CANADIAN HYDROGRAPHER CERTIFICATION PANEL

CHCP – SELF ASSESMENT FORM

Surname: _____ ☐ Dr. ☐ Mr. ☐ Ms. ☐ Mrs.

First Name: _____

Please provide an Office or Residence address ☐ Office ☐ Residence

Company Name (if applicable): _____

Address: _____

City or Town: _____ Prov. / Terr. / State: _____

Postal or Zip Code: _____

Country: _____ Tel: _____ Ext.: _____

Email: _____

CBEPS Exemptions Requested are as follows:

- ☐ C1 – Mathematics
- ☐ C2 – Least Squares Estimation and Data Analysis
- ☐ C4 – Coordinate Systems and Map Projections
- ☐ C5 – Geospatial Information Systems
- ☐ C6 – Geodetic Positioning
- ☐ C7 – Remote Sensing and Photogrammetry
- ☐ C12 – Hydrographic Surveying
- ☐ E2 – Advanced Hydrographic Surveying

SELF-ASSESSMENT TOOL

HOW TO COMPLETE YOUR SELF ASSESSMENT FORM

You must complete the following self-assessment. This self-assessment will assist you in determining your knowledge and skill levels in each competency. Each competency is outlined on an individual page. You will assign yourself a score for each performance criteria using the rating scale (0-5); add up the assigned ratings and calculate your average score for the competency. Then list the kind of evidence you will provide to demonstrate that you have the knowledge and skills required for the competency.

FIRST: Read and become familiar with the Rating Scale. The Rating Scale is located at the top right corner of each competency form. The Rating Scale runs from 0 (you have no experience with this criteria) to 5 (you can successfully do this without assistance and lead
others in doing it).

SECOND: Assess your performance for a competency by rating your performance in the "Performance Criteria". First, review the competency you are assessing. Then, utilizing the "Rating Scale", provide a rating of your performance in each of the "Performance Criteria" that are listed. Place the rating you assign yourself beside the performance criteria in the Assigned Rating column.

THIRD: In the "Possible Evidence" Column, list any evidence of your performance in the competency you are assessing, for instance: relevant courses, workshops, workplace experience, etc. Do not provide any documents as evidence yet - just list what evidence you plan to provide.

FOURTH: Calculate an average rating for each competency at the bottom of the table. To determine your average rating, add up your assigned ratings, and divide the total by the number of ratings you added. Competencies include behaviours, knowledge, expertise and skills that have been mastered according to a set of standards as laid out in a particular field, discipline, job, or other area. These competencies are measurable and verifiable.

The starting point for the self-assessment is a candid, thoughtful appraisal of your level of competence related to the competencies and performance criteria. The form has been designed to help you compare your knowledge and skills to the competencies and
performance criteria for the four knowledge areas. Please check the level of performance which best describes your competence for each of the four knowledge areas. A rating scale has been designed and included on the Form to help you determine your level of competence in relation to the competencies and performance criteria provided.

SCALE : 0 1 2 3 4 5

RATING:

0 - Have no experience/knowledge with this.
1 - Have observed this or been familiarized to this.
2 - Can participate in and assist with this.
3 - Can do this with minimum assistance.
4 - Can successfully do this without assistance.
5 - Can successfully do this without assistance and lead others in doing it.

Carefully review the description and performance criteria for each of the areas. Using the self-assessment scale, record what you think is your present level of competence for each criterion. Make notes of possible sources of evidence in the right-hand column of **any particular tasks, projects, responsibilities, courses, training programs, specific equipment training, self-directed study in which you have participated that may help you demonstrate your level of competence**.

You may find that one piece of evidence is strong enough to demonstrate competence in more than one function. However, you will probably need more than one piece of evidence to demonstrate competence in any one area. Providing diverse sources of evidence to demonstrate your knowledge and skills is a critical element of the process.

Evidence to Support Competence

Direct evidence refers to products, reports, plans, and performances that you have created and produced. In most cases, direct evidence is the strongest evidence to support your claim that you really do have the knowledge and skills that you say you have in
relation to the competencies and performance criteria for the four knowledge areas. It is important that you collect as much direct evidence related to the competencies as possible in support of your claim of competence.

Indirect evidence generally refers to information about you and your achievements/competencies. Examples of indirect evidence include letters of validation written on your behalf by employers, supervisors, co-workers, members of professional associations, formal job evaluations, awards, commendations, etc.
Throughout the assessment process emphasis should be placed on ensuring that diverse sources of evidence are used i.e. **at least three sources for each of the competencies in each of the areas.**

C1 Mathematics

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) With respect to functions, continuity and limits	• define and describe mathematical functions, • define and illustrate continuity of a function at one point, and • define and evaluate mathematical limits.				
2) With respect to differentiation and applications	• define differentiability of a function at one point, • differentiate simple functions, and • interpret the derivatives of a function.				
3) With respect to integration, quadratures and applications	• define and describe integration of a function, • integrate simple functions, • describe indefinite and definite integrals, and • evaluate numerically definite integrals.				

4) With respect to plane curves, tangency and curvature	• formulate representations of plane curves, • describe the tangent to a curve at one point, and • describe the curvature of a curve at one point.				
5) With respect to sequences, series and Taylor expansions	• describe sequences and series, • define convergence of sequences and series, • formulate tests of convergence for sequences and series, and • perform Taylor series expansions of simple functions.				
6) With respect to partial differentiation and differential operators	• define and describe partial differentiation, • partially differentiate simple functions, and • define gradient and Laplacian operators and describe their applications.				
7) With respect to multiple integrals and numerical approximations	• define and describe multiple indefinite and definite integrals, and • describe numerical approximation techniques for multiple integrals.				
8) With respect to vector operations	• define and describe real and complex vectors,				

and analytical geometry	• evaluate scalar and vector products of vectors, and • express analytical geometry equations or formulae in terms of vectors.				
9) With respect to first and second order linear differential equations and solutions	• describe linear ordinary differential equations, • describe linear partial differential equations, • describe and execute solution methods for simple ordinary differential equations, and • describe and execute solution methods for simple partial differential equations.				
10) With respect to introduction to matrix algebra, linear equations and transformations	• describe matrices and simple matrix algebra, • express the matrix representation of linear algebraic equations and solutions, and • express the matrix representation of linear transformations.				
11) With respect to complex variables, linear spaces and subspaces	• define and describe complex variables, • describe linear real and complex spaces and subspaces, and				

