

**Proposed East Manson Unit No. 2**  
**Application for Enhanced Oil Recovery Waterflood Project**  
**Middle Bakken**  
**East Manson, Manitoba**

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**Crescent Point Energy Corporation**

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## Introduction

The East Manson Field, which is located in Township 13 and Range 28W1, first produced in 2010 from 00/14-09-013-28W1/0 targeting the Middle Bakken formation. The field has been primarily developed with horizontal wells. In January 2012, Reliable Energy drilled the first well in the proposed unit at 00/01-03-013-28W1/0. Crescent Point Energy Corporation (CPG) has since purchased Reliable Energy and is now the operator of the East Manson lands in the proposed unit.

CPG is proposing a unit be created in Section 3, Township 13 and Range 28W1 and believes potential exists for incremental production and reserves from a waterflood EOR project in the Middle Bakken formation. Currently, there are 4 producing horizontal wells and 2 producing verticals in the proposed unit. CPG plans to drill 3 more horizontal producers. Vertical and horizontal injectors will both be tested and CPG will therefore convert both vertical wells and 2 horizontal wells to injection. CPG plans to produce the wells for a year before converting them to injectors. CPG hereby submits an application to establish East Manson Unit No. 2 and implement an Enhanced Oil Recovery Waterflood Project within the Middle Bakken Formation (Figure 1).

The proposed East Manson Unit No. 2 falls within the Manson Bakken –Three Forks pool – 17-62B (Figure 2).

## Summary

1. The proposed East Manson Unit No. 2 is to include 6 existing producing wells (4 horizontals and 2 verticals) within 16 legal subdivisions (LSD) that was completed in the Middle Bakken formation (Figure 1).
2. The original oil in place (OOIP) for the proposed East Manson Unit No. 2 is  $931.4 \text{ e}^3\text{m}^3$  (5,861.3 mbbl) for an average of  $58.2 \text{ e}^3\text{m}^3$  (325.6 mbbl) per LSD.
3. Cumulative production in the proposed East Manson Unit No. 2 up until the end of September 2013 is  $12,185.0 \text{ m}^3$  (76.7 mbbl) of oil. This represents a 1.3% recovery factor of the total OOIP.
4. The expected ultimate oil recovery (EUR) of oil on primary production within the proposed East Manson Unit No. 2 using decline analysis and a horizontal type well for the five remaining locations is  $152.0 \text{ e}^3\text{m}^3$  (956.4 mbbl) with  $139.8 \text{ e}^3\text{m}^3$  (879.7 mbbl) remaining as of September 2013. The expected recovery factor would be 16.3% of the OOIP.
5. In September 2013, production from the proposed East Manson Unit No. 2 peaked at  $53.6 \text{ m}^3/\text{d}$  (337.1 bbl/d) or  $8.9 \text{ m}^3/\text{d}$  (56.2 bbl/d) per well with a 66% watercut (Figure 3).

6. Initial pressure of the Middle Bakken reservoir within the proposed East Manson Unit No. 2 is 5.7 MPa.
7. The Kola Units No. 1 & 2, located in sections 20, 21, 28, 29, 32 and 33-10-29W1, were used as an analogy to predict the recovery factor under waterflood. With the implementation of a waterflood, an incremental reserves of  $97.2 \text{ e}^3\text{m}^3$  (611.9 mbbbl) for a total EUR of  $249.2 \text{ e}^3\text{m}^3$  (1,568.3 mbbbl) is expected. The incremental recovery factor is expected to be 10.5% for a total recovery factor of 26.8%.
8. The development plan includes drilling 3 additional horizontal producing wells. The 2 vertical wells and 2 of the future horizontal wells will be converted to injection for a total of 4 injectors (Figure 4). To date only 1 horizontal and 1 vertical have been hydraulically fractured. There are no plans at this time to complete the remaining 3 horizontals with multi-stage hydraulic fractures.

