# Site C Clean Energy Project

## Site C Total Dissolved Gas Monitoring Program (Mon-11)

## Gas Bubble Disease Assessment Protocol

**Construction Year 10 (2024)**

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**August 1, 2024**

**REPORT**

# Site C Gas Bubble Disease (GBD) Assessment

*Site C Clean Energy Project*

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## APPENDICES

# 1.0 SUMMARY AND BACKGROUND

Spill discharge from the Site C Clean Energy Project (the Project) may result in increased total dissolved gas (TDG) pressure downstream of the Project. Additional background information on TDG is available in WSP (2023, 2024) and BC Hydro (2014). Elevated TDG may lead to negative effects on fish due to gas bubble disease (GBD). GBD is a condition where supersaturated gas that has been absorbed by a fish comes out of solution and forms bubbles in the fish's blood or tissues, which can result in injury and possibly death. Weitkamp (2008) provides a summary of the biological effects of GBD on fish.

The purpose of this document is to outline GBD assessments that will be implemented to identify the extent of GBD in fish downstream of the Project due to elevated levels of TDG in response to Project operations, particularly during reservoir filling.

The GBD assessment includes the capture of fish in the approximately 16 km long portion of the Peace River between the Project and the Pine River's confluence with the Peace River (i.e., the study area). Captured fish will be visually assessed for GBD symptoms. These symptoms can include air bubbles and hemorrhaging in a fish's fins and eyes, overinflated swim bladders, and exophthalmia (bulging eyes).

TDG levels during spillway operations will be recorded at TDG monitoring stations downstream of the Project. If the monitoring data from these stations indicate that critical TDG thresholds are reached, assessments may be conducted downstream of the Project to document instances of GBD in fish. Fidler and Miller (1997) defines the risk to aquatic life from GBD as Low when TDG is less than 110 TDG% and defines the risk as High when TDG is 120 TDG% or greater. Further, BC Hydro (2014) states that chronic exposure to TDG greater than 115 TDG% can lead to adverse effects in fish, particularly in waters shallower than 0.5 m. Based on these thresholds, GBD assessments will be initiated downstream of the Project under two different scenarios:

1. When TDG is equal to or exceeds 115.0 TDG% for 2 or more days.
2. If TDG is equal to or exceeds 120.0 TDG% for any duration.

The GBD assessment is intended to document the presence of GBD-related symptoms in fish downstream of the Project. The assessment is not intended to quantify the magnitude of impact that these symptoms have on the Peace River fish community (i.e., an Impact Assessment as detailed in BC Hydro 2014); however, the GBD assessment will provide data to support an overall assessment of effects on the fish community. A GBD assessment can include two different components: 1) Low Effort Monitoring; and, 2) Intensive Effort Monitoring. Low Effort Monitoring includes a visual inspection of shallow-water areas, back channels, eddies, and shoreline areas within the study area where dead or injured fish would be expected to accumulate or become impinged. Intensive Effort Monitoring includes the active collection of fish within the study area using boat electroshocking. Fish encountered during both Low Effort and Intensive Effort monitoring will be examined for symptoms of GBD. This examination includes an assessment of the fish's unpaired fins and eyes to identify the presence of gas bubbles in the tissue of these structures. The extent of bubbles will be characterized based on the percent area of the fin or visible portion of the eye that is covered with bubbles as detailed in USGS (2022).

This GBD assessment procedure is consistent with, and builds upon, the guidance in BC Hydro's Total Dissolved Gas Management Strategy (the Strategy; BC Hydro 2014). The Strategy outlines a systematic approach to addressing high TDG at all of BC Hydro's facilities and has previously been reviewed by regulatory agencies. The Strategy outlines monitoring efforts based on measured thresholds in TDG. This GBD assessment procedure describes the specific monitoring plan to be implemented during the reservoir filling phase of the Project's development using information and practices employed at other hydroelectric facilities in BC and the US.

# 2.0 TDG LEVELS THAT TRIGGER GBD ASSESSMENTS

The initiation of a GBD assessment will be based on real-time TDG data recorded at two TDG monitoring stations installed along the left (Stn_107.1L) and right (Stn_106.8R) banks of the Peace River approximately 1 km downstream of the Project (Figure 1 and Table 1). A summary of the TDG station equipment and their setup is provided in Appendix A. Both stations are expected to be operational throughout reservoir filling and are suitable for year-round TDG monitoring. Four additional stations (Stn_111.1R, Stn_112.5L, Stn_134.1R, and Stn_134.5L) are deployed further downstream; however, these stations will only serve as backup data sources and will only be referenced if one or both of the primary stations (Stn_107.1L and Stn_106.8R) fail. All six stations operate the same way, as detailed in Appendix A and summarized below.

**Table 1: TDG station locations downstream of the Project.**

| Station Name | Zone | Easting | Northing |
|---|---|---|---|
| Stn_106.8R | 10V | 630652 | 6229298 |
| Stn_107.1L | 10V | 630939 | 6229642 |
| Stn_111.1R | 10V | 635018 | 6229897 |
| Stn_112.5L | 10V | 636351 | 6230367 |
| Stn_134.1R | 10V | 654937 | 6221865 |
| Stn_134.5L | 10V | 655254 | 6222302 |

Each TDG station records data in 5-minute intervals, and records TDG to one decimal place (e.g., 118.7 TDG%; percent TDG). Recorded data are uploaded to a website every 30 minutes. The two upstream stations (i.e., Stn_106.8R and Stn_107.1L) are the primary stations and will be the stations used to determine if assessment criteria are reached. If one of the two assessment criteria (defined below) are reached at one of the backup stations but not at one of the two primary stations, the data from the backup station will be considered suspect and data QA/QC procedures will be initiated for this station. An instance like this would not trigger a GBD assessment. If all six stations fail, TDG levels will be monitored by taking handheld/manual readings three times per day, at approximately 08:00, 12:00, and 16:00 each day.

Two additional TDG loggers have been installed approximately 118 km downstream of the Project. Unlike the six TDG stations detailed above, these two loggers do not allow for real-time data presentation and require on-site downloads. They are intended to provide information on how Peace River TDG levels change between the Project and the Project's Local Assessment Area (LAA) boundary due to dissipation and dilution by tributary inflows. Data from these loggers will not be considered as part of the GBD assessment. These TDG loggers are not discussed further in this document.

As defined in the BC Hydro Strategy (BC Hydro 2014), GBD assessments may be conducted when TDG measurements meet one of the following criteria:

1. Criterion #1 - When hourly mean TDG (i.e., the mean of the twelve 5-minute readings recorded within an hour) is equal to or exceeds 115.0 TDG% for 48 consecutive hours. For this criterion, the highest hourly mean value recorded between Stn_106.8R and Stn_107.1L must equal or exceed 115.0 TDG% for a minimum of 48 continuous hours.
2. Criterion #2 - When TDG is equal to or exceeds 120.0 TDG% for any duration at either station (e.g., a single 5-minute interval reading at one station that is equal to or exceeds 120.0 TDG%).

Under the above criteria, fish are more susceptible to GBD and could potentially exhibit physical symptoms of GBD that may be identifiable by field personnel. Therefore, a GBD assessment may be initiated (weather permitting) under either scenario.

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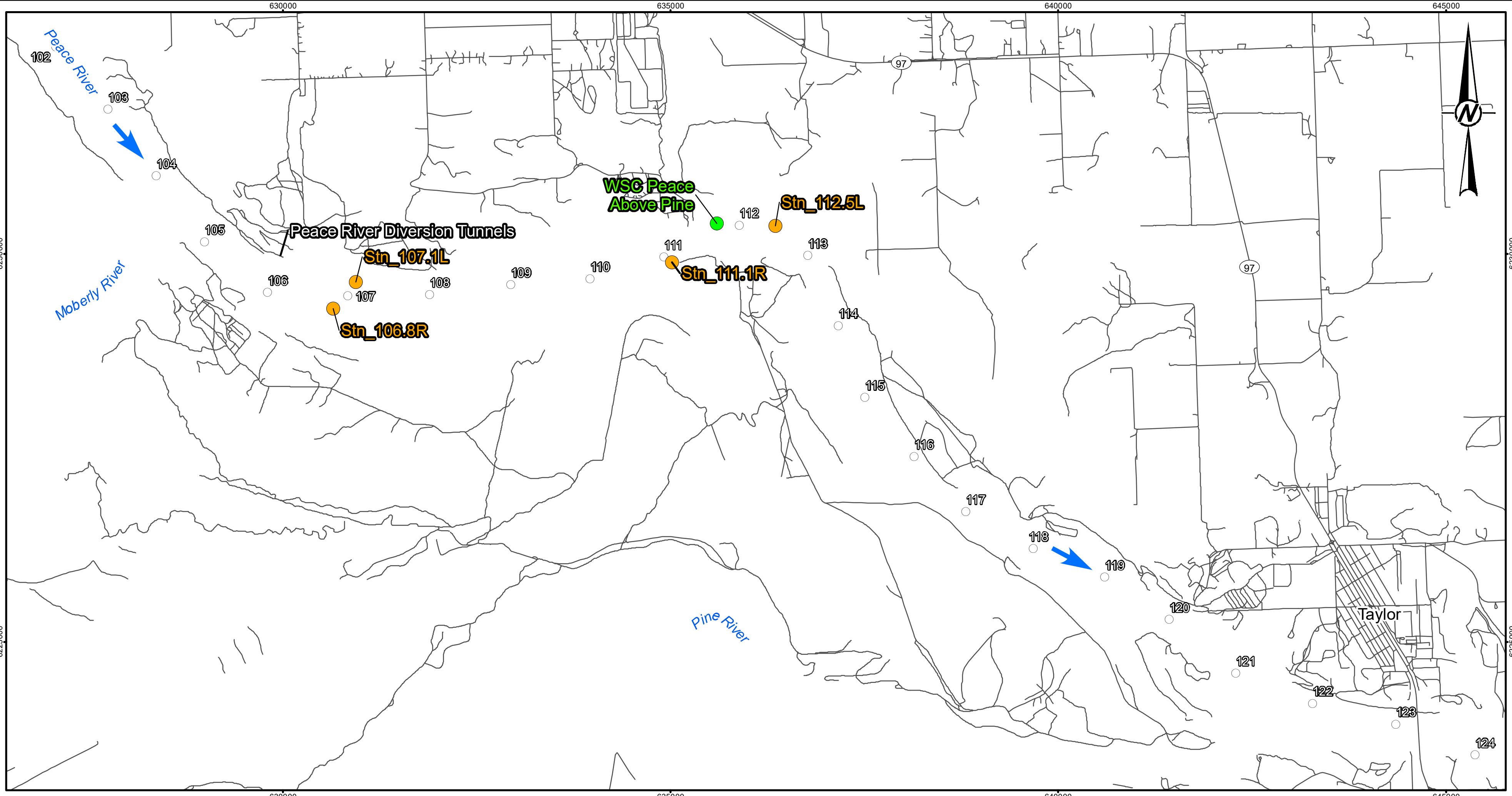


**LEGEND**

- TOTAL DISSOLVED GAS MONITORING LOCATION, 2023
- WSC PEACE ABOVE
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD

0 1 2

1:75,000 KILOMETRES

**REFERENCE(S)**

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TITLE
**OVERVIEW OF TOTAL DISSOLVED GAS MONITORING STATION LOCATIONS AND GAS BUBBLE DISEASE ASSESSMENT STUDY AREA**

| PROJECT NO. | CONTROL | REV. | FIGURE |
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# 3.0 GBD ASSESSMENT

When TDG levels downstream of the Project meet either of the criteria detailed in Section 2.0, a GBD assessment may be initiated. A GBD assessment includes the components detailed in the following sections.

