JACKFISH IN SITU PROJECT
DIRECTIVE 54 ANNUAL
PERFORMANCE PRESENTATION
Commercial Scheme Approval 10097 (as amended)
November 2019
## Outline – Subsurface

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# Outline – Surface

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Subsurface Operations
Project Background
3.1.1-1
Brief Background of Scheme

Jackfish

3.1.1.1

- Jackfish 1, 2, and 3 utilize steam-assisted gravity drainage (SAGD) to recover bitumen from the McMurray formation
- Located 150 km south of Fort McMurray
- Jackfish 1 scheme approval granted August 2006; first steam August 2007
- Jackfish 2 scheme approval granted August 2008; first steam May 2011
- Amalgamation of Jackfish approvals (including Jackfish 3) November 2011; first steam July 2014
- Jackfish Expansion approval granted in August 2019
Brief Background of Scheme

Jackfish

3.1.1-1

Jackfish Expansion

[Map showing the locations of Jackfish 1 Pad, Jackfish 2 Pad, and Jackfish 3 Pad, along with the Jackfish Expansion area. The map includes sections labeled QO, KK, BB, AA, DP, FF, EE, RR, and J1, J2, J3 CPF.]
## Brief Background of Scheme

### Jackfish

#### 3.1.1-1

<table>
<thead>
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<th>Asset</th>
<th>Number of Operating Pads</th>
<th>Number of Operating Well Pairs</th>
<th>Upcoming Pads</th>
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<td>Jackfish 2</td>
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<td>60</td>
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<td>Jackfish 3</td>
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Geology, Seismic
3.1.1-2, 3.1.1-6
Geology
Jackfish Gross Rock Volume Pay Definition

3.1.1-2a

Gross Rock Volume (GRV)

• Characterizes the complete package accessible through SAGD

• Defined by:
  - \( S_o > 50\% \)
  - \( V_{sh} < 40\% \)
  - encompasses all brecciated intervals

• \( V_{sh} \) and \( S_o \) are standard petrophysical curves calculated from gamma ray, resistivity, and porosity logs, and correlated to image logs and core data
**Geology**

**Jackfish Net Continuous Pay Definition**

3.1.1-2a

---

**Net Continuous Bitumen (NCB)**

- More conservative definition used to define continuous bitumen pay, used for pad and well pair planning.

- Defined by:
  - \( V_{sh} < 40\% \)
  - can contain up to 1m continuous non-reservoir
  - excludes breccias that do not meet \( V_{sh} \) cutoff
  - base defined by producer (actual or estimated) elevation

- \( V_{sh} \) and \( S_\phi \) are standard petrophysical curves calculated from gamma ray, resistivity, and porosity logs, and correlated to image logs and core data.
## Geology

### Jackfish Volumetrics and Average Reservoir Properties

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<th>Area (Ha)</th>
<th>OBIP ($10^6 m^3$)</th>
<th>Avg. GRV thickness (m)</th>
<th>Avg. Oil Saturation (So)</th>
<th>Avg. Porosity (%)</th>
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<th>Jackfish 3</th>
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<td>Avg. Reservoir Depth (mTVD)</td>
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<td>Avg. Reservoir Depth (mASL)</td>
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<td>Avg. Original Reservoir Pressure (kPa) @ scheme startup</td>
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<td>Avg. Reservoir Temp. (°C)</td>
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<td>Avg. Kh (md)</td>
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<tr>
<td>Avg. Kv (md)</td>
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<td>Avg. Phi (%)</td>
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<tr>
<td>Avg. Bitumen Viscosity (Cp)</td>
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<td>1,000,000+</td>
<td>1,000,000+</td>
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<tr>
<td>Original Bottom Water Pressure (kPa)</td>
<td>2,300</td>
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*Total for all producing, drilled, and planned pads*
Geology
Jackfish Gross Rock Volume Pay Thickness

3.1.1-2c
Geology
Jackfish Expansion Gross Rock Volume Pay Thickness

3.1.1-2c
Geology
Jackfish Net Continuous Bitumen Isopach

3.1.1-2c
Geology
Jackfish Expansion Net Continuous Bitumen Isopach

3.1.1-2c
Geology
Jackfish McMurray Water Contact to Paleozoic Isopach

3.1.1-2c
Geology
Jackfish Expansion McMurray Water Contact to Paleozoic Isopach

3.1.1-2c
Geology
Jackfish Top Structure of Gross Rock Volume

3.1.1-2d
Geology
Jackfish Expansion Top Structure of Gross Rock Volume

3.1.1-2d
Geology
Jackfish Base Structure of Gross Rock Volume

3.1.1-2d
Geology
Jackfish Expansion Base Structure of Gross Rock Volume

3.1.1-2d
Geology
Jackfish 1 Representative Well Log

3.1.1-2e
Geology

Jackfish 2 Representative Well Log

3.1.1-2e
Geology
Jackfish 3 Representative Well Log

3.1.1-2e
Geology
Jackfish Expansion Representative Well Log

3.1.1-2e
Geology
Jackfish 2019 Drilling Program and Cored Wells

3.1.1-2f

Project Area
2018-2019 Wells: 39
2018-2019 Core: 22
Total Well Count: 732
Total Core: 304

Special Core Analysis
No special core analysis conducted on core from the 2019 drilling program.
Geology
Jackfish 1 Representative Structural Cross-section

