Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation

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EXECUTIVE SUMMARY

On June 25, 2018, InnoTech Alberta, the Environmental Services Association of Alberta and Alberta Economic Development and Trade co-hosted a workshop entitled *Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation* at the McDougall Centre in Calgary. The purpose was to identify potential solutions to facilitate reclamation for the current backlog of approximately 167,500 oil and gas wellsites in Alberta that have yet to be reclaimed. These sites are at various stages in the asset retirement process, which includes well decommissioning and 'ARR' activities including environmental assessment, remediation (if required), and reclamation. Activities in the ARR process account for much of the time and cost of retiring assets; hence, enhancing efficiency has the potential to reduce costs and shorten timelines for reclamation, while supporting the environmental services sector and driving development of technology.

The goal of the workshop was to create a forum to identify high priority solutions that could be championed through the province's research and innovation system. The objectives of the workshop were to:

1. Articulate challenges related to the ARR process and how they could be addressed to more efficiently move sites toward full reclamation (closure).
2. Identify and harness the expertise of ARR stakeholders to identify potential innovative solutions to high priority challenges.
3. Foster collaboration amongst stakeholders to address system-wide challenges.

The event brought together a diverse group of 45 stakeholders including 8 members of the upstream oil and gas industry, 6 from the provincial government, 15 environmental consultants, 4 environmental service providers, 5 academics and researchers, and 7 technology developers. Geographically there were participants from Alberta, British Columbia, Quebec, and New Brunswick; several with international experience. The interactive workshop sought to identify challenges and bottlenecks in the ARR process from various perspectives, with the goal of full reclamation and site closure.

Key challenges in various stages of the ARR process were identified. Participants noted many reasons that initial assessments are not undertaken, including a lack of incentive, a culture of avoidance, high or unpredictable costs associated with completing activities, difficulty prioritizing sites and activities, and risk that expensive remediation may be required based on what was found during assessments. Through the Phase 1 and 2 stages, low budgets leading to poor quality information; missing records; site access challenges (seasonal); data and risk assessment complexity; excessive sample analysis requirements; time and cost of completing reporting; and, turnaround time required for reporting resulting in delays, were identified as challenges. Where remediation was required, limited options for soil remediation; high cost; unsustainable practices and greenhouse gas emissions due to trucking; and, challenges in meeting remediation guidelines, were all flagged. Challenges at the reclamation stage were identified as stringent regulatory requirements (select cases); need for repeat justification for non-routine applications; ongoing weed control; and, costs of ongoing monitoring.

Recommendations to address these challenges were focused on making it easier to begin and carry out all stages of the ARR process to lower costs, shorten timelines, increase sustainability, and reduce the risk of not achieving closure requirements. Specifically, there were recommendations to focus efforts on sites with higher risk, with streamlined processes to justify minor exceedances or reclamation deficiencies; to enhance planning and intra- and inter-company collaboration opportunities; to facilitate long-term

strategy; to align corporate budget cycles to allow efficient ARR planning; to develop cost-effective remediation options; to shorten reclamation time frames for faster return on investment; and in some cases, to develop more realistic guidelines or a streamlined process for assessing risk on a site-specific basis.

At the regulatory level, changes are ongoing to support and enhance efficiency of various aspects of the ARR process. Therefore, while initiatives can be championed through the province's research and innovation system, government, industry and private sector collaboration are required for success. The following recommendations were developed to guide potential technology and process innovation to address regional, field-scale and site-level challenges.

At the regional or provincial level, enhanced **Strategic Planning** could be supported through a digital platform with up-to-date data for informed decision making and prioritizing areas for closure in the province. It is anticipated that this platform would allow the ability to analyze various scenarios, and would therefore include financial, time, sustainability and logistics data. Recommendations for next steps in the Strategic Planning category are:

a. **Define User Needs**: Identify potential users of such a platform, and determine, in collaboration, what information, business processes, and data types need to be gathered, processed and tracked.
b. **Technology Scan:** Determine whether technologies exist that could be adapted to meet the needs identified in the user needs assessment.
c. **Pilot**: Evaluate platform functionality to support effective decision making and plan multi-year closure programs, and ability to interface with other existing systems (e.g., Alberta Energy Regulator's OneStop system).

Systems and technologies for **Optimizing Operational Logistics** were recommended to facilitate intra- and inter-company collaboration, make best use of equipment and staff to support the environmental services sector, and to coordinate resource use. Centralized soil treatment facilities and/or soil banks were identified as a key potential innovation in this category, as were opportunities in business innovation to support licensees. Recommendations for next steps in the Strategic Planning category are:

a. **Technology Scan or Challenge**: Conduct a technology scan to determine what available technologies are available to facilitate process streamlining and collaboration, or develop a defined challenge for technology developers.
b. **Pilot:** Conduct a retrospective pilot with available operations data from industry member(s) or associations to validate potential efficiencies through a collaboration platform or other process optimization tool(s).
c. **Business Case:** Assemble and support a team to create a business case for one or more soil treatment facility or soil bank concepts.

Finally, **Supporting Best Practices for Assessment, Remediation and Reclamation** through a coordinated research and innovation program, tied in with regulatory enhancements, was recommended to more efficiently move sites through the ARR process. Recommended next steps related to Supporting Best Practices for Assessment, Remediation and Reclamation are:

a. **Gap Analysis**: Identify and prioritize research needs in support of effective ARR, including technology, science, and process optimization.
b. **Review**: Determine where information is currently housed on applied research or risk justification for taking various approaches to managing risk for contaminated sites. Explore the need for an

information repository including case studies and peer reviewed best practices and identify a suitable organization to host and maintain such a repository, if a need is identified.

Collaboration in driving forward the proposed next steps is welcome and necessary; those with ideas or suggestions may contact Simone Levy, Reclamation Researcher at simone.levy@innotechalberta.ca.

TABLE OF CONTENTS

TABLES

FIGURES

Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation

SIMONE LEVY AND MARIAN WEBER

1. INTRODUCTION

On June 25, 2018, InnoTech Alberta, the Environmental Services Association of Alberta and Alberta Economic Development and Trade co-hosted a workshop entitled *Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation* at the McDougall Centre in Calgary (Appendix A). The event brought together a diverse group of 45 stakeholders including 8 members of the upstream oil and gas industry, 6 from the provincial government, 15 environmental consultants, 4 environmental service providers, 5 academics and researchers, and 7 technology developers (Appendix B). Geographically there were participants from Alberta, British Columbia, Quebec, and New Brunswick; several with international experience. The interactive workshop sought to identify challenges and bottlenecks in the Assessment, Remediation and Reclamation (ARR) process and identify potential (non-regulatory) solutions.

While the asset retirement process includes more than ARR activities, this portion of asset retirement can be costly, logistically complicated and time intensive. Industry members and environmental service providers feel that the complexity of the process and intensive management required are part of the reason for the current backlog of approximately 167,500 oil and gas wells which are at various stages of the ARR process in Alberta (AER, 2018; OWA, 2018). ARR is the bread and butter of Alberta's environmental services industry, which is highly technical in nature. Remediation and reclamation are big business in Alberta with $1.1B in annual capital and operating expenditures from oil and gas producers spent annually (Statistics Canada, 2014), and this supports many of the over 1,600 environmental service companies that operate in the province.

A 'stress test' conducted in 2017 by the C.D. Howe Institute (C.D. Howe, 2017) reported potential unfunded liabilities of over $8.2B for well decommissioning and site reclamation costs associated with the obligations of licensee companies at risk of insolvency. The total cost to industry for addressing the current backlog is far greater. Industry and government stakeholders realize that the way asset retirement and *specifically* ARR activities have been conducted over the past decades will not achieve environmental, social or reclamation goals without *prohibitive cost*. Strategic regulatory initiatives and operational reform are needed to address the backlog and manage the ARR process more effectively into the future. As potential liabilities continue to grow there is an opportunity to proactively address these challenges. Moreover, significant export potential exists if major industry and regulatory advances are made, as jurisdictions all over the world are grappling with contaminated site issues.

1.1 THE ASSESSMENT, REMEDIATION AND RECLAMATION OPPORTUNITY

A simplified diagram of the current asset retirement process, including the ARR process, is shown in Figure 1 (adapted from AEP, 2016). Activities within the ARR process can involve desktop assessments; environmental assessments including soil and water sampling, and installation of groundwater monitoring wells; repeat monitoring; deployment of heavy equipment; import, export, and disposal of soil; remediation of contaminated soil or water; weed control; reclamation activities; and, generation of multiple reports and applications. The process of taking a site from a decommissioned well state to final

reclamation spans a minimum of 2 to as many as 20 years (OWA, 2013). Factors that influence both the time and cost to achieve regulatory closure include whether or not there is soil or groundwater contamination, and to what extent; the age of the site and how it was constructed; what the well produced; how the site was managed; and, both human and capital resources dedicated to moving sites through the ARR stages.

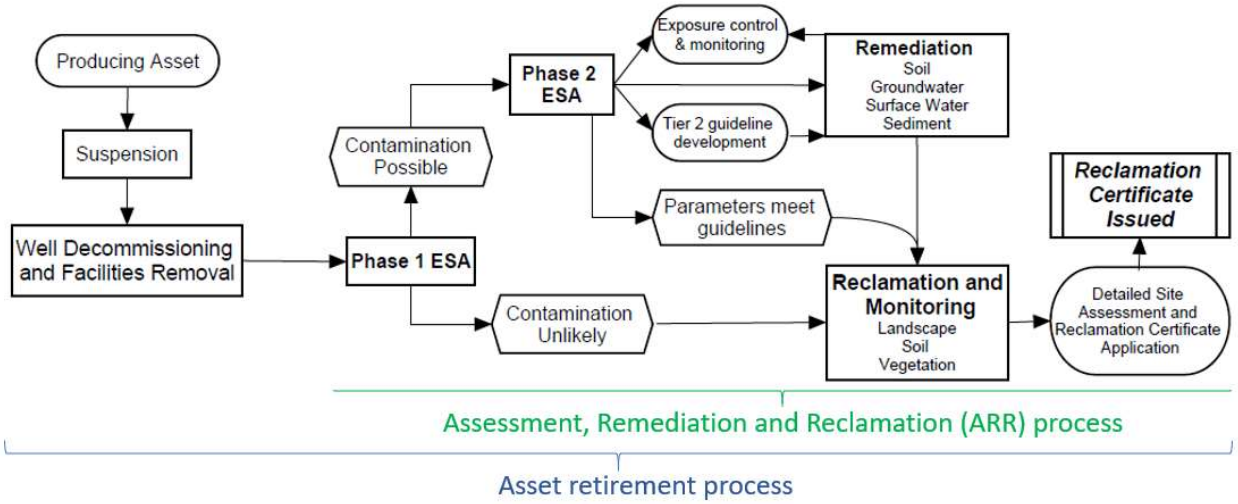

Figure 1. Overview of the steps involved in the asset retirement process, highlighting those activities in the ARR process that are the focus of this document (adapted from AER, 2016; ESA = environmental site assessment).

"Can we harness the innovation system to more efficiently address the backlog of sites, support licensees, and develop exportable processes and technology?"

With current developments in *technology platforms, tracking systems, machine learning and remote monitoring technologies*, there are many potential avenues for developing tools that can help industry operate more efficiently and effectively, assist in protecting and restoring ecological integrity, reduce greenhouse gas emissions, and improve Alberta's bottom line. Additional benefits may include improved public and stakeholder perception of the upstream oil and gas industry, economic diversification, potential for application to other provincial high-volume asset management industries, and technology export. Potential partners and beneficiaries from a streamlined ARR system range from small energy producers to international players, equipment and service providers, environmental and engineering consultants, waste management companies, and software and digital service/data providers.