## 3.1 GBD Assessment Initiation Form

As part of a GBD assessment, a GBD Assessment Initiation Form will be completed by the field crew lead (Appendix B). The initiation form includes information regarding TDG levels (e.g., the criterion that was met, relevant dates, times, and recorded TDG levels). The initiation form also includes information that will allow the crew lead to determine if current conditions are suitable for an assessment (e.g., weather conditions, air temperature, water temperature, boat launch availability). Information provided in the completed initiation form will be used, in consultation with BC Hydro, to determine if a GBD assessment can be effectively and safely conducted. Currently, GBD assessments will only be conducted when air temperature and windchill combined in the City of Fort St. John are above -15°C, as measured by Environment Canada[1]. This is to ensure that equipment required for the assessment (e.g., boat engines, electroshocking equipment) can function properly and to reduce risks to fish associated with exposure to cold air during processing.

If a GBD assessment can be conducted, sampling effort (i.e., the number of sites assessed and the type of assessment conducted), as detailed in the following sections, will be influenced by local weather conditions and the amount of daylight available.

## 3.2 Discharge-based Site List Selection

Sites selected for inclusion in a GBD assessment will be based on water depths because water depth influences both the effectiveness of fish sampling and the vulnerability of fish to GBD. Assessments will focus on habitats less than 2 m deep because boat electroshocking is effective up to approximately that depth. Further, fish residing deeper than approximately 2 m are less at risk to GBD, given depth compensation as summarized in the Strategy (BC Hydro 2014).

For ease of presentation, the study area was divided into an Upper and a Lower section. The Upper Section encompasses RiverKm 106 to RiverKm 112 of the Peace River, as measured downstream from the outlet of WAC Bennett Dam, and includes the Project downstream to approximately Old Fort. The Lower Section encompasses RiverKm 112 to RiverKm 123, and includes Old Fort downstream to the Pine River's confluence with the Peace River.

To assist with the identification of potential sample locations, a bathymetric model (NHC, personal communications) was used to identify locations within the study area where water depths were less than 2 m at three different Peace River discharge levels that could occur during reservoir filling (i.e., 390, 600, and 1200 $m^3/s$) (Figures 2 to 4). When a GBD assessment is required, BC Hydro's "7-day STC Tunnel and Forebay Forecasts" and BC Hydro's "E-XL STC_Forebay Report Group 3" forecasts will be used, in conjunction with the bathymetric model outputs, to establish a list of candidate locations where sample sites could be established and included in

[1] Fort St. John, BC - 7 Day Forecast - Environment Canada (weather.gc.ca).

the GBD assessment. The actual sites within these candidate locations will be delineated at the time of the assessment such that habitats and water depths within each site are similar; substantial changes in water depth or changes in habitat characteristics will be used to delineate site endpoints. Each sample site will be classified as either an index site or a non-index site:

1. Index sites are defined as sites expected to be accessible to fish (i.e., flooded), and therefore available to be assessed, at all potential discharge rates between 390 and 1200 $m^3/s$. Index sites will be located where bank slope is higher, resulting in similar habitats within the site, regardless of water level.
2. Non-index sites include side channel and gravel bar areas that flood only at higher water surface elevations, or become too deep to effectively assess (i.e., greater than 2.0 m water depth) at higher discharges. Non-index sites will be located where bank slope is lower, resulting in more dynamic habitats that vary based on water level.

For planning purposes, a GBD assessment is expected to take one day. During an assessment, field crews will survey as many sites as possible, and the number of sites surveyed will be influenced by catch-rates and fish processing times, weather conditions, and the amount of daylight available. If catch is low and time is limited, effort may be allocated to sites where more fish would be expected to be captured, based on past catch rates, the quality of habitat available within the site, and the opinion of the crew’s Qualified Environmental Professional (QEP). These decisions will be made by the QEP at the time of the assessment.

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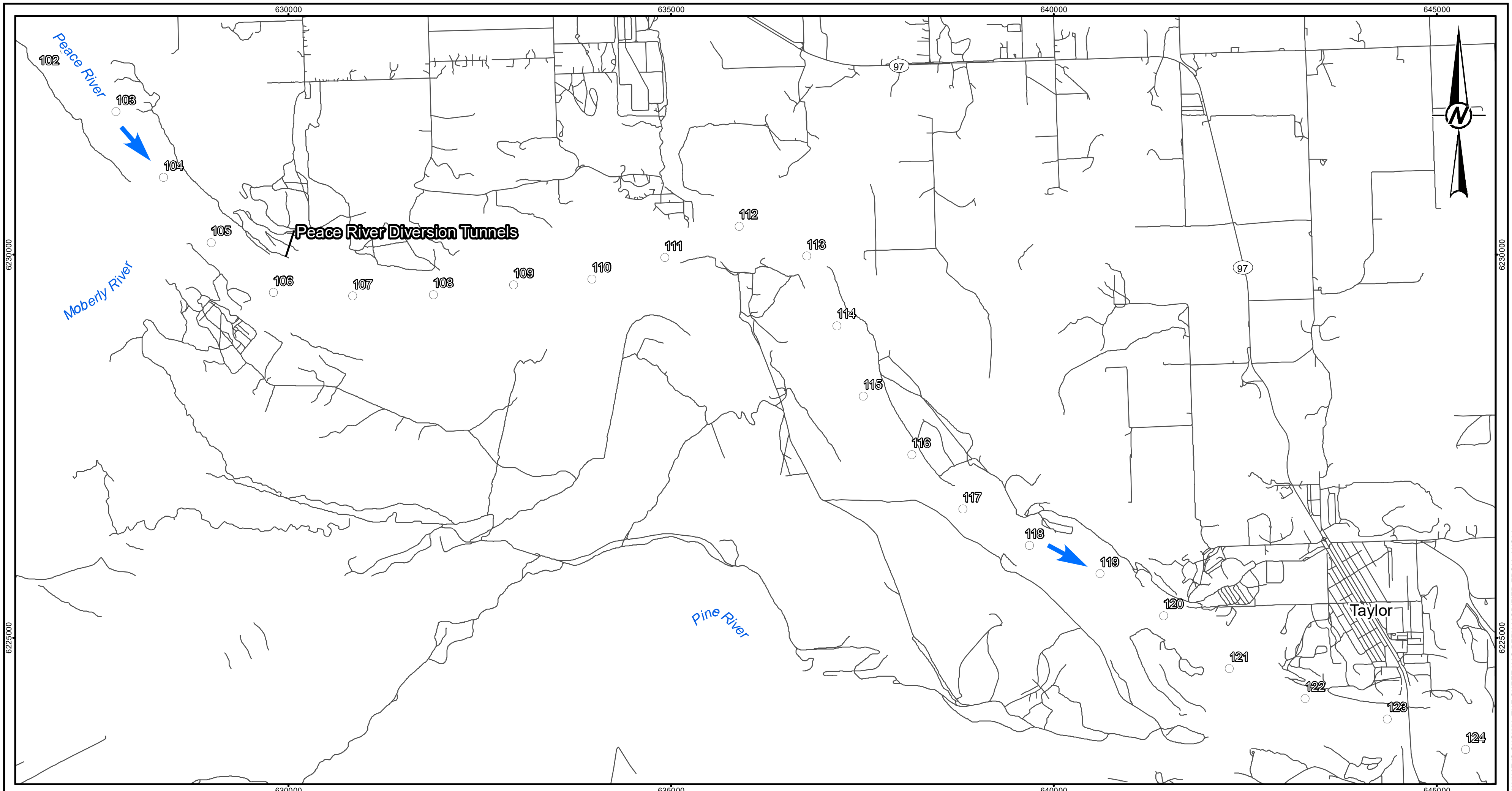


**LEGEND**

○ RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM

—— ROAD

**DEPTH**

High : 1.5

Low : 0.01

0 1 2

1:75,000 KILOMETRES

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TITLE
**BATHYMETRIC PROFILE AND CANDIDATE SAMPLE SITE FOR THE GAS BUBBLE DISEASE (GBD) ASSESSMENT STUDY AREA BASED ON MODELLED DISCHARGE VALUES OF 390 $m^3/s$**

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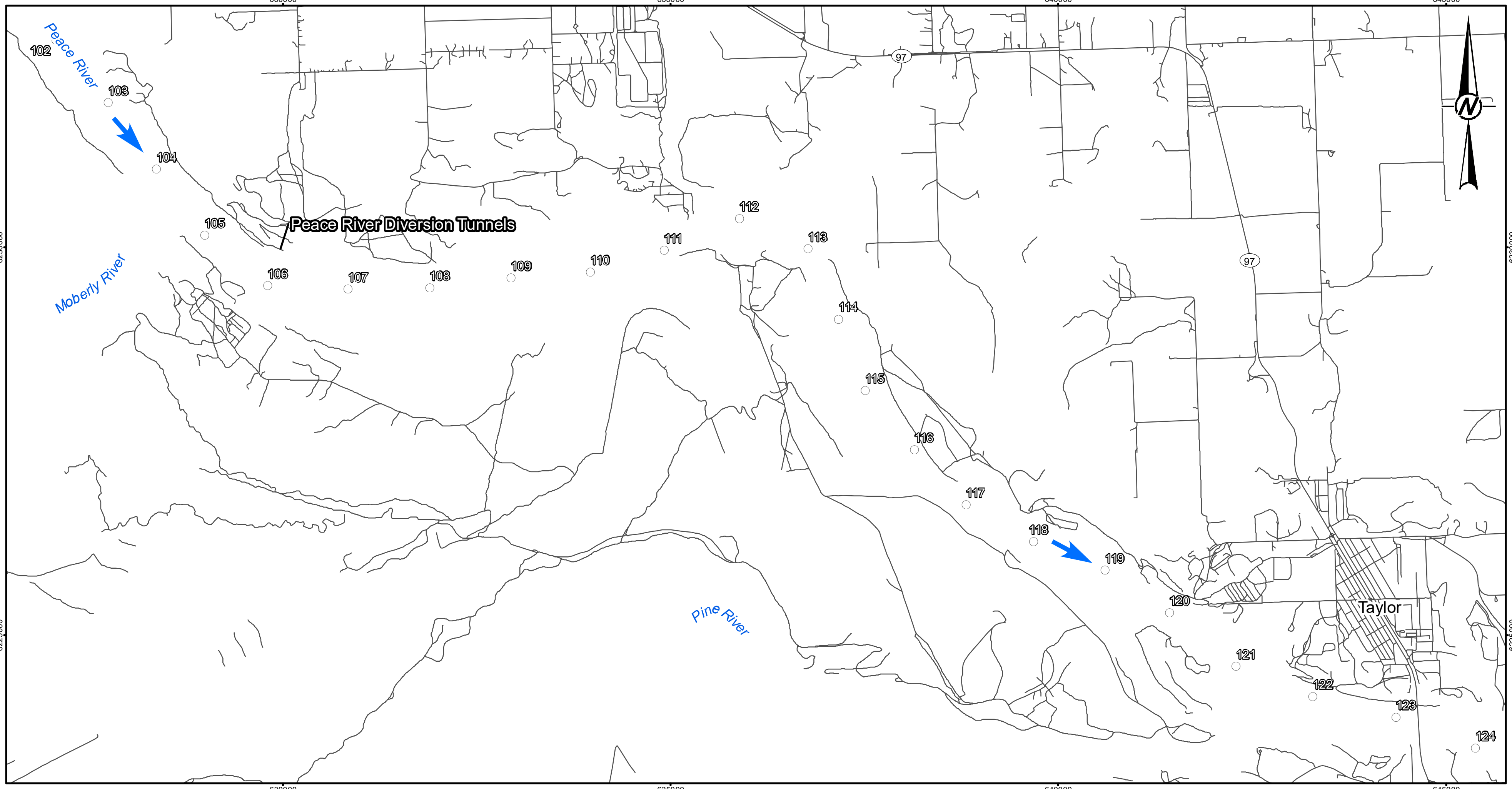