	• express the projections in real and complex spaces.				
12) With respect to quadratic forms, orthogonal and unitary matrices	• define and describe quadratic forms and applications, and • define orthogonal and unitary matrices and describe their applications.				
13) With respect to spherical geometry and trigonometry	• define and describe spherical triangles, and • explain the methods for the solution of standard spherical triangles and the equations • involved and execute those solutions.				

C2 Least Squares Estimation & Data Analysis

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) Apply Knowledge of matrix theory, statistics and estimation	• conduct manipulation of matrix algebra involved in adjustment of observations, • linearize a non-linear system, • apply knowledge of probability and statistics, and • demonstrate an understanding of the principles of least square estimation and properties.				
2) Analyze measurement errors and modelling, perform random error propagation & pre-	• demonstrate an understanding different types of errors and their characteristics, • demonstrate an understanding different				

analysis of survey measurements	types of models and characteristics, • apply law of random error propagation to determine variance and covariance matrix, and • conduct pre-analysis of survey measurements.				
3) Formulate least squares adjustment problems (condition, parametric and combined cases)	• formulate parametric adjustment models (functional and stochastic), • formulate condition adjustment models (functional and stochastic), and • formulate combined adjustment models (functional and stochastic).				
4) Derive adjustment equations of different cases and conduct least square adjustment for geomatics problems such as levelling, traverse, triangulation and trilateration networks	• derive parametric adjustment equations, • derive condition adjustment equations, • derive combined adjustment equations, and • apply to geomatics problems such as levelling, traverse, triangulation and trilateration networks.				
5) Assess the quality of the adjustment	• estimate the variance factor,				

solutions (variance factor, variance-covariance matrix, error ellipse)	• determine variance-covariance matrix of parameters obtained from least square adjustment • demonstrate an understanding the concept of absolute and relative error ellipse and determine its major axes and orientation.				
6) Perform statistical tests on mean and variance to detect and identify outliers in observations (normal, Chi-square, t Student and F distributions, statistical hypotheses, type I and II errors)	• perform statistical tests on mean and variance to detect and identify outliers in observations, • determine the confidence interval of adjusted parameters, • select appropriate testing methods (normal, Chi-square, t Student and F distributions), • determine the confidence level and error probability of statistical decisions (significance level, test power, type I and II errors)				

C4 Coordinate Systems and Map Projections

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) Describe the celestial sphere and its main coordinate systems (Horizon, Right Ascension, Hour Angle, and Ecliptic).	• State the basic assumptions and approximations involved. • Identify the locations of the origins and the orientations of the coordinate axes. • Relate celestial spherical coordinates to Cartesian coordinates, celestial systems to each other, and celestial systems to terrestrial coordinate systems. • Explain major uses of each of the celestial coordinate systems.				
2) Interpret and apply time systems (sidereal, apparent and universal).	• Identify the characteristics of the time systems, their relationships and applications.				

	• Define epochs, intervals and time scales with regard to the time systems. • Select a time system and required corrections for a given situation.				
3) Describe the Earth-fixed coordinate systems (natural coordinate system and ellipsoidal coordinate system).	• Explain the specific properties of the coordinate systems. • Illustrate (showing the locations of the origins and the orientations of the coordinate axes) the different coordinate systems. • Explain the mutual relationships among the different coordinate systems				
4) Analyze the elements of celestial inertial coordinate system.	• Explain the importance of inertial reference system. • List different motions that must be eliminated from astrometric observations in order to define inertial frame of reference. • Relate Conventional Terrestrial (CT) system to Conventional Inertial (CI) system.				
5) Describe the orbital coordinate system	• Identify the characteristics (origins and directions of coordinate axes) and applications of the orbital coordinate system.				

	• Identify the elements involved in transforming satellite positions in instantaneous system to Conventional Terrestrial (CT) system.				
6) Discuss the characteristics and applications of spatial reference systems and spatial reference frames.	• Use the following terms correctly: coordinate system, spatial reference system, spatial reference frame, horizontal datum and vertical datum. • Explain the characteristics (origin, coordinate axes, etc) of commonly used reference systems (CSRS, ITRS); reference frames (NAD83, ITRF); and datums (NAD27, NAD83, WGS84, CGVD28, CGG20000 or latest version, hybrid datum, etc.). • Describe how reference systems and reference frames are defined.				
7) Demonstrate an understanding of the principles of map projections (including introductory principles of	• Identify the general problems of map projections (including edge-matching), the different models of the earth, and the uses and applications of map projections.				

derivation to enable critiquing of software output).	• Explain different map projection types with regard to different projection surfaces (or developable shapes), aspects, cases tangent and secant) and distortion characteristics (e.g., azimuthal, equidistant, conformal, equal-area, Tissot's indicatrix and scale factor). • Derive distortion characteristics (conformality, equivalency and equidistancy conditions, scale factor, etc.) from given mapping equations (from the reference sphere or from the reference ellipsoid, to the plane). • Use the graticule appearance of map projection and distortion theory to recognize and classify map projections. • Use general map projection selection guidelines to choose a suitable map projection for a region.				
8) Demonstrate an understanding of the characteristics of the Mercator projection.	• Identify the characteristics, appearance and applications of the projection.				

