to operability of the gates.

Kemano T2 Project – Existing Intake and Tunnel, Kitimat BC, Canada, Mechanical Engineer.

- Responsible for selection and specification of new intake hydromechanical equipment (stoplogs, wheeled gate and hoist), and detailed design of tunnel plug removable doors (10 ft wide by 10 ft high~300 ft of head), tunnel unwatering system, and 132" penstocks.
- Design flow of the project is approximately 5000 cfs.

Innergex/CRT Construction, Northwest Stave Hydroelectric Project, North of Mission, BC, Design Manager/Penstock Engineer.

- Design manager for the Northwest Stave hydroelectric project. Project includes detailed design of a 1,100 cfs (29 m3/s) intake, 148 in. (3.7 m) and 118 in. (3.0 m) buried penstock (pipeline) and a 20 MW powerhouse in British Columbia.
- Powerhouse civil/mechanical design consisted of preparing concrete outline and reinforcing steel design for accommodating three turbine/generators, incorporation of the flow bypass systems, and balance of plant equipment design/layout.
- The powerhouse was modeled and drawings developed using 3D building information software (Inventor) to ensure coordination between electromechanical equipment, structural concrete, excavation, anchor bolts and architectural elements.

Innergex/CRT Construction, Kwoiek Creek Hydroelectric Project, Boston Bar, BC, Canada, Design Manager/Penstock Engineer.

- Detailed design of a buried and surface penstock (pipeline) on the Kwoiek Creek Hydroelectric Project. Penstock diameter of 76 in. (1.8 m) with 1840 ft/560 m of gross head.
- Technical oversight of FEA analysis (ANSYS) for penstock supports at creek crossing (ring girders and saddles) done to ASME Boiler and Pressure Vessel Code Sec VIII Div. 2.
- Reviewed welding procedure specifications (WPS) and procedure qualification records (PQR) for shop and field welding of high strength steel with yield strengths to 100 ksi (690 MPa) and thicknesses up to 2 in. (50 mm).
- Performed field inspections of pipe installation, backfilling and welding.

- New 40,000 gpm facility was designed with extremely robust pumps, high velocity suction and discharge piping, and expanded electrical/controls systems.
- Responsible for the selection and setting of pumping units, sizing of suction and discharge piping to maintain minimum scour velocities for actual sediments, and design of oil-water separator and sump pumps.
- Coordinated structural, civil, electrical/controls design to ensure that the project meets tight design schedule while delivering quality product for National Park Service.

Puget Sound Energy, Snoqualmie Falls Hydroelectric Project, Snoqualmie, WA, United States, Mechanical Engineer.

- Detailed design of the trashracks for 48 MW project. Project included intake flow modeling to establish velocity distribution and frequency analysis of the system to ensure potentially harmful flow induced vibrations are avoided.
- Prepared requests for proposal, reviewed vendor submittals and coordinated design for a sleeve valve flow bypass system, trashrack cleaning machines and elevator for a seven-unit redevelopment project.
- Independent design check for wheeled gates.

BC Hydro, Ladore Spillway Gates, Campbell River, BC, Canada, Mechanical Engineer.

- Existing spillway gates are 30 ft wide by 30 ft high vertical lift gates operated by dedicated screw stem hoists.
- Conceptual design included analysis of existing gates under normal and seismic conditions, determination of hoist capacities, and recommendations on upgrades.
- Upgrade options were considered which included replacement vs rehabilitation of the gates, upgrade of the screw stem hoists vs replacement with wire rope hoists, and upgrade vs replacement of existing towers.
- Detailed cost estimates were prepared for each option to enable comparison based on cost, schedule, risk, and impacts.

Kiewit/BC Hydro, Buntzen Gates Refurbishment, Near Coquitlam, BC, Canada, Project Engineer.

- Design to provide a new isolation gate and replace the two existing low-level outlet gates at their current locations in the tunnel. while maintaining the current discharge capacity of 40 m3/s and the head of approximately 25 meters.
- Scope of work included upgrade for the electrical and control system to enable full remote control of the facility via satellite. Refurbishment work to be accomplished during 4 major outages with outage 3 recently completed.