**LEGEND**

RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM

ROAD

**DEPTH**

1.5m

0.01m

0 1 2

1:75,000 KILOMETRES

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TITLE
**BATHYMETRIC PROFILE AND CANDIDATE SAMPLE SITE FOR THE GAS BUBBLE DISEASE (GBD) ASSESSMENT STUDY AREA BASED ON MODELLED DISCHARGE VALUES OF 600 $m^3/s$**

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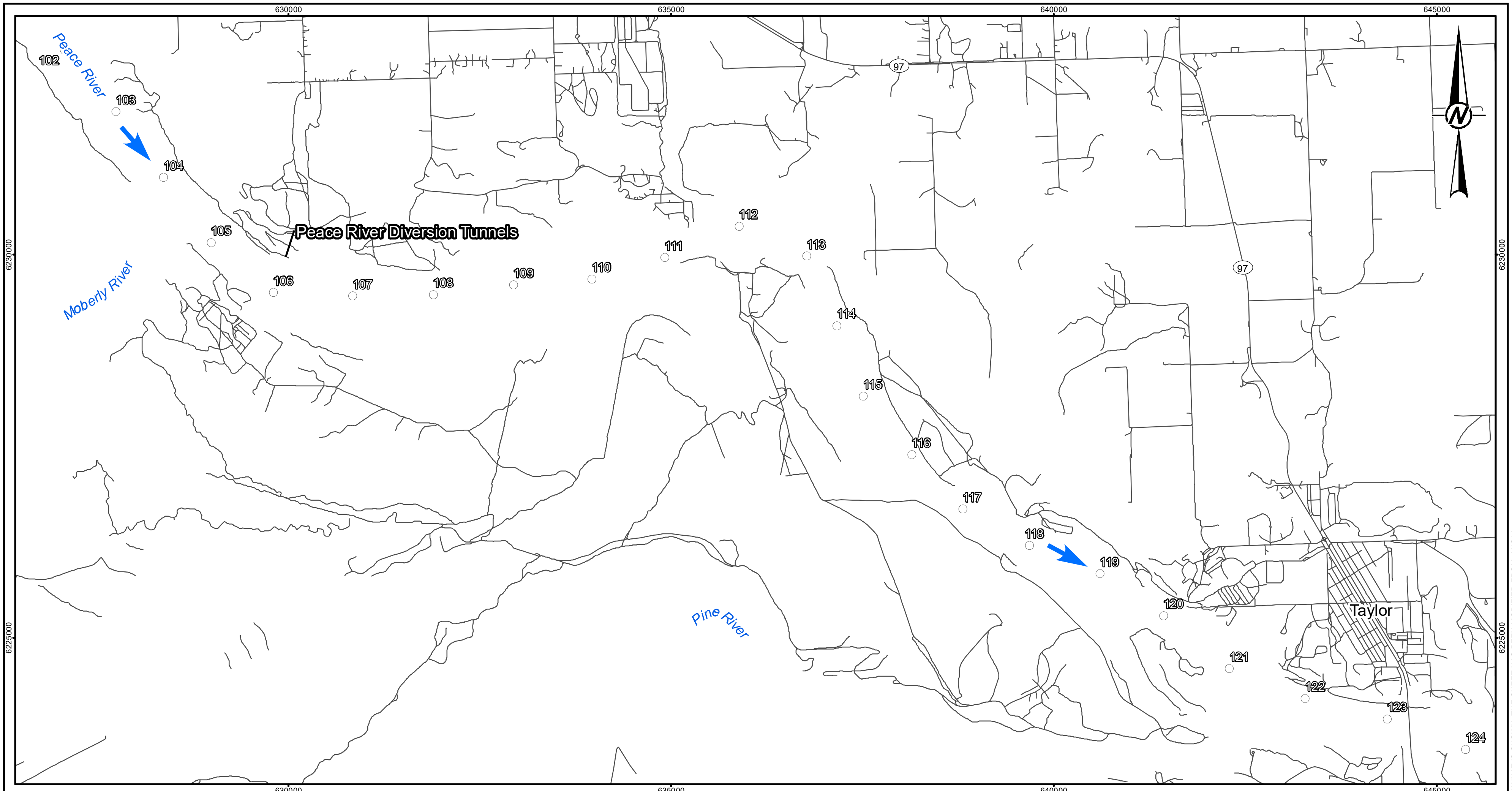


**LEGEND**

RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM

ROAD

**DEPTH**

1.5m

0.01m

0 1 2

1:75,000 KILOMETRES

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TITLE
**BATHYMETRIC PROFILE AND CANDIDATE SAMPLE SITE FOR THE GAS BUBBLE DISEASE (GBD) ASSESSMENT STUDY AREA BASED ON MODELLED DISCHARGE VALUES OF 1200 $m^3/s$**

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## 3.3 Field Surveys

The GBD assessment assumes that sub-lethal GBD symptoms will be detectable prior to evidence of substantial mortality, and that these symptoms will progressively increase over time with continued exposure and as TDG levels increase. The GBD assessment comprises two parts consistent with those described in the Strategy (BC Hydro 2014): Low Effort Monitoring and Intensive Effort Monitoring. Both Low Effort and Intensive Effort monitoring collect similar GBD data and use the same data collection form. The primary difference between the two is that Low Effort Monitoring includes passively sampling for dead or injured fish afflicted by GBD, whereas Intensive Effort Monitoring includes active sampling to obtain live fish for assessment of GBD symptoms. Low Effort monitoring, Intensive Effort monitoring, or both can be conducted during a single GBD assessment. The decision to conduct Low Effort or Intensive Effort monitoring will be decided by the QEP at the time of the assessment and may change within an assessment based on the work during the assessment (e.g., high catch during Low Effort monitoring may negate the need for Intensive Effort monitoring). Factors that may be considered by the QEP include the following: the amount of daylight/time available to conduct surveys, weather conditions, preliminary or anticipated catch rates, water temperatures, water levels, TDG levels, and length of time that TDG levels have been high.

As fish that exhibit symptoms of GBD can die from other causes, the cause of mortality of dead fish recovered during a field survey cannot necessarily be attributed to GBD. As such, the cause of mortality for most recovered fish will likely be unknown.

### 3.3.1 Low Effort Monitoring

Low Effort Monitoring will be conducted between the Site C tailrace and the Peace-Pine confluence. During a typical Low Effort Monitoring survey, a three-person boat-based crew will start at the Peace Island Park boat launch near Taylor, BC and proceed upstream to the Project. Enroute, the crew will visually inspect shallow areas, back channels, eddies, and shoreline areas where distressed, moribund, and dead fish would be expected to accumulate or become impinged. If fish are recovered during Low Effort Monitoring, their location will be recorded (UTM coordinates) and the fish will be processed as described in Section 3.3.3. The crew will also note and investigate areas where potential predators (e.g., birds, bears, otters) are actively feeding.

Locations where fish are recorded during a Low Effort Monitoring survey will be prioritized during subsequent surveys to expedite the assessment.

### 3.3.2 Intensive Effort Monitoring

Within each site, sampling as part of Intensive Effort Monitoring will consist of a single pass by a boat electroshocker in water depths of between 0.5 and 2.0 m. The location of the upstream and downstream points of each site will be recorded (UTMs). For each site sampled, the sample duration, start and end times, boat electroshocker settings, water conductivity, and water temperature will be recorded. Water depths will be recorded as the site is navigated, providing an approximation of the depths that fish were encountered. Boat electroshocking procedures will be similar to those employed during other Site C FAHMFP studies (e.g., Golder 2022). As detailed in Section 3.2, sites should be delineated based on substantial changes in water depths or habitat characteristics such that fish within a single site would be expected to reside in similar habitats and display similar GBD symptoms. The length of each site will vary and will extend until there is a substantial change in habitat/water depth, or until 30 fish have been collected, whichever occurs first. Limiting the catch within each site to 30 fish will facilitate the assessment of additional locations and habitats.

During GBD assessments, spot measurements of TDG will be taken at a subsample of sites when practical.

Fish should be assessed for GBD symptoms as soon as practical following capture. The water depth, and therefore the hydrostatic pressure, in the boat's livewell is expected to be lower than the location where the fish was encountered. This decrease in hydrostatic pressure will increase the likelihood of fish developing GBD symptoms, potentially over-representing GBD severity. To assess the influence of holding time on GBD symptoms, the time of capture of the first fish within a site will be recorded and the time of examination of each individual fish will be recorded, providing a maximum time between capture and examination for each fish.

### 3.3.3 Fish Handling and Processing

The highest GBD risk to fish associated with reservoir filling is expected to occur in the fall and winter when cold air temperatures pose logistic challenges. These challenges include safety concerns (e.g., slipping hazards), equipment concerns (e.g., freezing nets and electronics, frost on microscope lens), and health concerns for fish (e.g., fish freezing when exposed to air during processing). Mitigation for cold weather may influence the procedures detailed below.

A review of GBD assessment protocols was conducted based on their applicability to anticipated field assessment conditions expected during reservoir filling. The fish examination protocol selected is based on the protocol developed by The Fish Passage Center (USGS 2022). Other protocols that were reviewed were deemed more suitable for a laboratory setting (e.g., Vela´zquez-Wallraf et al. 2023). The Fish Passage Center's protocols were designed for downstream fish collection facilities, backpack electrofishing, and beach seining, and were therefore adapted to accommodate fish capture by boat electroshocking and working in cold weather conditions.

Captured fish will be placed in the boat's livewell and will remain in the livewell until processing. To reduce holding time, a second crew may be used to assist with fish processing (i.e., a single fish capture crew, but two fish processing crews). Each fish will be assigned a Fish ID number and the fish's disposition will be assessed (alive/dead). The fish will be identified to species, measured for length to the nearest 1 mm, and scanned for the presence of a PIT tag. The fish will then be moved to an illuminated viewing stage to be examined with a LED 8x ring magnifier or and LED magnifier headlamp.