	• Use appropriate formulas to solve direct and inverse problems (geographic to grid and grid to geographic transformations), including loxodrome evaluations. • Use the appropriate formulas to compute the meridian convergence and scale factor on the projection plane.				
9) Demonstrate an understanding of the characteristics of the Transverse Mercator Projection and MTM projections (3 degree and 6 degree (UTM)).	• Illustrate the graticule appearances and the interrelationship of the following specific map projections: Transverse Mercator (TM); Universal Transverse Mercator (UTM) and its extensions; and Local Transverse Mercator (LTM), such as Transverse Mercator in 3-degree zones (3°TM). • Discuss the uses and applications of the projections. • Use appropriate formulas to solve direct and inverse problems (geographic to grid and grid to geographic transformations) for the TM, UTM and LTM projections. • Use appropriate formulas to compute the meridian convergence and scale factor				

	on the TM, UTM and LTM projection planes. • Carry out the reduction of angle (direction), azimuth and distance observations onto the TM, UTM and LTM projection planes.				
10) Demonstrate an understanding of the characteristics of the Stereographic Double Projection.	• Illustrate the graticule appearance of the projection. • Discuss the uses and applications of the projection. • Use appropriate formulas to solve direct and inverse problems (geographic to grid and grid to geographic transformations) of the projection. • Use appropriate formulas to compute the meridian convergence and scale factor on the projection plane. • Carry out the reduction of angle (direction), azimuth and distance observations onto the Stereographic Double Projection plane.				
11) Demonstrate an understanding of the characteristics of the Lambert Conformal Conic projection.	• Illustrate the graticule appearance of the projection. • Discuss the uses and applications of the projection.				

	• Use appropriate formulas to solve direct and inverse problems (geographic to grid and grid to geographic transformations) of the projection. • Use appropriate formulas to compute the meridian convergence and scale factor on the projection plane.				

C5 Geospatial Information Systems

RATING SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) Describe the concepts, principles, techniques and applications that are fundamental to GIS and that differentiate GIS and geographic science from other information systems, technologies and sciences.	• Define GIS terms as shown in the Glossary of GIS Terms in the appendix section of the essential reference. • Explain the basic concepts and principles associated with geospatial information management and systems, including how they differ from other information systems, and why. • Describe the functional basis of a GIS, including its classical three-tier architecture, • major system components, typical software components (functions), and how it works. • Explain how the real-world is represented based on a				

	feature model (i.e., point, line and area) in GIS. • Illustrate the range and diversity of GIS applications for solving real-world problems. • Describe the map projections and geo-referencing methods adopted in Canada and their importance to GIS. • Use common GIS techniques for spatial query, analysis, modeling, and related scientific computing.				
2) Explain the nature and characteristics of geospatial data, data representations, methods of data input and editing, and data organization and/or management in GIS.	• Explain the main characteristics (spatial and thematic) of geospatial data. • Differentiate the vector and raster methods of geospatial data representation. • Explain how topological data is created and handled in GIS by recalling the concept of topology and topological data structures in relation to geospatial data. • Illustrate how commonly-used data editing methods (such as generalization, edge matching, rubber sheeting, and address geocoding) work.				

	• Describe characteristics of DEM and TIN model. • Explain the concept of database, database management system, and how databases are linked to GIS following either relational database model or object-relational database model. • Outline GIS data modeling process by identifying and explaining the different levels of data abstraction (conceptual, logical and physical), data models and their features.				
3) Apply GIS concepts, principles and techniques to real-world spatial problem solving and mapping applications.	• Differentiate between data, information and knowledge. • Discuss the difference between spatial information retrieval and analysis. • Compare vector and raster data in terms of data storage, analysis and representation. • Explain common data query and analysis operations available in a typical GIS. • Perform attribute-based and location-based (spatial) queries. • Perform spatial analysis using vector-based and				

	raster-based buffering and overlay operations, and basic network analysis. • Categorize different spatial interpolation methods in terms of local vs. global and exact vs. inexact. • Discuss the characteristics of thematic maps (e.g., choropleth maps, dot map and graduate symbol maps) and general reference maps (e.g., topographic maps). • Explain the characteristics of measurement scales and their relationships to visual variables. • Apply basic cartographic principles, visual variables, and map symbology in map design and visualization in GIS. • Create process models for spatial (analytical) modeling under a set of constraints. • Demonstrate with examples how GIS analysis and modeling skills can be used to solve spatial problems				
4) Evaluate different GIS data collection approaches and data sources that require	• Describe the main sources of geospatial data and different GIS data acquisition				

the knowledge of data quality, data fusion, data exchange, metadata management, and other issues such as data pricing, data access policies, privacy, security, and organizational influences.	• methods, including digital terrain data. • Describe the types and sources of errors present in geospatial data. • Explain the main data quality indicators as included in most spatial data quality standards. • Outline the key data quality issues involved in using GIS. • Discuss the importance, possible usage, and components of spatial metadata as related to geospatial information management and GIS. • Explain briefly various types of standards related to geospatial information management and GIS. • Discuss why various data standards are important to GIS. • Use diagrams to explain how data interchange format works and the benefits of using a data interchange format.				
5) Design appropriate implementation procedures and GIS	• Discuss the issues of implementing GIS with special reference to: data,				

development strategies that follow the general principles of business modeling, software engineering, and project management.	people, technology and application. • Explain user requirements and how the user requirements may be acquired, defined and formally specified using a CASE tool or modeling language. • Recall the principles and methods of software engineering as applied to the development of GIS applications. • Contrast the benefits and shortcomings of using GIS in a specific application context. • Evaluate strategies, plans and procedures for implementing an effective GIS system. • Be aware of related organizational aspects (e.g., human resources, budget).				
6) Outline the new developments on web-based mapping services and GIS for better geospatial information dissemination,	• Describe the concepts of web GIS/mapping and web mapping services. • Describe different types of web mapping, including how their end users interact with client and server programs and their				

decision support and applications.	advantages and disadvantages. • Give examples of existing commercial web GIS/mapping software and online mapping services provided by the mainstream IT firms. • Compare between traditional GIS and web-based GIS and mapping services. • Identify some technical, organizational and social issues related to the development of web GIS/mapping and services. • Demonstrate the basic understanding of the implications of these new developments in geospatial information dissemination, decision support and applications.				

