APPENDIX E - TERMS OF REFERENCE

1.0 Contract Title

Survey, Orthoimagery, Shore-based Work – Coral Harbour NU & Sanikiluaq NU

2.0 Contract Period

Contract Award to November 30, 2021

3.0 Background Statement

The Department of Fisheries & Oceans Canada (DFO) – Small Craft Harbours (SCH) Branch, Ontario & Prairie Region, develops and maintains commercial fishing harbours in Manitoba, Saskatchewan, Alberta, Northwest Territories and Nunavut. The typical developments undertaken at our facilities include the construction of the following items:

- Breakwaters
- Fixed Wharves
- Basin/Channel Dredging
- Boat Launch Ramps
- Floating Wharfs

4.0 Objectives of the Requirement

Small Craft Harbours requires a contractor to: perform topographic and bathymetric surveys, provide colour digital aerial Orthoimagery, and conduct shore-based work; to allow SCH to assess harbour development at two locations in Nunavut:

- Sanikiluaq, NU
- Coral Harbour, NU

The survey information is necessary to support Feasibility Studies for Small Craft Harbours at the listed sites. This information details the spatial and vertical relationship of a given site's existing features (both human-made and geological).

The imagery will be used by SCH for site assessment, mapping, planning, historical and future analysis and other activities.

The shore-based work is required to facilitate the transfer of datum information between previously established Canadian Hydrographic Service (CHS) benchmarks to new benchmarks established by the contractor as included in this project scope. This also includes secondary work as part of a tide gauge installation at one of the sites, which will help CHS establish datum information.

5.0 Scope of Work

The scope of the work is to include the following items:

5.1 <u>Topographic and Bathymetric Surveys</u>

- Undertake a Topographic and Bathymetric survey of three potential harbour locations (Coral Harbour NU & Sanikiluaq NU) within the limits of the "AREA TO BE SURVEYED" shown in Appendix AA.
- Establish one (1) permanent control point at each of the sites in a location that is convenient for future use and in a position likely to be safe from damage. Permanent control point(s) are to be specifically identified on all drawings produced. The permanent control point locations must be within or in close

proximity to the AREA TO BE SURVEYED outlined in Appendix AA. Planned locations for permanent control points shall be determined in consultation with the Project Authority. Permanent control point must be occupied for a minimum 24 consecutive hours simultaneously with an existing CHS control point at each site, see Section 5.3 below. The monument type for the control points shall be brass cap/plug type, installed into bedrock or other suitable location.

- The survey must be conducted in accordance with the CHS Standards for Hydrographic Surveys: https://www.charts.gc.ca/documents/data-gestion/standards-normes/standards-normes-2021-eng.pdf
- The bathymetric survey must be undertaken using a multi-beam echo-sounder and result in complete 100% coverage of the total bathymetric survey area.
- Horizontal Control:
  - All points to be in UTM coordinates referenced to the NAD83 (CSRS) datum.
  - Primary shore control points shall be established by ground survey methods to a relative accuracy of 1 part in 100,000. When geodetic satellite positioning methods are used to establish such points, the error shall not exceed 10 cm at 95% confidence level with respect to NAD83 (CSRS).
- Vertical Datum:
  - All depths must be reduced to a low water datum.
  - In tidal waters, soundings are reduced to Lowest Low Water Large Tide (LLWLT).
  - Sounding datum must be referred to a minimum of 3 vertical benchmarks whose elevations must be determined to the accuracy stated in the Canadian Tidal Manual.
  - Geodetic datum shall be chart datum and used for the Site Plan and associated CAD files. Shift values from CGVD2013 to chart datum to be provided within 21 days after receipt of the following deliverables as outlined in Section 6.3: Raw 24 hr GNSS occupation data, RINEX files, NRCAN PPP Reports.
- Undertake a topographic and bathymetric survey to the limits (as shown on the attached drawings) that is accurate in all planes to within +/- 0.05m of the control point for points on land and +/- 0.1m for points underwater. Indicate in your proposal if you are able to exceed these parameters.
- Survey lines are to start at the limits of the upland area and extend into the water to the limits of the water area. Survey lines are to be spaced at a maximum offset of 10m. A minimum of one (1) topographic survey point along each survey line shall overlap the bathymetric data coverage such that there is no gap between the topographic and bathymetric data.
- Survey points along the lines are to have a maximum spacing of 5m for points underwater and a maximum spacing of 5m for points on land. Additional survey points may be required along or between the lines to completely identify significant site features.
- Significant site features to be surveyed include but are not limited to the following:
  - Locations and elevations of any existing structures (buildings, wharves, floats, launch ramps, power poles, concrete pads, parking lots, culverts, etc.);
  - Shoulder of roads;
  - Top of slope and toe of slope of any breakwater, shore line or naturally sloped feature;
  - Extents of any topographical or geological features (bedrock outcrops, cliffs, ravines, streams, ditches);
  - Location of any evidence of high water lines in addition to Ordinary High Water Mark;
  - Locations of any navigational aids (lights, ranges, buoys);
  - Edge of water on the given day;
  - Property pins;
  - Existing benchmarks, and;
  - Any other site conditions that may impact the development of a harbour at the site.

5.2 Orthoimagery

- Acquire new high resolution (6.5 cm/pixel or better) digital colour imagery of three potential harbour locations (Coral Harbour NU & Sanikiluaq NU) within the limits of the “COLLECTION AREA” shown in Appendix BB. Following acquisition the contractor shall prepare an ortho-rectified, geo-referenced image for each photographed harbour.