The GBD exam will include an assessment of the fish's unpaired fins (i.e., caudal fin, anal fin, dorsal fin), followed by an examination of the eyes. Consistent with USGS (2022), GBD data will be recorded based on the percent area of the fin or visible portion of the eye that is covered with bubbles or other injuries consistent with GBD. The examiner will visually divide each fin into quarters and then estimate the combined areal extent of bubble inclusion/damage in the fin. This estimate is done subjectively by the examiner by estimating the areal extent of bubbles/damage in relation to area as a percent of total fin coverage. If a portion of a fin is missing, the percentage will be based on the portion of the fin that is present; however, the estimated percentage of the fin that is missing will be recorded. Air bubble occlusions within each eye will be assessed in a similar manner using the same ranking as for fins; however, only the eye facing towards the observer at the time of the assessment will be ranked (i.e., the fish will not be rotated to observe the second eye). Below is a brief description of the rankings that will be used for assessing GBD, followed by conceptual diagrams of how to assess GBD in unpaired fins and eyes (Table 2; Figure 5). For each fish, paired fins, the head, and body wall will also be visually inspected for the presence or absence of symptoms of GBD. These data will provide additional qualitative support for the GBD ranking for each fish.

**Table 2: GBD ranking descriptions of bubble inclusions in the fins or eyes of fish (USGS 2022).**

| Rank[a] | GBD Symptoms |
|---|---|
| Rank 0 | No Bubbles |
| Rank 1 | 1% to 5% of fin or eye is covered with bubbles |
| Rank 2 | 6% to 25% of fin or eye is covered with bubbles |
| Rank 3 | 26% to 50% of fin or eye is covered with bubbles |
| Rank 4 | More than 50% of fin or eye is covered with bubbles |

[a] If the percent area covered is near the boundary for two rankings, and it is difficult to determine which ranking is most appropriate, then the higher ranking will be assigned.

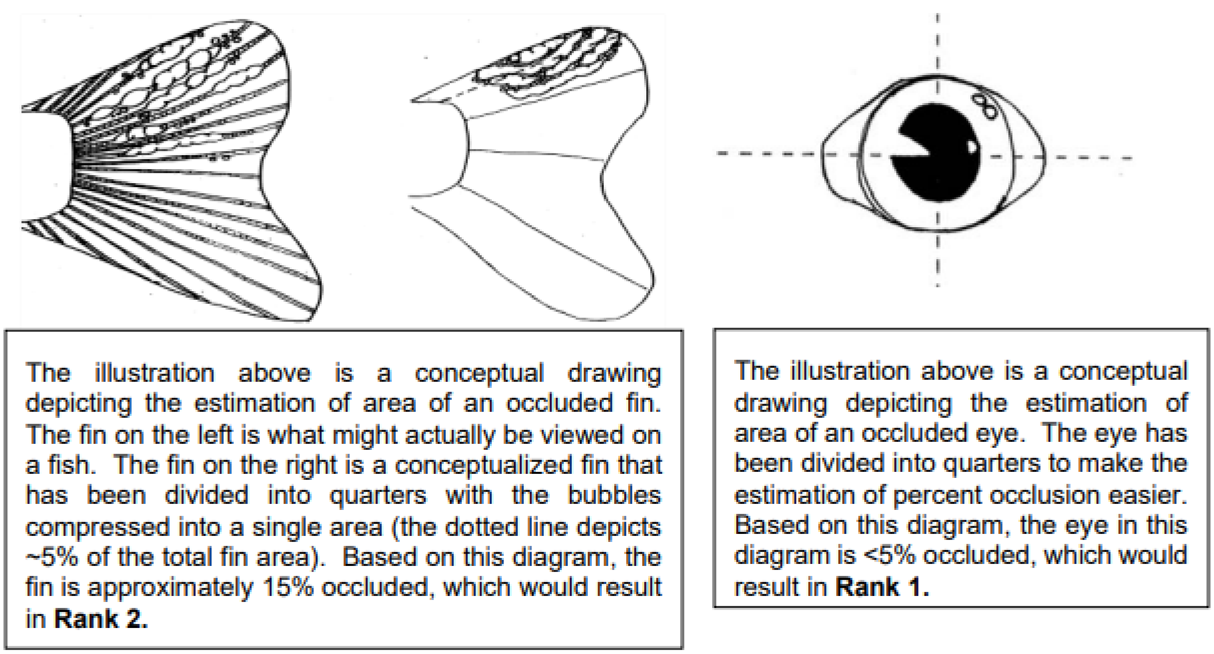


**Figure 5: Conceptual drawing of how to estimate the areal extent of bubble occlusions in non-paired fins and eyes (GBT.Net 2022).**

Fish exposed to TDG in excess of 125 TDG% may die from pneumatic embolisms before exhibiting substantial external symptoms of GBD (Beeman et al., 2003; USGS 2004). If TDG exceeds 125 TDG%, dead fish recovered during both Low Effort and Intensive Effort monitoring should also be examined for the presence of vascular occlusions in the gill lamellae and connecting blood vessels, in addition to the external GBD examination process

detailed above. Fish subject to this additional examination should have recently died (i.e., not exhibiting signs of putrefaction that could result in the generation of gases). The gill lamellae and blood vessels should be viewed under magnification and photographs of the vascular occlusion should be recorded, when possible.
After assessment, dead fish will be disposed of mid-river after puncturing the swim bladder to ensure they sink.

During both Low Effort and Intensive Effort monitoring, field crews will document instances where fish appear to have overinflated swim bladders. Swim bladder overinflation, when present, can range from minor to severe, and is typically assessed based on the swimming orientation/ability of the fish (Table 3). The criteria detailed in Table 3 were developed specifically for the Site C GBD assessments. Evidence of swim bladder overinflation will be documented through visual observations during Low Effort and Intensive Effort monitoring. Livewell observations will be excluded from this portion of the assessment to limit the influence of behavioral responses of fish to electroshocking, capture, and holding.

**Table 3: Swim bladder overinflation severity rankings developed for Site C GBD assessments.**

| Rank | Symptoms evidence of Swim Bladder Overinflation |
|---|---|
| 0 | No evidence |
| 1 | Swimming orientation slightly head up, surface oriented |
| 2 | Swimming ability notably affected, fish appears bloated and struggles to maintain dorso-vertical orientation |
| 3 | Swim bladder greatly overinflated, emerging from mouth, swimming ability limited to none. |

## 3.4 Data Analysis and Interpretation

All GBD assessment data will be entered directly into a custom MS-Access database, similar to other components of the Site C FAHMFP. After each GBD assessment, data will be compiled and checked for errors before being analysed to produce a GBD Status Update (see Appendix C for a template of a GBD Status Update). A GBD Status Update will be provided to BC Hydro, as soon as practical, after each GBD assessment.

GBD Status Updates will include an analysis of data from Low Effort and Intensive Effort monitoring. The update will include summaries of fish observed or captured by site and survey date, and key data about sampling conditions. Fish examination data collected from Lower Effort and Intensive Effort monitoring will be grouped by site and species. For each fish, the GBD rankings for each assessed body part (i.e., caudal fin, anal fin, dorsal fin, eye) will be provided. For each assessment, a GBD index for each site and species will be presented based on the overall mean of mean GBD rankings for each fish. The GBD index will then be used to assess the prevalence and severity of GBD for the overall assessment based on a modified version of the classifications provided in USGS (2022):

Low – evidence of GBD was not observed in any fish.

Moderate – less than 15% of fish examined showed signs of GBD in their non-paired fins or eyes, or less than 5% of examined fish showed signs of GBD in their non-paired fins or eyes where more than 25% of the surface area of the fin/eye was occluded by gas bubbles.

High – more than 15% of fish examined showed signs of GBD in their non-paired fins or eyes, or more than 5% of examined fish showed signs of GBD in their non-paired fins or eyes where more than 25% of the surface area of the fin/eye was occluded by gas bubbles.

In addition to the GBD index, the GBD Status Update will include a detailed summary of observations made by the QEP.

Several variables may influence the extent of GBD symptoms observed during an assessment, these include the level of TDG and the duration of exposure experienced by the fish, water temperature, the size/life stage of the fish, and the depth of water selected by the fish and the availability of “compensation depths”. These variables should be considered when interpreting a GBD index.

# 4.0 CLOSURE

GBD assessment data will be used to identify data gaps, identify low and high priority candidate sample sites, and inform the frequency and intensity of follow-up GBD assessments. GBD assessment data can also be included, as needed, in BC Hydro’s notification to regulatory agencies and First Nations as detailed in the Strategy (BC Hydro 2014).

We trust that this report provides the information required at this time. Questions or requests for further detail can be addressed to the undersigned.

**WSP Canada Inc.**

Paul Grutter
*Lead Scientist*

Dustin Ford
*Senior Principal Scientist*

PG/DF/cmc

https://wsponline.sharepoint.com/sites/gld-124586/project files/5 technical work/2024/tdg/gbd/gbd assessment protocols/20136470-053-r--gbd assessment protocol document _24.docx

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**APPENDIX A**

# TDG Monitoring Array Summary

REPORT

# Total Dissolved Gas (TDG) Monitoring Array at Site C

*Site C Clean Energy Project*

Submitted to:

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Vancouver, BC V6B 5R3

Submitted by:

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20136470-052-R-Rev0

01 August 2024

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## TABLES



## FIGURES

# 1.0 BACKGROUND

Spill discharge from the Site C Clean Energy Project (the Project) may result in increased total dissolved gas (TDG) pressure in the Peace River downstream of the Project. Additional background information on TDG is available in WSP (2023, 2024) and BC Hydro (2014). Elevated TDG may lead to negative effects on fish due to gas bubble disease (GBD). GBD is a condition where supersaturated gas that has been absorbed by a fish comes out of solution and forms bubbles in the fish's blood or tissues, which can result in injury and possibly death. Weitkamp (2008) provides a summary of the biological effects of GBD on fish.

TDG levels downstream of the Project will be monitored by the Site C TDG Monitoring Array ("the array"). The array consists of eight TDG stations positioned downstream of the Project that continuously record TDG. The purpose of this document is to outline and describe the components, location, design, and operation of the array.

# 2.0 SITE C TDG MONITORING ARRAY STATION LOCATIONS AND OVERVIEW

The Site C TDG Monitoring Array consists of eight TDG monitoring stations, with four stations located in the 16 km long section of the Peace River between the Project and the Pine River's confluence with the Peace River and two stations located approximately 36 km downstream of the Project. The two remaining stations are located approximately 118 km downstream of the Project near the Many Islands area in Alberta, which is the downstream extent of the Project's Local Assessment Area (LAA; Table 1; Figure 1).

Stn_107.1L[1] and Stn_106.8R are located along the left and right banks, respectively, as viewed facing downstream, of the Peace River approximately 1 km downstream of the Project. Stn_111.1R is deployed approximately 6 km downstream of the Project on the right downstream bank. Stn_112.5L is deployed approximately 7 km downstream of the Project on the left downstream bank. Stn_134.1R and Stn_134.5L are located approximately 30 km downstream of the Peace-Pine confluence. All six stations are shore-based stations, report data in real-time, and are suitable for year-round TDG monitoring. Water depth at Stn_112.5L are deep enough to accommodate deployment of a buoy-based station. The difference between shore-based and buoy-based stations are described in Section 3.0. Station Stn_106.8R and Stn_107.1L are accessible by road; however, servicing of Stn_111.1R, Stn_112.5L, Stn_134.1R, and Stn_134.5L, or the removal of in-water components at any of the stations, requires a boat-based field crew.