C6 Geodetic Positioning

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) Physical aspects of geodetic positioning	• Explain the basics of the physical concept of the Earth's gravity field and how it affects coordinate systems and observations. • Define the deflections of the vertical and evaluate their effects on positioning. • Define the concept of geopotential numbers and explain how geopotential numbers are obtained.				
2) Space reference systems	• Explain the establishment of a classical horizontal datum, a classical vertical datum. • Explain how modern 3D datums are established nowadays.				

	• Explain when and why there has been the evolution of datums in Canada: NAD27 – NAD83 – NAD83(CSRS) and the transformation between these datums. • Explain the relationship between NAD83(CSRS) and the different ITRFs and the transformation between these different 3D coordinate systems. • Explain the effect of plate tectonic on coordinates and their impact on the definition of coordinate systems and on transformations. • Explain the underlying principle of the upcoming new Canadian vertical datum and the differences compared to the existing one.				
3) Computation of coordinates	• Identify and select the appropriate coordinate system (either on a 3D space, on the ellipsoid or on the mapping plane) to be used in the				

	support of a specific geodetic application. • Reduce terrestrial observations (angular and distance measurements) collected on the Earth surface of the Earth relating them to the coordinate system chosen. • Perform coordinate transformation between the above-mentioned coordinate systems.				
4) Time scales and astronomy	• Define the difference time scales their realisation and relationships. • Explain the basic principles of the determination of astronomical latitude and longitude • Explain the basic principles of determination of astronomical azimuth. • Make observations, and determine values from them, on Polaris at any time for latitude or for azimuth, on Polaris at the optimal time for latitude or for				

	azimuth, on the Sun for latitude or azimuth.				
5) GPS and other GNSS	• Explain the complications of electromagnetic wave propagation in the conditions of ranging from an extra-terrestrial source to the surface of the Earth. • Explain the concepts and the constituents of a GNSS, • Explain the signal structure of GPS. • Define the different types of GPS observations, pseudo-range, and phase observables, their characteristics and the associated mathematical model. • Explain the different positioning modes (absolute, differential, RTK, PPP), and compare them in terms of observation methods, mathematical models, measuring procedure, receiver type, and achievable accuracy. • Explain the error sources and achievable accuracy				

	associated with each positioning mode. • Design a GPS survey for a given application. • Comment on recent developments (modernization of GPS and GLONASS, Galileo).				

C7 Remote Sensing & Photogrammetry

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) Introductory level of understanding	• ability to explain and illustrate the role of remote sensing and photogrammetry in mapping applications (image acquisition, image measurement, object reconstruction, and information retrieval). • the ability to work in a basic fashion with remote sensing imagery (optical, infrared, and microwave radiation), spatial transform (convolution), corrections and calibration (noise reduction, radiometric calibration, and geometric corrections), geometric manipulation (registration, geo-coding, and ortho-rectification), and thematic classification (supervised/unsupervised				

	classification and accuracy evaluation). • the ability to apply concepts and principles of determining spatial positions using photogrammetric techniques (e.g., machine-to-image coordinate transformation, space intersection, and space resection).				
	• perform mission planning for airborne sensing operations.				
	• assess geo-referencing data acquired with tools such as GPS and inertial technologies, • and control requirements in photogrammetric networks.				
	• assess the quality of different rectification methodologies (e.g. ortho-rectification, • polynomial rectification).				
	• discuss the concept of electromagnetic radiation and how it interacts with matter, • particularly land surface, oceans, and atmosphere.				
	• infer valid information from remote observations (e.g., electromagnetic spectra).				
	• apply the principles, techniques, and practice of the				

	quantitative analysis of digital imagery.				
	• demonstrate an understanding of remote sensing technologies and their spatial and temporal sampling characteristics.				
	• relate observations to models (mathematical, computational, and conceptual) of photogrammetric data.				
	• apply the concepts and principles of determining spatial positions using photogrammetric techniques.				

C12 Hydrographic Surveying

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) Underwater Acoustics	• **Acoustic Velocity:** Describe effects of the physical properties of water on the calculation of the speed of sound in fresh, mixed and sea water. Understand how to calculate sound speed from measurements of temperature, pressure (depth), and salinity (conductivity). • **Sound Wave Propagation:** Understand how sound wave refract and reflect as they propagate according to Snell's law. Describe Harmonic Mean Sound Speed and how it is used in single beam sounding reduction. • **Acoustic System Parameters:** Define frequency, wavelength, amplitude, beamwidth, pulse duration (pulse length), pulse repetition rate, detection threshold, bandwidth,				

	resolution, continuous wave pulse, Linear Frequency Modulated (CHIRP) pulse.				
2) Single Beam Echo Sounders (SBES)	• **Transducers:** Discriminate between the following types of transducers: narrow beam, wide beam, parametric. Explain methods of mounting transducers: hull, towed, over the side, and boom. • **Data Recording:** Differentiate between analogue and digital recording systems and media. • **Sounder Calibration:** Evaluate and select appropriate echo sounder calibration methods and equipment for specific applications. • **Sounding Reduction:** Explain and apply the reductions to measured depths due to water level variations, draft, dynamic draft (settlement, squat, fuel depletion, and buoyancy changes) and speed of sound in water. Evaluate and apply all appropriate factors affecting depth reductions for specific applications. • **Sounding Accuracy (or Error Budget):** Calculate and assess the uncertainty in soundings due to errors in the				

	positioning system, SBES, water level measurement, vessel motion, speed of sound in water, and seabed topography. Evaluate and select appropriate methods for controlling or reducing sounding uncertainty for specific applications. • **System Selection:** Identify SBES characteristics that affect performance in varying survey applications. Specify appropriate SBES characteristics (e.g. resolution, depth capability, frequency, bandwidth, beamwidth) for specific applications. • **Equipment Evaluation:** Understand the technical limitations of various SBES systems and understand how to select the appropriate system for a given requirement.				
3) Multibeam Echo sounder (MBES)	• **Multibeam Transducers:** Explain the basic principles of MBES transmit and receive beam forming and steering using flat or curved transducers. Describe the difference between beam forming and phase differencing multibeam systems. Understand the importance of sound velocity in determining sounding direction. • **Coverage and Accuracy (or Error**				

