

2024

# Enhance Origins CCS Project – Closure Plan

**Enhance Energy Inc.**

CLOSURE PLAN  
DECEMBER 2024



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## TABLE OF CONTENTS

<b>Table of Contents</b>	<b>2</b>
<b>1 Introduction</b>	<b>4</b>
<b>2 Project Stages</b>	<b>5</b>
<b>3 Definitions</b>	<b>5</b>
<b>4 Scope of Closure Activities</b>	<b>6</b>
4.1 Post Closure Stewardship Fund (PCSF)	6
4.2 Subsurface Plume Understanding	6
4.3 Carbon Sequestration Lease Boundary	7
4.3.1 Injection Update	7
4.3.2 Subsurface Storage Complex Behavior Evaluation	8
4.3.3 Injection well	8
<b>5 Storage Performance Criteria for Site Closure</b>	<b>9</b>
<b>6 Storage Performance Evidence</b>	<b>9</b>
<b>7 Operating Plan Update</b>	<b>10</b>
<b>8 Preliminary Closure Activities</b>	<b>10</b>
8.1 Storage Site and Satellites	11
8.2 Well Suspension and Abandonments	11
8.3 Well Pads	11
8.4 Groundwater Monitoring Plan	12
8.5 Other Monitoring	12
8.6 Environmental Reports	13
8.7 Site Reclamation and Remediation Plan	13
<b>9 References</b>	<b>15</b>

**Table of Figures**

Figure 1: Hub Project Development Phases (Adapted from Alberta Energy Regulatory Framework Assessment, 2013)..	5
Figure 2: Reclamation and Remediation Flow Chart.....	14
Table 1: Evaluation Well.....	9

## 1 INTRODUCTION

Enhance Energy Inc. (“Enhance,” “the Operator”) is a world-class leader and trusted provider of low-carbon solutions for the transition to a low-carbon economy. Enhance is the founding partner of the Alberta Carbon Trunk Line (ACTL) project, the world’s largest capacity dedicated anthropogenic CO<sub>2</sub> transportation system. Enhance is also the operator of Alberta’s largest carbon utilization and storage initiative located in Clive, Alberta.

Since its first CO<sub>2</sub> injection in 2020, the Clive CO<sub>2</sub> (Enhanced Oil Recovery) EOR scheme has captured and injected over 5.5 million tonnes of anthropogenic CO<sub>2</sub> emissions that would have otherwise been emitted into the atmosphere. The captured CO<sub>2</sub> is injected into a deep geological formation that was largely depleted of oil and gas resources decades ago, making it an ideal storage project.

In 2022, Enhance announced the Origins Project (“the Project”) in Central Alberta. The project is envisioned as an open access CO<sub>2</sub> sequestration hub with the capacity to manage CO<sub>2</sub> from hard-to-abate industries, like cement, power generation and petrochemicals that exist along Alberta’s Highway 2 Corridor — including the Alberta Industrial Heartland, but also from existing large emissions sources in Central and Southern Alberta, making it one of the largest CCS initiatives worldwide.

Enhance is committed to the safe, efficient, orderly, and environmentally responsible development of the Origins Project to support Alberta’s move toward a low-carbon economy. As the owner and operator of a 1.5 MTPA CO<sub>2</sub> EOR operation in Clive, Alberta, Enhance has key advantages toward the timely execution of the Origins sequestration hub leveraging operational expertise in local geologies and the utilization of proven MMV techniques and baseline data to demonstrate long-term storage containment.

Enhance is applying for AER Directive 065, *Section 4.1.6 for a CO<sub>2</sub> Sequestration Scheme*, Approval to inject commercial volumes of CO<sub>2</sub> into the Leduc formation at the 100/04-36-039-25W4/00 well. The AER D065 application contemplates injection of approximately 28 MT of CO<sub>2</sub> into the 100/04-36-039-25W4/00 wellbore with injection targeted to begin in the second half of 2025.