The shore-based TDG stations and the buoy-based TDG station are equipped with a Data Collection Platform (DCP) that records station data in 5-minute intervals. Recorded data are uploaded via a satellite modem to the ReliLink™ Solution/ Connect™ cloud website every half-hour. Users with access to the website can query and download TDG data on demand. The DCP also allows the operational status of each station to be queried and will send automatic notifications, if user-defined high or low sensor readings are recorded, or if communication with a station is lost. A description of the DCP and data management for the Site C TDG Monitoring Array is provided in Section 3.3.

[1] River Km values presented in this report are values measured downstream from W.A.C. Bennett Dam (River 0.0).

Two additional TDG stations, Stn_223.2R and Stn_224.4L, have been installed at the downstream boundary of the Project's LAA, approximately 118 km downstream of the Project. Each of these two stations consists of an automatous TDG data sonde that records continuous data at 15-minute intervals. On-site data downloads and servicing of these station requires a boat-based field crew. TDG data recorded at these stations are intended to provide information on how Peace River TDG levels change between the Project and the LAA boundary due to dissipation and dilution by tributary inflows. A full description of the sonde-based TDG station design is provided in Section 3.4.

**Table 1: Site C TDG Monitoring Array station names, station type, data type, use, and location.**

| Station Name | Station Type | Data Type | Data Use | Zone | Easting | Northing |
|---|---|---|---|---|---|---|
| Stn_106.8R | Shore-based | Real-time, Continuous | Monitor TDG immediately downstream of the Project along the right bank | 10V | 630652 | 6229298 |
| Stn_107.1L | Shore-based | Real-time, Continuous | Monitor TDG immediately downstream of the Project along the left bank | 10V | 630939 | 6229642 |
| Stn_111.1R | Shore-based | Real-time, Continuous | Verification of Stn_106.8L and Stn_107.1R data | 10V | 635018 | 6229897 |
| Stn_112.5L | Shore-based or Buoy-based | Real-time, Continuous | Verification of Stn_106.8L and Stn_107.1R data | 10V | 636351 | 6230367 |
| Stn_134.1R | Shore-based | Real-time Continuous | Monitoring TDG downstream of the Peace-Pine confluence | 10V | 654937 | 6221865 |
| Stn_134.5L | Shore-based | Real-time Continuous | Monitoring TDG downstream of the Peace-Pine confluence | 10V | 655254 | 6222302 |
| Stn_223.2R | Sonde | Manual Field Download, Continuous | Monitoring TDG near the Project's LAA boundary | 11V | 363253 | 6240672 |
| Stn_224.4L | Sonde | Manual Field Download, Continuous | Monitoring TDG near the Project's LAA boundary | 11V | 363808 | 6241772 |

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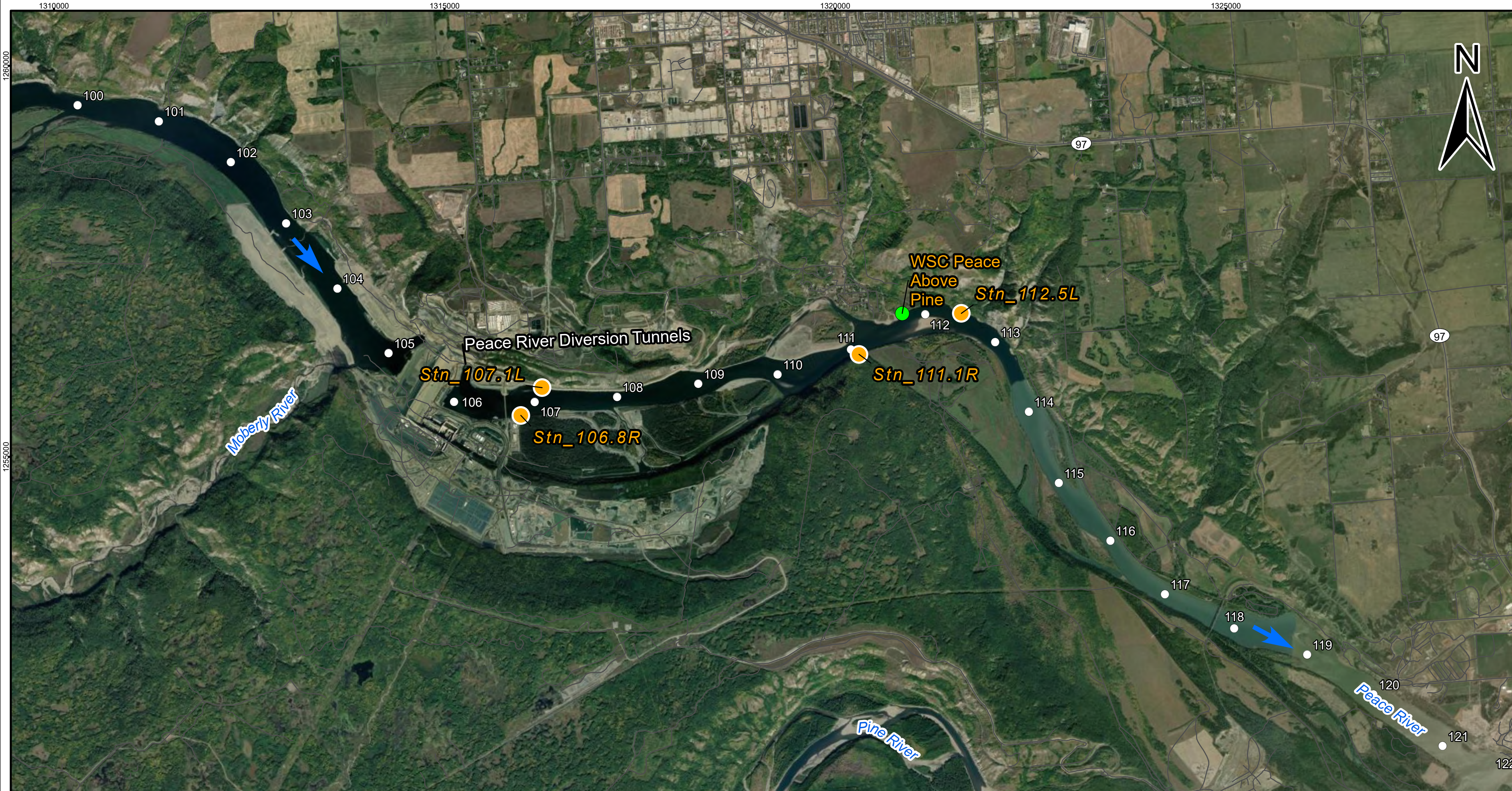


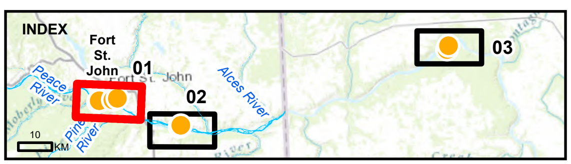


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SPATIAL REFERENCE: NAD 1983 BC ENVIRONMENT ALBERS

**LEGEND**

- TOTAL DISSOLVED GAS MONITORING LOCATION, 2024
- WSC PEACE ABOVE PINE
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD

CLIENT
BC HYDRO

CONSULTANT
wsp

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| DESIGNED | PG |
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| REVIEWED | DF |
| APPROVED | PG |

PROJECT
SITE C CLEAN ENERGY PROJECT

TITLE **THE SITE C TDG MONITORING ARRAY STATIONS STN_106.8R, STN_107.1L, STN_111.1R, AND STN_112.5L UPSTREAM OF THE PEACE-PINE CONFLUENCE**

| PROJECT NO. | CONTROL | REV. | FIGURE |
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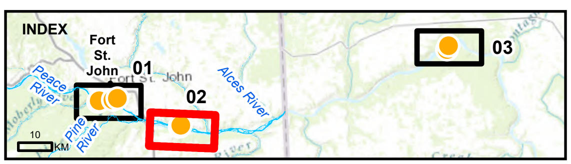


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**LEGEND**

- TOTAL DISSOLVED GAS MONITORING LOCATION, 2024
- WSC PEACE ABOVE PINE
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD

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PROJECT
SITE C CLEAN ENERGY PROJECT

TITLE **THE SITE C TDG MONITORING ARRAY STATIONS STN_134.1R AND STN_134.5L DOWNSTREAM OF THE PEACE-PINE CONFLUENCE**

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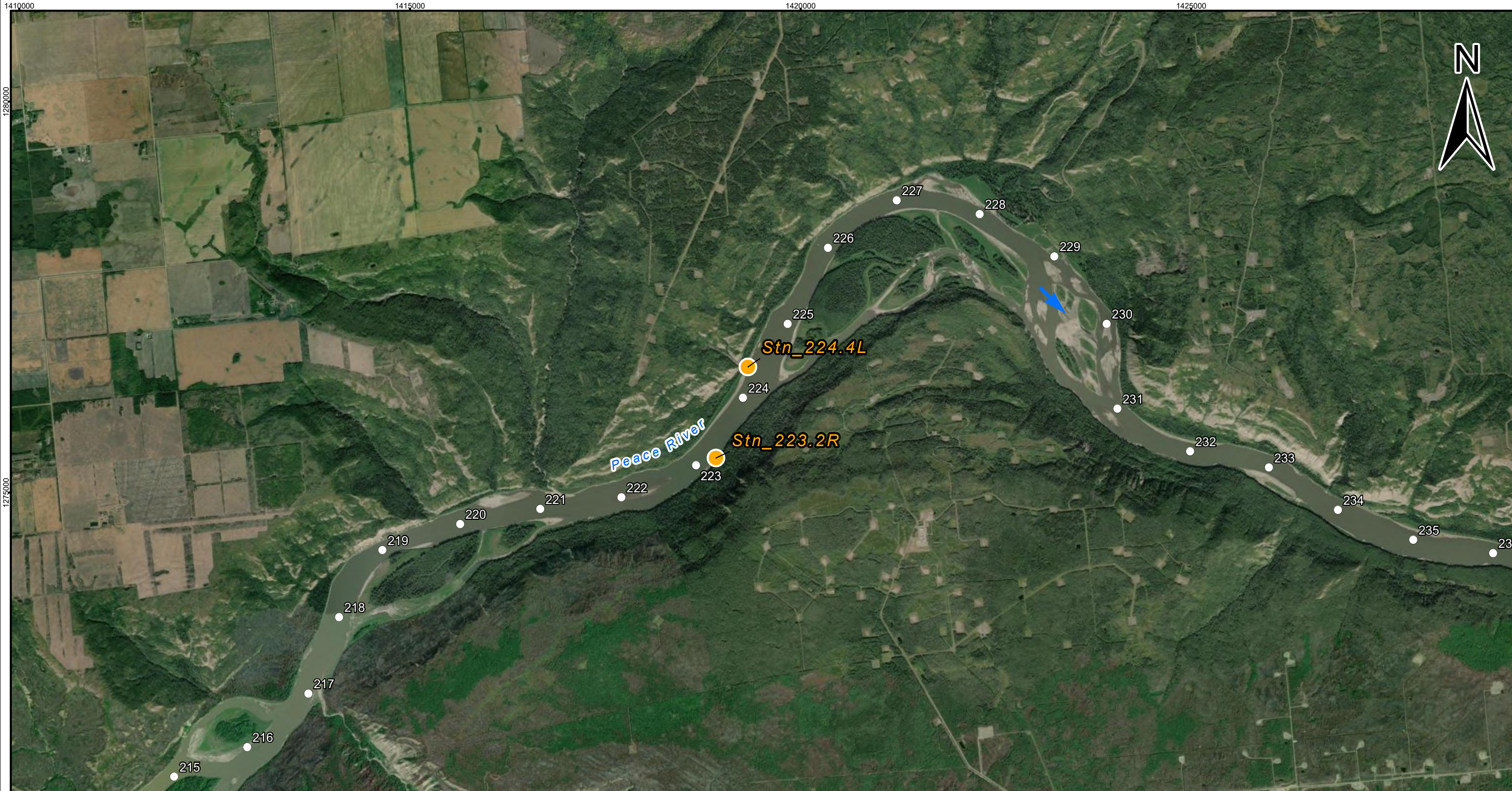


