

Rapid Phase 1 Environmental Site Assessment (ESA1) Praedico

Alberta Innovates File #232402747 – CLEAN RESOURCES

Public Final Report
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Prepared for
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CLEAN RESOURCES FINAL PUBLIC REPORT TEMPLATE

1. PROJECT INFORMATION:

Project Title:	Rapid Phase 1 Environmental Site Assessment (ESA1)
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AI Project Advisor:	Dallas Johnson

2. APPLICANT INFORMATION:

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3. PROJECT PARTNERS

The ESA1 Project was funded with support from Alberta Innovates, NRC-IRAP, SR&ED, and SDTC with in-kind contributions for capability requirements, ways of working, subject matter expertise, testing and design received from numerous industry partners, non-profit organizations and government. Organizations included EPAC and CLRA as well as government agencies such as the Department of Energy and the Alberta Energy Regulator. Evolve Surface Solutions and H3M Environmental were among the many industry contributors that made the project successful. Software development support was provided by a Calgary-based development partner SME Analytika.

A. EXECUTIVE SUMMARY

Environmental remediation of inactive oilfield sites in Alberta

In Alberta, inactive oilfield sites represent a significant environmental challenge, as they have rendered substantial tracts of land unusable and exerted a negative impact on biodiversity. Before land reclamation can proceed, including any necessary water and soil remediation, these sites mandate a regulatory Phase 1 Environmental Site Assessment (ESA1). The ESA1 process involves compiling historical information pertaining to well and site construction, operational usage, and incident history, specifically documenting any uncontrolled fluid or vapor releases.

The Rapid ESA1 initiative: streamlining wellsite reclamation

To enhance and expedite wellsite reclamation efforts across Alberta, the Rapid ESA1 project was launched. Its primary objective was to automate data aggregation, digitize critical information, and integrate project workflows within Closure's proprietary cloud-based software platform, Praedico.

Key project objectives included:

- **Automated ESA1 Templates:** Development of systems to generate ESA1 reports automatically.
- **Integrated Subsurface and Surface Workflows:** Unifying information and processes related to both underground and above-ground site characteristics.
- **Geospatial Data Extraction and Linking:** Extracting relevant data from industry documents and linking it with geographical coordinates on digital maps.
- **Surface Environmental Risk Assessment:** Implementing methodologies for evaluating environmental risks based on surface indicators.
- **AI-Enabled Object Recognition and Lease Categorization:** Utilizing Artificial Intelligence to identify specific objects and categorize lease boundaries from imagery.

Encouraging results and project outcomes

The project encountered notable challenges, both in its technical requirements and in the underlying processes of data acquisition, extraction, handling, and presentation. Through prototype development and comprehensive data mapping exercises, critical system upgrades required for the planned applications and seamless integration within Praedico were identified. The outcomes ultimately surpassed initial expectations. By leveraging state-of-the-art technologies, including machine learning and artificial intelligence, the project uncovered latent solutions and insights within the vast datasets, poised to significantly impact the industry.

For instance, the automatic orientation and scaling of survey drawings from paper documents into active mapping layers, a concept akin to science fiction merely a year prior, has become a reality. Furthermore, the development of object recognition capabilities for satellite imagery, specifically for identifying lease boundaries and oilfield equipment, holds substantial commercial applicability. The automated data extraction of compliance option information enables the "fast fail" assessment of ESA1s, thereby identifying site candidates with the most efficient route to reclamation in terms of both time and cost. The convergence of these advanced technologies with robust data aggregation and automation has yielded powerful new applications for the industry.

Key learnings: collaboration, research, and communication

From the initial conceptualization and charter development, it was deemed imperative to engage industry and subject matter experts throughout the project lifecycle. This engagement was facilitated through an end-user committee and iterative project design, leveraging user stories to capture functional requirements. The intricate demands of the environmental workflows necessitated platform optimization to support the desired outputs, specific data requirements, and advanced mapping features. Key learnings derived from the project encompassed: the paramount importance of effective communication, the need for thorough research when considering "build vs. buy" decisions for plug-in applications, the critical necessity of efficient code, and ultimately, the inherent value of bringing development capabilities in-house.

Project benefits: accelerate site reclamation in Alberta

This initiative has directly contributed to the creation of new, highly skilled employment opportunities within Alberta, fostered the development of new Canadian intellectual property assets, and, most critically, delivered invaluable modern digital tools for the industry. Praedico Rapid ESA1 is poised to enhance the capacity and improve the capability of environmental professionals across Alberta. As articulated by one End User Committee collaborator in our final meeting, "You hit the nail on the head."

Rapid ESA1 delivered on the Praedico platform, combined with Closure's existing suite of project management tools, will facilitate the realization of numerous economic, social, and environmental benefits, chief among them the acceleration of site reclamation in Alberta.

B. INTRODUCTION

Sector introduction

The inactive oilfield well inventory in Western Canada exceeds 100,000 sites and is growing at an estimated 6% per year. The cost to address the issue, Asset Retirement Obligations (ARO), in Western Canada have accumulated over its productive history to an estimated range of \$60 - \$260B. Since 2014, a sharp increase in bankrupted assets transferred to the Alberta's Orphan Well Association has revealed a need for a response from social, legal and regulatory stakeholders. The threat of substantial unremediated wells and land disturbance becoming an unfunded taxpayer liability has grown increasingly visible.

Awareness of the societal risk has seen three forces for change emerge: First is accelerated global attention to environment, social and governance (ESG) matters, effected by the rise of stakeholder capitalism which demands a broader responsibility from corporations beyond just their shareholders' interests. The resulting focus on operator reputation with environmental stewardship, has become a basic requirement for social license-to-operate and retaining shareholder support. Second, the Supreme Court of Canada Redwater Decision affirmed the principle of "polluter pays". After bankruptcy, an oil and gas company must fulfill provincial environmental obligations prior to paying out creditors or shareholders. Third, the regulators in the western provinces have implemented the regulation of annual minimum spend requirements in each jurisdiction, with an overall intention to draw down ARO inventories by an average of approximately 4% per year, translating to a cleanup campaign that may take 30 - 40 years.

Producers have maintained their capital focus on cash generating activities using their best available talent, meanwhile Asset Retirement Obligations ("ARO") activities have received minimal attention. Producers have been ad hoc in meeting regulatory or fiduciary ARO requirements, resulting in labour-intensive and unsystematic efforts. The ability to scale up ARO activity by 10-20X historical spending (for some companies) to address the 4% per year objectives of the regulators is not easily achievable. Until recently, the tendency has been to actively defer closure activities or to divest of ARO liabilities, culminating in a critical risk level that requires a step change in approach.

Inactive oilfield sites in Alberta have rendered significant amounts of land unusable and negatively impact biodiversity. These lands require a regulatory Phase 1 Environmental Site Assessment (ESA1) before land reclamation can proceed, including any water and soil remediation. The ESA1 is a compilation of historical information regarding well and site construction, site usage, and, incident history, including uncontrolled fluid or vapor releases. By leveraging state of the art technology, including machine learning and artificial intelligence, it is possible to automate data aggregation, digitize information, and support project workflows within Closure's Praedico Platform; all to improve and expedite reclamation in Alberta.

Knowledge and technology gaps

Inactive oilfield sites in Alberta have rendered significant amounts of land unusable and have negatively impacted biodiversity. These lands require a regulatory Phase 1 Environmental Site Assessment (ESA1) before land reclamation can proceed, including any water and soil remediation. The ESA1 is a labour-intensive compilation of historical information regarding well and site construction, site usage, and

incident history, including uncontrolled fluid or vapour releases. The ability to scale up oilfield reclamation activity by 10-20X historical spending (for some companies) to address the 4% per year objectives of the Alberta regulators and backlog of surface sites is not easily achievable.

Producers' internal resources and the environmental service providers do not have the capacity to scale their operations to meet the demand. The lack of documented industry best practices, collaborative workflows, and purpose-built digital tools have resulted in a fragmented cottage industry of costly customized solutions.

The industry lacks modern digital tools for data aggregation, risk identification, assessment, prioritization, and automated reporting functionality. This requires leading-edge technology to integrate siloed information and fragmented processes in the oil & gas industry. Machine learning and AI are necessary for data learning to generate industry best practices and to accelerate wellsite reclamation in Alberta.

C. PROJECT DESCRIPTION

Knowledge and technology description

The Closure Praedico platform is a web-based application with cloud computing and storage that will host the surface module comprising of the Rapid ESA1 project deliverables. Praedico is designed to create a streamlined process for wellsite reclamation from downhole well plugging through to surface reclamation. The Praedico surface module will include data aggregation and integration to risk assessment, prioritization, and automate reporting functionality. Praedico will leverage leading-edge technology, including Machine learning and AI, to integrate all aspects of this process, which are otherwise disconnected in the oil & gas industry.

Praedico brings together multiple disparate data from public, private and proprietary sources; normalizes the data and auto populates the required ESA1 data fields. Unique Well Identification ("UWI") wellsite locations correspond to geo-spatial instructions to retrieve satellite imagery necessary for the report and to inform the user. Object Recognition technology identifies the wellsite boundaries and surface equipment present on the lease. The ESA 1 report automation is a highly ordered output, however the information collected to generate the report has many valuable benefits to understanding the status of the lands and indications of the work required to reclaim the site. For example, ESA1 fast fail technology to identify sites that can be fast tracked to reclamation versus those likely to require a more thorough and costly ESA phase 2 report. Fast fail also provides budgeting and forecasting indicators for cost and timelines to site reclamation certification (varying from 3 to 10+ years).

Updates of project objectives

The objectives of this project remained unchanged and can be written succinctly as:

- Providing users with the technology and knowledge to streamline the process of Phase 1 Environmental Site Assessments generation by creating a leading-edge web-based platform that can:

- Ingest disparate data sources from multiple providers.
- Enable users to manage multiple well sites and projects.
- Enable users to locate and retrieve aerial imagery of sites
- Enable users to digitize documents, extract data, and automatically save that data in a central cloud-based repository.
- Enable users to semi- automate and complete the ESA1.
- Enable users to view aggregated data and make overrides. Overrides will be stored by user in separate tables from the aggregated data to ensure no data is lost, and that no user can have unauthorized access to data.
- Enable advanced data validation and calculations (e.g. risk calculations).
- Enable computer vision/ML/AI to greatly improve the user's capacity to complete ESA1's.

Performance metrics

Clean Resource Metrics focused on retention of highly skilled jobs as well as the creation of new employment opportunities for highly skilled work in the province. Additional metrics included the creation of new products and advancement of technology readiness level (TRL) starting from level 5 and ending at level 8. Closure collaborated with industry throughout the development cycle to receive feedback, subject matter expertise and create a beach head to commercialization.

Program specific metrics included accelerated land reclamation resulting in industrial footprint reduction and reduced greenhouse gas emissions from fugitive methane at unreclaimed sites. Accelerated land reclamation increases biodiversity from restoration of natural habitat and returns lands to their original use.

Project success metrics included technological advancements such as object recognition for surface oilfield equipment on site, OCR / ICR technologies to extract and digitize key data fields from scanned paper or unstructured digital documents. Development of Intellectual Property in proprietary processes, code, and internally facing AI and ML for data validation and analysis.

D. METHODOLOGY

Agile Development

To ensure the most efficient development of the Surface Module, we had adopted an Agile development methodology. This approach is critical for our organization as it allows for an iterative, adaptive, and collaborative approach between the business project sponsors, and the development team. Our teams are able to test incremental software iterations and pivot focus based on user feedback. Closure utilized waterfall project management to manage the project as a whole. The waterfall methodology was used for global planning, to ensure that the platform development fits

Closure's overall needs and supports Closure's business model. It was also used for high-level risk management and management of the triple-constraint (time, scope, and cost).

