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February 27, 2015

Manitoba Innovation, Energy and Mines

Box 1359, 227 King Street West

Virden, Manitoba

R0M 2C0

Attention: Stacy McBride, Chief Petroleum Engineer, Virden Office

**RE: Annual Report – Enhanced Oil Recovery Project**

As per section 73 of the Drilling and Production Regulations, ARC Resources Ltd. (“ARC”) as operator of an Enhanced Oil Recovery (EOR) project, is submitting an annual report for the Waterflood project in the Goodlands area of Manitoba (the “Project”).

The injection wells within this Project were originally drilled as Lower Amaranth producers, and were converted to water injectors between 2002 and 2004 to provide pressure support to offsetting new producers. Initial development in the Lower Amaranth utilized vertical wells, but ARC now drills horizontal wells as they are more economic with advances in drilling and completion techniques. ARC drilled and completed its first horizontal well within the Project, 00/1-15-001-24W1, in late 2010, with production beginning in January 2011. The unit development continued as follows:

* 2011 – 2 horizontal oil wells
  + 02/07-10-001-24W1
  + 02/11-11-001-24W1
* 2012 - 4 horizontal oil wells,
  + 103/07-10-001-24W1/00
  + 103/11-11-001-24W1/00
  + 102/12-11-001-24W1/00
  + 104/07-10-001-24W1/00
* 2014 - 3 horizontal oil wells,
  + 102/01-15-001-24W1/00
  + 102/03-14-001-24W1/00
  + 105/07-10-001-24W1/00

Water Injection continues to be a serious challenge. As of August 2014 we not injecting any water into formation due to filtering problems. We are conducting a thorough investigation into our water quality with an emphasis on solids injection and wax formation to try and solve our injectivity issues. Mercury injection testing done on core in the area suggested that damage due to solids could be minimized in the near wellbore region with filtering less than 2 microns. The feasibility of this kind of filtering program is being evaluated. We are going review our injection system along with more testing of produced water and filtered water to try and see what improvements can be made in water quality.

The following information, as requested by the Department of Innovation, Energy and Mines, is contained in this report, and will illustrate the current status of the project:

1. the oil production rate, injection rate, GOR, and WOR during each month for each injection pattern and for the whole project;
2. the cumulative volume of oil, gas, and water produced and fluid injected for each injection pattern and for the whole project at the end of the year;
3. the monthly wellhead injection pressure for each injection well;
4. a summary of the result of any survey of reservoir pressure conducted during the year;
5. the date and type of any well servicing;
6. calculations of the voidage replacement ratio on a monthly and cumulative basis for each injection pattern and for the project area;
7. an outline of the method used for quality control and treatment of the injected fluid;
8. a report of any unusual performance problems and remedial measures taken or being considered;
   1. any other information that the operator or director considers necessary to evaluate the performance of the project such as, but not limited to, the following:
   2. discussion the overall performance of the EOR project;
   3. discussion of any trends in production or development; and
   4. discussion of comparison of current recovery against original forecasted recovery.

Should you have any questions, or require additional data, please do not hesitate to contact me by phone at 403 509 7230 or by email at dkearl@arcresources.com