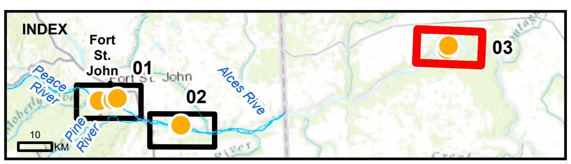


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SPATIAL REFERENCE: NAD 1983 BC ENVIRONMENT ALBERS

**LEGEND**

- TOTAL DISSOLVED GAS MONITORING LOCATION, 2024
- WSC PEACE ABOVE PINE
- RIVER KILOMETRE AS MEASURED DOWNSTREAM FROM W.A.C. BENNETT DAM
- ROAD

CLIENT
BC HYDRO

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| APPROVED | PG |

PROJECT
SITE C CLEAN ENERGY PROJECT

TITLE
**THE SITE C TDG MONITORING ARRAY STATIONS STN_223.2R AND STN_224.4L 118 KM DOWNSTREAM OF THE PROJECT AND NEAR THE DOWNSTREAM BOUNDARY OF THE PROJECT'S LOCAL ASSESSMENT AREA.**

| PROJECT NO. | CONTROL | REV. | FIGURE |
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# 3.0 SITE C TDG MONITORING ARRAY STATION DESIGN

The following is a description of the components and a summary of the design of the shore-based and buoy-based TDG stations, and of the autonomous sonde TDG stations. The design and components of the DCP and data management system through the ReliLink Connect™ website are also provided.

## 3.1 Shore-based TDG Station Component and Design

Shore-based TDG stations are currently installed on the Peace River at four locations upstream of Peace-Pine confluence (i.e., Stn_106.8R, Stn_107.1L, Stn_111.1R, and Stn_112.5L) and at two stations downstream of the Peace-Pine confluence (i.e., Stn_134.1R and Stn_134.5L). A generalized description of a shore-based TDG station is provided in Figure 4. Each shore-based TDG station consists of the following components:

- a 35 m long Pro-Oceanus Solu-Blu TDG probe (Pro-Oceanus Systems Inc., Bridgewater, Nova Scotia).
- a custom-designed ballasted steel anchor housing on which the TDG probe is deployed in the river.
- a steel weather-resistant cabinet, positioned on shore above the annual highwater mark, to house the station DCP and station power supply.

Shore-based TDG stations are expected to operate year-round and compared to a buoy-based station, offer more protection for the DCP electronics, the battery power supply, and the cable connections between the DCP and TDG probe. The TDG probe, which is attached to a metal 30 kg ballasted steel anchor housing, is deployed by boat below the water surface where it is protected from floating debris during freshet and drifting river ice. The cable between the probe and cabinet is deployed within a length 1” diameter aluminum flex-conduit starting from where the cable exits the weather-resistant cabinet to a point several metres below the low-flow wetted perimeter of the river. Both in the water and on shore, the conduit protects the probe cable from abrasion, weathering, and other damage (e.g., chewing by beavers or porcupines).

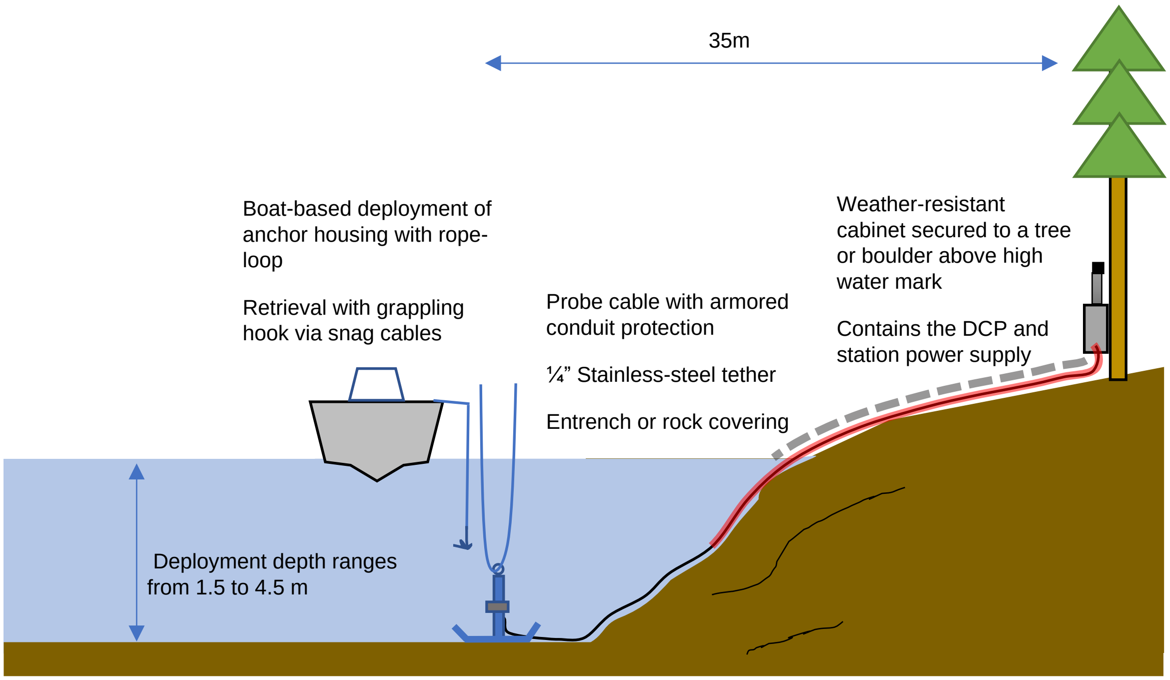


**Figure 4: Stylized illustration of the components and design of a shore-based TDG station.**

## Shore-based station TDG probe

The shore-base stations are each equipped with a Pro-Oceanus Solu-Blu™ TDG probe with the following attributes:

- The Pro-Oceanus Solu-Blu™ TDG probe uses a semipermeable membrane called Enduraflux™, which was developed by Pro-Oceanus specifically to measure TDG.
- The Solu-Blu™ TDG sensor's primary strengths include a rapid response time and low maintenance and calibration requirements for the sensor.
  - The TDG sensor's accuracy is ±0.1 TDG% (percent TDG); the TDG sensor's resolution is 0.1 TDG% saturation level; and the TDG sensor's measurement range is 75 to 150 TDG%.
  - Water temperature range 0 to 35°C.
- The probe contains a vented (air referenced) internal barometer used to record barometric pressure, which allows the calculation of percent saturation as an output parameter.
- Data outputs of the Solu-Blu™ TDG probe include water temperature, barometric pressure, total gas pressure, and percent TDG.
- All parameters are output as a single data stream, which simplifies data capture and transmission.
- Factory calibration and maintenance are recommended every three years.
- Equipped with a marine-grade waterproof and abrasion resistance 35 m long probe cable.

- Plastic cable wrap is applied to the length of exposed cabled outside of the aluminum conduit to confer addition protection from mechanical damage and abrasion.
- A perforated ABS guard is attached to the end of the probe to protect the TDG membrane from floating debris and abrasion damage.

## Ballasted steel anchor TDG probe housing

At each shore-based station, the Pro-Oceanus Solu-Blu TDG probe is deployed in the river on custom welded ballasted steel anchor housing with the following attributes (Figure 5):

- Bottomed weighted with a wide base to allow the housing to remain upright, keeping the TDG probe within the water column, and aluminum mesh to prevent submersion of the housing when deployed in soft substrate.
- Total weight of the housing is approximately 30 kg.
- Horizontal probe mounts prevent the accumulation of debris and sediment on the TDG probe membrane.
- Welded cable and rope attachment points for a TDG probe strain relief and to facilitate deployment.
- Secured to shore with an approximately 30 m long stainless-steel cable to allow retrieval and to prevent displacement.

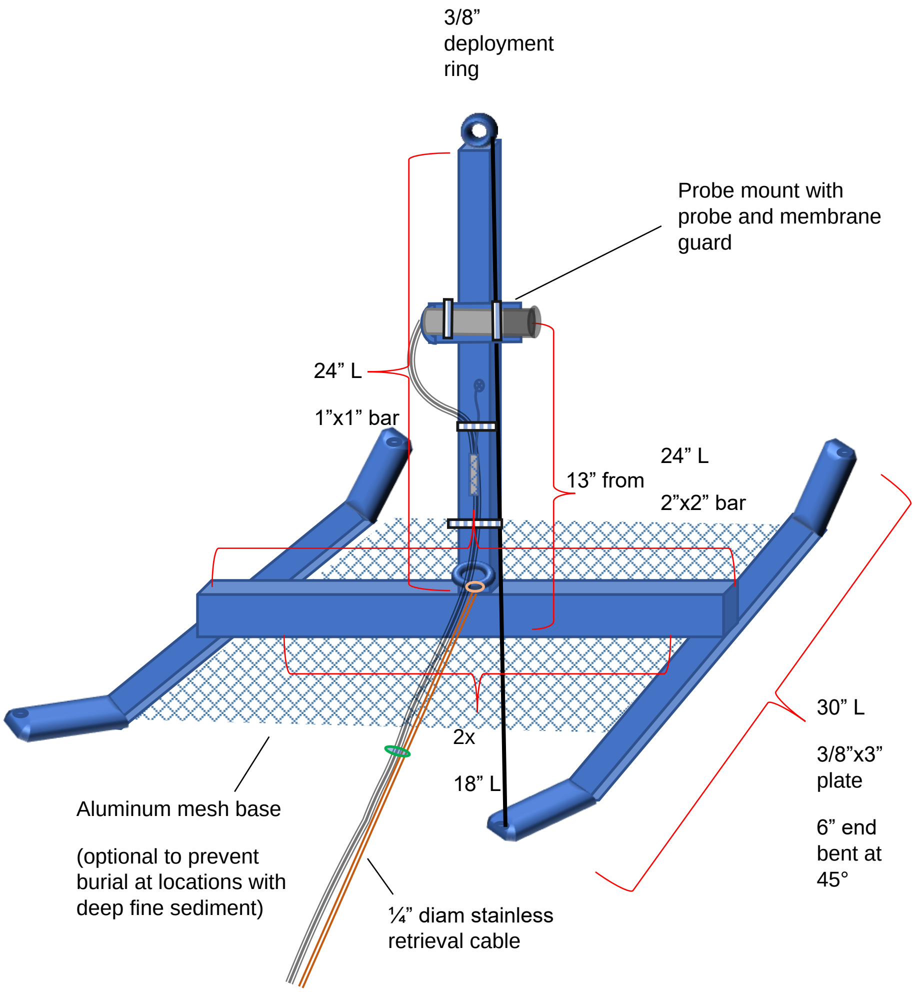


**Figure 5: A schematic of the steel ballasted anchor mooring to secure and orient a Solu-Blu TDG probe at shore-based TDG stations.**

## Weather-resistant cabinet of shore-based station

At each shore-based station, a weather-resistant cabinet by Saginaw Control and Engineering®, is installed above the highwater mark and secure to a tree or other fixed structure. The cabinet is used to house the DCP, power supply, and connectors (Figure 6). The cabinets have the following attributes:

- Cabinet dimensions are 20” wide by 24” tall by 6” deep.
  - Heavy gauge metal-walled construction.
  - Venting to ensure equilibrium between the cabinet interior and outside, allowing changes in barometric pressure to be detected.

- Lockable metal access door with weather-resistant O-ring seal equipped with door edge hold-downs.
- Top and bottom Unistrut™ braces to allow mounting on a steel post or other fixed structure. The cabinets are deployed using one of the following methods:
  - The cabinet is secured to a large tree using lag bolts with washers (Stn_106.8R and Stn_112.5L; Figure 6a).
  - The cabinet is secured to a 48" long 3" wide steel pole mounted in a steel pole base. The steel base is mounted level on a flat rock surface using expansion bolts. A tension steel cable is used to counter-balance the weight of the cabinet (Stn_107.1L; Figure 6b).
  - The cabinet in secured to a steel pole as above, but the steel pole base in attached with bolts to a custom-made 40" by 48" metal frame base positioned on a flat and level location. Sandbags are placed on the metal frame base to counter the cabinet weight and to stabilize the frame (Stn_111.1R, Stn_134.1R, and Stn_134.5L; Figure 6c).
- The TDG probe cable enters the cabinet through a 1" diameter hole in the bottom of the cabinet; a length of aluminum and PVC flex conduit is used to protect the probe cable.
- The weather-resistant cabinet houses the DCP and its top mounted satellite antenna, power supply, barometric pressure air reference line desiccant, and any excess probe cable.
  - A sealed satellite antenna is mounted on a mast on top of the box; an optional external mast can be used to position the antenna in the open for better satellite reception, if required.
  - The satellite antenna is sealed to prevent water entry into the cabinet.
  - The DCP is housed in a secondary waterproof housing within the cabinet.
  - The TDG probe is connected to the DCP with a 4-wire molex connectors; the power supply is connected to the DCP with a screw-style 3-pin connector.
  - The power supply consisted of two waterproof PVC power packs each with 36 AA 1.5 V lithium-ion batteries configured in six parallel banks of six cells, linked in series in each bank, to produce 9.0 V and an approximate total battery capacity of 24,000 mAh. The power packs are equipped with desiccant packs and sealed with a water-tight lid with an O-ring gasket. Station battery life is estimated at between approximately 7 months when set to record data at 5-minute intervals with a 30 minute satellite transmission interval to the ReliLink™ Solution/ Connect™ cloud website.
  - The TDG probe's barometric air reference line enters the cabinet with the probe cable and is protected by the flex conduit. An inline desiccant cartridge inside the cabinet is used to control humidity and prevent water blockages from forming in the air reference line.
- The cabinet is secured with a cut-resistant lock.
- A label, affixed to the cabinet door, identifies that the equipment is for scientific research and provides a local contact phone number.


**Figure 6: An example of deployment of a weather-resistant cabinet at a shore-based TDG station using lag bolt to secure the cabinet to a tree (inset A; Stn_112.5L). The cabinets were also deployed by mounting them to a steel pole with the base secured to either a rock (inset B; Stn_107.1L) or onto a steel frame (inset C; Stn_134.1R). The components of a shore-based station housed within the cabinet are shown in inset C.**

## 3.2 Buoy-Based TDG Station Design

In lieu of a shore-based station, a buoy-based station with real-time data download can be deployed at Stn_112.5L. Stn_112.5L is located in a large back eddy where water velocity is low and water depth ranges between 3 and 6 m, which is suitable for deployment of a buoy-style TDG station. The buoy station consists of a custom-designed NexSens CB-25 Data Buoy (NexSens Technology, Inc., Fairborn, OH) which houses the DCP and TDG probe components. These components are attached to either the top of the buoy, within the interior of the buoy's central canister, or to the bottom of the buoy as described below (Figure 7):

TDG probe:

- A Pro-Oceanus Solu-Blu TDG probe with a 3 m long probe cable is deployed at the bottom of a 1.5 m long stainless-steel instrument tube secured to the bottom of the buoy. The instrument tube is attached in the center canister base plate of the buoy. The probe cable is routed up through the buoy and connected to the DCP and power supply. With the exception of the cable length, the TDG probe in the buoy is identical to the TDG probe specifications used in the shore-based stations.

- The length of the TDG instrument tube (1.5 m) is designed keep the TDG probe sensor below the TDG compensation depth, below which air bubbles would not be expected to form on the TDG probe sensor under conditions associated with Project construction and operation.
- Paired in-line desiccant tubes on an elevated mount are used to control condensation and reduce the risk of water blockages in the TDG probe air reference line.
- The DCP electronics are housed in a clear acrylic cylinder and secured within the interior of the buoy canister with a top plate. The DCP housing is sealed with two double O-ring end caps. The end cap affixed to the top plate contains the TDG probe connector, power connector, and an Iridium satellite antenna (Iridium Communications Inc., McLean, VA). Desiccant and a moisture indicator strip in the DCP housing are used to monitor and reduce moisture, and the housing is sealed with a double O-ring end cap.
- The power supply is mounted on an aluminum bracket and consisted of a waterproof PVC container with 36 AA 1.5 V lithium-ion batteries configured in six parallel banks of six cells, linked in series in each bank, to produce 9.0 V and an approximate battery capacity of 12,000 mAh. The power supply is equipped with desiccant packs and sealed with a water-tight lid with an O-ring gasket. Station battery life is estimated at between approximately 3 to 4 months when logging data at 5-minute intervals.

Other station components:

- An active radio telemetry tag is affixed to the buoy to allow the station to be located by radio telemetry, if needed.
- Components on the top of the buoy are protected from weathering and UV damage by a fabric cover.
- Around the instrument tube, at the base of the buoy, a life-ring and up to four 2” thick closed-cell foam floats are used to provide additional buoyancy and stability. The additional flotation keeps station components on the top of the buoy (i.e., the power supply and desiccant tubes) higher above the water surface and helps keep the station oriented vertically in the water column.

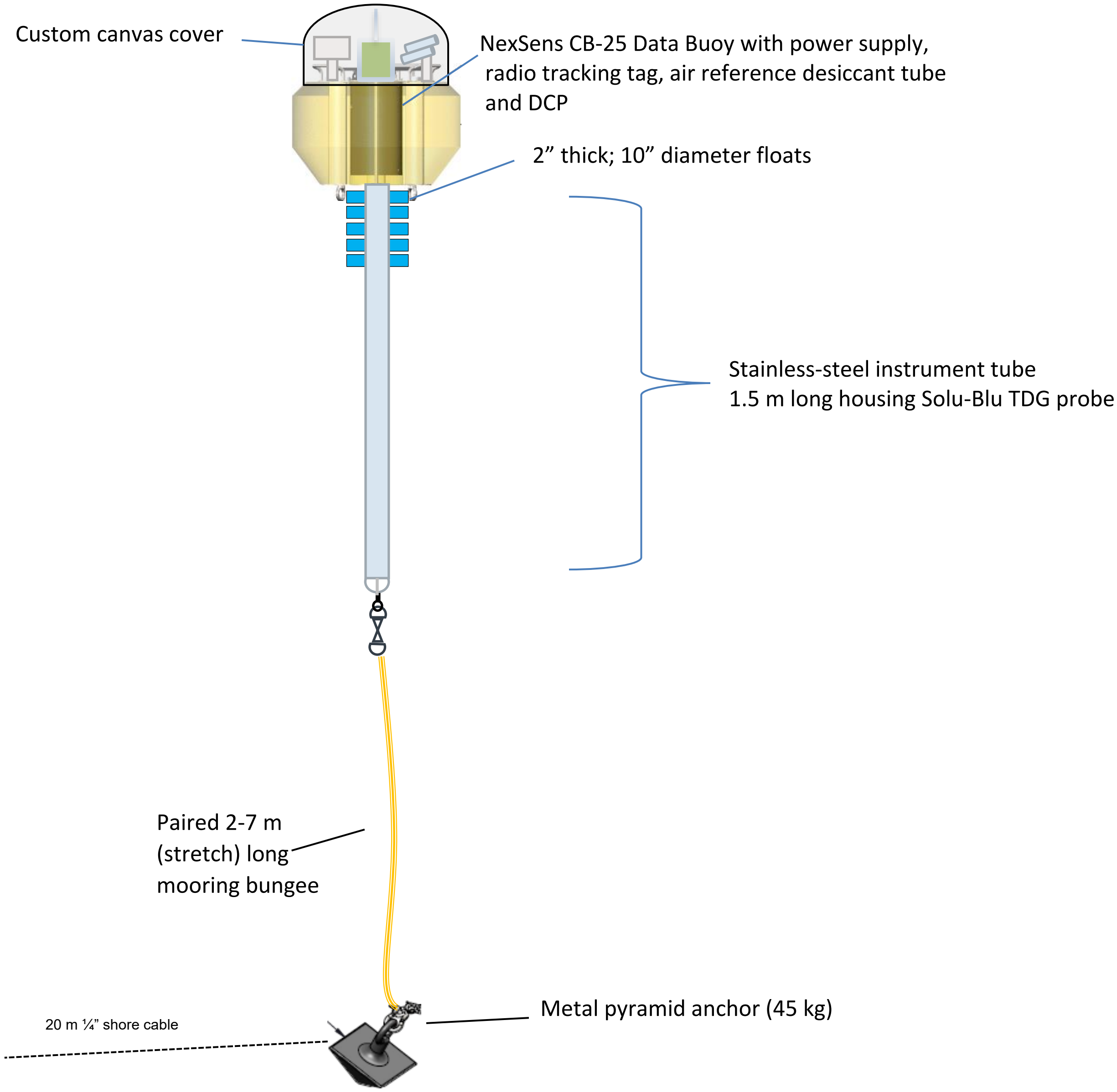


**Figure 7: A schematic of a buoy-based TDG monitoring station deployed as part of the Site C TDG Monitoring Array.**

## 3.3 DCP and TDG Data Management System

The DCP used by all real-time TDG stations (i.e., shore-based and buoy-based stations) in the Site C TDG Monitoring Array are equipped with a ReliLink™ Solution/ Connect™ DCP system designed and fabricated by Sullivan Telemetry LLC dba ReliLink™ (formerly GolderWatch®/GoldConnect™) in association with WSP USA Inc. based in Denver, Colorado. The general design and specifications of the DCP are as follows:

- The DCP consists of a ReliLink™ remote monitoring unit (RMU) with hardwire connections to the TDG probe, a satellite modem and antenna, and an onboard battery power supply.
- The RMU powers and records data from the TDG probe.
- Data stored within the RMU memory buffer are transmitted over a satellite connection to the Connect™ cloud-based server.
- Through Connect™, data can be queried, plotted for review, and algorithms and equations can be applied and exported by users. Station status and functionality can be monitored and automated email or SMS text message alerts can be sent to users based on user-defined criteria (e.g., loss of connection, low battery voltage, high TDG).
- If required, administrators can conduct over-the-air programming of the RMU to change data recording and transmission time intervals.
- In the event of a prolonged communication failure (i.e., greater that 2-hours), Connect™ sends an automated email alert to technical staff as a notification. Alert email notifications continue every 2-hours until communication is reestablished, at which point the alert is cancelled and an alert cancellation notification sent. If communication is not re-established, the onboard RMU can store up to 2 days of 5-minute interval TDG data.
- Email alerts and clearances are also issued in response to changes in sensor readings and battery voltage.