1.2 WORKSHOP OBJECTIVES

The workshop evolved from industry consultations on challenges in ARR by InnoTech Alberta in 2018 (InnoTech Alberta, 2018). The goal of this workshop was to bring together parties from the environmental services industry, regulators, government and other stakeholders in one forum to identify high priority innovations that could improve ARR and be championed through the province's research and innovation system. The objectives of the workshop were to:

1. Articulate challenges related to the ARR process and how they have contributed to liability status in Alberta.

2. Harness expertise of ARR stakeholders to identify potential innovative solutions to high priority challenges.
3. Foster collaboration amongst stakeholders to address system-wide challenges.

1.3 WORKSHOP STRUCTURE

The workshop included a panel of 3 speakers from industry who framed ARR challenges and the current state from social, economic, and environmental perspectives. Questions were designed to update workshop participants on political and regulatory status of the liability situation in Alberta, and to provide examples of overcoming systemic challenges in other industries (e.g., forestry). The panelists brought perspectives on financial/economic, social and environmental implications of the liability situation. Details from the panel discussion are provided in Appendix C.

This was followed by break-out sessions to further refine the group's understanding of the challenges and their drivers. Three speakers then presented innovative approaches to planning and collaboration, technologies to facilitate activity streamlining, and opportunities to better manage soils from contaminated sites. A final break-out session was used to brainstorm possible solutions to challenges in the ARR process that could be addressed through research and innovation.

Break-out groups were divided into designated 'innovation challenge categories', as follows: 1) Soil as a Resource, 2) Managing Contaminated Sites, 3) Activity Streamlining, 4) Portfolio Strategy and Risk Assessment, 5) Data Capture and Management. The best 'solution' for each group was developed into a "Dragon's Den"-style pitch that was presented to a panel of expert "Dragons" who provided feedback to the teams on the strengths of each proposal, with the goal of winnowing down a list of high priority innovations that could assist companies in the ARR process and be championed and/or taken to the next stage by participants.

2. BACKGROUND

2.1 UPSTREAM OIL AND GAS ASSET RETIREMENT IN ALBERTA

From 2014 to 2017, Alberta experienced the worst recession in a generation, leading to solvency challenges for many companies in the upstream oil and gas industry. The cyclical pressure is magnified by the adverse effects of the Redwater[1] decision, which have created incremental uncertainty and risk to the Orphan Well fund. Concerted effort is being made by Government, the AER and industry to identify and advance opportunities to enhance the current liability management system to ensure that decommissioning and reclamation costs are addressed by site owners in a timely manner. For their part, the Canadian Association of Petroleum Producers (CAPP) is focused on three strategic areas to support producers in actively addressing their legacy assets in a risk-informed and cost-efficient manner. These include:

- A greater focus on inactive site closure (i.e., sites with wells that no longer produce);
- A modernized liability management program to enable more selective risk-mitigation from operators that have the potential to go defunct; and
- The creation of a well assurance fund (or Legacy Fund).

The ability for producers to plan for the costs of site decommissioning and reclamation has also been identified as a challenge. On average throughout the province, the cost to decommission and reclaim a site varies greatly, but ranges between approximately $50,000 and $300,000 based on calculations from the Orphan Well Association (OWA, 2013) and estimates made by consultants and industry environmental coordinators. However, liability estimates for reclamation in Directive 11 (AER, 2015) range from $16,500 to $42,125 throughout the province. These estimates, if relied upon for planning purposes, leave producers short of funds to complete site remediation (if required), and reclamation. Remediating soil and groundwater can be a large cost for which many licensees may not be prepared, presenting a major risk in the ARR process (XI Technologies, 2018).

> *"The source of the greatest discrepancy between [licensee liability rating (LLR)] and [true asset retirement costs] is remediation, within the general term 'reclamation'. The biggest reason for this discrepancy is that LLR is not designed to account for contamination, including both the assessment and remediation of impacted materials. Other influencing factors include large pads and revised vegetation standards introduced in the mid-1990s."*

Timelines to take sites through the process have been logged, on average, at 8 to 13 years in agricultural, grassland and forested areas, and between 11 and 20 years for peatland sites (OWA, 2013). A portion of the sites cannot meet closure criteria and remain in risk management or monitoring status indefinitely. Extended timelines result in a delay in a licensee's return on investment dollars in earlier stages, with a risk that liability will not be reduced through receipt of a reclamation certificate if the site does not meet

[1] Redwater Energy, a small Alberta oil company, entered creditor protection in 2015. The lender wanted to sell properties of value to pay creditors, rather than use proceeds of the sale to decommission and reclaim the wellsites. In May 2016, the Alberta Court of Queen's Bench ruled in favour of the bankruptcy trustee that represented Redwater Energy Corp. Under the ruling, profits from the sale of assets would go first to creditors — not towards decommissioning and reclamation of its inactive sites. This case has subsequently been appealed to the Alberta Court of Appeal and in February 2018 to the Supreme Court of Canada, decision pending as of October 2018.

requirements. Further, these unreclaimed sites account for a portion of the human footprint in the province, of which the oil and gas sector accounts for approximately 10% (ABMI, 2016).

2.2 Addressing Potential Outcomes

While there is a desire on the part of licensees and numerous other stakeholders to resolve the liability situation in the province and responsibly manage oil and gas assets, there are several potential drivers which will be important for informing ongoing and future efforts at the system level. Key performance indicators, or measures of success in addressing this liability, may be considered through four potential outcomes:

1. Social – improving social license for the petroleum industry; generating employment; improving public relations for government as well as industry; minimizing potential risk to taxpayers and the public.
2. Financial/Economic – reducing liability and costs for companies; growth of the environmental service sector and potentially the waste management sector; supporting the petroleum industry as a driving force behind Alberta's economy.
3. Environment – reclamation of disturbed land; returning habitat and functioning ecosystems.
4. Innovation – world leadership in resource management; developing 'clean tech'.

> *"The workshop is an opportunity to understand the complexity of the ARR stages of asset retirement. It will be an opportunity to share successes and ideas, vent frustration, find synergy and common ground with others, and leverage the innovation system and the environmental services sector to find solutions."*

These potential outcomes in addressing the liability situation were consistent themes in the discussions around potential improved processes.

3. CURRENT STATE AND CHALLENGES

A simplified, linear 'ARR Process' diagram (Figure 1) was drawn on a large roll of paper that was attached to the wall. Participants were separated into groups to discuss what they perceived as bottlenecks and challenges in the ARR process when managing a group of approximately 20 sites. The goals of the exercise were: 1) to allow all participants to understand the process and related nuances (i.e., challenges in different parts of the province, stakeholder involvement, differences in approach between licensees, regulatory requirements), and 2) to identify perceptions, challenges and bottlenecks that contribute to licensee and stakeholders' difficulties in moving sites through the ARR process.

3.1 CHALLENGES AND BOTTLENECKS IN THE ARR PROCESS

Comments placed along the Figure 1 process diagram were discussed with the group. The ARR process was interpreted to be much more complex than it appears on the surface – hence the 'obstacle course' theme presented in Figure 2. Challenges in addressing contaminated sites were highlighted, as many decisions need to be made through the process; there are multiple stakeholders and parties involved; and, often there is real or perceived financial risk that can stall the process. While the overarching goal of the workshop was to identify opportunities for new or adapted *planning processes and technologies* to improve integration between different stages of the upstream oil and gas asset retirement process, all challenges were welcome in the discussion.

The values of the group for effectively managing asset retirement were identified as:

- Ensure responsible spending and value for money (return on investment);
- Use talent resources efficiently, and include the environmental services sector in high level decision making;
- Responsible natural resource management (e.g., soil, habitat, greenhouse gas emission reduction, avoiding unnecessary disturbance) for 'net environmental benefit';
- Improve timeliness and certainty in reaching site closure;
- Find ways to reduce risk through the process (financial, environmental, safety and reputational);
- Track and publicize advancements to promote Alberta as a responsible asset manager and leader in resource management.

Challenges were grouped by category, to facilitate identification of potential solutions. The categories are as follows:

Planning

- In the majority of cases, **communication** between those conducting decommissioning and subsequent ARR stages does not occur; there could be potential to combine activities for greater efficiency, but without communication this does not occur.
- It is **difficult or impossible to collaborate with other licensees** in an area due to perceived competition for equipment and services; different approved vendors for various clients; challenges related to timing; and, challenges in finding the right contacts with whom to plan (more details available in Grant Thornton and JWN, 2018).
- The **perceived timing window/seasonality** to conduct ARR activities limits potential advancement in the process, and report turnaround time after field work, to inform on next steps, can lead to missing windows of opportunity; and,

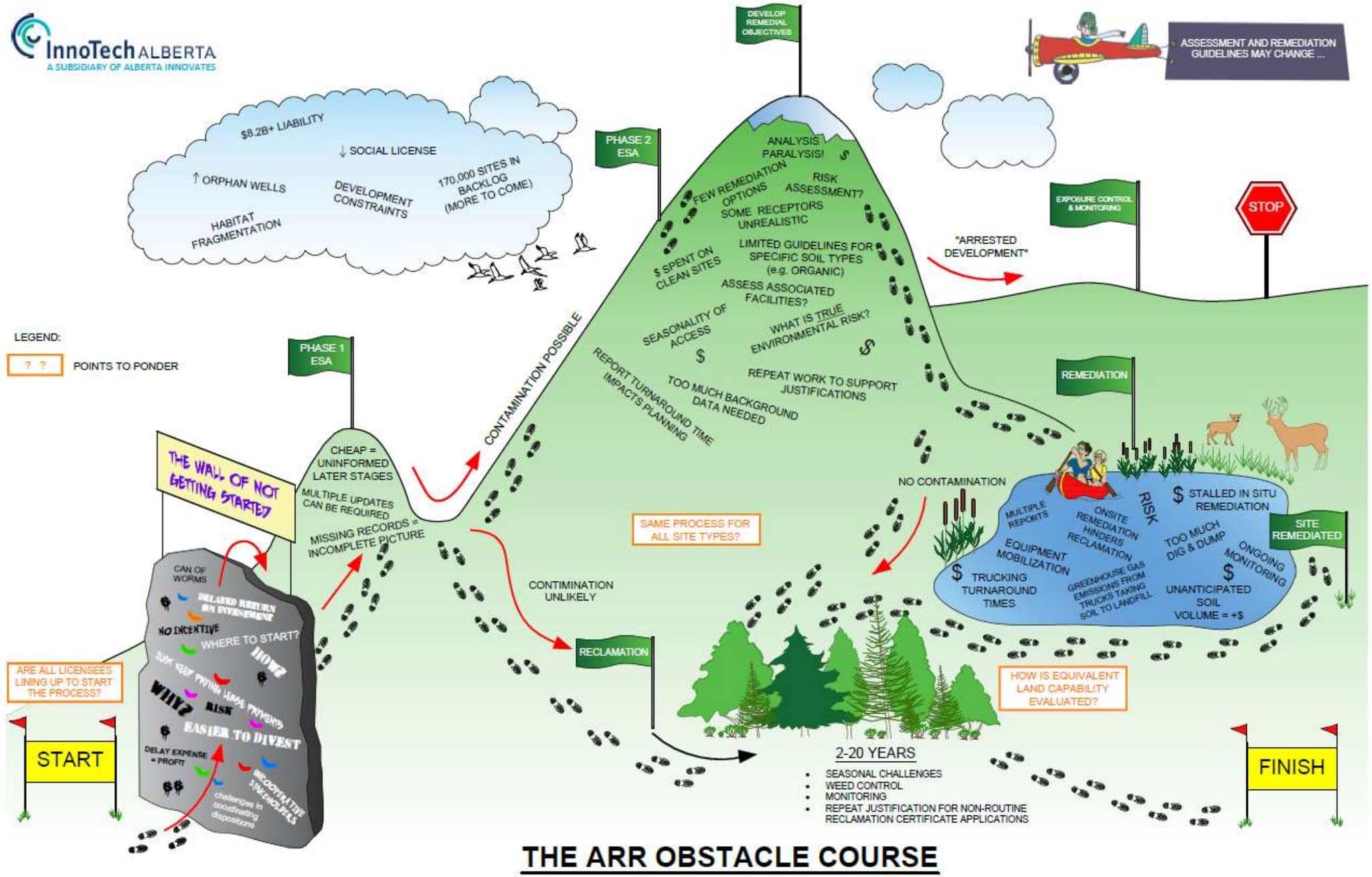

Figure 2. Challenges identified by workshop participants in the ARR process, depicted as an obstacle course.