Sincerely,

David Kearl, C.tech

List of Attachments

Attachment 1: Schematic of the Injection Facilities

Attachment 2: Map of the Water Flood including Patterns

Attachment 3: Allocation factors for Waterflood Patterns

# A: Oil rate, injection rate, GOR and WOR in graphical form

# A: Oil rate, injection rate, GOR and WOR in tabular form

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **CD Oil Rate bbl/d** | | | | | | | |
| **Date** | **Pattern A** | **Pattern B** | **Pattern C** | **Pattern D** | **Pattern E** | **Pattern F** | **Unit Total** |
| Jan-14 | 50.7 | 58.6 | 23 | 22.5 | 54.2 | 12.7 | 221.6 |
| Feb-14 | 50 | 62.1 | 22.4 | 19.8 | 54.4 | 9.9 | 218.6 |
| Mar-14 | 46.2 | 58.8 | 21.9 | 19.1 | 50.7 | 9.9 | 206.7 |
| Apr-14 | 49.2 | 61.3 | 17.1 | 17.7 | 50.9 | 8.3 | 204.5 |
| May-14 | 41.6 | 72.9 | 12.8 | 13.5 | 50.6 | 6.8 | 198.3 |
| Jun-14 | 38.8 | 64.9 | 15.8 | 13.6 | 48.3 | 6.2 | 187.7 |
| Jul-14 | 37.3 | 71.7 | 15 | 12.8 | 45 | 6.7 | 188.4 |
| Aug-14 | 37.9 | 77.4 | 16 | 12.1 | 39.1 | 7.3 | 189.9 |
| Sep-14 | 35 | 69.2 | 13.4 | 9.8 | 32.6 | 5.9 | 165.8 |
| Oct-14 | 37.2 | 88.2 | 12 | 9.3 | 47 | 4.9 | 198.6 |
| Nov-14 | 44 | 85.4 | 13.8 | 8.5 | 54.3 | 4.4 | 210.5 |
| Dec-14 | 59.8 | 103.3 | 23.7 | 9.1 | 58.3 | 5.1 | 259.2 |
| **CD Water Injection Rate bbl/d** | | | | | | | |
| **Date** | **Pattern A** | **Pattern B** | **Pattern C** | **Pattern D** | **Pattern E** | **Pattern F** | **Unit Total** |
| Jan-14 | 110.4 | 20.2 | 0.2 |  |  | 11.8 | 142.6 |
| Feb-14 | 91.9 | 17.4 | 0 |  |  | 12.9 | 122.2 |
| Mar-14 | 75.4 | 18.9 | 0.5 |  | 0.6 | 22.2 | 117.6 |
| Apr-14 | 93.4 | 16.6 | 0.4 |  | 0 | 19.9 | 130.3 |
| May-14 | 92.7 | 15.1 | 0 |  |  | 19.7 | 127.6 |
| Jun-14 | 89.4 | 10.5 |  |  |  | 17.8 | 117.6 |
| Jul-14 |  | 0.3 |  |  |  |  | 0.3 |
| Aug-14 |  | 0.2 |  |  |  | 0.2 | 0.4 |
| Sep-14 |  | 0 |  |  |  |  |  |
| Oct-14 |  | 0 |  |  |  |  |  |
| Nov-14 |  | 0 |  |  |  |  |  |
| Dec-14 |  |  |  |  |  |  |  |
| **GOR mcf/bbl** | | | | | | | |
| **Date** | **Pattern A** | **Pattern B** | **Pattern C** | **Pattern D** | **Pattern E** | **Pattern F** | **Unit Total** |
| Jan-14 | 0.30 | 0.44 | 0.58 | 0.42 | 0.54 | 0.67 | 0.49 |
| Feb-14 | 0.24 | 0.39 | 0.58 | 0.28 | 0.39 | 0.72 | 0.43 |
| Mar-14 | 0.23 | 0.39 | 0.67 | 0.24 | 0.37 | 0.79 | 0.45 |
| Apr-14 | 0.19 | 0.36 | 0.61 | 0.25 | 0.34 | 0.74 | 0.41 |
| May-14 | 0.23 | 0.35 | 0.73 | 0.23 | 0.36 | 0.67 | 0.43 |
| Jun-14 | 0.28 | 0.38 | 0.70 | 0.24 | 0.38 | 0.75 | 0.45 |
| Jul-14 | 0.30 | 0.41 | 0.76 | 0.26 | 0.42 | 0.87 | 0.50 |
| Aug-14 | 0.27 | 0.40 | 0.71 | 0.32 | 0.50 | 0.83 | 0.50 |
| Sep-14 | 0.21 | 0.32 | 0.94 | 0.35 | 0.52 | 0.99 | 0.56 |
| Oct-14 | 0.24 | 0.23 | 0.62 | 0.36 | 0.33 | 0.89 | 0.45 |
| Nov-14 | 0.24 | 0.25 | 0.51 | 0.34 | 0.30 | 0.79 | 0.40 |
| Dec-14 | 0.22 | 0.23 | 0.28 | 0.32 | 0.31 | 0.73 | 0.35 |

