# 1 Technology Opportunity

·  Provide a description of the proposed solution (e.g. technology, practice, etc.) to be demonstrated in the project and how it works, using diagrams and photographs as appropriate.

·  Provide a clear process flow diagram to demonstrate the full scope of how the solution functions and what inputs it requires, including mass and energy balances and product/material specifications as necessary.

·  Describe what problem the technology solves and how it addresses a market need. Clearly justify how the proposed solution represents a potentially transformative improvement compared with current practice.

·  Identify competitors or alternatives to the proposed solution and compare them to the chosen approach.

·  Discuss the aspects of the solution that make it novel and innovative and how they will contribute to a sustainable competitive advantage.

·  Describe the current status of the innovation (i.e. stage of development/commercialization) and how it will be advanced through the proposed project. Clearly outline how ERA investment in the project will accelerate the solution toward commercialization (i.e.: what risks and challenges will be resolved and how?).

**The Problem: A Persistent Challenge Requiring Innovative Solutions** The presence of Naphthenic Acids in the ~1.4 trillion litres of tailings within Alberta's oil sands tailings ponds is a primary contributor to oil sands processed water (OSPW) toxicity and a critical barrier to achieving sustainable production, water management and reclamation objectives. These compounds delay land reclamation, escalate environmental risks, and contribute to substantial long-term financial liabilities for operators. Existing management practices struggle with the scale and cost, highlighting a clear market need for innovative technologies that are both effective and sustainable.

Need more details on the liability of ongoing ponds without treatment plan.

**Our Solution: An Integrated Biological Approach to Naphthenic Acid Management**

Luminous BioSolutions is advancing an integrated biotechnological platform designed to address the complex and persistent challenge of Naphthenic Acids (NAs) in OSPW. Current analytical and remediation methodologies face limitations in terms of speed, cost, scalability, and environmental footprint when applied to the vast scale of oil sands tailings facilities. Our approach leverages microbiological expertise for a more efficient, sustainable, and data-driven solution:

**1. Rapid, Quantitative Biosensing of Naphthenic Acids**: The foundation of our platform is a panel of patented whole-cell bacterial biosensors1. These biosensors are engineered using *Pseudomonas* strains native to tailings environments, and specific NA-inducible promoters (e.g., atuA, marR, 3680) fused to *lux* reporter genes. Upon exposure to NAs, these biosensors exhibit a rapid bioluminescent response, typically within minutes, with light intensity directly proportional to NA concentration. These NA-induced promoters control the expression of bioremediation or antibiotic efflux genes, allowing bacteria to degrade or pump out diverse NA compounds. Increasing luminescence with increasing NA concentration allows for quantitative assessment. Our research, as detailed in Bookout et al. (2024)2, demonstrates that these sensors can detect various NA compounds mixtures with limits of detection between 1.5 and 15 mg/L, a range highly relevant to OSPW conditions (typically 10-120 mg/L NAs ). This technology enables high-throughput and density sampling, screening and near real-time monitoring, offering a significant improvement in NA data resolution and operational responsiveness compared to conventional analytical chemistry methods. The biosensors were developed by Canadian Natural Resources oil sands industry funding and NSERC.

Pilot testing in Genome Canada LSARP

**A computer screen shot of a computer game

AI-generated content may be incorrect.**

**Figure 1.** Naphthenic acids in an OSPW water sample or extract enter the bacterial cell, are sensed, which leads to the induced expression of genes specific to transport, degrade, or pump out various NA compounds, leading to the production of light from the *lux* reporter. Luminescence data can be produced within 24 hrs of receiving water samples.

**2. Targeted Biological Remediation Strategy:** Beyond NA detection, our platform facilitates enhanced NA bioremediation. Recognizing the inherent resilience and metabolic capabilities of native OSPW microbial communities, our strategy focuses on:

**Identifying Potent Native NA Degraders**: Our biosensors can rapidly measure the degradation of NA in small volume, high-throughput culture conditions, and have rapidly screened 1000s of bacterial isolates for NA degradation abilities. We will identify a simple, stable bacterial community with the most effective NA-degrading properties possible. NA degradation is first biosensor screend and then validated by a high-resolution mass spectrometry method (LC-QTOF-MS), by our partner Vogon Labs (Cochrane, Alberta).

**Pilot Bioaugmentation process in mesocosms:** This ERA project will pilot the large volume bioreactor growth and deployment of these validated, superior OSPW-derived cultures in mesocosm scale, bioremediation experimental systems. We will test bioaugmentation first in greenhouse scale mesocosms that mimic an overflow wetland and compare to a flow through wetland. These small-scale experiments will permit an investigation of multiple bacterial cultures (single species vs communities), as well the frequency of bioaugmentation (single, multiple, continuous doses) in order to optimize NA reduction. We will also explore biostimulation by the addition of proprietary nutrients to enhance the degradation activity of the existing microbial communities in OPSW, and/or the exogenous microbial consortia *in situ.* This biological approach aims for specific and sustainable NA degradation beyond what is capable in constructed wetlands. This approach has a low environmental footprint, lower operational costs compared to energy-intensive chemical, oxidative or physical adsorption or separation methods, which can also produce secondary waste streams.

**3. Large volume mesocosms for treating naphthenic acids.** After demonstrating the potential for bioaugmentation in small scale mesocosms, we will scale up to test bioaugmentation in large outdoor mesocosms (5000 – 15000 L) that are managed and housed by Innotech Alberta. Mesocosms will be designed similar to systems that have shown to be successful in remediating NA.

**4. Data-Driven Environmental Management Platform**: Data from our biosensors are integrated into a cloud-based analytics platform. This system provides real-time visualization of NA spatial and temporal trends, incorporates AI for predictive insights into NA dynamics, and supports streamlined regulatory reporting and transparent stakeholder communication.

**GREG: THIS SECTION NEEDS BETTER DESCRIPTION AND JUSTIFICATION OF BUDGET**

**Process Flow Diagram –Draft image to depict the various processes captured in the ‘mermaid’ diagram. I think this is better than a mermaid.**

**A diagram of a bio biomaterial

AI-generated content may be incorrect.**

**Competitive Landscape**

Current Naphthenic Acid (NA) management in the oil sands utilizes a range of tools and strategies under development. Conventional mass spectrometry methods for NA detection (orbitrap-MS, GC-MS) provide accurate monitoring but are resource-intensive, high cost ($500-$1000 per test) and slow reporting times. Other commonly used methods (FTIR) are lower cost but also have low specificity. For remediation, alternatives advanced oxidation processes (UV, ozone, TiO2 photocatalysis) or adsorption (coke, activated carbon), which can be effective but involve high operational costs, substantial energy demands, and potentially generate secondary waste streams. Passive biological systems like constructed wetlands are under investigation by the major oil sands mining companies; these offer a more natural approach where plants, and native OSPW microbes remediate NA in situ. Wetlands can operate at the necessary scale and are effective at reducing NA levels, however their exact mechanism is unclear, and the residual NA levels are still at toxic levels.