- **Site classification** is not done consistently or effectively (i.e., complexity, required activities, existence and status of associated facilities), limiting the ability for long term planning.

Financial

- Cost constraints lead to **lowest bidder** for Phase 1 ESAs, often resulting in missing information and the need to repeat reconnaissance work later in the process;
- **Corporate budget cycles** are poorly timed to allow efficient planning of ARR activities;
- Several participants felt that excess effort and budget are spent on justifying **minor issues** (e.g., obtaining numerous background samples to justify natural exceedance; proving that impact to an access road is due to recreational use versus operations), taking away from addressing high risk or a greater volume of sites;
- **Delaying closure to avoid expense** results in lower debt ratio (show maximum company profitability);
- Properties with aging and therefore less profitable wells may be sold to companies less inclined to undertake ARR activities; and,
- **Alternatives to remedial excavation** and disposal may not result in financial benefit, especially when risk of failure is taken into account.

Quality

- Poor construction and drill practices exacerbate end of life challenges;
- **Increased complexity of regulatory process** can result in challenges to collect all required data and produce high quality reports in a timely manner; and,
- **Unrealistic budgets** result in inability to assign proper talent resources (i.e., junior level staff completing work more appropriate for intermediate or senior staff).

Risk

- Perception that licensees find it **easier/less risky to divest** a site than to reclaim it;
- Phase 2 ESAs are avoided in case remediation (with associated cost) is required;
- **Risk aversion and justification challenges** result in available budgets spent 'chasing compliance' instead of effective/more situationally-matched solutions (risk-based closure);
- Lack of stakeholder engagement was perceived to be a barrier to risk management/tolerance;
- Reclamation certification is not guaranteed and can be difficult to achieve, making budget allocation to remediation a **risk that return on investment will not be realized**; and,
- Remedial alternatives to excavation and landfill disposal are seen to be unreliable (risky) – landfill disposal is considered a low risk remedial option.

Stakeholders

- **Landowner buy-in** is taking longer for land use approvals, resulting in delayed return on investment for ARR spend; and,
- Landowner and municipalities that are resistant to closure due to loss of lease payment income increase risk of not achieving site closure.

Regulatory

- Sites don't get into the system due to really weak 'carrots' and few 'sticks';
- Policy could change to align with **recurring justifications** (e.g., low risk situations that need to be justified repeatedly to regulators) and guidance should be available for justifying risk by scenario, so that multiple consultants don't need to do the same work;
- **Milestones** with associated liability reduction through the ARR process would be helpful as incentive;

- **Difficulty eliminating receptors** even with sufficient justification – some participants felt that remedial guidelines are unrealistic;
- The number of sites currently classified as "active" according to the definition that are actually "inactive" could potentially increase backlog substantially; and,
- **Remediation guidelines** that are not specific to soil type (e.g., organic soils) may result in misalignment with true risk.

Talent resources and the environmental services sector

Environmental management within the ARR scope can be highly technical, both at the individual site and portfolio level. When budgets are unrealistically low or unavailable to meet required timing windows, inefficiencies result that impede workflow and frustrate stakeholders including those in the environmental services sector. With minimal ability to reliably forecast, service providers are challenged to manage their supply chain to meet demands. Improved planning and foresight would support improved budgeting for licensees, and would support environmental service providers, resulting in better supply chain management to most effectively meet industry needs, while growing the economy through the environmental services sector.

4. INNOVATION OPPORTUNITIES

Three innovators in this space presented on initiatives underway that have potential to improve efficiency of the ARR process. Examples of both technical and business innovation were shared, along with the underpinnings of successful collaboration. Details and presentations are provided in Appendix D.

"Key to successful collaboration was the development of trust between proponents. Identifying boundaries, getting leaders aligned and building relationships were critical."

One speaker described various collaborative initiatives in support of technology innovation in the province, including Canada's Oil Sands Innovation Alliance (COSIA), the Oil Sands Leadership Initiative (OSLI), and others. Key to successful collaboration was the development of trust between proponents. Identifying boundaries, getting leaders aligned and building relationships were critical. Taking these concepts to the formation of successful teams and collaboration in addressing the upstream oil and gas liability situation, was identified as a key to success.

4.1 CURRENT INNOVATION EXAMPLES

Getting Liability Aggregation Started (GLAS) is a corporation under development by John Van Ham and Ian Murphy, both of whom attended the ARR workshop. GLAS aims to create an economy of scale in support of smaller producers to address asset retirement, including ARR activities. This initiative is an example of business innovation to address a need, which could potentially be combined with other innovative strategies to accelerate site reclamation. This concept could address many of the 'Planning' and 'Financial' challenges identified in section 3.1.

IronSight is a cloud-based software application for coordinating and tracking field services. It allows real-time location and schedule of approved service providers, visible on a map. They do not presently operate in the environmental sector, but theirs is an example of technology developed to address a specific need, which could potentially be adopted by others. This technology could address many of the 'Planning' and 'Quality' challenges identified in section 3.1.

Figure 3. View of the IronSight dashboard, DispatchHub.

Borrowing a concept from Europe, the treatment and re-use of contaminated soil was put forward as a sustainable option for reducing costs, making use of a natural resource, and lowering greenhouse gas emissions associated with current remediation practices. 'Managing Contaminated Sites, Efficient Upstream Oil and Gas Wellsite Reclamation' was presented by Robert Martens, M.Sc., P.Eng., P.Ag., who is the Technical Manager, Regulatory Compliance with Enbridge. The presentation focused on soil remediation versus disposal, finding opportunities for re-use, and finding use for 'clean' excess soil. Social acceptance and regulatory hurdles were discussed as hurdles to moving this concept forward. Based on the challenges identified in section 3.1, this concept could provide alternatives to remedial excavation and disposal, greatly lowering the cost of remediation.

4.2 PROPOSED INNOVATIVE SOLUTIONS

Based on the challenges identified in section 3.1, groups of 5 to 8 participants discussed the challenges and potential solutions. Notes from these discussions and subsequent presentation of favoured solutions in the 'Dragon's Den' exercise are provided in Appendix E.

From the challenges identified, discussions, and Dragon's Den presentations, three theme areas were identified with potential to improve the ARR process to reduce costs and risk, shorten timelines for reclamation, enhance collaboration and support the environmental services sector, and drive development of pertinent technology.

At a regional or provincial level, enhanced **Strategic Planning** could be supported through a platform with up-to-date data for making informed decisions and prioritizing areas for closure within the province. Enhanced strategic planning would address challenges in the 'Planning' category, support forecasting for financial management, and better controlling risk.

Systems and technologies for **Optimizing Operational Logistics** were recommended to facilitate collaboration between companies and within companies; make best use of equipment and staff to support the environmental services sector; and, to coordinate resource use. Centralized soil treatment facilities were identified as a key potential innovation that could allow sites to progress faster through

remediation to avoid stalling the reclamation process, while creating economies of scale to reduce costs. Improved systems and technologies in this space have potential to address challenges identified in 'Planning' and 'Financial' categories.

Finally, **Supporting Best Practices for Assessment, Remediation and Reclamation** through a coordinated research and innovation program, tied in with regulatory enhancements, was recommended to more efficiently move sites through the ARR process. Initiatives in this space would contribute to addressing challenges in the 'Regulatory' category, as well as increasing quality, reducing costs and shortening timelines.

Additional information on the three theme areas is as follows:

1. **Strategic Planning**

To facilitate strategic planning beyond the current single producer approach, a digital platform would allow site categorization and screening at a macro level. Participants in the workshop agreed that the required data is available; more so, it is a question of accessibility that is the issue. The confidentiality of proprietary data would require protection, which has been done with numerous other large-scale datasets through brokers, such as Alberta Data Partnerships. Key functionality of such a platform includes:

- Gain 'field visibility' of site inventory including wellsites and associated facilities that require asset retirement activities, including their association with other dispositions.
- Categorize sites to determine needed activities and stage in the asset retirement process.
- Forecast potential contamination based on known and inferred site characteristics, even without intrusive sampling.
- Implement soil or groundwater treatment early based on sampling results to prepare sites for eventual closure, thus reducing landfill disposal.
- Capture completed activities with updated site status to plan subsequent activities.
- Support assessment of risk with layers that identify environmental receptors, background parameter concentrations, geophysical and chemical data (other, as needed).

Key benefits of [a digital platform] would be 1) proactive budgeting and activity coordination; 2) informed creation of project bids for sub-contractors; 3) support area-based closure with multiple clients; and 4) work within an integrated management framework to address sensitive areas.

Key benefits of such a tool would be 1) proactive budgeting and activity coordination; 2) informed creation of project bids for sub-contractors; 3) support area-based closure with multiple clients; and 4) work within an integrated management framework to address sensitive areas.

Secondary benefits in optimizing strategic planning are:

- Optimizing geographical efficiencies, thus producing fewer greenhouse gas emissions in mobilization of equipment.
- Expanding activities beyond current 'timing windows' to move sites ahead and coordinate service providers through the supply chain.
- Informing the supply chain to support service providers in managing their staffing and equipment needs.

- Incentivizing producers in a region to address asset retirement at a more affordable cost and with lower risk.
- Identifying potential alternative closure options (i.e., geothermal, solar farm)
- Planning multi-year closure programs.
- Developing key performance indicators that expand beyond the number of reclamation certificates obtained, for increasing incentive.

