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1.0 INTRODUCTION

BP Canada Energy Group ULC (BP) conducted visual surveys of the seafloor to evaluate the deposition of discharged muds and cuttings resulting from the drilling of the Aspy D-11A exploration well. Aspy D-11A was the first well drilled as part of the Scotian Basin Exploration Drilling Project (the Project). The project consists of drilling up to seven exploration wells. Drilling began in April 2018 and the well plugging was completed on November 28, 2018 with well operations suspension on December 11, 2018. The well is located approximately 330 km offshore of Halifax, Nova Scotia (UTM Zone 20, Northing 4745644.76m, Easting 720856.41 m) in approximately 2,800 m of water.

The sediment deposition surveys were completed in accordance with Condition 3.12.2 of the Decision Statement Issued under Section 54 of the Canadian Environmental Assessment Act, 2012 (CEAA) for the Project;

_The Proponent shall develop and implement follow-up requirements to verify the accuracy of the predictions made during the environmental assessment as it pertains to fish and fish habitat, including marine mammals and sea turtles, and to determine the effectiveness of mitigation measures identified under conditions 3.1 to 3.10. As part of these follow-up requirements, the Proponent shall:_

_3.12.2 collect drill waste deposition information after drilling of the first well is complete to verify the drill waste deposition modeling predictions and report the information collected to the Board._

BP contracted Stantec Consulting Ltd. (Stantec) to evaluate the results of the sediment deposition surveys and verify dispersion modelling predictions made in the Technical Report: Scotian Basin Exploration Drilling Project: Well NS-1 – Drilling mud and cuttings dispersion modelling (Document No. UHSE-RCE-REP_2016-198) and provided in Appendix C of the Environmental Impact Statement (EIS) for the Scotian Basin Exploration Drilling Project (Stantec 2016).

The present sediment deposition report is prepared for provision to the Canadian Environmental Assessment (CEA) Agency and Canada-Nova Scotia Offshore Petroleum Board (CNSOPB) within 90 days of the Aspy D-11A well being abandoned (i.e., well operations suspension). This report includes:

- an overview of the deposition survey methods;
- a characterization of the seafloor, particularly the surficial sediment texture and features, before and after drilling activities were completed to better understand sediment deposition and distribution on the seafloor attributed to the discharge of drill muds and cuttings; and
- a discussion of deposition survey results in relation to the modelling predictions.
2.0 SEDIMENT DEPOSITION AND MODELLING

Sediment deposition refers to the drill muds and cuttings discharged and deposited on the seafloor as the result of drilling the Aspy D-11A well. Drilling is completed in two phases; 1) pre-riser and 2) riser drilling. Pre-riser drilling is the drilling of the top hole of the well when there is no direct drill fluid return to the drilling rig, the West Aquarius. Water based muds (WBM) are used and the resulting cuttings and muds are discharged directly on the seafloor. Riser drilling is characterized by a closed-loop system with direct drill fluid return connection to the drilling rig. Synthetic based muds (SBM) and all generated cuttings are returned to the drilling rig. The cuttings and drilled solids are either treated to 6.9% or less synthetic-on-cuttings (as per the Offshore Waste Treatment Guidelines (OWTG) (NEB et al. 2010)) prior to being discharged to the marine environment or returned ashore for disposal if higher than 6.9%.

The deposition of drilling muds and cuttings on the seafloor as a result of drilling activity is largely dependent on water depth and currents, as well as the volume and density of the discharged cuttings. Persistence on the seafloor is related to sediment transport and re-suspension as well as biodegradation of the base fluid. Biological effects of cuttings are dependent on the toxicity of the cuttings and the spatial extent and deposition thickness of the drill cuttings on the seafloor. Effects may be related to a combination of physical burial, changed grain size in the upper sediment layer, drilling fluid toxicity and drilling fluid-induced sediment anoxia (IAOGP 2003).

