OSRIN Annual Report: 2012/13

Oil Sands Research and Information Network

University of Alberta, School of Energy and the Environment

April 2013

Oil Sands Research and Information Network

The Oil Sands Research and Information Network (OSRIN) is a university-based, independent organization that compiles, interprets and analyses available knowledge about managing the environmental impacts to landscapes and water impacted by oil sands mining and gets that knowledge into the hands of those who can use it to drive breakthrough improvements in regulations and practices. OSRIN is a project of the University of Alberta's School of Energy and the Environment (SEE). OSRIN was launched with a start-up grant of $4.5 million from Alberta Environment and a $250,000 grant from the Canada School of Energy and Environment Ltd.

OSRIN provides:

- **Governments** with the independent, objective, and credible information and analysis required to put appropriate regulatory and policy frameworks in place
- **Media, opinion leaders and the general public** with the facts about oil sands development, its environmental and social impacts, and landscape/water reclamation activities – so that public dialogue and policy is informed by solid evidence
- **Industry** with ready access to an integrated view of research that will help them make and execute reclamation plans – a view that crosses disciplines and organizational boundaries

OSRIN recognizes that much research has been done in these areas by a variety of players over 40 years of oil sands development. OSRIN synthesizes this collective knowledge and presents it in a form that allows others to use it to solve pressing problems.

Citation

This report may be cited as:

OSRIN, 2013. *OSRIN Annual Report: 2012/13*. Oil Sands Research and Information Network, School of Energy and the Environment, University of Alberta, Edmonton, Alberta. OSRIN Report No. SR-9. 56 pp.

Copies of this report may be obtained from OSRIN at osrin@ualberta.ca or through the OSRIN website at http://www.osrin.ualberta.ca or directly from the University of Alberta's Education & Research Archive at http://hdl.handle.net/10402/era.17507.

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ACKNOWLEDGEMENTS

The Oil Sands Research and Information Network (OSRIN) acknowledges the continuing and valued guidance of the Board of Directors.

OSRIN is also very grateful for the advice and guidance provided by Joseph Doucet, past Director of the School of Energy and the Environment and Chair of the OSRIN Board of Directors, and the leadership provided by Dr. Steven Moran during his tenure as Executive Director of OSRIN.

OSRIN is grateful to Leah Vanderjagt and Carrie Jackson of the University of Alberta Libraries for their support of the Education & Research Archive storage facility for OSRIN's reports.

Finally, OSRIN thanks the core funding agencies – Alberta Environment and Water and the Canada School of Energy and Environment Ltd. – for their commitment to the program.

1 INTRODUCTION

This report describes Oil Sands Research and Information Network (OSRIN) activities and accomplishments for the fiscal year (FY) April 1, 2012 to March 31, 2013.

Key accomplishments for OSRIN this past year include:

- Extension of the Alberta Environment and Sustainable Resource Development grants until December 31, 2014 providing additional time for OSRIN to fulfill its mandate to provide both research funding and information sharing;
- Management of 39 research projects and support of 6 conferences;
- Publication of 12 technical reports arising from contracted research;
- Addition of an OSRIN Videos series with release of our first video on the University of Alberta's Education & Research Archive and the University of Alberta's You Tube channel
    - Rooney Productions, 2012. *Assessment Methods for Oil Sands Reclamation Marshes*. OSRIN Video No. V-1. 20 minutes. Also available on the University of Alberta You Tube Channel (recommended approach).
    - Rooney Productions, 2012. *Assessment Methods for Oil Sands Reclamation Marshes*. OSRIN Video No. V-1. Nine-part mobile device version. Also available on the University of Alberta You Tube Channel (link to Part 1 - recommended approach).
- Publication of 1 new staff report, as well as updating 3 previous reports;
- Development and publication of a chart showing how OSRIN's research reports are linked to the research program areas and to each other;
- Continued digitizing and making publically available historical research and policy reports as pdf documents (316 made available to date);
- Outreach efforts by the OSRIN Executive Director through presentations at 7 seminars and conferences.

Publication of OSRIN reports provides the public and researchers with additional information on environmental management of oil sands impacts. They are available from the University's Education & Research Archive (http://hdl.handle.net/10402/era.17209).

Over 16,000 copies of OSRIN's reports have been downloaded since September 2011[1].

[1] The University's ERA site changed the way it measures report downloads in September 2011. Prior to making the change there were 3,739 report downloads.

1.1 Board of Directors

The Board of Directors met in November 2012. The Board was chaired by Dr. Stefan Scherer, Director, School of Energy and the Environment, University of Alberta. Chris Powter, Executive Director of OSRIN participated as a resource to the Board and Barbara LeFort provided secretariat functions.

At the end of the fiscal year the Board members were:

Chris Holly	Alberta Energy
Haneef Mian	NAIT Ledcor Group Applied Research Chair – Oilsands Environmental Sustainability
John Zhou	Alberta Innovates – Energy and Environment Solutions
Julia Foght	University of Alberta
Murray Anderson	Alberta Environment and Sustainable Resource Development
Robert Skinner	Canada School of Energy and Environment (CSEE)
Roger Ramcharita	Alberta Environment and Sustainable Resource Development
Mel Miller	Alberta Energy, Oil Sands Secretariat
Ted Cyr	Alberta Energy
Terry Abel	Energy Resources Conservation Board

1.2 More about OSRIN

OSRIN operates with minimal staff – Chris Powter is the Executive Director and Barbara LeFort was the Administrative Assistant. The Administrative Assistant position ended March 31, 2013. OSRIN is grateful for the assistance provided by Barbara LeFort for the last two years.

More information on OSRIN's research strategy is available in the following report:

> OSRIN, 2011. *OSRIN's Design and Implementation Strategy*. OSRIN Report No. SR-7. 10 pp.

More information on past work undertaken by OSRIN is available in the following report:

> OSRIN, 2011. *Summary of OSRIN Projects – November 2012 Update*. OSRIN Report No. SR-5. 74 pp.

1.3 Report Organization

Section 2 provides an overview of projects funded by OSRIN in each of the core research program areas during 2012/13.

Section 3 outlines OSRIN's revenue, expenditures and remaining funds. OSRIN received $2,500.00 and spent $877,857.60 during 2012/13, leaving $858,775.98 available for future work.

Section 4 provides an outlook for FY 2013/14.

2 2012/13 PROGRAM

OSRIN has identified six program areas in which we are funding work. Within each program area we fund projects to scope out the state of knowledge, identify knowledge gaps, and provide

insights regarding research priorities. OSRIN also directs funds to commission or support new work that will expand the knowledge base and fill in knowledge gaps.

The six research program areas are:

- Tailings Reclamation
- Regional Landscape Reclamation
- Monitoring Ecosystem Impacts
- Increasing Awareness
- Social, Economic and Regulatory
- Strategic Design

OSRIN publications, arising from the work described below, and from previous work, are found on the website at http://www.osrin.ualberta.ca/en/OSRINPublications.aspx.

Projects are listed in alphabetical order in each program area. The research performer is noted, followed by a table that shows the project funding and key milestone dates, the title of the final report (if applicable) and a description of the project (or the report abstract, if applicable).

2.1 Tailings Reclamation

This program seeks to identify challenges that must be addressed in accelerating the reclamation of tailings ponds and tailings disposal areas and to catalyze necessary research, demonstration and development efforts to resolve them.

2.1.1 *2013 Tailings Technology Development and Commercialization Seminar – Haneef Mian, NAIT*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Seminar held March 19, 2013 Report will be released April 2013
Funding	$0	$0	$0	$5,000 committed

On August 28, 2012, Canada's Oil Sands Innovation Alliance (COSIA) along with the Alberta Innovates – Energy and Environment Solutions (AI-EES), published an oil sands tailings technology deployment roadmap and action plan[2] ("Tailings Roadmap/Action Plan"). The report identified a number of potential candidate solution technologies and has grouped them into various classes. COSIA anticipates that a number of existing and new technologies will need to

[2] See Sobkowicz, J., 2012. Oil sands tailings technology deployment roadmaps. Project Report Volume 1 - Project summary. Alberta Innovates - Energy and Environment Solutions, Edmonton, Alberta. 60 pp. plus appendices. http://www.ai-ees.ca/media/7375/1906-project_summary_report.pdf

be pre-screened, validated, and further developed before being considered for a pilot and/or commercial application.

The NAIT Centre for Green Chemistry and Engineering (CGCE) under the Leadership of the Ledcor Group Applied Research Chair in Oil Sands Environmental Sustainability enables solutions developed by third party innovators and small- and medium- sized enterprises (SMEs) to be screened, validated, scaled-up, and integrated within a systems-based approach to complex mineable oil sands tailings management challenges. Such a system-based perspective is crucial to ensure that solutions in one area of complex oil sands operations do not create problems elsewhere in the process. A collaborative approach is essential to bridge the gap between technology providers and oil sands industry to develop solutions in a time and cost-effective manner, while reducing risk and time to market.

The CGCE realizes that a number of third party inventors and small companies with potential solutions may have challenges in accessing and speaking to the right people within oil sands companies. The CGCE also realizes that oil sands operators need technology providers to have a minimum set of information available before they can engage in meaningful discussions on adopting technologies. A number of the technologies are at various levels of development. Some of the entrepreneurs may have conceptual schemes having little or no experimental testing, other vendors may have developed and tested their technologies and may be ready for pilot testing, and yet others may well be suited for commercial application. However, each of these technologies will need to be evaluated and graded to ensure that they could make it to the next level of development/application, and be picked up by the COSIA member companies.

To accomplish this – NAIT-CGCE, NAIT school of Sustainable Building and Environmental Management, and the NAIT JR Shaw School of Business, in collaboration with COSIA, AIEES, and the Oil Sands Research and Information Network (OSRIN), held a technology innovation workshop on March 19, 2013 at the NAIT campus to open the dialogue between Oil Sands Industry, Academia, Research and Development Organizations, and third party innovators.

The technology innovation discussions focused on the following five themes:

- Tailings Processing
- Tailings Deposition
- Process Water Treatment
- Chemical Amendment of Tailings, and
- Bitumen Recovery from Tailings

One of the main focuses is to bridging the gap between existing oil sands environmental research and cost effective real-world solutions that have an immediate impact on oil sands sustainable development. It is expected that as a result of the workshop some protocols may emerge e.g., steps that need to be taken at the early stage of technology innovation before engaging the oil sands operators, an open line of communication with the oil sands industry, and a clear path forward for third party technology developers.

2.1.2 *Application of Forward Osmosis Membrane Technology for Oil Sands Process-Affected Water Desalination – Dr. Yang Liu, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start April 2013 Report will be released April 2014
Funding	$0	$0	$0	Committed $25,000

Extracting bitumen from oil sands produces large volume of process-affected water (OSPW) containing a high concentration of total dissolved solids (TDS). The high salinity is a major concern facing the oil sands industry, which hampers the reuse of OSPW in process operations and the safe discharge to the environment. Conventional desalination technologies, such as reverse osmosis (RO), nanofiltration (NF) and electrodialysis (ED), require intensive heat or electrical energy input and produce large volume of concentrated brine streams that need to be managed, which hamper their application for OSPW treatment.

As a newly emerging desalination technology, forward osmosis (FO) has shown great promise in saving electrical power requirements, increasing water recovery, and minimizing the brine discharge. Recent studies also show that FO can be coupled to microbial fuel cells to treat wastewater and produce electricity. However, this technology has never been tested for OSPW treatment. The goal of this project is to evaluate and optimize FO technology to remove the TDS in OSPW and to evaluate its ability to be coupled with microbial fuel cells to self-generate electricity. This project could provide a highly efficient and cost effective treatment option for oil sands industry to recycle process-affected water for reuse without the consequences of toxic stress on the environment.

2.1.3 *Benign By Design: Engineered Si Nanoparticles for Oil Sands Process Water Contaminant Remediation – Dr. Jonathan Veinot, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start April 2012 Report will be released November 2013
Funding	$0	$0	Committed March 2012	$44,000

This project is co-funded with the Canada School of Energy and Environment Ltd.