3.1.1-2i
Geology
Jackfish 2 Representative Structural Cross-section
Geology

Jackfish 3 Representative Structural Cross-section

3.1.1-2i
Geology
Jackfish Expansion Representative Structural Cross-section

3.1.1-2i
Geology
Jackfish Caprock Overburden Map and Mini Frac Wells

3.1.1-2m
Geology
Jackfish Expansion Caprock Overburden Map and Mini Frac Wells

3.1.1-2m
Seismic
Jackfish Historical Surveys

- No seismic was acquired in 2019
- Historically, seismic acquisition is extensive, totaling 21.7 km²
Seismic
Jackfish Expansion Historical Surveys

3.1.1-6a
Drilling and Completions
3.1.1-3
Drilling and Completions

Overview

3.1.1-3a

Operating SAGD Horizontal Wells
- **Jackfish 1**: 78 well pairs on eleven pads (horizontal sections are 790 – 1,200m)
- **Jackfish 2**: 60 well pairs on eight pads (horizontal sections are 790 – 1,200m)
- **Jackfish 3**: 51 well pairs on seven pads (horizontal sections are 720 – 1,200m)

Observation Wells
- 61 active SAGD observation wells (two to three wells per operating pad)
- 21 regional multi-zone monitoring wells equipped with piezometers

Service Wells
- Six Grand Rapids brackish source water wells
- Two McMurray brackish source water wells
- 14 water disposal wells (Class 1b)
  - 12 active wells
  - 1 inactive well (102/12-05-076-06W4)
  - 1 suspended well (102/03-22-075-06W4)
Drilling and Completions
Jackfish 1 Overview – SAGD Wells

Existing Pads
- Pad A, B, C, D, E, G, H, I, O: Seven well pairs per pad
- Pad F: Nine well pairs and three additional producers
- Pad R: Six well pairs
- Pad EX: Three well pairs, planned for steam Q4 2019
- Two observation wells per pad (heel and toe)
Drilling and Completions
Jackfish 2 Overview – SAGD Wells

3.1.1-3a

Existing Pads
• Pad AA, BB, CC, DD, and KK: Seven well pairs per pad
• Pad OO and PP: Eight well pairs per pad
• Pad FF: Nine well pairs
• Pad QQ: Ten well pairs, planned for steam Q4 2019
• Pad MM: Four well pairs, planned for steam Q4 2019
• Two observation wells per pad (heel and toe), three wells at Pad FF
**Drilling and Completions**

*Jackfish 3 Overview – SAGD Wells*

3.1.1-3a

**Existing Pads**

- Pad J and EE: Seven well pairs per pad
- Pad VV and K: Ten well pairs per pad
- Pad RR: Nine well pairs
- Pad EEE: Ten well pairs, five operating
- Pad III: Eight well pairs, three operating
- Two observation wells per pad (heel and toe)
Drilling and Completions
Jackfish Inter-well Spacing

3.1.1-3a

• Standard lateral inter-well spacing at Jackfish is 80m

• Currently drilled pads that differ from the standard are:
  • Pad VV: Spacing of 60m
  • Pad F: Spacing of 60m at the heels fanning to 90m at the toes
  • Pad O: Spacing of 75m at the heels fanning to 90m at the toes
  • Pad R: Spacing varies from 71 to 90m due to boundary restrictions
  • Pad III: Spacing of 80m at the heels fanning to 90m at the toes
Drilling and Completions

Typical Injection Well Schematic

3.1.1-3c

- Shiftable steam subs utilized on several injection wells
- Majority of new wells have steam sub(s) installed on the long injection string to improve steam distribution

- 406.4 mm (16") surface casing
- 298.5 mm (11 ¾") intermediate casing
- Short and long tubing are from 88.9 to 114.3 mm (3 ½" to 4 ½"
- 25.4 mm (1") coil tubing instrument string with thermocouples and a conduit to pump down fiber optics
- 219.1 mm (8 5/8") slotted liner
Drilling and Completions
Typical Gas Lift Production Well Schematic

- Inflow Control Devices (ICDs) are trialed on select wells
- Goal is to gain better understanding of this technology in SAGD environment
- Devices promote production through uniform inflow

219.1 mm (8 5/8”) slotted liner or wire wrap screen

406.4 mm (16”) surface casing

298.5 mm (11 ¾”) intermediate casing

31.8 mm (1 ¼”) lift gas coils

Short and long tubing are from 88.9 to 114.3 mm (3 ½” to 4 ½”)

25.4 mm (1”) coil tubing instrument string with thermocouples and a conduit to pump down fiber optics
Drilling and Completions

Typical ESP Production Well Schematic
Drilling and Completions
Inflow Control Devices (ICDs)

3.1.1-3c

- Tubing-deployed systems on wells CC1P, DD2P, DD7P, OO1P, OO8P
  - Installed successfully via service rig

  - Installed successfully via drilling rig

- Key learnings to date:
  - Actual pressure drops in original ICDs different than design.
  - Incorporated lab test data in recent deployments and pressure drop to date is within expected design range.
  - Observed well production improvements range from 0 to 100%, uplift sustainability is being evaluated
  - Able to operate wells at lower subcool with positive impact on temperature conformance
Drilling and Completions
Wire Wrapped Screens

3.1.1-3c

• Expected benefits of wire wrapped screens:
  • Reduced liner pressure drop
  • Increased open flow area
  • Mechanical strength
  • Sand control