In 2015, as part to the Project Environmental Assessment (EA) process, BP conducted model simulations of the theoretical dispersion of drilling muds and cuttings associated with the Project within the Project Area (Figure 1). Two location scenarios were modelled, representing the shallowest (2,104 m) and deepest (2,790 m) water depths within the Project Area. The objective of the dispersion modelling was to evaluate seafloor deposition associated with the operational release of mud and cuttings anticipated during offshore drilling.

Drilling discharge simulations were completed using the SINTEF Marine Environmental Modelling Workbench (MEMW) software which includes Particle Tracking (ParTrack) to predict the deposition of drilling mud and cuttings on the seafloor. Modelling simulations were conducted with an assumed drilling initiation date of July 1 and a duration of 100 days. Currents are the main driving force for the transport and dispersion of discharged drilling muds and cuttings in the water column. The modelling used vertically and time-varied currents derived from daily Hybrid Coordinate Ocean Model (HYCOM) current speeds with tides from the Bedford Institute of Oceanography. Wind fields data were generated from the National Center for Atmospheric Research (NCAR)/ National Centre for Environmental Protection (NCEP) Climate Forecast System Reanalysis (CFSR) dataset.
Although the modelling showed that between >50% (shallow well location) and >46% (deep well location) of the mud and cuttings released would be transported outside of the boundaries of the modelling domain, sediment deposition with thicknesses between 1 mm to 10 mm were predicted to extend a maximum of 563 m from the drill site and cover an area of 9.9 ha. This thickness represents areas where deposits on the seafloor might be visible. Sediment deposition with thicknesses >10 mm were predicted to extend up to 116 m from the drill site and cover an area of 0.5 ha. This thickness is considered to represent areas where benthic communities comprised of sedentary or slow-moving species may be smothered and the sediment quality will be altered in terms of nutrient enrichment and oxygen depletion.

For a deposition thickness of 100 mm or greater, the modelling predicted deposition of the drill cuttings would extend up to 30 m from the well (deep well scenario). Table 1 below presents the maximum distances and areal extent of sediment deposition for both modelled scenarios for varying deposition thicknesses.
Table 1  Maximum extent of thickness contours

<table>
<thead>
<tr>
<th>Deposition Thickness (mm)</th>
<th>Maximum Extent of Thickness (m) and Area (ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Shallowest Well Location</td>
</tr>
<tr>
<td>0.001</td>
<td>11,213 (4,872.7)</td>
</tr>
<tr>
<td>0.1</td>
<td>1367 (104.8)</td>
</tr>
<tr>
<td>1</td>
<td>563 (9.9)</td>
</tr>
<tr>
<td>10</td>
<td>78 (0.5)</td>
</tr>
<tr>
<td>100</td>
<td>21 (0.07)</td>
</tr>
<tr>
<td>500</td>
<td>7 (0.02)</td>
</tr>
</tbody>
</table>


Simulations predicted that the post-drilling seabed sediment deposition with thicknesses >0.5 mm would have a footprint that is elongated toward the east and northeast for the shallow well location, while the simulations for the deep well location predicted a deposition footprint elongated toward the southwest which would be the case for the Aspy D-11A deep well. Figure 2 shows the predicted deposition thickness contours for the deep well scenario in the area of the well.

The model and predictions were discussed in the EIS for the Project (Stantec 2016) that was submitted to the Canadian Environmental Assessment (CEA) Agency and in the Environmental Assessment Report (CEA 2018).
3.0 METHODS

3.1 RATIONALE AND APPROACH TO SURVEY METHODOLOGY

BP consulted with the CNSOPB and offshore industry partners in Atlantic Canada to determine the best approach for collecting sediment deposition information and verifying the modelling predictions (as per Condition 3.12.2).