Phased Approach

The project development underwent six unique phases. These include planning phases, foundation development, feature development, and QA/QC. The completion of each phase represented a major success milestone as the development team delivered critical functional requirements. Each set of features achieve the Technology Readiness Levels ("TRL") independently, for example, foundation development moved from 5 to 8 through that phase, then the first feature development phase moved from 5 to 8, etc. In this way the phases mark milestone deliverables and demonstrate system functionality. The workplan anticipated the need for continuous improvement opportunities and end-user feedback emerging throughout each phase.

User-Focus

Closure took an end-user focus, design thinking approach to our application development. Each milestone included relevant User Stories to characterize product deliverables to address the customers' needs. Our technology was initially developed to bring efficiency and scalability to our own field execution of reclamation products. As such, our engineering team and content specialists were critical contributors to the detailed requirements gathering phase of our development. In addition, our project partners and industry collaborators were primary contributor and participated in our 'Sensemaking' workshops and "End User Committee" meetings as a constant touchpoint with industry throughout development.

Partnerships

The bulk of the project work was executed internally in the Closure offices in Calgary and with our in-house development team and our Calgary-based development partner SME. Our development and technology hosting was built within the Amazon Web Services ecosystem. The advantages of the AWS platform in processing speed, cloud based multi-user environments, big data repository, and machine learning capabilities make it the desired architecture for platform development. AWS' pre-integrated capabilities are immediately available to Closure for our application development and will support continuous improvement and ongoing modernization of our application. As new security layers or features are added to the AWS environment, those capabilities are immediately available to the Closure ecosystem without having to undertake disruptive maintenance and upgrade windows. AWS provides a high-availability, robust, enterprise-grade environment that supports the growth scalability of the Closure Platform long into the future.

E. PROJECT RESULTS

Milestone 1

Closure has completed Sensemaking workshops that involved the Closure team, third party developer and industry collaborators. The team developed a project charter and moved towards a rigid and detailed project planning phase. Project management tools were developed to control cost, scope, and schedule tracking. This includes a forecasting model for the full duration of the project, and clear visuals and tables to see the original and forecasted cost and schedule. These are still being used to control the project.

Milestone 1 Description	
Task Description	Deliverable
Establish project with Project Charter	Project Charter signed by Steering Committee
Develop Project Plan	Complete Project Plan (note: we may use rolling wave planning, progressive elaboration)
Establish End User Committee	Hold recurring user committee meetings to document features, pain points, processes
Identify data requirements	Document listing all data required and acquisition strategies for acquiring it
Prototype POC	Label and map data fields from AER ESA1 template, auto ingest existing fields in Praedico

Establish project with Project Charter

In accordance with PMI best practices, a Project Charter was drafted and signed internally by Closure's steering committee. This process established the need for the project, and the Project Manager's authority going forward. This plan acted as an initial stage-gate prior to developing the detailed project plan.

Develop Project Plan

Passing the initial feasibility stage gate, the Project Manager assigned resources to the project team to complete detailed planning of the project's scope, schedule, and budget. The project planning phase took considerable effort to decompose the scope established by the Charter, into work packages that could be completed by individual resources. This process involved internal and external stakeholders, including the End User Committee.

End User Committee

As part of planning, Closure established an End User Committee to ensure that the solution provided by Closure would meet the needs of industry, and that industry would be willing to purchase that solution. Committee members include individuals from Closure, environmental service companies, and producing oil and gas companies.

Identify Data Requirements

Closure's internal environmental resources, as well as the User Committee, compiled a detailed list of the specific data requirements to complete an ESA1 for the Alberta Energy Regulator. This was further broken into potential data sources, and an analysis was performed to see which data was available to Closure, could be available during the ESA1 project, and could be available in the future. A strategy was identified to target data and data sources with the greatest "bang for your buck," providing End Users the greatest support on their ESA1's while optimizing costs. Some data can only be acquired via paper documents of potentially very low quality (as one would anticipate when working on a well that is nearly 100 years old).

Prototype Proof of Concept ("POC")

Closure created an ESA1 report prototype that could populate an ESA1 template with data from Praedico's database. While this could only populate a small portion of the fields required (due to Praedico not yet having "ESA1" data), it did provide the user with the benefit of time savings and reduction of human error. This was tested with an industry partner via an End User Committee member.

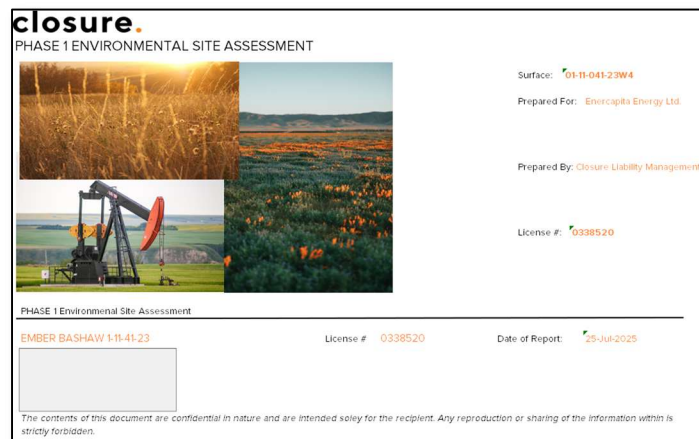


Figure 1: Cover Page from POC (Orange fields are Autopopulated)

Milestone 2

This Milestone contained the largest portion of the work required for the ESA1 project. It covered all the foundational upgrades to the system to elevate Praedico's capabilities to the ESA1 surface requirements. Praedico capabilities were initially designed to support the requirements of the subsurface module.

Milestone 2 Description	
Task Description	Deliverable
Upgrade Existing Praedico Features for ESA1	Modify existing features for ESA1. E.g. Upgrade risk assessment to include risk factors relevant to ESA1.

Add Additional ESA1 Features to Praedico	Add new features for ESA1. E.g. Collaborator functionality, ESA1 Report Page, etc.
Work With End User Committee	Include End User Committee in development to ensure developed features meet their needs
Monitoring and Controlling (Testing/QA/QC)	Testing to ensure the Foundation scope is complete and functional
Release	Opening ESA1 Foundation to End Users (early adopters then as a SaaS offering)

Upgrade Existing Praedico Features for ESA1

Most of the work to Praedico has been on the backend, building the foundational features to support the improved frontend interface. This has included a major upgrade to Praedico’s underlying infrastructure, database, calculations, data connections, etc. This has enabled the team to establish the methods and approaches that are required for the additional features (for example, new methods for large scale calculations that will be used for the “Fast Fail” calculations, and the ESA1 Risk Assessment (below)). Praedico’s new configuration tables were also implemented, providing backend control of frontend features, making it easier to build, manage, and maintain new frontend features, as well as the data flow within Praedico.

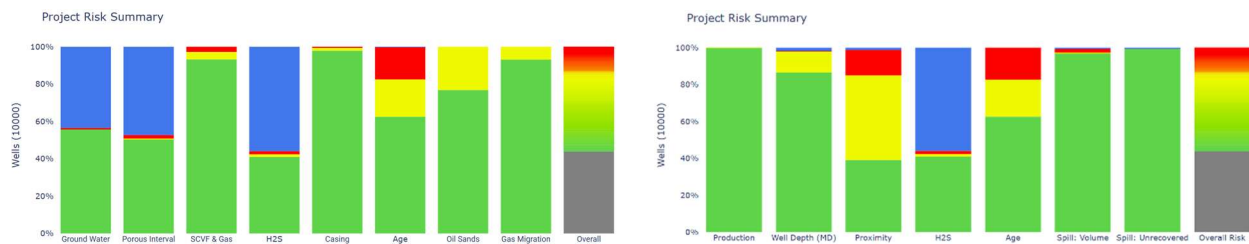


Figure 2: Risk Assessments - Subsurface (Left) vs. ESA1 (Right)

Add Additional ESA1 Features to Praedico

The data structure for the ESA1 features has been completed, creating many tables in Praedico’s backend to house the new “ESA1” data. This has enabled the creation of collaborator capabilities, where users can share their Projects to work on ESA1s together.



Figure 3: A Menu Demonstrating Collaborators on a Project

Another key component includes the One Stop form, which is a critical deliverable for this project. It can be auto populated where possible, further completed by the user, contains nearly all of the data used within an ESA1 and is used for submission to regulatory bodies.

One Stop Report.

1 Asset Information

General

Operator: Sanling Energy Ltd.

Location:

One Stop Submission ID:

Asset Information

Assets

Asset Reference	Asset Name	Asset Status	Asset Status Date	Authorization Holder	Activity Type	Legal Land Description
0146322	SLE RONALANE 1-1-15	Abandoned	22-Jan-2024	Sanling Energy Ltd.	Oil	01-01-013-13W4

Associated Activity

Activity Type	If Other (Describe)	Legal Land Description

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Figure 4: One Stop Report Form - A Key Output for any ESA1

Additional ESA1 features largely build on this work, for example, data populated into the One Stop form can be extracted and added into the ESA1 Report. The ESA1 Report was the largest deliverable to be generated using the ESA1 Module, allowing users to create their final reports, cost estimates, and directly attach their appendices.

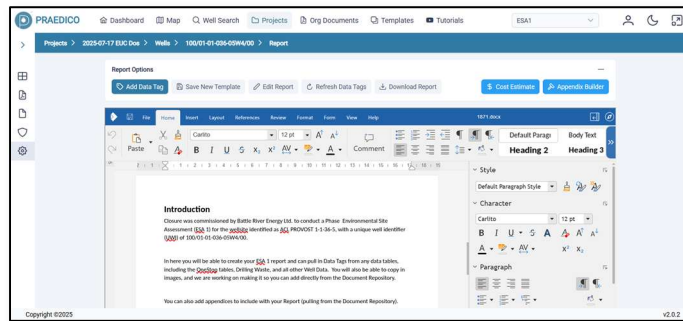


Figure 5: ESA1 Report Writer

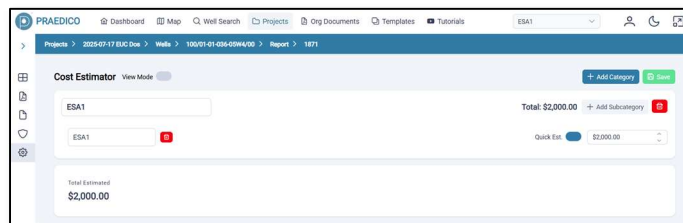


Figure 6: ESA1 Cost Estimate

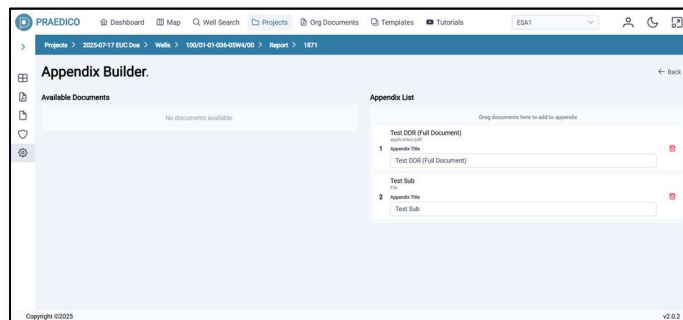


Figure 7: ESA1 Appendix Builder

These features are also supported by a number of other components, such as the Template library and Document Repository.

Work With End User Committee

An End User Committee was established early in the ESA1 Project, ensuring that the objectives of the project aligned with the needs of the End Users. The End User Committee provided feedback throughout development and is still engaged and supporting development and testing of new features beyond the scope of the ESA1 Project.

Monitoring and Controlling (Testing/QA/QC)

A Calgary based SME was the primary development team for the majority of the ESA1 Project until Closure internalized development in late 2024. Direction was provided via the project documentation and the

Closure team to build the features needed for the ESA1 project. Agile Project Management was used to manage development using daily Scrums and two-week sprints. Tasks were documented in JIRA, assigned by the Project Manager to individual resources, and then moved by those resources from development and into test. Closure tested the features and iterated if needed. Once features passed testing, they were moved from the Test environment into the Production environment for End User consumption.