• Recent implementation at Jackfish includes Pad F, Pad O and Pad R
  • Successful start-up of these wells using wire wrapped screens
Artificial Lift
3.1.1-4
Artificial Lift

Summary

3.1.1-4a,b

- Combination of Gas lift and ESP utilized for artificial lift at Jackfish District

- Gas lift continues to be an effective lift strategy for Jackfish operating conditions
  - Typical producer operating pressure above 1,800 kPag
  - Ability to handle over 1,000 m³/day emulsion flow
  - No operating temperature limitation

- ESP use has expanded from single well (B3P) in 2015 to full pad installation over past 2 years
  - ESP Wells: B3P, F10-F12P, O1-O7P, R1-R6P
  - Upcoming ESP Wells: MM1-MM4P, EX8-EX10P (Pads pending circulation)
  - Plan to continue to deploy ESPs as deemed necessary
Instrumentation

3.1.1-5
Subsurface Temperature Instrumentation:
- 25.4 mm (1") coil tubing instrument string with four to eight evenly spaced thermocouples and a conduit to pump down fiber optics
- Fiber optics currently in 49 wells on Pads C, G, I, J, CC, DD, EE, KK, FF, OO, RR and III
- Future fiber optics installations planned for Pad QQ producer wells
Jackfish 1, 2, and 3 SAGD observation wells contain:

- 20 points thermocouples (25 points in more recently drilled wells), spaced above, below, and within pay interval
- Two to four pressure sensors spaced above, below, and within pay interval
Instrumentation in Wells
Regional Multi-Zone Monitoring Wells

3.1.1-5b

Twenty-one monitoring wells cover areas of Jackfish 1, 2, and 3

- 00/07-32-75-6W4 (5 piezometers)
- F1/08-28-75-6W4 (4 piezometers)
- F1/09-14-75-6W4 (4 piezometers)
- F1/12-31-75-6W4 (4 piezometers)
- F1/10-22-75-6W4 (5 piezometers)
- F1/04-26-75-7W4 (5 piezometers)
- F1/06-28-75-7W4 (5 piezometers)
- F1/15-19-75-6W4 (5 piezometers)
- F1/09-24-75-7W4 (5 piezometers)
- F1/14-25-75-6W4 (5 piezometers)
- F1/05-12-75-6W4 (5 piezometers)
- F1/09-22-75-7W4 (4 piezometers)
- 02/12-23-75-7W4 (4 piezometers) *
- 02/01-35-75-7W4 (3 piezometers)
- 00/15-07-75-5W4 (4 piezometers)
- 00/07-22-75-7W4 (2 piezometers)
- 00/03-15-75-6W4 (3 piezometers) **
- 02/09-33-75-6W4 (4 piezometers)
- 00/04-30-75-7W4 (3 piezometers)
- 00/01-19-75-6W4 (3 piezometers) **
- AA/11-30-75-6W4 (5 piezometers)

* Perf with a Level Logger
** Perf for water sampling

2019 Jackfish Directive 54 Presentation
## Instrumentation in Wells

### Regional Multi-zone Monitoring Wells

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<th>UWI</th>
<th>Rig Release</th>
<th>Quaternary</th>
<th>Colorado Group</th>
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<th>Wabiskaw</th>
<th>McMurray Bitumen</th>
<th>Basal McMurray Water</th>
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Performance Prediction

- Well pad performance forecasts generated using Jackfish and industry analogues; validated with numerical simulation and analytical methods

- Facility service factors based on historical data, future plans, and quantified risks
Scheme Performance
Jackfish 2 Project Life Plot

3.1.1-7a

Flow Rate (m³/d)
0 5,000 10,000 15,000 20,000
Jan-11 Jan-12 Jan-13 Jan-14 Jan-15 Jan-16 Jan-17 Jan-18 Jan-19 Jan-20

SOR (m³/m³), Gas Injection (E³/m²/d), Well Pairs
0 50 100 150 200

- Daily Steam Injection
- Daily Oil Production
- Daily Water Production
- ISOR
- CSOR
- Well Pairs
- Daily Gas Injection

Pad KK startup
Pad FI startup
Pad OO, Pad PP startup
Turn around
Turn around
Government Mandated Curtailment
Turn around
Maintenance
## 2019 Scheme Performance

### Jackfish 1 Pad Recoveries

<table>
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<th>Pad</th>
<th>Area (m²)</th>
<th>Avg. GRV Pay (m)</th>
<th>Net GRV Pay S₀ (%)</th>
<th>Net GRV Pay Porosity (%)</th>
<th>OBIP (10⁶m³)</th>
<th>Ult Rec (10⁶m³)</th>
<th>Cum Prod (10⁶m³)</th>
<th>RF (%) to Date</th>
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## 2019 Scheme Performance
### Jackfish 2 Pad Recoveries

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<th>Avg. GRV Pay (m)</th>
<th>Net GRV Pay S₀ (%)</th>
<th>Net GRV Pay Porosity (%)</th>
<th>OBIP (10⁶m³)</th>
<th>Ult Rec (10⁶m³)</th>
<th>Cum Prod (10⁶m³)</th>
<th>RF (%) to Date</th>
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## 2019 Scheme Performance
### Jackfish 3 Pad Recoveries