2. Optimizing Operational Logistics

There were three recommended innovations brought forward to support operational optimization at the field level, including an equipment and resource coordination platform, centralized soil treatment facilities, and business innovation in the form of centralized support for licensees in managing sites through the ARR process.

i. Equipment and Resource Coordination Platform

A key challenge in the ARR space is facilitating work between licensees, particularly in a geographical area. It was reported that there are many opportunities for greater staff and equipment utilization, and this could incent licensees to complete activities with considerable cost savings. A recent report highlights the challenges that companies face in collaboration, as well as some potential solutions that could also be supported through a digital platform (Grant Thornton and JWN, 2018). A platform or system could be created or adapted to facilitate collaboration, sharing of resources and to advertise availability of specific resources, such as soil for backfill. Such a platform could:

- Coordinate trucking and equipment geographically to reduce mobilization.
- Create a resource barter platform for soil re-use, seed and other resources.
- Identify equipment near a site for the benefit of the contractor and service provider.
- Track activities conducted onsite.
- Identify time required for specific activities to allow better budgeting and time allocation (benchmarking).
- Allow service providers to optimize equipment and staff utilization, thus potentially reducing overall rates.

ii. Centralized Soil Treatment Facility

A centralized soil treatment facility was elaborated in detail by the team in the Dragon's Den pitch. Operational efficiencies that would result from having such a facility in a strategic area are related to the potential for removing contaminated soil from sites to progress with reclamation, and reduced trucking time that is common for remediation in remote areas. In addition, treated soil could be obtained from the facility and taken to the site in a round trip, thus maximizing usage of trucks. De-risking this concept would require creation of a business case and access to some of the data outlined in the 'Strategic Planning' theme area, to inform on 1) required treatment technologies needed at the facility; 2) likely volumes of soil that would be treated or require disposal, and 3) facility siting for maximum efficiency. Such a facility in a remote area could serve as a business and training opportunity, resulting in social benefit.

iii. Business innovation

Innovation in the ways ARR work is *managed* could be key to addressing the backlog of sites, supporting licensees in what can be highly technical and challenging work. Smaller licensees would benefit especially from centralized support; such an initiative would need to be driven through the business community, possibly with support from the innovation system.

3. Supporting Best Practices for Assessment, Remediation and Reclamation

At the asset level, participants felt strongly that more support was needed for justifying risk-based closure or site management strategies. This included both: 1) scientific support (e.g., risk to receptors from certain chemical parameters; definitions of (and likelihood of encountering) specific receptors), and 2) consistent response from regulators when making a case for a certain scenario. Participants stated they would like to see policy align with 'recurring justification'. Some specific initiatives, technologies or processes that could be supported through research and innovation include:

1) Coordinating applied research to address high priority challenges related to contaminants of concern, such as anthropogenic salt.
2) De-risking and optimizing soil and water treatment technologies, where these are required to conduct onsite remediation or in *ex situ* treatment.
3) Developing a best practices and risk assessment portal where stakeholders could solicit input from others working in the field.
4) Creating a library of peer-reviewed case studies and technology validation studies (similar to the US EPA's FRTR website[2] (US EPA, 2018); specific to western Canada)
5) Conducting research and synthesizing available information to better understand equivalent land capability in support of reclamation to achieve functioning ecosystems.

4.3 Recommendations Outside the Research and Innovation System

Recommendations brought up at the workshop that require collaboration or leadership from regulators and other entities include:

- Regulators could better align policy with re-occurring justifications for risk-based closure or provide more guidance on compliance limits. An example of success is the development of 'Subsoil Petroleum Hydrocarbon Guidelines for Remote Forested Sites in the Green Area' (ESRD, 2014).
- Producers that face uncooperative landowners require support to ensure that sites can be dealt with in the most efficient manner possible.
- Industry associations may need to consider the opportunity in business innovation to support licensees in managing asset retirement, and specifically ARR activities.
- Regulators and industry need to find ways of ensuring that sufficient budgets are available at the right time for conducting the work required to most effectively meet regulatory closure.
- Stakeholders need to align on reasonable and fair key performance indicators and tracking mechanisms for reducing the number of sites in 'backlog'; this could, in part, be supported through research and innovation but has a strong regulatory and industry component.

[2] U.S. EPA website link: https://frtr.gov/matrix2/section3/table3_2.pdf

5. NEXT STEPS

The following recommended next steps were developed based on the proposed solutions to high priority challenges, with the goal of *fostering collaboration* amongst stakeholders to address system-wide challenges. The next step in moving this initiative forward is the formation of a steering committee to:

1) confirm and further develop key priority areas in alignment with industry and regulatory initiatives;
2) identify specific projects and delivery teams to address priority areas; and
3) identify and pursue potential funding opportunities.

At the regulatory level, changes are ongoing to support and enhance efficiency of various aspects of the ARR process. Therefore, while initiatives can be championed through the province's research and innovation system, government, industry and private sector collaboration are required for success. The following recommendations were developed to guide potential technology and process innovation to address regional, field-scale and site-level challenges.

At the regional or provincial level, enhanced **Strategic Planning** could be supported through a digital platform with up-to-date data for informed decision making and prioritizing areas for closure in the province. It is anticipated that this platform would allow the ability to analyze various scenarios, and would therefore include financial, time, sustainability and logistics data. Recommendations for next steps in the Strategic Planning category are:

a. **Define User Needs**: Identify potential users of such a platform, and determine, in collaboration, what information, business processes, and data types need to be gathered, processed and tracked.
b. **Technology Scan:** Determine whether technologies exist that could be adapted to meet the needs identified in the user needs assessment.
c. **Pilot**: Evaluate platform functionality to support effective decision making and plan multi-year closure programs, and ability to interface with other existing systems (e.g., Alberta Energy Regulator's OneStop system).

Systems and technologies for **Optimizing Operational Logistics** were recommended to facilitate intra- and inter-company collaboration, make best use of equipment and staff to support the environmental services sector, and to coordinate resource use. Centralized soil treatment facilities and/or soil banks were identified as a key potential innovation in this category, as were opportunities in business innovation to support licensees. Recommendations for next steps in the Strategic Planning category are:

a. **Technology Scan or Challenge**: Conduct a technology scan to determine what available technologies are available to facilitate process streamlining and collaboration or develop a defined challenge for technology developers.
b. **Pilot:** Conduct a retrospective pilot with available operations data from industry member(s) or associations to validate potential efficiencies through a collaboration platform or other process optimization tool(s).
c. **Business Case:** Assemble and support a team to create a business case for one or more soil treatment facility or soil bank concepts.

Finally, **Supporting Best Practices for Assessment, Remediation and Reclamation** through a coordinated research and innovation program, tied in with regulatory enhancements, was recommended to more

efficiently move sites through the ARR process. Recommended next steps related to Supporting Best Practices for Assessment, Remediation and Reclamation are:

a. **Gap Analysis**: Identify and prioritize research needs in support of effective ARR, including technology, science, and process optimization.
b. **Review**: Determine where information is currently housed on applied research or risk justification for taking various approaches to managing risk for contaminated sites. Explore the potential for an information repository including case studies and peer reviewed best practices and identify a suitable organization to host and maintain such a repository, if a need is identified.

6. CONCLUSIONS

Several opportunities to harness the innovation system were identified for supporting efficient upstream oil and gas wellsite assessment, remediation and reclamation. Challenges were identified and categorized to facilitate solution identification and development.

Innovative technologies, processes and examples were presented, and many more were described that are either in development or could possibly be adapted from other industries or applications. Key to developing relevant technologies and improved processes are:

1) Clear articulation of the needs of industry, reclamation practitioners, the environmental services sector, government entities, and stakeholders that function in the asset retirement space; and,
2) Opportunities for technology developers and practitioners developing relevant technologies to showcase their ideas and products; funding opportunities for further development; demonstration site availability; and, optimization and validation of technologies.

Collaboration in driving forward the proposed next steps is welcome and necessary; those with ideas or suggestions may contact Simone Levy, Reclamation Researcher at simone.levy@innotechalberta.ca.

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APPENDIX A – WORKSHOP AGENDA AND BACKGROUND MATERIAL

Workshop Agenda: "Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation"

Introduction and Purpose

9:00-9:45

- InnoTech Alberta – Simone Levy and Marian Weber – InnoTech and innovation system concept introduction, background research findings, workshop and initiative goals (15 mins)
- Ministry of Economic Development and Trade – Alberta Telfer – Accelerating Alberta's Cleantech industry, strengthening the environmental services sector, and contributing to Alberta's economic diversification efforts (5 mins)
- Facilitator - Sarah Laughton – workshop format, expectations and participant introductions (20 mins)

Panel: Framing the Discussion – Dallas Johnson (Alberta Innovates), moderator

9:45-10:30

Panelists will be asked 3-4 questions around economic, social & environmental implications of current asset retirement challenges/status in Alberta.

- (Social and Industry) Canadian Association of Petroleum Producers – Richard Wong
- (Financial) 360° Energy Liability Management Ltd. - Mike Newton
- (Land) Silvacom – Andrew Vandenbroeck

10:30-10:40 Coffee break

Process Outline

10:40-12:00

Plenary activity to review the upstream O&G ARR process. Validate key challenges, identify others.

12:00-12:30: Lunch

Innovation Categories – Speakers Primer

12:30-1:00

Speaker #1 (Former ConocoPhillips/COSIA – John Van Ham): Planning and Collaboration
Speaker #2 (IronSight – Adam Jessome and Shawn Martens): Process streamlining example
Speaker #3 (Enbridge - Robert Martens): Soil as a Resource/Managing contaminated sites

1:00-1:30: Break-out session:

Break-out Sessions – 5 innovation categories Working Groups

1. Soil as a Resource
2. Managing Contaminated Sites
3. Activity Streamlining
4. Portfolio Strategy
5. Data capture and management

Addressing key challenges - brainstorm solutions to meet outcomes; identify roadblocks to implementation

1:30-2:00: Rank solutions and prepare pitches for $1M solution

2:00-2:30pm Plenary 'Dragon's Den' presentations

Recommendations and Path Forward

2:30-2:50: Dragons' feedback

2:50-3:00: Wrap up: What was the greatest value of the day for you?

3:00-5:00 Networking Session

Workshop Background Material: Harnessing the Innovation System to Support Efficient Upstream Oil and Gas Wellsite Assessment, Remediation and Reclamation

"Can new or adapted planning processes and technologies improve integration between different stages of the upstream oil and gas asset retirement process to move sites more efficiently toward regulatory closure, and thus reduce licensee liability?"

In 2014, Alberta companies spent approximately $1.1 billion on reclamation and decommissioning activities according to Statistics Canada. Despite this significant investment, a liability concern for Alberta's oil and gas industry is the growing number of inactive and orphaned oil and gas wellsites and their associated facilities. Currently there are about 85,000 inactive wells, of which approximately 3,500 are orphaned. Upstream oil and gas stakeholders are working to address the backlog of sites, and to prioritize asset retirement into the future.

While it is simple to say that more resources and focus should be put toward asset retirement, the reality is that it is can be costly, logistically complicated, and time intensive. Decommissioning a well is usually straightforward; however, subsequent stages of asset retirement (assessment, remediation and reclamation; ARR) can involve desktop assessments; site assessments; repeat monitoring; deployment of heavy equipment; import, export, and disposal of soil; remediation of contaminated soil or water; weed control; and, reclamation activities (Figure A1). These activities require tracking and coordination by those overseeing the work, and multiple reports are generated through this process. Efficiently moving a portfolio of sites through the ARR process is an important and often underestimated challenge of asset management.

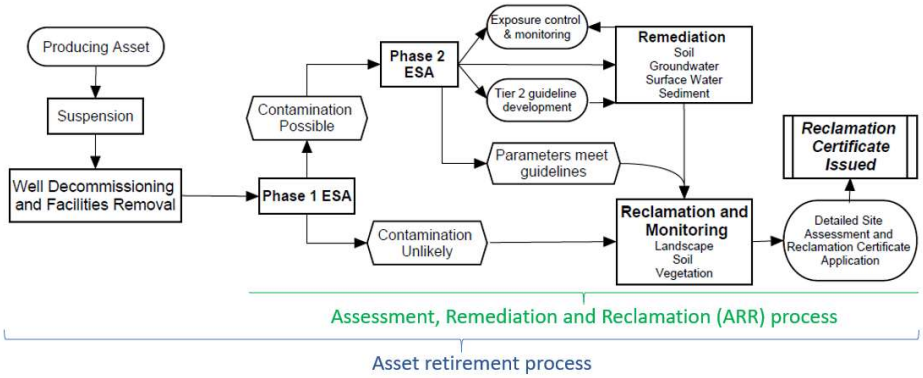


Figure A1. Overview of the steps involved in the asset retirement process, highlighting those activities in the ARR process that are the focus of this document.