## **Geology**

### Stratigraphy

The stratigraphy of the Bakken Formation in East Manson section 3-13-28W1 is shown on the type log 5-3-13-28W1 in Appendix 1. The Bakken Formation in the 5-3-13-28W1 well consists of the Upper Bakken Shale and the Middle Bakken Sandstone. Underlying the Middle Bakken is the Torquay Formation with the contact between the two being an unconformable surface which Crescent Point refers to as the Three Forks Unconformity. Overlying the Upper Bakken is the Basal Limestone of the Lodgepole Formation. The Middle Bakken Sandstone forms the reservoir for the East Manson pool. The cross-section in Appendix 2 shows the continuous reservoir across section 3 and the reservoir quality to the north in the 11-10-13-28W1 well.

### Sedimentology

The Middle Bakken in section 3-13-28W1 normally consists of a fine-grained sandstone to a siltstone. The upper portion of the Middle Bakken is often referred to as the “Brachiopod zone” and normally consists of an oxidized fine grained quartz siltstone. It often contains common thin walled Brachiopods and is usually quite bioturbated. This zone is indicative of a Middle Bakken shoreface type deposit and does not normally form reservoir in the East Manson area. The lower portion of the Middle Bakken consists of a fine-grained sandstone characterized by cross laminations, rip up clasts, and scouring. This zone is indicative of a higher energy environment likely representing the upper shoreface to beach facies. This zone is the main Middle Bakken producing reservoir. Permeability in this zone in Section 3 ranges anywhere from 0.18 md in the 8-3-13-28W1 (Appendix 3) well to 199 md in the 5-3-13-28W1 (Appendix 4) well. Porosity in this zone ranges from 10 to 23 percent.

### Structure

The Upper Bakken Structure Map in Appendix 5 shows the dip of the beds from northeast to southwest across section 3-13-28W1 from a high of -164 m to -196 m. The

Three Forks Unconformity Map in Appendix 6 also shows the dip of the beds from the northeast to southwest from a high of -169 m to -198 m. Crescent Point proprietary 3 dimensional seismic confirms the structure dipping from the northeast to the southwest.

#### Reservoir

Porosity ( $\phi$ -h), permeability (k-h), and net pay maps are provided in the Appendices 7, 8, and 9. These maps were generated using the open hole logs and core data. The net pay map in Appendix 7 shows a maximum net pay thickness of 4 m. The porosity ( $\phi$ -h) map in Appendix 8 demonstrates higher average porosity and net pay thickness associated with the well in 5-3-13-28W1 (Appendix 4) versus the 8-3-13-28W1 (Appendix 3) well. The permeability (k-h) map in Appendix 9 demonstrates the much higher permeability associated with the 5-3-13-28W1 well versus the 8-3-13-28W1 well. As well, the permeability map demonstrates that the higher permeability is trending north-south through section 3.

### **Reservoir Properties and Technical Discussion**

#### Original Oil in Place (OOIP)

The OOIP for the Middle Bakken within the proposed East Manson Unit No. 2 based on volumetrics is estimated to be  $931.4 \text{ e}^3\text{m}^3$  (5,861.3 mbbbl) for an average of  $58.2 \text{ e}^3\text{m}^3$  (325.6 mbbbl) per LSD. OOIP values were calculated using a 9% porosity net pay cutoff, which can be found in Figure 10.

PVT analysis was obtained from 00/03-16-013-28W1/0 and relative permeability analysis was obtained from a core at 00/07-16-013-28W1/0. The formation rock and fluid properties for the Middle Bakken have been summarized in Appendix 10.

#### Historical Production

The first well that was drilled was 00/01-03-013-28W1/0 and was placed on production in January 2012. In April 2013, two vertical wells, 00/05-03-013-28W1/0 and 00/08-03-013-28W1/0, and one horizontal, 00/02-03-013-28W1/0, were placed on production and in August 2013 another two horizontals, 00/03-03-013-28W1/0 and 00/04-03-013-28W1/0, were placed on production (Figure 3). Production peaked in September 2013 at  $53.6 \text{ m}^3/\text{d}$  (337.1 bbl/d) or  $8.9 \text{ m}^3/\text{d}$  (56.2 bbl/d) per well with a 66% watercut. In November 2013, CPG plans to drill the last 3 horizontals at 02/02-03-013-28W1/0, 03/02-03-013-28W1/0 and 02/03-03-013-28W1/0.

