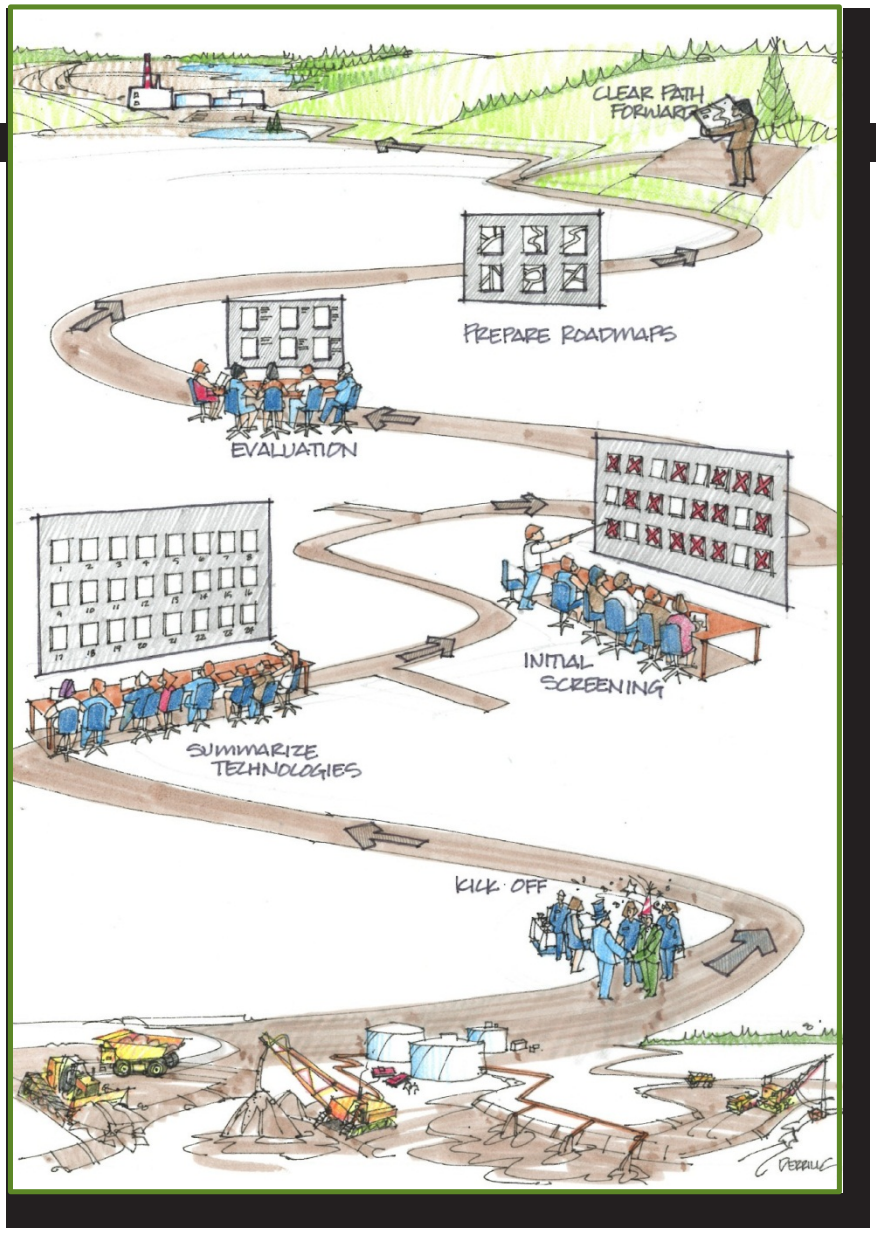
CCE SHOWCASE AWARDS

Natural Resources, Mining, Industry & Energy

- Oil Sands Tailings Technology Deployment Roadmaps



amec

BGC

Golder Associates

Klohn Crippen Berger

NORWEST CORPORATION

THURBER

UNIVERSITY OF ALBERTA

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PROJECT INFORMATION

Project Name: OIL SANDS TAILINGS TECHNOLOGY DEPLOYMENT ROADMAPS

Location: Alberta

Year Completed: 2012

Entering Firms: The Consortium of Tailings Management Consultants (CTMC): AMEC, BGC Engineering Inc., Golder Associates Ltd., Klohn Crippen Berger Ltd., NorWest Corporation, Thurber Engineering Ltd., and The University of Alberta Geotechnical Group