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **WOR bbl/bbl** | | | | | | | |
| **Date** | **Pattern A** | **Pattern B** | **Pattern C** | **Pattern D** | **Pattern E** | **Pattern F** | **Unit Total** |
| Jan-14 | 3.81 | 1.81 | 0.99 | 0.81 | 1.31 | 1.16 | 1.92 |
| Feb-14 | 1.83 | 1.85 | 1.01 | 0.97 | 1.4 | 1.3 | 1.54 |
| Mar-14 | 1.82 | 1.8 | 0.99 | 0.85 | 1.38 | 0.95 | 1.49 |
| Apr-14 | 1.62 | 1.68 | 0.87 | 0.79 | 1.23 | 0.8 | 1.37 |
| May-14 | 1.77 | 1.54 | 0.79 | 0.92 | 1.26 | 0.78 | 1.4 |
| Jun-14 | 1.51 | 1.15 | 0.67 | 0.86 | 1.1 | 0.5 | 1.13 |
| Jul-14 | 1.58 | 1.02 | 0.67 | 0.93 | 1.11 | 0.7 | 1.11 |
| Aug-14 | 1.45 | 0.95 | 0.71 | 0.78 | 1.09 | 0.67 | 1.04 |
| Sep-14 | 1.25 | 0.88 | 0.8 | 0.96 | 0.93 | 0.92 | 0.97 |
| Oct-14 | 1.13 | 0.95 | 0.61 | 1.12 | 1.07 | 1.03 | 1 |
| Nov-14 | 1.63 | 1.18 | 1.03 | 1.18 | 1.44 | 1.08 | 1.33 |
| Dec-14 | 1.66 | 1.21 | 1 | 1.08 | 1.46 | 0.9 | 1.34 |

# B: Cumulative oil volume, cumulative water produced and cumulative water injected in graphical form

**B: Cumulative oil volume, cumulative water produced and cumulative water injected in tabular form**

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Pattern** | **Cumilative Oil Produced (mstb)** | **Cumulative Gas Produced (mcf)** | **Cumulative Water Produced (mstb)** | **Cumulative Water Injected (mstb)** | **Total** |
| Pattern A | 216.32 | 39.66 | 692.84 | 156.5 | 1105.32 |
| Pattern B | 296.85 | 44.07 | 196.07 | 305.96 | 842.95 |
| Pattern C | 113.12 | 30.65 | 58.04 | 121.22 | 323.03 |
| Pattern D | 116.53 | 31.47 | 50.67 | 153.41 | 352.08 |
| Pattern E | 191.74 | 1.77 | 110.71 | 72.54 | 376.76 |
| Pattern F | 71.68 | 28.25 | 36.15 | 101.84 | 237.92 |
| **Total** | 1006.24 | 175.87 | 1142.34 | 911.47 | 3235.92 |