Luminous BioSolutions is designed to enhance and integrate within a constructed wetland treatment system, offering unique advantages and synergies.

- Integrated & Adaptive Intelligence (Our Core Differentiator): Our primary innovation is the synergistic combination of rapid, quantitative NA biosensing with a data-driven platform that supports and optimizes biologically-based remediation efforts. This creates an intelligent, adaptive system.

- Accelerating Nature-Based Solutions (e.g., Constructed Wetlands): Our adaptive bioremediation approach, focusing on OSPW acclimatized microbes, is a powerful complement to systems like constructed wetlands. By identifying optimal native microbial consortia or designing effective biostimulation strategies based on real-time biosensor data from within the wetland, we can significantly enhance the NA degradation efficiency and resilience of these biological systems. This means potentially smaller footprints or faster throughput for existing or new wetland designs.

- Agnostic Data Platform for Holistic Oversight: Our analytics platform is designed to be versatile. While it natively integrates our biosensor data, it can also incorporate data inputs from various other sensors and monitoring techniques (e.g., pH, temperature, flow rates, even results from conventional lab analyses). This allows for a more holistic, centralized view of the entire treatment process, providing comprehensive insights into the current state and progress of NA remediation, regardless of the specific combination of technologies employed.

- Targeted Biological Enhancement vs. Broad Chemical/Physical Intervention: Our biological pathway, focused on selecting and stimulating robust OSPW native microbes, inherently aims to minimize the harsh chemical inputs or high energy demands characteristic of many alternative standalone remediation methods. This offers a more environmentally congruent and potentially more cost-effective route to achieving NA reduction targets.

Luminous BioSolutions seeks to provide the critical missing pieces; rapid, actionable intelligence and targeted biological enhancements, that can make existing and future NA management strategies more efficient, effective, cost-conscious, and environmentally sound.

Novelty, Innovation & Sustainable Competitive Advantage

Our innovation is driven by cutting-edge science and a dedicated commercialization focus. The scientific underpinnings of our biosensors are detailed in publications such as Bookout et al. (2024), which was funded by an NSERC Discovery Grant, and matched with industrial funding from Canadian Natural Resources and Mitacs. In addition, the NA biosensor is currently being filed tested in greenhouse mesocosms and in the Kearl Wetland from Imperial Oil, as part of a Genome Canada Large Scale Applied Research Project (https://wpsites.ucalgary.ca/grow/). The results from this project have demonstrated that mesocosms and wetlands are effective at reducing naphthenic levels, but we are proposing a relatively simple additional ‘polishing’ step to further reduce to NA levels.

Luminous BioSolutions was founded by microbiologists specifically to accelerate such promising research into field-deployable, commercial applications for NA management. Unlike many advancements that remain primarily within academic institutions, our core mission is to provide an integrated and practical biological solution to the oil sands industry. This singular focus on NAs, from rapid detection to enhanced bioremediation and intelligent data analysis, provides us with deep, specialized expertise and a clear pathway to delivering tangible results in a complex operational ecosystem. Our advantage stems not just from individual technological components, but from this dedicated, expert-driven mission to solve the NA challenge comprehensively.

**Current Status & Project Advancement**. The foundational biosensor technology has achieved TRL 5-6, with testing and validation in water samples from small scale, pilot greenhouse mesocosm, and large scale constructed wetlands. The bioremediation technology has achieved a TRL 4, as our NA biosensors have rapidly screened 1000s of potential NA degraders, and currently efforts are underway to characterize an optimal, bacterial consortia for NA bioaugmentation. This ERA-funded project is designed to advance existing water treatment approaches to increase the efficiency of NA degradation to below toxic levels, although the regulations for water release are not currently defined. This ERA proposal would advance the integrated Luminous technology to TRL 7-8. This involves deploying and validating the bioaugmentation technology first in a lab scale mesocosm experimental water treatment system, and next in a medium/large scale outdoor mesocosm pilot test. If successful in these mesocosm systems, this technology would then be ready to test within the operational wetlands built by CNR or Imperial oil. We are very confident that a carefully selected bioaugmentataion approach will function as a productive treatment strategy, to improve NA remediation beyond the capabilities of other technologies.

ERA's Role in Accelerating Commercialization

ERA’s partnership is vital in enabling a specialized, expert-driven company like Luminous to translate deep scientific understanding of NA microbiology into a commercially viable, impactful solution for Alberta.

- Validate Field Performance & Scalability: Bridge the gap from controlled lab environments to the complexities of operational tailings facilities, resolving uncertainties around performance in variable OSPW and at a larger scale.

- Generate Bankable Data: Produce the comprehensive, quantitative performance data required by industry operators for adoption and by the AER for regulatory consideration.

- Optimize the Biological System: Utilize mescosm water treatment data to validate biosensor deployment, to optimize the selection and application of bioremediation cultures, and enhance the predictive capabilities of the data platform.

- Catalyze a Sustainable Solution: Support the advancement of a biological solution that offers significant environmental (reduced toxicity, enabling reclamation) and economic (lower monitoring and potentially remediation costs) advantages over conventional chemical/mechanical strategies, aligning with industry's need for effective and sustainable technologies. This project, with ERA's support, will de-risk key technical and operational aspects, significantly accelerating the path to commercial deployment of a uniquely integrated biological solution for NA management.

# 2. Implementation Plan

·  Provide a description of the overall objectives, work scope, and deliverables for the proposed project.

·  Clearly describe the nature of the prototype, pilot, demonstration, or first-of-kind deployment proposed, including the size/scale and the relevance to the anticipated fully commercial system (e.g. 1:10 commercial scale).

·  List the specific location(s) of project activities.

·  Provide an overview of the project work plan, indicating major project milestones and anticipated timeline for completion of each milestone. Please fill in and follow the Milestone Summary Table template at the end of this document. This table does not form part of the 10-page limit and may be attached separately.

·  Provide a summary budget for the proposed project according to the milestones in the work plan. Clearly identify the total budget for the project.

·  List the organization(s) involved in the project consortium, their roles, status (confirmed, in discussion, etc.) and the overall project execution structure.

·  Identify the core team members who will carry out and/or support the project and outline their relevant expertise and experience, including those within the applicant organization and partnering organizations.