Oil sands process water (OSPW) is contaminated with hydrocarbons, salts, chloride, ammonia, dissolved organic species, and trace heavy metals. Naphthenic acids (NAs) are among the greatest environmental concerns associated OSPW because they are environmentally persistent and acutely toxic toward aquatic life at the levels found in the tailing pond water. There are many candidate technologies that could be applied to the treatment of OSPW. Advanced oxidation processes (AOPs) are particularly useful for degrading biologically toxic or non-degradable materials such as aromatics, pesticides, petroleum constituents, and volatile organic compounds in wastewater. Unfortunately, these approaches are very energy intensive and methods to increase both the efficacy and energy efficiency of AOPs must be explored. One avenue to achieve this is through the application of thoughtfully designed photocatalysts based upon nanomaterials that *do not require post treatment removal* since they are designed have no toxicity to aquatic organisms.

The Veinot-Goss team has established that rationally designed, environmentally benign engineered silicon nanocrystals (SiNCs) effectively remediate cyclohexanoic acid (the generally accepted NA model compound) in the laboratory upon exposure to ultraviolet irradiation.

The remediation efficiency of this process exceeds that of equivalent hydrogen peroxidebased advanced oxidation processes by approximately 40%. An important consideration for our technologies is that the spent catalyst degrades into sand ($Si0_2$) and does not require recovery.

Having identified a suitable photocatalyst, this grant will be used by the Veinot-Goss team to take the next step in pushing this exciting discovery to practical application. Our goal is to increase the investigations from bench top to lab pilot plant scale.

2.1.4 *Catalogue of Analytical Methods for Naphthenic Acids – Dr. Haneef Mian, NAIT*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start May 2011	Report released May 31, 2012 Zhao, B., R. Currie and H. Mian, 2012. *Catalogue of Analytical Methods for Naphthenic Acids Related to Oil Sands Operations*. OSRIN Report No. TR-21. 65 pp.
Funding	$0	$0	$22,000	$0

The purpose of this report is to identify challenges in analyzing naphthenic acids (NAs) associated with oil sands process water (OSPW). Naphthenic acids are present naturally in oil sands bitumen and have the classical formula $C_nH_{2n+Z}O_2$. Within this formula n represents the carbon number and Z is an even, negative integer corresponding to hydrogen deficiency mainly due to ring formation in the structure. Thus the absolute value of Z divided by 2 gives the number of the rings in the compounds. A Z-value of 0 means acyclic acids, which are believed

to be highly branched rather than linear natural fatty acids. A Z-value of -2 represents monocyclic NAs; -4 represents bicyclic and so on. The Z-value may also include unsaturation in the chemical structure. The generality of the formula allows for a vast array of isomers for each value of n and Z. The challenge in analyzing NAs from OSPW is that microbial activity alters the structure of classical naphthenic acids creating a large number of compounds that are labeled as naphthenic acids but differ from the $C_nH_{2n+Z}O_2$ general formula. This increased number of compounds elevates the demands on the analytical methods used to characterize these compounds obtained from OSPW. In this report, issues affecting both qualitative and quantitative data from a variety of analytical methods will be reviewed to generate an awareness of the challenges faced by laboratories conducting NA determinations. The report also highlights the issues of naming these compounds "naphthenic acids" since many of the compounds being extracted from OSPW do not conform to the classical NA formula.

The method chosen has a significant effect on the interpretation of the analytical data. Analytical results are dependent on sampling, extraction and clean-up techniques. The report examines various approaches used to prepare samples for analysis based on the following themes: sampling tools and techniques, sample preservation and transport, extraction, and clean-up methods. There are numerous analytical instruments currently being used in the analysis of NAs. Within the field of spectroscopy Fourier Transform Infrared Spectroscopy (FTIR) has been used and is often considered the reference method for quantitative assessment of NAs in OSPW. Both, UV-Vis and fluorescence spectroscopy, and more recently Synchronous Fluorescence Spectroscopy (SFS) have been applied to studies of NAs in OSPW. Each of these methods are limited in the information that can be provided, however, they have value in assessing the types and possible sources of NAs being evaluated in a sample.

Major advancements in the analysis of NAs are being accomplished using the power of chromatography to attain a partial separation of thousands of compounds found in a NA extract and mass spectrometry (MS) for their detection. Early methods of analysis using unit mass resolution MS have created problems in properly assessing NAs present in OSPW. This has led to the overestimation of NA concentrations in OSPW. Similar problems have been encountered with FTIR. Misclassification and identification of false positives has been another issue plaguing early adopters of these analytical methods. Fortunately, new analytical tools are being developed which enable high resolution mass spectrometry (HRMS) to be performed enabling these errors in classification to be partially rectified. Although many efforts have been made in the development of analytical methods, no rugged routine method that can separate, identify, and quantify the individual components of NA mixtures has been achieved to date. This review will provide an overview of methods currently used for the analysis of NA class of compounds including sampling, sample preservation, sample transport, extraction and clean-up, analytical techniques, and future needs, with a major focus on NAs from OSPW.

No method currently exists that is capable of identifying all isomers of NAs. Without this capability it is impossible to clearly assess the toxicity of individual "naphthenic acids" encountered in OSPW. Additionally it makes it difficult to fully understand the potential for

biodegradation and remediation of NAs in fluid tailings or their long term impacts in the reclaimed landscape.

2.1.5 *Community Structure and Bio-Prospecting in Oil Sands Tailings Ponds – Dr. Joel Dacks, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start May 2012 Report will be released January 2014
Funding	$0	$0	$0	$58,000

The microbiology of oil sands tailing ponds is already an active area of research with studies showing that microbes are actively metabolizing organic constituents in the ponds. This echoes research on open ocean bioremediation of hydrocarbons by bacterial action. There is more to microbiology than bacteria, however. Microbial eukaryotes, or protists, represent the vast majority of non-bacterial life on earth, dwarfing the number of animal and plant species. Protists have been shown as crucial components of the microbial food web in naturally occurring and anthropogenically perturbed environments. Indeed, the dynamics of microbial eukaryotes including ciliates, heterotrophic flagellates and fungi have been shown to experimentally improve bioremediation rates of crude oil by modulating bacterial populations and improving carbon flow through the system. The protist community of the tailing ponds is, as yet, entirely unexplored.

This project will determine the community diversity and structure of microbial eukaryotes by analyzing DNA from tailings pond samples. Essentially, we will find out, for the first time, "who is there and in what numbers" in terms of microbial eukaryotes in the tailing ponds.

2.1.6 *CONRAD 3rd Biannual Oil Sands Clay Conference and Workshop Sponsorship*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Conference held February 20-21, 2013.
Funding	$0	$0	$0	$1,176

The CONRAD Clay focus group and the NSERC Industrial Research Chair in Pipeline Transport Processes hosted the 3rd Oil Sands Clay Conference and Workshop February 20- 21, 2013. This conference/workshop was a continuation of the successful 2011 CONRAD Clay Workshop and

addressed four topics: Clays in Tailings, Clay Characterization, Clay Mixture Properties and Clays in Extraction.

2.1.7 *Development of Silicon-based Optofluidic Sensors for Environmental Monitoring – Dr. Ray DeCorby, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start April 2012 Report will be released May 2013
Funding	$0	$0	Committed March 2012	$12,000

This project is co-funded with the Canada School of Energy and Environment Ltd.

The oil-sands industry in Alberta produces large volumes of process-affected water, which is known to contain heavy metals and organic compounds (such as naphthenic acids) that are toxic and hazardous to the environment. The industry has an ongoing need to improve the monitoring of concentrations and breakdown of these compounds. Currently, this is mainly accomplished by collecting samples for shipment to a laboratory for analysis. Portable and ideally distributed and real-time monitoring techniques would greatly improve efficiency and the potential knowledge base regarding these environmental concerns.

The project aims to refine and exploit several recently developed technologies, which enable us to monolithically integrate complex optical devices (air-core optical waveguides, spectrometers, and microcavities) within microfluidic channels on a silicon chip. The fabrication processes are novel (protected by pending patents) and employ standard silicon materials, implying potential for co-integration with electronics. Building on these technologies, we propose to develop a prototype lab-on-a-chip based sensor for optical detection of target molecules using spectrally resolved fluorescence detection. The proposed sensor would offer a high level of integration between the fluidic and optical components, potentially reducing the cost and complexity of the overall system while also improving the performance (sensitivity, signal-to-noise ratio (SNR), alignment tolerance, etc.). In the long term, such miniaturized sensors hold promise as low-cost, highly distributed environmental monitoring devices.

We aim to implement a chip-scale, spectrally resolved fluorescence detection sensor, in which all components except for the light source would be integrated onto a single chip. If successful, this system would offer an unprecedented degree of integration between microfluidic and optical componentry.

2.1.8 *Engineered Biological Processes to Accelerate Oil Sands Tailings Consolidation and Improve Reuse Water Quality – Dr. Tong Yu, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	Project start November 2009	Ongoing	Ongoing	Report will be released 2013
Funding	$150,000	$0	$30,000 Additional funds for naphthenic acid sample analysis	$0

Methanogenesis has been demonstrated to occur in oil sands mature fine tailings with improved fine tailings densification. While research is on-going as to the microbial processes occurring, there is no open public research to adapt engineered wastewater treatment technologies that exploit the microbially-mediated processes. This study will explore engineered microbially-activated water treatment to significantly accelerate oil sands tailings consolidation and improve quality of water produced from the treatment processes for reuse. The project will study a number of biological processes and engineering reactor types. The engineered biological processes will employ both suspended and attached microbial growth and both anaerobic and aerobic processes. In addition to determination of the parameters for the design and operation of these engineered reactors, additional measures for enhancement of the reactor performances will also be investigated. If successful, the proactive engineering approach could significantly shorten the time for water-solids separation, reduce the volume of tailings produced, and improve water quality for reuse. The long-term goal is to avoid production of mature fine tailings as we now know it. The knowledge and experience obtained from this study can also be used to better treat existing mature fine tailings.

2.1.9 *In-Situ Tailings Ozonation: A Combined Tailings Consolidation and Remediation Process – Dr. Yang Liu, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start April 2012 Report will be released November 2013
Funding	$0	$0	Committed March 2012	$44,000

This project is co-funded with the Canada School of Energy and Environment Ltd.

This project will explore an in-situ ozone-assisted tailings consolidation and remediation process to significantly increase the settling rate of the mature fine tailings (MFT) and to remove organic components and other hazardous components in the tailings, and to allow more water to be recycled or released to the environment.

Our recent studies show that ozonation of oil sands tailings, even at a low ozone dose (~1 mg/L), can improve the settling capacity of fine particles, break the highly branched and/or highly cyclic fraction of naphthenic acids, and enhance the biodegradability of the recalcitrant organic fractions of the tailings. Albeit its high efficiency and low cost, the in-situ ozone-assisted consolidation and remediation process for oil sands tailings has never been systematically tested.

This project will explore:

- the impact of ozone doses on MFT settling;
- the effect of ozonation on the interfacial properties of fine tailings and microbial biofilm communities growing on the surface of fine particles;
- the basic mechanisms controlling the interfacial interactions among fine particles and at different ozone treatment conditions under the complex water chemistry environment found in oil sands tailings;
- the impact of in situ ozonation on the removal of organic compounds in tailings; and
- ozone-assisted consolidation and remediation process optimization for in-line process technologies.

2.1.10 *Synthesis of Toxicological Behavior of Oil Sands Process-Affected Water Constituents – Dr. Mohamed Gamal El-Din, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start January 2013 Report will be released September 2013
Funding	$0	$0	$0	$50,000

Oil sands process-affected water (OSPW) refers to the water that has been in contact with oil sands or released from tailings deposits and is primarily used for bitumen extraction. OSPW is a very complex mixture of suspended solids, salts, inorganic compounds, dissolved organic compounds, and trace metals. Despite the advances in analytical techniques, the complete characterization of OSPW is still unknown. OSPW contains thousands of organic compounds that have not been identified so far because of the complexity of the OSPW mixture and the variety of different structures of naphthenic acids (NAs), among other organics, present in OSPW. There are concerns about the environmental and human health impacts as a result of any possible future release of treated OSPW into the environment. NAs have been reported to cause both acute and chronic toxicity to a variety of organisms, including fish, amphibians, and mammals. To date, the principal toxic component(s) of OSPW towards test organisms have not yet been identified mainly due to the complexity of the organic fractions in OSPW. The complete characterization of OSPW and the knowledge about the fate of the OSPW constituents are indispensable requirements to assess the long-term cumulative effects of process-affected water on the receiving environment and to determine the most suitable remediation and management strategies for OSPW.