Release

Early in 2023, Closure completed the development of Praedico which was the development of an integrated cloud-based platform to host downhole well abandonment risk analysis module and additional future analytical modules. The Praedico project spanned 13 months and Closure partnered with Alberta Innovates under the Clean Resources Digital Innovations in Clean Energy (DICE) program. As part of the lessons learned from participation in the successful Alberta Innovates Digital Innovation in Clean Energy 2.0 program (“DICE”) in 2022/2023, the Development Team worked to release features as they became available, instead of waiting until large feature sets were complete. This maximized the benefit for the end users and improved Praedico’s feedback/testing cycles with end users. Early release of features maximized the benefit derived from those features.

All features from the ESA1 Project (including this milestone) have now been qualified through test and demonstration and are available to End Users in Praedico’s Production environment.

Milestone 3

This milestone extended throughout the project, as data ingestion, processing, management, and analysis were ongoing. Earlier work was focused on data ingestion and processing, while later work focused more heavily on computer vision AI/ML.

Milestone 3 Description	
Task Description	Deliverable
Add Document Repository Feature	Add new document repository page and backend storage solution
Add OCR and Data Extraction Capability	Develop and train OCR and extraction model
Add Computer Vision Capability	Develop and train computer vision model (survey extraction and map recognition)
Monitoring and Controlling (Testing/QA/QC)	Testing to ensure the data ingestion and computer vision scope is complete and functional
Release	Final release of OCR, Data Extraction, and Computer Vision features to the Praedico SaaS offering

Add Document Repository Feature

Creation of the Document Repository began with an evaluation of current alternatives, to establish whether this feature should be “built” within Praedico, or “bought.” After evaluating alternatives such as Microsoft Office and Google, it was established that for the flexibility required for Praedico’s features, a custom frontend should be designed, leveraging AWS’s S3 service for file storage. This approach avoided many challenges with integrating with third parties, including authentication, data privacy, and inherent development complexities.

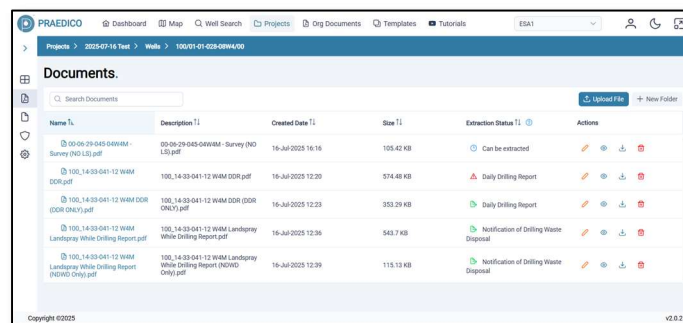


Figure 8: Praedico's Document Repository

The design of the Document Repository leveraged best practices from many sources but has then incorporated Praedico specific document extraction and validation processes to enable data from paper documents being extracted and leveraged throughout Praedico.

Add OCR and Data Extraction Capability

Several different technologies were investigated for OCR/ICR and data extraction, aligning the needs of the ESA1 project with the available alternatives. Some considerations were AWS’ Textract, MS Azure’s Computer Vision, as well as a number of open source libraries. It was determined that the technological capabilities of the artificial intelligence backing Textract and Azure’s Computer Vision could produce comparable results, and the ease of integration with Textract over AWS made it the ideal alternative. Experiments with alternate OCR technologies yielded inconsistent results but will likely be incorporated into Praedico for future purposes (where accuracy is less critical). Textract is the primary OCR tool for Praedico and is used to digitize user documents for extraction. Textract’s capabilities in identifying tables has assisted in data extraction. Praedico’s current extraction processes target specific information on key document templates, as identified by the End User Committee. This data is extracted and translated into “key-pairs” and then analyzed for use on the Compliance Options Pages, to assist in “Fast Fail” calculations.

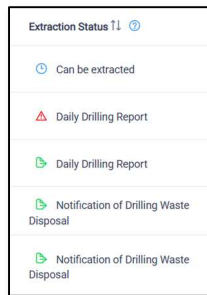


Figure 9: Extraction Statuses on User Documents in the Document Repository

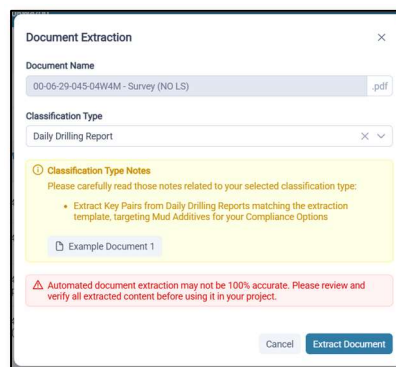


Figure 10: Praedico's Extraction Utility

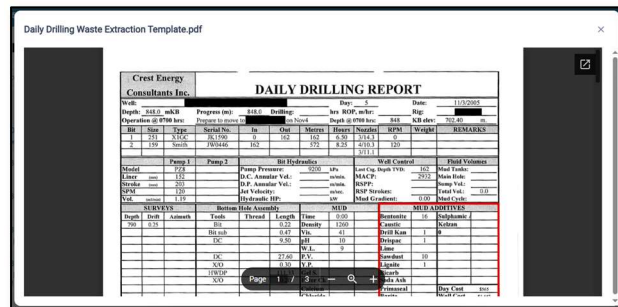


Figure 11: An Example Extraction Template (Highlighting Targeted Data)

As data extraction is not currently a 100% accurate process, a data validation step was added into Praedico's Document Viewer. This allows the User to see the results of the extraction process, and to correct them if needed. In the case of computer printed documents, extraction is typically near 100%, but for handwritten documents, User validation becomes more important.

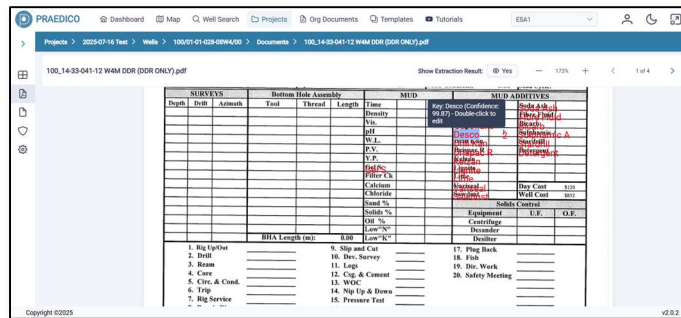


Figure 12: Praedico's Extraction Validation Interface

The extraction process has been supported by the End User Committee and will become more valuable as additional documents are set up for extraction. The establishment of the entire process has also made it possible for Praedico to leverage larger AI models for extraction in the near future.

It is important to note that while Praedico is targeting data in the extraction process, it was also set up for the extraction and digitization of well site surveys, to bolster GIS and visual deliverables of the ESA1 Process.

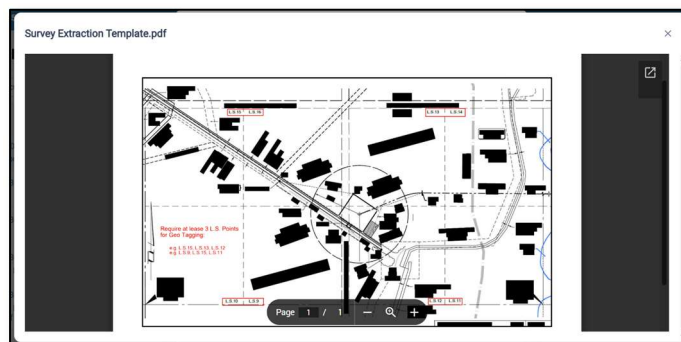


Figure 13: Survey Extraction Template

In addition to data extraction from “paper” documents, we have initiated extraction from geospatial (GIS) data. This approach uses code to extract data from free, and readily available, GIS data sources, bypassing the need for a mapping system. This mining initiative automates aspects of the ESA1 process that have never been automated before. As a start, we have extracted three sets of data that are required for the ESA1, proximity to residences, proximity to water wells, and proximity to waterbodies. The data is being extracted and saved in the ESA1 data tables for easy recall into the One Stop form, and we have also created a deliverable/visual so that the user can verify the results visually. This is new for the ESA1 process, and initial feedback has been extremely positive.

Add Computer Vision Capability (artificial Intelligence training)

Praedico has different avenues of manipulating and displaying data. Traditional data is managed and analyzed in Praedico's databases, but geospatial/GIS data is handled differently. The initial intent with the ESA1 Project was to use Computer Vision to help identify elements on satellite imagery, but following feedback from the End User Committee, Praedico's GIS initiatives expanded.

Computer vision is a field of artificial intelligence that enables computers to "see" and interpret images and videos in a way that is human-like. It involves training machines to analyze visual data, identify objects, understand scenes, and even make decisions based on what they "see". Satellite images were automatically extracted from Google based on an individual wellsite's GPS coordinates. The image was then evaluated to determine whether a wellsite existed (or had been reclaimed already), and then to assess whether there were still man-made structures on site. This work included testing many different mechanisms for computer vision, including standard image processing and artificial intelligence. The resulting models are capable of accurately determining if a site is disturbed and may still require reclamation, and whether structures exist (though the latter still requires refinement). These models are available for use by Closure but have not been implemented in Praedico's front end.

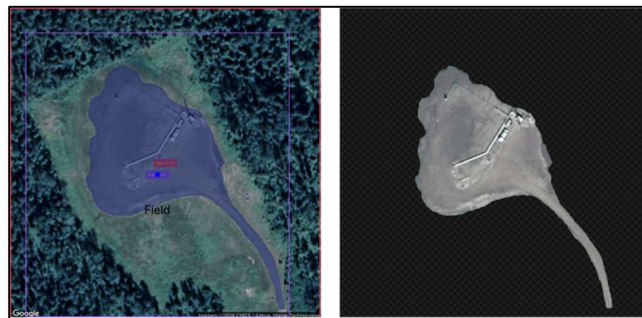


Figure 14: Identification of Well Site to be Reclaimed

Additional work with computer vision has been to automatically extract satellite imagery, and then align it with publicly available feature layers, creating deliverables such as the Proximity Map, which are currently only created manually by specialists completing ESA1s. This work has been furthered by the extraction of wellsite surveys and then combining them with the Proximity Maps. The result has been extremely helpful deliverables for End Users, and a process capable of generating high-end GIS deliverables without the use of a mapping system. Proximity Maps and the results of Survey Extraction are available to Praedico Users.