·  Using the table below, identify all confirmed and anticipated financial contributors to the project, including the funding amount and the current status for each source. Add or subtract rows as necessary.

·  Describe the overall plan for financing the project and the estimated timelines for securing funds. Please ensure that this description aligns with the sources of funding listed in the Grant Manager.

·  Summarize the line of sight from the current status to the beginning of major project activities, including any required internal approvals, budgeting, site selection, agreements, permitting, studies, and similar factors.

·  Provide a brief overview of the key risks that could result in delay or failure of the project, and the plan for risk mitigation.

·  Explain why ERA funding is being requested. Describe what risks and/or barriers ERA funding mitigates and justify the funding amount requested from ERA.

Overall Objectives, Work Scope, and Deliverables

Key Project Objectives:

1. To identify optimal microbial consortia designed for maximal NA degradation.
2. Large scale bioreactor growth of viable bacterial NA degrading communities and Mesocosm Scale bioreactor cultivation of NA degrading consortia.
3. To design and test overflow and flow through greenhouse mesocosms for NA remediation
4. To scale up bioaugmentation and NA remediation in large, outside mesocosm systems.
5. GREG, IT INFRASTRUCTURE OBJECTIVE

Work Scope: The project will include the design, construction, and operation of controlled mesocosm systems. These will act as models of constructed wetlands, allowing us to test our biosensors and compare bioremediation approaches. We will compare the ability of soil, plants and bioaugmented cultures to reduce NA levels. This will provide the opportunity to systematically test various bacterial communities, and to understand the dosing regimen. Learnings from this pilot will inform the design and execution of a field pilot in a constructed wetlands at a selected oil sands operational site. This will involve establishing contained pilot zones (treated vs. control), deploying our integrated monitoring and remediation technologies, and conducting continuous performance assessment. Throughout both phases, our data analytics platform will be central to tracking, analysis, and adaptive management. The end stage of this project will emphatically determine the potential for the real world application of bioaugmentation to treat OSPW.

Key Deliverables:

>Identification of ideal NA degrading bacterial isolates and communities in lab scale experiments

>Development of method of growing large scale cultures for optimal bioaugmentation performant

>Small and large scale Mesocosm Design & Operational Plan.

>Mesocosm Trials Performance & Optimization Report

>Validated Biosensor Field Performance in Mesocosm treating OSPW

>Fully operational data analytics platform with pilot data.

>Comprehensive Final Project Report (technical achievements, GHG/economic analysis, operational learnings, modular scale-up recommendations).

>MMV Report for ERA. WHAT is THIS?

>Knowledge Dissemination Materials, Peer-Reviewed Publications

Specific Location(s) of Project Activities

- Greenhouse Mesocosm Trials: The University of Calgary, Dr Doug Muench

-Outdoor Mesocosm Trials:  Meocosm facilities in InnoTech Alberta (Subsidiary of Alberta Innovates) in Vegreville, AB.

- BioReactor: Operational in lab space at Athabasca University in Athabasca. Bioreactor service may also be provided by InnoTech Alberta (Vegreville, AB).

- NA Detection Testing Facilities: Water monitoring will be performed at the University of Calgary, Dr Shawn Lewenza, and Vogon Labs, Cochrane Labs, Ralph Hindle.

- Project Management Office Space: at Luminous offices at Assembly, Calgary, AB

Overview of Project Work Plan, Milestones, and Timeline The project is planned over a four-year period (Target: Q1 2026 – Q4 2029), structured around our staged deployment:

**Phase 1 (Years 1) Focus): Identification of optimal NA degrading microbes**. This work would be performed by 2 scientists at the University of Calgary, using our established methods or rapid, high throughput screening of bacterial cultures that degrade NA. Hundreds of isolates can be tested in a period of weeks. This would include the testing of combinations of NA degraders in simple consortia of 4-8 microbes. In addition, we can systematically explore variations in all growth parameters with high throughput liquid handling robots, to screen 100s-1000s of conditions, in search of conditions and/or supplements that promote growth and NA degradation. The genomes of NA degrading isolates will be sequenced and interrogated to identify potential NA degradation pathways.

**Phase 2 (Years 1-2) Greenhouse mesocosm trials of bioaugmentation**. At the University of Calgary, small scale mesocosms that have already been design, will be operational for pilot bioaugmenation experiments using microbes identified above. This approach can test multiple variables, including dose frequency, single species vs microbial community, bacterial density and growth stage, as well as any biostimulation conditions identified above. Ideal plants for remediation have already been identified in ongoing projects. Intensive NA monitoring and analysis using biosensors and mass spectrometry.

**Phase 3 (Year 3) Large scale, outdoor mesocosm trials of bioaugmentation.** Using the information gained from lab bench and mesocosm experiments, we intend to scale up the process in 5000 or 15000 L mesocosm experimental systems. Although fewer conditions can be tested, it is possible at this level to test a variety of experimental systems to promote NA degradation at scale. Microbial cultivation will likely be performed on site at Innotech, to simplify the bioaugmentation transport processes. Intensive NA monitoring and analysis using biosensors and mass spectrometry.Detailed engineering and logistical planning for the future scale up to constructed wetlands will also be performed.

**Phase 4 (Year 1-3): Commercial Pathway Development**. Development of the integrated Luminous NA monitoring system for commercial application. JEFF/GREG, we need the IT development, customer services and data pipeline here?

Summary Budget The estimated Total Project Budget for this staged program is [$6.0M - $7.0M CAD – NEEDS FINAL VALIDATION]. This budget supports all phases, from mesocosm setup and operation through to full field pilot demonstration and analysis. It covers our dedicated Alberta-based team, specialized equipment (including mesocosm infrastructure, biosensor arrays, bioreactors), materials, analytical services, travel, and overhead, fully aligned with ERA's eligible cost guidelines. A detailed breakdown will accompany the Milestone Summary Table.

Project Consortium, Roles, Status, and Execution Structure

- Lead Applicant: Luminous BioSolutions Inc. (Overall project lead, technology development & deployment, mesocosm & field operations, data analytics, scientific oversight, reporting).

- Oil Sands Host Partner(s):  Canadian Natural Resources, Imperial Oil, and/or Pathways Alliance - \_Status: In Discussion\_: Role providing OSPW samples for mesocosm trials, input on experimental design. Co-funding partner.

- Academic Partners: University of Calgary & Athabasca University - Existing Collaboration on wetlands and microbiology of NA remediat.\_. Role: Access to lab facilities for biosensor testing, greenhouse mesocosms, advanced microbial characterization, Highly qualified Personel (HQP) training.