#### Primary Recovery

Cumulative production in the proposed East Manson Unit No. 2 up until the end of September 2013 is  $12,185.0 \text{ m}^3$  (76.7 mbbbl) of oil and  $25,095.4 \text{ m}^3$  (157.9 mbbbl) of water. This represents a 1.3% recovery factor of the total OOIP. Based on decline analysis and a  $19.9 \text{ e}^3\text{m}^3$  (125.0 mbbbl) type well for the future horizontal locations, the EUR on primary production is  $152.0 \text{ e}^3\text{m}^3$  (956.4 mbbbl) with  $139.8 \text{ e}^3\text{m}^3$  (879.7 mbbbl) remaining as of September 2013 (Figures 8 and 9). The expected recovery factor would be 16.3% of the total OOIP (Figure 10).

### Secondary Recovery

The Kola Units No. 1 & 2, located in sections 20, 21, 28, 29, 32 and 33-10-29W1, were used as an analogy to predict the recovery factor under waterflood (Figures 5, 6 and 7). Based on  $1,255.4 \text{ e}^3\text{m}^3$  (7,900.0 mbbbl) OOIP, the total recovery factor with waterflood is 27.0%.

With the implementation of a waterflood in the proposed East Manson Unit 2, the incremental reserves would be  $97.2 \text{ e}^3\text{m}^3$  (611.9 mbbbl) for a total EUR of  $249.2 \text{ e}^3\text{m}^3$  (1,568.3 mbbbl) (Figures 8 and 9). The incremental recovery factor is expected to be 10.5% for a total recovery factor of 26.8%, which matches the analog in Kola (Figure 10).

### **Unitization**

The basis for unitization is to implement a waterflood is to increase the overall recovery of the OOIP from the proposed project area.

### Unit Name

CPG proposes that the official name of the new unit shall be East Manson Unit No. 2.

### Unit Operator

CPG will be the Operator for East Manson Unit No. 2.

### Unitized Zones

The unitized zone to be waterflooded in the East Manson Unit No. 2 will be the Middle Bakken Formation.

### Unit Wells

The 6 producing wells (4 horizontal and 2 vertical) and 3 horizontal locations in the proposed East Manson Unit No. 2 are outlined in Appendix 11 with their current status. The projected timing of the new drills and injector conversions is also included.

### Unit Lands

The East Manson Unit No. 2 will consist of all 16 LSDs in section 3 of Township 13, Range 28W1. The lands included in the 40 acre tracts are outlined in Appendix 12.

### Tract Factors

The proposed East Manson Unit No. 2 will consist of 16 tracts based on remaining OOIP using maps created internally by CPG per LSD, as of September 2013. The production from the horizontal wells was divided according to the existing production allocation agreement. The calculation of the tract factors are outlined in Appendix 13.

### Working Interest Owners

Appendix 12 outlines the working interest for each recommended tract within the proposed East Manson Unit No. 2. CPG will have an 81.25% WI with Fort Calgary as a partner with an 18.75% WI across all tracts.

## **Waterflood Development**

The remaining 3 horizontal locations will be drilled and placed on production before year end. CPG is planning on testing both vertical and horizontal injectors. There will be a total of 2 vertical wells and 2 horizontal wells converted to injection after being produced for one year (Figure 4). The 2 vertical wells, 00/05-03-013-28W1/0 and 00/08-03-013-28W1/0, will be converted in March 2014 and the 2 horizontal wells, 03/02-03-013-28W1/0 and 02/03-03-013-28W1/0, will be converted in December 2014. After full development and the implementation of the waterflood, there will be 5 horizontal producers, 2 horizontal injectors and 2 vertical injectors.

### Waterflood Operating Strategy

The proposed East Manson Unit No. 2 will be tied into CPG's battery at 16-4-13-28W1. Injected water will be a combination of Middle Bakken produced water and Lower Lodgepole water from a future source well located at 00/01-09-013-28W1/0. Production is sent to the battery at 16-4-13-28W1, where the water is separated, filtered and distributed to the injection system. A simplified process flow diagram of the system from the 16-4-13-28W1 to the injectors is located in Figure 16.

Compatibility testing will occur once the source well at 00/01-09-013-28W1/0 has been drilled. All potential mixture ratios between the source water and produced water will be simulated and evaluated for scaling and precipitate producing tendencies.

The injector wells will be equipped with injection volume metering and rate/pressure control (Figures 13 and 14). Water injection volumes and metre balancing will be utilized to monitor the entire system measurement and integrity on a daily basis.

The corrosion control program outlining the planned system design and operational practices to prevent corrosion is located in Figure 15.

### Reservoir Pressure

The initial pressure taken at 00/05-03-013-28W1/0 was measured to be 5.7 MPa. The saturation pressure from PVT analysis done on 00/03-16-013-28W1/0, which CPG believes is the same fluid, is 3.6 MPa. Based on the recent production drop in the first well 00/01-03-013-28W1/0 and the lower initial productivity in 00/02-03-013-28W1/0, CPG estimates that the reservoir pressure has dropped below the bubble point in the east half of the unit. The PVT analysis has also indicated a low solution GOR of  $6 \text{ m}^3/\text{m}^3$ . The combination of the potential drop below the bubble point with almost no gas in solution means that there is very little energy in the reservoir. CPG believes a waterflood is required to provide energy for the reservoir and increase oil recovery. Reservoir pressure will be increased back to original reservoir pressure by maintaining a monthly voidage replacement ratio (VRR) of 1.3-1.5 until a cumulative VRR of 1.0 is reached.

### Waterflood Surveillance and Optimization

The response and waterflood surveillance of East Manson Unit No. 2 will consist of the following:

- Regular production well testing to monitor fluid rate and water cut to watch for waterflood response
- Comparison of daily injection rates and pressure monitoring to targets
- Monitor monthly and cumulative voidage replacement ratio by pattern and overall unit
- Evaluation of Hall plots
- New injection targets will be sent to the field on a regular basis

### Injector Conversions

The producing wells that will be converted to injection will be produced for a full year before conversion. The 2 vertical wells, 00/05-03-013-28W1/0 and 00/08-03-013-28W1/0, will be converted in March 2014 and the 2 horizontal wells, 03/02-03-013-28W1/0 and 02/03-03-013-28W1/0, will be converted in December 2014. The tubing and rods will be removed and replaced with internally coated tubing. A typical injector schematic for a horizontal injector is shown in Figure 11 and for a vertical injector is shown in Figure 12.

### Injection Rates and Pressures

CPG plans to inject water into the Middle Bakken to re-pressurize and add energy to the reservoir. Initial instantaneous VRR targets will be between 1.3 and 1.5 until a cumulative VRR of 1.0 is reached. Initial forecasts suggest the injection requirements will be between 250 m<sup>3</sup>/d (1,573 bbl/d) and 300 m<sup>3</sup>/d (1,887 bbl/d) or 63 m<sup>3</sup>/d (393 bbl/d) and 75 m<sup>3</sup>/d (472 bbl/d) per injector.

Completion data from wells that have been stimulated by hydraulic fractures in the East Manson area indicates a fracture gradient of 20.0 kPa/m. This works out to a fracture pressure at the sandface 13,400 kPa or 6,700 kPa at the wellhead. The requested maximum wellhead injection pressure will be 90% of the fracture pressure which is 6000 kPa.

### Economic Limit

The economic limit will be when the net oil rate and net oil price revenue stream becomes less than the current producing operating costs. Based on current price forecasts, the economic limit for the project would be 1 m<sup>3</sup>/d.

### **Notifications**

CPG has notified all surface and mineral owners within the proposed unit and the surrounding 500m of the unit boundary about the application for unitization and waterflood of section 3-13-28W1 by mail (Appendices 14-18). Copies of receipts and delivery notifications to all stakeholders are attached in Appendix 19.



East Manson Unit No. 2 unitization and execution of the formal East Manson Unit No. 2 agreement by affected mineral owners will occur once the Petroleum Branch has reviewed the tract factors. Copies of the agreement will be forwarded to the Petroleum Branch to complete the East Manson Unit No. 2 application.

Please contact Jeff Smith at 403-767-6946, by email at [jsmith@crescentpointenergy.com](mailto:jsmith@crescentpointenergy.com) or at Suite 2800, 111-5<sup>th</sup> Ave SW, Calgary, Alberta, T2P 3Y6 for any other questions or clarification.

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## **Proposed East Manson Unit No. 2**

### **Application for Enhanced Oil Recovery Waterflood Project**

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