5.2.1. Imagery Acquisition: Environmental Conditions

Imagery must meet the following requirements:

- Less than 5% cloud cover unless deemed acceptable by the Project Authority.
- At least 25 degrees sun angle.
- Clear atmospheric conditions: no haze, smoke, dust, fog, or combination thereof or other effects limiting visibility.
- No snow cover on ground.
- No sea ice unless deemed acceptable by the Project Authority. Acceptance must be given prior to flying if it appears there is sea ice cover at harbour sites.
- Low tide conditions (within + or – two (2) hours of a predicted daily low tide) unless deemed acceptable by the Project Authority. Acceptance must be given prior to flying for image acquisition outside of the four hour tidal window.

There will be no additional payment for any expenses incurred while waiting for acceptable environmental conditions.

5.2.2. Imagery Acquisition: Bands and Resolution

- The imagery must be captured at a Ground Sampling Distance (GSD) of 6.5 cm or better.
- The imagery must be captured using a mapping camera.
- Imagery acquisition must be RGB colour or better.

5.2.3. Image Acquisition: Accuracy and Flight Parameters

- The imagery must have a minimum of 60% forward overlap and 30% side overlap.
- Global Positioning System (GPS) technology must be used to capture x and y image centre positions.

5.2.4. Ortho-imagery Deliverable: Bands and Resolution

- The final imagery mosaic for each site must be 6.5 cm per pixel or better, true colour or RGB, ortho-rectified, geo-referenced and seamless.
- Adjacent images used to develop the final mosaics must be tone and contrast matched to give the appearance of a continuous image.
- There must be no gaps or slivers between image tiles in the final mosaics.
- There must be no smears or blurred imagery in the final mosaics.

5.2.5. Ortho-imagery Deliverable: Accuracy

- Internal (within an ortho-image) measurements between readily defined points must be within 0.5 meters of ground measured distances.
- Absolute accuracy (relationship to actual UTM co-ordinates) must be less than 2.0 meters.
- The imagery must be compensated for all factors such as, but not limited to: terrain relief, lens distortion, and other camera and viewing angle parameters that affect the accuracy of the ortho-image.

5.2.6. Ortho-imagery Deliverable: Digital Format

- A single mosaic for each site encompassing the entire Collection Area is required, delivered in the following formats:
    - Uncompressed TIFF (not Geo Tiff) format (.tif) with associated TFW (.tfw) file(s).
    - Compressed JPEG (.jpg) format with associated JGW (.jgw) file(s).
    - Compressed ER Mapper (.ecw).
- The TIFF and JPEG formats must be readable by non-GIS Windows-based image viewers such as Windows Picture and Fax Viewer and must not contain embedded ‘Pyramid’ schemes or other artifacts.

- The JPEG format images must have a maximum file size of 10 MB.

5.2.7. Raw imagery Deliverable: Digital Format

- A single raw imagery mosaic for each site encompassing the entire Collection Area is required, delivered in the following formats:
    - Compressed JPEG (.jpg) format.
- The JPEG format must be readable by non-GIS Windows-based image viewers such as Windows Picture and Fax Viewer and must not contain embedded 'Pyramid' schemes or other artifacts.
- The Raw imagery mosaic is not required to be ortho-rectified.
- The JPEG format images must have a maximum file size of 10 MB.

5.2.8. Ortho-imagery Deliverable: Visual Quality Control

Prior to delivery, a visual inspection of the images must be performed by the contractor to verify the quality of the imagery. Items of particular concern include areas of inconsistent tone relative to the surroundings and areas of apparently smeared or blurred imagery.

- Linear features including but not limited to buildings, roads, bridges, wharves, railways, and other structures must appear straight or as smooth curves where appropriate and unwavering. Any anomalies that might occur during capture or processing must be corrected prior to delivery.
- Mismatching of linear features at seams must not be noticeably visible and therefore not exceed 2x (two times) the pixel size.
- Adjacent images used to develop the final mosaics must be tone and contrast matched to give the appearance of a continuous image.
- There must be no gaps or slivers between image tiles in the final mosaics, to give the appearance of a continuous image.
- There must be no solar hot spots, light streaks, or lens flare in the imagery.

5.2.9. Coordinate Systems for Digital Elevation Models and Ortho-imagery

The geo-referenced ortho-imagery, Digital Elevation Model (DEM, DSM, DTM), and other data for each site must be delivered in the North American Datum 1983 (NAD83) Canadian Spatial Reference System (CSRS), and the Universal Transverse Mercator (UTM) projection in the appropriate zone.

5.2.10. Delivery Media and Method

Digital information for each site is to be delivered on external portable hard drives. The Project Authority is not responsible for the return of the external hard drives to the contractor. In addition to delivery by hard media, an ftp site may also be developed by the contractor for interim deliveries of digital data. Any such ftp site must be accessible by and approved by the Project Authority prior to use.

If digital data for more than one site is included in one delivery, the data for each site should be in separate directories and sorted by Location Name, and Image Format.

5.2.10.1 Directory Name by Location Name

Directory name must be unique through the contract and be formatted as: Location Name Territory

For Example: Coral Harbour NU

5.2.10.1.1 First sub-directory Names by Deliverable

First sub-directory names must be unique throughout the contract and be formatted as: Deliverable.

For Example: Orthoimagery

5.2.10.1.2 Second sub-directory Names by Image Format

For the Orthoimagery sub-directories, second sub-directory names must be unique throughout the contract and be formatted as: Image Format.

For Example: JPEG
For Example: ECW
For Example: TIFF

5.2.10.2 File Names: Orthoimagery

Image file names must be unique throughout the contract and be formatted as:

LocationName_Territory_DDMMMYYYY_O.extension

Where DDMMMYYYY is the date the image was captured. See the example below to fully understand the Upper and Lower case letters in the name, without a space, the month format and the numbering format.