BP completed a pre-drill ROV video survey of the proposed well site, extending 500 m from the wellhead to identify any potential surface or shallow subsurface hazards and to confirm seabed conditions and provide information on the macro-infaunal and epifaunal benthic community assemblages. The results of this survey confirmed the physical condition of the seabed and the limited potential effects sediment deposition may have on marine benthic habitat or species.
In determining the approach to meet the intent of Condition 3.12.2, it was decided that visual surveys using a remotely operated vehicle (ROV) were an appropriate method for characterizing the deposition of drill muds and cuttings on the seafloor and to verify modelling predictions.

### 3.2 ROV PROCEDURE

BP engaged a marine contractor to examine the seafloor and provide underwater video of the seafloor for review. Underwater video of the seafloor at and around the well location were collected using an Ocean Pro HD deep-sea camera with a wide-angle lens, mounted on an ROV. The video and photos were used to verify the presence and extent of deposition modelled within the area surrounding the wellhead. The pre-drilling survey was conducted to establish the baseline conditions. Video and photos were also obtained during the post-drill survey to meet Condition 3.12.2. This phase represents the collection of sediment deposition information “after” drilling when treated SBM drilling muds on cuttings were discharged from near the water surface.

The spatial boundaries for the ROV surveys were completed to a conservative distance from the wellhead based on the modelling predictions made regarding sediment thickness for shallow and deep-water well scenarios. The modelling indicated that sediment deposition at a thickness of >10 mm was not predicted beyond 116 m from the wellhead. It was predicted that much of the cumulative drill muds and cuttings would be confined to within this area; however, sediment deposition thicknesses of one mm were predicted up to 563 m (shallow-water well scenario) and 358 m (deep-water well scenario).

Based upon these predictions and considering that the water depth for the Aspy D-11A well more closely resembles the modelled deep-water well scenario, visual monitoring of sediment deposition for the pre-drill and post-drilling surveys was focused within 500 m of the wellhead, to be conservative.

The ROV survey pattern was intended to provide an assessment of the area around the wellhead. Sediment deposition information was therefore collected using eight (8) radial transects positioned at approximately every 45-degree angle around the wellhead in the N, NE, E, SE, S, SW, W, and NW directions.

The ROV-mounted camera was aimed slightly below the horizon at an angle to provide a field of view that included the seafloor in front of the ROV along each transect. The field of view was illuminated to be able to see the seafloor. The ROV was propelled forward at a relatively slow speed at a height ranging between approximately 1 to 5 m above the seafloor along each transect to record continuous video to identify the presence and spatial extent of any deposits of drilling muds and cuttings, topographic features, benthic fauna, and biological activity relative to the wellhead.
3.3 PRE-DRILL SURVEY

On April 14, 2018 BP conducted the pre-drill ROV survey of the seafloor at and around the proposed Aspy D-11A wells to collect information about the baseline condition of the seafloor prior to initiating drilling activities. The ROV survey comprised of eight (8) radial transects at approximately 45-degree intervals around the wellhead (i.e., N, NE, E, SE, S, SW, W, NW). Each transect extended out to 500 m in all radial directions. The water depth of the pre-drill survey area ranged from 2,769 m to 2,802 m. The altitude of the ROV along each transect ranged from 2 to 3 m above the seabed. The information collected from the pre-drill survey was sufficient to establish baseline condition of the seafloor at and around the wellhead prior to the commencement of drilling.

3.4 POST-DRILL SURVEY

The post-drill survey was conducted to visually assess the areal extent of the discharge of muds and cuttings from the exploration drilling for comparison with the modelled dispersion.

The post-drill survey was completed on December 11, 2018, approximately eight months after the pre-drill survey, and within a week of plugging the well. Eight (8) radial transects at approximately 45-degree intervals around the wellhead were surveyed to systematically record seafloor conditions in the area.
immediately surrounding the wellhead out to 500 m in all radial directions. The survey video for each transect was generally taken at 3 to 5 m above the seafloor. Still photographs were not collected during this survey.