Role of Entering Firm: Development of the Tailings Roadmap

Contact Names: Sue Longo, Golder Associates

Client: Alberta Innovates – Energy and Environment Solutions

PROJECT OVERVIEW

Oil sands mining and tailings production have operated in Alberta for 40 years and are expected to continue at increasing rates in the coming decades. There are persistent concerns about the geotechnical risks, environmental risks, and long-term liability related to tailings production, particularly related to production, storage, and reclamation of fluid tailings.

In response to some of these concerns, Alberta Innovates – Energy and Environment Solutions, in partnership with the Oil Sands Tailings Consortium, awarded a contract to the Consortium of Tailings Management Consultants (CTMC) to undertake an integrated project called "The Technology Deployment Roadmap and Action Plan for 'End-to-End' Solutions for Oil Sands Tailings" (The Roadmap).

The main objective for this project was "…to create a technology deployment roadmap and action plan that will assist regulators and industry to create and implement technology solutions that will meet the goals of Alberta Environment's (AEW's) Draft Tailings Management Framework ERCB's [Energy Resources Conservation Board] and Directive 074."

The Roadmap initiative was to provide a framework to government and industry that would:

- Help achieve more timely deployment of the end-to-end tailings technologies,
- Share the results and knowledge gained from tailings deployment activities,
- Document the current state of tailings reclamation technology and define future technology pathways to reach the end goal,
- Serve as a basis for accessing government and industry funding to accelerate commercial-scale demonstration of technology,
- Promote sharing and technology transfer,
- Identify technology options and establish a framework for operators to conduct detailed feasibility studies and deploy technology, and allow regulators to verify the performance during this process,
- Promote a collaborative approach to oil sands tailings technology to
    - expedite technology deployment,
    - reduce environmental impacts beyond the boundaries of the mine lease, and
    - enhance public trust, and
- Provide a medium for sharing the results and knowledge of effective tailings deployment initiatives.

The CTMC is comprised of leading oil sands tailings management engineering firms and academic researchers, and was created to carry out the proposed Roadmap project. This unified team provided a forum for developing the Roadmap that was based on the best available expertise and enjoyed broad endorsement. The CTMC includes: AMEC, BGC Engineering Inc., Golder Associates Ltd., Klohn Crippen Berger Ltd., Norwest Corporation, Thurber Engineering Ltd., and The University of Alberta Geotechnical Group.

INNOVATION

To initiate the project, private and public sources were globally solicited for tailings-related technologies from all areas of mining and mineral processing. This resulted in an astonishing 549 different technologies. A summary was compiled of mining history and mine and tailings plans for all operational and proposed oil sands mines. This allowed for the identification of the major challenges facing tailings technology development, upscaling, and commercialization. Extensive research condensed the technologies to a list of 101 unique technologies categorized across different stages of development and position in the mining life cycle. Ultimately an accurate snapshot of the state of practice in 2012 was captured.

This work is virtually unprecedented in terms of the breadth of the search for technologies, the format of the technology descriptions to allow for scoring and analysis, and in the wide range of expertise and experience represented in the work. It was a monumental effort and resulted in a very sound basis for the project.

It was immediately apparent to the team that there was a range of requirements in place concerning the management and closure of tailings facilities and that traditional engineering-oriented tools for decision making were not entirely appropriate to effectively evaluate the technologies under consideration. Objective screening criteria for the assessment of the technologies were required. Over a series of workshops and meetings, the team conceived and refined the key objectives and sub-objectives used in the assessment of the technologies based on regulatory frameworks already in place along with global best practices and anticipated changes in tailings management practices. The cooperation of regulatory, owner and industry consulting organizations was a key aspect of the success of this project, and is unique to projects of this type in the industry.