Example:

CoralHarbour_NU_15JUL2021_O.jpg (or .tif, .ecw)

5.2.10.3 File Names: Flight Reports

Flight report file names must be unique throughout the contract and be formatted as:

LocationName_Territory_FlightReport.pdf

5.3 Shore-based Work

- Two simultaneous 24hr GNSS occupations at each site: one over a pre-established CHS benchmark, the other at the new permanent control point described in Section 5.1. Coordinates and photographs of the pre-established CHS benchmark for each site are provided in Appendix DD. Field forms are provided in Appendix EE. Instructions are provided in Appendix CC.
- Level-loop between three pre-established CHS benchmarks at each site. Field forms are provided in Appendix EE. Instructions are provided in Appendix CC.
- Calibrations/water level checks (3 at high tide and 3 at low tide) at Coral Harbour. Tidal predictions will be provided to contractor after contract award. Field forms are provided in Appendix EE. Instructions are provided in Appendix CC. Bucket/stilling well for water level checks to be shipped to contractor after contract award.
- Deployment of barometer at Coral Harbour. Barometer to be shipped to contractor after contract award. Field forms are provided in Appendix EE. Instruction are provided in Appendix CC.
- Install new brass cap/plug type benchmark at Coral Harbour at the location of the pre-established CHS benchmarks. Instructions are provided in Appendix CC. Field forms are provided in Appendix EE.
- Obtain GPS coordinates (hand-held or RTK) for each pre-established CHS benchmark.
- Capture Site Photographs of: each pre-established CHS benchmark, new permanent reference points, leveling work, calibrations/water-level checks (Coral Harbour only), and as stated on field forms.

6.0 Deliverables

6.1 Bathymetric and Topographic Surveys

Preparation of a Bathymetric and Topographic Survey Report that includes the following items:

- Site Plan that illustrates the findings of the field work. Drawing is to be to a scale that shows the limits of the field investigation on an ARCH D sized paper in PDF format.
- Copies of any Field Notes recorded on site.

- Details of survey method used, equipment used and any pertinent site information.
- Details of permanent control points that were established and their installation method.
- Electronic copy of the Site Plan in AutoCAD and AutoCAD Civil3D format with all features drawn on separate layers.
- Electronic copies of all raw data collected on site, with attributes including but not limited to for each point: coordinates, date and time, horizontal and vertical precision.
- Electronic copies of survey data in raw, CGVD2013, and chart datum; in CSV, and point cloud or similar format.

6.2 Orthoimagery

- Raw imagery: One (1) colour raw imagery mosaic image of each site. Each image must encompass the full extent of the Collection Area. This image shall be supplied in formats as described in Section 5.2.7.
- Orthoimage: One (1) colour, ortho-rectified, geo-referenced image of each site. Each image must encompass the full extent of the Collection Area. This image shall be supplied in multiple formats as described in Section 5.2.6.
- Flight Report for each site containing information including but not limited to flight date(s), flight time, camera model, aircraft, flying height, navigational equipment, horizontal control parameters, weather conditions, problems encountered, and any other pertinent issues. The report is to be submitted in PDF (.pdf) format.
- Derived products used to develop the ortho-imagery, including but not limited to a Digital Elevation Model (DEM, DSM, DTM), horizontal and vertical control point data, and vector data. Data to be in a vector, point, point cloud, or other suitable format wholly compatible with Commercial-Off-The-Shelf (COTS) Geographical Information System (GIS), desktop mapping, and Computer Aided Drafting and Design (CADD) applications.

6.3 Shore-based Work

- Raw 24 hr GNSS occupation data, RINEX files, NRCAN PPP Reports.
- Completed field forms.
- Field notes.
- Site photographs.
- GPS coordinates of each pre-established CHS benchmark, new benchmark, and barometer location.

7.0 Constraints

All topographic and shore-based survey work shall be performed by a licensed Canadian Land Surveyor (CLS).

The bathymetric survey shall be undertaken by a Hydrographer, a Certified Hydrographer is preferred, but not mandatory.

Survey must be conducted in accordance with the CHS Standards for Hydrographic Surveys: https://www.charts.gc.ca/documents/data-gestion/standards-normes/standards-normes-2021-eng.pdf

The sites will not be closed to the public at any time during imagery acquisition for Orthoimagery or survey work.

A tide gauge is being installed at Coral Harbour in summer 2021 by DFO. The shore-based work water level checks shall not commence prior to the gauge being installed. Contractor shall schedule site work for water level checks to be completed after August 15, 2021.

8.0 Client Responsibilities

Project Authority shall respond to Contractor requests in a reasonable time frame (within four (4) working days)

9.0 Contractor Responsibilities

The work to be done by the Contractor under this Contract includes the furnishing of all travel costs, superintendence, overhead, labour, materials, equipment, tools, supplies, insurance, and all things necessary for and incidental to the satisfactory performance and completion of all work as specified herein.

Contractor is responsible for monitoring the ice conditions at the locations of work to ensure that the work is undertaken as per the timeframes outlined in section 11.0.

Contractor must use the equipment stated in their proposals for Orthoimagery image acquisition and production. Contractor must have back-up equipment (camera/sensor) available for this contract.

The contractor is responsible for all forms of ground, navigational, and image spatial control required for Orthoimagery.

The contractor must keep on file any original data for the entire duration of the contract and for one year thereafter and make available copies of final deliverables to the Project Authority upon request.

The contractor is to ensure that all required certifications, insurances, registrations, licenses, and documentation are current and maintained throughout the contract with relation to the work to be performed.

10.0 Progress Meetings

A Project Kick-Off meeting with the Project Authority will be held after award via telephone.
Progress meetings shall be with the Project Authority, as required, via telephone.

11.0 Time Schedule for Completion

The topographic and bathymetric survey is to be undertaken as soon as possible after ice-out when there are open water conditions, and completed prior to freeze-up.