The scope of this Project Closure Plan is limited to the storage component of the Project which includes the following elements:

- Hub location and gathering system
- Carbon Sequestration Lease
- Injection wells
- Other Wells
- Well Pads
- Related Infrastructure
- Subsurface storage complex within the sequestration lease boundary for the permanent storage of CO<sub>2</sub> in the geological formation

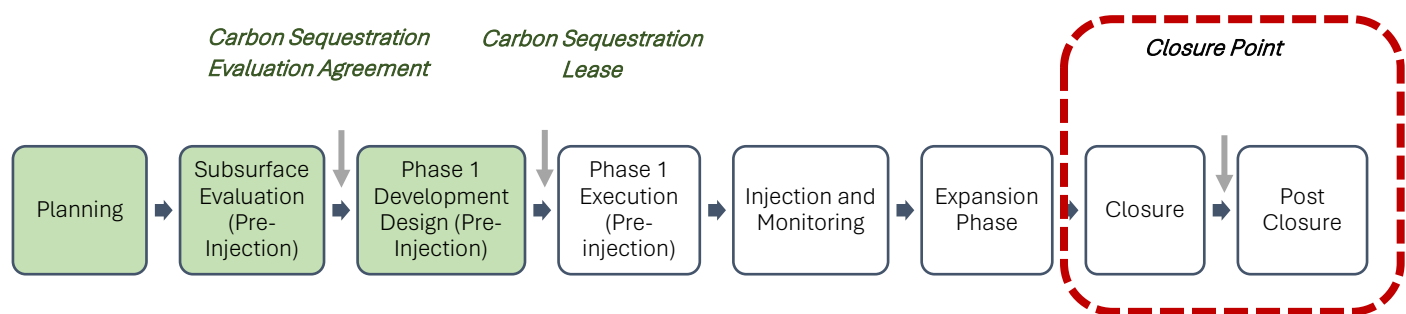
Following the completion of site closure activities, a Site Closure Certificate will be applied for. The post-closure period will begin with the issue of a Site Closure Certificate that will transfer the long-term liability from the Operator to the Crown in accordance with relevant regulations.

Per Section (19) of the Alberta Carbon Sequestration Tenure Regulation, the Project Closure Plan (PCP) approval from the Minister is valid for three (3) years upon which a new renewal is required. A renewal of the PCP may also be required at the time of the renewal of the Carbon Sequestration Lease (CSA) (whichever comes first – 3 years from previous PCP approval or CSA approval).

## 2 PROJECT STAGES

As described in the Project MMV plan, the carbon sequestration project would have associated MMV activities which could evolve throughout the life cycle of the Project. CO<sub>2</sub> injection in the Project well is targeted to begin in 2025. As represented in Figure 1 below, full commercial operations would end with the termination of CO<sub>2</sub> injection leading into the Closure period, which includes post-injection site care under the Operator.

Regulatory approval for the termination of the scheme, which includes the final MMV and closure plans to be reviewed and approved by the AER (or applicable regulatory body) would be required prior to commencing closure activities. The injection well and storage infrastructure will remain in place to continue the monitoring and verification processes as planned during the closure period to demonstrate sustained compliance with the required performance criteria.



**Figure 1: Hub Project Development Phases (Adapted from Alberta Energy Regulatory Framework Assessment, 2013)**

Closure activities will include well abandonment and reclamation of associated surface sites in accordance with relevant and applicable regulations. Subject to the required activities and conditions being met and following the site closure activities, a Site Closure Certificate will be applied for.

After the issuance of the Site Closure Certificate, in accordance with the Mines and Minerals ACT, Chapter M-17, Part 9, Section 120 [2], the Project will be in the Post Closure phase during which long-term liability will transfer from the Operator to the Crown.

## 3 DEFINITIONS

The following definitions are used in several sections of the MMV Plan, Directive 065 Application and the Closure Plan, and are consistent with Appendix C of Alberta Energy’s Carbon Capture & Storage: Summary Report of the Regulatory Framework Assessment.

Area of review: the surface area within which potential adverse effects may occur due to CO<sub>2</sub> plume migration and pressure elevation. The purpose of the area of review is to assist the regulator and all stakeholders in assuring that the sequestration risks are being appropriately managed.

Area of Influence: the spatial footprint of the maximum connected pore volume in the sequestration complex affected by an increase in pore pressure. The area of influence is a useful concept for the regulator to provide assurance for the allocation of pore space within a sequestration complex and on how close other injection activities could be placed.

## 4 SCOPE OF CLOSURE ACTIVITIES

The scope of this Project Closure Plan is limited to the storage component of the Project, which includes the following elements:

- Carbon Sequestration Lease
- Injection well(s)
- Groundwater Monitoring
- Soil Gas Monitoring
- Other Monitoring (Seismic, etc.)
- Other Wells
- Well Pads
- Related Infrastructure
- Subsurface storage complex within the sequestration lease boundary for the permanent storage of CO<sub>2</sub> in the geological formation

Closure activities are categorized as Surface, Subsurface, Short-term and Long-term for each of the elements comprising the Carbon Sequestration Lease.