Historically 'fatal flaw' or KT analysis were used to assess different technology options based usually on technical merit; however, it was decided that a more thorough and thus more complex evaluation process was required to accurately understand what the different technologies could bring to the table. An evaluation tool was built using the sustainability elements of technical, environmental, social, and economic factors. Within each element a list of specific criteria was developed with descriptors to define each along with a scoring, ranking and weighting system to quantitatively and qualitatively evaluate the technologies across the sustainability elements. This type of tool and process was a new development in the oil sands industry and allowed for objective evaluations to be completed that identified the strengths and weaknesses of each technology.

Ingenuity was required to synthesize the large volume of information and organize it into development and deployment roadmaps to meet certain technical and environmental objectives. A technology development model was created to define what the industry thought of as "standard" research and development processes, but which, in reality, had as many variants as proponents. The development model allowed for a powerful visualization of different processes and technology's place within that process.

This project was extremely high profile within the industry, government, and public spheres, and provided numerous challenges from the inception of the request for proposal. The two key overlying challenges through the life of the project were the data and the team itself.

Data Challenges

The project encompassed a wide range of technologies and their respective stages of development. These unique technologies spanned seven different stages of the mining life cycle, each with their own technical focuses, drastically different economic impacts, and a range of environmental and social implications.

The evaluation objectives were often in competition with one another, resulting in complex project decisions. Data quality was also a difficult challenge as it was necessary to determine what part of the information provided by third parties was solid and defensible (versus rhetoric or unfounded promises). A method for assessing the data quality was developed and became part of the evaluation tool. It was presented with the evaluation results for each technology. Issues routinely dealt with were:

- Protecting IP,
- Remaining impartial to all technologies,
- Calibration of the specific criteria to the overarching regulatory and project goals identified,
- The sheer volume and wide range of reporting styles and definitions,
- Evaluating the benefits and risks of technologies (due to the stage of development or state of knowledge, there was much uncertainty in technical and environmental performance even at a commercial scale), and
- Trying to predict future development pathways with little extrapolative data.

Organizational Challenges

Broad input was obtained for each component to compile the technology lists, set the objectives, complete the evaluations, and develop the Roadmap. It was critical to involve multiple disciplines across industry, government, universities, and consultants including technical people and those with an environmental, social and financial focus. This ensured that the execution of the project and the results were not skewed in any direction to the detriment of other considerations. It was a challenge to balance subject matter experts in the evaluation teams across the multiple technical areas such as extraction, tailings deposition, water treatment, environmental, and financial.

The best model would bring together recognized experts with multiple years of experience. The challenge here concerned the complexity around managing multiple and often conflicting opinions of different experts and stakeholders (industry, regulators, and technology proponents) and scheduling senior personnel for multiple face-to-face meetings over the 12 month project duration.

SOCIAL AND ECONOMIC BENEFITS

Government and industry initiated this Roadmap and action plan for "end-to-end" solutions for oil sands tailings as part of a broader strategy for sustainable management, and to provide important social and economic benefits. The project's objective was to provide a strong basis for cooperation and sharing by oil sands companies to help aid in the reduction of technological duplication, inspire increased spending on research, and reduce ineffective investments.

It is widely recognized that the oil sands industry fuels Alberta's economy and represents the principal economic stimulus for development of communities in Northern Alberta. Without an economic solution to the problem of tailings ponds in the environment of northern Alberta, continued operation and future developments could certainly be at risk. Development of the Roadmap was an essential element in preserving the oil sands industry's social licence to continue operation.

Successful execution of the Roadmap proved to be an important factor contributing to information sharing, open and honest communication, and joint funding of tailings research initiatives. The project involved many interactive meetings with industry, government, academia and consulting engineering firms. The meetings facilitated a variety of interactions ranging from presentations of research findings, assessment of project deliverables, discussion of tailings technologies and debates on the worthiness of research initiatives.