<table>
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<tr>
<th>Pad</th>
<th>Area (m²)</th>
<th>Avg. GRV Pay (m)</th>
<th>Net GRV Pay S₀ (%)</th>
<th>Net GRV Pay Porosity (%)</th>
<th>OBIP (10⁶m³)</th>
<th>Ult Rec (10⁶m³)</th>
<th>Cum Prod (10⁶m³)</th>
<th>RF (%) to Date</th>
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<tbody>
<tr>
<td>J</td>
<td>530,754</td>
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<td>71</td>
<td>34</td>
<td>4.9</td>
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<td>K</td>
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<td>RR</td>
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<td>34</td>
<td>80</td>
<td>34</td>
<td>6.7</td>
<td>3.5</td>
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<td>VV</td>
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<td>34</td>
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<td>33</td>
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<td>III</td>
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<td>82</td>
<td>34</td>
<td>6.6</td>
<td>4.7</td>
<td>0.0</td>
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</tbody>
</table>
Jackfish 2 – Pad DD Highlights
Low Performer

• First steam occurred in June 2011
• NCG injection commenced as of March 2016 on wells DD1, DD3, DD5, and DD6
• Heterogeneous reservoir with low mid-heel ceiling of ~5m pay thickness
  • Limited vertical steam chamber growth
  • Regions of poor temperature conformance
• Inflow Control Device installed in September 2013 (DD2)
• Inflow Control Device installed in November 2014 (DD7)
• Potential fluid interaction with Pad AA due to chamber growth on DD1-DD3 wells
Pad DD Toe Observation Well Temp
(10.5m from DD3 well pair)

3.1.1-7c
Jackfish 3 – Pad EE Highlights
Medium Performer

First steam occurred in July 2014
Seven well pairs in operation
Production currently in plateau phase
Wells EE1 – EE5 have clean sand with uniform ceiling
Wells EE6 – EE7 have low ceiling at toe of wells
Steam subs opened on EE1 – EE5 in 2015 to increase steam injection rates
Pad SOR historical average between 2.0 – 2.5
EE exhibiting signs of transition into decline
Pad EE Performance
Jackfish 3 Pad EE Life Plot

3.1.1-7c
Pad EE Heel Observation Well Temp
(4.8m from EE5 well pair)

3.1.1-7c
Jackfish 3 – Pad K Highlights
High Performer

3.1.1-7c

• First steam occurred in February 2015
• Ten well pairs are in operation
• Best performing pad at Jackfish 3
• Clean sand throughout all ten well pairs
• Historical SOR < 2
• Pad K starting to exhibit signs of potential decline
Pad K Performance
Jackfish 3 Pad K Life Plot

3.1.1-7c
Pad K Toe Observation Well Temp
(9.5m from K5 well pair)

3.1.1-7c
Five Year Outlook
Jackfish Pad Abandonments

3.1.1-7c

• No anticipated pad abandonments at Jackfish within the next five years
# Five Year Outlook

## Wellhead Steam Quality

3.1.1-7d

<table>
<thead>
<tr>
<th></th>
<th>Pressure (kPag)</th>
<th>Temperature (°C)</th>
<th>Quality (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant Gate</td>
<td>9,600</td>
<td>311</td>
<td>100</td>
</tr>
<tr>
<td>JF1 Wellhead</td>
<td>2,500-3,700*</td>
<td>226-246</td>
<td>97</td>
</tr>
<tr>
<td>JF2 Wellhead</td>
<td>2,500-4,400*</td>
<td>226-256</td>
<td>97</td>
</tr>
<tr>
<td>JF3 Wellhead</td>
<td>2,500-4,400*</td>
<td>226-256</td>
<td>97</td>
</tr>
</tbody>
</table>

*Maximum injection pressure for each facility in line with MOP

- Losses in steam quality occur as steam is transported to the pads
- Utilize condensate traps at each pad to maximize wellhead steam quality
NCG Co-injection

Overview:
- NCG source is fuel gas, primarily composed of methane
- 16 Pads with NCG co-injection capability:
  - JF1: A, B, C, D, E, H, and I
  - JF2: AA, BB, CC, DD, FF, KK
  - JF3: EE, RR, and VV

Learnings to date:
- NCG injection rates within expected range
- NCG successful in maintaining chamber pressure with reduced steam
- No negative impact to resource recovery observed in late life NCG co-injection
- Improved SOR observed

Go Forward Plan:
- Continue to monitor and evaluate NCG utilization and performance
Steam Additive

- Overview:
  - Chemical additive co-injected with steam into two injection wells on pad OO (Jackfish 2)
  - Limited scale pilot
  - Executed May 2018 – February 2019

- Pilot results inconclusive at this time

- Learnings to date:
  - Chemical additive impact on the downstream Central Processing Facility (CPF)
  - Identifying appropriate selection criteria for a steam additive pilot
  - Appropriate plan, design and facility construction
  - Testing and monitoring techniques, such as sample points selection and sampling frequency
  - Chemical additive transportation and logistics
Jackfish Performance

Key Learnings

3.1.1-7f

- District SOR improvements tied to pressure reduction and optimization
- Maintained focus on pressure balance with the aquifer is beneficial
- Successful use of NCG enables steam transfer to higher quality pads
Jackfish Performance
Well Operations, Drilling, and Trials