	Budget): Explain the dependence of depth coverage and uncertainty on bandwidth, beamwidth, swath width, beam elevation angle, grazing and incident angles, depth, pulse repetition rate, speed of sound in water uncertainty, vessel attitude and motion (speed, heave, roll, pitch, heading and yaw). • **MBES Calibration**: Explain the effects on depth and position uncertainty of errors in sensor locations, system latency and alignments within the vessel reference frame. Explain how to establish the vessel reference frame and sensor offsets and alignments. Define the "patch test". Select test area and lines to be run for "patch test". Calibrate the misalignments between transducer and motion sensor. • **Importance of Time:** Describe the importance of time synchronization in multibeam systems and surveys. Discuss how time can be managed. • **Importance of Motion:** Understand the effect of vessel motion on multibeam systems and how that motion can be measured. • **MBES Data Management:**				

	Describe issues affecting acquisition, processing, storage and retrieval of multibeam data. Explain methods for managing data quality. Specify and design a multibeam data management strategy for specific applications. • **Equipment Evaluation:** Understand the technical limitations of various MBES systems and understand how to select the appropriate system for a given requirement.				
4) Side Scan Sonar (SSS)	• **Side Scan Sonar Systems:** Describe the principles, geometry, and deployment of side scan sonar systems. Explain the effect on side scan sonar performance (range, resolution and target detection) of frequency, beam angle, range scale, gain, towing speed, and deployment (deep tow, shallow tow and pole mount). Evaluate and select appropriate side scan sonar frequency, features and deployment, for specific applications. • **Side Scan Sonar Data Interpretation:** Determine height and size of obstructions from sonar records. Describe sources of side scan image distortion. Explain sonar signatures of such items as debris, wrecks, pipelines, gas, fish and divers.				

	• **System Selection:** Identify side scan sonar characteristics that affect performance in varying survey applications. Specify appropriate side scan sonar characteristics (e.g. resolution, frequency, bandwidth, and beamwidth) for specific applications. • **SSS vs MBES:** Explain the differences between side scan sonar and similar data provided by MBES. • **Equipment Evaluation:** Understand the technical limitations of various SSS systems and understand how to select the appropriate system for a given requirement.				
5) Tidal and Non-Tidal Water Levels	• **Tidal Fundamentals:** Describe tide generating forces. Describe the major harmonic constituents. Identify and recognise the different types of tide. Define different tidal levels. Classify tidal regimes. • **Tidal Measurements:** Explain the principles of various types of water level gauges and poles. Describe characteristics of river, coastal and offshore water level gauges. Evaluate and select appropriate instruments and sites for water level monitoring. • **Tidal Streams and Currents:**				

	Describe the relation between streams and tides. Describe methods for measuring tidal streams and currents, including log ship, pole, current meters and ADCP (Acoustic Doppler Profilers). • **Tidal Information:** Predict water levels for main and secondary ports, using tide tables. Calculate water level at a particular time, and/or calculate the time at which a specific height will occur. • **Non-Tidal Water Level Variations:** Describe the temporal and spatial effects on water level caused by: atmospheric pressure, wind, seiches, and precipitation. Identify water level variations occurring in rivers and lakes, and due to dam operations. Evaluate and select appropriate locations for water level gauges in rivers, lakes, and near dams, for specific applications.				
6) Vertical Positioning	• **Previous Datums:** Describe the means of relating historical vertical datums, how these came about and their relationship with currently accepted Canadian reference				

	frames. Describe practical methods to confirm these relationships in theory and on site. • **Vertical Datum Fundamentals:** Explain and describe the characteristics of height systems (e.g. dynamic, orthometric and normal heights). Differentiate between gravity related and ellipsoidal heights. • **Datums:** Describe the role of, and methods of establishing, the various vertical datums used in hydrographic operations (e.g. Chart, Sounding, MSL, LAT, LW, and HW datums). Select, establish, interpolate and transfer datums in coastal waters, estuaries, rivers, and lakes for soundings and elevations. • **Elevation Measurements and Computations:** Describe methods for determining differences in elevation (e.g. by spirit level, vertical angle by theodolite, GNSS RTK and GNSS). Correct for effects of curvature and refraction, where appropriate. Compare and evaluate the observing methods and procedures for the determination of elevation. Select an appropriate system for specific applications. • **Heave:**				

	Describe the principles and limitations of heave compensation systems. Describe the role of filtering in making heave measurements. Evaluate and select appropriate heave compensation systems for specific applications. • **Orientation:** Describe the operation of heading sensors (e.g. flux-gate and other magnetic, fibre-optic and gyro compasses). Explain the principles of inertial roll and pitch sensors. Describe the principles and limitations of GNSS attitude sensors. Evaluate and select appropriate heading, roll and pitch sensors, for specific applications. Describe field alignment checking procedures.				
7) Understanding of Principles and Technology	• **Instrumentation:** Compare specifications of bathymetric systems SBES, MBES, SSS and other techniques. Explain the importance of the correct installation and determination of the attitude and position of each sensor. • **Operations:** Describe the roles of the following survey parameters: scale, positional				

	accuracy, survey speed, line orientation, interlines, cross lines, fix interval, data coverage. Explain methods for quality control of survey data, and the quality assurance of surveys. Describe cost estimating, and project scheduling. Create specifications for specific surveys, including appropriate requirements for scale, positional accuracy, survey speed, line orientation, interlines, cross lines, fix interval, and data coverage. Explain the methods to be used for quality control of survey data, and the quality assurance of surveys. • **Survey Data Processing:** Describe the requirements for processing of hydrographic survey data. Explain the use of Geographical Information Systems (GIS) within the marine environment. Explain the electronic charting concept as a special form of GIS. Describe the hydrographic applications of 3D modelling and visualisation.				
8) Hydrographic Surveys	• **Surveys in Support of River Crossings and Engineering:** Describe and distinguish between surveys for river crossings and bridge works.				