- Granting Agencies (Anticipated): Alberta Innovates (PDP), Canadian Foundation for Innovation (CFI); Bioreactor infrastructure request, National Research Council of Canada Industrial Research Assistance Program (NRC IRAP). Role: Co-funding

-Execution Structure: Luminous will spearhead and manage all project phases, ensuring tight integration between mesocosm learnings and field pilot execution. We will establish a joint project steering committee with the host oil sands partner(s) for the field pilot phase to ensure alignment, safety, and operational coordination.

**Core Team Members**

- Dr. Shawn Lewenza (CSO, Luminous, Athabasca University): Expert and lead in growing bacterial communities and utilizing NA biosensor technology, with deep experience in NA research.

- Jeff Violo (COO, Luminous): Decades of experience in operational leadership and strategic execution. Role: Overall Project Director, ensuring efficient execution of both mesocosm and field phases, budget management, and stakeholder relations.

- Greg Saunders (CTO, Luminous): Technology and commercialization strategist. Role: Lead for data platform integration, AI analytics development, and ensuring field data translates to commercial insights.

-

Dr Doug Muench (University of Calgary): Expert in plant remediation of naphthenic acids and mesocosms as water treatment systems. Role: Will lead the greenhouse scale mesocosm experiments to perform initial bioaugmentation trials, prior to advancing to the large scale mesocosms.

- Tyson Bookout MSc (Developer of NA biosensor technology)

- Key Hires (Alberta-based): The project will fund a dedicated team including a Tyson Bookout, MSc, (Lab Operations Manager, Contributing Scientist), Project Manager, Post-doctoral fellow, Lewenza lab, Bacterial remedation, Post-doctoral fellow, Muench Lab, Plant Remediation. Field Operations Support (Innotech Facilities).

- Partner Team Members: Innotech Alberta (Vegreville, AB) Will provide large volume, outside mesocosms for water treatment trials, and may provide bioreactor cultivation of microbial cultures to be used to bioaugment and enhance NA treatment.

Financial Contributors \_(Please insert the ERA-provided table format here, populated with your confirmed/estimated amounts and current statuses for each source, as discussed previously).\_

(Overall Plan for Financing and Timelines) Our financing strategy leverages ERA's crucial support (targeting ~50% of project costs) and combines it with Luminous BioSolutions' investment, anticipated non-dilutive grants (Alberta Innovates, NRC IRAP, CFI), and contributions from our oil sands host partner(s). We are actively pursuing these avenues and aim for full funding commitment within 6-8 months post-ERA EOI success, facilitating a timely project start.

(Line of Sight from Current Status to Project Start) We are well-prepared for a Q1 2026 project initiation. Current activities include advancing discussions with potential AOSR host partners for OSPW supply (for mesocosms) and field pilot sites. Key steps to full project launch include:

1. Successful ERA EOI & Full Project Proposal.

2. Formalizing host partner agreements (mesocosm OSPW access & field site).

3. Securing all co-funding commitments.

4. Luminous internal resource finalization.

5. Hiring core Alberta-based project team.

6. Procurement for mesocosm setup and initial field equipment.

7. Finalizing detailed HSE and operational plans for mesocosm phase.

Enhanced Key Risks and Mitigation Plan

Our project's success hinges on a proactive, transparent, and adaptive approach to risk management. The cornerstone of our mitigation strategy is our staged, iterative deployment (lab bench-to-small mesocosm-to-large mesocsom pilot). This scientifically sound methodology allows us to identify, understand, and address challenges systematically at a smaller, controlled, and more cost-effective scale before progressing to full field implementation, significantly de-risking the entire endeavor. Here's how we address key potential risks:

1. Technical Risk: Biological System Performance. The complex and variable nature of OSPW, and experimental mesocosms could impact bioaugmentation efficiency. To mitigate this risk, we propose a rigorous, staged level of testing at the lab bench, moving to small mesocosms, and to large mesocosm systems. Multiple NA monitoring technologies are being employed, with no reliance on any single method.

2. Scale-Up Risk: Translating Pilot Success to Commercial Viability. We are designing for scalability from the start, focussing on validating a ‘scalable treatment’ system for remediation and monitoring.

3. Regulatory & Stakeholder Acceptance Risk. Gaining acceptance from the Alberta Energy Regulator (AER) for novel monitoring data (from biosensors) and bioremediation approaches may face challenges for implementation. We will proactively engage with the AER, local and Indigenous community stakeholders with transparency to build public support.

data (e.g., via our data platform), and actively seeking input to ensure our project aligns with community values and concerns.

4. Co-Funding. It will be necessary to match financial contributions from grants and industry partners to fully execute the project scope. Our strong value proposition is a solution that addresses a critical, high-cost pain point for industry, offering significant potential environmental and economic benefits, which forms a compelling case for partner investment.

Why ERA Funding is Requested:

Luminous BioSolutions is at a critical juncture: we have scientifically grounded, lab-proven components for a transformative biological solution to Naphthenic Acid (NA) management. However, the journey from promising research to a field-deployed, commercially viable system for the complex oil sands environment presents significant technical, operational, and financial hurdles that ERA funding is uniquely positioned to help us overcome.

ERA's partnership is essential to mitigate key barriers and accelerate impact:

1. De-Risking Critical Field Validation & Scale-Up:

- The primary barrier is validating our integrated system (biosensors, bioremediation with OSPW-native microbes, data platform) under real-world, variable OSPW conditions and at a meaningful scale. While our staged mesocosm-to-field pilot approach is designed to meticulously de-risk this process, it is resource-intensive.

- ERA funding directly enables this crucial validation. It allows us to bridge the "valley of death" by funding the comprehensive testing in controlled mesocosms to optimize parameters \_before\_ progressing to larger, more complex field demonstrations. This mitigates the Technical Risk of underperformance and the Scale-Up Risk by proving the efficacy of a scalable modular unit. Without this support, achieving the necessary level of field validation to gain industry confidence would be significantly slower and more challenging for an innovation-driven company like ours.

2. Generating "Bankable" Data for Industry Adoption & Regulatory Acceptance:

- While individual operators have provided academic funding to our Biosensor initiative, they may be hesitant to fully fund the extensive validation required for a novel, integrated biological platform. ERA's co-investment facilitates the generation of independent, robust, and transparent performance data.

- This ERA-supported data generation is vital for:

- Building the confidence of oil sands operators for broader commercial adoption by clearly demonstrating technical efficacy and potential cost savings compared to conventional chemical/mechanical approaches.