• Jackfish 1
  • Pad EX – Startup planned Q4 2019
  • Pad A – 3 additional producers drilling planned Q3 2020
  • Pad S – SAGD drilling planned Q4 2020
• Jackfish 2
  • Pad MM – Startup planned Q4 2019
  • Pad QQ – Startup planned Q4 2019
  • Pad TT – SAGD drilling planned Q1 2021
  • Pad XX – SAGD drilling planned Q3 2021
• Jackfish 3
  • Pad OOO – drilled Q2 2019
Jackfish Performance
Jackfish District Steam Strategy

3.1.1-8c

• Jackfish 1
  • Utilizing steam capacity while managing SOR through steam allocation, execution of NCG co-injection, and continuing to balanced chamber pressures with aquifer

• Jackfish 2
  • Utilizing steam capacity while managing SOR through steam allocation, pressure management, and leveraging NCG co-injection across asset

• Jackfish 3
  • Utilizing steam capacity while managing SOR through steam allocation, pressure management, and leveraging NCG co-injection across asset
Facilities
Jackfish 2 Plot Plan

3.1.2-1a
Facilities
Jackfish 3 Plot Plan

3.1.2-1a
Facilities
Plant Performance

3.1.2-d

Turnarounds/Outages

• Jackfish 2 maintenance turnaround completed June 2019

Bitumen Treatment

• Stable operation and production rates at Jackfish 1 and Jackfish 3

Water Treatment

• Utilized brackish water wells with TDS ranging from greater than 4,000 - 22,000 ppm for all make up water requirements

Steam Generation

• 80% overall steam quality targeted to decrease blowdown disposal volumes and increase steam generation
Measurement and Reporting
3.1.2-2
Well Bitumen / Water Production

- Total battery production is allocated to each SAGD producing well based on individual well tests
- Battery Bitumen Production = Dispositions – Receipts + \( \Delta \)Inventory + Blending Shrinkage
- Battery Water Production = Inlet Produced Water + \( \Delta \)Inventory + Truck Out – Truck in – Desand Water to Treater and FWKO

Individual well test:

- Each pad equipped with test separator along with coriolis meter and watercut analyzer on liquid leg
- Vortex meter for gas measurement / water vapor calculation
- Tested water volume includes the calculated water vapor (from \( \frac{P_{sat}}{P_{measured}} \))
- Typical well test duration is nine hours
Measurement and Reporting

Methods

3.1.2-2a

• **Well Gas Production**
  • Well Estimated Test Gas Production = (GOR) x (Test Bitumen Production)
  • Battery Gas Production = Fuel + Fuel to IF + Flare – TCPL Purchase – Receipt Gas – Diluent Flash
  • Battery gas is allocation to each well based on well test

• **Steam Injection**
  • Total steam to field measured downstream of HP separators minus the steam condensate
  • Vortex meters at each wellhead are used to allocate total steam
Measurement and Reporting
Water Balance and Compliance

3.1.2-2b

Water Balance
• Water balance is done on each of the reporting injection facilities (4 total) included in the scheme

Calibration
• All meters used in water balance are verified and inspected as per Directive 017

Accuracy / Location
• Meter accuracies and locations have been reviewed for all water meters used for volume reporting
Measurement and Reporting
NCG Injection, Production Reporting

3.1.2-2d

• NCG being used across scheme as co-injection strategy as per approval
• NCG sourced from existing lift gas infrastructure (purchased TCPL gas)
• NCG injection is metered on a per well basis using vortex meters with live pressure and temperature correction applied
• As all gas production is consumed as fuel, NCG recovery is not estimated for Petrinex volumetric reporting
Water Production, Injection, and Uses
3.1.2-3
Water Disposal and Source Water
Well Locations

3.1.2-3a
Source Water Geology
Grand Rapids C Aquifer

3.1.2-3a

Jackfish Source Well
Source from Grand Rapids C
Jackfish Monitoring Well
Monitoring Grand Rapids C
Monitoring other formations
Quaternary Channel Outlines
Grand Rapids C Isopach
C.I. = 5m

Date: Oct. 10, 2019
Water
UWI of Fresh and Brackish Wells

- Brackish source water produced from the Grand Rapids ‘C’ and McMurray zones

- Available for Jackfish 1, Jackfish 2, and Jackfish 3

- Two McMurray Wells:
  - F1/07-30-075-06W4
  - F1/03-15-075-06W4

- Six Grand Rapid Wells:
  - F1/12-15-075-06W4
  - F1/15-15-075-06W4
  - F1/03-10-075-06W4
  - F1/03-11-075-06W4
  - F1/04-16-075-06W4
  - F1/05-17-075-06W4
### Water