The project delivered on its original objectives, but just as importantly, it delivered an integrated community of industry specialists with a shared objective of finding solutions to preserve a vibrant provincial economy and stimulus for local community development in Northern Alberta and other communities across Canada.

A sustained provincial economy and stimulated social development will justify unifying the pursuit of tailings management solutions of which this project represents an important element.

ENVIRONMENTAL IMPACT

The principal objective of the Roadmap project was improved environmental stewardship relating to the restoration of a productive terrestrial resource without harm to the aquatic environment. This initiative illustrates a common commitment to improving the environmental performance of oil sands mines by avoiding unnecessary diversion of fresh water, storage of process water and fluid tailings, and development of tailings ponds.

Joint effort by industry, academia, government and the private sector would replace existing tailings ponds with a dry landscape supporting terrestrial ecosystems and with productive wetlands ecosystems, while reducing the import of fresh water and eliminating large inventories of process water and fluid fine tailings.

Driven by a strong environmental imperative, this project considered 'end-to-end' solutions implying a broadly based technology assessment that took account of the stage of mine development from green field to mine closure including mine planning, plant processes (extraction and froth treatment), water re-use and treatment requirements, water inventories, potential water releases, environmental impacts, air emissions, reclamation requirements, and future vegetation establishment on a trafficable surface. This is in compliance with Alberta's Tailings Management Framework that requires:

- Oil sands mine areas be returned to productive, sustainable public lands
- Treatment of fluid fines tailings achieve progressive tailings reduction targets during mining
- Tailings management and reclamation knowledge and technologies be shared
- Credible and balanced communications to raise public awareness related to improved tailings management

RESULTS

The main project goal was to "create a technology deployment roadmap and action plan that will assist regulators and industry to create and implement technology solutions that will meet the goals of Alberta Environment's (AESRD) Draft Tailings Management Framework (TMF) and ERCB's Directive 074."

The TMF and Directive 074 provide the basis for long-term tailings management goals in the oil sands. The Roadmap has described the 'what' (technologies) and the 'when' (timeline for life cycle development) that are needed to get there. The 'how' has still to be determined through research efforts and operational changes or improvements.

One major contribution is that the Roadmap has confirmed once and for all that there is no "silver bullet" solution to the oil sands tailings problem. It has also identified promising new technologies that will require research and development efforts to bring to a commercial stage along with key performance improvement opportunities for existing technologies.

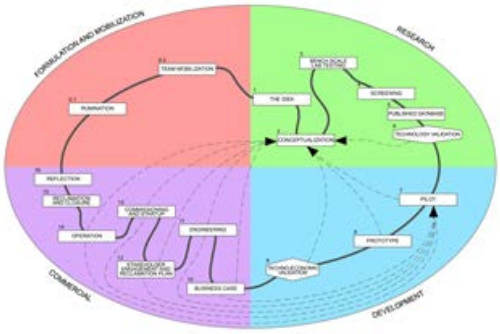
Regulatory agencies were involved during the development of the Roadmap and the identification and evaluation of the new technologies. In the effort they will have acquired a solid basis of understanding throughout the life cycle development of these technologies, which in turn can and will help drive the changes to regulations over time. In addition, areas of growing concern such as water treatment and storage and release of process-affected water have been flagged for regulators to start considering.

Industry now has a comprehensive "options identification plan" that can be applied to site-specific circumstances. The Roadmap will also help coordinate future efforts as companies combine forces to investigate priority research and development projects while minimizing duplication.