Leveraging technology to address these challenges could include developing information management platforms, tracking systems, integrating machine learning, process and supply chain optimization tools, and remote monitoring technologies. Development in these areas has potential to benefit small and large energy producers, equipment and service providers, environmental and engineering consultants, waste management companies, software and digital service/data providers, and the province of Alberta.

In 2017-18, InnoTech Alberta initiated discussions with stakeholders including members of the upstream oil and gas industry, service providers, government representatives and technology developers to explore opportunities to develop process innovations and technology to increase efficiency and reduce environmental and financial liabilities associated with the ARR process. Key challenges and potential opportunities identified are summarized in Table A1.

Table A1. Summary of challenges and potential solutions identified in 2017-18 outreach conducted by InnoTech Alberta, to be explored in the workshop.

Topic	Gap/Challenge	Potential Solution
Portfolio Strategy and Risk Assessment		
Portfolio prioritization	While risk-based prioritization systems have been established, challenges exist in developing efficiency-based strategy for multi-year closure programs.	Develop systems with flexible models to strategize, for example within a portfolio of sites or geographic area.
Collaborative and strategic access	Inter-company communication is currently limited; thus, collaborative efficiencies are not realized	Develop or identify tools to enhance companies' ability to collaborate with others in a geographic area (e.g., to open winter (or other) access), and to spatially optimize the areas of focus for asset retirement activities.
Activity Streamlining		
Resource sharing	Real-time information on resource availability is limited	Platforms could allow optimized deployment of resources including heavy equipment and personnel, and tracking of other resources, such as soil and seed.
Activity streamlining	Multiple site visits are often required through the ARR process that could be better coordinated to reduce travel time, distance and associated greenhouse gas emissions	Better communication tools, mapping and remote data capture could be developed to require fewer site visits and associated greenhouse gas emissions.
Data Capture and Management		
Information streamlining	Industry representatives, consultants and regulators all seek more efficient and straightforward ways to gather and transmit site data and information.	Designing data capture tools that can be directly transmitted to regulatory agencies versus current capture, transcribe, report and submit; requires identifying what is required by the various stakeholders, and how information would be used while respecting confidentiality.
Remote monitoring	Onsite monitoring results in many site visits where remote monitoring tools could be employed.	Optimization and validation of remote monitoring technologies may be required to be employed in lieu of onsite visits.
Soil as a Resource/Managing Contaminated Sites		
Remediation technologies	*In situ* remediation technologies can be effective but often require time to work	Include early assessment and develop a site assessment and technology selection screening tool.
	Some contaminants, such as anthropogenic salts, soil sterilants and sulphur are very difficult to manage	Identify and further develop technologies for management of salts and other stubborn contaminants.
Exploring logistical challenges of onsite treatment	Treatment of soil at wellsites & associated facilities is *logistically* challenging, resulting in landfill disposal as the quickest and easiest method; soil cannot be re-used as backfill, and remains a liability in another location.	Landfill alternatives could be explored including the potential for central treatment nodes or facilities, and integrating *in situ* technologies.

APPENDIX B – INTRODUCTIONS AND LIST OF PARTICIPANTS

7.1 INTRODUCTIONS

7.1.1 InnoTech Alberta

InnoTech Alberta's primary focus is to facilitate the conversion of applied research to economic, social and environmental benefits for Albertans. The organization aims to support and partner with service providers, industry, government and academia to solve Alberta-based problems. InnoTech Alberta is a wholly owned subsidiary of Alberta Innovates, under the Government of Alberta's Economic Development and Trade ministry (Figure B1).

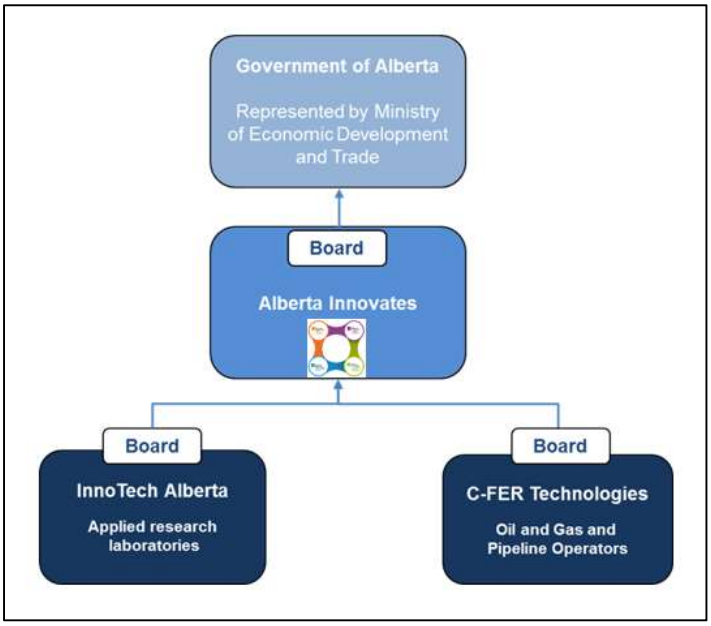


Figure B1. Structure of the Economic Development and Trade Ministry, including Alberta Innovates and two wholly-owned subsidiaries: InnoTech Alberta and C-FER Technologies.

Alberta Innovates (AI) is the province's largest research and innovation agency, whose mandate is to support and accelerate research, innovation and entrepreneurship in all sectors and markets, now and into the future. They direct targeted funding toward 'game-changing' projects and programs that meet rigorous criteria and support provincial innovation targets.

7.1.2 Alberta Economic Development and Trade

The mandate of Alberta EDT is to build a resilient, robust and dynamic Alberta economy. The ministry ensures outcomes are achieved by:

- supporting businesses and private sector job creation;
- enhancing access to capital for small and medium-sized enterprises;
- coordinating and leveraging research and innovation to increase the commercialization of Alberta ideas and meet the needs of Albertans, from environmental stewardship to improved health outcomes;
- facilitating export development and investment attraction from targeted international markets;
- enhancing Alberta's national and international presence; and,
- leading Alberta's negotiations on domestic and international trade agreements.

7.1.3 Environmental Services Association of Alberta

The Environmental Services Association of Alberta (ESAA)'s mandate is to be a leader in promoting and developing the environmental services industry through education, events and meetings which facilitate productive relationships with relevant organizations and government.

7.2 WORKSHOP PARTICIPANTS

Workshop participants were selected to include representation from industry and government, environmental service providers, financial specialists, technology developers, and researchers. Geographically there were participants from Alberta, British Columbia, Quebec, and New Brunswick. Several participants also brought experience working internationally, with perspectives on successful initiatives and regulatory drivers that supported them.

The 45 participants included:

- 5 academics/researchers
- 15 consultants
- 6 government or semi-governmental organizations
- 8 industry representatives
- 4 service providers
- 7 technology developers

A summary of participants' reasons for attending the workshop were as follows:

- Gain a collective view of issues;
- Learn more about what data is available;
- Identify exportable talents;
- Find new solutions and efficiencies/processes/technologies;
- Understand the ARR process and challenges;
- Identify methods for financial optimization;
- Identify active strategies for reclamation and remediation;
- Learn more about 'arrested development' sites, how they are managed, and what alternatives there are;
- Start of world leading innovation in land management;
- Site level challenges;
- Infuse circular economies[3];
- Seek innovative remediation and risk management methods; and,
- Break out of remedial excavation and disposal as 'go to'.

[3] A circular economy is an industrial system that is restorative or regenerative by intention and design. It replaces the end-of-life concept with restoration, shifts towards the use of renewable energy, eliminates the use of toxic chemicals, which impair reuse and return to the biosphere, and aims for the elimination of waste through the superior design of materials, products, systems and business models. (http://reports.weforum.org/toward-the-circular-economy-accelerating-the-scale-up-across-global-supply-chains/from-linear-to-circular-accelerating-a-proven-concept)

7.3 PARTICIPANT ORGANIZATIONS

Name	Organization
Adam Jessome	IronSight
Alberta Telfer	EDT
Amber Flamand	Earthmaster Environmental Strategies Inc.
Andrew Vandenbroeck	Silvacom Ltd.
Bill Whitelaw	JWN Energy/ERIS
Bipro Dhar	University of Alberta
Bonnie Drozdowski	InnoTech Alberta
Brent Lennox	Waterline Resources
Brent Walchuk	North Shore Environmental Consultants Inc.
Carlene Meeks	Trace Associates
Dallas Johnson	Alberta Innovates
Damian Brake	Core Drilling Corp
Darren Mason	Shell Global Solutions
Eleni Stroulia	University of Alberta
Elise Faryna	Alphabow Energy Ltd.
Garry Ogletree	Solstice Canada
Gary Winthrop	Matrix Solutions Inc.
Ian Murphy	Independent
Jean-Sebastien Rolland	Wikinet
John Van Ham	Independent
Juli Rohl	ReGenerate Alberta
Kevin Ball	AER-Edmonton
Laurent Pilon	Reseau Environnement
Liesl Hanlan	THINK Envirotechnical Services Inc.
Lisa Kinasewich	Environmental Services Association of Alberta
Louis Paquet	WikiNet
Marc Paquet	Wikinet
Marian Weber	InnoTech Alberta
Marissa Reckmann	AGAT Laboratories
Michelle Cotton	Solstice Canada
Mike Newton	360 Energy Liability Management Ltd.
Monica Brightwell	ATCO
Paul Fuellbrandt	Statvis Analytics Inc.
Peter Boyd	Moorland Technologies
Peter Olmsted	Matrix Solutions Inc.
Richard Wong	Canadian Association of Petroleum Producers (CAPP)
Rob Traynor	SLR Consulting (Canada) Ltd.
Robert Martens	Enbridge
Ron Thiessen	Advisian
Ryan Cox	North Shore Environmental Consultants Inc.
Simone Levy	InnoTech
Sonia Glubish	Canadian Natural Resources Limited
Stephen Bromley	Husky Energy
Stephen Lougheed	Alberta Biodiversity Monitoring Institute
Wanda Sakura	Orphan Well Association

APPENDIX C – PANELIST BIOS AND DETAILED PANEL DISCUSSION

A panel of 3 members was assembled and questions were developed to update workshop participants on political and regulatory status of the liability situation in Alberta, and to provide examples of overcoming systemic challenges in other industries (e.g., forestry). The panelists brought perspectives on financial, social and environmental implications of the liability situation. Panelists included:

Richard Wong. B.Sc., P.Eng. is the Manager of Operations for the Canadian Association of Petroleum Producers (CAPP). His role is to lead major regulatory initiatives and advocacy across western Canada to support competitiveness and enable responsible growth of Canada's upstream oil and natural gas industry. In his role, Richard is also responsible for leading CAPP's work on matters related to closure and liability. He represented industry during the Government of Alberta's 2017 liability management review, and he has worked with provincial governments and regulators across western Canada to advance liability management system enhancements that protect people and the environment, while also maintaining competitiveness for the upstream oil and natural gas industry.