	• **Surveys in Support of Port Management and Coastal Engineering:** Describe and distinguish between surveys for dredging, environmental monitoring and hydraulics, including surveys at a large scale. Describe the methods and instruments used (e.g. geotechnical, magnetic, diving, and under water cameras). • **Nautical Charting:** Describe the purposes of nautical charting surveys for rivers, lakes and the near shore to ensure safety of navigation. Define the components of a nautical charting survey (general depths, wrecks and obstructions, shorelines, navigation aids, etc.). Describe the IHO S44 specifications for hydrographic surveys.				

E2 Advanced Hydrograpic Surveying

RATING (R) SCALE:
0. Have no experience/knowledge with this
1. Have observed this or been oriented to this
2. Can participate in and assist with this
3. Can do this with minimum assistance
4. Can successfully do this without assistance
5. Can successfully do this without assistance and lead

Competency	What Constitutes Competency Attainment	R	Documentation or Other Evidence for Proof	R	Assessor Comments
1) **Background and the Natural Environment**	• **Historical Context:** Describe the history of hydrography including the development of hydrographic related measurement units, the echo sounder, radio positioning, other physical means of positioning, and aids to navigation. Describe the historic role of offshore surveying related to the international oil and gas industry. • **Marine Environment Introduction:** Describe oceanic marine geology, seawater properties, and seawater circulation. Describe continental margin geology and seawater circulation and composition. Describe near shore geology and seawater circulation, and river fresh and seawater mixing.				

2) Underwater Acoustics	• **Acoustic Fundamentals:** Distinguish between plane and spherical waves. Distinguish between sound speed and particle velocity. Describe the Active Sonar Equation. Define acoustic units, intensities and sound levels. • **Acoustic velocity:** Calculate sound speed from measurements of temperature, pressure (depth), and salinity (conductivity). • **Sound wave propagation:** Describe how acoustic waves are generated, define source level. Explain the causes of propagation loss and list the differences in water properties that affect propagation loss. • **Ray Tracing:** Describe the effects of variation of sound speed in the water column on the path of sound rays through the water. Describe the basic principles of ray path development and analysis. Predict shallow zones and sound channels. • **Reflection and Scattering of Acoustic Waves:** Describe the characteristics of the seafloor and seafloor targets that affect the reflection of				

	acoustic waves. Define the characteristic impedance of an acoustic medium. Assess the effects of varying seafloor composition, texture, and slope on echo strength. • **Acoustic Noise and the Directivity Index:** Identify the sources of noise in the environment and describe the effect of noise on echo sounding. Define the directivity index. Calculate the effect on sonar range of a variety of noise conditions and sonar directivity circumstances.				
3) Single Beam Echo Sounders (SBES)	• **Transducers:** • List the transducer characteristics that affect beam width. Describe the piezo-electric principle and explain its application to transducers. Describe the arrangement of single element and multi-element array transducers. • **Data Recording:** Evaluate and select appropriate range, scale, and pulse repetition rate for specific applications. • **Equipment Evaluation**: Describe and provide an in depth analyze the technical performance of various SBES				

	systems and how to select appropriate system(s) for certain site conditions.				
4) Multibeam Echo Sounder (MBES)	• **Multibeam Transducers:** Explain the basic principles of MBES shading and focusing, using flat or curved transducers. • **Coverage and Accuracy (or Error Budget):** Estimate depth coverage and uncertainty, taking all factors into account. • **Object Detection:** Predict the nominal sounding density on the seafloor using available information for depth, vessel speed, beam dimensions, and total swath angle. Determine the beam footprint size and sounding spacing across the swath and assess the limitations and likelihood of detecting objects on the seafloor under varying surveying conditions. • **Backscatter:** Describe the generation of backscatter data and the various modes of backscatter recording (e.g., beam average, side scan time series, beam time series). Explain the concept of angle dependence and describe the signal processing steps required to obtain corrected backscatter				

	data for seafloor characterization. • **Equipment Evaluation:** Describe and provide an in depth analyze the technical performance of various MBES systems and how to select appropriate system(s) for certain site conditions.				
5) **Phase Differencing Bathymetry (Interferometry)**	• **Phase Differencing Systems:** Explain the principles and geometry of interferometry and phase differencing bathymetric sonars and the arrangement of transducer arrays. • **Deployment and Mounting:** Describe the options for deployment and mounting of phase differencing systems. • **Equipment Evaluation:** Assess the relative merits of multibeam and phase differencing systems for specific mapping applications in water depths from very shallow to full ocean depths.				
6) **Side Scan Sonar (SSS)**	• **SSS vs MBES:** Explain the differences between side scan sonar and similar data provided by MBES, interferometric multibeam or bathymetric side scan systems. • **Equipment Evaluation:**				