4.0 RESULTS

4.1 PRE-DRILL SURVEY

Based on the pre-drill survey, the seafloor surrounding the wellhead appeared generally flat, with no evidence of large mounds or depressions. The seafloor was generally comprised of fine sand, generally light greyish-white in colour (Photo 1) with small craters (< 1 m) observed throughout. Photo 1 provides an example of the habitat observed at the proposed Aspy D-11A wellsite and is indicative of the typical habitat seen throughout the survey.

Photo 1 Native seabed and typical benthic habitat in the pre-drill survey for the Aspy D-11A wellsite (northwest transect near wellsite).

Based on the imagery obtained during the pre-drill survey, no aggregations of habitat-forming corals or sponges, or any other environmentally sensitive features were identified on the seafloor within the survey area. The typical benthic habitat observed at this proposed well site is relatively bare and generally devoid of epifauna, with sparse solitary macrofauna scattered in the surveyed area, when present. None of the macrofauna species observed are considered species of conservation interest (i.e., listed as endangered, threatened, or special concern under the Species at Risk Act or by the Committee for the Status of Endangered Wildlife in Canada).
4.2 POST-DRILL SURVEY

The general characteristics of the substrate for each 500 m transect from the wellhead for the post-drill survey were as follows:

- **North (Line 5)** – greatest amount of drill cuttings and mud to about 35 m from the wellhead, with a grey heaviest coating in the first 10 m out from the well. Beyond 35 m, evidence of deposition continues, albeit there appears to be a thinner coating, to approximately 290 m from the wellhead. In this area the substrate colour transitions to a lighter, grey-brown colour with drill cuttings observed in impressions from the ROV tether line and animal tracks. Mussels, which were not noted in the pre-drill survey, are abundant for the length of the transect with the exception of the immediate area around the wellhead. These mussels are believed to have fallen off the hull of the West Aquarius.

- **Northeast (Line 6)** – dark deposits and cobble-sized, angular material is observed within 10 m of the wellhead, with a uniform coating of deposited muds and cuttings observed within 50 m from the wellhead. Evidence of deposition further along the transect is observed by pitting in the seafloor and white particles present. Evidence decreases moving away from the wellhead and minimal evidence is present beyond approximately 310 m.

- **East (Line 4)** – greatest amount of deposition within 30 m from the wellhead (Photo 2). Evidence of deposition throughout entire transect as observed by colour variation in the impressions from the ROV tether line or animal tracks (Photo 3) extending to 180 m. Beyond 180 m, deposition is less obvious; however, some pitting and white or dark pebble-sized particles are noted. Mussels are present through the transect.

- **Southeast (Line 3)** – greatest amount of deposition within 30 m from the wellhead. Evidence of deposition out to approximately the 250-m mark with a slightly darker layer of substrate overlying a lighter coloured sand as shown on the craters and animal tracks observed intermittently. The substrate condition could not be determined from approximately 40 m to 100 m from the wellhead due to the ROV tether line disturbing the seafloor and suspending the sediments to the extent that the video image was blocked. Minimal evidence of deposition and little disturbance of the seafloor was noted from 250 m to the end of the transect.

- **South (Line 8)** – greatest amount of muds and cuttings deposition within 20 m from the wellhead. Beyond 20 m the amount of deposition decreases with distance from the wellhead to approximately 175 m, after which there is little indication of deposition.

- **Southwest (Line 7)** – greatest amount of muds and cuttings deposition within 25 from the wellhead with a thinner layer of brown-grey material, with light-coloured cuttings found in indentations extending to approximately 125 m. Beyond 125 from the wellhead there is little indication of deposition; however, white particles, which had not been noted in the pre-drill survey, are present beginning at approximately 325 m from the wellhead and extending the remaining length of the transect.

- **West (Line 1)** – greatest amount of deposition within 10 m from the wellhead with what appears to be muds or cuttings deposited with a relatively uniform deposition extending to approximately 45 m. Intermittent mud and cuttings were occasionally observed to a lesser degree extending out to 210 m (Photo 4) from the wellhead with minimal evidence of deposition from 210 m to the end of the transect.
• **Northwest (line 2)** – continuous even coating of dark grey deposition including what appears to be muds or cuttings within approximately 15 m from the wellhead. The substrate transitions to intermittent muds and cuttings observed as dark deposits in the ROV tether lines and animal tracks that mark the seafloor, extending from 15 m to approximately 40 m from the wellhead. White-coloured, gravel-sized particles believed to be salt cuttings are observed on the seabed starting at about 40 m from the well to 140 m. The remainder of the transect showed minimal evidence of deposition and was mostly uniform with a light-coloured substrate which had specks of pebble-sized dark materials and intermittent craters, consistent with the pre-drill survey of the same transect.

Analysis of the post-drill survey results indicates cumulative deposition of drilling muds and cuttings are visually detectable intermittently on all transects at distances ranging from 140 m to 325 m from the wellhead. For all transects a thicker, more uniform depositional layer was noted in the vicinity of the wellhead extending up to approximately 30 m. This was identified in the video recordings by the presence of darker and lighter substrates and animal tracks on the seafloor intermittently throughout these transects. This supports the modelling predictions made for the deep-water well scenario that potentially visible deposition could be expected up to 385 m away from the drill site. Although the greatest evidence of deposition was observed within 30 m from the wellhead along all transects, the modelling prediction of a depositional thickness of 100 mm or greater extending up to 30 m from the well cannot be verified. There were, however, no aggregations or communities of corals or sponges, and no species of conservation interest observed. These observations confirmed the limited potential effects sediment deposition may have on marine benthic habitat or species.

Macrofauna species observed during the post-drill survey included similar species to the pre-drill survey of the seabed for the well location. The benthic macrofauna observed during the post-drill survey include common brittle stars, chimaera fish, sea pen, octopus, shrimp, glass sponge, sea anemone, sea cucumbers, roundnose grenadier, and other occasional unidentified fish species. Mussels were abundant during the post-drill survey, where they had not been identified in the pre-drill survey. These mussels are believed to have fallen off the hull of the West Aquarius. Other than immediately adjacent to the wellhead, the presence of deposited material on the seafloor did not appear to impact the movement of species observed.
Photo 2  Darker deposits evident adjacent to impressions from animal track (Brittle Star; *Echinoderm – Ophiuroidea* visible) approximately 70 m from the wellhead.

Photo 3  Drilling muds and/or cuttings observed at approximately the 25-m mark on the east transect during the post-drill survey.
Photo 4  Minimal drilling muds and/or cuttings observed and a noted lack of deposition in tracks of the ROV tether lines approximately 60 m from the wellhead on the west transect during the post-drill survey. An unidentified fish is also visible.

Photo 5  Octopus visible to the left of the frame approximately 200 m from the wellhead on the southeast transect.
5.0 CONCLUSION


Visual observation was selected as an appropriate method for characterizing the deposition of drill muds and cuttings on the seafloor and to verify modelling predictions. The pre-drill survey results indicated that the benthic habitat at and around the proposed well location is generally sparse and devoid of epifauna. There were no aggregations or communities of corals, sponges, or other benthic epifauna and no species of conservation interest were observed. The results of these surveys confirmed the physical condition of the seabed and the limited potential effects sediment deposition may have on marine benthic habitat or species. The result of the post-drill survey confirmed that the benthic habitat did not change significantly.

Macrofauna species observed during the post-drill survey included similar species to the pre-drill survey of the seabed for the well location. The benthic macrofauna observed during the post-drill survey include common brittle stars, chimaera fish, sea pen, octopus, shrimp, glass sponge, sea anemone, sea cucumbers, roundnose grenadier, and other occasional unidentified fish species. Mussels were abundant during the post-drill survey, where they had not been identified in the pre-drill survey. Other than immediately adjacent to the wellhead, the presence of deposited material on the seafloor did not appear to impact the movement of species observed. No aggregations of habitat-forming corals, sponges or species at risk were observed in either of these surveys.

Visual information collected with an ROV during the post-drill survey verified the presence of muds and cuttings deposited during the drilling phase along each of the transects. Survey results are summarized below and compared to the corresponding modelling predictions. Although the model produced results for a shallow-water well scenario and a deep-water well scenario, only the deep-water well scenario is being carried forward for comparison as it more closely resembles the actual conditions of the Aspy D-11A well.

**Model: 50% by weight of the mud and cuttings released are transported outside the boundary of the site and deposited on the seafloor at an insignificant thickness of 0.001 mm.**

The amount of mud and cuttings and the thickness of any deposits transported beyond 500 m from the wellhead cannot be known, as this represents the maximum boundary limit of the survey. However, the modelling results suggest that all sediment deposits beyond 500 m would be < 0.001 mm in thickness and not visible. In contrast, the post-drill survey results within the 500 m boundary indicated that drilling mud and cuttings deposits were visible at maximum distances ranging from 140 m to 320 m from the wellhead, which agrees with the modelling predictions for sediment deposits > 1 mm, i.e., the thickness threshold where sediments might be visible (see below).
Model: The predicted deposition footprint is predominantly towards the southwest.

Using the extents of visible deposition observed during the post-drill survey, the depositional footprint is generally an oblong shape centred on the wellhead with a southwest-northeast orientation which generally agrees with the modelling predictions.

Model: Deposition at thicknesses that may allow it to be visibly identified (i.e., >1 mm) extend to a maximum of 358 m from the wellhead.

Analysis of the post-drill survey results indicates cumulative deposition of drilling muds and cuttings are visually detectable intermittently on all transects at distances ranging from 140 m to 325 m from the wellhead. The maximum distance observed generally agrees with the modelling prediction.

Model: Thickness of 100 mm or greater is confined to a distance of 30 m from the well

The modelling prediction of a depositional thickness of 100 mm or greater extending up to 30 m from the well cannot be verified as the ROV video survey did not gauge deposition thicknesses; however, the greatest evidence of deposition was observed within 30 m from the wellhead along all transects. Within 30 m there is evidence that the depositional layer was thick enough to cover animal tracks, mussels where, beyond 30 m animal tracks and mussels begin to be observed. Based on this evidence, the modelling prediction is inferred to be correct. It should be noted that no aggregations or communities of corals or sponges, and no species of conservation interest observed. These observations confirmed the limited potential effects sediment deposition may have on marine benthic habitat or species.
6.0  CLOSURE

This report was undertaken exclusively for the purpose outlined herein and was limited to the scope and purpose specifically expressed in this report and the referenced documents. This report cannot be used or applied under any circumstances to another location or situation or for any other purpose without further evaluation of the data and related limitations. Any use of this report by a third party, or any reliance on decisions made based upon it, are the responsibility of such third parties. Stantec Consulting Ltd. accepts no responsibility for damages, if any, suffered by any third party as a result of decisions made or actions taken.

This report represents the best professional judgment of Stantec Consulting Ltd. personnel available at the time of its preparation. Stantec Consulting Ltd. reserves the right to modify the contents of this report, in whole or in part, to reflect any new information that becomes available. If any conditions become apparent that differ significantly from our understanding of conditions as presented in this report, we request that we be notified immediately to reassess the conclusions provided herein.

STANTEC CONSULTING LTD.

Prepared by:

2019.02.06 23:17:07
-04'00'

Project Scientist
Phone: 902-468-7777
luke.miller@stantec.com

Reviewed by:

Digitally signed by Sam Salley
DN: cn=Sam Salley, ou=Environmental Services,
email=sam.salley@stantec.com, c=CA
Date: 2019.02.06 16:48:30 -04'00'

Sam Salley, M.Sc.
Senior Marine Scientist
Phone: 902-468-7777
sam.salley@stantec.com
7.0 REFERENCES