Mike Newton, B.Comm. has gained experience in a multitude of liability management fields over the last eight years that includes managing closure execution teams, insurance and developing an ARO analysis software (XI Technologies ARO Module). He has a strong understanding of the environmental and abandonment framework in Western Canada and excels at assessing and evaluating liability associated risk. Mike's combined expertise has been instrumental in the revival of asset retirement insurance through Lloyd's of London.

Andrew Vandenbroeck, B.Sc., MBA, RPF is the Manager of Energy & Environment at Silvacom, an Alberta-based firm providing consulting and software solutions to improve land management. During his 12-year career at Silvacom, Andrew has been involved in a variety of land management related projects including habitat assessment, landscape planning, cumulative effects modeling and the planning and implementation of over 500 km of linear restoration in Alberta.

Panel Questions:

3.2 Social license and Industry: Canadian Association of Petroleum Producers – Richard Wong

Q1: What changes are being made to the liability management system for oil and gas activities, and how will the changes prevent more sites from becoming orphaned?

Alberta has experienced the worst recession in a generation that has led to solvency challenges for many companies in the upstream industry. The cyclical pressure is magnified by the adverse effects of the Redwater decision that have created incremental uncertainty and risk to the Orphan Well fund. The liability management system functioned reasonably well during past economic cycles, but the most recent down-turn highlighted opportunities to strengthen the current system. A lot of work has already been done by many stakeholders to enhance the system. Through the liability management review launched nearly a year ago by the provincial government, CAPP recommends three strategic areas of focus to enhance the liability management system, namely:

- A greater focus on inactive site closure (i.e., sites with wells that no longer produce);
- A modernized liability management program to enable more selective risk-mitigation from operators that have the potential to go defunct; and

- The creation of a well assurance fund (or Legacy Fund).

First, to encourage inactive site closure CAPP recommended a portfolio-based approach with an annual inactive well reduction target that increases over time. This approach to liability management helps to ensure that operators in Alberta will be responsible for retiring inactive sites, but enables greater flexibility to address liabilities in a risk-informed and cost-efficient manner.

Second, to modernize and enhance the existing system CAPP has advocated for updates to the Liability Management Ratio and other changes that would allow the AER to better assess and manage pressures associated with at-risk licensees. While CAPP recognizes the need for an increased level of securitization overall, CAPP strongly believes that this securitization must be selective to manage the potential impacts of capital sterilization for an industry that has experienced a stretch of low commodity prices.

Third, the development of a Well Assurance Program to address the post-closure requirements of existing legacy assets – i.e., those wells that met the closure standards of the day, but are without a responsible party and may require further downhole or surface work to ensure safety and/or protect the environment.

While it has taken decades to get into the current situation of a large inventory of inactive wells, proactive steps to reduce that inventory can and should be undertaken, but in a way that enables cost efficient and effective closure.

Q2: What is the Redwater Decision? Could you explain the current implications of the Alberta court's decision? What is the potential impact to identified stakeholders (lenders, insolvency process, industry, the public and the environment) if the decision gets reversed?

The case itself focuses on a small Alberta oil company, Redwater Energy, which entered creditor protection in 2015. Only a few of the company's assets had value, so the lender wanted to sell those wells to recover some of its debt and renounce the rest of the uneconomic sites. The receiver to the lender felt only a small number of 127 of Redwater's properties were worth keeping. The question became whether Redwater's assets should help pay its debts or be used to pay for the cleanup cost of its uneconomic wells?

In May 2016, the Alberta Court of Queen's Bench ruled in favour of the bankruptcy trustee that represented Redwater Energy Corp. Under the ruling, profits from the sale of assets would go first to creditors — not towards cleaning up its inactive sites. This case has subsequently been appealed to the Alberta Court of Appeal and in February 2018 to the Supreme Court of Canada. The case has significant potential impacts to many industries across the country and to that end we saw significant interest on the part of many different groups - we are currently awaiting a ruling from the Supreme Court on this case.

In the view of industry, the greatest risk is that if *Redwater* is not reversed, it will leave the door open to oil and gas companies to use the insolvency process to discard their end of life obligations, potentially dramatically increasing the number of orphan wells. We have already seen a significant amount of incremental liability being partially renounced under a Redwater-type approach, this presents significant incremental risk for the rest of industry who are responsible for cleaning up these sites via the Orphan Fund. We strongly believe that industry, the public, and the

> *"We strongly believe that industry, the public, and the environment will all positively benefit from a situation where insolvency law does not encourage the proliferation of orphan wells."*

environment will all positively benefit from a situation where insolvency law does not encourage the proliferation of orphan wells. The alternative if the Redwater decision is upheld will be a game changer for industry and has the potential to negatively impact many sectors beyond our own.

3.3 Financial: Liability specialist - Mike Newton

Q1: In the introduction we talked about the actual costs of assessment, remediation and reclamation. Can you elaborate on the risks to industry if they are unprepared for these costs?

The obvious answer is that the number of orphan wells is going to continue to climb, and it will continue to burden the rest of the industry. The less obvious answer is how the liability situation impacts public perception of the industry as a whole and the ramifications it will generate. When you get articles in the paper about upstream oil and gas companies orphaning wells and not paying landowners, etc., it creates a negative perception of the industry. This can impact how the industry is viewed regarding broader issues such as pipelines and further development.

Q2: When producers acquire assets, some with unknown liabilities, how are decommissioning costs accounted for in the transaction?

Although we've seen an increase in the efforts of buyers to evaluate liabilities in the last 3 to 4 years, many buyers still rely on reserves reports, which only allocate liability to wells that are assigned a reserve life. These assigned liability values are generally quite low. Other companies look at the licensee liability rating, which is the AER's generic liabilities on licensed (operating) wells and facilities (AER, 2015). Some companies project these liabilities out onto the non-operating wells. Some potential buyers will use our services to estimate the asset retirement obligation (ARO). We use a four-stage process:

1. Stratify assets into risk categories
2. Review well, facility and environmental files and conduct site visits
3. Determine asset specific ARO values
4. Extrapolate across the population

"Potential remediation costs are consistently the most difficult to accurately estimate."

Potential remediation costs were noted to consistently be the most difficult to accurately estimate.

3.4 Land: Silvacom – Andrew Vandenbroek

Q1: What is the % disturbance in the province from upstream oil and gas compared with other types of disturbance and what are the implications for future resource extraction and the environment?

According to ABMI's Human Footprint Inventory (ABMI 2016), the energy sector represents 3% of Alberta's landscape and 10% of the total human footprint (excluding access features). This represents a land area about 60% the size of Vancouver Island. By comparison, forest harvest areas represent 4% of the landscape (14% of total human footprint) and agriculture is 21% of the landscape (72% of total human footprint). An important consideration, though, is the dispersion of the footprint across Alberta. Agriculture is concentrated within the White Area of the province and the forest industry is primarily concentrated in the Green Area (boreal & foothills regions). The energy footprint, by contrast, is dispersed across the province in all regions. Within the energy sector, wellsites, pipelines, and seismic lines make up the majority of the footprint. There are just over 1 million hectares in wellsites and pipelines.

Landscape footprint has potential implications for future resource extraction. The Land Use Framework regional plan development (GoA, 2012) has included thresholds which could relate to the level of disturbance on the landscape. Operating in Species at Risk habitat can also be limited by the level of disturbance. An example of this is the Federal recovery strategy for woodland caribou which sets an undisturbed habitat target of 65% (35% disturbance). The challenge being that the recovery strategy defines disturbance as the physical footprint plus a 500 m buffer. Therefore 3% landscape disturbance quickly becomes much larger when a zone of influence is included. The woodland caribou ranges in Alberta, which cover a larger portion of the boreal and foothills regions of the province, already significantly exceed these targets. The Draft Provincial Woodland Caribou Range Plan[4], released December 2017, signals the importance of reclaiming inactive oil & gas footprint as a key strategy in supporting a working landscape while progressing to the disturbance level targets. Furthermore, the Draft Provincial Range Plan signals a requirement for Integrated Land Management which will require collaboration in planning new footprint and retirement of inactive footprint.

"The Draft Provincial Range Plan, released December 2017, signals the importance of reclaiming inactive oil & gas footprint as a key strategy in supporting a working landscape while progressing to the disturbance level targets."

Q2: What should be considered when deciding where to focus reclamation efforts from the perspective of habitat fragmentation and potential future constraints?

When prioritizing areas for closure it will be important to consider a variety of factors based on regional goals to maximize the benefits from reclamation efforts (e.g., targeting areas that maximize the reduction in disturbance footprint for caribou, targeting areas that maximize the ecosystem service potential etc.). Planning and sequencing tools can help optimize outcomes subject to a set of constraints (e.g., cost, accessibility, seasonality, etc.). The key to this is having good inventory information about sites to characterize them from both a cost and benefits perspective.

[4] GoA (Government of Alberta), 2017. Draft Provincial Woodland Caribou Range Plan.

APPENDIX D – INNOVATION EXAMPLES

After discussions on the challenges and bottlenecks in the ARR process, three speakers were asked to present on their innovative approaches to planning and collaboration, supply chain management, and alternative soil remediation methods. Synopses of the speakers' presentations are provided below.

7.4 PLANNING AND COLLABORATION

Speaker #1 (Formerly ConocoPhillips – John Van Ham): Planning and Collaboration
Getting Liability Aggregation Started (GLAS) is a corporation under development through John Van Ham and Ian Murphy, both of whom attended the ARR workshop, to create an economy of scale in support of smaller producers.

Examples of both technical and business innovation were shared, along with the underpinnings of successful collaboration.

"Key to successful collaboration was the development of trust between proponents. Identifying boundaries, getting leaders aligned and building relationships were critical."

Prior to Canada's Oil Sands Innovation Alliance (COSIA) there was the Oil Sands Leadership Initiative (OSLI) and others. Groups tried to come together in collaborative ways many times over the years to support technological innovation, but it became clear that bigger picture aspects were getting missed, for example, market access and landscape-level reclamation. Identifying the urgent and broad themes to collectively address were key to overcoming challenges.

In the oil sands area, local social issues were hindering getting access to the land, which created a tipping point for industry members to find ways to work together. Collaboration between leaders was the first step, then others followed. Early discussions had a lot of 'parking lot' items as proponents desired confidentiality; as trust was built, discussions became more open. Key to successful collaboration was the development of trust between proponents. Identifying boundaries, getting leaders aligned and building relationships were critical. As the initiative moved forward, goals were transferred out of working groups and into the organizations to integrate into annual performance agreements and the goals of the organizations. Looking at different models when seeking innovation was a useful exercise, including a review of what is done in other jurisdictions (e.g., Restore the Earth Foundation (U.S.A.) using triple bottom line (social, economic and environmental) focus for restoration in the Mississippi Delta: http://restoretheearth.org).

7.5 PROCESS STREAMLINING

Speaker #2 IronSight – Adam Jessome: Process Streamlining

Developed to address pain points discovered first hand as service providers and supervisors in the oil and gas industry, IronSight is a cloud-based software application for coordinating and tracking field services. It allows real-time location and schedule of approved service providers, visible on a map. IronSight was invited to present a 'process streamlining' example from the oil and gas industry, but they do not presently operate in the environmental services sector.

Efficiencies through using the application include:

- Enhanced ability to adapt to changing schedules;
- Improved communication and less time spent coordinating services;
- Automatic information tracking, including automated job status updates and flags for 'next steps';
- Accountability for service providers in the time spent to complete a job;
- Streamlining jobs for service providers, resulting in less down time and more efficient utilization of equipment and staff;
- Ideal routing and resource availability shown on maps in real time.