	Describe and provide an in depth analyze the technical performance of various SSS systems and how to select appropriate system(s) for certain site conditions.				
7) Sub Bottom Profiler (SBP)	• **Sub Bottom Profiler Systems:** Explain the effect on sub bottom profiler performance of frequency, resolution, gain, towing speed, and deployment (pole mount and shallow tow). Evaluate and select appropriate sub bottom profiler frequency, features and deployment, for specific applications. • **Sub Bottom Profiler Data Interpretation:** Describe the different types of sub bottom profilers and their application. Explain sub bottom profiler signatures of such items as typical river bed strata, debris, wrecks, pipelines, and gas. • **System Selection:** Identify sub bottom profiler characteristics that affect performance in varying survey applications. Specify appropriate sub bottom profiler characteristics (e.g. resolution, frequency, bandwidth, and				

	beamwidth) for specific applications. • **Equipment Evaluation:** Describe and provide an in depth analyze the technical performance of various SBP systems and how to select appropriate system(s) for certain site conditions.				
8) **Marine Magnetometer**	• **Marine Magnetometer Systems:** Explain the effect on marine magnetometer performance of frequency, resolution, gain, towing speed, and deployment (towed or held by diver). Evaluate and select appropriate marine magnetometer frequency, features and deployment, for specific applications. • **Marine Magnetometer Data Interpretation:** Describe the different types of marine magnetometers and their application. Explain marine magnetometer signatures of such items as debris, wrecks, and pipelines. • **System Selection:** Identify marine magnetometer characteristics that affect performance in varying survey applications. Specify				

	appropriate sub bottom profiler characteristics (e.g. resolution and frequency) for specific applications. • **Equipment Evaluation:** Describe and provide an in depth analyze the technical performance of various marine magnetometers and how to select appropriate system(s) for certain site conditions.				
9) Tide and Non-Tidal Water Levels	• **Tidal Fundamentals:** Describe the static and dynamic tidal theories. Explain the concept of amphidromic points and co-tidal charts. • **Tidal Analysis and Prediction:** Determine a preliminary sounding datum from observed water levels.				
10) Surface Positioning	• **Surface Positioning:** Describe total station, GNSS RTK and inertial navigation systems positioning for small survey launches and explain the issues and benefits of each. Describe GNSS systems for vessel positioning. Describe INS systems used for hydrographic and offshore surveys.				
11) Acoustic Positioning	• **Acoustic Devices:** Describe the purpose and operation of acoustic devices				

	such as: transponders, pingers, acoustic release (tripping) devices, speed of sound in water meters and acoustic Doppler current profilers. Select appropriate acoustic devices for particular applications.				
	• **Acoustic Positioning Systems:** Describe the principles of long, short and super short baseline acoustic positioning system modes. Describe signal structure, sources of error, and expected uncertainties for each mode.				
	• **Deployment and Calibration:** Describe the deployment and calibration methods for each mode.				
	• **Error Sources and Accuracy:** Predict and evaluate sources of error and expected uncertainties for each system and appropriate application for positioning diver(s), a towed body(ies), autonomous underwater vehicles (AUV), and remotely operated vehicles (ROV).				
12) Hydrometric Surveys (Streams and Rivers)	• **Hydrometric Surveys:** Discuss the requirements for and observations required including water level recording, and stream or river velocity and area of flow to compute				

	discharge. Describe the various aspects of hydrometric surveys including stream reconnaissance, site selection, station design and construction, instrumentation, gauge height measurement, discharge calculation, stage-discharge rating and discharge compilation.				
	• **Water Sampling:** Discuss the requirements for and the equipment and methods used to collect stream or river water samples.				
13) Other Techniques	• **Laser Bathymetry:** Explain the principles, capabilities and limitations of shipborne and submersible laser bathymetry. Select survey areas suitable for laser bathymetry.				
	• **LiDAR Bathymetry:** Explain the principles, capabilities, and limitations of bathymetric LiDAR. Describe the environmental and operational environments in which bathymetric LiDAR surveys are complementary to echo sounder surveys.				
	• **Remote Sensing Bathymetry:** Describe other airborne and satellite remote sensing techniques that can be used for				

	bathymetry. Explain the limitations and advantages of remote sensing.				
	• **Mechanical Techniques:** Describe wire and bar sweeps.				
	• **Other Data Capture:** Describe other data capture techniques including underwater laser scanning and synthetic aperture sonar.				
14) Meteorology	• **The Atmosphere:** Describe the vertical structure of the atmosphere.				
	• **Meteorological Elements:** Define the following parameters, explain how they are measured / classified and describe their effect on hydrographic operations: temperature, humidity, dew-point, frost-point, atmospheric pressure, clouds and precipitation, rain, snow, visibility, advection fog and radiation fog.				
	• **Winds:** Explain the relation between atmospheric pressure and winds, the origin of geostrophic winds and Buys Ballot's law. Describe wind circulation around pressure systems and the effect of friction.				
	• **Climatology:**				

	Describe the general circulation of the atmosphere and the global distribution of pressure systems, air and sea surface temperatures, winds and precipitation over the oceans, local circulation and land and sea breezes.				
	• **Weather Systems:** Describe the elements of a weather system and their evolution (e.g. air masses, extra-tropical cyclones, anticyclones and associated weather; fronts, clouds and weather at different stages of fronts; intertropical convergence zone, tropical revolving storms and associated weather).				
15) Oceanography	• **Physical Properties of Sea Water:** Explain the effects of solar radiation. Describe the optical properties of sea water. Explain temperature and salinity (T/S) distribution and variation. Prepare T/S diagrams.				
	• **Marine Circulation Dynamics:** Define types of circulation (e.g. geostrophic, wind-driven, Ekman spiral, slope currents, coastal and thermohaline). Explain the effect of friction.				