In addition, project closure and post-closure activities will include all stipulated conditions from the AER Directive 065 approval as well as all applicable regulatory directives and guidelines including but not limited to AER Directive 020 and industry best practices.

### 4.1 POST CLOSURE STEWARDSHIP FUND (PCSF)

Per Section (20) of the Alberta Carbon Sequestration Tenure Regulation, Enhance is committed to contribute to the Post Closure Stewardship Fund (PCSF), which is a fee per tonne of CO<sub>2</sub> injected in accordance with the carbon sequestration lease at an established rate.

### 4.2 SUBSURFACE PLUME UNDERSTANDING

At the time of this plan, detailed studies and assessments are ongoing and a dynamic model has been developed to predict the subsurface plume area. As the Project progresses, this understanding will be adjusted based on observed results (pressure, plume monitoring, anomalies, etc.) to right-size the duration, capacity and scope of the storage complex.

The early injection period will provide an understanding of reservoir conformance relative to simulation predictions through regular gathering of data for visibility and accuracy of plume measurement. Data gathered will confirm CO<sub>2</sub> plume development pathways and identify any conformance anomalies.

Containment data gathering will confirm the quality of seals and ensure hydraulic isolation is being maintained.

This data gathering will continue to inform the Project Closure Plan (PCP) to adjust the scope of work required at the end of the life of the Project.

### **4.3 CARBON SEQUESTRATION LEASE BOUNDARY**

As of September 18, 2024, Enhance and Government of Alberta entered into a Carbon Sequestration Tenure Agreement 5924090003. Per Section 9 (3), the Carbon Sequestration Lease grants, in accordance with the terms and conditions of the lease, the right to drill wells, conduct evaluation and testing and inject captured carbon dioxide into deep subsurface reservoirs within the location of the lease. With the execution of the Carbon Sequestration Lease, Enhance has the requisite pore space authorization in place to proceed with the planned Carbon Sequestration project as proposed in this application.

Enhance is committed to implementing a Project Closure Plan (PCP) in compliance with applicable guidelines and directives upon the termination of the commercial phase of the Project. The PCP must be approved by the appropriate regulatory bodies and will be updated every 3 years to keep up with the developing Project.

In accordance with the Alberta Carbon Sequestration Tenure Regulation, the following activities have been undertaken by Enhance within the Carbon Sequestration Lease Boundary:

- A well was drilled and cased at 100/04-36-039-25W4/00 in February of 2024
- 89.5 m of core was retrieved and analyzed
- Standard open-hole logs including neutron, density, resistivity, SP, photoelectric, and gamma ray ran and analyzed
- Specialty open-hole logs including lithoscanner, formation imaging log (FMI), magnetic resonance log (CMR), and sonic scanner ran and analyzed
- The data gathered has been evaluated, interpreted and continues to be applied to refine the static geo-model, flow simulation (dynamic), define development plans, well injection expectations and operating conditions.
- In addition, seismic data was purchased for the area of interest to study reservoir integrity at the Leduc level and identify potential faulting, shear zones, or structural anomalies that would compromise Leduc's capacity for CO<sub>2</sub> storage or pose a seismicity reactivation risk following commencement of injection.
- 18 legacy wellbores that penetrate the Ireton caprock within the plume extent over the injection lifetime of the project, plus 10 years post injection, have been identified and reviewed.

#### **4.3.1 INJECTION UPDATE**

At the time of this plan, injection is planned to commence in 2025 post AER Directive 065 Approval. Enhance is proposing the following injector which will inject 28MT of CO<sub>2</sub> over an injection period of approximately 17.5 years per below:

- 100/04-36-039-25W4/00



Preliminary well pad design is still underway at the time of this edition of the Project Closure Plan and will be updated in subsequent revisions.

#### **4.3.2 SUBSURFACE STORAGE COMPLEX BEHAVIOR EVALUATION**

The Bashaw reef complex is vast and the Leduc formation within the Carbon Sequestration Lease Boundary was selected as the subsurface storage complex for the permanent storage of CO<sub>2</sub>.

Injection has not commenced at the time of this edition of the PCP and geological interpretations and calculations remain consistent with the dynamic simulation model.

There have been no changes to the associated pressure within the Carbon Sequestration Lease Boundary.

#### **4.3.3 INJECTION WELL**

Within the project area, the first evaluation well was drilled and cased in February 2024 at 100/04-36-39-25W4 and requires final completion for injection activities (Table 1).