The main objective of this study is to conduct an extensive literature review of the existing basic theoretical and practical knowledge of the physical, chemical, biological, and eco-toxicological behavior of OSPW constituents, both inorganics and organics, for known individual compounds and/or classes of compounds. Any information on the potential biological impacts and the fate of these constituents will also be gathered.

The project will produce:

- A report containing all the gathered information and eventually, a review paper will be developed out of the report, for publication in a peer review journal. The report will contain: (1) physical, chemical, biological and eco-toxicological behavior of OSPW constituents, both inorganics and organics, for known individual compounds and/or classes of compounds; and (2) suggested levels of individual and/or classes of compounds at which there might be no adverse effects based on the literature, internationally accepted standards, etc. The report will also identify the knowledge gaps.

- A database containing all the gathered information in a categorized fashion and with dynamic links to the sources of material will be prepared. The database will be updated in the future on a regular basis by Dr. Gamal El-Din`s research group.

2.1.11 *International Oil Sands Tailings Conference (IOSTC) Sponsorship – Oil Sands Tailings Research Facility, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	Sponsor IOSTC 2010	None	Sponsor IOSTC 2012
Funding	$0	$5,000	$0	$3,000

The Oil Sands Tailings Research Facility (OSTRF) and the Canadian Oil Sands Network for Research and Development (CONRAD) hosted the Third International Oil Sands Tailings Conference (IOSTC) in December 2012. Bringing together experts and interested individuals to address tailings technology and management in Alberta's Oil Sands Industry, the conference offered the most recent developments in oil sands tailings and management to the international community through invited speakers and select technical presentations.

2.2 Regional Landscape Reclamation

This program focuses on providing the knowledge necessary to support development of regional reclamation targets as well as site- and mine-level objectives.

2.2.1 *Boreal Plant Species for Reclamation of Athabasca Oil Sands Disturbances – Ann Smreciu, Wildrose Consulting, Inc.*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start November 2012 Report will be released December 2013
Funding	$0	$0	$0	$40,000 committed $15,964 spent

Wildrose Consulting, Inc. has been developing reclamation plant species profiles for many years. The original intent of the profiles was to inform decisions made by reclamation planners and practitioners in the oil sands and to promote the inclusion of these species in revegetation. However, the information has a much wider audience appeal: professionals in other industries as

well as provincial, municipal and federal government agencies, nursery producers, aboriginal groups, researchers, archeologists, cultural anthropologists and ethno-botanists, wildlife biologists, foresters, range managers, horticulturalists, naturalists and the general public.

This project will update previously prepared species profiles and add up to 20 new ones focusing on wetland and rare plants. Individual species profiles comprise the following information:

- Species Nomenclature – up-to-date scientific names and widely used common names along with plant family designations.
- Plant Descriptions with specific information regarding fruits and seeds.
- Habitat and Distribution of the species locally and worldwide.
- Phenology - particularly based on observations from north eastern Alberta.
- Pollination mechanisms are described if known.
- Genetic information (ploidy)
- Known symbioses
- Seed processing including seed metrics
- Propagation - including seed and vegetative propagation
- Greenhouse timelines for seedling production
- Aboriginal utilization
- Wildlife and forage uses
- Reclamation role

Each profile is illustrated with photographs of the plant, flowers, fruit and/or seeds if available and line drawings are also included if available.

2.2.2 *Development of a Geomatics Monitoring Tool for Oil Sands Reclamation Monitoring – Dr. Karl Staenz, University of Lethbridge*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start September 2011	Ongoing Report will be released January 2014
Funding	$0	$0	$50,000	$0

OSRIN, Alberta Environment and Water, and TECTERRA are providing funding for this project. The project will support both oil sands reclamation monitoring and monitoring related to other forms of industrial land in Alberta. The proposed mapping/monitoring software system will fill a significant gap in monitoring reclamation success by offering a novel technology that can be implemented within Alberta Environment's reclamation monitoring process. The software system will consist of newly developed algorithms in combination with existing ones, which will be adapted within the context of Alberta Environment's requirements. It will link the processing steps, including a spectral and radiometric normalization module, geometric

rectification module, information extraction module, change detection module and results assembly module. The workflow for each type of processing is encapsulated within a dedicated job script that uses different software components including open source, commercial and in-house tools. The software system will provide the capabilities to produce indicators about vegetation condition using LiDAR and passive optical remote sensing technologies.

A report will be prepared for OSRIN providing information on:

- background and utility of remote sensing to assess disturbance and ecosystem recovery including aspects of vegetation succession, site productivity and ecosystem health
- introduction and rationale for study design and technology choices to monitor reclamation success at different scales (well sites, pipelines, coal mines, in situ oil sands, oil sands mines)
- results and recommended approaches

2.2.3 *Factors Affecting Ecological Resilience of Reclaimed Oil Sands Uplands – Dr. Clive Welham, FORRx Consulting Inc.*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start October 2012 Report will be released April 2013
Funding	$0	$0	$0	$29,800

The reclamation goal for oil sands mines as specified in the environmental operating approvals issued under the *Environmental Protection and Enhancement Act* is to *reclaim the land so that the reclaimed soils and landforms are capable of supporting self-sustaining, locally common boreal forest ecosystems, regardless of the end land use* (see, for example, s. 6.2.1 in the Total E&P Canada Ltd. Joslyn North Oil Sands Processing Plant and associated Mines approval – http://envext02.env.gov.ab.ca/pdf/00228044-00-00.pdf).

Ecological resilience, first defined by Holling in 1973, can be broadly described as the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly (Wikipedia), but other authors have provided variations on this theme since 1973.

Ecological resilience is one potential measure of the goal of a *self-sustaining* ecosystem and is being considered for inclusion in the Cumulative Environmental Management Association's Criteria and Indicators Framework for assessing reclamation success (Poscente 2009). For reclaimed oil sands uplands to be considered *self-sustaining*, they should respond to natural and anthropogenic disturbances in a similar manner as an analogous undisturbed landscape might respond to the same disturbances.

Reclaimed oil sands mine landscapes will have a diversity of slopes and aspects, substrates (e.g., overburden, tailings sand, soft tailings), soil depths and mixes, vegetation (planted and volunteer) and potential land uses (e.g., commercial forestry, recreation, wildlife habitat, traditional use), each of which may impact the ability of the system as a whole to respond to disturbance.

A comprehensive literature review is required to develop further understanding of ecological resilience to promote successful land reclamation in Alberta's mineable oil sands region.

This literature review will:

- define ecological resilience for boreal forest ecosystems, and determine if this definition can be applied to reclaimed oil sands upland landscapes or requires modification
- describe a range of ecological and anthropogenic disturbances a reclaimed oil sands upland site might reasonably be expected to experience
- describe physical, chemical and biological characteristics (structure, composition, function) of reclaimed upland sites that would confer resilience to the range of ecological and anthropogenic disturbances identified above
- describe reclamation and management practices necessary to generate ecological resilience in oil sand upland landscapes

The review will also:

- identify the top five characteristics that confer ecological resilience in oil sand upland landscapes
- provide relevant examples where ecological resilience in other degraded landscapes was tested or evaluated

2.2.4 *Oil Sands Terrestrial Habitat and Risk Modeling for Disturbance and Reclamation – Dr. Clive Welham, FORRx Consulting Inc.*

	2009/10	2010/11	2011/12	2012/13
Project Activity	Phase I start April 2009	Phase I completed; report released Start Phase II	Phase II completed; report released Start Phase III	Ongoing Phase III report will be released June 2013
Funding	$104,000	$70,000	$87,500	$0

The objective of this project is to develop a framework that integrates risk management and strategic decision-making in order to evaluate the impact of disturbance (natural and industrial) on ecosystem products and services, and on habitat availability for terrestrial species in Alberta's

Lower Athabasca planning region. This will include an evaluation of the impact of disturbance (including natural disturbance due to insect outbreaks, fire and wind, and industrial and agricultural disturbance), conservation, and reclamation activities associated with oil sands development both at the lease and regional levels.

In Phase I a basecase analysis (no climate-related impacts) was conducted using information from the Imperial Kearl Mine. In Phase II an evaluation of the impact of climate and climate change on reclamation success was conducted. In Phase III, regeneration potential under climate change on actual oil sands reclamation materials will be assessed and a more rigorous analysis of the risks to ecosystem productivity from climate change as a consequence of moisture stress will be conducted.

2.2.5 *Oil Sands Wetlands Assessment Training Video – Brenda Rooney, Rooney Productions*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start July, 2012 Videos released December 6, 2012 Rooney Productions, 2012. *Assessment Methods for Oil Sands Reclamation Marshes*. OSRIN Video No. V-1. 20 minutes. Also available on the University of Alberta You Tube Channel (recommended approach). Rooney Productions, 2012. *Assessment Methods for Oil Sands Reclamation Marshes*. OSRIN Video No. V-1. Nine-part mobile device version. Also available on the University of Alberta You Tube Channel (link to Part 1 - recommended approach).
Funding	$0	$0	$0	$20,330

Oil sands mining closure plans call for the construction of wetlands as part of mine reclamation. Extensive work, funded in part by the Cumulative Environmental Management Association, has been devoted to developing sophisticated tools for evaluating shallow open water marshes within this context. These tools use environmental and biological measurements to assess the condition of individual wetlands, providing integrative scores that will help industry track wetland development and may assist the government in reaching certification decisions. These tools have undergone rigorous calibration and validation, have passed the peer review process, and are published in the scientific literature. In other words, they provide a scientifically sound and

defensible approach to wetland assessment in the context of oil sands reclamation. However, to facilitate their implementation, a detailed assessment handbook and training video are necessary.

Alberta Innovates – Energy and Environment Solutions is funding the creation of a handbook that details the field collection, sample processing, and analysis methods broken down into easy to follow protocols. OSRIN funded development of a video tutorial that lays out the field sampling process from start to finish in easy-to-follow steps and visually clarifies how protocols should be enacted. This will help standardize otherwise subjective decisions, like how to determine if a plant lies within a floristic quadrat. It also provides practice quadrats to help train field workers' eyes to quantify the relative abundance of different plants. The video is optimized to play on a handheld device, enabling practitioners to consult the video in the field and to stream it anywhere with cell phone reception.

2.2.6 *Potential Impacts of Beavers on Oil Sands Reclamation Success – Brian Eaton, Alberta Innovates - Technology Futures*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start June 2011	Report will be released April 2013
Funding	$0	$0	$24,500	$0

Beavers are commonly identified as a potential "threat" to the success of oil sands reclamation efforts, both from a water flow perspective and from a vegetation ecology perspective. This review will:

- Describe the characteristics (habitats and habits) of beavers as they may impact reclamation
- Describe the characteristics of reclaimed water bodies with a focus on their suitability and attractiveness to beavers
- Discuss the potential impacts of beavers on reclamation success
- Recommend potential design considerations to avoid or mitigate beaver impacts

2.2.7 *Preliminary Watershed Hydrology and Chemical Export Model for Reclaimed Oil Sands Sites – Dr. Gordon Putz, University of Saskatchewan*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start September 2011	Ongoing Report will be released June 2013
Funding	$0	$0	$70,000	$0

The overarching goal of this research project is to take the first steps toward development of a watershed streamflow and water quality assessment tool (model) to support oil sands mine reclamation in Alberta. An extensive monitoring and research program following natural and harvest disturbance in forested watersheds on the Boreal Plain (FORWARD) has indicated that vegetation, streamflow, water quality and bio-indicators follow predictable impact and recovery trajectories. A watershed streamflow model (SWATBF) has been constructed and successfully applied in several reference watersheds on the Boreal Plain associated with Alberta's forestry sector. In addition, a hydrologic modelling framework utilizing SWATBF has been developed to model changes in water yield from harvested sites. The framework has been applied in two detailed forest management plans. To further advance the model and apply it in support of oil sands reclamation, the past two decades of soil, vegetation and hydrologic research on oil sands reclaimed sites needs to be compiled and used to set-up and calibrate the model. These oil sands reclamation data exist in several forms including theses, journal papers, grey literature (internal and external reports) and company databases.