Alberta Environment and Parks, Dam Safety Inspection and FMEA for Travers/Little Bow, AB, Canada, Mechanical/Electrical Lead.

- DSI and semi-quantitative Failure Modes and Effects assessment for the Travers and Little Bow dams.

Alberta Environment and Parks, Multiple Systems, Failure Modes and Effects Analysis, AB, Canada, Mechanical/Electrical Lead.

- DSI and semi-quantitative Failure Modes and Effects assessments/ Val provided mechanical/electrical expertise on multiple systems operated by Alberta Environment.

BC Hydro, GM Shrum Spillway Gates, GM Shrum, BC, Canada, Mechanical.

- GMS spillway radial gates are 45 ft m wide by 56 ft high. The gates are operated by a 165-tonne wire rope hoist.
- Design work included analysis of gate hoist loads under normal and overload conditions, check of existing hoist drivetrain components, selection of fluid coupling for limiting overload loads, detailed specifications for upgrades, as well as specific items required prior to inspection/upgrades.
- Detailed design of a system to enable replacement of components in the primary gearbox for spillway gates. Design work included implementation of a blocking device to carry full gate weight. The design work included 100-ton hydraulic jack with locking collar to be able to unload gearbox components in the event of a failure. Connection of the blocking device to the hoist relied of slip-critical friction connection.
- Procedure for gearbox component swap was prepared as part of this project.
- Project was implemented with limited interruptions to operability of the gates.

Kemano T2 Project – Existing Intake and Tunnel, Kitimat BC, Canada, Mechanical Engineer.

- Responsible for selection and specification of new intake hydromechanical equipment (stoplogs, wheeled gate and hoist), and detailed design of tunnel plug removable doors (10 ft wide by 10 ft high~300 ft of head), tunnel unwatering system, and 132" penstocks.
- Design flow of the project is approximately 5000 cfs.

Innergex/CRT Construction, Northwest Stave Hydroelectric Project, North of Mission, BC, Design Manager/Penstock Engineer.

- Design manager for the Northwest Stave hydroelectric project. Project includes detailed design of a 1,100 cfs (29 m3/s) intake, 148 in. (3.7 m) and 118 in. (3.0 m) buried penstock (pipeline) and a 20 MW powerhouse in British Columbia.
- Powerhouse civil/mechanical design consisted of preparing concrete outline and reinforcing steel design for accommodating three turbine/generators, incorporation of the flow bypass systems, and balance of plant equipment design/layout.
- The powerhouse was modeled and drawings developed using 3D building information software (Inventor) to ensure coordination between electromechanical equipment, structural concrete, excavation, anchor bolts and architectural elements.

Innergex/CRT Construction, Kwoiek Creek Hydroelectric Project, Boston Bar, BC, Canada, Design Manager/Penstock Engineer.

- Detailed design of a buried and surface penstock (pipeline) on the Kwoiek Creek Hydroelectric Project. Penstock diameter of 76 in. (1.8 m) with 1840 ft/560 m of gross head.
- Technical oversight of FEA analysis (ANSYS) for penstock supports at creek crossing (ring girders and saddles) done to ASME Boiler and Pressure Vessel Code Sec VIII Div. 2.
- Reviewed welding procedure specifications (WPS) and procedure qualification records (PQR) for shop and field welding of high strength steel with yield strengths to 100 ksi (690 MPa) and thicknesses up to 2 in. (50 mm).
- Performed field inspections of pipe installation, backfilling and welding.

Hatch is an employee-owned, multidisciplinary professional services firm that delivers a comprehensive array of technical and strategic services, including consulting, information technology, engineering, process development, and project and construction management to the Mining, Metallurgical, Energy, and Infrastructure sectors.

Hatch has served clients for over six decades with corporate roots extending over 100 years and has project experience in more than 150 countries around the world.

Address:

1999 Harrison Street, Suite 620
Oakland, California 94612
Tel: +1 415 520 8850

www.hatch.com

HATCH