The draft Bathymetric and Topographic Survey Report must be submitted by October 31, 2021. The final report must be submitted by November 30, 2021.

Raw imagery mosaic for Orthoimagery must be submitted by October 15, 2021. Orthoimage, Flight Report, and Derived Products for each site must be submitted by November 30, 2021.

Raw 24 hr GNSS occupation data, RINEX files, and NRCAN PPP Reports must be submitted by September 29, 2021. All deliverables must be submitted by November 30, 2021.

12.0 Data Ownership

The re-use of data produced under this contract by the contractor for other projects, promotional materials or in any other form may or may not be given and will require the prior consent of the Project Authority.

13.0 Location of Work

Normally, the work will take place in Coral Harbour NU, Sanikiluaq NU and the Contractor’s own place of business.

14.0 Basis of Payment

The Basis of Payment shall be a fixed lump sum price which must include all field work, office work, travel, and all applicable miscellaneous costs.

The contractor must submit a price breakdown by task (bathymetric surveying, topographic surveying, orthoimagery and shore-based work) for each location, within one (1) week of contract award.

15.0 Project Authority

To be provided upon contract award.

APPENDIX AA – SURVEY LIMITS

(ATTACHED AS ATT A003.PDF)

APPENDIX BB – COLLECTION AREAS

(ATTACHED AS ATT A004.PDF)

APPENDIX CC - Instructions for Shore-based Work

Objective:

1. To establish vertical datum ties to the data being collected by a submersible tide gauge to be deployed at Coral Harbour summer 2021 for the purpose of establishing chart datum. To verify stability of pre-established benchmarks (BMs) through levelling at Sanikiluaq and Coral Harbour. To obtain GNSS data to transfer chart datum from pre-established benchmarks to a new permanent benchmark (control point) in each community.

Required equipment:

1. GNSS occupation equipment (quantity 2 of each) (receiver and antenna geodetic grade, tripod/mast and battery (battery and external battery cable).
2. Levelling equipment (level, rod, tripod and bucket/stilling well for water level checks), level must be accurate to 1 mm or better.
3. Equipment and supplies to install brass cap/plug type control point Coral Harbour **(should the three CHS brass plug benchmarks not be in-place/or are destroyed)**.

Documents provided:

1. Work Instructions
2. Example of levelling notes (loop and water level check)
3. Blank GPS log form, level form and water level check form, benchmark form, barometer form all contained within Appendix EE.
4. Instructions for GNSS observations with approximate time frame
5. Instructions for water level checks with approximate time frame
6. Instructions for levelling with approximate time frame
7. Benchmark information for Sanikiluaq and Coral Harbour
8. Tidal predictions for 5180 Coral Harbour – to be provided after contract award
9. List of survey activities with deliverables

Shore-based work Instructions:

1. Level loop between pre-established CHS benchmarks (3 at each site) using differential levelling techniques (survey level and rod):
    a. Sanikiluaq: BM 90T9453 to BM 90T9454 to BM 90T9455 and return to BM 90T9453
    b. Coral Harbour: BM 1-1970 to BM 2-1970 to BM 3-1970 and return to BM 1-1970
2. Simultaneous minimum 24 hour occupations on two benchmarks at each site: one on CHS pre-established benchmark and the other on the new permanent control point to be established by the contractor. submit RINEX file to NRCan PPP to validate the occupation data is good.
    a. CHS pre-established benchmark for the occupation should be the one that is the most stable of the three at each site. This BM should be the starting BM for the level loops in 1a and 1b.
3. Obtain GPS coordinates (XYZ; by hand-held or RTK) for each pre-established CHS benchmark.
    a. Sanikiluaq: BM 90T9453, BM 90T9454, BM 90T9455
    b. Coral Harbour: BM 1-1970, BM 2-1970, BM 3-1970
4. Conduct water level checks at Coral Harbour coming off BM 1-1970 (70T9506) which is closest to the water and easiest for water level checks. The water level checks need to be conducted at high and low tide events, set-up and start 45 minutes before start of event, take a water level reading every 3 minutes, until 15 minutes after or its certain the event has been captured. This will provide a means to “calibrate” the water level checks to the water level data being collected by the submersible gauge and calculate BM elevations relative to chart datum. In addition compare water level observations with tidal predictions.
5. Note that water level checks are best done when the water is calm (no wind set-up).
6. Water level checks should be completed from the same benchmark and set-up such that it is one set-up for backsight to the BM 1-1970 (70T9506) and foresight to bolt head / rod in stilling bucket.
7. CHS note templates are provided as well as an example, please ensure notes are clear and filled out with the appropriate information.
8. **Important:** Water level checks need to be completed **after** tide gauge is deployed. Contractor shall schedule site work for water level checks to be completed after August 15, 2021.

9. Deploy barometer on land close to sea-level above high water mark near CHS pre-established benchmarks. Obtain GPS coordinates of barometer location (XYZ; by hand-held or RTK). Detailed deployment instructions to be provided after contractor award.
10. **Note:** Should the three pre-established CHS benchmarks at Coral Harbour (BM 1-1970, BM 2-1970, BM 3-1970) not be in-place/ or are destroyed; then the contractor is to install a brass cap/plug type benchmark. Brass plug is to be installed above the high water line into bedrock at the approximate location of BM 1-1970. The installed benchmark shall then be used for the 24-hr simultaneous GNSS occupation along with the new permanent reference point installed in the community. The installed benchmark shall also be used for the levelling to the fixed point in the water for the Water Level Checks. Details to be provided after contract award.