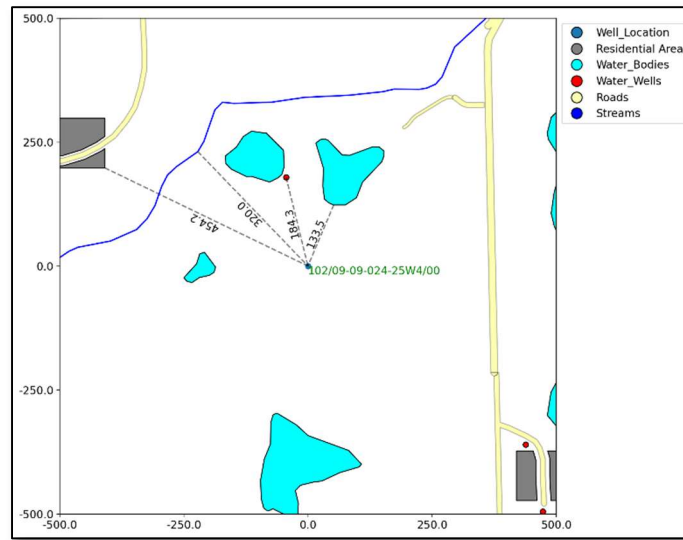


Figure 15: Proximity Map

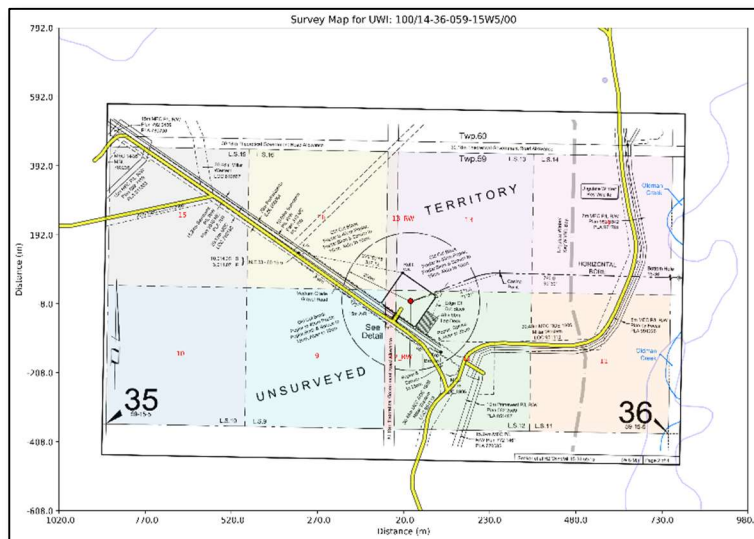


Figure 16: Extracted Survey Overlaid with Key Map Features

Monitoring and Controlling (Testing/QA/QC)

The same process was used for all milestones focusing on Testing/QA/QC to ensure that stable and effective features are released on Praedico.

Release

All features from the ESA1 Project (including this milestone) have now been qualified through test and demonstration and are available to End Users in Praedico's Production environment.

Milestones 4

Milestone 4 Description	
Task Description	Deliverable
Add Drilling Waste Functionality	Add new pages/calculators
Continue Drilling Waste Extraction	Continue to train extraction models as needed to extract critical drilling data
Work With End User Committee	Include End User Committee in development to ensure developed features meet their needs
Monitoring and Controlling (Testing/QA/QC)	Testing to ensure the Drilling Waste scope is complete and functional
Release	Releasing ESA1 Drilling Waste to the ESA1 Foundation as a SaaS offering

Add Drilling Waste Functionality

The Compliance Options forms are standard regulatory deliverables dictating their layout. While this restricted their design, End User feedback indicated the forms could be improved through things like conditional question and answers, to bypass unnecessary questions. These changes were implemented, and ongoing improvements are expected as End Users continue to use the Compliance Options forms to improve their process.

Figure 17: Praedico's Compliance Options 1 Checklist

The calculations for “passing” or “failing” the Compliance Options were also implemented in the forms, bypassing the conditional questions to provide an accurate assessment. These calculations have been established in such a way that information that is automatically populated via source data or extraction can update the calculations, providing information on “Fast Fail” as quickly as possible.

Figure 18: Passing Results from the Compliance Options "Fast Fail"

It is also important to note, that there is 100% data transparency within Praedico, so if a question in the Compliance Options is marked off due to source data or extracted data, the user is always able to see the source to verify that it is correct.

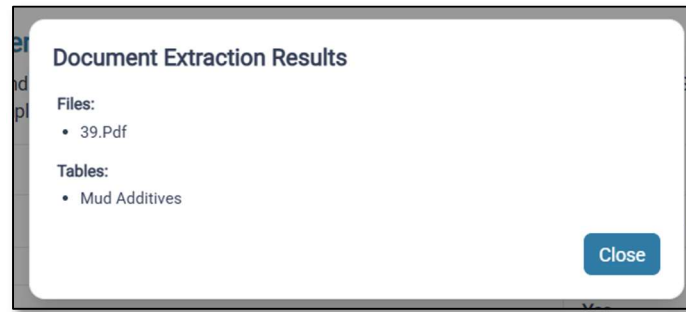


Figure 19: Source for a Compliance Options Question, providing 100% Data Transparency

Continue Drilling Waste Extraction

To “Fast Fail” an ESA1, a significant amount of data is required. Closure has secured a public data source that contains valuable drilling waste data. The compliance options leverage the combination of document extracted customer data and the public database to populate the compliance options table. Using the combination of data sources, we are able to complete up to 70% of the Compliance Options 1 Checklist required in an ESA phase 1. Depending on the data provided, this may be sufficient to “Fast Fail” an ESA1, or not. The ESA1 Project was focused on creating the data pathways and extraction flow to facilitate “Fast Fails.” This has included significant research in how additional data could be acquired from the regulators, third-party data providers or the producers themselves. With the pathways established, and the End User Committee guiding additional data acquisition beyond the ESA1 Project, the “Fast Fail” feature will become more valuable.

Work With End User Committee

Consultation with the end user committee consistently reaffirmed the importance of drilling waste information and the difficulty in sourcing this data. The committee identified multiple sources for this data (e.g. databases, documents, third-parties) and Closure has implemented, or is poised to implement, data acquisition for all of them. By creating a flexible aggregation engine, it was possible to expedite the entire drilling waste process, as currently being demonstrated by Praedico.

Monitoring and Controlling (Testing/QA/QC)

The same process was used for all milestones focusing on Testing/QA/QC to ensure that stable and effective features are released on Praedico.

Release

All features from the ESA1 Project (including this milestone) have now been qualified through test and demonstration and are available to End Users in Praedico’s Production environment.

Milestones 5

Milestone 5 Description	
Task Description	Deliverable
Add Mapping Functionality	Add mapping upgrades, survey overlay, aerial/satellite imagery
Implement Computer Vision Capability	Implement and continue to train extraction for surveys and visual recognition of site objects
Work With End User Committee	Include End User Committee in development to ensure developed features meet their needs
Monitoring and Controlling (Testing/QA/QC)	Testing to ensure the Mapping Upgrade scope is complete and functional
Release	Releasing ESA1 Mapping Upgrades to the ESA1 Foundation as a Saas offering

Adding Mapping Functionality

Earlier versions of Praedico leveraged Mapbox as a mapping provider. Due to the limitations of Mapbox, a search for additional alternatives began. While many systems were evaluated, ESRI's ArcGIS system rose to the top due to its technical capabilities, as well as its position as market leader with the key user groups targeted by Praedico.

A new map was built inside Praedico leveraging ArcGIS and eclipsing the capabilities of Praedico's previous map. The vast amount of data involved with plotting nearly one million wells on a map caused significant challenges in MapBox (and ArcGIS), but through the use of Map Vector Layers it was possible to create massive displays, and enable heat mapping based on the different ESA1 risk factors.

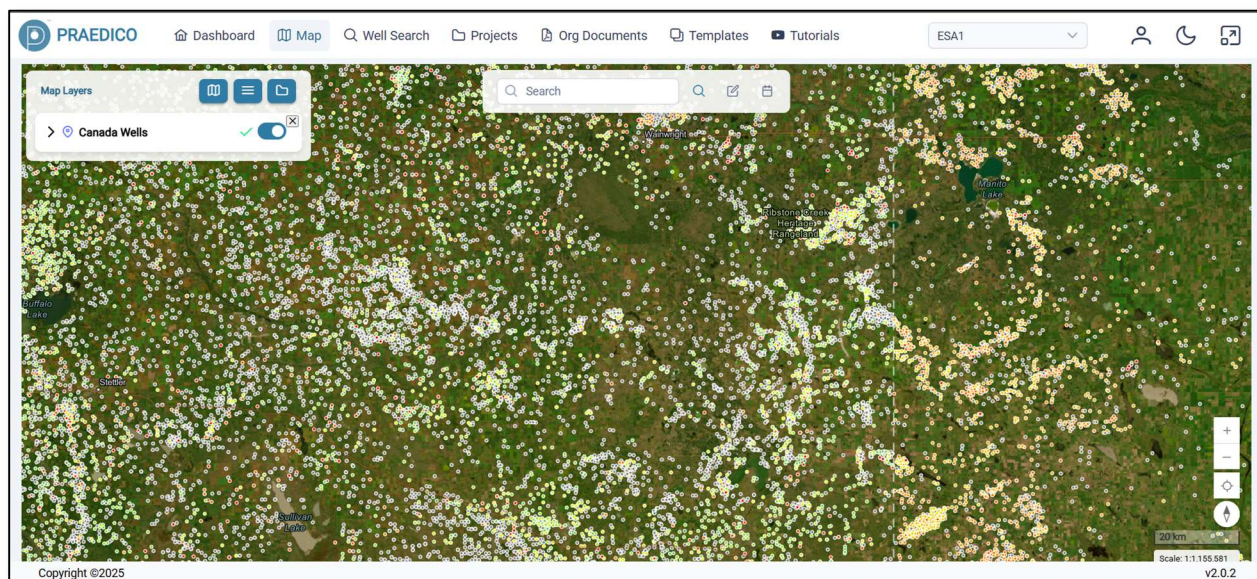


Figure 20: Risk Heat Mapping on the Canada Wells Layer

Combining this with the ability to display individual projects, provides users with an incredible amount of insight around their projects, their wells, and the trends of risks across western Canada.

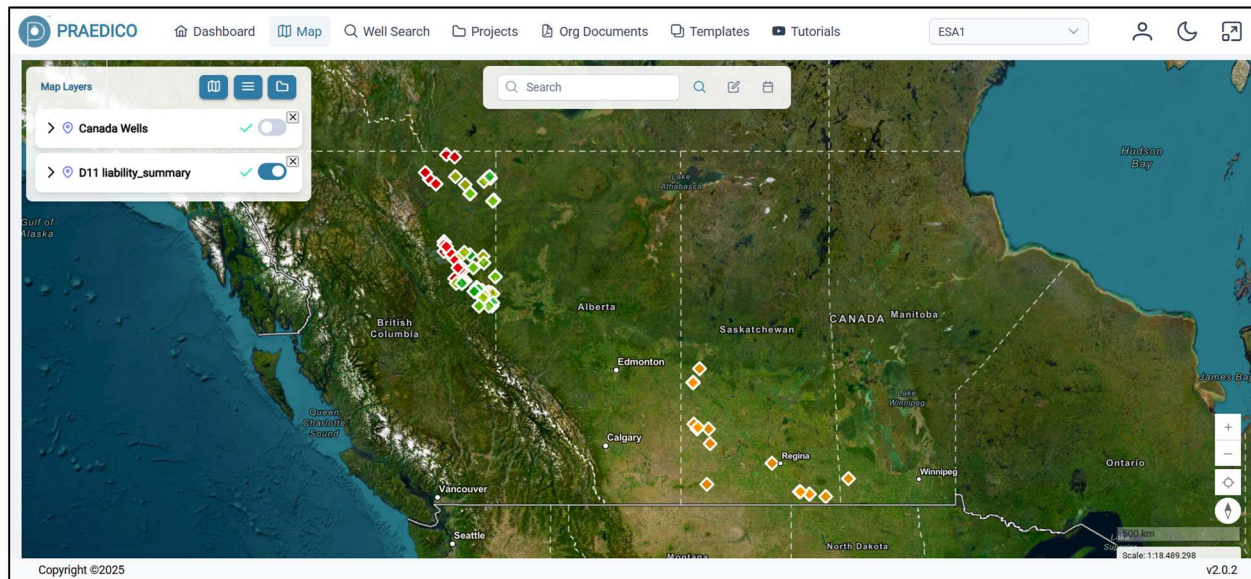


Figure 21: ESA1 Risk for a Single Project

This capability was magnified by being able to add additional feature layers on the map, and more importantly for ESA1 users, the ability to view historical satellite imagery to observe how the wellsite changed over time.

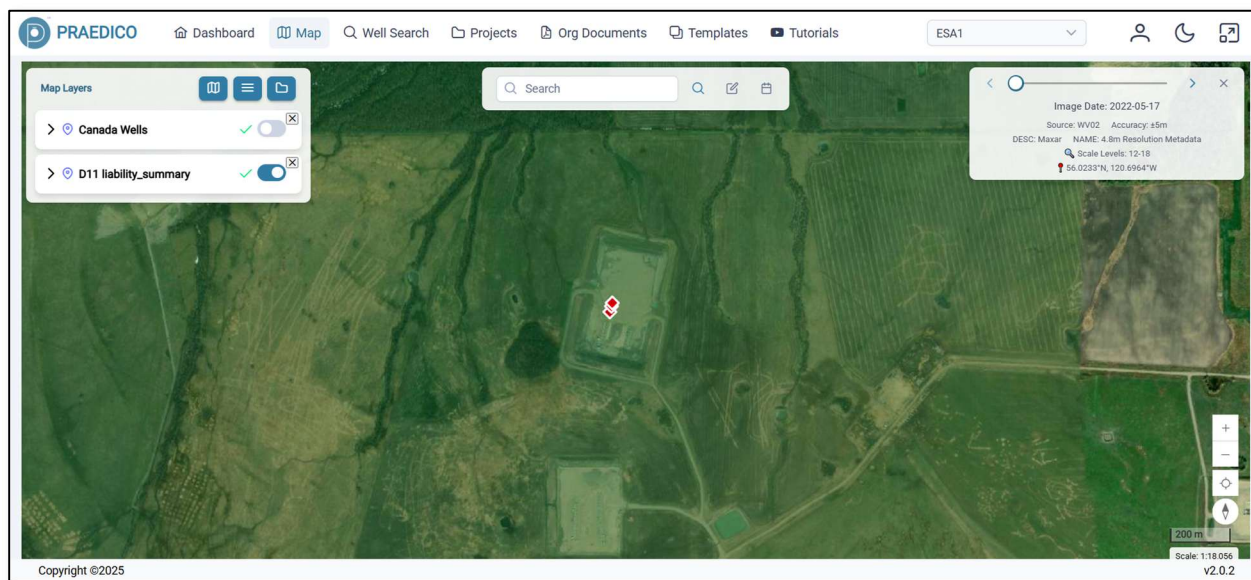


Figure 22: Wells in 2022

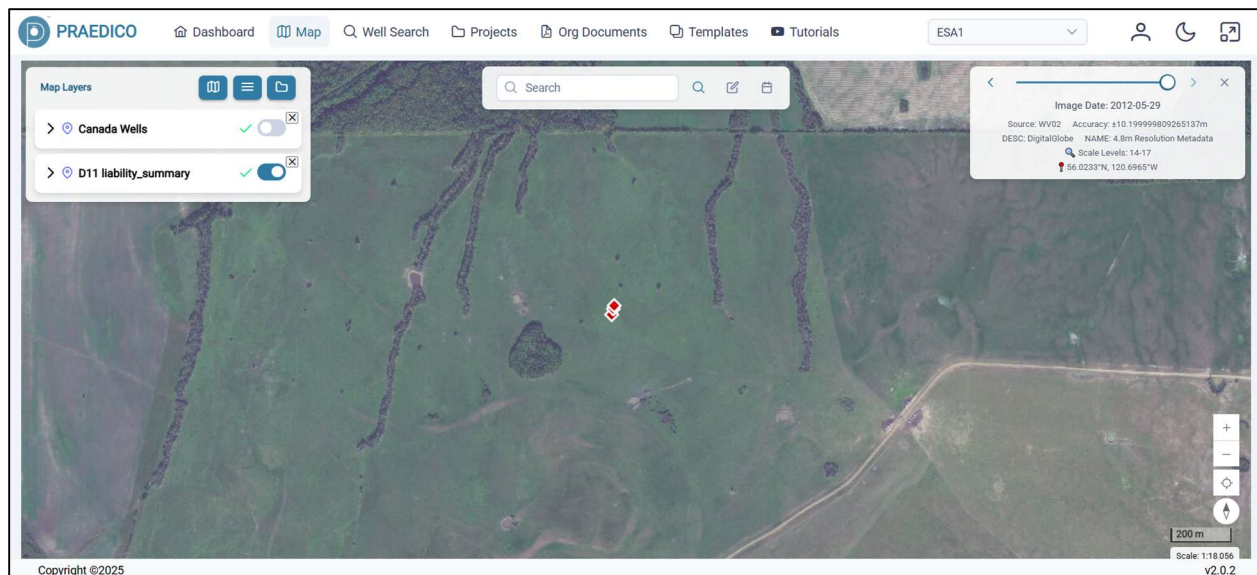


Figure 23: Wells in 2012 (Pre-Disturbance)

This mapping functionality is the foundation for even more mapping features to be developed in the future which will enable Praedico’s ESA1 users to complete more of their processes within the Praedico workflow.

Implement Computer Vision Capability

The work on identifying Praedico’s final approach to Computer Vision overlapped with Milestone 3. Specific models and approaches have been tested using imagery from free sources such as Google, as well as industry collaborators. In the end it was a combination of Computer Vision and Textract that proved successful for wellsite and equipment object recognition as well as in the extraction of surveys and orientation to the map. For more details, see Milestone 3.

Work with the End User Committee

The End User Committee provided sufficient information for the initial build of the mapping upgrades within Praedico. When the Committee was reconvened, they reaffirmed the initial design requirements and that the map within Praedico meets the needs of ESA1. They have further provided feedback that will help in the planning of future mapping upgrades.

Monitoring and Controlling (Testing/QA/QC)

The same process was used for all milestones focusing on Testing/QA/QC to ensure that stable and effective features are released on Praedico.

Release

All features from the ESA1 Project (including this milestone) have now been qualified through test and demonstration and are available to End Users in Praedico’s Production environment.

Milestone 6

Milestone 6 Description	
Task Description	Deliverable
Upgrade Existing Project Management Workflow	Modify existing workflow to reflect the ESA1 process
Add Additional Project Management Features to Praedico	Add human management component, including Kanban and collaborator communication
Work With End User Committee	Include End User Committee in development to ensure developed features meet their needs
Monitoring and Controlling (Testing/QA/QC)	Testing to ensure the Project Management scope is complete and functional
Release	Releasing ESA1 Project Management Upgrades to the ESA1 Foundation as a SaaS offering

Upgrade Existing Project Management Workflow

During the work with the End User Committee, it was determined that most environmental practitioners follow a specific workflow to complete their ESA1s. While there is some differentiation, the main components remain the same. This workflow was reviewed in depth, to determine the easiest way to modify it for more automated flow. Multiple iterations were drafted, but the final (simplified) workflow that was used in Praedico is as follows:



Figure 24: Flow of the ESA1 Module

This process also identified additions to the ESA1 workflow that were out of scope for the ESA1 Project but could further improve the value of the ESA1 Module.

Add Additional Project Management Features to Praedico

Initially a Kanban page was planned to augment the project management features for ESA1, however, due to schedule/budgetary constraints, and upon discussion with our critical stakeholders, this was deemed unnecessary (and not critical to the main scope). Similar results were achieved through Praedico's collaboration features, without requiring a full Kanban.

There have also been improvements to the creation and management of projects, improving project management on a larger scale. For example, it is much easier to locate wells through the Well Search, enabling the users to create custom projects. They can also then break these projects into sub-projects for better management. With the use of the collaboration features, enabling sharing projects between

individuals, it has become much easier to manage work within Praedico, and this will only improve in the future.

Work With End User Committee

The End User Committee was heavily involved in the refinement of features to ensure the Rapid ESA1 module meets their needs at the conclusion of Milestone 6.

Monitoring and Controlling (Testing/QA/QC)

The same process was used for all milestones focusing on Testing/QA/QC to ensure that stable and effective features are released on Praedico.

Release

All features from the ESA1 Project (including this milestone) have now been qualified through test and demonstration and are available to End Users in Praedico's Production environment.

F. KEY LEARNINGS

Milestone 1

As part of the lessons learned from participation in the successful Alberta Innovates Digital Innovation in Clean Energy 2.0 program ("DICE") in 2022/2023, we identified many opportunities for improvement in the lifecycle of our projects. Many of these opportunities were logged as lessons learned from DICE to carry forward. We incorporated these lessons learned into the ESA1 project, and for Milestone 1, our greatest lessons learned came in the form of reinforcement that our improvements in how we manage projects were successful.

Establish project with Project Charter

The key learning that we carried over from DICE was to use the Project Charter for alignment with stakeholders to manage the scope. Our chartering process took longer with ESA1, but the greater alignment and clarity of scope amongst stakeholders has streamlined ESA1, reduced rework, and helped us develop a "parking lot" for items that will be needed for future modules, but that are out-of-scope for ESA1.

Develop Project Plan

To eliminate rework, and streamline development, the ESA1 Project Plan included additional details on specific ESA1 features. While these were under development throughout the project, the lesson learned was that additional clarity in this aspect of planning can save significant confusion between the Closure Team and the development team. This includes aspects of the methods used to develop specific as well as visual representations to aid in communication.

Another lesson learned was to create a “Guide” document, clarifying Closure’s overall vision for Praedico. This has included details on how development should be performed on both the back and frontend, as well as how to manage the project. For example:

- Praedico is meant to be capable of powerful analytics on all data within it, meaning that all data must be saved in the backend in a method that is easy to access and used for analytics.
- Praedico was designed by Closure to use repeatable components. This means that instead of coding a feature multiple times, it can be coded once and used in multiple locations. The development team needs to keep this in mind to reduce the amount of code needed and to provide consistent features to the End Users.
- Progress on the project must be tracked throughout the duration of the project so that we have clarity and are able to identify risk occurrences in scope/schedule/cost early to navigate the consequences. This can be assisted by Rolling Wave Planning, through Progressive Elaboration.

While many communication hurdles dissolved when Closure internalized its development team, these same lessons applied.

Establish End User Committee

The initial input for the DICE project came from a small End User Committee. It was identified that to find a balanced feature set for ESA1, capable of satisfying many customer groups and aiding in product market fit, a larger committee with a broader membership was required. We adopted this lesson and have planned (and are developing) a well-balanced module. This has been reinforced by many customer presentations to different audiences.

Identify Data Requirements

While the data requirements for ESA1’s are quite regulated, we learned that the bigger issue was sourcing the data from many different locations and then letting the user access that data. There were many iterations for this design, but our final approach, and our lesson learned, was to keep the data stored in the backend in many tables corresponding to the specific data sources, then, to let the user select from all the sources in the frontend. For example:

- We can pull H2S from AER records: 20 ppm (1998)
- We can extract data from an uploaded PDF: 0 ppm (2012) (60% accuracy)
- And the user can choose which they want to use

This makes it possible to keep all the data for reference but give the user the flexibility they need to perform their job. The user can also validate the extracted value against the source document in Praedico.

Prototype POC

A prototype was used for DICE and proved invaluable. We continued the practice with ESA1. What we learned from this process was the complexity of the ESA1 requirement, requiring multiple sources of data: paper, digital, and geospatial. The web of how data needs to flow through Praedico is incredibly complex.

The prototyping process reinforced the value of prototyping but also made the ESA1 project possible. Without this kind of feasibility testing, we could have made it halfway through the project and then needed major redesigns. We discovered the challenges early with the prototype, allowing us to iterate designs on paper, as opposed to in code.

Milestone 2

The largest part of the work of the project is in Milestone 2, providing many opportunities for lessons learned, especially around building new functionality onto an existing data platform.

Upgrade Existing Praedico Features for ESA1

When building the DICE version of Praedico, it was built knowing that additional modules would follow, even though the specific features of those modules was unknown. We learned the importance of building all aspects of the code in a way that would make them flexible moving forward.

As development proceeded, we identified an approach to improve the quality of the code, reduce maintenance, improve customizability, and increase the development velocity of new features (and more). This approach leverages customization tables in the backend that drive reusable frontend components. By improving these components it has improved the foundation of Praedico, and expedited the development of the ESA1 specific features.

Add Additional ESA1 Features to Praedico

We learned the importance of stakeholder management on this type of project, where new functionality is added onto an existing platform. Many stakeholders expect to see changes quickly in the project, however, due to the complexity of the ESA1 work, Praedico required a significant upgrade to the backend before the frontend features could be developed. While we did manage stakeholder expectations, we will be clearer in the future that even though work has started, useable features may not be available on the frontend for some time.

Through our extensive planning process, we attempted to avoid common development type pitfalls from shortsightedness, however, due to the progressively iterative nature of development and the high speed of technological advancement, we learned that we must continue to ask ourselves what is the best approach forward? Initial planning identified a rough plan, but we had to continually pivot when faced with unexpected challenges. From performance issues from working with large datasets, to managing many different types of data, we have had to not only be open about different approaches, but to seek them out. For example, our initial deliverables were hardcoded, making them slow to build and hard to change, but with the configuration tables update we are looking at making the flow of data, from new data in the backend all the way to forms in the front end customizable and configurable. The means that changing a form doesn't need a programmer, and it takes little time. With a few minor changes in the configuration tables all of Praedico is updated. We are still learning the extent of how far we can take this approach.

Work with End User Committee

The Praedico End User Committee was extremely helpful to the development of this project. The challenges we have faced are getting engagement from those we need without having an incentive for them. Some committee members would persistently not be able to attend meetings because of their schedules or would not respond timely to communications. Our solution, and lesson learned for going forward, is to be as flexible as possible. We have promoted in-person meetings for engagement but have made virtual attendance possible as well. We have worked to create a team identity and provide snacks for in-person engagements. If a member cannot attend, we have made ourselves available to do individual feedback sessions, to capture their input. Regarding communication, we have made every possible means possible to make it easier for members, and improve our feedback capture, including phone, text, email, in-person, virtual, etc. We have also learned that some input from End Users is better than none, and that we cannot hold up development because of the availability of committee members. That said, to mitigate this, in the future we want to explore a more regular meeting schedule, with more lead time before meetings, though there are inherent challenges with this as development is often nonlinear.

Monitoring and Controlling (Testing/QA/QC)

We integrated the Closure and SME teams much closer together as the project proceeded. By working more closely, with much faster turnaround in communication, we were able to ensure that development met Closure's expectations, with a minimum amount of rework. This worked much better and is an excellent lesson for us. For example, instead of just meeting 2-3 times a week, Closure/SME worked from the same JIRA, where Closure could test, and SME can revise, features up to multiple times per day until the feature tests successfully.

An improvement to the development process, and rigour in executing it, has also improved testing/QA/QC:

- Closure provided SME feature requirements in JIRA.
- SME built the features in the "Test" environment. Once working the developer will send it to another SME developer to test the feature.
- If the SME review passed, the feature was moved to the "Staging" environment and sent to a Closure team member for testing.
- If the Closure review passed, the feature was moved to the "Production" environment and released to End Users.
- If at any time the feature failed, it was moved back again until it is fully functional and bug free.

Hot fixes were also implemented directly in the Production environment if there were critical issues that needed to be addressed immediately in emergency situations only. This was the option of last resort and triggered an investigation into the events leading up to such a requirement.

These processes greatly improved the output from SME, but there were still issues with this arrangement. It was still difficult to have all SME developers adhere to Closure's guidelines, and communication was difficult, resulting in lower velocity, and re-work.

In December 2024/January 2025, Closure internalized its development team, hiring new developers as employees of Closure. While there was an initial decrease in velocity during the transition, through the improved internal communication, and ability to easily enforce adherence to Closure's standards, the quality and quantity of code outputs vastly increased. This also improved the overall architecture and approach of Praedico as Closure's new team was able to focus on best practices, reducing rework and maximizing the benefit of using repeatable components.

In the new process, work is broken up on a feature-by-feature basis, leveraging fullstack developers, to ensure that the workflow through any given feature is flawless, and exceptionally close communication with other developers, including morning scrums, has enabled a seamless stitching together of features.

Without internalizing the development team, it would not have been possible for Closure to complete the ESA1 Project on time, or with the high level of quality that Praedico's End Users expect.

Release

Closure has learned an enormous amount about releasing features from our Test to Production environments. With many developers working on the code there is room for conflict. Since the DICE Project, Closure has used BitBucket for managing source code, but even with BitBucket, code conflicts do occur. We have seen instances where one developer's code overwrites another developer's code and features do not work properly, we have seen problems with configuration files, directing functions to the wrong places, and we have seen modifications made in the Test database that were not carried over into Production.

Throughout the ESA1 Project we have done a number of things to improve our release process (and are still improving):

- Developers are to code in their "Local" environments, then import the "Test" code to repair any conflicts before merging their "Local" branch into "Test"
- Developers should make smaller pushes of code where possible, to avoid significant risk of conflicts
- All configuration files should be based on variables and not hard coded, and all code should be based on configuration files where possible, so variables are not hard coded
- Migration scripts are used for all database changes, to ensure that changes can be automatically carried over from Test to Production
- Automated pipelines for deployment are used anywhere possible (e.g. migration scripts for the database, the automated CI/CD pipeline for deployment from BitBucket to AWS, etc.)

- Migrations should be performed with total open communication from the team, and not last thing on a Friday when there is no time to fix it (earlier in the week is preferred, and in a way that minimized downtime)
- Testing should be performed in Praedico in the Test environment and should pass completely. The migration should be performed, and then the same test should be performed in the Production environment. Results must match or be diagnosed.

Closure is also in the process of documenting the migration process based on best practices and establishing a migration “Lead” to be accountable for the migration as a whole.

Milestone 3

All milestones are complete for the ESA1 Project.

Add Document Repository Feature

Our biggest lesson learned from this feature was to think outside the box. Our previous features around the viewing and editing of documents left tech debt and barriers to moving forward. We took a step back to determine how to get the functionality we needed in a way that we could afford to develop. This opened up many opportunities around open source code, or one-off solutions, but also opened up additional avenues around leveraging fully-developed third-party features. This brought us to the point where we could reinvent the wheel, or just install wheels on Praedico. We performed a feasibility study, looking at Microsoft or Google as third-party providers for document viewing/editing. It was determined that a Microsoft integration was not feasible. Google however promotes the type of integration needed with Praedico and looked like an excellent option, however there were considerable limitations on how we could interact with the data within the Google Sheets product, which would be required for the ESA1 Report Writer. Ultimately, it was determined that it would be best to build our own Document Repository feature, however, for a Document Viewer/Editor, we did find Collabora, which was an excellent solution, as it provided access to functionality similar to Microsoft/Google, but was easier to embed in Praedico and was more affordable. We learned that there was value to being patient in our feasibility testing. Had we selected Microsoft or Google without the thorough feasibility tests, we would have needed an enormous amount of rework once we hit unsurpassable limitations.

Add OCR and Data Extraction Capability

Starting this project it seemed very much like OCR (Optical Character Recognition) was all the same. As we began to investigate, we learned this is not the case, and that varying OCR models provide different results. This is also a rapidly evolving field, so early in our investigations it appeared that AWS’ Textract was inferior to Azure’s Computer Vision, but the technological gap has narrowed, and the ease of migration made Textract an ideal candidate. It is important to note that the AI models behind different OCR features are different, and some perform better with text, or tables, or more complex deliverables.

Textract performed favorably compared to some other open-source alternatives (e.g. Python's native OCR engine). The lesson for us was again in the value of the initial assessment of technologies, but also that the field is developing rapidly. Textract is the best choice now, but it might not always be. Also, some extractions might work best for Textract, but we may need to incorporate different OCR engines in the future for different functions. Ultimately, focusing on being effective has proved to be key.

Working on the extraction of data from geospatial sources, we learned a great deal. Working with the geospatial data has required new libraries and approaches specifically designed for working with GIS data. We were working to bypass the need for an actual mapping system, and have been successful, however, as different maps have different coordinate systems it can be difficult to convert them, so they match. Without a mapping system it is difficult to validate the data results, especially since a minor issue in coordinate conversion can make a big difference in the resulting data. We have learned that while establishing the different extraction protocols, validation using visual mapping systems (Google Earth, etc.) is critical, but once the protocol is working, it becomes unnecessary (bypassing the mapping system for expedited calculations, etc.). This has made it possible to automate the generation of geospatial insights without GIS specific software, letting Praedico produce the results needed automatically and quickly.

Add Computer Vision Capability

During the early stages of this task, we learned a great deal about satellite imagery. Different satellites take different resolutions, different zooms, timelines, etc., and are free, or not, and have historical images available, or not. We have explored how to extract images from Google, and then run into many limitations that impact computer vision, zoom, colouring, resolution, etc. For computer vision to be successful, we need sufficient contrast, and sufficient models to identify onsite objects at different resolutions. While we had hoped to identify specific oilfield equipment, it proved prudent to start first by trying to identify whether equipment is onsite or not, or perhaps only identify specific equipment on higher resolution images. Overall, Closure's knowledge of computer vision has exploded, and we are gradually learning what is possible. This new lesson and knowledge will be carried forward as we continue developing this feature, and onward, as we push the limits of computer vision.

We have also learned that to achieve the desired results a number of computer vision models may be required. For example, if you look for oilfield structures in a satellite image there may be too much noise to get a useful result, but if you first locate the oilfield lease with one model, and then look for oilfield structures within, the results are significantly improved. We have tested several models to help us in this way yielding positive results for identifying wellsites, and whether equipment exists or not.

Milestone 4

All milestones were completed for the ESA1 Project.

Add Drilling Waste Functionality

While the creation of the Compliance Options forms was not technically complex, the ability to tie them into the entire upload/extraction/validation/form flow proved to be quite challenging. We started with a traditional database approach for data storage, as with well data, however, due to the challenges of extraction and then interpretation of data for the Compliance Options we changed our approach. In order to remain flexible, so we could extract data from a variety of forms, we leveraged structured data fields in the database. This made it possible to extract from each form differently, interpret the data, and then merge the data from the database and potentially several uploaded forms into the Compliance Options output.

This approach has opened the door for more flexible data extraction, which will certainly be needed as we extract more information to support the “Fast Fail” capabilities.

Continue Drilling Waste Extraction

To extract the precious drilling waste data that makes a Fast Fail possible, we have learned about the enormous complexity of this problem. 100 years of oil and gas, countless drilling practices, countless reporting practices, some handwritten, some typed, some carbon copied, some on different form templates, many from different sources, whether the government, the operator, a dusty old well file, etc. These complexities have forced us to consider many approaches on how to extract the most drilling waste data possible with our limited budget. Our focus is then on government sources, provider sources and the operator. Looking at digital reports, and analog reports we can digitize and OCR. We are starting by focusing on the main templates for extraction and will then branch out to less common templates.

One of the bigger issues we have identified is that there can be multiple data sources for a single field. This has prompted a change in how data is handled in Praedico, from having one backend field supplying one frontend field, to having multiple backend fields supplying multiple frontend fields. This has been resolved by providing a merge protocol in place in the extraction and Compliance Option loading processes. As additional sources are provided, this merge protocol will be improved, as we have learned that in the complexities of the data, the End User remains the source of truth as to which data should be used. Praedico will facilitate this, so all of the data can be aggregated for the user, and the User can choose which data to use.

Milestones 5

Add Mapping Functionality

Similar to several of our lessons learned, we learned the importance of planning and feasibility testing. MapBox was not a suitable mapping platform. Fortunately, what we learned about mapping on MapBox, we were able to incorporate into ESA1. For our base mapping, most of our lessons learned are about handling enormous data sets. Shape layers can be effective for some things, but when rendering massive datasets Map Vector Tiles have some advantages. This has shaped our approach, trying to leverage the most flexible layers that can give us the potential for high speed and large-scale mapping. By moving over to ArcGIS, we can leverage their features. We have been able to leverage their developer toolbox, acting as a library of existing features to build out our map interface, but have had to balance tile hosing and provision of advanced layers and the associated costs. Our mapping capabilities are split between ArcGIS and Praedico's own AWS Server, making it possible to balance and optimize costs. We will continue to take this hybrid approach, ensuring that Praedico users get the performance they require, but while minimizing cost and ensuring that data remains secure between Praedico and ArcGIS.