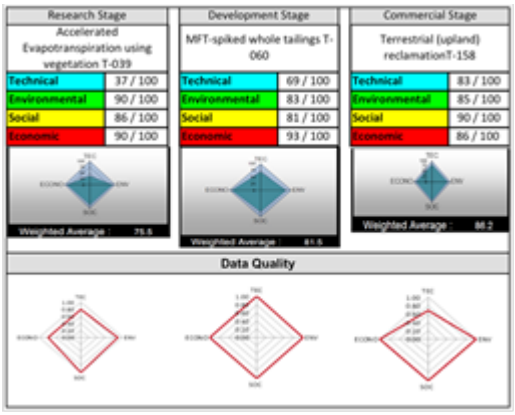
Perhaps the biggest aspect of the Roadmap's success was the cooperation and transparency achieved among industry, government, consultants, and third parties. The productive interdependence of all parties clearly demonstrated that the path to success will be achieved through partnerships.

> *"The Roadmap was a successful piece of work that involved extensive and uncommon collaboration among consultants and their clients."*
>
> – Rick Nelson, Alberta Innovates – Energy and Environment Solutions

PHOTOS



The Roadmap generic model schematic



The evaluation tool created to identify the strengths and weaknesses of each technology

The evaluation team hard at work during one of the work shops

Goal: mining from fine fluid to storage closure and reclamation

CANADIAN CONSULTING engineer

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

ENTRY CONSENT FORM
CANADIAN CONSULTING ENGINEERING AWARDS 2013

INSTRUCTIONS

This Entry Consent form must be signed by someone from the entering firm(s) and also by the client and/or owner of the project.
The completed form must be attached at the front of the Project Entry Binder.

PROJECT NAME & LOCATION OIL SANDS TAILINGS TECHNOLOGY DEPLOYMENT ROADMAPS

Alberta, Canada

1. TO BE COMPLETED BY AN INDIVIDUAL SIGNING ON BEHALF OF THE ENTERING COMPANY (COMPANIES)

I (We) confirm that this entry complies with the contest rules and that the information submitted is accurate.

I (We) also agree to accept as final the decision of the panel of jurors.

Name Sue Longo

Position Associate / Mechanical Engineer

Company Golder Associates Ltd.

Address 102, 2535-3 Ave S.E.

City Calgary Province Alberta Postal Code T2A 7W5

Tel. 403-387-8483 E-mail SUE_LONGO@GOLDER.COM

Signed Sue Longo Date April 17, 2013

2. TO BE COMPLETED BY PROJECT OWNER

I (We) agree with and support the entry of the above project into this awards program, and the release for publication of the information supplied.

Name Sue Longo

Position Associate / Mechanical Engineer

Company or Organization Golder Associates Ltd.

Address 102, 2535-3 Ave S.E.

City Calgary Province Alberta Postal Code T2A 7W5

Tel. 403-387-8483 E-mail SUE_LONGO@GOLDER.COM

Signed Sue Longo Date April 17, 2013

CANADIAN CONSULTING engineer

ASSOCIATION OF CONSULTING ENGINEERING COMPANIES | CANADA
ASSOCIATION DES FIRMES D'INGÉNIEURS-CONSEILS | CANADA

ENTRY CONSENT FORM (continued)
Canadian Consulting Engineering Awards 2013

3. TO BE COMPLETED BY ENTERING FIRM'S CLIENT (If not the same as the Project Owner)

I (We) agree with and support the entry of the above project into this awards program, and the release for publication of the information supplied.

Name _____

Position _____

Company or Organization

Address _____

_____

City _____ Province _____ Postal Code

Tel. _____ E-mail

Signed _____ Date _____

4. TO BE COMPLETED BY ENTERING FIRM, PROJECT OWNER, ENTERING FIRM'S CLIENT

PERMISSION TO PUBLISH THE PROJECT ON CCE'S WEBSITE

After the awards have been announced, would you be willing to have *Canadian Consulting Engineer* magazine publish your entire Project Entry in an archive on its publicly accessible Web site www.canadianconsultingengineer.com? (Publication on this CCE archive would be for all entered projects, not just the winners.)

ENTERING FIRM	PROJECT OWNER	ENTERING FIRM'S CLIENT
L No x Yes	L No x Yes	L No L Yes
Signed _____	Signed _____	Signed _____

PLEASE ATTACH THIS SIGNED FORM IN THE FRONT OF THE PROJECT ENTRY BINDER.