The primary objective of this project is to compile the oil sand reclamation research data, assess its suitability for establishment of watershed streamflow models based upon SWATBF and to provide a summary report on the pertinent data. A second objective is to establish a preliminary watershed model as a test case utilizing the existing research data and to recommend parameter calibration ranges for SWATBF. The second objective is contingent upon the existence and availability of the required data.

2.2.8 *Resiliency of Reclaimed Boreal Forest Landscapes – Matthew Pyper, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Seminar held January 22, 2013 Report released February 13, 2013 Pyper, M.P., C.B. Powter and T. Vinge, 2013. *Summary of Resiliency of Reclaimed Boreal Forest Landscapes Seminar*. OSRIN Report No. TR-30. 131 pp.
Funding	$0	$0	$0	$2,384

Ecological resilience, first defined by Holling in 1973, can be broadly described as the capacity of an ecosystem to respond to a perturbation or disturbance by resisting damage and recovering quickly, but other authors have provided variations on this theme since 1973.

Ecological resilience is one potential measure of the goal of a self-sustaining ecosystem and is being considered for inclusion in the Cumulative Environmental Management Association's Criteria and Indicators Framework for assessing reclamation success in oil sands mines. For reclaimed lands to be considered self-sustaining they should respond to natural and anthropogenic disturbances in a similar manner to an analogous undisturbed landscape might respond to the same disturbances.

The University of Alberta's Department of Renewable Resources and the Oil Sands Research and Information Network jointly hosted a one-day seminar on January 22, 2013 at the University of Alberta to discuss the concept of ecological resiliency and how it can be applied to reclaimed landscapes. 108 people from a variety of organizations and technical interests attended the seminar.

There was general agreement amongst the presenters that resilience is a valuable topic to consider in reclamation planning. However, there was also agreement that implementing management systems based on resiliency would require a shift away from managing for consistency and single objectives (e.g., soil depth, stems/ha), to a system that embraces change and is focused on ensuring ecological processes are reintroduced to reclaimed landscapes (i.e., resiliency).

Some of the key ecological processes that were identified included: nutrient cycling and moisture availability; soil characteristics (e.g., pH, nutrient availability, propagules, soil biota, etc.); understory plant diversity (particularly when species are matched to the correct ecosite); presence of keystone species; and the proper construction of landforms which include slope, aspect and variability in their design.

The seminar was, by design, focused on providing information about the concept of ecological resilience and its potential application to land reclamation. The seminar participants recommended further sessions to bring the high-level concepts down to on-the-ground application.

There was also interest in holding a similar session in a year's time to provide more information and to focus on getting more technical detail, perhaps by focusing on specific research and implementation projects.

2.2.9 *Role of Professional Expertise in Reclamation Certification – Roger Creasey, Terrain FX Inc.*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start April 2012 Report released July 31, 2012 Creasey, R., 2012. *Workshop on the Information that Professionals Would Look for in Mineable Oil Sands Reclamation Certification*. OSRIN Report No. TR-25. 52 pp.
Funding	$0	$0	$0	$5,589

On June 18, 2012, the Oil Sands Research Information Network (OSRIN) convened a workshop to solicit the expert views from about 50 technical specialists from a variety of disciplines representing about 850 years of experience. The workshop, entitled Information That Professionals Would Look for in Mineable Oil Sands Reclamation Certification sought to document the field experience and "common sense" that a seasoned field specialist brings to the reclamation certification decision process.

The workshop was coordinated with the Reclamation Working Group (RWG) of the Cumulative Environmental Management Association (CEMA) to provide additional information in support of their Criteria and Indicators Framework project.

With some basic information on the hypothetical lands subject to a reclamation certificate application being considered, the groups were given three different scenarios to analyze from the viewpoint of their professional experience and technical knowledge:

Session One: You are going to visit a reclaimed oil sands mine site and decide if a reclamation certificate should be issued. You have only your five senses, experience and common sense to guide your decision.

- What positive and negative features do you look for?
- How confident (%) would you be that your decision is correct (i.e., mean and range)?

Session Two: Next, when you go onto the site you can bring one piece of equipment or one tool.

- What would you bring?
- What additional information will it provide for your assessment of the site?
- How much extra time (and time consuming logistics) would it add to your assessment of the site?
- Now how confident are you (%) in your assessment decisions (mean and range)?

Session Three: Next, in addition to your senses, experience, and the additional equipment you brought, you can ask for a report(s) regarding the site before the field assessment.

- What information would you want to see in the report/documents?
- Now, how confident are you (%) in your decision (mean and range)?

Session Four: For the final session in the workshop, the groups were asked to provide their comments on one of seven questions:

1. What do we need to know about contamination and remediation?
2. What advice can you give CEMA on criteria and the certification process?
3. Do expectations and process needs change depending on the reclamation goal(s)?
4. Do expectations and process needs change depending on when the site was reclaimed (i.e., older sites, currently reclaimed sites, sites reclaimed in the future)?
5. How long do we monitor for before applying for a reclamation certificate?
6. Do expectations and process needs change based on landform type (e.g., dump, tailings pond, Dedicated Disposal Area, plant site)?
7. What disciplines are missing from the discussion today?

The original intent of the workshop was to supplement the science-based reclamation certification criteria and indicators being developed by the Reclamation Working Group of the Cumulative Environmental Management Association with the knowledge and experience used by people with significant field experience. Although valuable suggestions about criteria were received, the discussions seemed to focus more on the information needs and process for assessing certification, suggesting the need for a Guide to the Reclamation Certification Process.

The workshop also sought to determine how confidence in decision making is affected by the use of field equipment/tools, and the value of background data and reports in increasing confidence. Given the extensive experience of the workshop participants, it was surprising to see how little confidence they had in using only their knowledge and experience to make reclamation certification decisions. Their confidence in making decisions increased somewhat if they were able to bring a piece of equipment into the field with them. If they were able to review a high quality report and supporting data from the site's historical file prior to going into the field their confidence increased substantially. This confirms the need for the CEMA RWG Criteria and Indicators work and suggests the need for a Guide to Reclamation Certification Application Content.

2.2.10 *Soil Microbiology as an Index of Oil Sands Reclamation Success – Dr. Sylvie Mercier Quideau, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start April 2013 Report will be released April 2014
Funding	$0	$0	$0	Committed $25,000

Following surface mining, reclamation efforts involve the reconstruction of entire landforms. Salvaged surface soils and near-surface geological materials are placed as a new soil cover on the reconstructed landscapes. The goal of reclamation in Alberta is to achieve land capability equivalent to that which existed prior to disturbance. Soil parameters that are currently used to examine reclamation success include chemical and physical attributes known to limit plant growth. Although it is essential to the functioning of these reconstructed ecosystems, soil biology is not yet included as part of the assessment.

This project will characterize for the first time the biodiversity of soil mesofaunal populations on natural and reclaimed oil sands sites. Specifically, we will focus on soil protists, as these bacteria-consuming organisms are responsible for much of the nutrient fluxes through the soil food web and have crucial downstream impact on animal and plant biodiversity. Protists are used as indicators of soil quality, allowing comparisons with other environments. A direct outcome of this project will be the definition of a sampling and analytical strategy to quantify protist diversity, and to examine how protists could be integrated as biological indicators in oil sands reconstructed soils.

2.2.11 *Support Wetland Reclamation Symposium – Cambridge University Press*

	2009/10	2010/11	2011/12	2012/13
Project Activity	Symposium held March 25-27, 2010	Develop book content	Ongoing	Book released by Cambridge University Press November 2012
Funding	Committed January 2010	$0	$0	$9,948

Disturbances in Canada's boreal forest include those in both upland forests and in peatlands. These disturbances originate from both anthropogenic and natural causes (especially fire) and

many are currently a concern of government, non-government organizations, and industry. Techniques for the restoration as well as the reclamation of peatlands and forests impacted by agriculture, urban development, or oil and gas activities have made significant advancement over the last decade and these techniques need to be incorporated into the regulation and management of peatland and forest ecosystems. How this research and management is affected by climatic change will be an important 21st century concern. The Symposium addressed these problems and the recent research that is being carried out in North America.

OSRIN funds paid for copies of the book *Restoration and Reclamation of Boreal Ecosystems: Attaining Sustainable Development* to be printed and distributed to symposium attendees.

2.2.12 *What Constitutes Success for LFH Salvage and Replacement – Dr. Anne Naeth, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	Project start February 2011	Ongoing Complete in FY 2012/13	Report will be released April 2013
Funding	$0	Committed February 2011	$25,000	$0

OSRIN and the coal mining sector commissioned a literature review that will summarize the expected benefits of using LFH (luvic-fulvic-humic) surface soils for forested land mine reclamation over traditional reclamation soil mixtures (e.g., peat, peat:mineral, peat:tailings sand, and peat:mineral:overburden in the oil sands and topsoil/subsoil mixtures in mountain/foothills coal mines etc.).

Based on research results documenting the benefits of using LFH in oil sands reclamation, Alberta Environment and Alberta Sustainable Resource Development recently attended three oil sands mine Energy Resources Conservation Board hearings and requested that industry be required to use soil luvic, fulvic and humic (LFH) materials for reclamation. Justification for the request was that using natural surface soil materials, rather than constructed ones, would provide a better environmental outcome after reclamation. This approach would be consistent with soil salvage and replacement approaches used on most other Alberta industrial sites. It is reasonable to assume that, in the near future, coal mines will be asked to undertake a similar LFH based salvage and replacement approach.

There is currently no clear and accepted description of what constitutes a better environmental outcome with LFH based reclamation. There is currently no clear documentation of what

successful LFH based reclamation would look like, and why it would be different from success achieved from mine reclamation practices using traditional soil salvage and replacement methods. Concern has been raised that the benefits of LFH based reclamation may be short lived, and thus in the long term not be an economical or environmentally sound basis for implementation.

2.2.13 *Woody Debris Field Guide – Dr. Vic Lieffers, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	Project start January 2011	Ongoing Complete in FY 2012/13	Report released February 15, 2013 Pyper, M. and T. Vinge, 2013. *A Visual Guide to Handling Woody Materials for Forested Land Reclamation*. OSRIN Report No. TR-31. 10 pp.
Funding	$0	$14,850	$0	$6,940 – additional funds for field work

In a short period of time, the conversation around handling woody materials – deadwood such as logs, branches and stumps – has shifted dramatically. From piling and burning, to mulching and now towards keeping 'whole logs' on sites. The changes have led to confusion and this guide is intended to provide clarity around wise use of woody materials in reclamation programs.

This guide is intended to answer the following questions:

- Why has there been a shift in how we manage woody materials?
- How can woody materials be managed effectively on sites?
- What do effective woody material applications look like?

Through this work, we hope to promote effective use of woody materials in an effort to encourage revegetation on industrial sites through the creation of microsites. For a more detailed look at managing woody materials see: Managing woody materials on industrial sites: Meeting economic, ecological and forest health goals through a collaborative approach by Tim Vinge and Matthew Pyper.

2.3 Monitoring Ecosystem Impacts

This program focuses on components of a comprehensive, robust system in Alberta to monitor the effects of oil sands mining operations on ecosystem health – a system that is scientifically sound and has the confidence of the general public.