We did learn an initial lesson around mapping, that ties directly to the End User Committee. Mapping, as a visual exercise, is exciting, and our End User Committee members provided a long list of features that they were interested in having in the ESA1 Project. Upon initial refinement it was determined that many of their requirements would not be required until ESA2. This instance will help us shape future End User Committee meetings, ensuring that we stay on scope, instead of building amazing features that are not actually in-scope.

Milestone 6

In working on Milestone 6 we learned how to work with the End User Committee to truly understand needs vs. wants.

Upgrade Existing Project Management Workflow

The key learning from this section, was to work very closely with the End Users. In our initial designs we "thought" we knew an efficient ESA1 workflow, but our designs were created from the lens of developers, looking at how best to manage the data and the code. Working with the End Users, we learned that they have a specific process that they follow, and if we want them to adopt Praedico, we needed to ensure that they could see their existing process in Praedico. We redesigned the workflow, making it clear for the End Users that their flow was completely captured within Praedico. Their reviews of the final ESA1 Project has been very favourable, largely because of this alignment of workflows.

Add Additional Project Management Features to Praedico

Working with End User Committee, we were able to understand the critical aspects of collaboration on an ESA1. While there are many “nice to have” features, that will be eventually included in Praedico (the Kanban, for example), what is critical is that we make it easy for people to work together on an ESA1, to share it, and to review it. To achieve this, we created a very simple sharing process, and despite lacking bells and whistles, they were delighted. This has highlighted the importance of understanding what the End Users actually need, as opposed to what they want.

Work With End User Committee

Working with the End User Committee and other expert stakeholders have helped us learn how to focus on features required for the ESA1 project. For example, in Milestone 1, a number of features were identified as critical to the ESA1 process, however, after working with industry experts we were able to split out features that were needed for the ESA1 process, and others that had been grouped in with ESA1 but were actually needed for the ESA2 process. By using this iterative review process with the experts we learned how to refine the scope and hone in on the actual project objectives, pushing off additional features to the appropriate future initiatives. Continuing to consult with the End User Committee throughout the development process and having added new members during the development journey, provided valuable feedback, additions / modifications, and process improvements.

G. OUTCOMES AND IMPACTS

PROJECT MILESTONES 1 – 6

All project milestones have been completed

The project results and learnings demonstrate how the technology and knowledge gaps identified have been overcome. The development of leading-edge technology, informed and designed by end user involvement, and delivered on a flexible and accessible platform provides Producers’ capacity to scale their workflows to meet the demand. The adoption of technology with embedded expertise, workflows that guide best practices and collaboration, and digital tools to automate labor intensive processes create efficiencies that do not exist in the market today.

Closure’s development of modern digital tools for data aggregation, risk identification, assessment, prioritization, and automated ESA 1 reporting functionality were in direct response to industry needs. Praedico’s ESA1 AI/ML data learning will contribute to industry’s best practices and will accelerate wellsite reclamation in Alberta.

Clean Resources Metrics

Metric	Project Target
Existing Sector HQP Jobs Retained	2
Sector HQP Trained	3
New products/services created	Rapid ESA1 Fast Fail
TRL advancement	8
Collaborators	Industry collaborators to be added as early adopters.

Existing Sector HQP Jobs Retained - Achieved

The project target has been achieved. Rapid ESA1 retained our project manager and engineer.

Sector HQP Trained - Achieved

All of our HQPs receive training in a continuous improvement approach including our team of Full-Stack Developers, Data Scientist, and Senior Environmental Specialist. In total the project added 6 highly skilled jobs. Mid-way through the project it was decided to bring the software development in-house to accelerate development, tighten controls and reduce costs.

New products/services created - Achieved

The ESA1 Fast Fail is a revolutionary concept and product that will have tremendous impact in the acceleration of land reclamation. Avoiding the false starts of high probability failed ESA's will ensure more sites advance to reclamation certificate and are returned to their original productive use.

TRL Advancement - Achieved

The ESA1 feature have been qualified through system testing and demonstrations. Consumers are eagerly awaiting commercialization of the features on the Praedico platform.

Collaborators - Achieved

The End User Committee (EUC) and Early Adopter Program (EAP) are ongoing with many collaborators in enrolled in the program. Industry was heavily involved in shaping the requirements for the Rapid ESA1 project as it was designed to meet immediate needs in the market to help automate labor intensive (high cost) low margin work.

Program Specific Metrics

Metric	Project Target
Land and Biodiversity Program Metric	Support all four Land and Biodiversity Program Metrics (footprint reduction, GHGs, biodiversity, natural habitats) by expediting the Phase 1 process for early customers.
Unique product/process	Build-out novel software and process to expedite creation of ESA Phase 1 reports

Land and Biodiversity Program Metric – Achieved

The Rapid ESA1 project applications support all four Land and Biodiversity Program Metrics (footprint reduction, GHGs, biodiversity, natural habitats) by accelerating land reclamation through automation and powerful insights.

Unique Product/Process – Achieved

The ESA1 module of Praedico will have broad application to industry, government, municipalities, and the investment community. With the features developed, the next step in commercializing the technology is hosting the module on Closure's Praedico platform. The initial phase will be an Early Adopter Program (EAP) which includes our End User Committee members to ensure the product is meeting their needs before the broader product launch and marketing campaign.

Project Success Metrics

Metric	Project Target
object recognition	Train and develop Computer Vision AI to identify oilfield equipment remaining on site
Ability to extract data from paper documentation	Develop OCR/ICR process to digitize data and then extract it for use (likely requiring ML/AI) for key data
IP	Development of many proprietary processes and code as core IP. Development of ML/AI where the benefit is substantial (initially focusing on computer vision and data extractions). It is also likely that we will generate internal facing ML/AI to aid with data validation and analysis.

Object Recognition – Achieved

Object recognition models have been developed and trained which demonstrate the ability to identify the presence surface equipment and the well site from satellite imagery. The resolution of the images will

have a significant impact on the success of the application and the ability to recognize and characterize the objects (equipment). Closure has adopted ArcGis for its mapping and image quality to support integration of this feature.

Ability to extract data from paper documentation – Achieved and Ongoing

Extraction of data from paper documentation using Textract models has been successful in testing. Multiple types of documents have been used in the training and testing process which will continue using customer supplied data until OCR / ICR confidence levels are acceptable for product release in commercialization.

IP – Achieved and Ongoing

A significant amount of IP has been generated in this project in the form of proprietary code and trade secrets. This IP includes (but is not limited to) the calculation and visualization of risk, automated GIS deliverables, and ESA1 Fast Fail; the process of data extraction, interpretation, and manipulation; models around extraction, GIS calculation, and Computer Vision; every piece of code that makes Praedico a robust data aggregation and analysis engine; and Praedico's innovative user interface.

H. BENEFITS

Economic Benefits

Jobs

During the project 6 highly skilled jobs were created including the addition of 3 new full stack developers to our in-house software development. The decision to bring the software development in-house mid-way through the project has been a success. Development and iteration times have greatly improved which accelerated development and overall costs were reduced. The project required the retention of two highly skilled jobs and valued employees. Looking forward to product launch, new jobs are to be added for commercialization while 7 highly skilled jobs are sustained.

Industry Activity

Upon successful commercialization of the Surface Module, we anticipate the reduction in time intensity for the preparation of ESA1 to be 75%. Saving companies up to \$1,500 per ESA1. Bottlenecks are removed as capacity is increased by efficiencies in labor through automation resulting in a higher number of well sites being assessed annually. A typical well site measures 100m x 100m which equates to 1 hectare (2.5 acres). Increasing output by 20% equates to over 5,000 additional acres completing the ESA phase 1 each year and moving to reclamation. Corresponding demand for environmental services, earth works equipment, and revegetation services will all increase.

Revenues

The Rapid ESA1 application is being met with a receptive audience of familiar End User Committee members shifting to the Early Adopter Program and then to be converted to customers. For existing Praedico customers, the surface features will be introduced and factored into their existing subscriptions. Forecasted SaaS revenues from the surface module in the first 12 months is \$325,000 increasing to an estimated \$1,000,000 in the following year.

Commerce and Capital

Closure also anticipates risk assessment, ESA1 Fast Fail and the associated cost estimates generated will be impactful in the mergers and acquisitions market and in primary lending. Business combinations have been unable to overcome the uncertainties of appraising environmental liabilities associated with a contemplated transaction, the elimination of uncertainty could unlock M&A activity, attracting new capital investment to the province.

Exports

Many of the surface features are universal in nature like object recognition, OCR, survey extraction and risk assessment and only need to be modified for the data being ingested and the regulatory environment of the jurisdiction. This makes the ESA1 surface application accessible on Praedico platform and ideal product for export to neighboring energy producing provinces or internationally.

Environmental Benefits

Closure's Praedico software is a clean technology focused exclusively on end-of life oilfield assets and is uniquely positioned to generate a positive impact on ARO liability management. Accelerated land reclamation will reduce industrial footprint and increase biodiversity conservation. Closure is a purpose driven company focused on facilitating the reclamation and remediation of the energy industry. The successful commercial deployment of Closure's Praedico software with Rapid ESA1 capabilities will have significant environmental impacts to air, land, and clean ground water.

Accelerated oilfield restoration reduces green house gases ("GHGs")

Dormant well sites, wells that have not been zonally abandoned, will emit on average 8 tonnes per year of CO₂ equivalent green house gases as a result of fugitive methane emissions (methane emissions are 10x more damaging than CO₂ as GHG emissions). The current inventory of wells is estimated to take at least 40 years to clean-up. That equates to an opportunity cost of 320 tonnes for each additional well that can be abandoned today instead of in the future. Combining the Fast Fail surface risk assessment and the downhole risk assessment already functioning in Praedico, the user can identify and fast track the sites that are most time and cost effective to abandon and reclaim. Therefore more sites (including both surface and subsurface) are included in an annual budget. This has the effect of accelerating the overall number of wells and well sites being reclaimed each year. Increased professional capacity allows for prioritization

and planning that translates to operational efficiencies. It all coalesces in Praedico workflow to increase the cadence of site reclamation in Alberta.

Revegetation for CO2 sequestration

Accelerating the remediation of sites will advance the revegetation timeline to sequester carbon sooner. At 2.5 acres per site reclaimed site and a 40-year backlog of sites in the province, any additional site revegetated today has 40 years of additional impact on the carbon cycle. A 20% increase in the number of sites reclaimed each year would add 5,000 acres per year. Calculating and monitoring the value of the CO2 sequestration provides valuable information for ESG reporting and has become a key indicator in many organizations. Revegetated sites with native species offer natural habitat for biodiversity conservation.

Ground water protection, site location, and contamination migration

Topography plays key role in mapping the path of travel of contaminants in soil and seasonal run-off. Integrating GIS system capabilities with wellbore and historical production and fluid disposal information in the Praedico will yield hot spots for targeted field study and measurement. Poorly isolated groundwater due to poor or absent cement across surface groundwater provides the conditions for potential contamination. Only with Praedico can these sites be quickly identified and flagged. The locations can then be cross referenced to the mapping layers, including the extraction of site surveys to accurately identify wellsite location, waste disposal pits, lease dimensions, and access points. Vulnerable topography is flagged for contaminant migration investigation. Alerts to proximity to drinking water wells can be automated using the well receptor features unique to Rapid ESA1.

Reducing industry footprint

Fully remediated well sites return land to agricultural or recreational use. Productive lands that can be redeveloped will contribute to the economy and increase property values and tax base in the province. Recreational lands and natural sites offer habitat for biodiversity conservation. Reclaimed lease roads and well sites remove the manmade barriers to forest and grassland continuity and encourage natural migration of biodiversity in flora and fauna. Rapid ESA1 on Praedico will enable more site evaluations per year leading to more sites moving to reclamation. The automation of ESA1 features on Praedico has reduced overall costs for individual sites and therefore increase the rate of reduction in industrial footprint and increase biodiversity through accelerated reclamation.