**C: Wellhead injection pressure in tabular form**



# 

C**: Wellhead injection pressure in graphical form**

# D: 2014 Reservoir Pressures

In 2014 we collected several casing pressures and fluid levels to calculate the bottom hole pressure in the area. Bolded wells are in or close to the unit. The results are shown in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| **Pressure Summary Sheet** | | | |
| UWI | Test Date | Shut-in time days | Pressure Mpa |
| 100/01-09-001-24W1/00 | 1/20/2014 | 896 | 2.2 |
| 100/02-09-001-24W1/00 | 1/20/2014 | 797 | 2.5 |
| 100/05-04-001-24W1/00 | 1/20/2014 | 833 | 0.7 |
| 100/04-04-001-24W1/00 | 1/20/2014 | 951 | 3.7 |
| 100/02-04-001-24W1/00 | 1/20/2014 | 776 | 8.6 |
| **100/05-11-001-24W1/00** | 1/20/2014 | 18 | 1.3 |
| **1A0/13-11-001-24W1/00** | 1/20/2014 | 1,020 | 4.5 |
| **100/08-15-001-24W1/00** | 1/20/2014 | 909 | 3.6 |
| 100/02-22-001-24W1/00 | 1/20/2014 | ~1480 | 8.2 |
| 102/05-04-001-24W1/00 | 6/5/2013 | 26 | 3.3 |
| **103/04-10-001-24W1/00** | 6/5/2013 | 26 | 1.7 |
| **100/15-11-001-24W1/00** | 4/6/2014 | 18 | 6.5 |
| 100/02-23-001-24W1/00 | 4/6/2014 | ~4015 | 4.9 |
| 102/12-15-001-24W1/00 | 4/6/2014 | 18 | 2.1 |
| 103/14-09-001-24W1/00 | 4/6/2014 | 18 | 2.2 |
| Average |  |  | 3.7 |

# E: 2014 Well Servicing Summary

|  |  |  |
| --- | --- | --- |
| UWI | Workover Date | Comment |
| 1D0/13-11-001-24W1/00 | 7/10/2014 | Pump Change |
| 102/05-11-001-24W1/00 | 8/6/2014 | Pump Change |
| 105/13-11-001-24W1/00 | 1/18/2014 | Pump Change |
| 1C0/16-10-001-24W1/00 | 5/10/2014 | Pump Change |
| 103/11-11-001-24W1/00 | 11/28/2014 | Pump Change |
| 100/01-15-001-24W1/00 | 12/5/2014 | Pump Change |

# F: Voidage Replacement Ratio Calculations

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Monthly VRR** | | | | | | | |
| **Date** | **Pattern A** | **Pattern B** | **Pattern C** | **Pattern D** | **Pattern E** | **Pattern F** | **Unit Total** |
| Jan-13 | 0.443 | 0.119 | 0.004 | 0 | 0 | 0.410 | 0.213 |
| Feb-13 | 0.625 | 0.095 | 0.000 | 0 | 0 | 0.544 | 0.211 |
| Mar-13 | 0.556 | 0.111 | 0.011 | 0 | 0.005 | 1.088 | 0.219 |
| Apr-13 | 0.697 | 0.097 | 0.011 | 0 | 0 | 1.253 | 0.257 |
| May-13 | 0.774 | 0.078 | 0.002 | 0 | 0 | 1.531 | 0.257 |
| Jun-13 | 0.881 | 0.071 | 0 | 0 | 0 | 1.783 | 0.281 |
| Jul-13 | 0 | 0.002 | 0 | 0 | 0 | 0 | 0.001 |
| Aug-13 | 0 | 0.002 | 0 | 0 | 0 | 0.013 | 0.001 |
| Sep-13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Oct-13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Nov-13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Dec-13 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| **Cum VRR** | **0.168** | **0.584** | **0.662** | **0.854** | **0.225** | **0.882** | **0.404** |

# G: Quality Control and Treatment of the Injected Fluid

The current quality and treatment control for the injection water at Goodlands begins with a two phase filtering process. Filters are changed 2-3 times per week to ensure the water quality is maintained.

Phase 1: Fluid is filtered down to 10 microns.

Phase 2: Fluid is further filtered to 5 microns.

The operators monitor the water tanks to ensure there is no oil carryover. In the event that oil is noticed on top of the water, the tanks will be skimmed to ensure that the oil is not re-injected through the water injection wells.

We are currently reviewing this process to improve our water quality so we can resume injection.

Please see Attachment 1 for further details and specifications on the Injection system in place.

