

# Enhance Energy Inc. and North West Redwater Partnership

KNOWLEDGE  
SHARING  
REPORT

DIVISION A:  
SUMMARY REPORT  
Calendar Year 2014

Submitted on:  
March 31, 2015



*Green River, by Tom Milosz*



**Government  
of Alberta** ■



# TABLE OF CONTENTS

<b>DISCLAIMER</b> .....	<b>4</b>
<b>CERTIFICATION LETTERS</b> .....	<b>5</b>
<b>PART A – EXECUTIVE SUMMARY</b> .....	<b>7</b>
<b>PART B – PROJECT STATUS OVERVIEW AND COMMENTARY</b> .....	<b>14</b>
<b>SECTION 1: FACILITY DESIGN</b> .....	<b>14</b>
A) <i>AGRIUM CO<sub>2</sub> Recovery Facility (“Agrium CRF”)</i> .....	14
B) <i>NWR Rectisol<sup>®</sup></i> .....	15
C) <i>NWR CO<sub>2</sub> Recovery Facility (“NWR CRF”)</i> .....	20
D) <i>Pipeline Facility</i> .....	20
E) <i>Injection Facility</i> .....	21
<b>SECTION 2: FACILITY CONSTRUCTION</b> .....	<b>22</b>
A) <i>Agrium CO<sub>2</sub> Recovery Facility (“Agrium CRF”)</i> .....	22
B) <i>NWR Rectisol<sup>®</sup></i> .....	22
C) <i>NWR CO<sub>2</sub> Recovery Facility (“NWR CRF”)</i> .....	22
D) <i>Pipeline Facility</i> .....	22
E) <i>Injection Facility</i> .....	21
<b>SECTION 3: GEOLOGICAL FORMATION SELECTION</b> .....	<b>22</b>
<b>SECTION 4: FACILITY OPERATIONS – CAPTURE</b> .....	<b>29</b>
<b>SECTION 5: FACILITY OPERATIONS – TRANSPORTATION</b> .....	<b>29</b>
<b>SECTION 6: FACILITY OPERATIONS – STORAGE AND MONITORING</b> .....	<b>30</b>
<b>SECTION 7: FACILITY OPERATIONS – MAINTENANCE AND REPAIRS</b> .....	<b>31</b>
<b>SECTION 8: REGULATORY APPROVALS</b> .....	<b>31</b>
<i>Enhance Approvals</i> .....	31
<i>NWR Approvals</i> .....	32
<b>SECTION 9: PUBLIC ENGAGEMENT</b> .....	<b>34</b>
<i>Enhance</i> .....	34
<i>NWR</i> .....	35
<b>SECTION 10: COSTS AND REVENUES</b> .....	<b>36</b>
<b>SECTION 11: PROJECT TIMELINE</b> .....	<b>42</b>
<i>Enhance Timeline</i> .....	42
<i>NWR Timeline</i> .....	42
<b>SECTION 12: GENERAL PROJECT ASSESSMENT</b> .....	<b>43</b>
<i>Successes and learnings arising from the project</i> .....	43
<b>SECTION 13: NEXT STEPS</b> .....	<b>47</b>

# LIST OF FIGURES

Figure 1 – Overall ACTL Project Schematic.....	8
Figure 2 – Agrium CRF Plot Plan .....	15
Figure 3 – North West Sturgeon Refinery Plot Plan .....	17
Figure 4 – Gasifier Unit Plot Plan .....	18
Figure 5 – Rectisol® 3D South View .....	19
Figure 6 – ACTL Route Map.....	21
Figure 7 – Relative Location of Clive Reservoirs and its Stratigraphy .....	24
Figure 8 – Graph of Porosity, Permeability and its Interdependence at Nisku .....	26
Figure 9 – Graph of Porosity, Permeability and its Interdependence at Leduc.....	26
Figure 10 – Enhance Project Timeline .....	41
Figure 11 – NWR Project Timeline .....	42
Figure 12 – Agrium CRF Equipment Diagram .....	43

# LIST OF TABLES

Table 1 - Enhance Regulatory Approvals Table.....	32
Table 2 - NWR Regulatory Approvals Table .....	32, 33, 34
Table 3- Main Questions and Concerns.....	34, 35
Table 4 - Enhance Operating Costs.....	36, 37
Table 5 - Enhance Capital Costs .....	38
Table 6 - Rectisol® Capital Costs .....	39
Table 7 - Rectisol® Operating Costs .....	40
Table 8 - ACTL Pipeline Procurement List.....	45
Table 9 - Agrium CRF Procurement List.....	46

## Disclaimer

### **NOTICE OF COPYRIGHT & PROPRIETARY RIGHTS**

© 2015, North West Redwater Partnership. © 2015, Enhance Energy Inc. All rights reserved.

This document contains the information of, and is the sole property of, North West Redwater Partnership ("NWR"), Enhance Energy Inc. ("Enhance") and their respective licensors and shall not be used, reproduced, copied, disclosed, published, distributed, sold, leased, lent, altered, transmitted in any form or by any means, or otherwise exploited for any purpose other than the limited purpose(s) for which it is furnished to the Province of Alberta and in accordance with NWR's and Enhance's respective written agreements with the Province of Alberta, except with the written permission of NWR and/or Enhance, as the case may be. For greater certainty, the diagrams, flowcharts and technical descriptions included herein are for information purposes only and may not be used for any other purpose.

While reasonable efforts were undertaken so that the information contained in this document was accurate at the time of printing, neither NWR nor Enhance assume any liability for errors or omissions. Changes and corrections to the information in this document may be incorporated in future versions hereof. Except as may be otherwise expressly agreed to in writing by NWR and/or Enhance, as the case may be, the information contained in this document is provided without any express, statutory, or implied representations, warranties or conditions, all of which are hereby disclaimed, and none of the authors, NWR, Enhance or their respective licensors will be liable for any damages or liability arising from or caused by any use or reliance upon this documentation. Neither NWR nor Enhance is responsible for any modifications, additions or deletions to the original version of this documentation provided by NWR and Enhance to the Province of Alberta, unless such modifications, additions, or deletions were performed by NWR and/or Enhance as the case may be.

## Certification Letters



### Certification on behalf of Enhance Energy Inc.

CERTIFIED on behalf of Enhance Energy Inc., named in the "CCS Funding Agreement – The Alberta Carbon Trunk Line Project", to be true, accurate and complete, to the best of my knowledge, based on reasonable inquiry and due diligence, as of the date of this certification.

This Certification applies to the information supplied by Enhance Energy Inc. only and does not imply certification of information supplied by other Recipients.

A handwritten signature in black ink, appearing to read "Blair Eddy", is written over a horizontal line.

Per: Enhance Energy Inc.

Blair Eddy

Senior Vice President, Operations

MARCH 31, 2015

Date



**CERTIFICATION ON BEHALF OF NORTH WEST REDWATER PARTNERSHIP**

CERTIFIED on behalf of the North West Redwater Partnership, named in the "CCS Funding Agreement – The Alberta Carbon Trunk Line Project", to be true, accurate and complete, to the best of my knowledge, based on reasonable inquiry and due diligence, as of the date of this certification.

The Certification applies to the information supplied by the North West Redwater Partnership only and does not imply certification of information supplied by other Recipients.

Per:

A handwritten signature in black ink that reads "Terry Kemp". The signature is written in a cursive style and is positioned above a horizontal line.

Terry Kemp  
Vice-President

Marketing and Business Development

Date:

A handwritten date in black ink that reads "March 31, 2015". The date is written in a cursive style and is positioned above a horizontal line.

## Part A – Executive Summary

Enhance Energy Inc. (“Enhance”) and North West Redwater Partnership (“NWR” or “NWRP”) are developing a fully integrated Carbon Capture and Storage (“CCS”) project, the Alberta Carbon Trunk Line (“ACTL”), incorporating:

- CO<sub>2</sub> capture from the existing Agrium Redwater fertilizer plant;
- CO<sub>2</sub> capture from the North West Sturgeon Refinery project under development using gasification and Rectisol<sup>®</sup> synthesis gas purification and conditioning technology;
- A 240 km CO<sub>2</sub> transportation trunk line; and
- Storage, including Enhanced Oil Recovery (“EOR”).

The ACTL project will provide critical CO<sub>2</sub> gathering and distribution infrastructure to enable the cost-effective management of CO<sub>2</sub> emissions. The project also represents an opportunity to showcase how the Province’s vast bitumen resources can provide competitive and environmentally sustainable energy amid tightening environmental standards.

This Summary Report will highlight the information contained in the attached Division B Detailed Report. The status and progress of each component (see Figure 1 below) of the ACTL will be summarized, as well as the relevant financial information.

# Overall ACTL Project Schematic

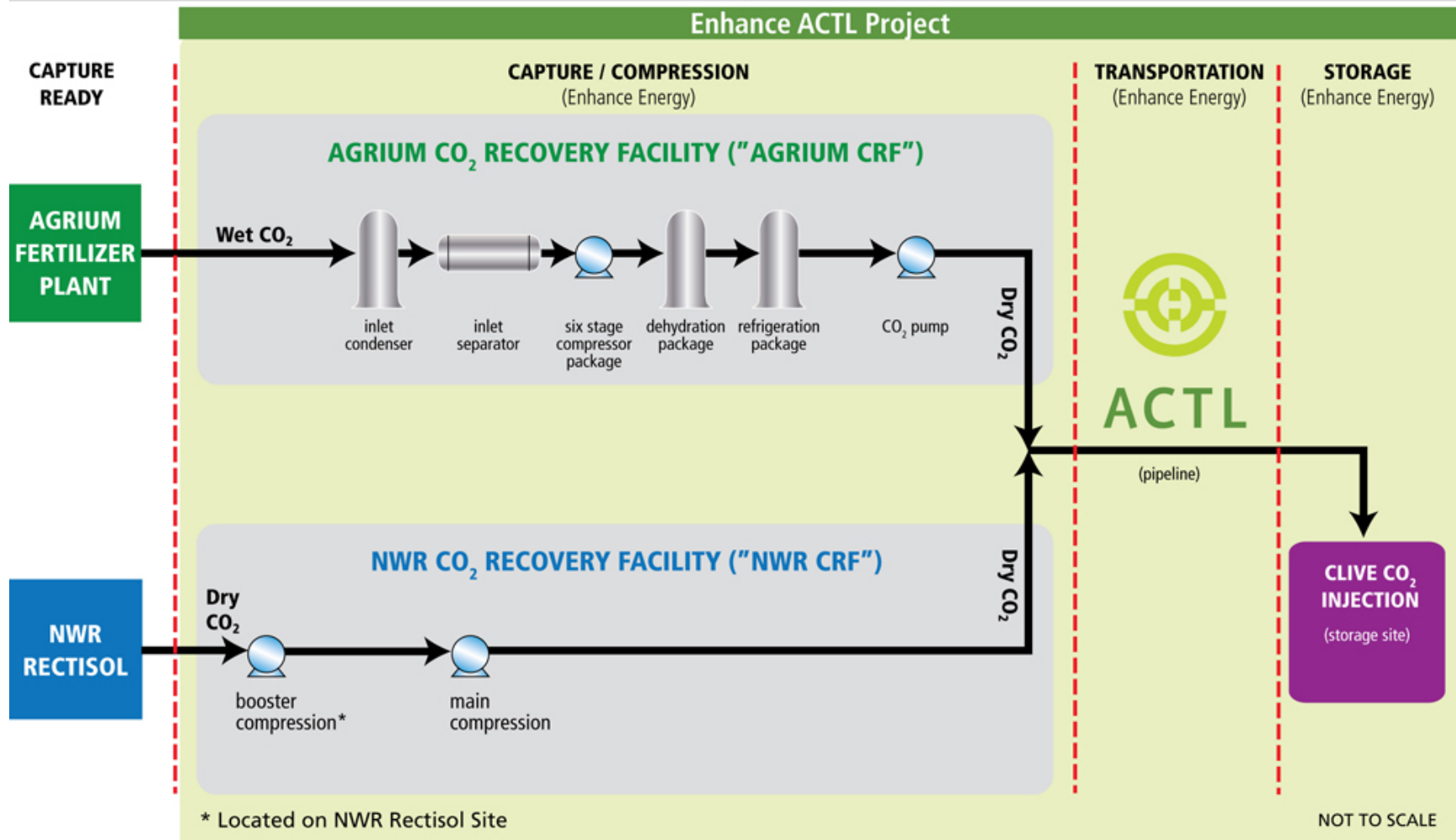


Figure 1 - Overall ACTL Project Schematic



Substantial progress has been made on the ACTL project, particularly the NWR portion. The ACTL is forecast to start-up with Agrium volumes in mid-to-late 2016, and NWR volumes coming on-stream in mid-2017. An updated timeline as of December 31, 2014 is shown in Section 11: “Project Timeline”.