2.3.1 *An Evaluation of Wireless Sensor Networks and their Potential Implementation to Monitor Environmental Variables at Oil Sands Sites – Dr. Arturo Sanchez-Azofeifa, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start December 2012 Report will be released January 2014
Funding	$0	$0	$0	$25,000

Wireless sensor networks are emerging as standards for environmental monitoring for their flexibility to install, operate and also because they provide levels of information at spatial scales not available with common environmental monitoring systems. This project will provide OSRIN with a comprehensive report on:

- Current status of the technology in terms of sensor development, field deployment and data analysis approaches based on all available literature since 1998 (1998 is selected since this year is the first which mentions wireless sensing technologies in the scientific literature). It is estimated that there are between 50 to 80 scientific papers published in several areas: sensor design, sensor implementation, cyber-infrastructure, and visualization. Journals range from pure ecological journals to more technology driven such as IEEE journals.
- Implementation of cyber-infrastructure efforts to monitor, visualize and analyze information from wireless sensor networks, and linkages to metadata generation.
- Economic costs associated to the implementation of wireless sensor networks in oil sands regions.
- Opportunities and limitations associated to the implementation of wireless sensor networks for environmental monitoring.

2.3.2 *A Rapid Solution for Screening and Quantifying Targeted and Non-Targeted Analytes in Oil Sands Process Water and Natural Waters in the Athabasca Region – Dr. Jonathan Martin, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start October 2012 Report will be released January 2014
Funding	$0	$0	$0	$60,000

A particular challenge for environmental analytical chemists is that there are currently no standard analytical techniques for oil sands monitoring that meet requirements for accuracy, sensitivity, reliability, and throughput.

At the root of the analytical challenge is the utter complexity of oil sands process affected water (OSPW), and the fact that we currently do not know which chemicals represent the greatest chemical hazard(s) to humans or wildlife. Making matters more difficult, is that water in the Athabasca River contains most of the same chemicals as OSPW, owing to natural erosion of bitumen by stream and river flow. The current trend for characterizing natural water samples for evidence of industrial activity is to extract 1 L of water with a large volumes of organic solvent (e.g., 1L of dichloromethane), and to analyze this extract by ultra-high resolution mass spectrometry (Orbitrap or FTICR-MS – see OSRIN's previous report for more information on analytical methods). However, these methods are not ideal because different extraction solvents yield different results for the same sample.

Furthermore, inherent to all liquid-liquid extraction techniques is the high probability of contaminating a sample, the high variability of the extraction efficiency from sample to sample, and the procedure is also very slow and cumbersome.

The project will develop and validate a new sensitive, accurate, rapid, clean, and reproducible analytical method for natural water monitoring. Specifically, it will develop a method for direct injection of natural water (up to 20 mL) into the Orbitrap MS via an in-line solid phase extraction column. The in-line extraction column can then be back-flushed directly onto the analytical column for analysis of naphthenic acids and >5,000 "other analytes". The method will be equally sensitive to the liquid-liquid method described above, but will boast major improvements in reproducibility and cleanliness. Such approaches are the gold-standard approach to biomonitoring of contaminants in human samples, as outlined by the U.S. Centres for Disease Control and Prevention.

The method is expected to be developed in under 6 months, and be ready for validation in natural surface water and groundwater in under 1 year.

2.3.3 *Microcosm Evaluation of CLPP in Oil Sands Process Affected Water – Dr. Jim Davies, Alberta Innovates - Technology Futures*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start August 2011	Report released November 2, 2012 Davies, J., B. Eaton and D. Humphries, 2012. *Microcosm Evaluation of Community Level Physiological Profiling in Oil Sands Process Affected Water*. OSRIN Report No. TR-28. 33 pp.
Funding	$0	$0	$60,000	$0

A microcosm-based experiment was conducted to investigate the ability of community level physiological profiling (CLPP) to detect changes in an aquatic microbial community resulting from exposure to oil sands process affected water (OSPW). Detection of the microbial response was done by using the Biolog EcoPlate system, a commercially-available system originally developed for the assessment of rhizosphere microbial communities. The Biolog system consists of a 96-well microtitre plate. Each well on the plate contains both a pure organic compound (the substrate), and a tetrazolium dye. When a microorganism metabolizes the substrate, the dye is reduced into a purple formazan product. The purple colour of each well is characterized using a spectrophotometer measuring optical density (OD) at 590 nm. In this study, we used the EcoPlate version of the Biolog System.

Reductions in metabolic activity and inoculum density were detected in the high OSPW group. Overall, indicators of microbial metabolic activity decreased over time. One of these indicators, the sum of substrate means (SSM), showed a dramatic response to weekly water changes. Low cyclicity naphthenic acids demonstrated a reduction over the first and last weeks of the exposure period. Higher cyclicity naphthenic acids demonstrated reductions in the first but not the last week of exposure. The total naphthenic acid (TNA) content of the microcosms appeared to increase over the last week of the exposure period, which may reflect the accumulation of products of microbial metabolism.

Our results suggest that inoculum density remains a source of variability for CLPP results. Furthermore, the biological context under which the microbial community forms has a strong influence on its metabolic characteristics. The changes in naphthenic acid concentration (total and speciated) likely reflect adsorption and/or microbial metabolism. Our observation of increased phytoplankton in the presence of OSPW is consistent with the available literature. Additional research will be required to determine if this finding can be developed into an indicator of toxic effect, rather than just the presence/concentration of OSPW.

2.3.4 *Oil Sands Groundwater – Surface Water Interactions Workshop – Oil Sands Research and Information Network and Canadian Environmental Assessment Agency*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start March 2012	Report released June 5, 2012 Oil Sands Research and Information Network and Canadian Environmental Assessment Agency, 2012. *Summary of the Oil Sands Groundwater – Surface Water Interactions Workshop*. OSRIN Report No. TR-22. 125 pp.
Funding	$0	$0	Committed March 2012	$1,190

A number of factors led to the need for a workshop to discuss surface water – groundwater interactions in the oil sands. These included:

- Current government policies and the development of new policies and frameworks
- Continued uncertainty regarding the potential for interactions and the resulting impacts, particularly for fisheries habitat and resources
- Initiation of the Cumulative Environmental Management Association's Groundwater Working Group and their initial research results

- Work being undertaken by industry, particularly in the Southern Athabasca Oil Sands

The Workshop:

- Considered mineable and in-situ oil sands operations in general (i.e., did not focus on specific geographic regions, except when discussing specific examples)
- Focused mainly on groundwater (quality and quantity) – with discussion of surface water being limited to "groundwater – surface water interaction"
- Acknowledged, but did not address, that the different regulators have different responsibilities and authorities regarding groundwater, surface water and fisheries impacts related to interactions

The objectives of the Workshop were to:

- Develop a common understanding of the current knowledge regarding groundwater resources, groundwater-surface water interactions in the oil sands area, ongoing applied research, monitoring and potential impacts
- Develop recommendations regarding research, monitoring, modelling, etc. to address knowledge gaps and/or regulatory and environmental protection issues

The Workshop was structured with initial presentations by several speakers to set the context, and summarize current policy and recent research. The participants were then asked to respond to a series of general and topic-specific questions.

The report recommendations have not been directed to any specific individual or organization. Rather, the Steering Committee members will bring the recommendations back to their respective management teams for further consideration.

2.3.5 *Organic Footprint of Atmospheric Deposits: Snow and Surface Water Fingerprinting Across the Athabasca Region – Dr. Jean Birks, Alberta Innovates – Technology Futures*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start March 2012	Ongoing Report will be released May 2013
Funding	$0	$0	Committed March 2012	$60,600

Following up on a previous OSRIN project, this study will characterize the dissolved organics present in rivers, lakes and process affected waters in the Athabasca oil sands region and from lakes and river samples collected during the spring and summer of 2011. The results of this study will provide oil sands researchers with a better understanding of the composition of the compounds present in dry and wet deposition across the region and possibly also a tool for partitioning contributions of organics from different sources. The transfer of atmospherically derived organics to aquatic ecosystems is a key knowledge gap in the region and this study will help address this by evaluating if the organics detected in the snow survey can be detected in spring runoff in the Athabasca or in nearby lakes. This study will provide a more complete picture of the types of organics present in snow and surface water across the Athabasca oil sands region and a better understanding of the proportion of these organics captured by existing monitoring.

2.3.6 *Surface Water – Groundwater Interactions in the Lower Athabasca Region – Melanie Dubois, Cumulative Environmental Management Association*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start September 2011	Report released January 18, 2012 Birks, J., J.P. Jones and J. Gibson, 2012. Surface water - groundwater interactions in the lower Athabasca region. Cumulative Environmental Management Association, Fort McMurray, Alberta. CEMA Contract No. GWWG 2011-0042. 75 pp. [Available from the CEMA website at http://library.cemaonline.ca/ – you must register to download the report].
Funding	$0	$0	$10,000	$0

Recently, there has been an increased interest in further characterizing groundwater systems for a number of upcoming Oil Sands projects in the Lower Athabasca Region. Concomitant to this increased interest is a rising appreciation for the potential influence groundwater may have on surface water systems and vice versa. To date, the majority of the surface water – groundwater interaction work performed in the Lower Athabasca Region has focused on local scale processes with limited efforts at the regional scale. However, it is generally recognized that effective planning and management of the region's water resources will require a better understanding of these interactions at all scales.

The primary objective of this document is to present an outline of the initial steps and tools that will be necessary to achieve that better understanding. Section 1 discusses the current level of

knowledge regarding surface water – groundwater interaction in the Lower Athabasca Region, identifies some of the anthropogenic processes that could be influencing them and outlines current and proposed monitoring frameworks relevant to those interactions. Section 2 presents an overview of the current spectrum of tools and techniques used to measure surface water – groundwater interaction in the Lower Athabasca Region and other jurisdictions. Section 3 summarizes some projects currently being conducted by government, industry and academics that are relevant to this topic. Section 4 presents a scope of work outlining the research that will be required in the short, medium, and long-term to improve our understanding of these interactions across the region. As well, a large bibliography of pertinent literature and reports is included for those wishing to explore some of the information discussed in this document further. Overall, it is hoped that the information and work scope presented in this document will help advance the ability to identify and quantify the cumulative effects of development in the region.

2.3.7 *Wild Plant and Soil Sampling in Support of Oil Sands Contaminant Load Assessment – Dr. Cindy Jardine, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start August 2012 Report will be released July 2013
Funding	$0	$0	$0	$50,000

Wild plant and soil samples will be collected in the mineable oil sands region, with an emphasis on the area around Fort McKay, and analyzed for metal and polycyclic aromatic hydrocarbon concentrations. The data will be used as input into a separate project on environmental health risk assessment that will focus on chemical exposures from multiple media and sources. A report will be prepared that explains how environmental samples related to consumption of country foods fit into the overall Human Health Risk Assessment process and the issues related to their sampling and analysis.

2.4 Increasing Awareness

This program aims to increase awareness of OSRIN and oil sands issues through an active website presence (www.osrin.ualberta.ca), sponsoring oil sands related conferences, digitizing historical information and publication of OSRIN research results, sponsoring oil sands related conferences, digitizing historical information and publication of OSRIN research results.

OSRIN provides support to conferences and other venues to ensure that there are opportunities for practitioners to access oil sands information.

In 2012/13 we changed the way we account for these sponsorship expenditures:

- Where a conference is focused primarily on one of OSRIN's other research program areas we account for the expenditure in that program area (for example the 3rd International Oil Sands Tailings Conference is accounted for in the Tailings Reclamation program).
- Where a conference is more general in nature, or covers more than one of OSRIN's research program areas it is accounted for in the Increasing Awareness program (for example the RemTech 2012 Conference). Rather than group these together into one lump sum we will report each event sponsorship as a separate entry in this report.

2.4.1 *CEMA Oil Sands Bibliography Enhancements – Kyle Harrietha, Cumulative Environmental Management Association*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Database reconfigured and reference list updated.	Project start August 2012 Database updates will be completed March 2013
Funding	$0	$0	$25,000	$20,000

There is a large and growing literature on oil sands reclamation and related disciplines. OSRIN has identified a need to make publicly available an online, searchable bibliography of current and historical references (wherever possible with links to electronic copies). OSRIN has confirmed this need with a number of reclamation specialists and potential users. The lack of a readily accessible, current listing of research can lead to unintentional repetition of previous work which wastes valuable resources. In addition, access to historical information will allow researchers to focus on key issues, or components of previous studies that were not explored.