Uses and Volumes Needed for Fresh and Brackish Water Make-Up

3.1.2-3b

#### Brackish Water Usage

<table>
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<tr>
<th>Date</th>
<th>Monthly Volume (m³)</th>
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</thead>
<tbody>
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<td>J1: 60,000, J2: 70,000, J3: 50,000</td>
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<tr>
<td>2018-10</td>
<td>J1: 80,000, J2: 90,000, J3: 70,000</td>
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<tr>
<td>2018-11</td>
<td>J1: 100,000, J2: 110,000, J3: 90,000</td>
</tr>
<tr>
<td>2018-12</td>
<td>J1: 120,000, J2: 130,000, J3: 100,000</td>
</tr>
<tr>
<td>2019-01</td>
<td>J1: 140,000, J2: 150,000, J3: 110,000</td>
</tr>
<tr>
<td>2019-02</td>
<td>J1: 160,000, J2: 170,000, J3: 120,000</td>
</tr>
<tr>
<td>2019-03</td>
<td>J1: 180,000, J2: 190,000, J3: 130,000</td>
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<tr>
<td>2019-04</td>
<td>J1: 200,000, J2: 210,000, J3: 140,000</td>
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<tr>
<td>2019-05</td>
<td>J1: 220,000, J2: 230,000, J3: 150,000</td>
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<tr>
<td>2019-06</td>
<td>J1: 240,000, J2: 250,000, J3: 160,000</td>
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<td>2019-07</td>
<td>J1: 260,000, J2: 270,000, J3: 170,000</td>
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<tr>
<td>2019-08</td>
<td>J1: 280,000, J2: 290,000, J3: 180,000</td>
</tr>
<tr>
<td>2019-09</td>
<td>J1: 300,000, J2: 310,000, J3: 190,000</td>
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</tbody>
</table>

- **J1**
- **J2**
- **J3**
Water Treatment Technology
3.1.2-4
Water Treatment Technology

3.1.2-4

- New water treatment technology in the Jackfish District includes:
  - Implementation of permanent polymer skids at Jackfish 1, 2, and 3
  - Upgraded lime and magox feeder
  - Implementation of soda ash feed for HLS across Jackfish district
Water, Disposal Wells, Landfill Waste
3.1.2-5
Water, Waste Disposal Wells, and Landfill Waste
UWI's of Disposal wells

3.1.2-5a

Disposal System is shared between Jackfish 1, 2, and 3

• Two disposal streams:
  • Blowdown and regen waste

• Fourteen Class 1b disposal wells in total:
  • Twelve active (see list below)
  • One inactive (102/12-05-076-06W4)
  • One suspended (102/03-22-075-06W4)

• Approved MWIP of 6,000 kPa (July 2009)

• Jackfish 1 disposal wells:
  • 00, 02, and 03/09-14-075-06W4 (blowdown)
  • 00 and 02/12-14-075-06W4 (regen)

• Jackfish 2 disposal wells:
  • 02 and 03/07-13-075-06W4 (blowdown)
  • 02 and 04/12-15-075-06W4 (regen)

• Jackfish 3 disposal wells:
  • 00 and 02/05-12-075-06W4 (blowdown)
  • 00/03-22-075-06W4 (regen)
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

- Volume Summary - Approval No. 10790

Blowdown Water Volumes

Regen Water Volumes
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 1: 00/09-14-075-06W4 BD Disposal Well

- Monthly Volume (m³)
- Average Wellhead Pressure (kPag)

Graph showing the monthly volume and average wellhead pressure for Jackfish 1 from September 2018 to September 2019.
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 1: 02/09-14-075-06W4 BD Disposal Well

[Diagram showing monthly wellhead pressure and volume over time from September 2018 to September 2019]

- Monthly Volume (m^3)
- Average Wellhead Pressure (kPag)

Canadian Natural

2019 Jackfish Directive 54 Presentation 103
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 1: 03/09-14-075-06W4 BD Disposal Well

- Monthly Volume (m³)
- Average Wellhead Pressure (kPag)

Graph showing the monthly volume and average wellhead pressure for Jackfish 1 from September 2018 to September 2019.
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 1: 00/12-14-075-06W4 Regen Disposal Well

- Monthly Volume (m³)
- Average Wellhead Pressure (kPag)


Graph showing monthly volume and average wellhead pressure for Jackfish 1.
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 1: 02/12-14-075-06W4 Regen Disposal Well

- Monthly Volume (m³)
- Average Wellhead Pressure (kPag)

Graph showing monthly volume and average wellhead pressure for Jackfish 1 from September 2018 to September 2019.
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 2: 02/07-13-075-06W4 BD Disposal Well

- Monthly Volume (m³)
- Average Wellhead Pressure (kPag)

- Graph showing Monthly Volume and Average Wellhead Pressure from Sep-18 to Sep-19.
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 2: 03/07-13-075-06W4 BD Disposal Well

- Pressure transmitter failure mid November, brought back online late December
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

**Jackfish 2: 02/12-15-075-06W4 Regen Disposal Well**

- **Monthly Volume (m³)**
- **Average Wellhead Pressure (kPag)**

<table>
<thead>
<tr>
<th>Month</th>
<th>Average Wellhead Pressure</th>
<th>Monthly Volume (m³)</th>
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<td>5,000</td>
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<td>Nov-18</td>
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<td>Dec-18</td>
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<td>Jan-19</td>
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<td>Feb-19</td>
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<tr>
<td>Mar-19</td>
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<td>Apr-19</td>
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<td>May-19</td>
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<td>Jun-19</td>
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</tr>
<tr>
<td>Jul-19</td>
<td>1,000</td>
<td>1,000</td>
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<tr>
<td>Aug-19</td>
<td>2,000</td>
<td>1,000</td>
</tr>
<tr>
<td>Sep-19</td>
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<td>1,000</td>
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</table>
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 2: 04/12-15-075-06W4 Regen Disposal Well

Monthly Volume (m³)

Average Wellhead Pressure (kPag)

- Monthly Volume
- Average Wellhead Pressure
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 3: 00/05-12-075-06W4 BD Disposal Well

[Graph showing monthly volume and average wellhead pressure for the period Sep-18 to Sep-19]
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 3: 02/05-12-075-06W4 BD Disposal Well

![Graph showing monthly volumes and average wellhead pressure for Jackfish 3 disposal well from September 2018 to September 2019.](image-url)
Water, Waste Disposal Wells, and Landfill Waste
Disposal Volumes, Pressure, Temperature

3.1.2-5b

Jackfish 3: 00/03-22-075-06W4 Regen Disposal Well

- Monthly Volume (m³)
- Average Wellhead Pressure (kPag)
Water, Waste Disposal Wells, and Landfill Waste
Basal McMurray Aquifer
## Water, Waste Disposal Wells, and Landfill Waste

Location of waste disposal site and volumes associated with the scheme

### 3.1.2-5c

<table>
<thead>
<tr>
<th>Disposal Facility</th>
<th>Volume Injected (m³)</th>
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</thead>
<tbody>
<tr>
<td>Tervita Lindbergh Cavern Facility (AB WP 0000557)</td>
<td>1,408</td>
</tr>
<tr>
<td>Cancen New Serepta (AB WP 0099677)</td>
<td>165</td>
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<tr>
<td>Tervita Ft. McMurray (AB WP 0133414)</td>
<td>923</td>
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<tr>
<td>CEIBA ATHABASCA (AB WP 0136010)</td>
<td>369</td>
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<tr>
<td>White Swan Atmore (AB WP 0139656)</td>
<td>112</td>
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<tr>
<td>White Swan Conklin (AB WP 0142079)</td>
<td>12,644</td>
</tr>
<tr>
<td>Cancen Morinville (AB WP 0144022)</td>
<td>2,997</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>18,618</strong></td>
</tr>
</tbody>
</table>
Sulphur Production and Air Emissions
3.1.2-6
Sulphur Production
Operations with Sulphur Recovery

3.1.2-6a (i) & (ii)

- Jackfish 1 – Sulphur Recovery not required as inlet Sulphur content <1 t/d
Sulphur Production
Operations with Sulphur Recovery

3.1.2-6a (i) & (ii)

- Jackfish 3 – Sulphur Recovery Unit run intermittently to maintain facility and district compliance
Sulphur Production
Peak Daily SO₂ Emissions

3.1.2-6c

• Sulphur recovery reduced in December 2018, March 2019 and August 2019 in line with outage allowance in EPEA approval
• Emissions throughout year remained below allowable emissions limits stipulated by EPEA approval
Ambient Air Quality Monitoring

Summary

3.1.2-6d

**Passive air monitoring**
- At minimum there are four passive stations located at each Jackfish site to monitor sulphur dioxide and hydrogen sulphide
- Monitored parameters: sulphur dioxide and hydrogen sulphide

**Continuous ambient monitoring**
- September 2018: Jackfish 1 and Jackfish 2/3 continuous monitoring stations joined the Wood Buffalo Environmental Associations (WBEA)’s integrated monitoring network. The monitoring stations are now operated by WBEA, on behalf of Canadian Natural
- Monitored parameters: sulphur dioxide, hydrogen sulphide, nitrogen dioxide, total hydrocarbons, wind speed, and direction

All ambient air quality monitoring and reporting requirements were satisfactorily met in 2017-2018.
Ambient Air Quality Monitoring

Air Monitoring Station Map
### Ambient Air Quality Monitoring

**Jackfish 1 Continuous Results**

#### 3.1.2-6d

<table>
<thead>
<tr>
<th>Ambient Concentrations</th>
<th>SO2 (ppb)</th>
<th>NO2 (ppb)</th>
<th>SO2 AAAQO (ppb)</th>
<th>NO2 AAAQO (ppb)</th>
</tr>
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<tbody>
<tr>
<td>2018-Sep</td>
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<tr>
<td>2019-Aug</td>
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<tr>
<td>2019-Sep</td>
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<tr>
<td><strong>H2S (ppb)</strong></td>
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<tr>
<td><strong>H2S AAAQO (ppb)</strong></td>
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</tr>
</tbody>
</table>

May 31st 2019 one-hour H2S limit exceedance not attributable to Operations, reference WBEA report.
Ambient Air Quality Monitoring

Jackfish 2/3 Continuous Results

3.1.2-6d

Ambient Concentrations

SO2 (ppb)  NO2 (ppb)  SO2 AAAQO (ppb)  NO2 AAAQO (ppb)

H2S (ppb)  H2S AAAQO (ppb)
### AER Regulatory Approval Summary

**D78 Amendments**

3.1.2-7b

<table>
<thead>
<tr>
<th>Amendment</th>
<th>Date</th>
<th>Approval Code</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackfish 3 Pad OOO and Jackfish 1 Pad S Proposal</td>
<td>October 25, 2018</td>
<td>100977TT</td>
<td>2</td>
</tr>
<tr>
<td>Jackfish Sulphur Recovery Variance</td>
<td>November 29, 2018</td>
<td>100977UU</td>
<td>2</td>
</tr>
<tr>
<td>Jackfish Expansion Area</td>
<td>December 19, 2018</td>
<td>100977VV</td>
<td>3</td>
</tr>
<tr>
<td>Jackfish NCG Blowdown Application for Pads A, C, D &amp; KK</td>
<td>January 11, 2019</td>
<td>100977WW</td>
<td>2</td>
</tr>
<tr>
<td>Jackfish 1 Pad F PLECO Proposal</td>
<td>January 24, 2019</td>
<td>100977XX</td>
<td>2</td>
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<tr>
<td>Jackfish 1 Pad P Proposal</td>
<td>February 26, 2019</td>
<td>100977YY</td>
<td>2</td>
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<tr>
<td>Jackfish Sulphur Recovery Waiver</td>
<td>March 11, 2019</td>
<td>100977ZZ</td>
<td>2</td>
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<tr>
<td>Jackfish 1 Pad S Proposal</td>
<td>May 6, 2019</td>
<td>100977AAA</td>
<td>2</td>
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<tr>
<td>Steam Additive Reporting Deferral</td>
<td>June 7, 2019</td>
<td>100977BBB</td>
<td>1</td>
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<tr>
<td>Jackfish 2 Pad XX Proposal</td>
<td>July 23, 2019</td>
<td>100977CCC</td>
<td>2</td>
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<tr>
<td>Devon to Canadian Natural Ownership Transfer</td>
<td>August 9, 2019</td>
<td>100977DDD</td>
<td>-</td>
</tr>
</tbody>
</table>
AER Regulatory Approval Summary
Jackfish District
3.1.2-7b

Pad VV and Pad EE NCG Amendment letter
• Approved November 2018

Landfill WM 105G
• Approval for Cell 3
AER Regulatory Approval Summary
Jackfish District
3.1.2-7b

Water Diversion Licenses
• Potable Water Act Amendment approved December 2018

Water Act Approval (383056-00-01)
• Amendment for diversion of groundwater relating to Landfill Underdrains

CEMS Monitoring Plans
• Monitoring plans approved April 2019
• Certification testing ongoing

Sewage Lagoon Approval for use as temporary storage
• Approved May 2019
Water Management
Jackfish 1, 2, and 3

3.1.2-7c

Groundwater
• Jackfish 1, 2, and 3 groundwater monitoring occurs twice per year
• No significant impacts observed
• Revised proposal including Thermally Mobilized Constituents submitted Q2 2019

Surface Water – Groundwater Interaction Monitoring Program
• Remained within the expected variability
• No noticeable influence from project related effects

Wetlands
• Wetland monitoring sites surveyed Q2 and Q3 2019
• No significant impacts observed to date
• Revised proposal due Q4 2019
Soil Monitoring and Soil Management
Jackfish 1, 2, and 3

District soil monitoring program for Jackfish 1, 2, and 3 was executed August 2017

- Soil monitoring proposal submitted to AER November 2017
- Execution of the soil management occurred in Fall 2018:
  - Soil Management Program report submitted to AER March 2019
  - No additional soil management required for the Jackfish projects

Next Soil Monitoring Program proposal due November 2020
AER Regulatory Reporting Requirements

3.1.2-7c

- Industrial Wastewater and Industrial Runoff Report
- Groundwater Monitoring Report
- Wetland and Waterbody Monitoring Report
- Potable Water Monitoring Report
- Air Monitoring Report
- Soil Management Report
- Soil Monitoring Report
- Conservation and Reclamation Annual Report
- Comprehensive Wildlife Report
Wildlife & Caribou Mitigation and Monitoring

- Jackfish Wildlife Monitoring Program was authorized July 2012
- Comprehensive Wildlife Reports submitted in 2015 and 2019
- Long term monitoring ongoing
- No significant project related impacts observed to date
Reclamation Program Work

3.1.2-7e

**Summary of Jackfish construction, operation and land reclamation activities from 2005 to 2018:**

- Total area of lands on which Jackfish activities occurred as of the end of 2018: 681.4 ha
  - 71.8 ha under construction
  - 586.3 ha operational
  - 23.3 ha undergoing permanent reclamation

- Reclamation Monitoring Program proposal currently due Q4 2019
Compliance
3.1.2-8,-9
Canadian Natural believes the Jackfish Project is in compliance with AER approvals and regulatory requirements. As of September 30/2019, Canadian Natural has no unaddressed non-compliant events.
Summary of Spill Releases

The following list summarizes spills reported to the AER within the reporting period

<table>
<thead>
<tr>
<th>Site</th>
<th>No. of Reportable Releases</th>
<th>Volume released (m³)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jackfish 1</td>
<td>4</td>
<td>47.2</td>
</tr>
<tr>
<td>Jackfish 2</td>
<td>5</td>
<td>0.5</td>
</tr>
<tr>
<td>Jackfish 3</td>
<td>3</td>
<td>1.1</td>
</tr>
</tbody>
</table>
# AER Summary of Noncompliance

3.1.2-9

The following list summarizes non-compliant events within the reporting period. For all events corrective actions were identified and are being tracked to completion.

<table>
<thead>
<tr>
<th>Date</th>
<th>Event</th>
<th>Corrective Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>March 1, 2019: Jackfish 1, 2 and 3</td>
<td>Did not meet 90% uptime requirement in CEMS code – Approval Requirement</td>
<td>Install new CEMS units</td>
</tr>
<tr>
<td>May 1, 2019: Jackfish 2 and 3</td>
<td>Waste Water Limit Exceedance</td>
<td>Sampling error, sampling practices adjusted</td>
</tr>
</tbody>
</table>
Future Plans
Major Activities and Target Dates

• No major projects for 2020
• Scheduled turnaround for Jackfish 3 Q3 2020
• Focus on reliability enhancements