Send Project Entry Binders to:
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PRINT

From: entryForm@bizinfogroup.ca
To: Coquet, Pamela
Subject: CCE Entry Form -- Oil Sands Tailings Technology Deployment Roadmaps-- DO NOT REPLY
Date: Tuesday, April 16, 2013 4:19:48 PM

Project Name:	Oil Sands Tailings Technology Deployment Roadmaps
Project Location:	Calgary, Alberta
Completed By:	0 2012
Category:	E. Natural Resources, Mining, Industry & Power
Entering Firm Name:	The Consortium of Tailings Management Consultants
Firm Address:	102, 2535-3 Avenue S.E., Calgary, Alberta T2A 7W5
Project Role:	Development of the Tailings Roadmap
Member of the (ACEC)?:	Yes
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Contact 3 Email:	Sue_Longo@golder.com
P.Eng:	Yes

Summary:
The Consortium of Tailings Management Consultants, led by Golder Associates Ltd., was contracted by Alberta Innovates – Energy and Environment Solutions and the Oil Sands Tailings Consortium to create a technologies deployment roadmap and action plan. The purpose of the plan was to assist government and industry to understand the available technologies, achieve more timely deployment of end-to-end tailings solutions, and develop a sustainable management plan for the oil sands industry.

Innovation:
To initiate the project, private and public sources were solicited for tailings technologies from all areas of mining and mineral processing globally. This resulted in an astonishing 549 different technologies. These were condensed to a list of 101 unique technologies that set a framework for the stage of technology development, position in the mining cycle, and ultimately captured the state of practice in 2012. This work is virtually unprecedented due to the breadth of the search for technologies, the format of the technology descriptions to allow scoring and analysis, and for the wide range of expertise and experience that went into the work. It was a monumental effort, and resulted in a sound basis for the project. Objective screening criteria for the assessment of the tailings technologies were required for this project. To develop them, the team was able to draw on the combined resources of the consulting consortium team and the client organizations including a broad range of government and industry stakeholders. Over a series of workshops and meetings these groups conceived and refined the key objectives and sub-objectives used in the assessment of the technologies. The participation of regulatory, owner, and industry consulting organizations was a key aspect of the success of this project and was unique to projects of this type in the industry. Historically 'fatal flaw' or KT analysis had been used to asses different technology options based usually on technical merit; however, it was decided that a more thorough and thus more complex evaluation process was required to accurately understand what the different technologies could bring to the table. An evaluation tool was built using sustainability elements and technical,

environmental, social, and economic principles. Within each element a list of specific criteria was developed with descriptors to define each one along with a scoring, ranking and weighting system so each technology could be quantitatively and qualitatively evaluated across the sustainability elements. This type of tool and process was not previously available in the oil sands industry. Ingenuity was required to synthesize the large volume of information and organize it to meet certain technical and environmental objectives into development and deployment roadmaps. A technology development model was created to define what the industry thought of as “standard” research and development processes, but which in fact had as many variants as proponents. The development model allowed for a powerful visualization of different processes and technology’s place within that process.

Complexity:

This project was high profile within the industry, government, and public spheres, and presented numerous challenges from the inception of the proposal. The two key overlying challenges through the life of the project were the data and developing and organizing the team itself. Volume/Range of Data Challenges: A key theme throughout the project was the wide range of technologies under consideration and their respective stages of development. These unique technologies spanned seven different stages of the mining life cycle and each had different technical focuses and drastically different economic, social, and environmental impacts. The evaluation objectives developed were more often than not competing against one another, resulting quite complex project decisions. Issues routinely dealt with were: • Protecting IP • Remaining impartial to all technologies • Calibration of the specific criteria to the overarching goals identified • The sheer volume and wide range of reporting styles and definitions Organizational Challenges: Broad input was obtained for each component to compile the technology lists, set the objectives, complete the evaluations, and develop the Roadmap. It was critical to involve multiple disciplines across industry, government, universities, and consultants including technical people and those with an environmental, social and financial focus. The best model would bring together recognized experts with multiple years of experience. The challenge here concerned the complexity around managing multiple and often conflicting opinions of different experts and stakeholders (industry, regulators, and technology proponents) and scheduling senior personnel for multiple face-to-face meetings over the 12 month project duration.