IRONSIGHT

Taking oil&gas services out of the dark ages

Software History

- 3 friends with oil&gas experience start a vac truck company
  - Adam Jessome – *P.Eng*
  - Shawn Martens – *Operations Manager for large service company*
  - Tyler Jessome – *Completions Supervisor*
- Efficiency problems discovered first-hand from both sides of the equation – as service providers and as employees for large oil companies
- Decide to develop technology to solve the many problems with coordinating field services - IronSight

Pain Points of Running a Service Company

- Who should I assign this new job to?
  - No real-time location and schedule of workers
- Missed calls from customers
- Phone communication between dispatch, customer, and service provider in field is time-consuming
- Adapting to changes, like a job taking longer than expected, and shuffling responsibilities nearly impossible
- Logging/referencing information is a waste of time

Pain Points (Oil Company Perspective)

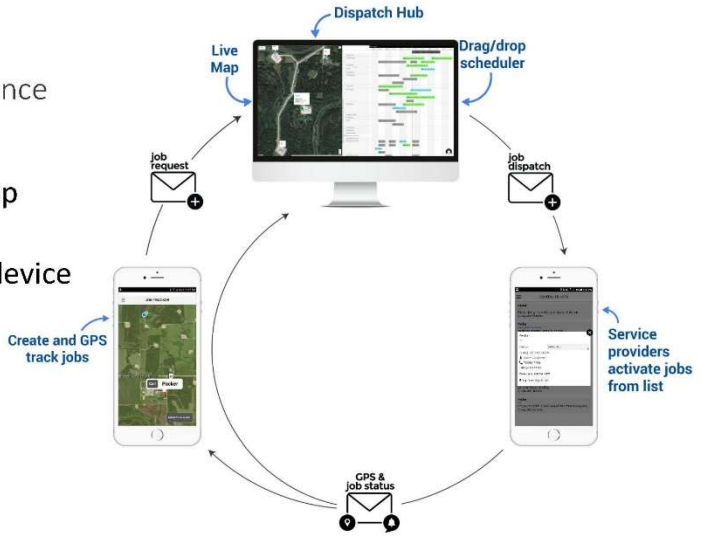
- Late services… where's my truck?
- Requesting a job is difficult
- No data to hold providers accountable
- Producing assets offline longer than they should be

LACK OF A LIVE MAP SHOWING ALL WORK AND PEOPLE IN THE FIELD

IronSight

Solution at a glance

- Cloud-based
- Available on app stores
- Works on any device (No hardware purchases required)



IronSight's Simple Workflow

Step 1: Job request created in seconds with Uber-like app

Step 2: Job aligned by dispatcher to optimal service provider based on availability, live location, and expertise

Step 3: Operator activates job from a list on their app, automatically sending GPS and job status updates

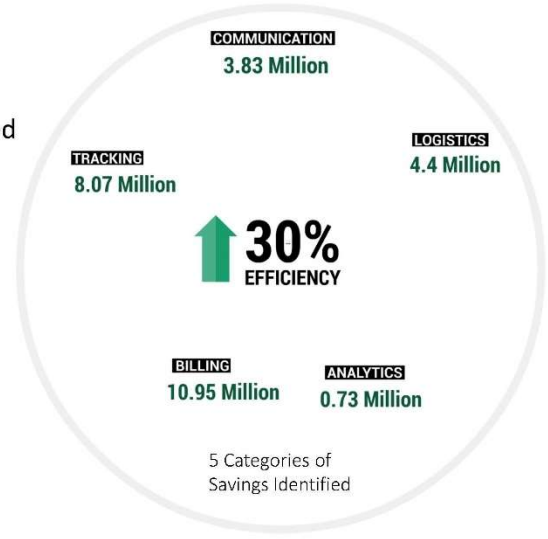
Case Study (Prior to Adopting IronSight)

- 12 months at large CSS and SAGD operation – 160,000 bpd
- 100 distinct service provider units in field completing approximately 5 jobs per day
- Each contracted company had its own dispatcher
- 100 wellsite supervisors requesting services
- 30 Service Rigs

Case Study (Results)

5 Categories of Savings Identified

SUMMARY OF ANNUAL SAVINGS	
Billing	$10.95 million
Analytics	$0.73 million
Logistics	$4.4 million
Communication	$3.83 million
Tracking	$8.07 million
Total	**$27.8 million**



Case Study

Savings from Improved **LOGISTICS** – Reduced Overhead

Human-assisted AI reduced the amount of required dispatchers from 10 to 5.
Algorithm auto-aligns job, and asks for confirmation from dispatcher.

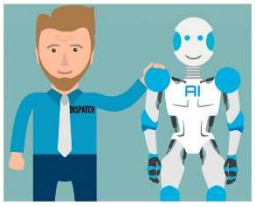
How you work

The old way

1 dispatcher per 5 units

How IronSight works

The new way



Human-assisted AI

5 * $150,000 annual salary = $750,000

Case Study

Savings from Improved **LOGISTICS** – Limiting Travel Distance

Each service provider spends 30 minutes less time driving due to improved routing resulting in less emissions, more jobs completed, and improved safety

The old way

Intuition and educated guesses

How IronSight works

The new way

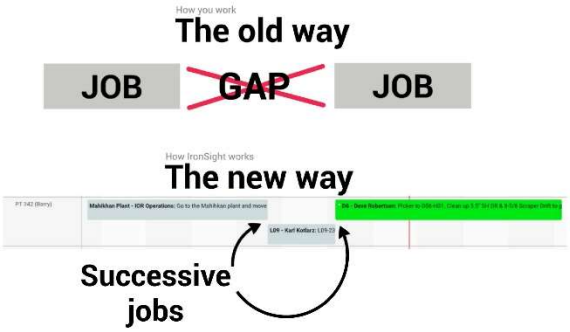
Live map with statuses

100 units * 0.5 hrs * $200/hr = $10,000/day

Case Study

Savings from Improved **LOGISTICS** – Schedule Optimization

Live color-coded schedule allows dispatcher to line up successive jobs for each unit, maximizing utilization of resources.



Case Study

Savings from **GPS TRACKING** – Arrival Monitoring

Knowing exact arrival times allows employees to prepare crews for service arrival and improve job sequencing, which drastically reduces non-productive time.

30 rigs * 0.5 hr/day * $800/hr rig rate = $12,000/day

Case Study

Savings from **GPS TRACKING** – Remote Surveillance

When the service provider knows that the customer is monitoring their work, they are motivated to complete jobs as efficiently as possible.

How you work
The old way

Non-existent

How IronSight works
The new way

Surveillance as a motivator

100 trucks * 0.5 hr/day * $200/hr = $10,000/day

Case Study

Savings from **GPS TRACKING** – Tracking Hardware

Tracking can be done right from employee's personal phone/tablet, eliminating the need for a massive hardware investment and associated monthly fee.

How you work
The old way

Pricey hardware, limited application

How IronSight works
The new way

Bring Your Own Devices

$400/unit * 100 trucks = $40,000

Case Study

Savings from **BILLING** – Billable Hour Round-up

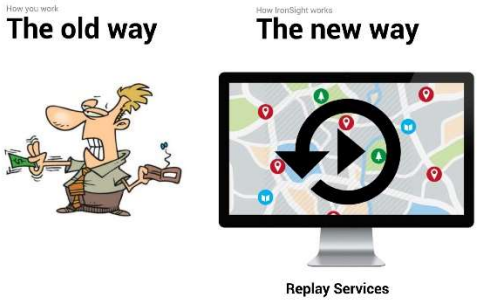
The industry standard of rounding up to nearest half hour increment results in massive overbilling. With IronSight, charges can be reduced to exact times, or to the nearest 15 minute increment.

500 tickets * 0.25 hrs * $200/hr = $25,000/day

Case Study

Savings from **BILLING** – Questionable Charges

The oil company now has GPS breadcrumbs and the historical data for each job's duration. Questionable charges from service provider can be disputed.



500 tickets * 5% of tickets * 1 hrs * $200/hr = $5,000/day

Case Study

Savings from **COMMUNICATION** – Automation and IM

Instead of long email chains and playing phone tag, IronSight's automated job status updates and Instant Messaging allow employees to focus on what matters.

The old way	The new way
	
1-4 hours/day	Fully automated

How IronSight works

100 employees * 0.5 hr/day * $100/hr wage = $5,000/day

Case Study

Savings from **COMMUNICATION** – Location Statuses

Location statuses and colors can be assigned to each location on the live map. This drastically reduces the number of wasted trips to offline fluid load stations.

How you work The old way	How IronSight works The new way
	
Wasted trips to offline sites	Update live map locations

5 units * 1hr wasted trip * $200/hr = $1,000/day

5 rigs * 1hr NPT * $800/hr = $4,000/day

Case Study

Savings from **COMMUNICATION** – Information Logging

Manually logging the data of each job is a large waste of an employee's time. IronSight automatically stores all job data. It can be searched and sorted for future reference.

How you work

The old way

labor-intensive

How IronSight works

The new way

automatic, unlimited storage
search and filter

5 dispatchers * 1 hr * $100/hr = $500/day

Case Study

Savings from **ANALYTICS** – Utilization and KPI Dashboard

Customer identified a drop in utilization of a full-time contracted unit. They released the truck, saving them thousands per day. Any question about you business can be answered from IronSight's KPI dashboard – compare vendor performance, investigate spikes in number of jobs, reward outstanding employees

How you work

The old way

oversupplied

How IronSight works

The new way

low utilization!

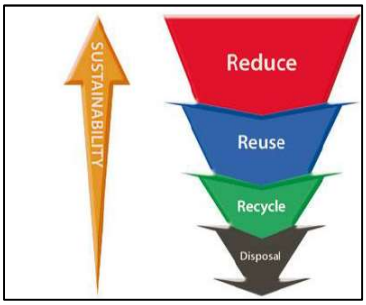
1 full-time unit dropped from contract = $2,000/day

IronSight's Zero-Risk Deployment

- 60 day free trial
- Start with a small segment of your business and assess value
- No hardware purchases required
- Minimal training of employees required
- Commit to monthly subscription following the trial, cancel at anytime

7.6 SOIL AS A RESOURCE

Speaker #3 (Enbridge – Robert Martens): Soil as a Resource/Managing Contaminated Sites



'Managing Contaminated Sites, Efficient Upstream Oil and Gas Wellsite Reclamation' was presented by Robert Martens, M.Sc., P.Eng., P.Ag., who is the Technical Manager, Regulatory Compliance with Enbridge. The presentation focused on soil management, including 1) beyond 'remedial excavation and disposal ' of contaminated soil; 2) seeking opportunities for re-use; and 3) finding use for 'clean' excess soil. The presentation reviewed: the costs and greenhouse gas emissions associated with trucking contaminated soil to landfill in Alberta and British Columbia; and, social acceptance and regulatory hurdles associated with soil re-use. Other jurisdictions where soil is scarcer find low-risk ways of re-using soil, which has side benefits of 1) promoting development of effective treatment methods, and 2) reducing the use of aggregate and borrowed soil for construction.