Key activities achieved during the 2011 year include:

**Agrium CO<sub>2</sub> Recovery Facility:**

- Detailed Engineering and Design completed
- Tie-in of the CO<sub>2</sub> supply line within the Agrium fertilizer plant site
- Ordering of major equipment, including compressor
- Compressor manufacture significantly underway

**NWR Rectisol:**

- Completion of Design Basis Memorandum (“DBM”)
- Engineering Design Specification (“EDS”) nearing completion (as of April 2012)
- Transitioning to Detailed Engineering stage

**NWR CO<sub>2</sub> Recovery Facility:**

- CO<sub>2</sub> Booster Compression unit
  - Completion of DBM
  - EDS nearing completion (as of April 2012)
  - Transitioning to Detailed Engineering Design
- CO<sub>2</sub> Main Compression unit
  - Development of DBM
  - Preliminary cost estimates completed
  - Transitioning to Detailed Engineering Design

**Transportation:**

- Approval of Alberta Energy Regulator (“AER”) construction license
- 98% of Right of Way from landowners acquired
- Right of Way survey completed
- Environmental assessments completed
- Detailed alignment sheets significantly completed
- Horizontal Directional crossing designs significantly completed
- Pipe material testing completed

**Storage:**

- Pressure survey analysis completed

- Geological characterization of sedimentary succession above the oil reservoir underway

Key activities achieved during the 2012 year include:

Agrium CO<sub>2</sub> Recovery Facility:

- Delivery and receipt of major equipment, including:
  - Stainless steel piping and fittings
  - Two inlet condenser units
  - Inlet separator vessel
  - CO<sub>2</sub> transfer pump
  - CO<sub>2</sub> booster pump
  - Facility isolation valves
- Signed contract with Fortis Alberta to design and build dedicated power line for facility
- Signed contract with Coronado Gas Coop to provide fuel gas pipeline and metering for facility
- CO<sub>2</sub> Compressor manufacturing progress:
  - Completed manufacturing of bull gears, pinion shafts and impellers
  - Completed dynamic testing of all three rotor sets
  - Completed casting and machining of stage volutes and main gear box housing
  - Completed assembly and testing of lubrication oil package
  - Main drive motor assembled and ready for run test
  - Completed FAT (factory acceptance testing) for main control panel
- Vessel fabrication for the dehydration package has commenced
- Vessel fabrication and purchase of all major components for the refrigeration package has commenced, including purchase of ammonia compressor, main drive motor and ammonia condensers
- Glycol recirculation pumps are assembled and ready to ship from factory

NWR Rectisol:

- Announcement on November 8, 2012 of Owner's approval for construction of Phase 1 of North West Sturgeon Refinery
- Updated Engineering Design Specifications including Cost Estimate and Schedule
- Initiated Cost Containment review
- Adoption of Rectisol design modernization
- Contract awarded for Air Separation Unit (in support of Gasifier)

NWR CO<sub>2</sub> Recovery Facility:

- CO<sub>2</sub> Booster Compression unit
  - Finalized location of CO<sub>2</sub> facility within Gasifier unit
  - Finalized CO<sub>2</sub> discharge piping route within refinery
  - Finalized technical specification and data sheet for booster CO<sub>2</sub> compressor
  - Currently evaluating bids from four vendors for compressor

- CO<sub>2</sub> Main Compression unit
  - Drafting technical specification and data sheet for main CO<sub>2</sub> compressor

Transportation:

- 100% of the Right of Way landowners now acquired
- Delivery and receipt of major equipment, including:
  - Pipeline valves and actuators
  - Pipe for major river crossing

Storage:

- Completed fourth report on geological characterization of the injection field, conclusions from that report are currently being evaluated

Key activities achieved during the 2013 year include:

Agrium CO<sub>2</sub> Recovery Facility:

- Completed mechanical run and performance testing of Six Stage Siemens compressor
  - After testing, compressor was disassembled for inspection and prepared for storage/shipment
  - Compressor motor completed and tested – in storage yard
- Optimized plant layout to reduce footprint and incorporate contractor suggested constructability improvements
  - Significant reduction in structural, piping and electrical materials due to more efficient layout
- Completed construction Request for Proposal (RFP) packages
  - Received construction proposals and conducted review and clarification process
  - Construction proposals within range of internal cost estimate

NWR Rectisol:

- Announcement on December 4, 2013 of NWR update to Sturgeon Refinery cost estimate, Bitumen Processing Agreements, and capital structure
- Finalized Engineering Design Specifications
- Gasifier unit Class 3 cost estimate and Level 3 resource loaded schedule were established as baseline for project execution
- All major equipment purchase orders placed
- 30% Model Review was completed for Gasifier unit

NWR CO<sub>2</sub> Booster Compression unit

- Completed Vendor Technical Submission evaluations for CO<sub>2</sub> booster compressor and completed clarification meetings
  - 17,000 hp, three stage Integrally Geared Centrifugal compressor

- Negotiated staged contract for booster compressor due to NWR project schedule.
- CO<sub>2</sub> Compressor was ordered from MAN Diesel & Turbo SE in Germany
- Completed Hazard Operability review and 30% 3-D design model review

#### CO<sub>2</sub> Main Compression unit

- Conducted starting/utility demand studies for Fortis Alberta
- Selected CO<sub>2</sub> compressor
  - 13,000 hp, five stage Integrally Geared Centrifugal compressor
- Finalized surface land acquisition for main compression site
- Worked extensively with Sturgeon County to establish utility corridor between NWR and Fort Hills

#### Transportation:

- Completed Phase 1 of Clearing of the ACTL right-of-way in Q1
- Received approval of Clearing and Reclamation Plan from Alberta Environment
- Prepared pipeline construction RFP documents
- Received Construction proposals and prepared for clarification and review process
- Significantly completed Issued for Construction drawings – minor revisions required in the Alberta Industrial Heartland (AIH) area (12" line) due to ability to parallel NWR product lines across North Saskatchewan river
- ROW routed through Suncor/AIH:
  - Finalization of the CP corridor route
  - Enhance continued discussions with the AIH counties regarding by-law discussions for pipeline corridors

#### Storage:

- Enhance has signed a Purchase and Sales Agreement with Santonia Energy Inc., which closed on September 17<sup>th</sup>, 2013. This now fully secures the storage site under Enhance's control.
- Alberta Innovates Technology Futures (AITF) were engaged to begin work on developing a baseline monitoring program that will feed into the project's Monitoring Measurement and Verification (MMV) plan
- Engineering underway for CO<sub>2</sub> recycle and storage
- Detailed engineering of injection site completed
- Draft EOR application submitted to the Alberta Energy Regulator (AER)
- Alberta Innovates – Technology Futures is examining the saline formations, potable aquifers, surface water accumulations and potable water wells
- Baseline CO<sub>2</sub> concentrations in these aquifers, water bodies and wells, as well as the overlying soil and air will be part of the MMV program

Key activities achieved during the 2014 year include:

Agrium CO<sub>2</sub> Recovery Facility:

- Design of tie in for Agrium Plant 1 – all required engineering drawings completed and issued for construction.
- Specification of required blower and compression equipment to be added to both Agrium and Enhance Energy sites.
- Long lead equipment ordered for the turnaround of the Agrium Plant 1 facility – scheduled for March 2015.

NWR Rectisol:

- Completed 60% model review, and significant progress on 90% model reviews with completion in the 1<sup>st</sup> quarter 2015.
- Detailed engineering is over 80% complete reaching 100% by mid-year 2015.
- Procurement is over 50% with all major equipment orders placed, bulk material orders and various construction contracts in progress.
- Module fabrication is just beginning and will continue through 2015.
- Site wide civil work is complete. Gasifier unit area was turned over to the gasifier construction team in mid-2014.
- Piling and foundation work commenced in 2014 and was approximately 30% complete by year end 2014. Now forecasting May 2015 completion and achievement of the first funding milestone.

NWR CO<sub>2</sub> Booster Compression unit

- NWR Booster Compressor ordered in February 2014 – manufacturing approximately 20% complete.
- Air cooled exchangers ordered in June 2014. Other related equipment orders complete.
- Equipment fabrication in progress with expected delivery dates in the 3<sup>rd</sup> and 4<sup>th</sup> quarters of 2015.
- Completed revised EPC contract with NWR for Booster Compressor and related equipment installation.
- 60% model review completed with 90% model review underway.
- Piling and other site construction progress integrated with NWR Rectisol as above.

CO<sub>2</sub> Main Compression unit

- Purchase and sale agreement executed with CP Rail for the main compressor site.

Transportation:

- Major utility crossing agreements sent out for approval – approximately 80% have been approved.

- Detailed hydraulic modeling of the pipeline has been completed – incorporated detailed elevations from survey data.
- Transmission and gathering line amendments accepted by Alberta Energy Regulator (“AER”) for incorporation into existing pipeline licence. These revisions reflected individual landowner and route optimization through the detailed engineering process.

#### Storage:

- Presently working on Phase IV of MMV plan in conjunction with AITF.
  - Phase IV involves assessing all available information to develop a program to acquire data for the various aspects, such as air quality, soil gas, groundwater chemistry and surface flux.
  - Sampling program has been identified and will be scheduled as part of the overall project execution.

## Part B – Project Status Overview and Commentary

The NWR portion of the project is now in early to mid-stage of development with the majority of early stage work occurring at the NWR capture site which is critical path for the overall project. Piling work at NWR is approximately 2 months behind plan otherwise there is little to report in regard to variations or significant problems and successes. As the project is further developed and achieves commercial operation there will be more to report.

The ACTL project will employ technologies that are commercially mature. The primary innovation of the project is its scope and integration of various existing technology to demonstrate an economic carbon solution for Alberta.

### Section 1: Facility Design

#### A) AGRIMUM CO<sub>2</sub> Recovery Facility (“Agrium CRF”)

##### Design of the CRF Facility (to date)

The design basis for the new Agrium Capture Facility is for economic recovery of CO<sub>2</sub> from the fertilizer plant’s CO<sub>2</sub> emission streams. The streams pass through inlet cooling, separation, compression, dehydration, and refrigeration. This process produces liquefied CO<sub>2</sub> that is then pumped into the Alberta Carbon Trunk Line (“ACTL”) at a pressure of 17,926 kPag [2,600 psig], which transports the CO<sub>2</sub> to EOR fields at the end of the line for permanent storage.

The facility was designed to recover the highest percentage of CO<sub>2</sub> from the incoming feed stream. Various process options were discussed before arriving at the proposed process design. This current design utilizes a “fit for purpose” philosophy by incorporating typical oilfield/industrial technology, sourced and serviced locally.

## Plot Plan and Facility Location

The plot plan (shown below) illustrates the layout of the CRF, which is located just outside the boundaries of Agrium's fertilizer plant in the Alberta Industrial Heartland.

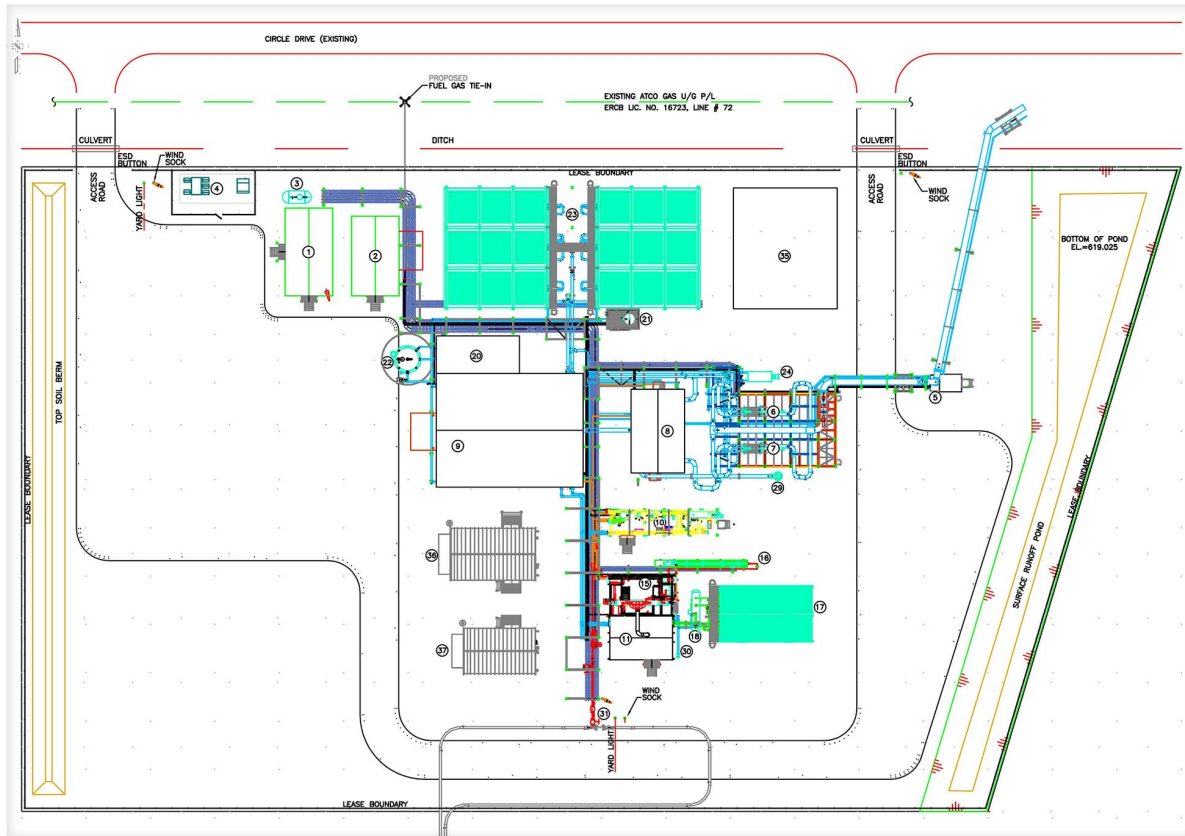


Figure 2 - Agrium CRF Plot Plan

\* A higher resolution plot plan with more detail is available in Appendix vi of the Detailed Knowledge Sharing Report

### Separation Process Type and Description

As the CO<sub>2</sub> Enhance receives from Agrium is wet, a separation process is needed at the Agrium CRF before the CO<sub>2</sub> can be put into the pipeline. Accordingly, the cooled two-phase stream flows into a carbon steel inlet separator that separates the condensed water from the wet CO<sub>2</sub> gas stream. One electric driven produced water pump maintains the level in the inlet separator and pumps the condensed water to a waste drain at the Agrium site. Produced water disposal volumes will be metered. The produced water will be disposed through the Agrium facility into their existing deep disposal well system.

### B) NWR Rectisol®

The NWR CO<sub>2</sub> capture system is heavily integrated into the design of the refinery's Gasification hydrogen supply unit. The Gasification unit uses the unconverted petroleum bottoms

(asphaltene) generated in upgrading as a feedstock to produce synthesis gas (syngas). The technology selected to condition the syngas is the Rectisol<sup>®</sup> acid gas removal process licensed from Lurgi, a German engineering and construction firm. When operational, the Rectisol<sup>®</sup> unit will produce over 3,600 tonnes per day of pure CO<sub>2</sub>. Rectisol<sup>®</sup> is a physical absorption process carried out at low temperatures and high pressures using cold methanol as an absorption medium. The Rectisol<sup>®</sup> process is a mature technology that has been used for decades in the coal gasification, fertilizer and refinery industries. Increased demand for products derived from synthesis gas since 2000 has led to resurgence in Rectisol<sup>®</sup> installations around the world.

The NWR refinery will be built in the industrial heartland of Sturgeon County, approximately 45 km north-east of Edmonton. The plot plans shown below indicate the location of the gasification unit and Rectisol<sup>®</sup> unit within the refinery.



# North West Sturgeon Refinery Plot Plan

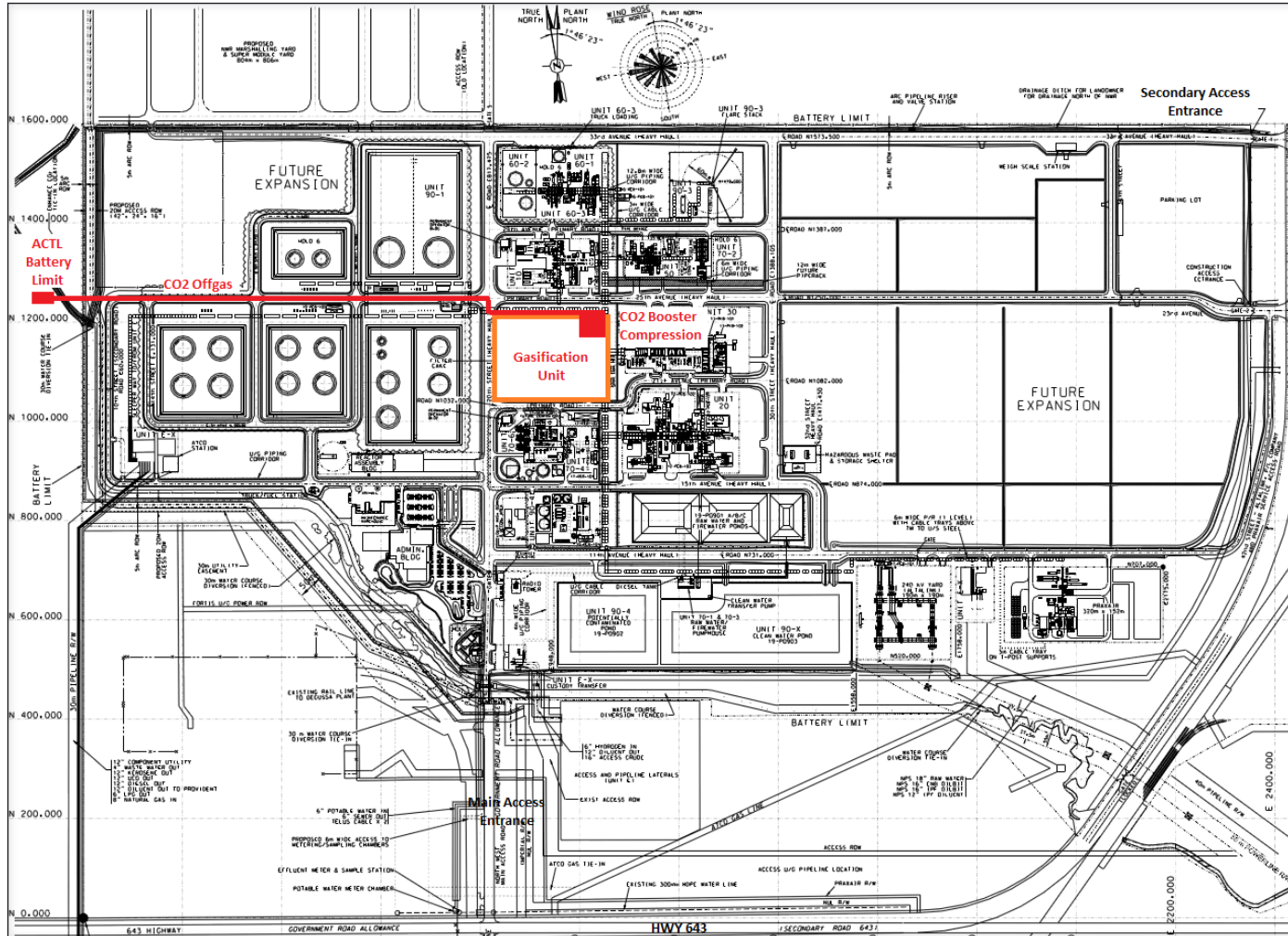


Figure 3 – North West Sturgeon Refinery Plot Plan

## Gasifier Unit Plot Plan

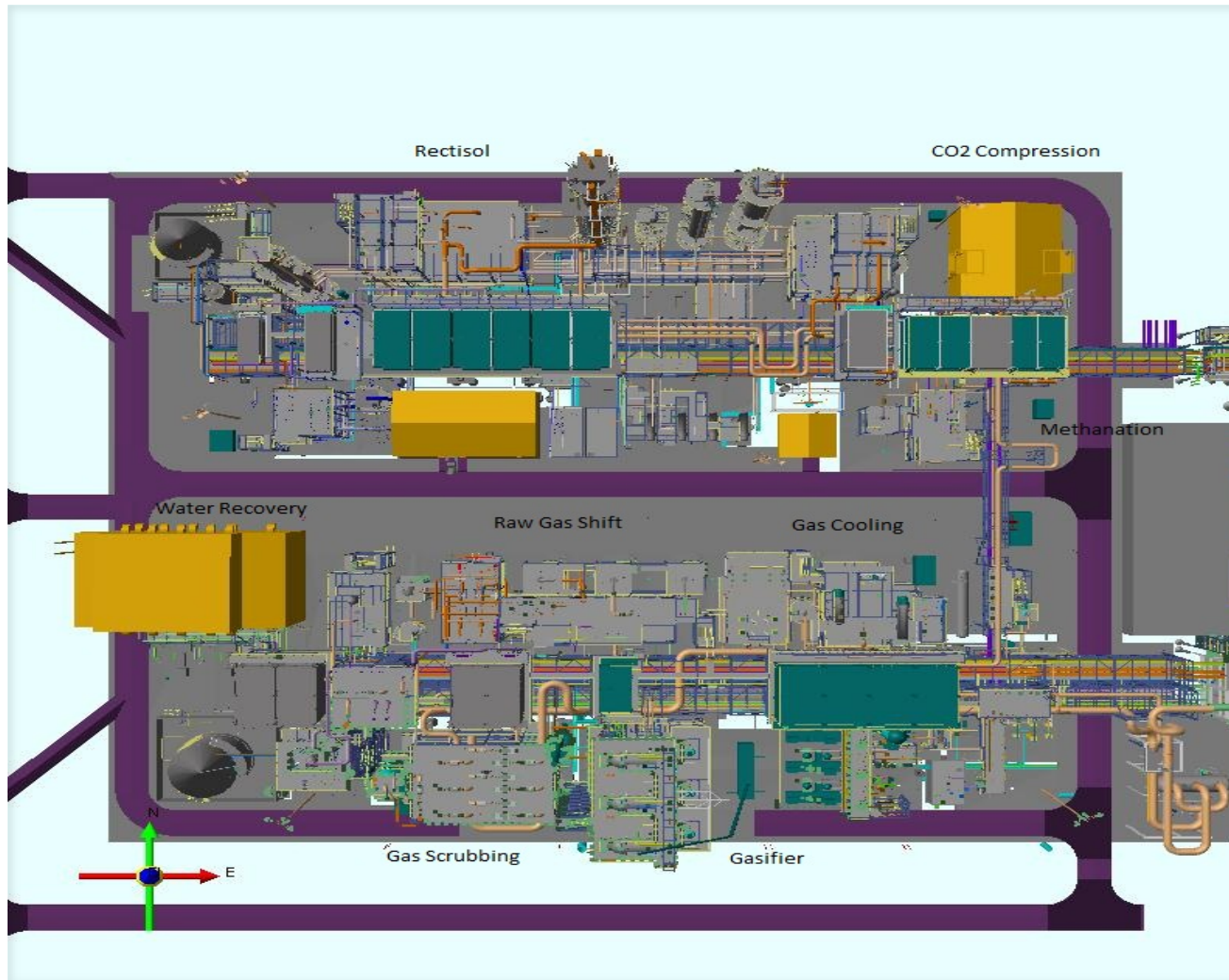


Figure 4 – Gasifier Unit Plot Plan

Rectisol® 3D South View

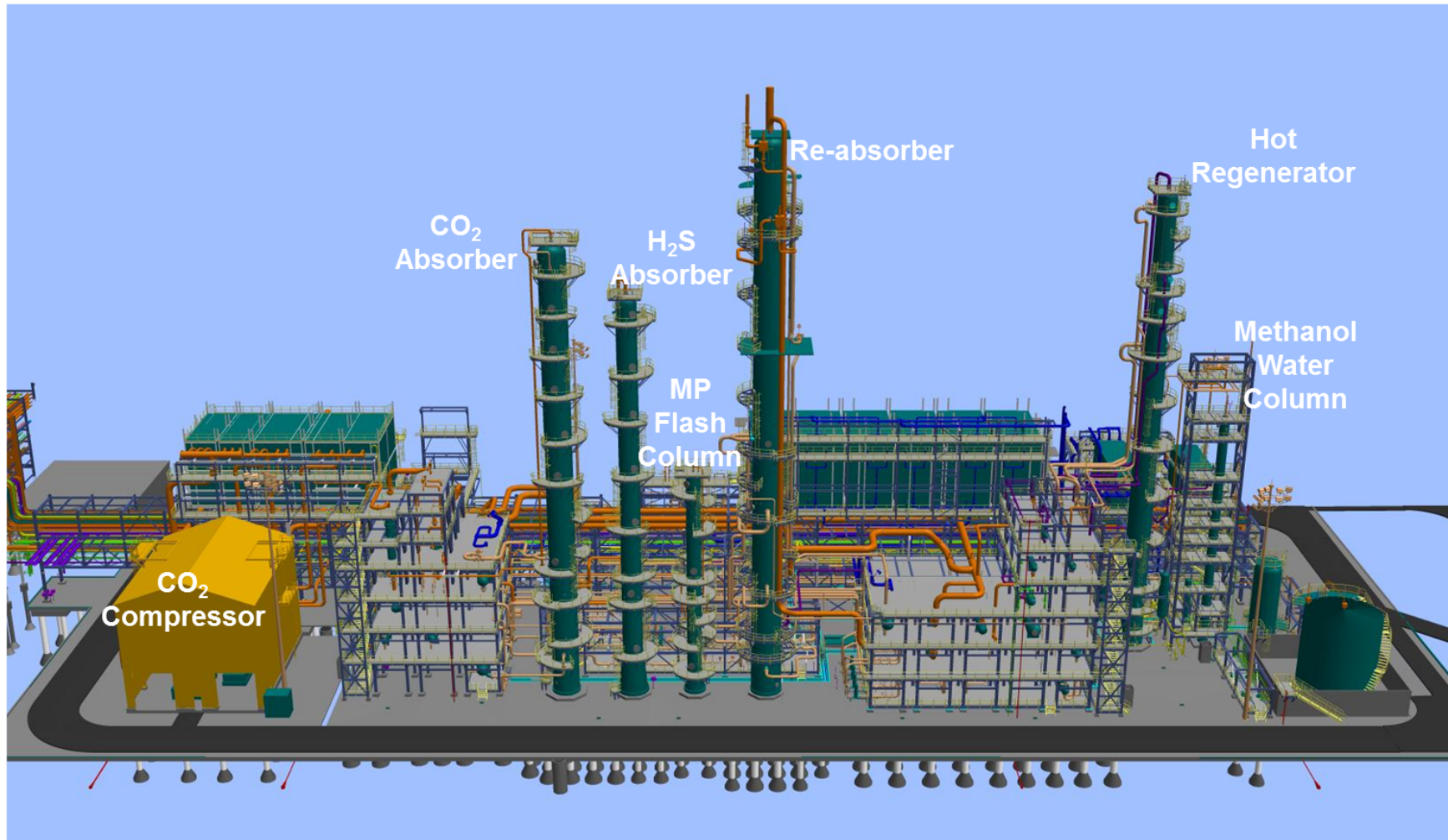


Figure 5 – Rectisol® 3D South View

### C) NWR CO<sub>2</sub> Recovery Facility (“NWR CRF”)

The NWR CRF consists of a three stage CO<sub>2</sub> booster compressor unit to be located in the north-west corner of the Gasifier site and a six stage main compressor unit which will be located outside the refinery in proximity to the Agrium plant. The booster compressor raises the NWR CO<sub>2</sub> from close to atmospheric pressure to approximately 1,400 kPag (203 psig) while the main compressor further increases the pressure of the CO<sub>2</sub> to a dense fluid state necessary for pipeline transportation.

### D) Pipeline Facility

The ACTL pipeline will be 240 kilometers in length, and will begin in the Alberta Industrial Heartland, by the Agrium and NWR CRFs, and go south ending at the Clive storage field (shown in Figure 6). The detailed alignment sheets for the pipeline are 99% complete as are the construction plans and Horizontal Directional Drill (“HDD”) crossing designs. 100% of the Right of Way (“ROW”) has been acquired from landowners. Procurement of materials is underway. Pipe specifications have been finalized and pipeline valves and actuators have been delivered.

The process of narrowing down a list of potential suppliers for pipe and investigating pipe mills capable of manufacturing to the ACTL specification has been completed, along with the preparation of the RFP documents.

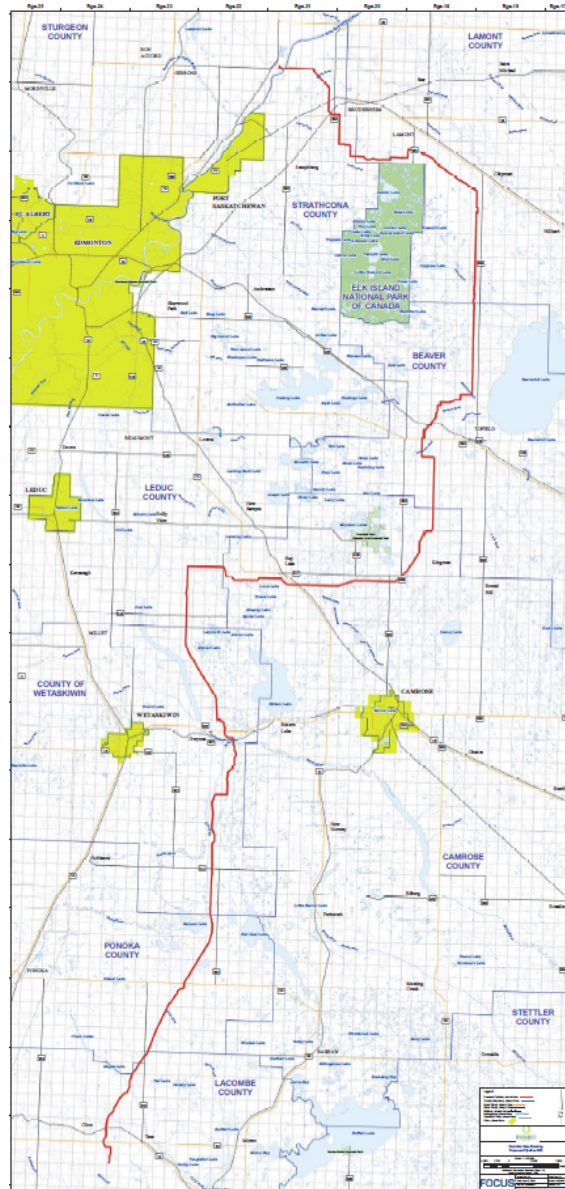


Figure 6 - ACTL Route Map

### E) Injection Facility

The injection facility will be located at the end of the ACTL pipeline at the Clive storage site (shown in Figure 6). The injection system design has been completed.

## Section 2: Facility Construction

### A) Agrium CO<sub>2</sub> Recovery Facility (“Agrium CRF”)

Enhance completed the tie-ins on the existing Agrium plant in June of 2011, during a scheduled shutdown of the plant for maintenance. This timing was strategically planned to minimize any inconvenience to Agrium.

All modules have been completed and are in storage. The Siemens compressor is prepped for shipping and is in storage in Germany at the manufacturing facility.

### B) NWR Rectisol®

Construction of the Gasifier unit, including Rectisol®, started in August 2014, and is currently underway with expected completion by the beginning of 2017. The Gasifier construction schedule and in-service date are interdependent on the overall refinery project development with other process units proceeding in parallel.

### C) NWR CO<sub>2</sub> Recovery Facility (“NWR CRF”)

Construction and operation of the Enhance CO<sub>2</sub> Booster Compressor is tied to the construction of the NWR Rectisol® unit, as it is located within the Gasifier boundary limits. Construction and operation of the Enhance Main Compressor is also tied to the construction of the Rectisol® unit, but will be located outside the NWR fence line. Construction of the NWR Booster Compressor is ongoing. Civil and underground work have been significantly completed, compressor and coolers have been ordered and are being manufactured. Additional piping/fabrication contracts were awarded in 2014.

### D) Pipeline Facility

Major equipment with long lead times, such as valves and actuators, has been purchased and delivered. Initial construction scoping along the pipeline route began in the first calendar quarter of 2013, including the scoping of the major horizontal directional crossing and initial clearing and timber removal of portions of the line. The main construction for the ACTL will begin in late 2015.

### E) Injection Facility

Well location and facility design is underway. The construction of the injection facility is set to begin in mid-2016.

## Section 3: Geological Formation Selection

Storage for Enhance’s ACTL project will take place at the depleted hydrocarbon reservoir at Clive.

### Summary of reasons for selecting the final site

### *Practical suitability*

There are many practical reasons which make Clive a suitable storage site for CO<sub>2</sub>. The Clive reservoirs are mature waterflooded oil reservoirs. In this context, they provide:

- Containment for CO<sub>2</sub> due to the fact that they have contained hydrocarbons for millions of years,
- Capacity for CO<sub>2</sub> storage due to significant production of oil and gas providing voidage,
- Injectivity for CO<sub>2</sub> due to substantial water injection operations for five decades, and
- Residual oil production to provide for economic support of large scale CO<sub>2</sub> sequestration.

The Clive reservoirs are also unitized, enabling common ownership and royalty interests across the reservoirs. This provides the opportunity to take advantage of the unique geology, with minimal complications due to competitive ownership interests, in order to maximize oil recovery and maximize sequestration of CO<sub>2</sub>.

### *Geographical suitability*

The storage site was also attractive due to its geographic location. As Clive is not adjacent to large residential developments, it makes it easier for surface access to design, build and operate a CCS EOR project with minimal disruptions to residents.

### *Potential EOR benefits*

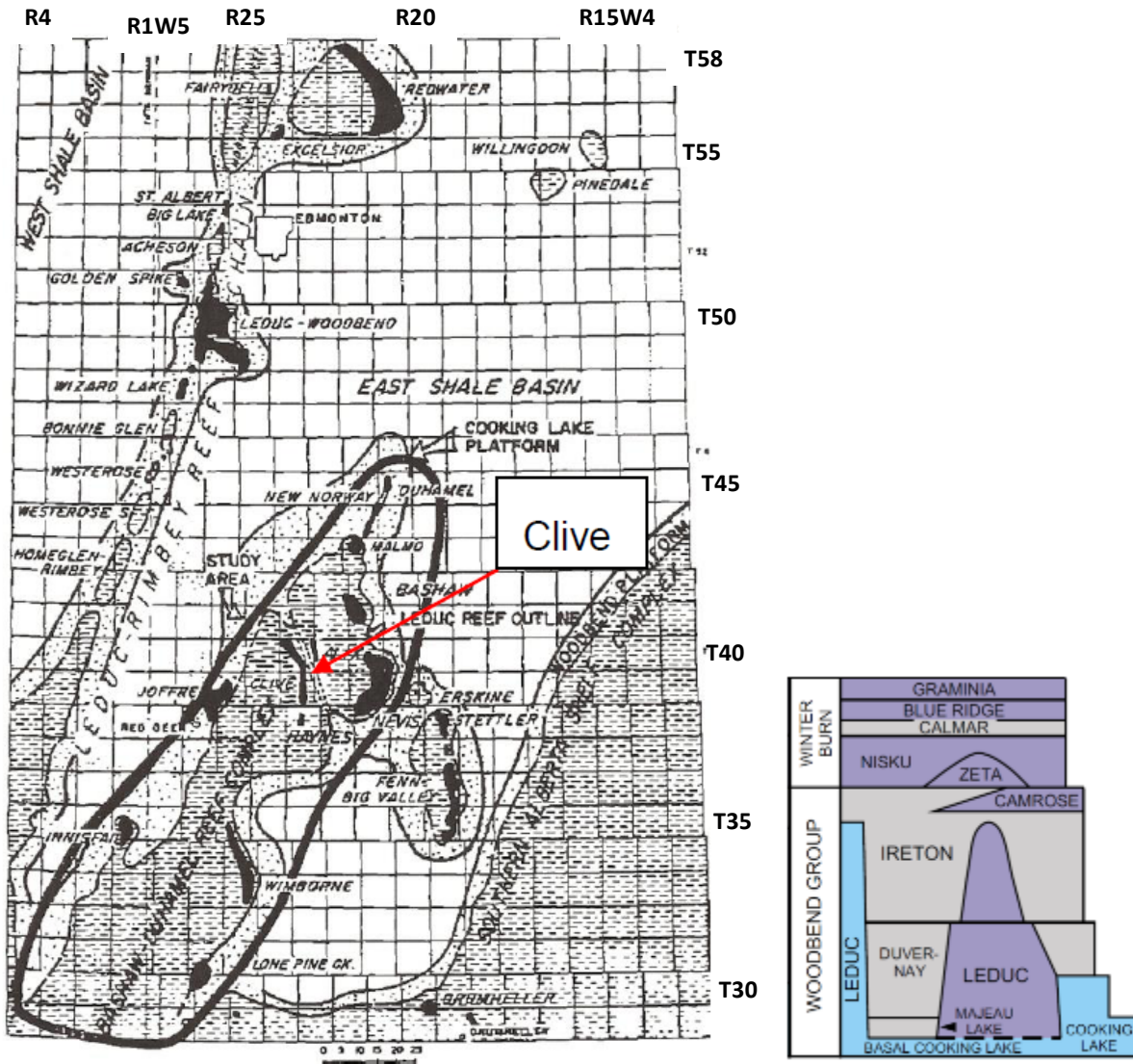
The potential EOR benefits of CO<sub>2</sub> sequestration sites are important criteria for consideration in the site selection process. This is due to the fact that the economic gains associated with EOR, and specifically the sale of incremental oil production, will financially support the cost of an expensive CCS scheme.

The EOR benefits extend beyond Enhance. Albertans benefit from this project through increased royalties to the Province and job creation. It is estimated that the project will create \$19 billion in royalty revenue for the Alberta government over the next 30 years.

Additional social benefits are created through revitalization of economic activity in an oil and gas field that is near abandonment. Job creation for the initial ACTL project is estimated at 2,000 direct jobs during peak construction and an additional 8,000 indirect jobs over the life of the project. To date, it is estimated that approximately 167,000 man-hours have been expended by suppliers, contractors and internal efforts. Ongoing job creation as the ACTL system expands is forecast to run in the tens of thousands.

**Key characteristics of the geological formation**

Location of injection reservoir: CO<sub>2</sub> will be injected into Clive, as shown in Figure 7.



Source: Tsang, G. and Springer, S.J., —Innisfail-Clive-Nevis Reef Chain Revisited□, CIM Paper 83-34-24, presented at the 34 ATM of the Petroleum Society, May 10-13, 1983, Banff.

Figure 7 - Relative Location of Clive Reservoirs and its Stratigraphy



### **Depth and thickness of the reservoir**

Comprehensive maps showing an interpretation of the storage formation's porosity tops, which also illustrate sub-sea depth and thickness at the reservoir, are found in section 3.4 of the detailed report.

This relates to a depth from surface of 1,775-1,915 m (mean: 1,831 m), with an average thickness of 6.4 m for the Nisku reservoir, and a depth from surface of 1,845–1,938 m (mean: 1,874m), with an average thickness of 8.75 m for the Leduc reservoir.

### **Injectivity of reservoir**

Injectivity of CO<sub>2</sub> is derived from historical performance of water injection. The Clive reservoirs have shown tremendous capacity for water injectivity. Typical determination of injectivity is based on equivalent volumes at the same reservoir pressure and reservoir temperature.

Water injection wells for the Clive reservoirs have not seen any rate limitations as they have been able to take water on vacuum. Thus, CO<sub>2</sub> injectivity at any Clive reservoir is not expected to be constrained by reservoir parameters but may be impacted by wellbore configuration or surface facility design.

### **Porosity and permeability of the reservoir**

Enhance contracted a study of the Clive reservoirs (Nisku and Leduc) in 2008 and in part, an examination was undertaken to determine the porosity, permeability and its interdependence for the Nisku and Leduc reservoirs. The following two graphs are a representation of this analysis.

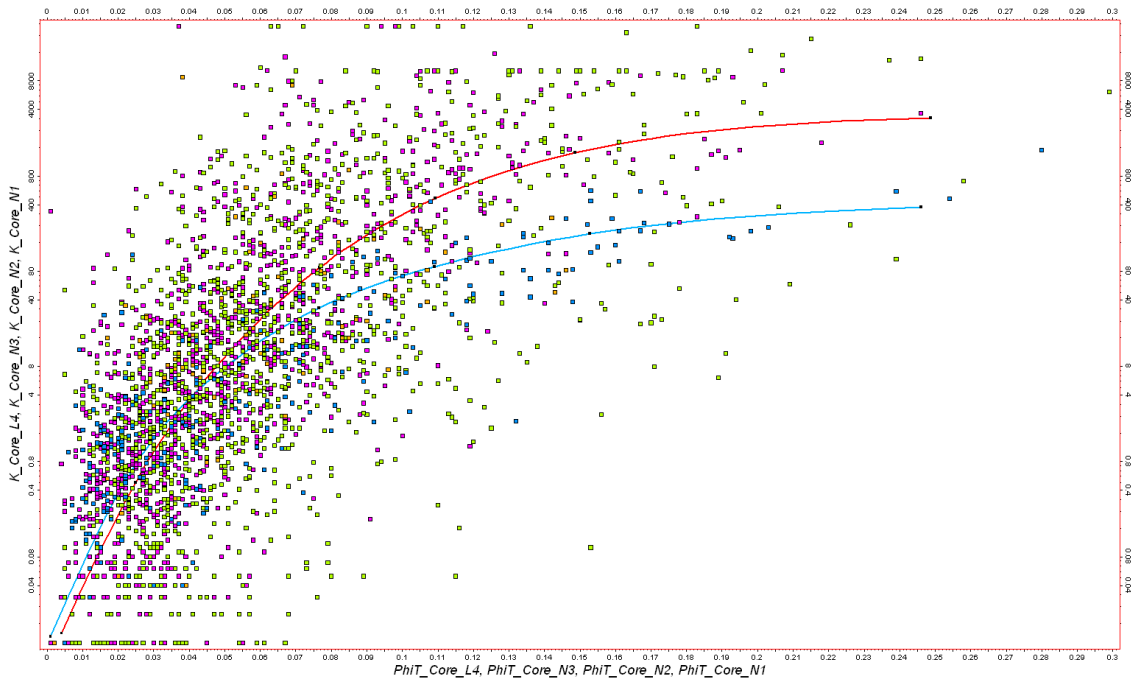


Figure 8 - Graph of Porosity, Permeability and its Interdependence at Nisku

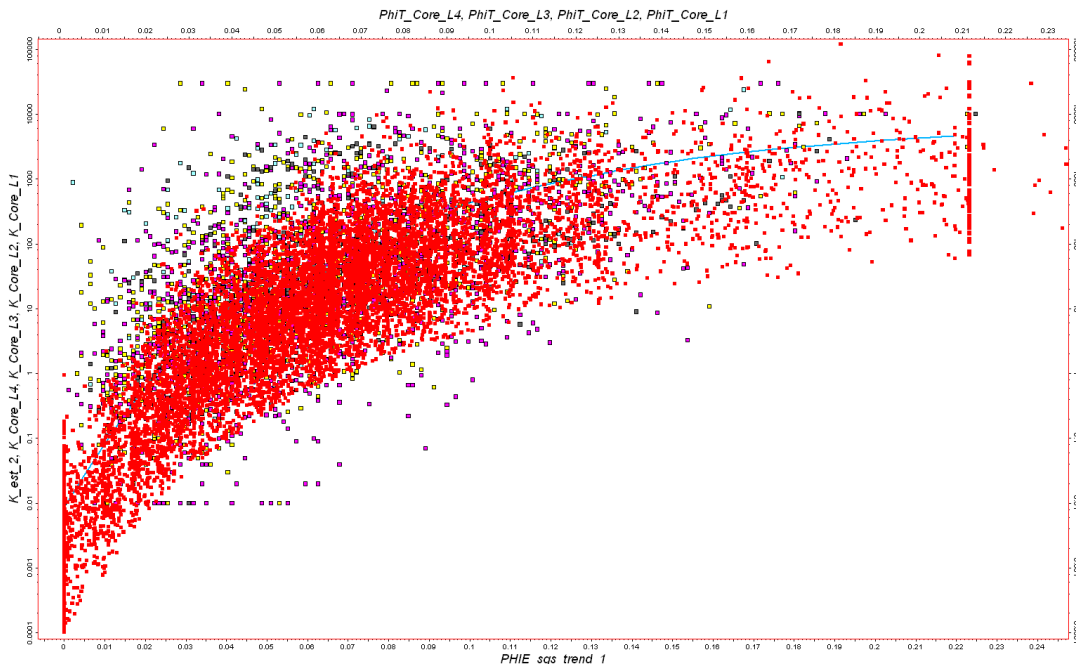


Figure 9 - Graph of Porosity, Permeability and its Interdependence at Leduc

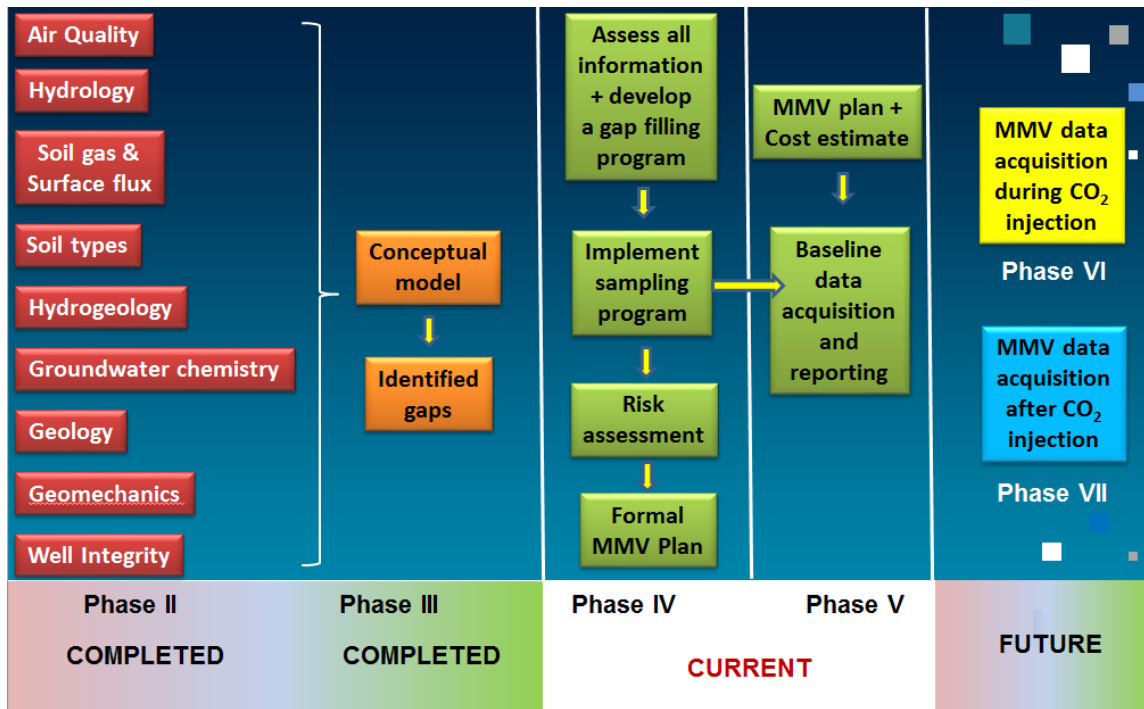
**Initial pressure and temperature:** The temperature at the Clive reservoirs is 69°C (156°F) and its pressure 1,813 psig (12,500 kpa).

**Estimate of storage potential:** The total CO<sub>2</sub> storage capacity at Clive due to replacement of produced oil and gas is estimated at 18.8 million tonnes (“MT”) (a more detailed calculation of this estimate is found in section 3.2 of the detailed report.)

**Risks of storage into the geological formations and the measures implemented to manage and reduce such risks:**

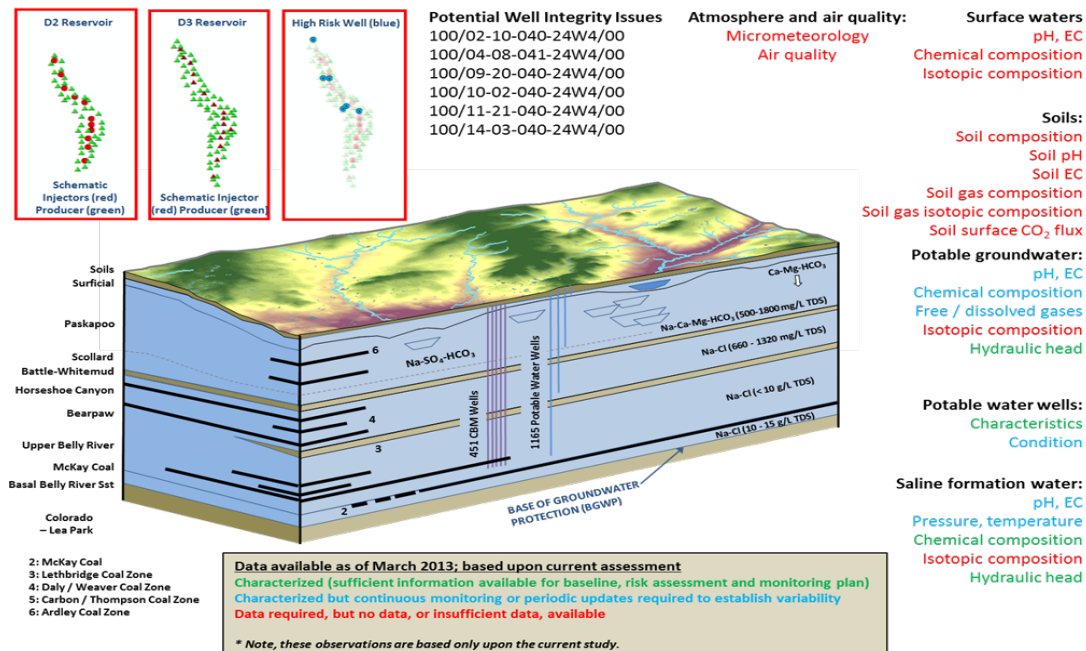
Storage for Enhance’s ACTL project will take place at the depleted hydrocarbon reservoir at Clive. As depleted hydrocarbon reservoirs have securely contained fluids for millions of years, these reservoirs are very well suited for containment and safe storage of injected CO<sub>2</sub> and pose very minimal risk of leakage. Depleted hydrocarbon reservoirs in Alberta have typically undergone waterflood operations whereby water has been used to replace produced hydrocarbons. The injectivity of CO<sub>2</sub> is typically estimated to be the same as injectivity of water at reservoir conditions. Such waterfloods have been conducted at Clive, again minimizing any risk of storage in this field.

Enhance is currently conducting comprehensive geological and geomechanical studies on the rock (from the bottom of the well to the well head). The first three phases of the MMV program have been completed with AITF. Presently working with AITF on Phases IV & V, and will be executed in conjunction with the complete ACTL project. The following pictorial illustrates the overall program.



The next pictorial illustrates the context of the MMV study area and various components that potentially may be quantified.

**ENHANCE ENERGY STUDY AREA (EESA)**



## Section 4: Facility Operations – Capture

As the project is still in its design phase, the CO<sub>2</sub> capture facilities have yet to start-up. Information regarding the efficiency of each step, impact upon the operating efficiency of the base facility, and purity of the CO<sub>2</sub> is not available at this time.

## Section 5: Facility Operations – Transportation

In its first phase, the pipeline will transport captured, compressed CO<sub>2</sub> from the Agrium fertilizer plant and the North West Sturgeon Refinery plant to selected EOR fields at the end of the pipeline.

**Flow capacity:** The maximum flow capacity of the pipeline, once filled to its full capacity, is 14.6 million tonnes of CO<sub>2</sub> a year.

**Pipeline diameter:** The pipeline will be 16” in diameter.

**Design pressure and temperature:** The maximum operating pressure is 17,926 kPag (2,600 psig). The operating temperature design of the pipeline is between -18°C to 60°C.

**Wall thickness:** The line pipe is a Nominal Pipe Size (“NPS”) at 14.3 mm wall thickness.

**Length:** The pipeline will be 240 kilometers long.

**Material:** The 16” ACTL pipeline will be made of welded-body carbon steel. The pipe specification shall be Grade 448, Category II M18°C electric welded (EW) pipe. Pipe supplied shall be fully kilned, fine grained, continuously cast steel. The maximum carbon equivalent calculated shall be as described in CSA Z245.1.

**Expected lifetime:** The pipeline has an expected lifetime of 100 years or more.

**Cathodic protection:** A cathodic protection system will be installed as part of the corrosion reduction program. The design of this system is underway as a part of the detailed design for the project. The system will incorporate the following considerations:

- Length of system and segments
- Coating specifications
- Locations of block valves
- Soil analysis and resistivity data
- Water table
- Proximity to other utilities

The pipeline will require cathodic protection test stations to be installed along the route of the pipeline at regular intervals. The pipeline will be fitted with insulating flanged gaskets at each end of the system.

The carbon dioxide water dew-point specification is less than 162mg/m<sup>3</sup> (10 lbs/MMscf); therefore, free water is not present during normal operating conditions, and corrosion due to the formation of Carbonic acid cannot occur. Post hydrostatic testing procedures will be incorporated to ensure the pipeline is dry prior to commissioning and operation. In the event the water dew-point is exceeded at the source, an on-line hydrometer signals an emergency shutdown valve (“ESDV”) to close diverting the off-spec gas to vent.

## Section 6: Facility Operations – Storage and Monitoring

No CO<sub>2</sub> has been injected and stored, as the project is still in its design phase. Therefore there is no data regarding the injection and storage of CO<sub>2</sub> and its direct monitoring to report at this time.

The planned CO<sub>2</sub> injection rate is the entire available CO<sub>2</sub> supply volume currently estimated at 4,300 tonnes of CO<sub>2</sub> per day. The minimum requirements for the CO<sub>2</sub> injection stream composition, pressure and temperature are as follows:

- 95 mol percent minimum CO<sub>2</sub>
- No more than 2 mol% hydrocarbons with a dewpoint not exceeding -20°F
- No more than 3 lb/mmscf of glycol or amines or ammonia or methanol
- No more than 10 lb/mmscf of water
- No more than 4 ppm H<sub>2</sub>S by volume
- No more than 16 ppm total Sulphur by volume
- Less than 1.0% N<sub>2</sub>, H<sub>2</sub>, CO, AR, or CH<sub>4</sub> each and total inerts less than 4% by volume
- Less than 0.1% O<sub>2</sub>
- Less than 100 ppm SO<sub>x</sub> or NO<sub>x</sub> by volume
- Less than 1 ppb Hg by volume
- No solid particles
- No free liquids including lube oils or glycol
- CO<sub>2</sub> shall be delivered at less than 25°C (77°F) and 2,600 psig (17,926 kPag).

Monitoring techniques that will be employed at the injection site are storage site specific and are still being developed with the assistance of technical experts and this work is currently underway. Injection rates and CO<sub>2</sub> recycle rates will be finalized as project moves into operations. Atmospheric CO<sub>2</sub> emissions in the scheme are limited to screwed connections for pipe 2” and smaller and flanged connections for pipe 3” and larger. Some emissions to the atmosphere will also occur during facility shutdowns and start-up. However, these emissions are considered to be fugitive emissions and are negligible.

## Section 7: Facility Operations – Maintenance and Repairs

As the ACTL is not yet operational, there are no maintenance and repair activities to report at this time.

## Section 8: Regulatory Approvals

### Enhance Approvals

No unusual hurdles were encountered throughout the application and approval process. The following table indicates approvals obtained by Enhance for the ACTL project:

Consent/Permit	General Timeline of Approval Receipt	Additional Hurdles Encountered
<b>Canadian Environmental Assessment Agency (“CEAA”)</b>	Submitted: January 2010 Approved: September 7 <sup>th</sup> , 2010	None
<b>Development Permit (County Level)</b>	Currently finalizing submission for Agrium  Typically two months from submission for review and approval	None
<b>Alberta Historical Resources Foundation (“AHRF”)</b>	Submitted: May 13 <sup>th</sup> , 2009 Approved: August 17 <sup>th</sup> , 2012	Ongoing routing changes delayed application process
<b>AER Directive 56 Pipeline Installation Approval</b>  (incorporates Alberta Environment approval)	Public consultation process: October 2008 – March 2009  Applied: March 20, 2009 Approved: April 26, 2011 License Number: 53252	On-going consultation required after approval
<b>Conservation Reclamation Plan (Alberta Environment)</b>	Submitted: March 18 <sup>th</sup> , 2009  Approved: April 17 <sup>th</sup> , 2013	None
<b>Alberta Energy Regulator (“AER”) (Draft EOR Scheme)</b>	Submitted in December 2013, review still underway with AER	None

<b>Alberta Energy Regulator (“AER”)</b>	Minor amendments to transmission and gathering line accepted September 2014; Licence #53252	None
<b>Alberta Energy Regulator (“AER”)</b>	Minor compressor station (Agrium Capture Facilities) amendments accepted October 2014; Licence #53252	None
<b>Alberta Energy Regulator (“AER”)</b>	North Saskatchewan River spare pipeline approved November 2014; Licence #56775	None

Table 1 - Enhance Regulatory Approvals Table

### NWR Approvals

All necessary regulatory approvals have been obtained to proceed with the construction and operation of the North West Sturgeon Refinery project. The table below describes the approvals obtained by NWR.

<b>BODY/ACT/ REGULATION</b>	<b>APPROVAL/PERMIT/ DESCRIPTION</b>	<b>UPDATE/NOTES</b>
<b>Energy Utilities Board</b> (now AER)/Oil and Gas Conservation Act/	Upgrader Approval No. 10994 dated September 6, 2007 / For construction and Operation of an oil sands bitumen upgrader, no expiry	Approval has been transferred to North West Redwater Partnership Holdings Corp. from North West Upgrading Inc.
<b>Energy Utilities Board</b> (now AER)/Oil and Gas Conservation Act	Decision 2007-058 dated August 7, 2007 / Application to Construct and Operate an Oil Sands Upgrader in Sturgeon County. NOTE that this is a DECISION document respecting public interest determination, and is NOT an approval, so transfer to NWR - Newco should not be required	None
<b>Alberta Environment</b> (now Alberta Environment and Sustainable Resource Development)/Environmental Protection and Enhancement Act	Approval No. 217118-00-00 dated September 20, 2007 to construct, operate and reclaim upgrader, as amended by Approval No. 217118-00-01 dated February 13, 2008, and as amended again by Approval No. 217118-00-02 dated December 04, 2012. Approval expires September 1, 2017	Amendment application submitted Dec 2013 for administrative matters and minor technical updates. DRAFT Approval received as at March 13, 2014. Approval is being transferred to North West Redwater Partnership Holdings Corp from North West Upgrading Inc.



<b>Alberta Environment</b> (now Alberta Environment and Sustainable Resource Development)/Water Act	Approval No. 00227771-00-00 as amended by Approval No. 00227773-00-00 dated February 13, 2008 and as amended again by Approval 00227771-00-01 dated October 15, 2012 to divert of water from site Precipitation and North Sask River for process. Approval expires September 1, 2017	Amendment application submitted Dec 2013 for increase to Phase 1 water use (no increase over 3 phases), as well as groundwater management procedures. Approval expected summer 2014
<b>Sturgeon County/Land Use</b> Bylaw 819/96	Development and Building Permits (Various expiry dates, each valid for one year from date of issue, until initiated, then valid to completion – NOTE each has been extended as required during project inactivity period, with expiry now ranging from Q4/13 through Q1/14)	Sturgeon County/Land Use Bylaw 819/96
<b>Sturgeon County/The Inspections Group Inc/Safety</b> Codes Act and Codes	Permit No. 305305-11-E0300 as issued Nov 24, 2011 for temporary electrical connection of construction trailers and facilities. Expires upon removal of temporary facilities	North West Redwater Partnership applied for and is approved by the Safety Codes Council to administer Safety Codes Act approvals required for the Project as at May 2013
<b>Alberta Transportation/Highways</b> <b>Development and Protection</b> <b>Act</b>	Roadside Development Permit 2511/049/10. Expires one year from issue, and has been extended as required per project delay. Note that there is another Roadside Development Permit applicable to Range Road 220 modifications, but that has been issued to Sturgeon County as the 'owner' of the road allowance	RDP 2511/049/10 has been extended as required to complete the approved scope. Alberta Transportation has issued RDP 2511/310/13 in respect of the complete construction and operation of Phase 1 of the Project
<b>Alberta Sustainable Resource</b> <b>Development/Public Lands</b> <b>Act</b>	Temporary Field Authorization for water course realignment. TFA 126500 as issued November 19, 2012. Expires April 15, 2013	TFA 134963 was issued Jul 22 2013 extending water course realignment authorization to June 30 2014, by which time the scope is scheduled to be complete
<b>Alberta Community</b> <b>Development/ Historical</b> <b>Resources Act</b>	Clearance Letter (note that his resulted in the AER Public Interest Determination, and these clearance letters should not require re-issue to NWR – Newco). Release Date: February 1, 2006, Release Date: November 29, 2006	No Change

<b>Industry Canada/Radio Communication Act and Regulations</b>	Mobile radio licence for use by construction workforce – Such Licences are already issued to NWR, not NWU, as they were issued recently enough to be done through the Partnership	No Change
<b>Energy Resource Conservation Board</b>	Pipeline licences for lines across North Saskatchewan River as per recent Bennett Jones assistance re applications. Have been issued to NWU	All required Pipeline Licences have been transferred to North West Redwater Partnership Holdings Corp. from NWU

Table 2 - NWR Regulatory Approvals Table

Note: Permits with expiry dates prior to initialization will be reapplied for as required to meet the construction schedule

## Section 9: Public Engagement

### Enhance

Enhance has undertaken an extensive and open public engagement program working with all directly or potentially impacted landowners and occupants, local authorities, industry stakeholders, and provincials regulators. Open houses were held in eight locations along the proposed pipeline route. A detailed account of Enhance’s public engagement is found in Appendix xii of the detailed report.

Below is a table of the main questions and concerns raised at meetings and open houses along with Enhance’s responses.

QUESTION	ENHANCE RESPONSE
<i>How deep in the ground does the pipeline get constructed?</i>	Typical construction practice of 1.2 meters unless special conditions warrant a change to cover depth.
<i>What is the operating pressure of the pipeline?</i>	In response this concern Enhance shared the following information with interested parties: <ul style="list-style-type: none"> <li>- The proposed line pressure, which is 2600 psi;</li> <li>- The proposed wall thickness; and</li> <li>- The planned corrosion protection plan, including the intended inspection of the pipeline regulatory requirements.</li> </ul>
<i>How is the post construction vegetation going to be managed?</i>	The Right of Way and Temporary Work Space lands will be fenced on pasture lands or lands identified by a landowner for a two year growing season to ensure proper regrowth.

<b><i>Regarding fencing on the quarter section boundary line (existing and new), would Enhance clean up the brush on fence lines and establish new fence boundaries?</i></b>	Fence lines would be established by way of survey and new fence will be constructed during final clean up if required.
<b><i>What will be the means of access across the Right of Way during construction?</i></b>	The necessary measures will be put in place (gates, plugs etc.) as required and arranged during initial acquisition process, and would also be discussed with the landowner during the pre-construction meeting.
<b><i>Are there going to be Above Ground Structures?</i></b>	No installation of any above ground structures required unless previously communicated and negotiated and accepted by the landowner.
<b><i>What are the setbacks from the pipeline Right of Way?</i></b>	The pipeline does not have any regulated setbacks other than the Right of Way boundary and outside of the regulated 30 meter safety zone.
<b><i>What are the conditions of the Right of Way through a treed area/bush land?</i></b>	The Right of Way will be left in a condition that would allow the landowner to work the land as with the adjoining lands on the quarter. Pasture land would be left as pasture, with the exception of any grazing lease lands, which under current regulations, have less stringent cleanup requirements but are still governed by best use land policy.
<b><i>How is trespassing managed – What measures are in place to keep the workers within the area of construction activities?</i></b>	All boundaries are staked out by the survey team, workers are informed of the work area limits and under normal circumstances workers will not be outside of the staked area. Landowners were advised that they (the landowners) are another set of eyes to monitor the situation, and if the workers are beyond the staked limits, the landowners should be contacting a company representative.
<b><i>How much restriction will I (the landowner) endure with respect to moving farming equipment across the pipeline after it's in the ground?</i></b>	Normal/Typical farming practises will be permitted to cross the pipeline Right of Way.

Table 3- Main Questions and Concerns

## NWR

A commitment to extensive public consultation by NWR for use in project decision making was made in 2005 at the outset of the environmental impact assessment (“EIA”) and regulatory

application process. At that time, CCS solutions for the project were not well advanced. Subsequently, the project was described in regulatory applications and communications with stakeholders as being carbon capture ready with the view that reducing the CO<sub>2</sub> emissions for the project was an important goal.

NWRP conducted personal consultations with all stakeholders within the local area, as well as with any person or organization that expressed a direct interest in the project. A confidential stakeholder contact list was prepared and is maintained to facilitate stakeholder communications.

Open houses in Redwater, Alberta were held in February 2005 upon public disclosure of the project and in November 2005, after collection of environmental data. The two open houses were attended by over 300 persons representing a range of interests and which generated hundreds of questions and comments.

Issues and concerns expressed by stakeholders were primarily in regards to government policy including the need for new regulatory requirements, municipal land use planning, and civil and other social infrastructure including roads that support anticipated development in the industrial heartland area. NWR has committed to constructively participate with stakeholders, residents, industry and governments in the region to understand their ongoing issues concerns and develop workable solutions.

The AER Decision Report 2007-058 (August 7<sup>th</sup>, 2007) notes that “The Board considers North West’s participant involvement program to be extensive. North West was proactive in its approach to involve the public at the early stages of project development and included both those potentially affected by the proposed project and others who expressed an interest in the project.... The board concludes that North West has met and exceeded the Board’s public consultation requirements.”

Since receiving AER approval to build the project in 2007, Project personnel have continued stakeholder consultation through personal consultations, participation in community advisory panel meetings, public information sessions and periodic public newsletters.

NWR is also a participant in multi-stakeholder committees facilitated by Alberta Environment and Sustainable Resource Development related to Cumulative Effects Management in Alberta generally, and the Industrial Heartland area specifically. CCS is one of the topics discussed, along with other emissions and project effects.

## **Section 10: Costs and Revenues**

### Costs

#### **Enhance**

#### **Operating Cost**

<b>Compression</b>	<b>Annual Average Cost</b>
<b>Agrium CRF</b>	
Electricity (\$/MWh)	\$ 81
Total Variable (\$/tonne CO <sub>2</sub> captured)	\$ 10
Total Maintenance and Turnaround (\$/tonne CO <sub>2</sub> captured)	\$ 4
Total Fixed (\$/tonne CO <sub>2</sub> captured)	\$ 5
<b>NWR CRF (Booster and Main Compression)</b>	
Electricity (\$/MWh)	\$ 83
Total Variable (\$/tonne CO <sub>2</sub> captured)	\$ 10
Total Maintenance and turnaround (\$/tonne CO <sub>2</sub> captured)	\$ 1
Total Fixed (\$/tonne CO <sub>2</sub> captured)	\$ 1
<b>Pipeline</b>	
Electricity (\$/MWh)	\$ 81
Total Variable (\$/tonne CO <sub>2</sub> captured)	\$ 0.4
Total Maintenance (\$/tonne CO <sub>2</sub> captured)	\$ 1
Total Fixed (\$/tonne CO <sub>2</sub> captured)	\$ 5
<b>Clive</b>	
MMV (\$/tonne CO <sub>2</sub> captured)	\$ 2
Injection Well Maintenance (\$/tonne CO <sub>2</sub> captured)	\$ 1

Table 4 - Enhance Operating Costs

The project is not yet operational, so there is no operational expenditure made to date data available yet.

## Capital Costs

Capital Cost Estimates	CAD \$MM
Agrium CRF	\$ 48
NWR CRF (Booster and Main Compression)	\$ 80
Pipeline	\$ 245
Clive CO <sub>2</sub> Injection	\$ 100
<b>Total</b>	<b>\$ 473</b>

Table 5 - Enhance Capital Costs

Enhance has made \$94.6 Million of eligible expenditures under the CCS funding Agreement to date (December 31<sup>st</sup>, 2014).

The project is not yet operational, so there is no operational expenditure made to date.

Cost per tonne values are being calculated and will be part of the Detailed Report.

**NWR Rectisol<sup>®</sup>**  
**NWR Rectisol<sup>®</sup> Unit**

The Rectisol<sup>®</sup> cost estimate prepared in 2013 is shown in Table 6 and 7.

**CAPEX**

**Table 6 – Rectisol<sup>®</sup> CAPEX Estimate**

<b>Rectisol<sup>®</sup> Cost Estimate 2013 (\$MM)</b>	
DBM/EDS Engineering	7.0
Detailed Engineering	32.5
Equipment	82.5
Material	71.5
Construction	104.7
Commissioning & Startup	18.9
Contingency	10.2
Owners	10.5
<b>Total</b>	<b>337.8</b>

Table 6 - Rectisol<sup>®</sup> Capital Costs

**Canadian Content**

The local socio-economic activity from on-site construction of the gasifier unit and off-site module fabrication is expected to be significant. An international firm with significant operations and history in Alberta has been selected to bring integrated engineering, design, procurement, module fabrication, construction and site management services to the project. A forecast of Canadian content for the Rectisol<sup>®</sup> unit will be prepared as construction planning progresses.

**OPEX**

The operating cost of the Rectisol<sup>®</sup> unit is provided for informational purposes and should not be used for comparing or benchmarking against other CCS projects.

**Table 7 – Rectisol® OPEX Estimate (not for inclusion in carbon capture cost profile)**

Categories	\$/tonne CO <sub>2</sub>	Percent
<b>Direct Operating Costs</b>		
Steam and Electricity <sup>2</sup>	7.46	52
Solvent	0.11	1
<b>Total Direct Costs</b>	<b>7.57</b>	<b>53</b>
<b>Indirect Operating Costs</b>		
G&A	2.41	17
Maintenance	2.87	20
Turnaround	1.03	7
Water Services	0.34	2
<b>Total Indirect Costs</b>	<b>6.65</b>	<b>47</b>
<b>Total Operating Cost</b>	<b>14.22</b>	<b>100</b>

- 1) Based on forecast avoided emissions of 1,211,341 tonnes/year.
- 2) Assumed cost of electricity is \$80/MWh.

**Table 7 - Rectisol® Capital Costs**

### Revenues

No industry benchmarks are available at this time. There is no revenue to report at this time.



## Section 11: Project Timeline

### Enhance Timeline

Shifts in the timeline during 2014 were made to accommodate NWR’s construction timeline and to avoid prolonged increased costs of operating the pipeline without full initial volumes. These changes allow for the most efficient and cost effective method of raising and spending capital leading up to Commercial Operations.

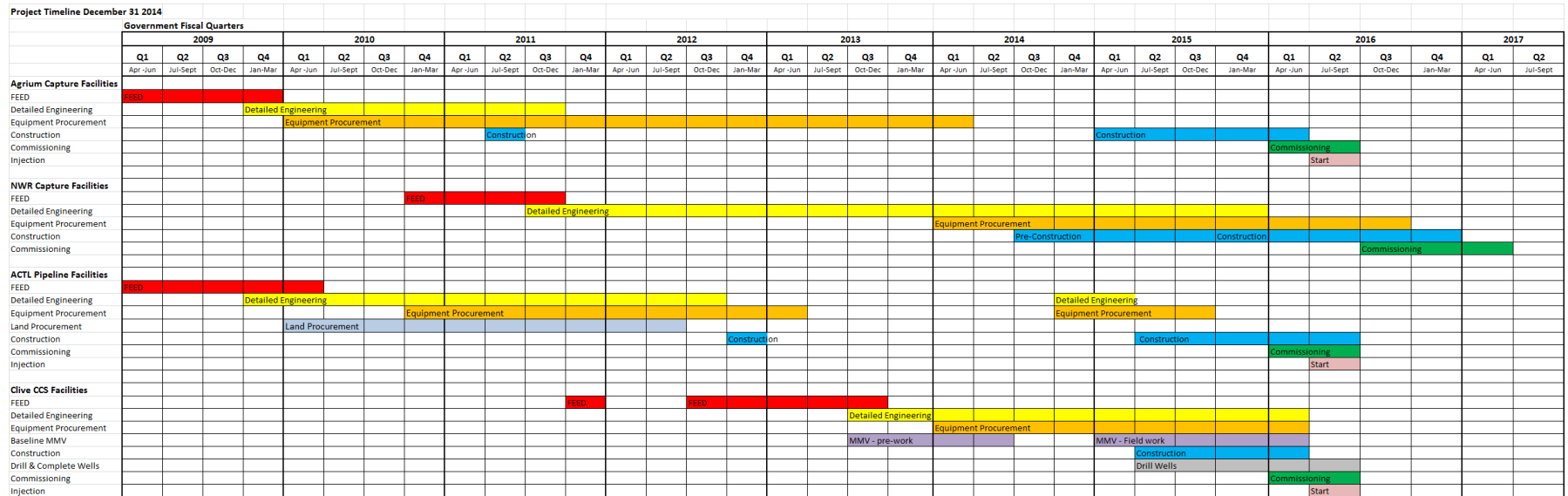


Figure 10 - Enhance Project Timeline

Above is the Enhance timeline as of December 31<sup>st</sup>, 2014 (a higher resolution version of the timeline can be found in Appendix xi of the detailed report).

## NWR Timeline

The NWR schedule of project milestones is shown below. Funding milestones 1, 2, & 3 have all slipped into the subsequent calendar quarter based on the current project updates. This slippage is a result of ongoing refinement and revision of forecasted work and normal construction delays. (For example and as mentioned earlier, piling is approximately 2 months behind prior schedule.) Final start-up date has not shifted due to planned flexibility in the overall schedule, so no impact from this slippage.

<b>NWR Project Schedule - CO<sub>2</sub> Capture</b>																	
Milestone	Calendar Year	2014				2015				2016				2017			
	Change from Previous Report	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND	JFM	AMJ	JAS	OND
		1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Detailed Design	No																
Site Wide Refinery Construction	No																
Gasifier & Rectisol Construction	No																
1. Piling Complete - Rectisol	Yes																
2. Rectisol Construction 50% Complete	Yes																
3. Rectisol Mechanical Completion	Yes																
Commissioning & Startup	No																
Commercial Operation - CO <sub>2</sub> Compression	No																

Figure 11 - NWR Project Timeline

## Section 12: General Project Assessment

### Successes and learnings arising from the project

The ACTL project is expected to encourage the development of an eco-industrial petrochemical cluster of additional value-added upgrading, refining, and petrochemicals projects that take advantage of sustainable and cost-effective solutions for CO<sub>2</sub> emissions. Once operational, the ACTL is strategically positioned to launch an integrated CCS sector and establish Alberta as a globally recognized leader for CCS and EOR technology. To date, the project has been successful in passing through key commercial, public consultation, regulatory, financial and design hurdles. Enhance and NWR will build on these successes as the project moves into its construction and operation phases.

#### *Landowner acceptance*

There are approximately 400 landowners along the ACTL who have been externally supportive of the project. This is a significant achievement and it highlights public support for the ACTL. Enhance's strong commitment to community engagement is evident in the fact that landowners readily accept the pipeline being built underneath their land. This level of acceptance occurs once all community questions and concerns have been adequately addressed and risks have been shown to be minimal.

#### *Procurement of major equipment*

Significant pieces of equipment have been purchased for both the Agrium facilities and the pipeline. The two inlet condensers, inlet separator, six stage compressor, dehydration package, and refrigeration package (shown in Figure 12) have been purchased and are at various stages of fabrication/delivery.

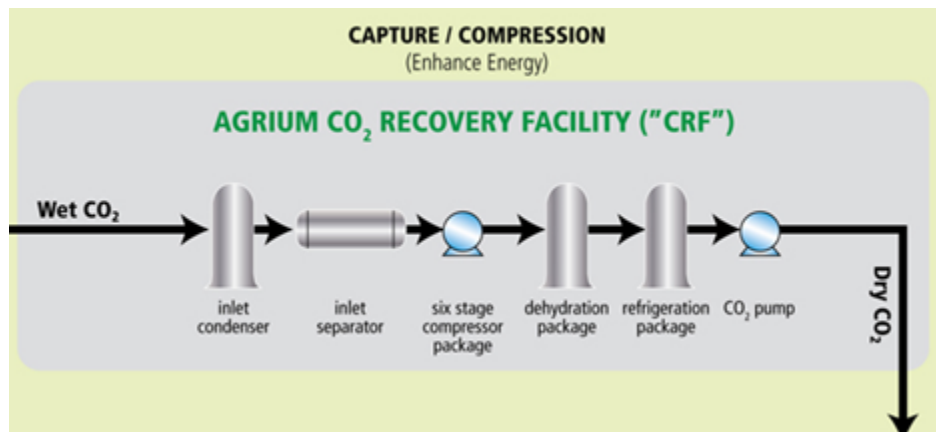


Figure 12 - Agrium CRF Equipment Diagram

Pipeline valves and actuators have also been delivered. These equipment purchases and receipts show Enhance's progress on the project's development and commitment to its completion.

#### *Regulatory approvals in place for pipeline*

Enhance received its CEAA approval on September 7, 2010 and its AER permit to construct on April 26, 2011. A major accomplishment was receiving the AER permit. The Board granted the ACTL a permit as the project met all of the requirements of Directive 56, and there were no relevant outstanding issues or concerns. This is very significant for a large-scale project. It stresses Enhance's compliance to regulations pertinent to CO<sub>2</sub> transportation and storage.

#### *Achievement of the project's first milestone*

Enhance met its first project milestone, "Issue of Construction Drawings for the Agrium Capture Facilities", in early 2012. Meeting this milestone was a large undertaking, resulting in over 850 detailed issued for construction drawings and required more than 30,000 engineering man-hours. Approximately 26,000 of those man-hours were expended in Alberta. Completing this aspect of the project helped finalize the front end engineering stage of the project and acts as an important stepping stone as the ACTL proceeds with the project.

#### *Knowledge sharing*

Enhance and NWR have committed to provide updates and deliver presentations to the community, industry and government in order to promote awareness about the ACTL project and highlight its benefits to a wide audience. As part of this commitment, Enhance and NWR have spent considerable time preparing knowledge sharing reports for the provincial and federal governments and the general public.

#### *Government funding*

The ACTL project has benefited from both the Province of Alberta and Government of Canada funding. Province of Alberta funds are paid once specific milestones are met; \$4.5 million (out of a total \$495 million) has been received to date. The Government of Canada funds are released on a quarterly basis as the project progresses (the Project has incurred sufficient eligible costs such that the contribution of \$63.2 million (less 10% holdback) has been received from Natural Resources Canada). The opportunity to access Federal funds early in the project has been critical to moving the project forward during an economic downturn in capital markets. Having access to the capital early in the project has supported the purchase of equipment and helped move the project from its design phase towards construction.

#### *Electricity Power Requirements*

Acquiring power for a project in Alberta from the Alberta Interconnected Electrical System (AIES) can be a very long process, and usually takes a minimum of two years. Understanding the long lead time for this aspect of the project, and proactively ensuring that the ACTL project remains on track, Enhance has begun to work closely with the local power distribution service

provider. The Enhance engineering team is currently working with Fortis Alberta to finalize the power delivery infrastructure required for both the Agrium and NWR sites.

*Direct economic benefits to Alberta*

The ACTL has already had a direct economic impact in Alberta, through the creation of jobs and procurement of equipment, even though the project is still in its design stage. These benefits are measured in terms of man-hours expended and equipment manufactured in the Province. Approximately 167,000 man-hours have been expended to date in Alberta on the project. 26,000 of those hours are engineering work done in 2011 to complete the first milestone “Issuance of Construction Drawings for the Agrium Capture Facilities.” An additional 14,000 man-hours were required to complete the Agrium CRF tie-ins in June 2011, and over 40,000 man-hours have been expended to date on the pipeline. Being a small Alberta based company; Enhance has always been committed to supporting more Alberta businesses. Direct efforts have been made to keep the majority of work in the Province. As shown in the two tables below, the majority of equipment for the pipeline and the large of the equipment for the Agrium CRF were procured for the project within the Province.

**ACTL Pipeline Procurement**

Equipment/Service	Vendor	Location
Engineering	SAW Engineering	Alberta
Environmental Assessment	Worley	Alberta
Environmental Planning	BOSS Environmental	Alberta
Regulatory	CH2M Hill	Alberta
Valves	KTI Limited	Alberta
Survey	Focus Surveys	Alberta
Geotechnical Assessment	Surface Search	Alberta
Land Acquisition	LandSolutions	Alberta

Table 8 - ACTL Pipeline Procurement List

### Agrium CRF Procurement

Equipment/Service	Vendor	Location
Inlet Separator	Bilton Welding	Alberta
Inlet Piping	Comco	Alberta
Pipe, Valves, Fittings	Comco & Pinnacle	Alberta
Dehydration Skid	Ensign/Opsco	Alberta
Air Cooled Exchangers	Exchanger Industries	Alberta
Glycol Pump	Smith Cameron Pump	Alberta
Refrigeration Skid	Startec	Alberta
CO <sub>2</sub> Transfer Pump	National Process Equipment	Alberta
Environmental Planning	BOSS Environmental	Alberta
Regulatory	CH2M Hill	Alberta
Inlet Condenser	Alfa Laval	Ontario
CO <sub>2</sub> Booster Pump	Clyde Union Canada	Ontario
Compressor	Siemens	Germany
Electrical Engineering and Controls	Beta Tech Inc.	Alberta

Table 9 - Agrium CRF Procurement List

#### *Economic benefit to Canada*

Enhance bought two pieces of equipment not manufactured in Alberta from Ontario. Unable to find manufacturers for the inlet condenser and the CO<sub>2</sub> Booster Pump in Alberta, Enhance preferred to have a Canadian supplier for these pieces so as to extend as much benefit as possible to Canadians.

#### *Opportunity to build expertise*

One piece of equipment that Enhance has had to order for the project from outside of Canada is the six-stage compressor for the Agrium CRF, which is being designed in Germany by Siemens. A Canadian manufactured compressor would have been preferred, however the technology and manufacturing capability has been built up in Germany over 50 years, and is hard to replicate here in a short time frame.

### *Indirect economic benefits of the project for Alberta and Canada*

Enhance commissioned the Canadian Energy Research Institute to conduct a study on the economic impact of the ACTL project. The study concluded that the estimated economic value of the overall integrated project, at design capacity, could increase Canada's total economic output by \$231 billion (approximately 80% of the impact in Alberta) and provide an additional 848,800 person-years of employment (approximately 70% of the impact in Alberta).

## **Section 13: Next Steps**

The North West Sturgeon Refinery Project is proceeding as planned with construction well underway. Significant progress was made in 2014 with the project meeting or exceeding all of its performance targets. Site earth works & deep undergrounds have been completed and access to site was handed over to sub-units at mid-year. Detailed engineering continues with 60% model reviews completed and 90% model review well advanced before year end. Long-lead vessels have been delivered to site and first modules have begun to arrive. Module assembly began in January 2015 with a significant surge in activity set to take place at site.

Enhance is focused on many varied tasks for the 2015 calendar year. The main area of focus will be finalizing construction contracts and procurement of long lead equipment such as pipe and compression. The MMV plan will be completed and initial data collection planned to occur in late 2015. During the year Enhance will also complete Issued for Construction pipeline drawings and initiate construction at the Agrium capture site.

### **Changes in the project plan and timeline**

NWR's Sturgeon Refinery is currently forecast to begin early operations in the 2<sup>nd</sup> quarter of 2017 with full commercial operations by the 3<sup>rd</sup> quarter 2017. The ACTL is forecast to start-up with Agrium volumes in late 2016, and NWR volumes coming on-stream thereafter.

Since the project's inception, the only changes to the project plan have been minor timeline changes. The most up to date schedules are shown in Figures 10 and 11 above.