Social & Economic Benefits:

The Roadmap and action plan for “end-to-end” solutions for oil sand tailings was an initiative of both government and industry as part of a broader strategy of sustainable management of the oil sands industry that would provide important social and economic benefits. The project’s objective was to provide a strong basis for cooperation and sharing by oil sands companies and help aid in the reduction of technological duplication, inspire increased spending on research, and reduce ineffective investments. It is widely recognized that the oil sands industry fuels Alberta’s economy and represents the principal economic stimulus for development of communities in Northern Alberta. Without an economic solution to the problem of tailings ponds in the environment of northern Alberta, continued operation and future developments could certainly be at risk. Development of the Roadmap was considered to represent an essential element in preserving the oil sands industry’s social licence to continue operation. Successful execution of the tailings roadmap proved to be an important factor contributing to information sharing, open and honest communication, and joint funding of tailings research initiatives. The project delivered on its original objective, but equally as important, it delivered an integrated community of industry specialists with a shared objective of finding solutions to preserve a vibrant provincial economy and stimulus for local

community development in Northern Alberta and other communities across Canada. A sustained provincial economy and stimulated social development will testify to the benefits of unifying for the pursuit of tailings management solutions, of which this project represents an important element.

Environmental:

The principal objective of the Roadmap project was improved environmental stewardship relating to the restoration of a productive terrestrial resource without harm to the aquatic environment. The initiative illustrates a common commitment to improving the environmental performance of oil sands mines by avoiding unnecessary diversion of fresh water, storage of process water and fluid tailings, and development of tailings ponds. The joint effort by industry, academia, government and the private sector would replace existing tailings ponds with dry landscape supporting terrestrial ecosystems and with productive wetlands ecosystems while reducing the import of fresh water and eliminating large inventories of process water and fluid fine tailings. Driven by a strong environmental imperative, this project considered 'end-to-end' solutions implying a broadly based technology assessment taking account of the stage of mine development from green field to mine closure including mine planning, plant processes (extraction and froth treatment), water re-use and treatment requirements, water inventories, potential water releases, environmental impacts, air emissions, reclamation requirements and future vegetation establishment on a trafficable surface in compliance with Alberta's Tailings Management Framework that requires: • Oil sands mine areas being returned to productive, sustainable public lands • Treatment of fluid fines tailings to achieve progressive tailings reduction targets during mining • Sharing of tailings management and reclamation knowledge and technologies • Public awareness through credible and balanced communications related to improved tailings management

Client Needs:

The successful completion of the project met the criteria set out by the clients and achieved other benefits. The Roadmap confirmed once and for all that there is no "silver bullet" solution to the oil sands tailings problem. It identified key performance improvement opportunities for existing technologies, and promising new technologies that will require research and development efforts to bring to the commercialization stage. In addition, areas of growing concern such as water treatment and storage and release of process-affected water were flagged for regulators to consider. Regulatory agencies were involved during the development of the Roadmap and in the identification and evaluation of new technologies. In doing so, they gained a solid basis of understanding of the impending life cycle development of these technologies, which in turn will help drive regulatory changes over time. Industry has been provided with a comprehensive "options identification plan" that can now be applied to site-specific circumstances. The Roadmap will also help coordinate future efforts as companies combine forces to investigate priority research and development projects, and minimize duplication. Perhaps the biggest success was the cooperation and transparency among industry, government, consultants, and third parties. This clearly demonstrated the interdependency of all parties and how future success will be achieved. "The roadmap study was a successful piece of work that involved extensive and uncommon collaboration among consultants and their clients." – Rick Nelson, Alberta Innovates – Energy and Environment Solutions