- Supporting our proactive engagement with the Alberta Energy Regulator (AER), providing the credible, benchmarked data necessary to facilitate Regulatory Acceptance of our novel monitoring and remediation techniques.

3. Accelerating an Alberta-Grown, Environmentally Superior Solution:

- Luminous offers an innovative, biological pathway that inherently avoids the harsh chemical inputs and high energy demands of many alternative NA treatment methods, promising a more sustainable and environmentally sound approach. As a specialized Alberta company founded by microbiologists dedicated to solving the NA challenge, we are committed to keeping this innovation and its benefits within the province.

- ERA funding acts as a powerful catalyst, accelerating the development and deployment of this made-in-Alberta solution. This not only addresses a critical environmental issue for a key provincial industry but also enhances Alberta's leadership in cleantech. It also strengthens our position to secure Co-Funding by signalling strong project viability and government backing.

Justification of Funding Amount: The requested funding of [$3.0M - $3.5M Estimate – NEEDS FINAL VALIDATION] is directly tied to the comprehensive scope of this multi-year, staged validation program. It will support our dedicated Alberta-based expert team, the establishment and operation of controlled mesocosm facilities, the execution of rigorous field pilots in the AOSR (including specialized equipment, consumables, and analytical services), and the robust data analysis required. This investment represents a strategic allocation of TIER funds to thoroughly de-risk and prove a technology with a high potential for significant, industry wide environmental and economic benefits, moving it decisively towards commercial success.

# GHG Benefits – STOPPED HERE

Luminous BioSolutions’ innovative approach to Naphthenic Acid (NA) management offers a clear pathway to greenhouse gas (GHG) benefits, primarily by enabling the vital process of tailings pond reclamation and by providing an inherently low-energy, low-GHG intensity solution compared to many existing or alternative NA treatment strategies.

How Our Solution Results in GHG Benefits

Our integrated biological platform contributes to GHG reduction through the following key mechanisms:

1. Enabled Methane Emission Abatement (Primary Benefit):

- It is well understood that oil sands tailings ponds are sources of fugitive methane (CH4), a potent GHG with a Global Warming Potential (GWP) approximately 25-28 times that of CO2​ over a 100-year period. This methane results from the anaerobic degradation of the rich organic matter present in the tailings, which includes components related to NAs.

- The Luminous platform, by providing rapid NA monitoring and supporting effective \_in-situ\_ NA bioremediation (using OSPW-native microbes or biostimulation), is designed to help operators meet the water quality criteria necessary for progressive reclamation more efficiently. Any acceleration in achieving "Ready-to-Reclaim" status for pond areas, as outlined in AER Directive 085, directly translates to an earlier cessation of ongoing methane generation and emissions from those reclaimed areas. This enabled reclamation is the most significant GHG benefit.

2. Low GHG Intensity of the Luminous Solution:

- Inherently Low Energy Demand: Our biological approach utilizing the metabolic capabilities of naturally occurring or selectively enriched OSPW native microbes is fundamentally a low-energy process. The primary energy input anticipated for our bioaugmentation/biostimulation strategies is for potential minimal aeration or mixing in specific applications, estimated to be significantly lower (e.g., Luminous estimates its aeration needs, if required for its biological processes, could be in the range of 0.5-1.5 kWh/m³, a fraction of alternatives).

- Displacement of Higher-GHG Alternatives: By providing an effective biological pathway for NA management, our solution offers an alternative to potentially more energy-intensive physical-chemical NA treatment methods (e.g., Advanced Oxidation Processes often cited in ranges of 15-25 kWh/m³, or thermal methods). Adopting a lower-energy biological solution displaces the GHG emissions that would have been generated by these higher-intensity alternatives.

- Reduced Ancillary Emissions: Our on-site/near-site biosensor technology reduces the need for frequent transportation of large volumes of samples to distant analytical laboratories, thereby decreasing associated logistical emissions.

3. Indirect GHG Benefits through Avoidance & Future Sequestration:

- Minimized Need for New Pond Construction: Effective treatment and accelerated reclamation of existing tailings volumes can optimize current storage capacity, potentially reducing the scale or deferring the need for new tailings pond construction and its associated land disturbance and construction-related GHG emissions.

- Enabled Carbon Sink Enhancement (Long-Term Vision): As reclaimed land is revegetated (e.g., with forests or wetlands), it begins to sequester atmospheric CO2​, creating new carbon sinks. Our solution contributes to this long-term benefit by enabling the reclamation process itself.

Quantitative Estimate of Annual GHG Reductions from the Proposed \_Project\_

The direct operational GHG footprint of the Luminous technology deployed in this pilot is anticipated to be minimal. The primary GHG benefit quantifiable \_from this project\_ is the demonstrated potential for future methane emission avoidance by successfully treating a defined pilot area and proving its readiness for accelerated reclamation steps.

- Project Goal & Benefit Demonstration: This project aims to validate NA reduction to target levels within a pilot treatment area of [LUMINOUS TO PROVIDE: e.g., X Hectares surface area or Y m³ OSPW volume]. The project's success will demonstrate that this specific area can proceed through reclamation stages [LUMINOUS TO PROVIDE: e.g., Z years, e.g., an estimated 1-2 years] sooner than a comparable untreated area.

- Calculating Avoided Emissions from the Pilot Area:

- \_Assumption 1:\_ The average baseline methane emission flux from an active tailings pond surface is estimated at [Chosen Value, e.g., 1.57 kg CH₄/m²/year or 15.7 tonnes CH₄/Ha/year – state source/rationale and acknowledge variability].

- \_Assumption 2:\_ The Global Warming Potential (GWP) of CH4​ is 28 over a 100-year timeframe.

- The \_annual\_ GHG benefit materializes \_after\_ the project successfully demonstrates that the pilot area is ready for these advanced reclamation steps. The benefit is the methane that \_would have been emitted\_ from that pilot area had it remained in its previous state.

- Estimated Annual GHG Reduction (from the specific pilot area, post-project success leading to advanced reclamation): `[Pilot Area in Ha]` \* `[Assumed CH₄ Emission Rate in tonnes CH₄/Ha/yr]` \* `28 (GWP)` = [Calculated Tonnes CO₂e/year potentially avoided from the successfully treated pilot area going forward].

- Cumulative GHG Reduction (from the specific pilot area over the accelerated period): `[Annual CO₂e Avoided from Pilot Area]` \* `[Z years reclamation accelerated for pilot area]` = [Total Tonnes CO₂e benefit directly attributable to the project's impact on the pilot area].

- Focus: This project will provide the critical data to confirm these calculations for the pilot scale and build confidence for broader application. The key outcome is \_proving the potential\_ for these enabled reductions.