OSRIN has partnered with the Cumulative Environmental Management Association (CEMA) to enhance and update CEMA's Reclamation Research Database (renamed as the Oil Sands Environmental Management Bibliography). Enhancements include improved searching and reporting tools and addition of references will be added to the database to make it more comprehensive.

2.4.2 *Digitizing Historical Research Project Reports*

OSRIN staff have digitized historical oil sands related government-sponsored research work from the Alberta Oil Sands Environmental Research Program (access all 217 reports or access list of digitized reports) and the Reclamation Research Technical Advisory Committee (access all 41 reports and two conference papers or access list of digitized reports) and placed them on

the University of Alberta's Education & Research Archive website to make information more readily accessible to stakeholders. These reports provide context and, in the case of the AOSERP reports considerable baseline information, to help stakeholders appreciate the depth and breadth of research undertaken since the mid-1970s to understand oil sands impacts and develop appropriate mitigation. Other Government of Alberta reports are also being digitized to provide additional context (access all 58 reports or access list of digitized reports).

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	Begin digitizing and posting reports	Ongoing digitization work	Ongoing digitization work
Funding	$0	$334.43	$1,717	$1,393

OSRIN appreciates the significant assistance from the University of Alberta Libraries and the submissions of digitized versions of reports from Environment Canada, Alberta Government Libraries (Great West Life branch), Pedocan Land Evaluation and Millennium EMS Solutions. OSRIN also appreciates receiving permission from Alberta Agriculture and Rural Development for digitization of a series of 1970's reports.

2.4.3 *iGEM Award Sponsorship – ConocoPhillips Canada (on behalf of the Oil Sands Leadership Initiative – OSLI)*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	Sponsor 2010 competition	Sponsor 2011 competition	Sponsor 2012 competition
Funding	$0	$25,000	$25,000	$25,000

The International Genetically Engineered Machine competition (iGEM) is the premiere undergraduate Synthetic Biology competition. Student teams are given a kit of biological parts at the beginning of the summer from the Registry of Standard Biological Parts. Working at their own schools over the summer, they use these parts and new parts of their own design to build biological systems and operate them in living cells. This project design and competition format is an exceptionally motivating and effective teaching method.

For the past two years OSLI and OSRIN have sponsored a special Oil Sands Challenge competition within the overall iGEM competition. In 2012/13 OSRIN contributed $25,000 to sponsor awards for participating teams in the oil sands competition within the overall iGEM competition. OSLI provided $125,000 to the award pool.

2.4.4 *Investigating a Knowledge Exchange Network for the Reclamation Community – Alberta Innovates - Technology Futures*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Workshop held February 29, 2012	Report released August 10, 2012 Alberta Innovates – Technology Futures, 2012. *Investigating a Knowledge Exchange Network for the Reclamation Community*. OSRIN Report No. TR-26. 42 pp.
Funding	$0	$0	$1,525	$0

Alberta Innovates – Technology Futures (AITF) and other parties have been investigating reclamation research, development and deployment capabilities and capacities in the province for several months. The concept of a 'Reclamation Centre' was first discussed through a Challenge Paper distributed in August 2011 to a variety of participants in the reclamation community.

The original key challenge was to engage the reclamation community in a dialogue to determine the benefits of forming a 'Reclamation Centre' in the Edmonton area. We obtained feedback from researchers, practitioners, regulators and other individuals and organizations who are interested in reclamation. The response from the participants clearly articulated that there was no need for additional reclamation research capabilities in central Alberta (e.g., greenhouses, buildings and other infrastructure). However, there was a need for a central point for collection and distribution of knowledge, information and data related to reclamation activities.

A Knowledge Exchange Workshop was held in Red Deer on February 29th, 2012. It focused on centralization, collection, distribution and synthesis of knowledge, information and data related to reclamation.

The workshop was used to answer a series of questions identified by the steering committee around knowledge exchange and the aspects of "What" (what kind of information, data, knowledge to share, etc.); "Why" (why would the community benefit from shared information, etc.) and "How" (type of format used to share the information, etc.). The intention was to have multiple stakeholder groups represented by the participants and to distribute them evenly throughout the room during the discussion to stimulate insightful, constructive and comprehensive conversation.

The desired outcomes were:

1. To gain an understanding of what the reclamation community needs (wants) in terms of information, knowledge and/or data;
2. To gain an understanding of why the reclamation community wants this information and how they intend to use it;
3. To obtain suggestions on how to best achieve this and ways to move forward.

It became obvious from the table discussions that to be successful, this initiative requires involvement from the entire reclamation community. This includes service/consulting organizations, oil and gas, mineable and in-situ oil sands, sand, gravel and other mining industries, academia, government, and applicable associations such as CLRA, ESAA, AIA, PTAC, etc. All of these industries and organizations have a role to play in collaboration within the reclamation community.

Overall the participants found the question of why access to information, knowledge and/or data would be helpful and who would utilize it, easier to address than specifically 'what' needed to be shared and how to share it. However, evidence of the potential benefits of a knowledge exchange initiative for the reclamation community is compelling enough to warrant further exploration of the concept.

Overall the conclusions from the discussion indicated the reclamation community was interested in multiple types of information and knowledge that could be shared through different mechanisms. The information required was a hierarchy of quality, from peer reviewed literature and knowledge to broadly defined grey literature and most importantly anecdotal practitioner experiences. A main desire is to have greater access to information, but also to the people who generated the information.

There were several challenges associated with this type of an initiative related to how the information would physically be shared and how to encourage more effective collaboration in the broader reclamation community. The participants concluded the information should be shared through a variety of mechanisms.

Although challenges were identified, the most important obstacles to overcome are to clearly identify the benefits for multiple users, determining a funding mechanism and how to get started. The issues associated with information and computing technologies (ICT) and large databases, intellectual property, QA/QC in data quality, privacy, links to other organizations, etc. could be resolved during the process.

Although there was agreement that the concept of exchanging information, knowledge and/or data within the entire reclamation community was feasible, it was determined that the scope and intent of the initiative must be clearly articulated to answer key questions such as who will do the work, what will it cost and who will participate. It was suggested to start the initiative small and grow it appropriately with well-developed and clearly defined goals.

2.4.5 *RemTech 2012 Conference Sponsorship*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Conference was held October 2012 and featured an oil-sands specific session.
Funding	$0	$0	$0	$3,049

2.4.6 *Tailings and Mine Waste 2013 Conference Sponsorship*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Conference will be held November 3-6, 2013 in Banff.
Funding	$0	$0	$0	$3,750

2.4.7 *University of Alberta Oil Sands Student Delegation Sponsorship*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Sponsorship to provide educational opportunities for students.
Funding	$0	$0	$0	$1,500

The University of Alberta Oil Sands Student Delegation (OSD) is a student organization that exists to provide an annual trip to Fort McMurray for student leaders from the University of Alberta. This year's trip was held October 13-14, 2012.

Due to the University's proximity and unique relationship with Alberta's oil sands, we students are in a privileged position to take a leadership role in developing solutions. The OSD was conceived to achieve this, by facilitating deeper understanding among students regarding the oil sands and issues related to its development through a bias-balanced presentation of information. In this trip, students can tour development facilities, assess technical features, and expose themselves to the various stakeholders' perspectives on oil sands development. The trip will be supplemented with on campus information sessions approximately two weeks prior to the trip, as well as forums and events that will share the trip's experiences with the wider community.

The five values of OSD, neutrality, quality, credibility, networking and education, inform every level of decision making. In light of the escalating and increasingly polarized debates, the bias-balanced and interdisciplinary approach of OSD is of vital importance to the discussion around oil sands development. Our long term vision is to increase the number of students attending this trip, and to encourage and assist other schools in Alberta in developing oil sands delegations.

2.4.8 *WaterTech 2013 Conference Sponsorship*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Conference will be held April 10-12, 2013 in Banff and features oil-sands specific sessions.
Funding	$0	$0	$0	$2,287

2.5 Social, Economic and Regulatory

This program seeks to identify social, economic and regulatory issues that may affect environmental management of oil sands and to evaluate the effectiveness of environmental management in addressing social, economic and regulatory issues.

2.5.1 *Alberta Energy Challenge – Commerce Energy & Environment Group, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start September 2012 Competition held September 27-30, 2012
Funding	$0	$0	$0	$10,000

OSRIN supported the 3rd annual Alberta Energy Challenge at the University of Alberta. The Challenge was a four-day interactive case competition focused on the energy sector, held September 27 –30, 2012. This year there were eleven teams competing at the University of Alberta, from across Canada, the United States, and one from the Middle East. Using the extensive resources provided to them and their own knowledge the teams had the opportunity to present innovative and engaging solutions to problems facing our energy sector. The 2012 Challenge is described below.

Transportation Deficit in Oil Sands Development

With the third largest oil reserves in the world, and the largest that are available for private development, the Alberta oil sands are attracting significant investment. Over the last ten years industry has invested $116 billion in oil sands development, and this investment is currently projected to increase by an additional $218 billion over the next 25 years. Further, this investment will raise bitumen production from its current levels of 1.75 Mbbl/day to a potential 5.0 Mbbl/day by 2035.

To achieve this level of growth, there are significant logistical and operational challenges to overcome. There are increasing problems with getting the needed materials and labour up to the sites; the rapidly increasing production is also straining the ability to get the hydrocarbons, along with their associated by-products and wastes, out of north eastern Alberta. The immense size, remote locations, extreme weather conditions, labour shortages, evolving technologies, ultra large equipment and infrastructure, social license approval, and environmental concerns also drive this issue.

In the face of all these challenges, it is clear that the transportation infrastructure in Northern Alberta needs to be improved.

- Context
- Innovative ideas have surfaced over the years to address the bottlenecks in oil sands supply logistics created by remote locations with relatively limited existing supply infrastructure.
- Oil sands developments are spread out over a large area of the north eastern part of the province (there are additional developments in the Peace River region but these will not be considered in this Challenge).
- In-situ operations are spread out over a much larger area than mining projects.
- The remote locations and the biophysical environment, including specifically significant areas of wetlands and major rivers, create challenges for infrastructure development.
- There are currently two major highways and one railway providing service to the region.
- Some companies have developed private airstrips.
- In-situ operations have different supply logistic requirements than mining projects.
- Development of Alberta's oil sands will occur over many decades.
- Forecasted oil sands production is greater than the current capacity to export oil from western Canada.

Tasks

1. Research and identify critical transportation bottlenecks that are currently, or may potentially, reduce operational efficiency and growth of the oil sands. (The focus of this task is on the logistics and operations of the oil sands. For example, from the Four-Access Framework this Challenge is more concerned about access to the natural resource at an operational level than access to the markets (e.g. Keystone XL, Gateway, etc.) The geographic area of concern is the corridor between Edmonton and the mining and in-situ sites in north eastern Alberta.)

2. From this research determine one or two key bottlenecks and give rationale for your choices.
3. Provide solutions to mitigate these bottleneck(s). Solutions should be feasible and sustainable with a focus on optimizing economic growth, reducing the environmental footprint, and improving public and worker safety.

2.5.2 *Audit Protocol to Support Implementation of the Mine Financial Security Program – Richard Dixon, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start June 2011	Report released August 23, 2012 Dixon, R.J., J. Kenney and A.C. Sandilya, 2012. *Audit Protocol for the Mine Financial Security Program*. OSRIN Report No. TR-27. 27 pp.
Funding	$0	$0	$30,000	$0

The Audit Protocol for the Mine Financial Security Program was commissioned to provide a framework to assist government or third-party auditors of Annual Reports under Alberta Environment and Sustainable Resource Development's Mine Financial Security Program (MFSP). The Audit Protocol seeks to assist in the verification of the information provided to Alberta Environment and Sustainable Resource Development under the MFSP by coal and oil sands mine companies.

The Audit Protocol was prepared based upon the requirements of the *Mine Financial Security Program Standard* and the *Guide to the Mine Financial Security Program*, with reference to accepted auditing standards and defined reclamation requirements. The Audit Protocol has been designed to systematically enable an auditor to review and assess an Approval Holder's MFSP Project's:

- MFSP Assets (e.g., reserves);
- MFSP Liabilities (e.g., closure and reclamations costs);
- Reporting requirements;
- Base Security Deposit;
- Operating Life Deposit;
- Asset Safety Factor Deposit; and
- Outstanding Reclamation Deposit.