Social Benefits

Social Equality and Accessibility

Praedico is a cloud-based platform and can be accessed remotely which liberates users from having to physically access well files at a central location or journey into the field to step onto the wellsite. The workflow supports a collaborative work environment, letting users on-site, in an office, or working remotely, progress seamlessly in the application. The cloud-based network and embedded subject matter

expertise supports diversity, equity and inclusion as participants from all backgrounds and areas of the industry can collaborate. Building a unified and shared knowledge base makes developing related technologies and business models more accessible.

Property Values

Wellsite liabilities are a drain on the economy. They sterilize lands with suspected contamination and have a negative impact on property values. Reclaimed lands provide opportunities for redevelopment, agricultural or recreational use. Productive lands that are redeveloped contribute to the economy, increase property values, and raise the tax base in the province. The work of reclaiming the sites and redevelopment of land create jobs in rural areas and support healthier communities by removing the risk of contamination.

Taxpayer Risk

The Energy industries environmental liabilities in Alberta is estimated from \$60 - \$260Bn resulting from habitual deferral of cleanup. It has been estimated that the current suspended well inventory is approximately 100,000 wells in Alberta alone, growing at 6% per annum. The risk of producer bankruptcies increased from 2014 – 2020, when commodity prices were low and wells put into the Orphan Well Association (OWA) also sharply increased. The taxpayers risk being saddled with an enormous unfunded liability is real. Modern tools are necessary to scale up and accelerate the clean-up efforts. A real world example of Praedico's technology would be in the transfer application to the Alberta Energy Regulator (AER) in a contemplated business combination. The regulator, acting in the best interests of the Alberta people, could quickly investigate using Praedico Rapid ESA1 mapping, object recognition, and fast fail software features to summarize the current state of the environmental liabilities associated with the transaction. The AER could confirm the buyer has the financial capacity to manage the liabilities and has a plan for the reclamation of the sites before title is transferred. This is precisely why Closure was invited to the Government of Alberta's Mature Asset Strategy industry consultations as a subject matter expert.

Emerging Clean Technology Sector

The commercial success of the Praedico platform has the potential to make Alberta a leader in environmental technologies in the Energy industry. There are over 5 million oil and gas sites worldwide that will require site rehabilitation, as well as a significant amount of energy infrastructure. International opportunities for "made in Alberta" clean technology creates jobs and exports for the province, diversifying and advancing the economy. Closure's efforts are divided between commercialization of the Praedico platform including the launch of Rapid ESA1 surface and the R&D team continuing to develop along our technology roadmap while integrating AI/ML enablement.

I. RECOMMENDATIONS AND NEXT STEPS

Long-Term Commercialization Plan for Closure's Praedico software solutions

Closure's long-term commercialization strategy for Praedico is structured, iterative, and grounded in real-world user feedback, and ongoing market research. Our approach builds on our proven methodology developed through the Alberta Innovates Commercialization Associate program and is designed to ensure market fit, scalability, and sustained adoption.

We are currently in the final stages of user acceptance testing with our End User Committee (EUC), a diverse group of industry stakeholders including oil and gas operators, environmental consultants, and technical advisors. These participants are actively validating Praedico's ESA1 risk logic, prioritizing features, and shaping the ongoing development roadmap for Environmental solutions. Their feedback is instrumental in refining usability, workflows, and technical assumptions to ensure Praedico meets the operational realities of the field.

Following this, we will initiate a second phase of our Early Adopter Program (EAP). This phase will expand outreach to a broader subset of industry users, targeting First-to-Buy (FTB) customers who are eager to integrate digital tools into their asset retirement workflows. Participants will engage in structured 30-day trials, providing critical feedback on onboarding, feature utility, and performance. This phase is designed to accelerate learning cycles, validate commercial readiness, and generate early subscription interest.

Upon successful completion of the EAP, we will proceed with a full commercial launch of Praedico's environmental tools, anchored by the ESA1 module. This launch will be supported by a robust go-to-market strategy that includes:

- Strategic partnerships with environmental consultants and industry associations
- Participation in regulatory and policy forums to align with evolving standards
- Targeted outreach to producers, consulting companies, and regulators through thought leadership and industry events
- Press releases and targeted marketing and advertising campaigns

Efforts will strategically concentrate on demonstrating the platform's compelling Return on Investment (ROI). For prospective clients, this means clearly quantifying the financial and operational advantages gained by adopting Praedico Rapid ESA1. This will involve meticulously tracking and presenting how the platform directly leads to reduced reclamation timelines. These tangible benefits will be substantiated by compelling real-world case studies and user testimonials from those who have experienced these efficiencies firsthand.

Partnerships

We are already in advanced discussions with large industry customers to integrate Praedico into their workflows. These engagements are focused on co-development expansion of commercial features such as automated ESA1 reporting, cost forecasting, and risk-based program generation - capabilities that directly address regulatory compliance and operational efficiency.

Our commercialization roadmap is further supported by a strong internal feedback loop. Insights from the EUC and EAP are continuously fed into product development, ensuring that Praedico evolves in lockstep

with user needs. This agile, customer-centric approach reduces go-to-market risk and enhances product-market fit.

Ultimately, our commercialization plan is not just about launching a product, it's about transforming how the energy industry manages environmental liabilities. Praedico is positioned to become the digital backbone of end-of-life asset management, delivering measurable value through automation, precision, and strategic insight. By embedding risk-based logic into workflows and enabling smarter, faster decisions, Praedico not only improves regulatory compliance and cost efficiency but also drives meaningful advancements in land reclamation, accelerating timelines, improving outcomes, and supporting more sustainable closure practices.

Looking Forward

The ESA1 Project has delivered the first iteration of the ESA1 module. It covers the key functions of the ESA1 process and can enable users to accelerate every ESA1 they work on. While this covers the key functions, there are additional components that would improve the commerciality of the ESA1 Module, namely, inclusion of Landowner Interview, Site Visit, and formal signing capabilities. There could be further improvements in satellite/aerial imagery, automatically generated deliverables, and automated submission of the OneStop form to the AER.

Closure will continue to work with the End User Committee, and commercial ESA1 Users to prioritize their needs. It is feasible that all remaining components of the ESA1 process could be included within the next two years.

There are also components of the ESA1 Module that could (and will) be improved using advanced computing, such as ML and AI. Already, Closure is investigating a statistical approach to improve the ESA1 risk assessment, that would use training data and machine learning to attempt to accurately predict whether an ESA1 assessment would pass or fail based solely on available data. There are also plans to improve the ability to automatically complete ESA1s through using advanced AI with data extraction, as well as advanced Computer Vision. In general, with the improvements in AI, the majority of the ESA1 process that needs to be completed by a human today, could be completed by a computer within the next two years of advancement on the ESA1 module.

J. KNOWLEDGE DISSEMINATION

Through our ESA1 development process, Closure has taken a proactive, collaborative approach to industry engagement and knowledge dissemination. Central to this was the formation of our Environmental End-User Committee (EUC), which brought together seasoned industry professionals to shape, validate, and refine the ESA1 module of our Praedico platform.

The EUC, comprised of oil and gas operators, environmental consultants, and technical advisors, played a pivotal role in validating the ESA1 risk logic and shaping platform development. Their feedback directly informed the prioritization of features, including automated risk indicators, streamlined workflows, and

collaborative tools supporting multi-stakeholder input. These sessions, held quarterly and supplemented by focused working groups, ensured that Praedico's ESA1 module was not only technically sound but also operationally relevant. Our engagement was not limited to feedback collection; it was an active co-development process. We presented the rationale behind our software's design, walked through legacy workflows, and invited participants to challenge assumptions and guide development based on their real-world experience. This transparent exchange not only built trust but created alignment between our technical roadmap and actual user needs.

From this dialogue, we identified key challenges in the current ESA1 process: fragmented data, time-intensive reporting, lack of standardization, and an over-reliance on individual experience to assess risk. These insights directly shaped the structure and features of Praedico, allowing us to embed engineering and environmental expertise into the platform, helping users complete ESA1s faster, more consistently, and with greater confidence in the outcomes.

To disseminate this knowledge, we've launched a multi-channel outreach strategy that includes:

- **Early Adopter Programs (EAPs):** Partners are already using ESA1 in commercial settings, stress-testing the system and validating its value. We will onboard a broader cross-section of industry users, enabling further refinement and adoption of these tools.
- **Live Demos and Technical Briefings:** Shared with stakeholders across operations, planning, finance, and leadership to showcase real examples of risk identification and remediation acceleration.
- **LinkedIn Insights and Case Studies:** Publishing engaging, accessible breakdowns of complex closure workflows to industry peers and policy stakeholders.
- **Conference Presentations and Regulator Engagement:** Building on past involvement with the Canadian Land Reclamation Association (CLRA), Alberta's Mature Asset Strategy sessions (GoA), we will continue engaging key industry and policy stakeholders. This includes attending conferences where we will share ESA1 insights, align with regulatory expectations, and promote broader industry awareness.

The impact of this dissemination is twofold. First, it is accelerating the adoption of digital closure tools to empower producers to plan and execute remediation programs more efficiently. Second, to embed site-specific risk and environmental science into an intelligent system (Praedico) supports the broader clean technology mandate: reducing methane emissions, protecting surface ground water, accelerating land restoration, and unlocking capital for reinvestment.

K. CONCLUSIONS

In summary, the challenges posed by the inventory of inactive oilfield sites in Alberta necessitate more efficient reclamation processes. The traditional Phase 1 Environmental Site Assessment (ESA1), while crucial for historical site analysis, presented clear opportunities for modernization and acceleration.

The Rapid ESA1 project successfully addressed these opportunities, leveraging advanced technology to streamline and automate critical aspects of data management. By digitizing information, integrating complex workflows, and deploying sophisticated tools like machine learning and artificial intelligence, the project surpassed expectations. It not only enabled aggregation and extraction of data but also provided powerful insights for risk assessment and identifying the most efficient reclamation pathways. This collaborative initiative, built on strong engagement with industry experts, has already yielded significant benefits which are profound and far-reaching.

Economically, it has directly contributed to the creation and retention of highly skilled jobs within Alberta, fostering new commercial opportunities and establishing potential avenues for technology exports, thereby strengthening the province's innovation economy.

Environmentally, the platform directly accelerates site reclamation, leading to a substantial reduction in the industrial footprint. Its ability to identify high-risk sites quickly enables targeted interventions, preventing groundwater and contamination migration, and contributing to overall GHG reduction by shortening the remediation lifecycle.

Socially, the expedited reclamation process increases land accessibility and can lead to improved land values in affected areas. By supporting informed decision-making and policy improvements, it helps reduce taxpayer risk associated with abandoned sites.

Looking forward, the commercialization of the Praedico Rapid ESA1 application is a key priority. This will involve strategic market penetration to ensure widespread adoption among producing oil and gas companies and environmental consulting firms. Efforts will focus on demonstrating the platform's Return on Investment (ROI) through reduced reclamation timelines and costs, supported by real-world case studies and user testimonials. Building robust sales and marketing channels, including partnerships with industry associations, will be essential to expansion.

The continuous evolution of Closure's Praedico platform is paramount. Future development of features will prioritize enhanced predictive analytics for site conditions, incorporating a broader spectrum of environmental risk indicators, and integrating with additional data sources to offer even more comprehensive insights.

Ultimately, the Praedico Rapid ESA1 platform, in conjunction with Closure's existing project management suite, is poised to accelerate site reclamation across Alberta, delivering substantial and ongoing economic, social, and environmental advantages, truly "hitting the nail on the head" in addressing a vital industry need and paving the way for a more sustainable future.