Estimated Annual GHG Reduction Potential by Market Implementation

Projecting market-wide GHG reductions at this early stage involves significant assumptions, but it illustrates the potential impact if the Luminous technology is broadly adopted and successfully enables accelerated reclamation.

- Context: Alberta's oil sands tailings ponds currently cover over 30,000 hectares.

- Key Assumptions for Market Potential:

- \_Assumption 3 (Reclamation Acceleration):\_ Successful widespread implementation of Luminous technology (or similar effective NA management leading to reclamation) could accelerate the "ready-to-reclaim" timeline for treated pond areas by an average of [LUMINOUS TO PROVIDE: e.g., a conservative 2-4 years].

- \_Assumption 4 (Market Penetration - Alberta):\_

- By 2030: [LUMINOUS TO PROVIDE: e.g., a conservative 5-10%] of tailings areas requiring NA management adopt effective solutions like Luminous, leading to initiated acceleration of their reclamation.

- By 2050: [LUMINOUS TO PROVIDE: e.g., a conservative 20-30%] of tailings areas adopt such solutions.

- Estimated Annual GHG Reduction Potential (Alberta) - Based on a cohort of ponds starting their accelerated reclamation pathway each year:

- By 2030 (Illustrative Range): `30,000 Ha` \* `[5-10% Market Penetration]` \* `[15.7 tonnes CH₄/Ha/yr]` \* `28 GWP` = Approximately [Calculate Range, e.g., 66,000 - 132,000] tonnes CO₂e/year.

- By 2050 (Illustrative Range): `30,000 Ha` \* `[20-30% Market Penetration]` \* `[15.7 tonnes CH₄/Ha/yr]`\* `28 GWP` = Approximately [Calculate Range, e.g., 264,000 - 396,000] tonnes CO₂e/year. \_(It is crucial to state that these market projections are estimates based on the successful validation and adoption of effective NA management technologies leading to reclamation. All market GHG benefits are currently projected to be within Alberta).\_

Contribution to Achieving Net-Zero GHG Emissions

The Luminous BioSolutions platform is a key enabling technology that can directly assist the oil sands sector in advancing its net-zero GHG emission ambitions by 2050, particularly aligning with industry commitments such as those by the Pathways Alliance:

1. Addressing Difficult-to-Abate Scope 1 Emissions: Fugitive methane from tailings ponds represents a challenging source of direct (Scope 1) operational emissions. By providing a viable pathway to accelerate pond reclamation, our solution helps operators directly mitigate and ultimately eliminate these emissions from treated areas.

2. Facilitating a Core Component of Net-Zero Strategies: Timely and effective tailings reclamation is an integral part of any credible net-zero plan for oil sands operations. Our technology provides essential tools to meet these environmental performance and land stewardship goals.

3. Promoting Lower Carbon Intensity Operations: By emphasizing a biological, lower-energy approach to NA management, Luminous contributes to reducing the overall carbon intensity associated with tailings treatment, supporting broader operational efficiency and emission reduction objectives.

4. Supporting Corporate Environmental & ESG Commitments: The ability to effectively manage NAs and accelerate reclamation, with transparent data provided by our platform, will directly support oil sands operators in meeting their corporate targets for fugitive emission management, tailings pond closure, overall environmental footprint reduction, and enhanced ESG performance reporting.

Luminous BioSolutions is dedicated to providing a scientifically sound, practical, and low-GHG intensity tool that empowers the oil sands industry to manage a significant environmental legacy and advance meaningfully towards its net-zero future.

# Economic and Environmental Benefits

The Luminous BioSolutions project and the subsequent commercialization of our integrated Naphthenic Acid (NA) management platform promise substantial environmental and economic benefits for Alberta, extending well beyond greenhouse gas reductions.

Non-GHG Environmental Benefits: Cleaner Water, Healthier Ecosystems, Accelerated Reclamation

Our technology directly tackles the ecological challenges posed by NAs in oil sands tailings:

1. Significantly Improved Water Quality:

- Project Level: This project aims to demonstrably reduce NA concentrations within the treated mesocosm and field pilot zones. We will target a quantifiable reduction in total NAs (e.g., aiming for a [LUMINOUS TO SPECIFY: X]% reduction or to below Y mg/L] within the pilot treatment timeline), using our biosensors and validated by conventional lab methods. This directly lowers the toxicity of the treated OSPW.

- Market Deployment: Wider adoption will lead to progressively improved water quality across numerous tailings ponds, making the water more amenable to natural ecosystem recovery or further polishing for potential safe release, aligning with the long-term goals of AER Directive 085.

2. Accelerated and More Effective Land Reclamation:

- Project Level: By proving effective NA management in the [X Ha pilot area – LUMINOUS TO SPECIFY], this project will demonstrate a pathway to advance this specific area towards "Ready-to-Reclaim" status sooner than baseline conditions would allow.

- Market Deployment: Each hectare of tailings pond reclaimed an estimated [LUMINOUS TO PROVIDE: e.g., 2-4 years] sooner due to effective NA management translates to a tangible reduction in Alberta's overall industrial footprint and a faster return of land to other productive uses or natural states. This is a critical step in managing legacy liabilities.

3. Reduced Ecotoxicity & Environmental Risk:

- Lowering NA concentrations directly mitigates risks to aquatic organisms, wildlife, and the broader Athabasca River Basin ecosystem. Our project will contribute to a healthier regional environment.

4. Minimized Secondary Waste from Treatment:

- Our biological approach, focused on \_in-situ\_ degradation by OSPW-native microbes, inherently avoids the generation of large volumes of chemical sludge or other hazardous secondary waste streams often associated with physical-chemical NA treatment methods. This reduces landfill burden and handling complexities.

Economic Benefits: Driving Growth, Innovation, and Cost Savings for Alberta

This project and the subsequent commercialization of Luminous technology will deliver significant economic advantages:

1. For Luminous BioSolutions (Applicant): Successful demonstration will be a catalyst for commercial contracts, revenue growth, and establishing Luminous as a leader in a specialized, high-need environmental technology niche.

2. For Oil Sands Partners & the Broader Industry:

- Operational Cost Savings: Potential for >50% reduction in NA monitoring costs due to the speed and efficiency of our biosensors compared to conventional lab analysis. Our biologically-driven remediation support also aims for lower lifecycle costs than energy-intensive chemical or physical alternatives.

- Reduced Long-Term Liabilities: Accelerating tailings reclamation directly reduces the immense financial liabilities (estimated in the tens to hundreds of billions ) associated with long-term pond management and closure.