	• **General Circulation of the Oceans:** Define the general characteristics of climatic mean ocean currents. Explain the western intensification of ocean currents and the vertical circulation, along with their driving mechanisms.				
	• **Wind Waves and Swell:** Define wave parameters. Explain the elements involved in the wave growth process including typical fetches. Explain the relationship between winds, waves, swell, sea state (Beaufort scale), and icing conditions.				
	• **Wave Propagation:** Define, giving practical examples: refraction, diffraction and reflection. Explain breaking waves, and long-shore and rip current processes.				
	• **Oceanographic Measurements:** Describe oceanographic sampling, and methods for measuring common oceanographic parameters.				
	• **Oceanographic Instruments:** Describe principles of oceanographic sensors including temperature / salinity (T/S)				

	probes, current meters, wave sensors and acoustic Doppler current profiler. Select equipment for specific applications.				
16) Marine Geology and Geophysics	• **Marine Geology:** Describe various river and sea bed grabs, corers and samplers including cone penetration test (CPT) and their uses. Describe various types of dredging equipment.				
	• **Seismic Profiling:** Define the objective of continuous reflection / refraction seismic profiling, and the equipment needed to conduct it.				
	• **Geotechnical Sampling:** Define the objective of geotechnical sampling. Describe geotechnical sampling equipment. Explain how samples are obtained, stored, and analyzed.				
	• **Deposition and Erosion:** Identify types of seabed material. Describe the processes of sediment transport and deposition, as well as the normal fluvial process and formation of bars and other focal points of deposition.				

	Describe the methods of spoil dispersal and selection of spoil grounds.				
	• **Environmental Impact:** Outline the basic concepts of environmental impact studies. List applications (e.g. to water quality, sedimentation, coastal development, shipping, living and non-living resource development, etc.).				
17) Data Management	• **Real-Time Data Acquisition and Control:** Collect hydrographic data manually and automatically. Describe and operate integrated navigation systems and data logging systems. Explain the significance and effect of the use of various data logging rates. Describe the process of on-line data sampling, validation and selection techniques. Explain the effects of using various gating and filtering parameters.				
	• **Analogue Data Capture:** Explain the manual input of alphanumeric data, raster scanning processes and vector digitisation. Describe digitising systems and scanners. Describe digital data formats. Carry out digital data transfer.				

	• **Approximation and Estimation:** Apply approximation and estimation procedures to survey measurements. Evaluate and select the best filtering and / or cleaning procedure, for specific applications.				
	• **Spatial Data Processing and Analysis:** Describe the properties of spatial databases and Database Management Systems (DBMS). Explain the concepts of raster and vector data. Explain the concepts of Geographical Information Systems (GIS) and Spatial data Infrastructures (SDI). Recognize algorithms used for spatial data selection, filtering, smoothing, approximation, estimation, correlation and analysis. Describe Digital Elevation Models (DEMs).				
	• **Visualisation and Presentation:** Explain and perform manual and automatic plotting and contouring of hydrographic data. Describe the use of vector and raster digitising and plotting systems. Describe the				

	hydrographic applications of 3D modelling and visualisation.				
	• **Chart and Marine Cartography:** Describe the chart compilation and composition process and flow line including chart compilation, adding coastal topography, Canadian and international hydrographic publications and correction of charts.				
	• **Electronic Charts:** Describe Electronic Navigational Charts (ENC), and Electronic Chart Display and Information Systems (ECDIS) (concepts, components, impact on hydrography).				
18) Hydrographic and Offshore Surveys	• **Flood Plain Mapping:** Explain the forecasting of floods and low waters in rivers draining a large basin. Describe methods of mapping flood plains. Explain how surveying is done under flood conditions.				
	• **Nautical Charting:** Describe and analyse the IHO S-44 specifications with respect to offshore industrial surveys.				
	• **Drilling Support:** Describe the purpose and conduct of drilling support surveys including drilling rig				

	positioning, drilling rig anchor placement in congested areas, drilling rig leg sea bed inspections and the role of ROVs in such work. Define terms used to describe offshore hydrocarbon structures and drill rig equipment.				
	• **Marine Seismic:** Explain the principles and conduct of marine seismic surveys including towed streamer and gravity, transition zone and shallow marine, ocean bottom cable, ocean bottom node, and marine controlled source electromagnetic (CSEM) surveys and the role of ROVs in such work.				
	• **Site, Hazard and Environmental Surveys:** Explain the principles and conduct of site, hazard and environmental surveys including prior to shallow water seismic surveys, engineering surveys prior to platform installation, pipeline route selection, surveys prior to offshore drilling, submarine cable route selection and lay, baseline and monitor environmental surveys. Describe the role of MBES,				

	SSS, SBP, marine magnetometer and of ROVs in such work.				
	• **Pipeline Lay and Rectification Work:** Explain the principles and conduct of pipeline lay including pre-lay, lay, as-built, trenching and ploughing surveys; and any rectification work required such as dead man anchor deployment(s), pipeline defenses and pipeline crossing(s), and the role of ROVs in such work. Describe general pipeline inspection procedures e.g. leak detection, damage, scouring.				
	• **Structure Emplacement:** Explain the principles and conduct of construction support surveys including platform installation, platform as-built, platform dimensional control surveys, and the role of ROVs in such work. Explain the use of drilling templates.				
	• **Platform Decommissioning:** Describe gravity-based, pile-driven, guyed, floating, and tension-leg platforms. Explain the principles and conduct of platform decommissioning surveys including hazard				

	survey, decommissioning and platform removal, debris clearance and sea bed rectification, and the role of ROVs in such work.				
19) Hydrographic Survey Legal Aspects	• **Product Liability:** Describe the liabilities associated with nautical charting and the above offshore surveys and how these risks are mitigated.				
	• **Rivers and Lakes:** Describe provincial and federal legislation related to surveys over rivers and lakes.				
	• **Law of the Sea Development:** Describe the historical development of the Law of the Sea. Explain its influence on hydrographic surveying, marine scientific investigations, and environmental impact.				
	• **Near Shore and Offshore:** Describe the United Nations Convention of the Law of the Sea (UNCLOS), Canada's Oceans Act, and Canada's offshore boundary regime. Describe federal, provincial and territorial laws and regulations related to coastal and ocean management.				
	• **Marine Law:**				

	Describe applicable maritime law to Canada's rivers, lakes, near shore and offshore. Describe the basic process of marine accident investigations and court cases, in relation to hydrographic issues.				
	• **Marine Cadastre:** Describe the concepts and practicalities of a marine cadastre.				