For each section of the MFSP Audit, a series of questions are presented to direct the auditor to the required information supporting the MFSP Annual Report.

2.5.3 *How Qualifying Environmental Trusts Work as Reclamation Security – Richard Dixon, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start June 2011	Report released July 30, 2012 Dixon, R., M. Maier, A. Sandilya and T. Schneider, 2012. *Qualifying Environmental Trusts as Financial Security for Oil Sands Reclamation Liabilities*. OSRIN Report No. TR-24. 32 pp.
Funding	$0	$0	$25,000	$0

The Alberta oil sands resource is vast; however, the amount that can be accessed via open-pit mining is limited. The process of extracting oil from bitumen via open-pit mining has now been going on for decades and could be considered a mature industry. Under Alberta law, plans for the suspension, abandonment, remediation and surface reclamation of each oil sands mine and associated processing plant must be in place before the government allows mining to take place. Each operator must also provide some form of financial security to the Government of Alberta to ensure that funding will be in place to pay for suspension, abandonment, remediation and surface reclamation liabilities, in the event that the Approval Holder is unable or unwilling to do so. As a mine approaches its end-of-life, the Approval Holder must increase the amount of financial security provided to Alberta Environment and Sustainable Resource Development, such that by the time the mine has less than six years of reserves left, the entire amount of the estimated clean-up cost is covered by financial security. One of the forms of financial security made available to oil sands operators, effective 2011, is a qualifying environmental trust (QET).

The royalty regime in Alberta for operators of mature oil sands mines (known as the post-payout phase) is such that royalties paid by oil sands operators to the government are calculated based on revenue less 'allowed' costs. Abandonment, remediation and surface reclamation costs are considered allowed costs. However, an Approval Holder cannot deduct allowed costs from royalties after bitumen production is complete; thus any suspension, abandonment, remediation and surface reclamation costs incurred after production are not deductible. On the other hand, the funding of a QET to provide financial security for future suspension, abandonment, remediation and surface reclamation costs is immediately deductible for royalty and income tax purposes. For reasons detailed herein, we expect that as oil sands mines approach their end-of-life, the operators will establish QETs to avoid forfeiting the deduction of their suspension,

abandonment, remediation and surface reclamation costs. The suspension, abandonment, remediation and surface reclamation liabilities that have accrued to the oil sands operators are now in the billions of dollars. If even a portion of these are funded by QETs, the effect on the amount of royalties and taxes flowing to the Government of Alberta will be in the hundreds of millions of dollars. Thus, understanding if and when oil sands operators will choose to use QETs is important for the forecasting of government revenues, particularly as oil sands royalties are now the single biggest contributor to Alberta's total royalty revenue.

It should be noted that a QET provides a very strong form of financial security. Various versions of environmental trusts are available to mining companies in jurisdictions throughout the world. They are generally deductible for tax purposes; however, we find almost no use of them anywhere, including other jurisdictions within Canada. In this report we discuss why we believe that oil sands firms will use QETs as the reserves in their mines run down. This is done in the context of Alberta Environment and Sustainable Resource Development's Mine Financial Security Program, introduced in 2011, and the fact that the end-of-life of a number of oil sands mines are in the not too distant future.

2.5.4 *Impacts of Changing Environmental Standards on Oil Sands Royalties – Elis Valera, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start August 2011	Report released June 21, 2012 Valera, E. and C.B. Powter, 2012. *Implications of Changing Environmental Requirements on Oil Sands Royalties*. OSRIN Report No. TR-23. 21 pp.
Funding	$0	$0	$5,758	$0

Environmental requirements for oil sands operations have increased over time and are likely to continue to do so. Oil sands operators are responsible for the costs associated with meeting environmental requirements prescribed by the government. However, the province's oil sands royalty regime incorporates deductions for *allowed costs* which include costs of meeting environmental requirements. Therefore, in effect, increasing environmental requirements, which often mean greater costs, results in reduced government royalties.

2.5.5 *Implications of Corporate Certification on Reclamation Security Estimates – Benjamin Thibault, Pembina Institute for Appropriate Development*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	Project start December 2011	Report released November 8, 2012 Thibault, B., 2012. *Assessing Corporate Certification as Impetus for Accurate Reporting in Self-Reported Financial Estimates Underlying Alberta's Mine Financial Security Program*. OSRIN Report No. TR-29. 37 pp.
Funding	$0	$0	Committed December 2011	$15,000

Alberta's Mine Financial Security Program (MFSP) establishes the procedures for determining and administering financial security for reclamation of oil sands and coal mining operations. The program establishes more transparent and consistent methods for determining the financial security amount required to cover the mine's suspension, abandonment, remediation and surface reclamation liabilities should the operator fail financially – while considering the value of the resource as assets against the liabilities. For oil sands mining operations, total MFSP liabilities can run in the hundreds of millions of dollars.

To determine financial security amounts, mine operators self-report estimates of the liabilities and assets in the operation. Accuracy of the asset and liability estimates is important to provide public assurance that the program is providing appropriate levels of financial security. Within the MFSP, certain mechanisms are used to improve regulator and public confidence in the accuracy of these estimates. Under analysis here is the corporate certification requirement: a high-level representative – either the Chief Executive Officer (CEO) or Chief Financial Officer (CFO) of a corporate mine operation or a designated financial representative (DFR) of a joint venture – must certify that appropriate procedures were used to determine the estimate values and that the estimates are reasonable.

By investigating the legal and regulatory setup for the MFSP, this paper assesses the expectation of increased confidence from the certification requirement by describing its legal implications and the impetus it places on corporations to ensure appropriate procedures for generating estimates.

In short, the corporate certification requirement ensures documentary evidence of officer involvement in any misreporting by mining operators. For any misreporting that constitutes an offence under the governing legislation – the *Environmental Protection and Enhancement Act*

(EPEA) – this could raise individual officer liability under the Act. EPEA has enforcement provisions to penalize misreporting under the MFSP, which can be applied to companies as well as individuals. The individual penalties, which can include imprisonment or monetary penalties, can be applied to a corporate officer where he or she had some minimum level of involvement in the misreporting.

With respect to some of the most important estimates, there is a link between the MFSP calculations and values reported under disclosure obligations in securities law. This is another mechanism for improving regulator and public confidence in the MFSP estimates and includes a similar certification requirement. While the effectiveness of this mechanism is not within the scope of this analysis, it provides a comparator against which to analyze the effectiveness of the MFSP corporate certification requirements, particularly in terms of the penalties available under each regime.

In light of the relatively small magnitude of the monetary penalties available under EPEA and important barriers to investigation and enforcement of misreporting violations, the extent to which certification requirements incent better estimate procedures is not clear. This is particularly true given the small penalties under EPEA relative to those available under securities law. Nonetheless, the risk of reputational injury could provide a less formal but still very powerful incentive that certification bolsters by demonstrating officer involvement. Unfortunately, the absence of a role for civil society in the scrutiny of the estimates precludes a potentially stronger role for certification to incent enhanced estimate veracity.

In conclusion, there is some expectation that the inclusion of the MFSP certification requirement provides an incentive for better procedures for asset and liability estimation in the MFSP Annual Report. It is difficult to assess the strength of this incentive, particularly because of uncertainties around the capacity to investigate reporting misconduct with respect to complex internal accounting procedures, on which the enforcement and, in turn, certification requirements rely for effectiveness. A few more conclusions are discussed further.

First, there is a lack of clarity in industry around the potential for liability against the certifying authority arising from certification. This can have two negative consequences. For one, the potential liabilities that do exist are not having their full deterrent effect if they are not properly understood by the actors they are intended to impact. Also, reduced certainty with respect to any business decision, but particularly for potential monetary and imprisonment penalties, can undermine efficient business behaviour and lead to suboptimal policy results. This can be improved by:

- more clearly explaining how individual liability attaches from the certification;
- providing concrete hypothetical examples of misreporting infractions that can lead to individual officer liability; and
- better linking the “effect” (wording) of the certification statement to EPEA’s standards for individual officer/agent liability.

Second, it is not clear what internal capacity or threshold triggers Alberta Environment and Sustainable Resource Development (ESRD) employs to initiate a more concerted governmental audit or third-party audit of an MFSP Annual Report. The effectiveness of these procedures is critical to the mechanism through which certification engages potential legal liabilities or reputational costs for certifying authorities. Uncertainty around ESRD's capacity or procedures for pursuing more concerted investigations undermines clarity around the certification's effectiveness. This can be improved by:

- providing more information to stakeholders around ESRD's review process and where and how ESRD chooses to exercise its audit powers and pursue enforcement measures; and
- establishing clearer presumptions or default values for certain parameters of asset and liability estimation, such as minimum per-hectare reclamation costs, derivation from which requires an explanation from the operator.

2.5.6 *Oil Sands Then and Now: How the Dialogue has Changed – Janice Paskey, Mount Royal University*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start October 2012 Report will be released May 2013
Funding	$0	$0	$0	$32,430

OSRIN and the Cumulative Environmental Management Association have developed the Oil Sands Environmental Management Bibliography (http://osemb.cemaonline.ca/rrdcSearch.aspx). The Bibliography contains over 2,100 references spanning the period 1914 to 2012. Over the years oil sands issues, and the language used to describe them, have changed. In many ways the dialogue has defined how people perceive Alberta, its people, and its regulatory and environmental management record.

The researcher will select five (5) to ten (10) key environmental, social and economic issues.

For each issue, the researcher will select relevant time periods and documents from the Bibliography and other sources that will help describe the changing dialogue surrounding the issue.

For each issue, the researcher will:

- describe the issue
- identify the key participant groups involved
- describe the framing of the issue by the participant groups and media and the language used to describe it

- discuss whether and why media interest in the issue has changed over time (e.g., none, local, regional, provincial, national, international)
- discuss whether the dialogue type has changed over time (e.g., media, discussion, technical, policy, regulatory, legal) and why
- discuss whether the quality of the dialogue has changed
- discuss whether lessons from the past have been learned or forgotten

Based on the findings and personal knowledge, the researcher will provide their views on how issues and dialogue have changed over the years and what the future might hold.

2.5.7 *Review of Environmental Responsibility for Oil Sands Developments under Federal Legislation – Dr. Michael Howlett, Simon Fraser University*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	None	None	Project start October 2012 Report will be released April 2013
Funding	$0	$0	$0	$32,430

There is a well-developed understanding of environmental responsibilities for mineable oil sands developments under provincial legislation. However, a recent review of a draft oil sands research report suggests that there is less awareness of the environmental responsibilities under federal legislation.

It is important to understand how the legislation would be applied as it may affect the design and implementation of reclamation plans (for example, if a pit lake is created and then managed over time until it is deemed reclaimed then it is critical to know if the *Fisheries Act* applies during the period the lake is being managed or only after reclamation certification or not at all).

This literature review will:

- Identify the key federal legislation that applies to environmental management of mineable oil sands activities
- Describe, for each of the questions identified below:
- the applicable legislative provision and any supporting policy guidance,
- the person(s) responsible for adhering to the provision,
- how and when the responsibility to meet the provision begins,
- the project lifecycle stages (construction, operation, decommissioning, post-closure) during which the provision must be met,
- the project components that the provision applies to (e.g., mine, plant site, tailings pond, tailings disposal area, pit lake),
- how and when the responsibility to meet the provision terminates (if ever), and
- the impact (if any) of any provincial regulatory requirement(s)

At a minimum, the following questions shall be addressed:

- When are submissions to the National Pollutant Release Inventory required and from what sources are emissions considered?
- What legislation applies to water quality in pit lakes, especially if the lakes contain tailings?
- What legislation applies to water quality released from pit lakes to the receiving environment (e.g., Athabasca River or a tributary)?
- What legislation governs the potential impacts of groundwater that affects surface waters?
- Are reclaimed water bodies and watercourses subject to the Navigable Waters Protection Act?
- Are reclaimed water bodies and watercourses subject to the Fisheries Act?
- How are fish habitat compensation lakes regulated?
- Is protection of migratory waterfowl required for pit lakes, especially those containing tailings?
- How does the Species at Risk Act apply to active and reclaimed mines?
- Under what legislation and circumstances would a mineable oil sands operator be responsible for impacts to Wood Buffalo National Park or the Peace Athabasca Delta?