- Enhanced Operational Certainty & Social License: Demonstrating proactive and effective environmental management of NAs strengthens operators' social license and can help maintain production goals by alleviating constraints related to tailings storage capacity.

3. For Alberta's Economy:

- Job Creation & Talent Development: This project alone will create/sustain approximately 10-15 new, direct, highly skilled FTE jobs in Alberta (Calgary and AOSR) in cleantech R&D, field operations, and data science. Commercial scale-up will create significantly more. \_(See quantification below).\_

- Attraction of Investment Capital: ERA's support leverages matching funds, bringing an estimated [$6.0M - $7.0M – NEEDS VALIDATION] in total project investment into Alberta's innovation ecosystem. Success will attract further venture capital.

- Economic Diversification & Innovation Leadership: Strengthens Alberta's growing biotechnology and environmental technology sectors, enhancing its global reputation as a leader in responsible resource development and cleantech innovation.

- Training Opportunities: Collaboration with Alberta post-secondary institutions will provide valuable training for students and researchers (HQP).

Quantification of Direct Employment

- Project Implementation (Years 1-4): We anticipate this project will directly support/create approximately 10-15 full-time equivalent (FTE) positions. These roles will include Project Management, Field Operations Leads and Technicians, Laboratory Scientists and Technicians (for microbiology and sensor support), and Data Scientists/Software Developers.

- Location of Jobs: All direct project employment is anticipated to be located within Alberta, primarily split between Calgary (for R&D, lab support, data analytics, and project management) and the AOSR (for field operations and on-site analysis).

- Nature of Jobs: These will primarily be new, highly skilled positions. The project may also support Alberta-based contractors for specialized services (e.g., third-party analytical validation, mesocosm construction).

Potential Negative Impacts Relative to Current Practice

Luminous BioSolutions is committed to ensuring our technology offers a net environmental benefit. Potential impacts are carefully considered and managed:

- Introduction of Microbial Cultures: Our bioremediation strategy prioritizes the use and stimulation of OSPW-native microbial strains already adapted to the tailings environment. This inherently minimizes the risk associated with introducing foreign organisms. Any bioaugmentation will involve non-pathogenic strains, deployed under controlled conditions with monitoring for unintended ecological effects (e.g., localized changes in dissolved oxygen).

- Nutrient Amendments: If biostimulation requires nutrient addition, dosing will be carefully optimized and monitored to prevent adverse effects like eutrophication, ensuring minimal and targeted application.

- Operational Footprint: The physical footprint of our bioaugmentation arrays and any on-site mesocosms or bioremediation support equipment is small and temporary, especially when compared to large-scale chemical treatment plants or the tailings ponds themselves.

- Comparison: Overall, the potential negative impacts of our carefully managed biological system are anticipated to be significantly lower than those associated with the status quo (ongoing accumulation of toxic NAs) or many energy-intensive chemical/physical treatment alternatives that may produce significant secondary waste.

Ancillary Benefits: Strengthening Communities and Knowledge

Beyond the direct environmental and economic outcomes, this project will foster broader societal benefits:

- Indigenous and Rural Engagement: We are committed to early and ongoing engagement with Indigenous Rights-holders and local communities in the AOSR. This includes transparently sharing project information and monitoring data (potentially via our data platform ), seeking input on local environmental concerns, and exploring opportunities for local employment, training, or contracting during field phases. Addressing NA toxicity directly contributes to the health and well-being of traditional territories and local ecosystems.

- Post-Secondary Collaboration & HQP Development: Our existing and planned collaborations with the University of Calgary and Athabasca University will provide valuable research opportunities and hands-on training for students, post-doctoral fellows, and technicians, cultivating Highly Qualified Personnel for Alberta's growing cleantech and environmental sectors.

- Improved Health and Safety Outcomes: By reducing NA toxicity in OSPW, the project contributes to healthier aquatic ecosystems. Furthermore, our biological approach generally involves handling safer materials compared to the potentially harsh or hazardous chemicals used in some alternative industrial treatment processes.

- Enhanced Transparency & Public Confidence: The ability of our platform to provide clear, accessible, and near real-time data on NA levels and treatment efficacy can significantly improve transparency for regulators and the public, fostering greater trust in environmental management practices.

This project is not just about developing a technology; it's about delivering a comprehensive solution that enhances environmental stewardship, builds economic resilience, and strengthens community well-being in Alberta.

# Market and Value Proposition

Luminous BioSolutions is positioned to address a critical, multi-billion-dollar challenge within Alberta's oil sands, offering a clear pathway to commercial success through significant environmental and economic value creation.

Target Market for Commercialization in Alberta

Our primary target market comprises the three major oil sands mining operators in the Athabasca Oil Sands Region (AOSR). These entities (including Suncor, CNRL, Imperial Oil) are responsible for managing vast tailings volumes and operate under stringent regulatory frameworks, notably AER Directive 085, which mandates progressive tailings treatment and reclamation. These operators are our key potential customers and pilot partners.

A secondary, yet crucial, market segment includes environmental consulting and engineering firms that advise and service these oil sands operators. These firms can act as key influencers, specifiers, and channel partners for our integrated solution.

Overall Market Potential in Alberta

The scale of the NA management challenge in Alberta defines a substantial market opportunity:

- Market for Deploying the Solution:

- There are approximately three major active oil sands mining operations, each managing multiple large tailings ponds or dedicated treatment cells.

- The total area of existing tailings ponds exceeds 300 km² (30,000 hectares), containing roughly 1.4 trillion litres of fluid tailings.

- Our solution (biosensor arrays, data platform subscriptions, and bioremediation support services) is designed for modular deployment, applicable across numerous monitoring points and treatment zones within each site. Each major operator represents a multi-million dollar annual service potential for comprehensive NA management.

- Market for Outputs of the Technology: The primary "outputs" are validated data insights, accelerated NA degradation, improved water quality, and facilitated reclamation readiness. The value is realized through reduced liabilities, operational efficiencies, and enhanced environmental performance for operators, rather than a tangible "product" sold in tonnes.

Dominating the Immediate Opportunity & Building Future Capacity

Our foremost priority and most significant immediate opportunity lies in successfully deploying and scaling the Luminous BioSolutions platform across Alberta's oil sands sector. The sheer scale of the NA management challenge here represents a substantial market with the potential for significant revenue generation once our solution is proven and widely adopted. Our clear focus is on achieving operational excellence and delivering tangible results for Alberta's key industry partners.