GNSS instructions: Approximate time: set-up one hour, 24 hour occupations, tear-down half hour plus travel to and from site (there are two occupations each 24 hours at the same time)

1. Operate receiver and rover (if tying in other marks by RTK) as per manufacturers instructions. For CHS BM occupations use the following as per advice from NRCan and CHS adopted standard.
    a. 30 second logging interval
    b. 0 degree masking angle
2. Accurate measurement from top of marker to antenna reference point and take a photo with measuring stick showing measurement.
3. Record serial numbers and models of equipment on the form
4. Record any obstructions and their direction take photo at antenna height looking to each of the compass points (N,S,E,W) to show horizon and upward (record any obstruction or item that could cause signal interference).
5. Fill out all required information on the GPS Data Log Form and take photos of the set-up.
6. Simultaneous 24 hour occupations on CHS pre-established benchmarks and new permanent reference points in communities to facilitate transfer of chart datum.
7. Note: the level loops cannot be completed while the GNSS is occupying one of the CHS pre-established benchmarks. **Run the level loop then set-up GNSS or vice-versa.** Use the most stable existing CHS BM for the GNSS, use this same BM for the start and close of the level loop.
8. The GNSS observations over the benchmarks must be done simultaneously for each community, with the overlap at each benchmark being a minimum of 24 hours.
    a. Sanikiluaq: Occupy one of BM 90T9453, BM 90T9454, BM 90T9455 PLUS the new permanent reference point at the same time.
    b. Coral Harbour: Occupy one of BM 1-1970, BM 2-1970, BM 3-1970 PLUS the new permanent reference point at the same time.
9. On completion of each GNSS 24 hour occupation create a RINEX file and submit to NRCan PPP online tool to obtain solution and verify the occupation was successful.

Instructions for Water Level Checks: Approximate time: set-up half hour (set the bucket, level to bucket, get set for reading water levels), water level checks 45 minutes, level back to BM 10 minutes, plus travel time. 1.5 to 2 hours per water level check (X6) plus travel to and from site.

1. Use the levelling and water level check forms provided in Appendix EE.
2. Level from BM 1-1970 (70T9506) to a fixed point in the water, this can be a bolt head in the bucket or a fixed rock (use only if there is no way to set a stilling bucket) in the water that a level rod can be set on and not move for the duration of the water level checks. Set-up 45 minutes ahead of the predicted event, observations prior to and after the event are needed so that its clear the event has been captured. Level to the fixed point in the water then take water level readings on the level rod by sight to the mm every 3 minutes on the three minute interval for a minimum of 15 observations (1 set) for the high and low tide events, ensure the high and low events are captured. Three high water events and three low water events are required. This will calibrate the water level checks to the submersible gauge data and enable the calculation of the BM elevations to chart datum. The water level observations should be conducted from CHS BM 1-1970 (70T9506) as it is closest to the water.
3. Water level observations need to be taken on the same interval and time the submersible gauge is recording, 3 minutes (3, 6, 9…from the top of the hour). Accurately note the time zone of the observations on the form.

4. Ensure the stilling bucket does not move during the water level checks. The water in the bucket should be the same level as out of the bucket without the high frequency wave action.
5. Once a set of 15+ observations has been completed (event has been captured) at a high or low event complete the level loop back to the BM, this closure tells us if the fixed point used in the water has moved.
6. If you notice the bucket is moving during the observations, stop, level back to the BM, note it in the notes and depending on where at in the process reset the bucket, level to the rod and resume water level observations.
7. Tip: set bucket into soft gravel or sediment at waters edge with enough room for water to rise or fall in the bucket for the duration of the water level check. Rising tide high water check, water at start should just cover pin enough to read on rod, Falling tide low water check water at start should be near top of bucket. If no soft sediment wedge bucket and for either case weight bucket by adding rocks.
8. Tip: person holding rod in bucket should not be the one reading the water level on the rod, need to read the rod straight on at bucket level.

Instructions for Levelling: Approximate time: locate bench marks, set-up, level loop 3 bench marks, tear down approximately 2 hours. For water level checks (BM to bucket) no side shots/intermediate shots.

1. A level loop to be run between the three CHS BMs at each site starting at one of the BMs and going through the other two BMs and closing back on the first BM. Use most stable BM to start and close level loop and use this same BM for the GNSS observations.
    a. Sanikiluaq: BM 90T9453 to BM 90T9454 to BM 90T9455 and return to BM 90T9453
    b. Coral Harbour: BM 1-1970 to BM 2-1970 to BM 3-1970 and return to BM 1-1970
2. A level loop for the water level checks at Coral Harbour. Level from BM 1-1970 (70T9506) to a fixed point in the water (bolt head in bucket or rock), then level back to BM 1-1970 (70T9506).
3. Form for levelling notes included in Appendix EE.
4. Assess and report on each benchmark condition at both sites (good, damaged, unstable), if damaged or unstable provide details and setting at Coral Harbour (vertical - post in ground able to set rod on top, horizontal - post is set in a vertical face such as a foundation or bedrock)
5. Tip: run the level loop and then set-up the GNSS occupation, then perform WL checks while 24 hour occupations are ongoing (for Coral Harbour).

Survey Activity and Deliverables for the shore based work:

1. GNSS occupations - observed raw data, field note forms, RINEX file and PPP solution output for both 24 hour occupations
2. Level Loops - levelling notes from level loops and water level checks (BM to pin in bucket back to BM).
3. Water level checks - notes with observed water level rod readings
4. Photos - GNSS set-ups, marker to ARP, BM occupied, BM’s in the level loop or established individually and an overview, and water level checks.
5. Any additional information that will add to the deliverables such as indicating weather conditions and sea state in notes where appropriate such as sea state for water level checks, bucket might have moved or condition of bench marks changed or other annotation.