Table 1: Evaluation Well

<b>100/04-36-39-25W4/00 CO<sub>2</sub> injection well</b>	
Well Status:	2024/01/25 Licensed 2024/02/20 Drilled & Cased
Govt KB:	881.9 mKB
RR:	2024/02/23
Total Vertical Depth (m TVD):	2210 m TVD
Formation at Total Depth:	Cooking Lake
Casing:	SRF: 244.5mm@600m; Wt 53.6 kg/m; J055 PRD: 177.8mm@2207.5; Wt 38.7 kg/m; L080
BGWP:	327.21 m asl (554.69 m KB) Edmonton Grp
Condition (as of Dec 2024):	Preliminary Completion – perforated, acidized, injection tested, retrievable bridge plug set above perforations.
Integrity Testing Results:	Required every five (5) years for injection wells used for the injection of captured carbon dioxide under the lease

## 5 STORAGE PERFORMANCE CRITERIA FOR SITE CLOSURE

The sequestration scheme performance goals and metrics are being developed internally. Injection commencement at 100/04-36-39-25W4/00 is targeted for 2025.

Some of the criteria that will influence the definition of storage performance goals, metrics (KPIs) and procedures for site closure are:

- Achieving CO<sub>2</sub> plume conformance within the storage complex
- Containment at offset wellbores
- Pressure plume remaining within approved operating range
- Meet or exceed geosphere, hydrosphere, biosphere and atmosphere monitoring expectations.

## 6 STORAGE PERFORMANCE EVIDENCE

Industry best practices and academia literature were reviewed to develop the following program to gather storage performance evidence in compliance with all project approvals and applicable guidelines and directives.

- Injection Performance Evidence
  - Total CO<sub>2</sub> Injection Summary
  - Injectivity Estimate
  - CO<sub>2</sub> Emissions Measurement
- Conformance Performance Evidence
  - Annual evaluation of the dynamic model against injection and reservoir data
  - Annual pressure monitoring evidence against formation fracture pressure
  - CO<sub>2</sub> Plume Prediction
    - Comparing simulation prediction against collected operational data
  - Conformance Monitoring Results
    - Time-Lapse seismic results track CO<sub>2</sub> plume pending technical success of the technology in this application
    - Pressure Monitoring results
- Containment Performance Evidence
  - Periodic Containment Risk Assessment Review and Update
  - Containment Monitoring Results
    - Injection Well Integrity Testing
    - Injection Well monitoring
    - Reservoir pressure monitoring
    - New Development
      - Surface/subsurface developments
      - New 3<sup>rd</sup> party wells within sequestration lease area
    - Atmospheric Monitoring
    - Biosphere Monitoring
    - Hydrosphere Monitoring
    - Geosphere Monitoring

## 7 OPERATING PLAN UPDATE

The project will be operated in accordance with the conditions of the AER Directive 065 approval, the Carbon Sequestration Lease, the Carbon Tenure Regulation and all other applicable regulatory requirements as well as best industry and global practices.

The Project along with the proposed injection well will require a site-specific ERP which will be submitted and approved by the AER prior to commencement of injection.

## 8 PRELIMINARY CLOSURE ACTIVITIES

The Operator would have and maintain the relevant site-specific liability assessments (SSLA) every five (5) years in order to maintain its provincial operating license.

This Project Closure Plan is limited to the storage component of the Project and does not extend to the associated infrastructure including the CO<sub>2</sub> capture or the associated pipelines as these are governed by separate regulations.

Under the closure protocol after terminating injection, a project-specific detailed decommissioning plan will be executed in accordance with relevant legislations and requirements in place at the time which will broadly cover the following staged approach:

**Stage 1:** An observation period following the termination of injection, keeping selected in-well monitoring to support conformance.

**Stage 2:** The isolation of the storage complex, followed by another observation period, to support containment of the storage complex while keeping the ability to re-enter the well if required.

**Stage 3:** The final subsurface and surface abandonment of all wells and sites

## 8.1 STORAGE SITE AND SATELLITES

The subsurface infrastructure will be abandoned in accordance with AER Directive 020: Well Abandonment and Directive 072: Well Abandonment Notification Requirements, and any other regulations and requirements that are applicable at the time of closure.

The surface abandonment of the wells, well sites and access roads will be completed in accordance with the applicable regulations and requirements.

## 8.2 WELL SUSPENSION AND ABANDONMENTS

Inactive and/or suspended wells will meet all requirements of AER Directive 013 until abandonment operations are completed.

Wells will be catalogued and ranked for abandonment timing and order based on technical and regulatory attributes in accordance with AER Directive 020 to ensure that the public and environment are protected before, during, and after abandonment operations. Per AER Directive 020, CO<sub>2</sub> injectors and any high-risk offset wells within 100 m of the CO<sub>2</sub> injection wells are classified as “Level-A” and would need to be abandoned in accordance with Level-A abandonment requirements.

## 8.3 WELL PADS

As of September 2024, regulations require that once an oil and gas facility has been decommissioned, the Operator must obtain a reclamation certificate. Site Reclamation can be broken down into 4 steps:

1. Initial Reclamation
2. Monitoring and Maintenance
3. Detailed Site Assessment (DSA)
4. Reclamation Certificate Application (RCA)

Some of the activities and considerations for the reclamation of the well pads include:

- returning the land disturbed by the Project to equivalent land capability at closure
- ensuring that a stable, self-sustaining closure landscape (including landforms, soil, vegetation and hydrological regime) is present after closure.
- The basic activities for reclamation and establishing the closure landscape include, but are not limited to:

- abandoning and decommissioning facilities
- removing infrastructure
- remediating contaminated areas (if required)
- restoring grade and drainage
- alleviating compaction
- replacing subsoil and topsoil
- re-vegetating

The Operator shall monitor reclamation of soils and vegetation according to the applicable regulations for Well sites and Associated Facilities for Forested Land.

#### **8.4 GROUNDWATER MONITORING PLAN**

Monitoring of the groundwater will occur within selected intervals occurring above the base of ground water protection (BGWP) which is the depth at which fresh water with a total dissolved solid composition of less than 4,000 mg/mL.

The protection of the geosphere will be inherent for the hydrosphere, however, due to the consequences of CO<sub>2</sub> migration, additional monitoring is implemented during the Pre-Injection and Injection period. The purpose of the groundwater monitoring program is to establish baseline conditions for groundwater quality in the area, which can then be compared to sampling during the project conditions in the event of possible CO<sub>2</sub> migrations and be utilized to ensure groundwater is of equivalent condition as baseline data. Groundwater monitoring during the Closure and Post-Closure phases will be determined based on data collected during the Injection Phase of the Project, reclamation requirements and available technology at the time of closure. Monitoring of the following areas may be continued during part(s) of the closure phase.

- Dedicated Water Well Monitoring – Dedicated water wells are utilized to monitor within the BGWP and protect freshwater aquifers. Dedicated water wells allow for high quality, consistent data throughout the lifetime of the project.
- Shallow Gas Monitoring – Headers and gathering systems from shallow gas producing formations in cooperation with Operators.

#### **8.5 OTHER MONITORING**

Closure and post-closure monitoring will be determined based on requirements and available technology at the time of closure. Data collection during the injection phase will inform monitoring requirements for the closure phase. This includes the following areas of monitoring:

- Induced Seismicity
- Plume Monitoring
- Geosphere Monitoring
- Hydrosphere Monitoring
- Biosphere Monitoring
- Atmosphere Monitoring

Decommissioning of the monitoring infrastructure will need to be evaluated upon closure planning to ensure conformance and containment in the above-mentioned staged approach and areas of monitoring meet remediation requirements at the time of decommissioning.

## **8.6 ENVIRONMENTAL REPORTS**

A Phase I Environmental Site Assessment ESA will be conducted in accordance with environmental regulations and the appropriate EPEA approvals will be secured. If no Areas of Environmental Concern (AoC) are identified, initial reclamation will commence, followed by monitoring and maintenance, DSA and RCA. If AoCs are identified, a Phase II ESA will be conducted, with the potential for additional assessment, remediation options evaluation, and remediation depending on findings at each step. If Phase II is required, it must be completed before initial reclamation, by Monitoring and Maintenance, DSA and RCA can occur, as shown in Figure 2. Site Closure certificate will be applied for following the execution of site closure activities and submission of the final Closure Plan and MMV update.

The post-closure period will occur following the issuance of a Site Closure Certificate, which will transfer the long-term liability from the Operator to the Crown. As part of this transfer of liability, the Operator shall provide advice and recommendations on other post-closure activities that may be relevant (new and existing).

## **8.7 SITE RECLAMATION AND REMEDIATION PLAN**

Complete site reclamation during the closure period may not be possible if access roads and monitoring equipment are needed for the regulator to continue monitoring in the post closure-phase. However, as concluded in the Carbon Capture and Storage Summary Report (2013), Conclusion 7, CO<sub>2</sub> injection site and pipeline site reclamation will follow the physical and technical requirements for upstream oil and gas projects and pipeline.

A site reclamation and remediation plan will be developed based on the outcome of the Phase I ESA. Figure 2 outlines the current flow of reclamation and remediation activities. Potential closure activities that will take place under the site reclamation and remediation plan include:

- Well pad removal & reclamation
- Well suspension/abandonment
- Heavy/light reclamation
- Monitoring and maintenance
- Access road abandonment

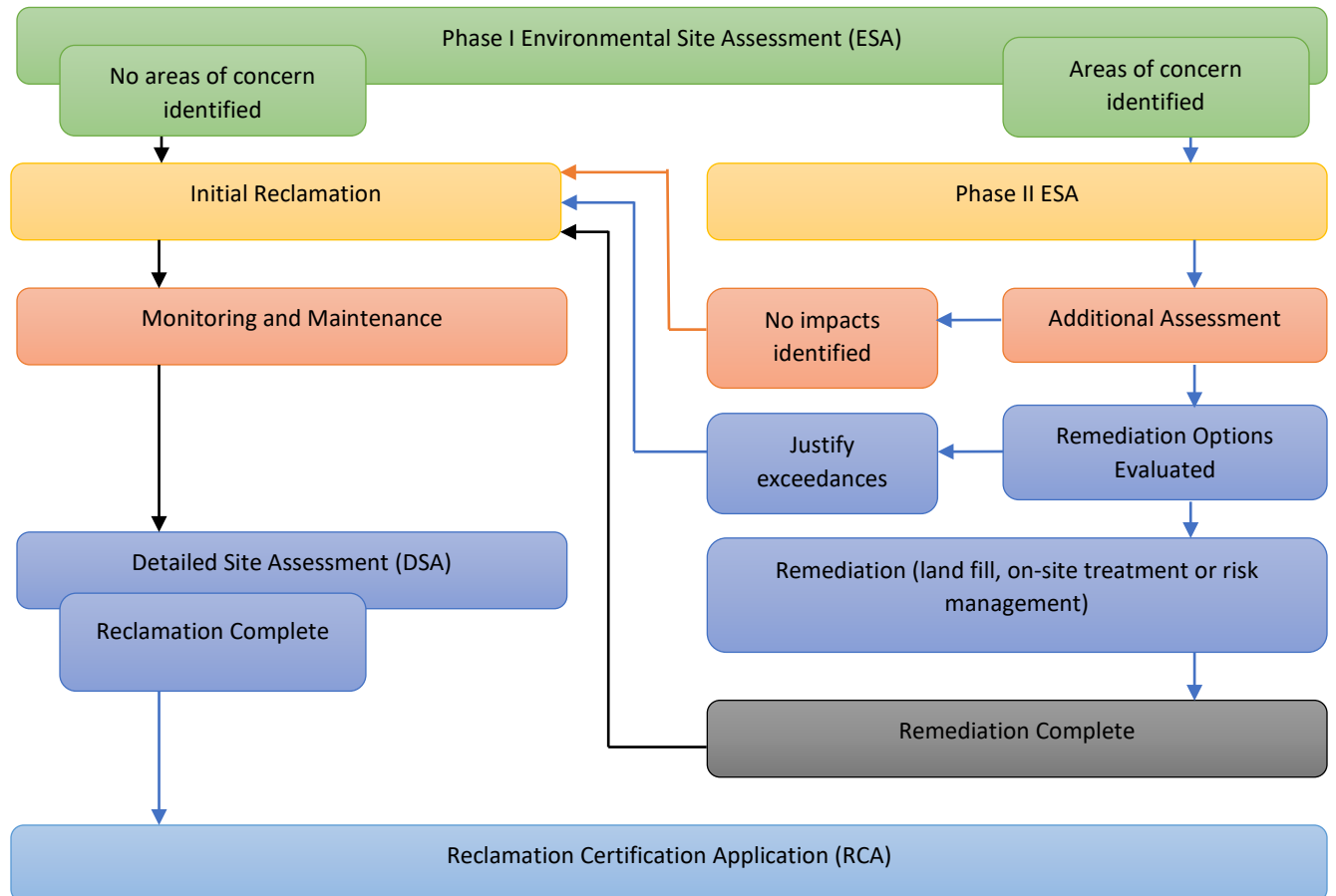


Figure 2: Reclamation and Remediation Flow Chart.

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