Successfully tackling this complex, large-scale environmental challenge in Alberta will provide Luminous BioSolutions with unparalleled advantages for future growth:

1. Field-Hardened Expertise & Proven Technology: Operating at the scale of the oil sands will provide invaluable learnings and refine our technology into a robust, field-proven system. Our team will possess world-leading, practical expertise in applied microbiology, large-scale environmental biotechnology deployment, and data analytics for complex industrial water systems.

2. Financial Strength for Organic Growth: Achieving a steady state of operations and significant revenue from the Alberta oil sands market will provide the financial resources to internally fund further research, development, and strategic expansion into new opportunities.

3. A Foundation for Opportunistic Expansion: Armed with proven technology, deep operational know-how gained from the AOSR, and a strong revenue base, the Luminous team will be exceptionally well-positioned to strategically identify and pursue a multitude of subsequent high-value opportunities. While specific future markets are not our primary focus \_at this EOI stage\_, our core competencies in advanced microbiology, biosensor technology, and data-driven biological process optimization have broad applicability.

Potential Future Horizons (Leveraging Core Expertise):

While our current, laser-focus remains on the Alberta oil sands, the specialized skills and technologies we are perfecting will inherently lend themselves to addressing challenges in:

- Other Resource Sectors: Mining operations (nationally and internationally) often contend with complex organic contaminants in process waters where tailored biological solutions could offer significant advantages.

- Industrial Wastewater Management: Various industries generating complex organic effluents could benefit from our rapid monitoring and biologically-based treatment support.

- Broader Environmental Biotechnology: Our core expertise in applied microbiology and biosensor development will allow us to be agile and opportunistic in tackling other emerging environmental challenges where biological solutions are key.

Our strategy is clear: achieve dominant success in solving the critical NA challenge for Alberta's oil sands. This will not only deliver immense value to the province but also forge Luminous into a company with the financial strength, unparalleled expertise, and proven technology to tackle a diverse range of future environmental and industrial biotechnology opportunities globally. This ERA-funded project is the crucial first step in that ambitious journey.

Applicability to Other Sectors

Beyond oil sands tailings, our core competencies are adaptable:

- Broader Environmental Monitoring: The biosensor technology and data platform can be tailored for rapid detection of other specific organic compounds in various water matrices.

- Industrial Process Water Treatment: Assisting industries in optimizing biological treatment processes or managing specific contaminants.

- Contaminated Site Remediation: Supporting assessment and remediation efforts at sites impacted by organic pollutants.

Commercial Scale Economics: CAPEX, OPEX, and ROI

This ERA-funded project is crucial for generating the field-validated data needed to solidify commercial-scale economics. However, our preliminary assessments indicate a strong value proposition:

- Anticipated CAPEX (for Operators adopting Luminous): Primarily involves the deployment of our modular biosensors and initial setup for data integration. We project this to be significantly lower than the CAPEX required for constructing large-scale, centralized physical-chemical treatment plants for NAs.

- Anticipated OPEX (for Operators):

- Monitoring: We project >50% reduction in NA monitoring costs due to the speed, automation, and reduced reliance on external lab shipments offered by our biosensors.

- Remediation: Our targeted biological approach (enhancing OSPW-native microbes) aims for lower lifecycle operational costs (e.g., reduced energy, minimal chemical inputs) compared to continuous, high-intensity alternatives like some AOPs.

- Return on Investment (ROI) for Operators: Will be driven by direct cost savings in monitoring and potentially remediation, accelerated reclamation (reducing long-term liability carrying costs and financial assurance obligations), minimized environmental risk (avoiding potential fines or operational shutdowns), and enhanced operational efficiency through data-driven insights.

Pathway to Commercial Implementation in Alberta

Successful completion of this ERA-funded project is the springboard for commercialization:

1. Leverage Pilot Success (Year 4-5): Utilize validated performance data, strong case studies from the pilot, and host partner testimonials to secure initial commercial service agreements, likely starting with our pilot partner(s).

2. Scale Production & Operations (Year 4-5): Establish scalable production for biosensors and microbial cultures/stimulants (potentially through contract manufacturing or phased in-house development). Expand our Alberta-based technical field support and data analytics team.

3. Broader Market Penetration (Year 5+): Target oil sands expansion with a proven, de-risked solution.

4. Continuous Improvement & AER Engagement: Continue refining the technology and work with the AER to facilitate broader regulatory acceptance and potential integration into standard monitoring/remediation frameworks.

5. Secure Growth Capital: Following successful demonstration and initial commercial traction, seek Series A or other growth financing to support wider market expansion.

Challenges, Barriers, and Risks to Commercialization

- Industry Adoption Inertia: Overcoming traditional practices and demonstrating clear, undeniable ROI and reliability for a novel biotechnology platform is key. Our staged pilot and strong partner engagement are designed to address this.

- Regulatory Acceptance Timelines: While we will proactively engage the AER, the formal acceptance of new methods can take time. Continuous data generation and transparent communication are vital.

- Scaling Operations & Maintaining Quality: Transitioning from pilot-scale to consistent, large-scale service delivery requires robust operational processes and quality control, which we are building into our planning.

- Securing Growth Capital: Accessing follow-on funding for commercial expansion will depend on achieving key technical and market milestones.

- Policy Environment: A stable and supportive policy environment that encourages or mandates improved tailings management and reclamation, and values innovative environmental technologies, will be conducive to successful commercialization. Continued government support for cleantech adoption is beneficial.

Plan for Distribution and Sharing of Results

Luminous BioSolutions is committed to maximizing the benefit of this project's learnings for Alberta:

- ERA Reporting: We will diligently fulfill all ERA reporting requirements, including Milestone, Final Technical, Final Outcomes, MMV, and post-project impact reports.

- Public & Industry Dissemination: A non-confidential summary of the project's key findings and achievements will be made available for public dissemination through ERA's channels. We plan to present results at relevant industry conferences (e.g., oil sands conferences, environmental technology forums) and targeted workshops for stakeholders (industry, government, community representatives).

- Academic Contributions: In collaboration with our university partners, and with due respect for any partner confidentiality, we aim to publish scientifically significant findings (e.g., on biosensor field performance, novel bioremediation insights) in peer-reviewed journals.

- Data Sharing Principles: While specific operational data from host sites will remain confidential as per agreements, aggregated, anonymized performance insights and general learnings on NA management best practices may be shared to benefit the broader industry and research community. Our data platform itself is designed to provide transparent, role-based access to relevant data for our clients and, where appropriate, regulators or community representatives.

- Intellectual Property: Foreground IP generated through this project will be managed by Luminous BioSolutions to support Canadian commercialization. We will explore appropriate strategies for IP protection and potential licensing where it aligns with our mission to deliver impactful solutions in Alberta and beyond.