# H: Unusual Performance Problems and Remedial Measures

There are several factors that affect production in the area. The most challenging issues would be:

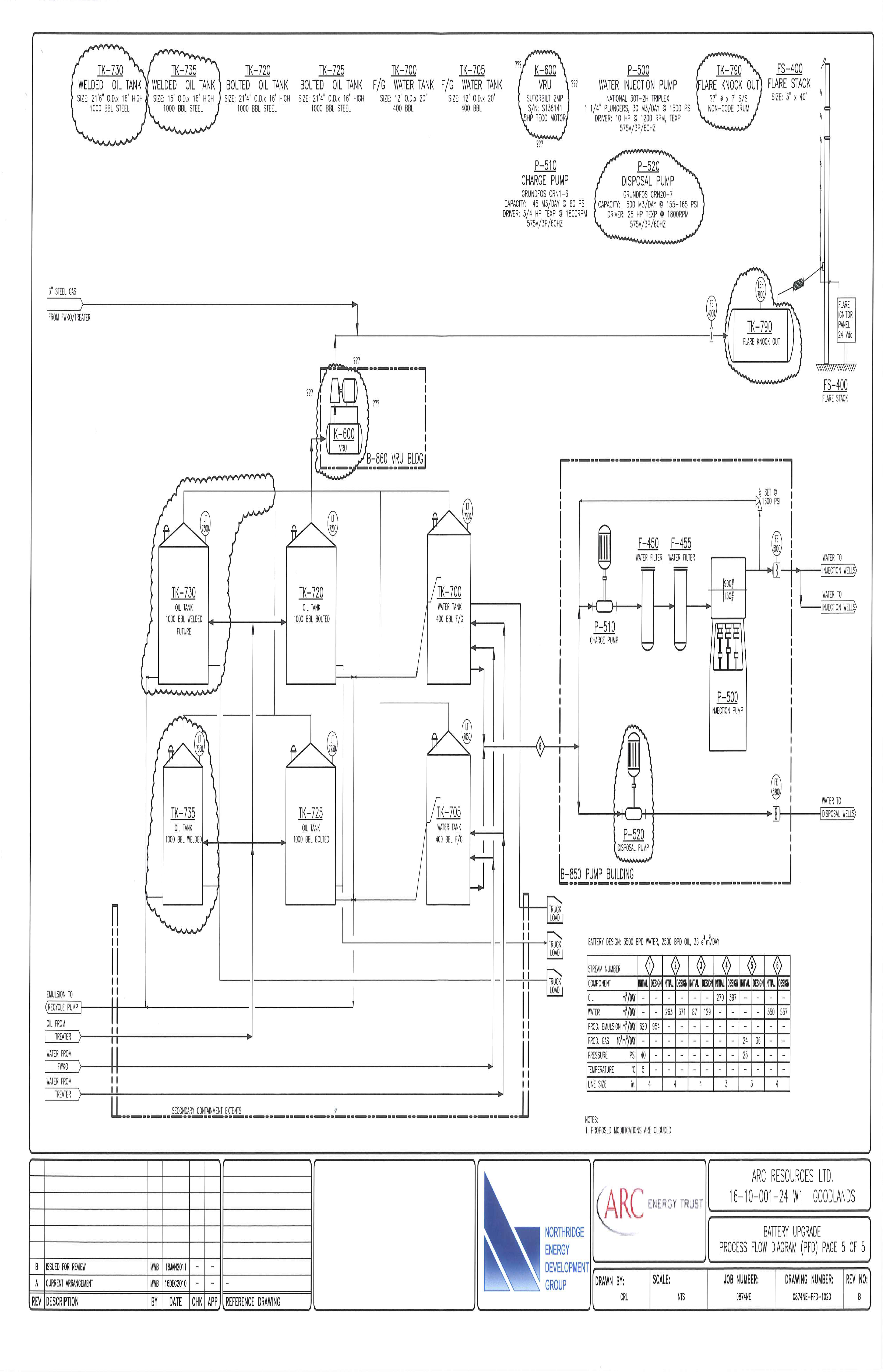
* Parraffin and asphaltene deposition in the flowlines, wellbores, and at the sandface
* Scale depostion in the wellbores and at the sandface
* Sand influx as a result of neighboring fracture treatments

Remedial methods used to address these issues include:

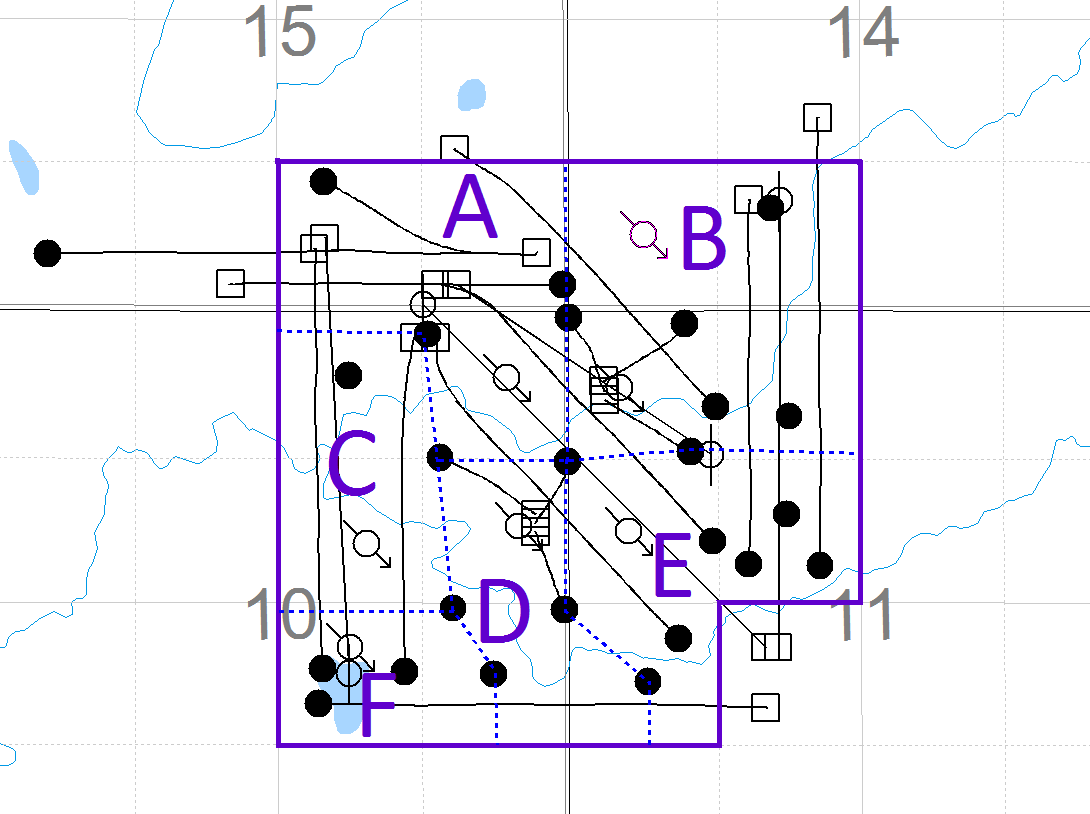
* Regular chemical batch treatments to combat parraffin and asphaltene deposition (most wells)
* We ceased the Microbial treatments (bacteria) to combat parraffin buildup halfway through 2014 due to high cost.
* Solvent stimulations for parraffin & asphaltene deposition
* Acid stimulation to address scale deposition
* Circulating cleanouts to address sand influx issues

As stated in the introduction we are no longer able to inject water into our waterflood wells as we were changing filters on a daily basis and the injectivity was very limited. We are currently have a plan to improve our waterflood and restore injection. We have completed a mercury injection test to better understand water injection into our formation. This study has prompted a review of our injection and filtration system. We also are planning a study to investigate the suitability of our reservoir rock for injection as well as continuing to understand our issues with wax. These finding will help us to design and optimize our water injection scheme to improve waterflood effectiveness.

# ATTACHMENT 1: Schematic of the Injection Facilities



# ATTACHMENT 2: Map of the Water Flood including Patterns



# ATTACHMENT 3: Allocation factors for Waterflood Patterns