2.5.8 *Review of Health Effects of Naphthenic Acids – Dr. Warren Kindzierski, University of Alberta*

	2009/10	2010/11	2011/12	2012/13
Project Activity	None	Project start September 2010	Ongoing	Report released April 11, 2012 Kindzierski, W., J. Jin and M. Gamal El-Din, 2012. *Review of Health Effects of Naphthenic Acids: Data Gaps and Implications for Understanding Human Health Risk*. OSRIN Report No. TR-20. 43 pp.
Funding	$0	$18,000	$0	$0

Oil sands mining involves removal of water from the Athabasca River basin in northeastern Alberta. Water produced during the extraction of bitumen from oil sands is referred to as oil sands process water (OSPW). Information on the likelihood of human exposure to OSPW-derived naphthenic acids and toxicological (dose-response) data are needed to have a complete understanding of the human health risk of these compounds. A review of literature was undertaken as a first step in framing potential human health risk associated with exposure to OSPW-derived naphthenic acids in surface water. Specifically, this review focused on

chemical characteristics of, and potential toxicological effects related to, OSPW-derived naphthenic acids.

General Chemical Characteristics of Naphthenic Acid Mixtures in OSPW

There are several important findings of the review with regard to chemical characteristics of naphthenic acid mixtures in oil sand process waters:

- OSPW represents a complex mixture of naphthenic acids along with other organic chemicals that can also contribute to potential toxicity of the mixture.
- There is a difference in the distribution of organic compounds and their contribution to potential toxicity of OSPW that is fresh (i.e., OSPW recently produced from the oil sands extraction process) versus OSPW that is allowed to age (i.e., OSPW that has been aged for a number of years in inactive storage ponds or pit lakes). Aged OSPW contains higher molecular weight, multi-ring naphthenic acids that have been shown to be more resistant to microbial degradation and less potent in toxicity to biological organisms.
- An understanding of the forms and composition of OSPW-derived naphthenic acids and other organic compounds present in fresh and aged OSPW, and the effect of aging and aging environment on this composition, and variation in OSPW composition across oil sands processes is incomplete.

Human Exposure Evidence

OSPW-derived naphthenic acids are not used by the human population and the potential for human exposure in the oil sands region will arise from their presence in surface water or from potential future release of reclaimed OSPW to surface water. Based on the information reviewed, it was found that:

- Direct contact activities with surface water (e.g., ingestion and skin contact) represent a plausible way in which human exposure may occur to OSPW-derived naphthenic acids.
- Low water-to-air transfer properties and dilute concentrations of aged and reclaimed OSPW-derived naphthenic acids provide no meaningful scientific evidence to support the inhalation pathway as being important for potential human exposure.
- Low octanol water partition values and apparent rapid depuration of aged OSPW-derived naphthenic acids offer no meaningful scientific evidence to support the fish ingestion pathway as being important for potential human exposure to these compounds.

Toxicological Evidence

Toxicity information of interest for understanding human health risk from chemicals in the environment includes: acute toxicity, subchronic/chronic adverse responses (e.g., weight loss,

immunosuppression, etc.), neurotoxicity, developmental and reproductive toxicity, and genetic toxicity (mutagenicity and carcinogenicity).

A general finding of this review is:

- Toxicological evidence observed for commercial naphthenic acids derived from crude oils and/or commercial naphthenic acid salts will not be representative of naphthenic acids in aged and reclaimed OSPW. Higher molecular weight, multi-ring naphthenic acids, which are more resistant to microbial degradation and less potent in toxicity to biological organisms, are the forms reported to be present in aged and reclaimed OSPW.
- OSPW-derived naphthenic acids come from bitumen which is considered to be extensively biodegraded petroleum, whereas commercial naphthenic acids are typically prepared from petroleum sources that have not undergone extensive biodegradation. Therefore, potential human toxicity and corresponding human exposure limits for OSPW-derived naphthenic acids should not be inferred from studies of commercial naphthenic acids.

Acute Toxicity

Naphthenic acids found within crude oils exhibit similar oral toxicity to table salt. Acute toxicity testing in rats revealed behavioral and histopathological effects from a single administration of OSPW-derived naphthenic acids, but at a dosage 50 times a worst case environmental exposure for small mammalian wildlife. This dosage is a not realistic exposure condition that would apply to humans in the oil sands region.

Subchronic/Chronic Noncarcinogenic Toxicity

A finding of this review is:

- Based upon limited information reviewed, uncertainty remains in the understanding of toxicokinetic (fate in the body) and toxicodynamic (mode of action and dose-response) information needed to infer noncarcinogenic human exposure-related responses to naphthenic acids and other acid-extractable organics present in aged and reclaimed OSPW.

A recommendation of this review is:

- There is a need to further examine potential subchronic/chronic toxicity of naphthenic acids and other acid-extractable organics present in aged and reclaimed OSPW.

Developmental and Reproductive Toxicity

A finding of this review is:

- Based upon limited information reviewed, uncertainty remains about knowledge of developmental and reproductive toxicity of naphthenic acids and other acid-extractable organics present in aged and reclaimed OSPW.

A recommendation of this review is:

- There is a need to further examine developmental and reproductive toxicity endpoints of naphthenic acids and other acid-extractable organics present in aged and reclaimed OSPW using *in vitro*/*in vivo* bioassay testing focusing on cellular response pathways.

Genetic Toxicity

A finding of this review is:

- Based upon limited information reviewed, uncertainty remains about knowledge of genetic toxicity of naphthenic acids and other acid-extractable organics present in aged and reclaimed OSPW.

A recommendation of this review is:

- There is a need to further examine genetic toxicity endpoints (including carcinogenic endpoints) of naphthenic acids and other acid-extractable organics present in aged and reclaimed OSPW using *in vitro* genetic (micronucleus) testing and/or other suitable tests focusing on cellular response pathways.

2.6 Strategic Design

This program focuses on the development and refinement of OSRIN's strategic intent and program delivery. No work was undertaken in this program area.

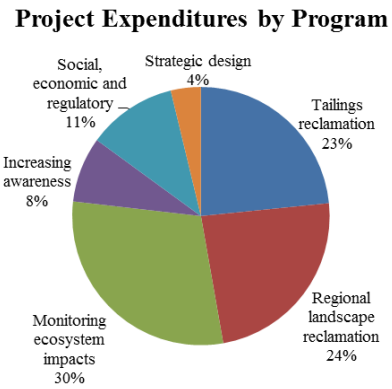
3 FINANCIAL STATUS

3.1 Revenue

During 2012/13 OSRIN received a $2,500 donation from a Calgary consulting firm.

3.2 Expenditure

In 2012/13, OSRIN spent $877,857.60 (broken down by program area and administration in the table below). The figure to the right shows the split of project funding by program from 2008 until March 31, 2013.

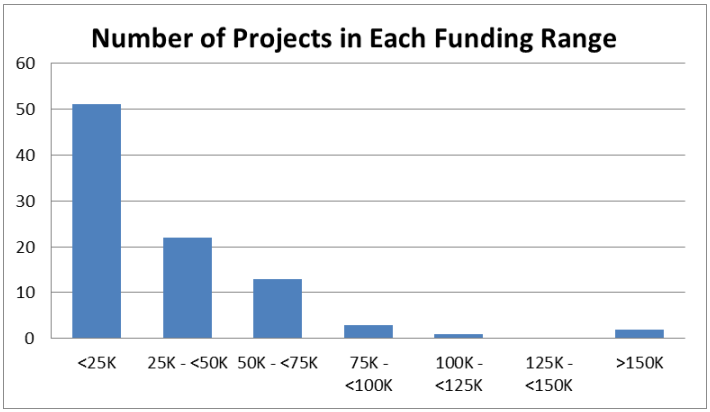


Cost Centre	$ Spent[1]	% of Total $ Spent
Tailings Reclamation	$212,176.10	24.17
Regional Landscape Reclamation	$90,955.49	10.36
Monitoring Ecosystem Impacts	$196,791.20	22.42
Increasing Awareness	$56,980.12	6.49

Cost Centre	$ Spent[1]	% of Total $ Spent
Social, Economic and Regulatory	$94,930.00	10.81
Strategic Design	$0.00	0.00
OSRIN Expenses[2]	$226,024.69	25.75
TOTAL	$877,857.60	100.00

[1] Includes grants, purchase orders, invoices and GST related to projects.

[2] Includes salaries, and travel and expenses for OSRIN staff as well as expenses directly attributable to a project or program area such as costs to host a workshop or travel to a conference sponsored by OSRIN.



Section 2 summarizes expenditures by project. As shown in the figure to the left, the majority of OSRIN projects costs less than $50,000, allowing us to undertake more research for the available budget.

3.3 Remaining Budget

At the end of March 31, 2013, total cumulative OSRIN expenditure since 2008 was $3,858,531.10. An additional $79,295.00 in outstanding commitments leaves an uncommitted balance of $858,775.98 which is available for future research work and to cover overhead.

4 FUTURE RESEARCH

OSRIN will continue to fund projects in the first five program areas during 2013/14, based on the results of current projects, advice from the Board of Directors, and discussions with other funding and research management agencies. OSRIN does not foresee work in the Strategic Design program area in 2013/14.

OSRIN notes the continuing emphasis on tailings and monitoring in the media and public policy arenas and will focus work in those areas to support regulators and industry and to improve public awareness.

Every effort will be made to co-fund projects with partners, likely by co-funding work of others. In some cases OSRIN may decide the issue is important enough that it should fund the work on its own; however, each case will be carefully examined to ensure the Board of Directors agrees the project will add value.

5 ACRONYMS USED IN THIS REPORT

AIA	Alberta Institute of Agrologists
AITF	Alberta Innovates – Technology Futures
AOP	Advanced Oxidation Processes
CEMA	Cumulative Environmental Management Association
CLPP	Community Level Physiological Profiling
CLRA	Canadian Land Reclamation Association
CONRAD	Canadian Oil Sands Network for Research and Development
ELC	Equivalent Land Capability
EPEA	*Environmental Protection and Enhancement Act*
ESAA	Environmental Services Association of Alberta
ESRD	Alberta Environment and Sustainable Resource Development
FY	Fiscal Year
HHRA	Human Health Risk Assessment
iGEM	International Genetically Engineered Machine
FTIR	Fourier Transform Infrared
LFH	Luvic-Fulvic-Humic (or Litter-Fibric-Humic)
MFSP	Mine Financial Security Program
MFT	Mature Fine Tailings
MS	Mass Spectrometry / Spectrometer
NA	Naphthenic Acid(s)
OSLI	Oil Sands Leadership Initiative
OSPW	Oil Sands Process Water
OSRIN	Oil Sands Research and Information Network
OSTRF	Oil Sands Tailings Research Facility
PTAC	Petroleum Technology Alliance Canada
QET	Qualifying Environmental Trust
RWG	Reclamation Working Group (of CEMA)
SEE	School of Energy and the Environment

VOC	Volatile Organic Carbon

LIST OF OSRIN REPORTS

OSRIN reports are available on the University of Alberta's Education & Research Archive at https://era.library.ualberta.ca/public/view/community/uuid:81b7dcc7-78f7-4adf-a703-6688b82090f5. The Technical Report (TR) series documents results of OSRIN funded projects. The Staff Reports (SR) series represent work done by OSRIN staff.

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Rooney Productions, 2012. *Assessment Methods for Oil Sands Reclamation Marshes*. OSRIN Video No. V-1. 20 minutes. Also available on the University of Alberta You Tube Channel (recommended approach).

Rooney Productions, 2012. *Assessment Methods for Oil Sands Reclamation Marshes*. OSRIN Video No. V-1. Nine-part mobile device version. Also available on the University of Alberta You Tube Channel (link to Part 1 - recommended approach).

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