Example Photographs of Water Level Checks

Levelling Example (Level loop WSC-2 to WSC-3 notes and sketch)

Levelling Example (Notes for water level check WSC-2 to Gnomon (fixed point) in water and sketch)

Level loop WSC-2 to WSC-3 notes and sketch

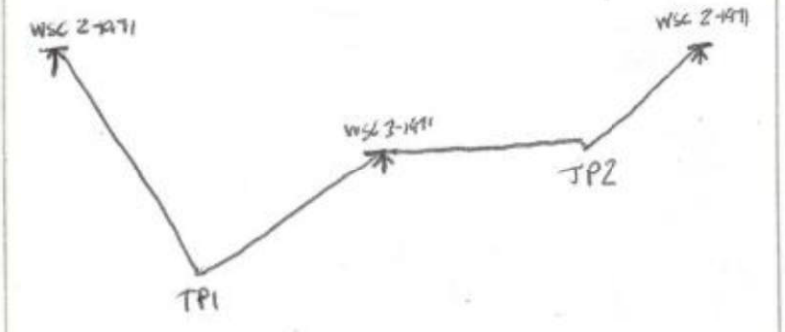
3940

Location: Clyde River
Page: 4 of 7
Inst no. 337402
Weather: Sunny light breeze 5km/h
Visibility: Good Clear
Line#: 00004

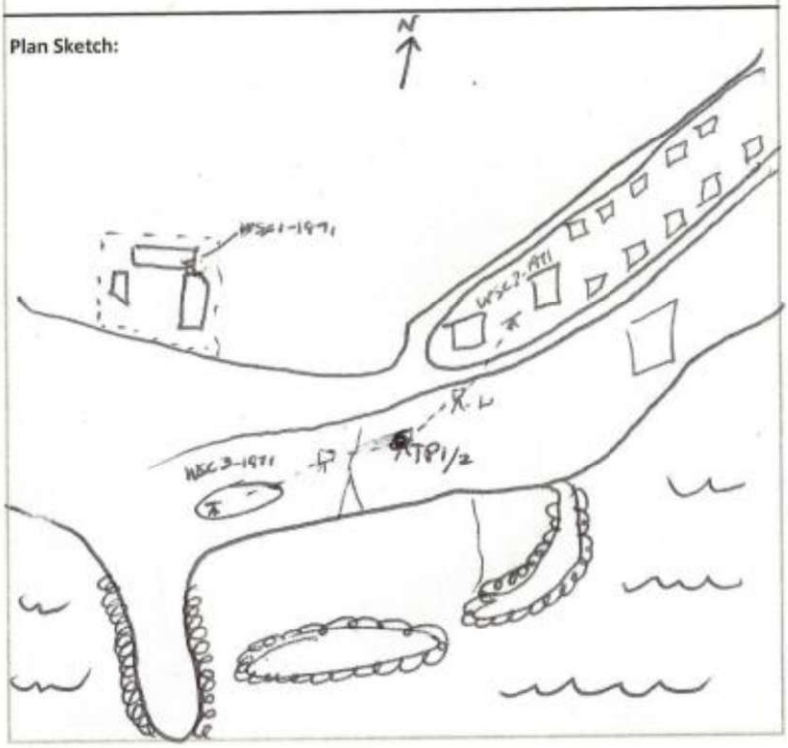
Date: 2018/08/12 (yyyy/mm/dd)
Observer: [redacted]
Rodman:
Recorder:
Job name: 3940Clyd .GSI

PtName	BS +	HI	FS-	Elevation	Comment
WSC 2-1979	1.5601			8.0002	
TP1			2.6294	6.9310	
TP1	1.2383			6.9310	
WSC 3-1979			0.7544	7.4149	
WSC 3-1979	0.7202			7.4149	
TP2			0.7220	7.4131	
TP2	2.1921			7.4131	
WSC 2-1979			1.6048	8.0004	
~~WSC~~					

Profile Sketch: LINE 00004



Plan Sketch:

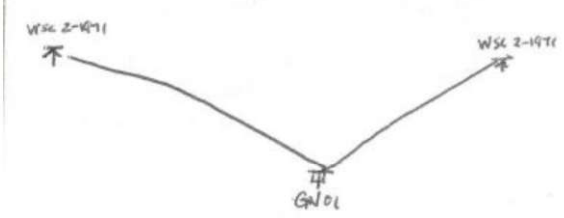


Notes for water level check WSC-2 to Gnomon (fixed point) in water and sketch

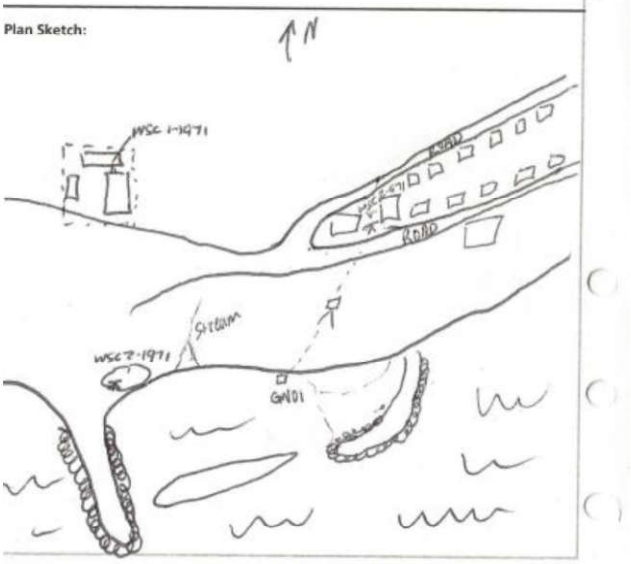
Location: 3940 Clyde River
Page: 5 of 7
Inst no. 337402
Weather: Diffuse + 10 kph wind
Visibility: GOOD
Line#: LC006
Date: 2015/08/12 (yyyy/mm/dd)
Observer:
Rodman: [redacted]
Recorder:
Job name: ety 3940 Clyde .GSI

PtName	BS +	HI	FS-	Elevation	Comment
WSC 2-1971	0.9577			8.0002	
GN01			3.6342	5.3237	WLC01
GN01	3.5288			5.3237	
WSC 2-1971			0.8523	8.0002	

Profile Sketch: LINE 00006



Plan Sketch:



APPENDIX DD – Pre-Established CHS Benchmarks

Benchmark photographs to be provided after contract award.