- The 2024 TDG monitoring approach and overall configuration of the TDG probe and DCP components are outlined in Figure 8.

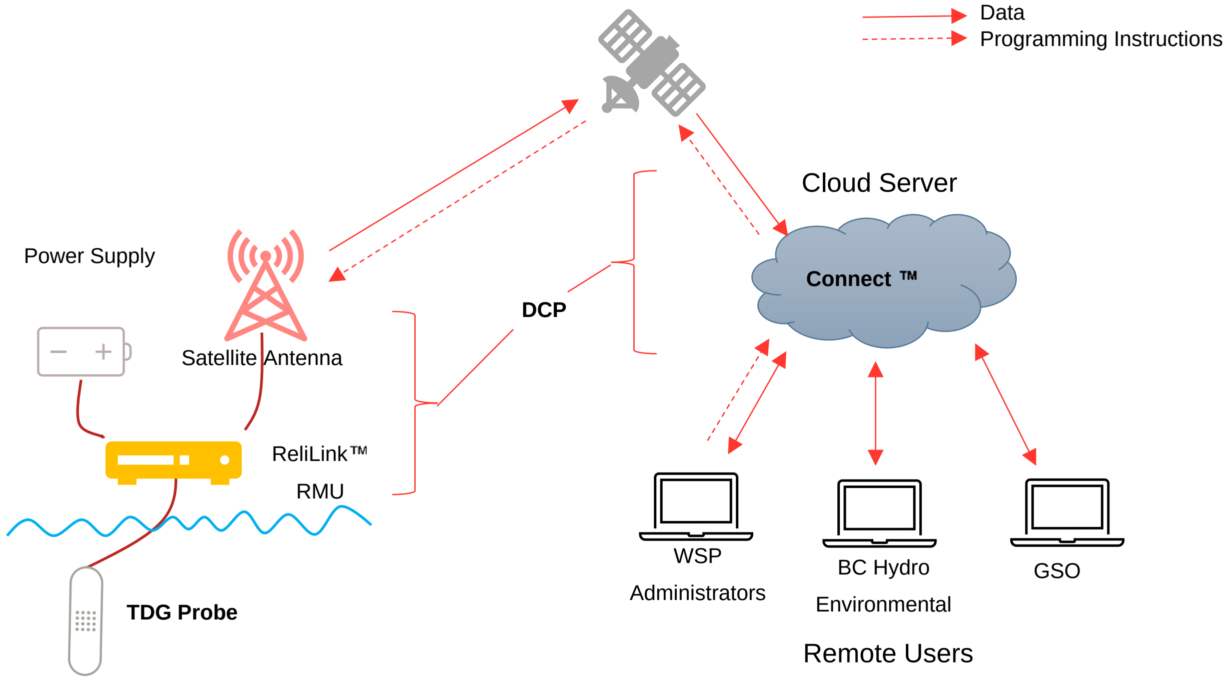


**Figure 8: A schematic of the design of the DCP and TDG equipment used at real-time TDG monitoring stations as part of the Site C TDG Monitoring Array.**

## 3.4 Sonde-based TDG Monitoring Station

The sonde-based TDG stations deployed at Stn_134.5L and Stn_136.5R downstream of the Peace-Pine confluence record continuous TDG readings at 15-minute intervals. These stations are not equipped with a DCP and cannot be queried remotely, as such, data recorded at the stations must be downloaded manually by field staff. Each station consists of the following components:

### Sonde-based station TDG probe

The Sonde-based stations are each equipped with a Pro-Oceanus Mini TDG™ (Pro-Oceanus Systems Inc., Bridgewater, Nova Scotia) with the following attributes:

- The Pro-Oceanus Mini TDG™ uses a semipermeable membrane called Enduraflux™, which was developed by Pro-Oceanus specifically to measure TDG.
- The Mini TDG™ TDG sensor's have a rapid response time and low maintenance and calibration requirements.
  - The TDG sensor's accuracy is ±0.1% (mbar); the TDG sensor's resolution is 0.002% of full scale (4 mbar); and the TDG sensor's measurement range is 0 to 2000 mbar.

   - Water temperature range is from -2 to 50°C.

- Data outputs of the Mini TDG™ sonde include water temperature, total gas pressure, and battery voltage.
- The Mini TDG™ sonde does not record barometric pressure. During data processing, regional barometric pressure data, adjusted for elevation, and total gas pressure are used to calculate percent TDG saturation as an output parameter.
- The Mini TDG™ sonde is equipped with an internal rechargeable 5 Amp-hour battery. When recording TDG data at a 15-minute log interval, the internal memory and battery power is of sufficient capacity to allow the unit to record data for up to 18 months.
- Due to calibration stability of the TDG sensor, factory calibration and maintenance are recommended every three years.

### Ballasted steel anchor TDG probe housing

The sonde stations are deployed on steel ballasted anchor housing identical to the housings used at the shore-based station (see Section 3.1). A length of stainless-steel cable is used to secure the housing to shore and to allow retrieval.

# 4.0 SITE C TDG ARRAY SERVICING AND MAINTENANCE

Service and maintenance of the Site C TDG Array is anticipated to be infrequent due to high battery longevity and the calibration stability of the Pro-Oceanus TDG sensors, which only requires factory calibration once every three years. The operational status of the six shore-based stations can be queried remotely and alerts issued automatically to notify technical staff in the event of communication failure or spurious sensor readings that may indicate a malfunctioning sensor.

Maintenance and servicing of the Site C TDG Monitoring Array will be conducted on an as-needed-basis by a combination of WSP Canada Inc field staff based in Fort St. John and by BC Hydro Natural Resource Specialists.

## 5.0 CLOSURE

We trust that this memo provides the information required at this time. Questions or requests for further detail can be addressed to the undersigned.

**WSP Canada Inc.**

Paul Grutter
*Lead Scientist*

Dustin Ford
*Senior Principal Scientist*

PG/DF/cmc

https://wsponline.sharepoint.com/sites/gld-124586/project files/5 technical work/2023/tdg/deliverables/tdg monitoring array summary/20136470-052-r-rev0-tdg monitoring array for gbd assessment 01aug_24.docx

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**APPENDIX B**

# GBD Assessment Initiation Form

# Gas Bubble Disease Assessment Initiation From

| | | | | | |
|---|---|---|---|---|---|
| GBDA ID | | | | | |
| Date of Current GBD Assessment | | | | | |
| TDG Initial Assessment | or | TDG Follow-Up Assessment | | | |
| GBD Asssessment Trigger | TDG | <115% | 115<TDG<120 | >120 | |
| | Exposure | <24hr | 1<days<10 | >10 days | |
| TDG Level Max Reported | | | | | |
| Date and Time | | | | | |
| TDG station | 106.8R | 107.1R | 112.5L | | |

| | | | | |
|---|---|---|---|---|
| Date of Last GBD Assessment | | | | |
| TDG Initial Assessment | or | TDG Follow-Up Assessment | | |
| TDG max during Last GBD Assessment | | | | |
| TDG station | 106.8R | 107.1R | 112.5L | |

**Condition Suitable For GBD Assessment and Type**

| | | | |
|---|---|---|---|
| Expected Daytime High Temperature during GBD Assessment | | | |
| Precipitation Expected | | Y | N |
| Fort St. John, BC - 7 Day Forecast - Environment Canada (weather.gc.ca) | | | |
| Air Temperature less than -15°C | | Y | N |
| Other Environment Factors | | | |
| GBD Assessment Go/ No Go | | **Go** | **No Go** |
| | | Crew lead signature | |

**Estimated Discharge During Current GBD Assessment**

| | |
|---|---|
| Project Qtotal | |
| Project Qspill | |
| Project Qgen | |

https://wateroffice.ec.gc.ca/report/real_time_e.html?stn=07FA004

Index Site List

Index Sites (Q400) Index Site (Q600) Index Site (Q1200)

**Total daylight available (hours sunrise-sunset)**

https://www.timeanddate.com/sun/canada/fort-st-john

| | | Estimate time to mob/demob (day) | Estimate time to Taylor and launch (day) |
|---|---|---|---|
| Date | | | |
| daylight time start (DLs) | | | |
| daylight time end (DLe) | | 0.05 | 0.05 |
| daylight total (DLt; hours) | | 1.25 | 1.25 |
| civil twightlight start (CTs) | | | |
| civil twightlight end (CTe) | | | |

| **Mob Start time CT-1hr** | **Depart FSJ to Taylo** | **Arrive at Taylor anc GBD Assessment** | **End GBD Assessmei DL end time-1hr** | **GBD Assessment Duration (hr)** | **Depart Taylor to FS** | **Demob and Email Summary** | **Total Work Day (hr)** |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

**APPENDIX C**

# GBD Status Update

# Session Effort Summary

| Session | Site Name | Sample Date | Water Temp. (°C) | Time Sampled (s) | Mean Depth (m) | Max. Depth (m) |
|---|---|---|---|---|---|---|
| 3 | GBD-U02 | 25-Oct-23 | 6.9 | 617 | 1.0 | 1.8 |
| | GBD-U03 | 25-Oct-23 | 6.6 | 747 | 1.1 | 3.8 |
| | GBD-U04 | 25-Oct-23 | 6.6 | 695 | 1.0 | 1.8 |
| Session 3 Summary | | | 6.7 | 2059 | 1.0 | 3.8 |
| All Session Summary | | | 6.7 | 2059 | 1.0 | 3.8 |

# Session Catch Summary

| | | | Number of Fish | | |
|---|---|---|---|---|---|
| Session | Sample Type | Species | Total | Alive | Dead |
| 3 | Intensive Effort | BT | 3 | 3 | |
| | Intensive Effort | CSU | 1 | 1 | |
| | Intensive Effort | LSU | 1 | 1 | |
| | Intensive Effort | LT | 1 | 1 | |
| | Intensive Effort | MW | 47 | 47 | |
| | Intensive Effort | NP | 3 | 3 | |
| | Intensive Effort | RB | 1 | 1 | |
| | Intensive Effort | RSC | 1 | 1 | |
| | Intensive Effort | TP | 3 | 3 | |
| | Intensive Effort | WSU | 8 | 8 | |
| Session 3 Summary | | | 69 | 69 | |
| All Session Summary | | | 69 | 69 | |

# GBD Session Summary

| | | | GBD Rankings | | | | |
|---|---|---|---|---|---|---|---|
| Session | Species | Number of Fish | Eye | Caudal | Anal | Dorsal | GBD Index |
| 3 | BT | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | CSU | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | LSU | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | LT | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | MW | 47 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | NP | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | RB | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | RSC | 1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | TP | 3 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| | WSU | 8 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Session 3 Summary | | 69 | 0.0 | 0.0 | 0.0 | 0.0 | 0.00 |