Managing Contaminated Sites Efficient Upstream Oil and Gas Wellsite Reclamation

June 25, 2018

Robert Martens, MSc, PEng, PAg
Technical Manager, Regulatory Compliance

Contaminated Sites Management Framework

- Risk adverse system with the majority of contaminated soil managed by "dig and dump"
- Dispose or remediate with limited opportunities for secondary use
- Substantial volumes of clean excess soils are disposed at landfills or disposed at designated ocean disposal sites

2017 stats:

- Total contaminated soil disposal AB / BC: ~ 945,000 Tonnes
- Total annual disposal fees: ~ $ 50 – 60 MM

Ocean disposal for "clean excess" soils:

- West Coast Canada has 10 soils disposal sites operational since 1938
- Total estimated disposal since 1930's is 24.4 MM m^3 or ~ 43 MM Tonnes
- Cost: $ 470 / 1,000 m^3, rate in effect since 1997…

Emissions footprint from trucking to landfills AB / BC:

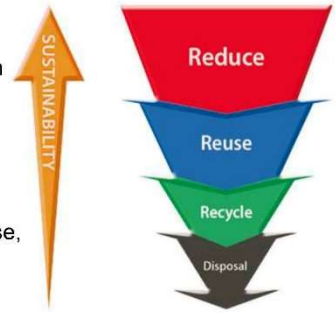
- ~4.3 $MtCO2_e$ / year (2017 data)
- Canada wide emissions from transportation 173 $MtCO2_e$ (2017, Environment Canada)

Current Challenges

- **Risk Based Closure Principles**
  - US Superfund approach has no generic contamination criteria compared to Canada
- **Reuse of remediated or secondary use of contaminated soil**
  - AB: Unless it meets Tier 1, it is a regulatory challenge to delist remediated soil for backfill or reuse
  - BC: Reuse of clean material is challenging if it exceeds background levels
- **Soil management and treatment opportunities**
  - Limited or no opportunity for reuse of remediated soil,
  - Application of immobilization technologies for soil with (minor) exceedances,
  - Lack of Province wide sustainable soil management guidance, and
  - Social acceptance of reusing remediated soil (NIMBY vs PIMBY).
- **Approximately 40% of remediation cost in AB / BC are related to excavation, transportation and disposal of soil**
- **Current liability provisions in EPEA and EMA especially when using remediated soils**
- **Climate**
- **Remoteness**

Alternatives to Consider Other Jurisdictions

- **Ontario**
  - Current draft Excess Soil Management regulation (comment period closed June 15, 2018)
  - Purpose: sustainable use and reuse of excess soil
- **UAE / California / Belgium**
  - Well established framework of immobilizing hydrocarbon and salt impacted soils in asphalt and concrete production
- **the Netherlands**
  - Annual soil "movement" is ~50 MM Tonnes
  - Creation of nation-wide soil bank network in 1991
  - Free intake of contaminated/clean surplus soils with the objective to treat and reuse,
  - Reduced landfills from 80 in 1990 to 11 in 2017
  - Since 2000, total of 38 MM Tonnes soil has been treated and reused
  - Since 2008, total of 1.5 MM Tonnes immobilized in concrete and asphalt production
  - Disposal volumes decreased 70% between 1992 and 2015



Reuse and Treatment Alternatives

- Use of low concentration impacted soil for new road foundation / construction
- Use of impacted soil for sound walls / barriers in high density urban development
- Soil bank concept – Treatment and reuse based on future (land) use / risk
- Immobilize in concrete, asphalt, brick production and roofing material
  - Aggregate production in BC is 50 MM Tonnes / year, which can be reduced by 50% (re)using impacted materials
- Limited or no availability of conditioned treatment facilities
- 2003 Thesis: Sustainable Soil Management Practices for Clean Surplus and Hydrocarbon Contaminated Soils in BC

Q & A

APPENDIX E - INNOVATION CATEGORIES AND DRAGON'S DEN

7.7 GROUP DISCUSSIONS – INNOVATION BRAINSTORMING

Participants were assigned to groups based on their technical backgrounds, aligned to each of the 'innovation categories'. Categories were assigned to help move into *system-wide solution thinking*, versus limiting potential solutions directly to the challenges identified in section 3.1. Participants were asked how different ways of doing things from each category perspective could result in improvements to the overall ARR process, while addressing the challenges identified. Potential solutions were to be evaluated based on environmental, social, economic and innovation outcomes. A list of potential solutions developed through the brainstorming exercise is provided in Table 2.

Table 2. Summary of potential improvements suggested by participants during brainstorming session.

Innovation Category	Potential Innovation or Change in Current Process	Requirement for Success
1. Soil as a Resource	Re-use contaminated soil in roads, quarries, as landfill cover	Possible amendments or granted leniency within Directives 1, 6, 58; Environmental Protection and Enhancement Act (EPEA); Alberta Tier 1 and Tier 2 Soil and Groundwater Remediation Guidelines; Alberta Reclamation Guidelines (various); accurate soil tracking mechanism
	Treat from multiple sites and store soil in a 'soil bank' – soil exchange co-op	Possible changes to Directive 58 (AER, 2006); mindset change in end users and public perception of risk
2. Managing Contaminated Sites	Assessment – shift from linear process	Regulatory approval; proven approach
	Adaptive site management approach[5]	Individual environmental consultant and industry representatives to coordinate
	Central repository for site data to avoid lost information and controlled access for improved planning	Creation of hosting platform (OneStop?)
	Risk-based closure and soil re-use – support for justification	Regulatory acceptance; science to prove acceptable environmental risk
	Change Drinking Use Aquifer definition or interpretation	Regulatory acceptance; rationale supported by science
	Remediation screening tool and AI	Development, validation and optimization of a tool or platform

[5] Defined as refinement of a conceptual site model (CSM) over the project life cycle with information obtained during site investigation, remedy design, and remedy optimization. It relies on a systematic, objectives-based site characterization process that includes defining the uncertainties and CSM deficiencies; determining data needs and resolution appropriate for site conditions; establishing clear, effective data collection objectives; and designing a data collection and analysis plan (ITRC, 2017).

Innovation Category	Potential Innovation or Change in Current Process	Requirement for Success
3. Data Capture and Management	Cloud-based, public (or user only) central repository for historical and new information at the asset level, including: • Consistent resource description • Searchable (structured data) • Well bore data • Date/age/product/etc. • Spatially accurate • Lifecycle submissions • Common data and terminology • Systems that speak to each other • Transparency • Remote sensing	Creation and maintenance of a platform for data collection and system maintenance; support for data integration
4. Portfolio Strategy and Risk Assessment	Portfolio strategy – area based	Available data for developing an area-based, multi-year strategy
	Integration of multiple industries and consistent regulations across industries	Data for multiple industries beyond upstream oil and gas
	Communication and alignment	Platform and meetings to facilitate collaboration
	Integrated land management	Data and a platform through which to plan activities for maximum benefit on a regional scale
	Finding commonalities	Site characterization data, a platform, and ability to classify
	Aggregating liabilities through private entities	Licensee cooperation, proven overall benefit (e.g., financial optimization, risk reduction)
	Benchmarking cost and technical data available (per environmental conditions or situation)	Data collection, central platform to host information, willingness of those collecting information to share it
5. Activity Streamlining	Industry financial budget cycle align closer to reclamation process (i.e., budgets forecasted for multiple years)	Tool or platform and access to necessary data to forecast site trajectory over multiple years; collaboration between individual licensees; willingness to dedicate financial resources
	A change in incentive systems could lead to an adjustment in liability management (not just easy sites getting attention, complex sites also seeing budget allocation)	Development of key performance indicators with various measures of success (e.g., # reclamation certificates; advancement of sites through process on a yearly basis; reclamation in sensitive areas; environmental risk reduction)

7.8 DRAGON'S DEN

Participants in the break-out sessions were asked to prioritize their innovation ideas and collaboratively prioritize the best idea under the innovation category. They then prepared a 'pitch' for their idea to revolutionize the ARR process to a 'dragons den'. Four 'dragons' were selected from the audience to

evaluate pitches for a hypothetical $1M grant to support a key project that each team outlined. The purpose was to get participants to think about and discuss the innovation ideas in terms of impact, feasibility, innovation, and financial sustainability. A summary of the project 'pitches' and dragon comments is provided below.

1. **Challenge Group 1: Options for Treatment of Soil**: If soil were treated as a resource rather than a waste, how could ARR be more efficient?
   Innovative Solution: Cooperative Soil Bank/Treatment Facility
   - Across industries and stakeholders; scalable, start small and with one or two and create something simple and easily replicable.
   - Social benefit: create local jobs, training, promote technology development (i.e., treatment, assessment, tracking and traceability); reducing traffic and associated accidents.
   - Soil conservation and re-use: prevent potential resource going to landfills; find use for excess, treated, or marginally contaminated soil.
   - Greenhouse gas reduction: reduced trucking for moving soil if treatment facilities are in proximity to source, with a provincial tax credit for reducing greenhouse gas emissions as added incentive.
   - Investors could change focus from landfills with no return on investment to soils co-op with greater opportunity for return. Understand that some soils are suitable for some things and not others. Define list of primary and secondary uses keeping land use targets in mind.
   - Environmental – soil conservation; less disturbance in the form of borrow pits for backfill; more remediation completed at lower cost.

2. **Challenge Group 2: Managing Contaminated Sites**: How could managing contaminated sites differently result in improved efficiency?
   Innovative Solution: Data Silo Buster - Environmental Data Sharing Platform
   Geochemical and hydrogeological data would be housed on a central data sharing platform, available to users through a subscription. Data would include geochemical data for surface water, groundwater and soil, including soil type, hydraulic conductivity, and depth to groundwater, as examples but not a complete desired dataset. This would result in efficiency through decreased cost/time in obtaining offsite (background) samples; informing strategy for onsite sampling and testing (i.e., preliminary conceptual site model); and, better understanding where background chemical concentrations could be of natural origin, thus supporting justification when remediation is unnecessary. Environmental data could also be used to prioritize sites and understand 'what is out there' in terms of types and volumes of contamination requiring remediation (*in situ* or *ex situ*). It is assumed that data would be provided by those who collect it, but data mining of reports may also be required for obtaining information.

3. **Challenge Group 3: Activity Streamlining**: How could ARR activities be managed differently to improve efficiency?
   Innovative Solution: Provincial Asset Database
   A provincial database would be created with publicly available information on liabilities tied to individual assets, including their status. The system would allow streamlining of activities for consultants, service providers, stakeholders and regulators. The platform or database would allow all relevant, available data to be compiled. Having information centralized, as opposed to held hostage in licensee/owner files, would create collaboration and streamlining pathways. This would support area-based closure.

4. **Challenge Group 4: Portfolio Strategy and Risk Assessment**: How could portfolios of sites be managed to meet environmental, social and economic outcomes?
   Innovative Solution: Data Marketplace
   Relevant datasets would be combined into one; for example, geospatial datasets, Crown dispositions, ABMI data. Currently there are silos and we propose leveraging data to move beyond them. Confidentiality can be respected based on datasets from other industries and datasets (e.g., ABMI database, the Alberta Data Partnership database).

5. **Challenge Group 5: Data Capture and Management**: How could data be captured and managed to streamline ARR activities?
   Innovative Solution: OneStop – Asset Level Information
   The OneStop single central data repository would hold all the information about each asset, including historical data and current status. This database will be publicly available with searchable and downloadable data. It will include automation of data collection. The vision is that every asset, well, pipeline, *in situ* scheme, coal mine is its own entity. Right now, all legislation is at the asset level and needs closure at the asset level. We're having more insolvencies, some assets are getting divested, information is getting lost as it's handed off so if information was tied to the asset and available at that level rather than tied to owners, liabilities and action recommendations will be clear. Another way this will promote efficiency is in streamlining the type of information and data required for submission, to increase efficiency in data collection, processing and reporting efforts.