Sanikiluaq, NU (CHS Station No #4628):

Benchmark Number (Latitude, Longitude)

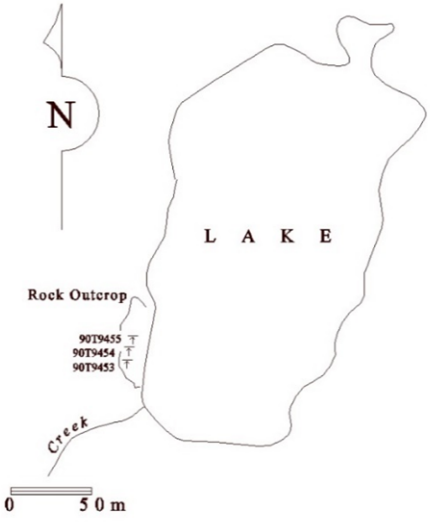
90T9453 (56.564908 º N, 79.170351 º W)

90T9454 (56.565 º N, 79.170417 º W)

90T9455 (56.565217 º N, 79.170317 º W)

Benchmark Details: https://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/twl-mne/benchmarks-reperes/station-eng.asp?T1=4628&region=CA

Station Sketch



Coral Harbour, NU (CHS Station #5180):

Benchmark Number (Latitude, Longitude)

1-1970 (70T9506) (64.130695 º N, 83.259214 º W)

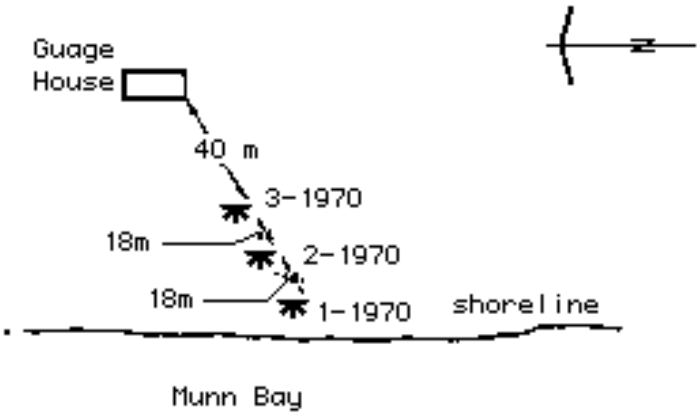
2-1970 (70T9507) (64.130732 º N, 83.258984 º W)

3-1970 (70T9508) (64.130782 º N, 83.258757 º W)

Benchmark Details: https://www.meds-sdmm.dfo-mpo.gc.ca/isdm-gdsi/twl-mne/benchmarks-reperes/station-eng.asp?T1=5180&region=CA

Located between the navigation aid and Snafu Beaches.

Station Sketch



APPENDIX EE – Field Forms

Levelling Field Form (1002-03-CF10C)

Water Level Check Comparison Field Form (1002-03-CF10D)

GPS Data Log Field Form (1002-03-CF10E)

Bench Mark Description Field Form (1002-03-CF10F)

RBR Data Logger Deployment Field Form (1002-03-CF10B) – Note this form is for the deployment of the barometer, which should be deployed on land.

GPS Data Log Field Form

Project Name: Location:

Receiver Model: Tide Stn. no:
Receiver SN: Station name:
Software Version: Benchmark no:
Date: *(yyyy/mm/dd)* Operator:

START Time: Time Zone: UTC
END Time: Time Zone: UTC

Initial Position — Lat:
Long:
dd-mm-ss.sss

Antenna Type:
☐ Trimble Zephyr Geodetic 2
☐ Other:

Antenna SN:
Masking Angle: 0°

Mast:
☐ Tripod ☐ 2 Sections ☐ 3 Sections
☐ Other:

Logging Interval: ☐ 1 Second ☐ 30 Seconds ☐ Both

Log File Name:

Height of Antenna Reference Point (ARP): ***True*** *or* ***Slope***

Before:		After:	
	m		m
	m		m
	m		m

Final ARP: m

Photos:
☐ Looking North ☐ Looking East ☐ Looking South ☐ Looking West
☐ Level Bubbles ☐ On Benchmark (BM# visible) ☐ Overview

Comments (sketch on back)

Version:1.0 1002-03-CF10E
Effective Date: 2019-03-01 TCWL Operations

GPS Data Log Field Form

Project Name: Location:

Receiver Model: Tide Stn. no:
Receiver SN: Station name:
Software Version: Benchmark no:
Date: (yyyy/mm/dd) Operator:

START Time: Time Zone: UTC
END Time: Time Zone: UTC

Initial Position — Lat:
Long:
dd-mm-ss.sss

Antenna Type:
☐ Trimble Zephyr Geodetic 2
☐ Other:

Antenna SN:
Masking Angle: 0°

Mast:
☐ Tripod ☐ 2 Sections ☐ 3 Sections
☐ Other:

Logging Interval: ☐ 1 Second ☐ 30 Seconds ☐ Both

Log File Name:

Height of Antenna Reference Point (ARP): True or Slope

Before: m After: m
m m
m m

Final ARP: m

Photos:
☐ Looking North ☐ Looking East ☐ Looking South ☐ Looking West
☐ Level Bubbles ☐ On Benchmark (BM# visible) ☐ Overview

Comments (sketch on back)

Notes:

Sketch:

Version:1.0 1002-03-CF10E
Effective Date: 2019-03-01 TCWL Operations

Notes:

Sketch:

Version:1.0 | 1002-03-CF10F
Effective Date: 2019-03-01 | TCWL Operations

Benchmark Description Field Form Station: Date:

CANADA HYDROGRAPHIQUE HYDROGRAPHIC SERVICE
BM ______

BM Name:______________________ Agency:____________________________

Condition:____

Latitude:______________________ Longitude:______________________

Setting: Horizontal ( ) Vertical ( )

CANADA HYDROGRAPHIQUE HYDROGRAPHIC SERVICE
BM ______

BM Name:______________________ Agency:____________________________

Condition:____

Latitude:______________________ Longitude:______________________

Setting: Horizontal ( ) Vertical ( )

CANADA HYDROGRAPHIQUE HYDROGRAPHIC SERVICE
BM ______

BM Name:______________________ Agency:____________________________

Condition:____

Latitude:______________________ Longitude:______________________

Setting: Horizontal ( ) Vertical ( )

Surveyor:____________________

(Descriptions & Sketches on Reverse)

Version:1.0 | 1002-03-CF10F
Effective Date: 2019-03-01 | TCWL Operations

Benchmark Description Field Form Station: Date:

CANADA HYDROGRAPHIQUE HYDROGRAPHIC SERVICE
BM ______

BM Name:______________________ Agency:____________________________

Condition:____

Latitude:______________________ Longitude:______________________

Setting: Horizontal ( ) Vertical ( )

CANADA HYDROGRAPHIQUE HYDROGRAPHIC SERVICE
BM ______

BM Name:______________________ Agency:____________________________

Condition:____

Latitude:______________________ Longitude:______________________

Setting: Horizontal ( ) Vertical ( )

CANADA HYDROGRAPHIQUE HYDROGRAPHIC SERVICE
BM ______

BM Name:______________________ Agency:____________________________

Condition:____

Latitude:______________________ Longitude:______________________

Setting: Horizontal ( ) Vertical ( )

Surveyor:____________________

(Descriptions & Sketches on Reverse)

Sketch:	**Station #:**_____ **Station Name:**_____
	Notes:
	BM Name:
	BM Name:
	BM Name:

Version:1.0
Effective Date: 2019-03-01

1002-03-CF10F
TCWL Operations

Sketch:	**Station #:**_____ **Station Name:**_____
	Notes:
	BM Name:
	BM Name:
	BM Name:

Version:1.0 1002-03-CF10C
Effective Date: 2019-03-01 TCWL Operations

Levelling Field Form

Location: _____ Date: _____
Page: _____ *(yyyy/mm/dd)*
Inst no. _____ Observer: _____
Weather: _____ Rodman: _____
Visibility: _____ Recorder: _____
Line#: _____ Job name: _____ .GSI

PtName	BS +	HI	FS-	Elevation	Comment

Version:1.0 1002-03-CF10C
Effective Date: 2019-03-01 TCWL Operations

Levelling Field Form

Location: _____ Date: _____
Page: _____ *(yyyy/mm/dd)*
Inst no. _____ Observer: _____
Weather: _____ Rodman: _____
Visibility: _____ Recorder: _____
Line#: _____ Job name: _____ .GSI

PtName	BS +	HI	FS-	Elevation	Comment

Profile Sketch:

Plan Sketch:

Version:1.0 1002-03-CF10C
Effective Date: 2019-03-01 TCWL Operations

Profile Sketch:

Plan Sketch:

Water Level Check Comparison Field Form

Location: _____ Weather: _____
Stn no: _____ Time Zone: _____
Date:*(yyyy/mm/dd)* _____ Gnomon Height: _____

Time	Staff / Rod Reading	Water Level (Staff + Gnomon)	Gauge (Pre/Obs)

Comments:

Version:1.0 1002-03-CF10D
Effective Date: 2019-03-01 TCWL Operations

Water Level Check Comparison Field Form

Location: _____ Weather: _____
Stn no: _____ Time Zone: _____
Date:*(yyyy/mm/dd)* _____ Gnomon Height: _____

Time	Staff / Rod Reading	Water Level (Staff + Gnomon)	Gauge (Pre/Obs)

Comments:

Notes:

Notes:

Version:1.0 1002-03-CF10B
Effective Date: 2019-03-01 TCWL Operations

RBR Data Logger Deployment Field Form

Inst SN _____ Location: _____
Popup SN _____ Latitude: _____
Release Code: _____ Longitude: _____
Station number: _____

Deployment Information:

Date: _____ Observer: _____
yyyy/mm/dd

Into the water:

Time: _____ Time zone: _____
Depth: (Max m) _____ Recording Interval: _____ min.

Resting on bottom:

Time: _____ Time zone: _____

Comments (sea state, wind, problems)

Recovery Information:

Date: _____ Observer: _____
yyyy/mm/dd

Out of the water:

Time: _____ Latitude: _____
Time zone: _____ Longitude _____

Comments (sea state, wind, problems)

Version:1.0 1002-03-CF10B
Effective Date: 2019-03-01 TCWL Operations

RBR Data Logger Deployment Field Form

Inst SN _____ Location: _____
Popup SN _____ Latitude: _____
Release Code: _____ Longitude: _____
Station number: _____

Deployment Information:

Date: _____ Observer: _____
yyyy/mm/dd

Into the water:

Time: _____ Time zone: _____
Depth: (Max m) _____ Recording Interval: _____ min.

Resting on bottom:

Time: _____ Time zone: _____

Comments (sea state, wind, problems)

Recovery Information:

Date: _____ Observer: _____
yyyy/mm/dd

Out of the water:

Time: _____ Latitude: _____
Time zone: _____ Longitude _____

Comments (sea state, wind, problems)

Notes:

Notes: