Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Standards and Procedures

Prepared by

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for the

Resources Inventory Committee

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Abstract

This manual describes the Resources Inventory Committee (RIC) standard for Reconnaissance (1:20 000) Fish and Fish Habitat Inventory for British Columbia. The reconnaissance is a sample-based survey covering whole watersheds. It provides information regarding fish species distributions, characteristics and relative abundance. It also provides stream reach and lake biophysical data for interpretation of habitat sensitivity and capability for fish production. This manual presents all phases of the inventory, from pre-field data review to data compilation, and preparation of final reports and maps.

Acknowledgments

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The Resources Inventory Committee consists of representatives from various ministries and agencies of the Canadian and the British Columbia governments as well as from First Nations peoples. RIC objectives are to develop a common set of standards and procedures for the provincial resources inventories, as recommended by the Forest Resources Commission in its report "The Future of our Forests."

For further information about the Resources Inventory Committee and its various Task Forces, please access the Resources Inventory Committee Website at: http://www.for.gov.bc.ca/ric.

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Chapter 1.
Introduction

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1.1 Introduction

This manual describes the standards for Reconnaissance (1:20 000) Fish and Fish Habitat Inventory for British Columbia.

The Reconnaissance Fish and Fish Habitat Inventory is a sample-based survey covering whole watersheds (i.e., all lakes, stream reaches and connected wetlands within the watershed), fourth order or larger, as defined from 1:20 000 scale maps and air photos. This inventory is intended to provide information regarding fish species characteristics, distributions and relative abundance, as well as stream reach and lake biophysical data for interpretation of habitat sensitivity and capability for fish production. The drainage network for reconnaissance inventory is that depicted on the 1:20 000 Terrain Resource Information Management (TRIM) map base.

The Reconnaissance Fish and Fish Habitat Inventory consists of two components:

1. Fish: This includes identifying and mapping fish-bearing stream reaches and lakes, using both existing and new field information. Field inventory includes:
   - in streams: sampling for species presence and characteristics (e.g., size, age, relative abundance), stratified by channel type, with emphasis on species diversity and the determination of upper distribution limits; and
   - in lakes: sampling for fish presence in all field-sampled lakes, and for species composition and characteristics in primary or main lakes within the watershed.
2. Fish Habitat: This includes identifying and coding all waterbodies (at 1:20 000) and, where necessary, augmenting the mapped stream network:
   - in streams: identifying and characterizing all reaches (e.g., confinement, order, pattern, gradient), and recording site characteristics at a sample of reaches stratified by reach type. Field work includes classifying channels (channel assessment procedure [CAP] type), locating and identifying obstructions, describing riparian area properties (e.g., vegetation, presence of fisheries sensitive zones), and mapping critical habitat locations;
   - in lakes: identifying all lakes; determining lake size (i.e., surface area), elevation, and biogeoclimatic zone; characterizing lake riparian area (e.g., vegetation, land use, access); and assessing fish production potential. Field work includes:
     - for all field-sampled lakes, sampling to determine maximum depth, water quality (dissolved oxygen, pH, temperature, Secchi depth), and tributary presence;
     - for primary lakes, lake bathymetric characteristics, lake tributary quality, and additional water quality (e.g., nutrients, TDS, and alkalinity) to determine fish production potential.

The products of the reconnaissance inventory include watershed-based mapping (1:20 000) showing known fish species presence and predicted distribution, lake characteristics (e.g., surface area, depth), stream reach boundaries and characteristics (e.g., width, gradient), channel classification, and location and characteristics of obstructions.

Reconnaissance inventory products provide a suitable baseline of fish and fish habitat information for a range of uses in fisheries conservation and management. Reconnaissance level information can be used to help determine habitat capability for assessing the status of fish populations. Reconnaissance information is also suitable for identifying the location of critical and sensitive aquatic and riparian habitats for consideration in land and resource planning. Reconnaissance data are useful for determining the potential impacts of fish and fish habitat on access to resources (e.g., timber) and selection of best management practices. Data can be applied to initial Riparian Management Area and Lake classifications required under the Forest Practices Code at the strategic level (e.g., Timber Supply Review) and at the development planning level (e.g., to focus decisions regarding additional information requirements).

1.2 Fish and Fish Habitat Inventories

While the reconnaissance fish and fish habitat inventory provides the information required to meet the needs of many business drivers, it does not satisfy all fish and fish habitat inventory needs. It is important to understand what is intended by the reconnaissance inventory in relation to other types of fisheries inventories.

1.2.1 Business Drivers

In a broad sense, fish and fish habitat inventories provide information about fish distribution and population status and about the condition and capability of supporting habitats. The primary business driver comes from the joint objectives of BC Fisheries and MELP to build and sustain healthy and diverse fish stocks, including their habitats. There are numerous resource management issues that require inventory information at a variety of scales. Issues range from broad area planning, which requires general information on fish and fish habitats, to site specific fisheries management and impact assessments, where detailed data about a site or a fish population are necessary.

1.2.2 Inventory Types

In order to meet the various needs for fish and fish habitat information, including those of FRBC, a series of inventories and products are needed. The content and relations among these inventories must be understood in order to place the reconnaissance-level inventory into context. Fish species and habitat inventory intensity levels and relations are illustrated in Figure 1.1. Some inventory "types," in addition to reconnaissance, include:

1.2.2.1 Fisheries Information Summary System (FISS)

FISS is a standardized, systematic, province-wide compilation of office-generated, anecdotal and existing information about fish, fish habitat and fishing (resource use). The data set includes map-derived habitat information for all streams and lakes on 1:50 000 NTS maps and an extensive standardized bibliography. Summary results from reconnaissance fish and fish habitat inventory projects are included. FISS provides experienced staff with data to interpret values, capabilities and sensitivities for broad area planning and for ranking watersheds in order of priority for more detailed inventories. FISS is digital, fully georeferenced, and linked to the 1:50 000 BC Watershed Atlas for ease and flexibility of access and use.

1.2.2.2 Fish and Fish Habitat Overviews

These overviews add cursory field information to the FISS data set where very little is known (e.g., northern BC) and will also occasionally be required, primarily for prioritizing watersheds for more detailed inventories. Fish and fish habitat overviews generally cover very large areas (e.g., many watersheds) or species ranges.

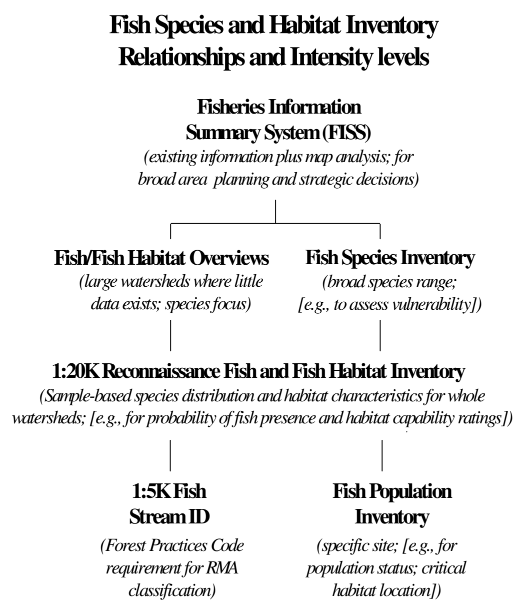

Figure 1.1. Fish species and habitat inventory relationships and intensity levels.

1.2.2.3 Fish species and population inventories

These inventories provide information vital to the protection and management of fish species and populations. In addition, these inventories address the BC government's responsibility under the Code to provide landscape level biodiversity objectives, to identify and characterize species at risk, and to determine measures required to protect critical habitats of those species that have been designated as identified wildlife under the Code. Fish species inventory provides information, over the broad species range, about fish abundance, distribution, life history characteristics and timing, habitat utilization and capability, and within-species diversity. It also aids in the process of defining units or measures for conservation. Population inventories are similar, but focus on detailed local information for species subgroups.

1.2.2.4 Fish Stream Identification

Fish Stream Identification (Fish Stream ID) is an example of what could be a series of intensive level inventories undertaken to address specific issues. Fish Stream ID addresses forest licensee responsibilities for the identification of fish-bearing streams as required for operational planning under the Code (e.g., silviculture prescription, road layout and design).

Fish Stream ID is required for all stream reaches that may potentially be affected by forest harvesting.

The reconnaissance inventory is intended to form the foundation for intensive inventories, such as Fish Stream ID, where fish species distribution and physical habitat data are required. The reconnaissance is intended to provide the 1:20 000 data required for strategic planning down to the level of the forest development plan. Fish Stream ID is then conducted where required to address the data requirements at the silviculture prescription and road layout and design planning levels for specific areas affected by forest harvesting activities.

In addition to providing data such as known fish presence, which is directly applicable to riparian assessments, the reconnaissance is intended to identify stream reaches where site-specific "drill down" may be required to determine fish presence. On the basis of a reconnaissance inventory, stream reaches can be described as having very high probability of fish presence, very low probability of fish presence, or something in between. Further requirements for site specific Fish Stream ID, in the context of the reconnaissance information, can be directed at those sites where fish presence is in question. This "drill down" has been endorsed as a practical approach to Code riparian classification for forest development and "stand level" planning (Mitchell and Agnew, 1996).

1.3 Reconnaissance Inventory Process

The Reconnaissance Fish and Fish Habitat Inventory follows a phased approach. Phases 1–3 (planning phases) can be found in chapters 1–2. Phase 4 (field phase) can be found in chapters 3–4. Phases 5 and 6 (data compilation, and final reports and maps) can be found in chapter 5.

Phase 1

Review and analyze existing data.

- Review FISS and other significant sources of relevant information.
- Determine the 1:20 000 drainage network and identify all streams with watershed/ waterbody identifiers. These identifiers are carried through the project and provide the link for inventory data.
- Transfer relevant information to working copy maps to be used in the reconnaissance inventory.

Phase 2

Identify and characterize *all* watersheds, stream reaches and lakes within the watershed by map and airphoto analysis. The inventory is intended to provide an understanding of fish distribution and habitat capability for whole watersheds. Classifying all waterbodies in the project area allows information collected at field-sampled lakes and stream reaches to be related to those lakes and reaches not sampled.

- Record data in the Field Data Information System (FDIS).
- Define watershed characteristics and reach boundaries, and record the reach characteristics for all streams in the project area. This information is sufficient to develop a sampling program and to subsequently extrapolate sampling results. Select reaches for field sampling following a statistical sampling design, adding discretionary reaches to cover biological (e.g., fish species distribution) and logistical concerns.

- Record lake characteristics for all lakes in the project area. Group and designate lakes as primary or secondary on the basis of location and connectivity within watersheds. Select primary and secondary lakes for field surveys.

Phase 3

Develop a project plan. This plan includes details of the proposed field sampling program, such as sampling design, sample site selection, sampling requirements, logistic considerations, and budget requirements to complete the field program and project reporting. The project plan should include all information required to adequately integrate the project with WRP projects, past inventories, and “species” type information needs.

Phase 4

Conduct the field inventory following the project plan. Sample and record data for primary and secondary lakes and selected stream reaches on working copy maps and standard FDIS data forms.

- Record stream site characteristics on a site card.
- Record lake characteristics on a lake survey form.
- Sample for fish at each reach site and at each primary and secondary lake, and record data on a fish collection form.
- Deliver collected samples of fish and/or water for processing.

Phase 5

Compile and quality assure all pre-field data, field data and post-field analysis results.

- Analyze field samples and enter results into FDIS.
- Convert interim locational points to watershed codes.
- Conduct quality assurance on the data and correct any errors.

Phase 6

Produce final reports and maps.

- Prepare individual lake inventory reports.
- Prepare a report for the entire watershed project area.
- Emphasize maps and data over extensive written descriptions.

1.3.1 Reconnaissance Inventory Tools

A number of tools have been designed to assist in the efficient delivery of high quality Reconnaissance Fish and Fish Habitat Inventory data.

1.3.1.1 Field data information system (FDIS)

Collection, acquisition and quality assurance (QA) of the immense volumes of data generated by inventory projects demand standardization and well-defined data management procedures. Both easy access to inventory data and its effective use depend on the presence of database management systems and a data management framework that simplify and automate data capture, QA, and ongoing data management.

The Field Data Information System (FDIS), is designed to enter, store, and retrieve data collected by the various phases of the Reconnaissance 1:20 000 Fish and Fish Habitat Inventory. FDIS is also designed to be used with other data tools, such as FishMap and

FHAT20, that analyze and map reconnaissance-level inventory data. The use of FDIS is critical to the effective use of reconnaissance inventory data.

1.3.1.2 Fish inventory mapping system (FishMap)

The Fish Inventory Mapping system (FishMap) is an ArcView extension designed for GIS data entry and map production for Reconaissance (1:20000) Fish and Fish Habitat Inventory projects. FishMap includes a number of programs and utilities designed to automate the steps required to complete the pre-field data collection (e.g. whole watershed stream, reach and lake information) and mapping components of inventory projects. FishMap is designed to be used with the Fish QA tool. Further information and user guide for Fish Map and the Fish QA Tool is available from the *Fish Inventory* web site.

1.3.1.3 Fish and fish habitat assessment tool (FHAT20)

While the reconnaissance inventory is intended to cover whole watersheds, time, money, and personnel are not available to survey every stream reach and lake in the watershed; therefore only a subset of reaches and lakes in the watershed is sampled. However, many planning processes require the development of products showing the extent of fish distribution or stream channel widths for the entire planning area, not just their distribution in sampled reaches and lakes. These products must be interpreted from the sampled-based inventory. The Fish and Fish Habitat Assessment Tool (FHAT20) is a computer program designed to analyze reconnaissance-level inventory data to produce a set of standardized interpretive products.

FHAT20 is an extrapolation program used to estimate fish habitat characteristics, fish presence and capability in non-sampled reaches based on their remote-sensed characteristics (derived from 1:20 000 scale maps and air photos) and models relating these characteristics to field-based observations in the sampled reaches. FHAT20 uses data stored in the Field Data Information System (FDIS), the standard reconnaissance inventory project database. The end product from FHAT20 is a set of predictions of channel characteristics (e.g., width) and probability of fish presence for all reaches in the project area. These predictions are used to estimate the most likely Forest Practices Code (FPC) stream class (S1–S6) for each reach and the level of certainty associated with each prediction.

FHAT20 has also been designed to produce the information necessary for the Interpretive Maps that are a component of the Reconnaissance Inventory. The *Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: User's Guide to the Fish and Fish Habitat Assessment Tool (FHAT20)* RIC provides further information.

1.3.2 Importance of Pre-field Work

Significant emphasis is placed on work done prior to the field inventory component; in particular, on the identification and classification of all lakes and stream reaches in the project area using map and air photo analysis, and in the development of a field project plan. The emphasis on preparation prior to initiating field surveys comes from the need for watershed-scale data. These data will permit extrapolation of field sampling information to areas that have not been sampled, for which maps and airphotos are the only information available. This extrapolation can only take place after standard watershed-scale data are available. A clear project plan is required for implementation and quality assurance (QA) of the field components.

1.3.3 Major Issues

Regarding the reconnaissance fish and fish habitat inventory methodology, several significant issues remain unresolved or incomplete at this time.

1.3.3.1 Map base

The drainage network as defined on TRIM and forest cover maps is an issue. Mapping for some areas of the province appears to have inadequate representation of the stream network, while in other areas this is not the case. Problems include:

- errors in the map base, and
- small streams that do not show up on the 1:20 000 scale map.

Any major errors to the map base should be noted and sent to Geographic Data BC. In general, small unmapped streams are best dealt with at the site level (e.g., fish stream identification). If significant concentrations of unmapped small streams are found, these should be noted during the field survey.

1.3.3.2 Watershed/waterbody identification at the 1:20 000 scale

Most fish and fish habitat information is spatial in nature and users commonly employ location as a primary access criterion and for data analyses. The 1:50 000 digital Watershed Atlas base and associated watershed/waterbody identifier system presently provides the only full-featured, province-wide foundation for the management, analysis and sharing of locational aquatic information. The 1:20 000 TRIM product has many desirable features including digital elevation data, but it currently does not contain the drainage network information and unique identifier system to support the full range of analyses. These standards require that all lakes and streams in an inventory project area be identified using the hierarchical system in the 1:50 000 Atlas. Until a TRIM watershed atlas is available, watershed/waterbody identifiers will be generated as required to adequately reference inventory projects. The 1:20 000 TRIM Watershed Atlas is currently under development and is available for some areas of the province.

1.3.3.3 Sampling design

The current design for stream reach sampling is based on statistical protocols that suggest a minimum sample size of between 11 to 30 reaches per watershed (and up to 100) will be needed to provide acceptable statistical confidence (at $\alpha = 0.8$) of our sampled estimates and proportions. When the sampling procedure is implemented for small watersheds (with low total numbers of reaches, e.g., 50 to 100), this will lead to a high sampling intensity (due to the minimum sample size required).

Investigation and refinement of the sampling design is in progress. One method to satisfy the requirements for minimum samples and avoid high sampling rates is to statistically evaluate the inventory findings over a broader area (e.g., multiple contiguous 5th and 6th order watersheds), thereby increasing the total population of reaches. This may require the inclusion of data for similar reaches outside your survey area.

Random sampling was chosen to enable statistically valid statements to be made about our estimates. Concerns regarding this manner of site selection include:

- requires sampling of isolated reaches, presenting significant access problems; and
- sample sites may be clustered in one or two basins.

Sampling design using basin classification alleviates some of the clustering problems associated with random sampling.

1.3.3.4 Channel classification

The reconnaissance inventory makes use of channel classifications developed for the CAP. These channel types provide information related to habitat suitability and capability for fish species, (e.g., as discussed in the FHAP manual). Research on this subject is ongoing. Until more information is available, the reconnaissance inventory includes comments that will assist users in interpretation of habitat information.

1.4 Quality Assurance (QA)

Delivery of high quality data demands that significant emphasis be put on quality assurance. Quality Assurance is applied to the inventory process through a combination of manual and automated checks that are applied by both the ministry and the contractor.

QA procedures are applied to all deliverables produced in the inventory process. In addition, field audits are conducted, to ensure that field data are collected and recorded to standards. Field visits are essential to ensure individual field crews are collecting data consistently and as intended by the standards. Verification of Fish identification is also required. Quality Assurance Procedures are discussed in the current *Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Quality Assurance Procedures* RIC.

It is important for the contractor to methodically check the quality of work during each of the phases of an inventory project. This practice will pick up errors as they are made, and prevent them from being carried through or compounded by successive steps in the inventory process.

To complement the methodical checks automated QA tools associated with the reconnaissance inventory are available. The advantage of these electronic QA tools is that computers can check all data very quickly. For critical data elements, where zero error tolerance is required to further use the data, electronic data checking is imperative. It should be noted however, that electronic error detection is unable, in all cases, to detect errors that fall within acceptable ranges. Electronic checks available include:

- The FDIS tool has a built in QA check, that must be used before the submission of deliverables. The FDIS QA tool generates a list of errors that must be corrected as appropriate. A final QA report indicating no errors exist must be provided as part of the QA deliverables.
- The Fish Quality Assurance Tool (Fish QA Tool) is an ArcView extension that will perform quality assurance tests on the GIS component of Reconnaissance Inventory deliverables. The Fish QA tool checks digital deliverables for mapping and some critical elements of FDIS. The Fish QA tool generates a list of errors that must be corrected in the digital mapping tables and in FDIS as appropriate. Information on the Fish Quality Assurance Tool is available from the *Fisheries Inventory* web site.
- The fish and Fish Habitat Assessment Tool (FHAT20) requires high quality error free data in order to run. Use of FHAT20 may uncover errors, particularly inn watershed codes, that may have been missed by other QA routines.

1.5 Qualifications and Training

In addition to fish biology, the reconnaissance inventory relies on airphoto interpretation and classification of channel types associated with the fields of geography and geoscience. The inventory requires the use of teams that combine staff with knowledge and experience in fish biology and physical geography or geomorphology. A registered professional biologist will be required to sign off each project.

1.6 Manual Layout

The Reconnaissance (1:20 000) Fish and Fish Habitat Inventory manual is structured as follows:

Chapter 1 – Introduction

Chapter 2 – Pre-field activities

- existing data review;
- stream reach and lake identification and characterization through map and air photo analysis; and
- development of a project plan.

Chapter 3 – Lake inventory field and reporting components

Chapter 4 – Stream site inventory

Chapter 5 – Fish and Fish Habitat Report preparation

Field guides, web sites, RIC Standards and other documents referred to in this document can be found in the References section. Additional information pertaining to the Reconnaissance (1:20 000) Fish and Fish Habitat Inventory not specifically mentioned in this document, can be found through the *Fisheries Inventory* web site (e.g., Frequently Asked Questions [FAQs], Technical Notes, and Example Products]. Web site references for information and materials specific to Fish and Fish Habitat Inventory can be found through the *Fisheries Inventory* web site, which can be accessed directly or found through the *BC Fisheries* web site.

Chapter 2.
Pre-field Phases

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2.1 Introduction

The Reconnaissance (1:20 000) Fish and Fish Habitat Inventory places considerable importance on aspects of the inventory carried out prior to field work. The whole watershed lake and stream reach classification provides the data necessary to predict fish distributions and habitat characteristics for the entire watershed project area from the sampled reaches. Chapter 2 provides information on procedures associated with the pre-field phases of a reconnaissance inventory, including the development of a field project plan. The pre-field phases are:

Phase 1. Review and analysis of existing data;

Phase 2. Lake and stream reach classification, and selection of lake and stream reach field sample sites; and

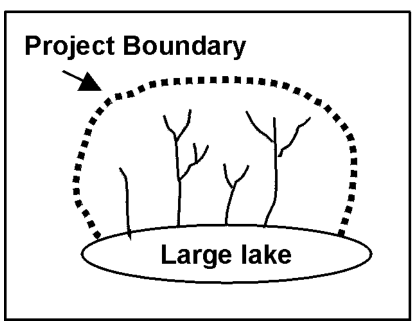
Phase 3. Development of a project plan.

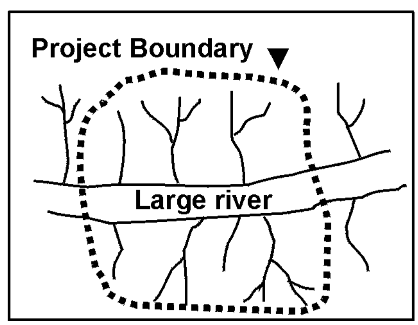
The project plan developed in Phase 3 is intended to provide a clear description of how the inventory will proceed, including the field activity, data compilation and project reporting phases. It is an important tool for project budgeting, scheduling and quality assurance.

2.1.1 Determining a Reconnaissance Inventory Project Area

The Reconnaissance Fish and Fish Habitat Inventory is a sample-based survey covering whole watersheds (i.e., all lakes, streams and connected wetlands within the watershed), fourth order or larger, as defined from 1:20 000 scale maps and airphotos. Planning and sampling design must be completed on this individual, whole watershed basis.

An exception to the single watershed rule are contiguous low order watersheds (first to third order) connected by a major body of water (large lake, or sixth order or higher stream):[1]





The large body of water must be included in the project design to provide continuity within the system. These exceptions must be discussed and approved by the Regional Fisheries Inventory Specialist.

Generally, projects should be between 1000 and 5000 reaches in size. Larger projects result in unmanageable data sets, and smaller projects result in large sampling rates. Any exceptions to this guideline must again be discussed with the Regional Fisheries Inventory Specialist.

[1] **Note:** These diagrams are intended as a visual aid only. In order to limit complexity, only a limited number of small order streams are shown—project areas should include more streams than shown.

2.1.1.1 Issues and Implications

The results of the fish inventory sampling design permit the application of fish habitat and fish presence/absence predictive modelling. Predictions will be applied for unsampled portions of the project watershed and will support such activities as Fish Stream Identification.

The ability of the model to function as designed requires whole watershed samples from a minimum of 1000 reaches. When disparate small watersheds are used, the ability to use network topology as a predictive tool is lost and the results of the predictive model are significantly compromised.

2.2 Project Referencing

All reconnaissance fish and fish habitat inventory projects must be referenced with a project code. The project code consists of a ministry-defined code and year, and is used on data forms, and in databases and reports.

The project code is in the format: R#-WSGR-CCCCSSSS-YYYY where R# represents the region number (e.g., 01, 04, 7A, etc.); WSGR represents the dominant watershed code (e.g., CHWK); CCCC represents a ministry defined inventory code (e.g., 0079); SSSS represents a ministry defined sub-code (e.g., 0002); and YYYY represents the year of the project.

This reference information is used to generate a project-specific set-up file for the Field Data Information System (FDIS). Contact the regional fisheries inventory specialist to obtain the reference codes for your project.

Send the project code, along with other contractor and project information, to BC Fisheries Information Services Branch in Victoria to obtain your FDIS start-up file. This file is required to set up FDIS for each new project—it contains such things as watershed codes and code tables. Consult the *Fisheries Inventory* web site for a list of the information required in your submission.

Other project coding (e.g., MELP and FRBC project numbers) may be required for reporting purposes. Formats and usage vary regionally. Contact the contract monitor for formats and usage in the project.

2.3 Phase 1 – Data Review

The initial step in a reconnaissance fish and fish habitat inventory is to review project objectives, and review and analyze all existing data. To this end, identify and collate existing data that is pertinent to project objectives. It is important in phase 1 to determine the 1:20 000 base map and drainage network that will be used throughout the inventory project. See Figure 2.1 for a listing of steps in the data review phase.

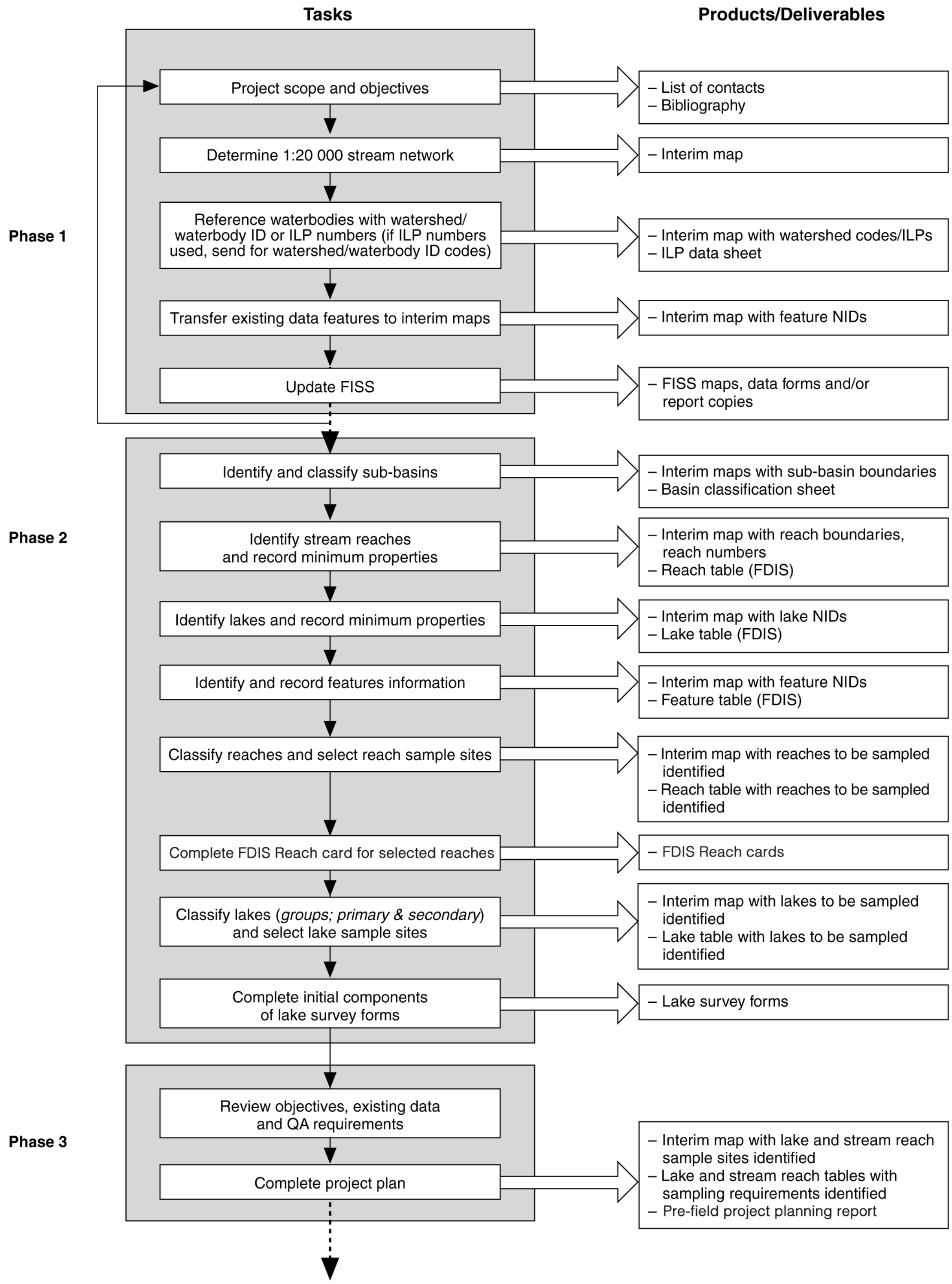


Figure 2.1. Flowchart of tasks and products for phases 1, 2 and 3.

2.3.1 Existing Information

All data pertaining to the project area must be reviewed thoroughly. This review will help to confirm that the planned inventory is needed and it will ensure that full use is made of previously collected data. Most available fisheries information has been compiled into the Fisheries Information Summary System (FISS). This should be the starting point for your review. FISS availability is discussed in Appendix 1, *Information Resources*.

Information from recent projects or significant sources that may have been missed in FISS, or may be more recent than the latest FISS update, should be sought. Contact regional fisheries staff regarding the status of FISS for your project areas. Also check FishWizard and the Fisheries Project Registry. Principle sources for information on lakes and streams in British Columbia are provided in Appendix 1.

Compile a list of contacts and references used during the data review phase, as a list of contacts and a bibliography are required as deliverables. The list of contacts must include the following information in a tabular format.

Contact number	Name	Title	Organization	Telephone number	Date	Comments

The bibliography should include all documents, reports, maps and project plans that are reviewed and/or used, in the format of a standard bibliography, as shown below:

DeGisi, J.S. and J.A. Burrows (1995) Reconnaissance Survey of Fleming Lake. Unpublished report submitted to BC Min. Environ., Lands and Parks, Fisheries Branch, Skeena Region. 41 pp.

De Leeuw, A.D. (1981) A British Columbia Stream Habitat and Fish Population Inventory System. BC Min. Environ., Lands and Parks, Victoria, BC. 23 pp.

BC Forest Company (1996) Forest Development Plan: TFL 9999. BC Forest Company Ltd., Specific Office, Township, BC.

2.3.2 FISS Updates

Individual projects may require that a copy of the fisheries information be provided, or may require that updated FISS data forms and maps be produced. Please provide the ministry with any relevant fisheries information collected during the pre-field phase that pertains to the project area and was not referenced in FISS. This will be incorporated into the FISS dataset. Procedures for completing FISS updates are provided in:

Fisheries Information Summary System: Data Compilation and Mapping Procedures, RIC.

2.3.3 Base Map and 1:20 000 Stream Network

The standard map base for reconnaissance fish and fish habitat inventory is the 1:20 000 Terrestrial Resource Information Management (TRIM) map. It is recognized that the quality of TRIM varies in terms of drainage networks, and that in some cases significant streams have been excluded. To address this issue, streams noted on 1:20 000 forest cover maps may be added to the TRIM network for reconnaissance inventory purposes. Sketch these streams on the TRIM base as accurately as possible.

2.3.4 Waterbody Referencing

The inventory requires that all streams on the 1:20 000 base map be identified using a unique watershed/waterbody identifier. The watershed/waterbody identifier is the essential link for all aquatic data in the inventory databases, and must be used on all data forms. Where there are no watershed codes, interim identifiers must be used. Provide watershed/waterbody identifiers for all water bodies in the project area. Use the following standard watershed and waterbody information to ensure data are properly referenced:

- Gazetted Name

The gazetted name is the official name of the lake, stream or wetland, as listed in the *Gazetteer of Canada for British Columbia* (Anon, 1985). If the waterbody is not gazetted, record ‘unnamed’ in the appropriate field.

- Alias

The alias is an unofficial or locally used name for the lake, stream or wetland. Obtain the alias from ministry archives containing old lake summary reports, regional MELP offices, or other local sources.

- Watershed/Waterbody Identifier System

The Watershed/Waterbody Identifier System is a computer-generated coding system that uniquely identifies watersheds and waterbodies in BC. It is a component of the 1:50 000 BC Watershed Atlas. The identifier has two parts; a watershed code, and a waterbody identifier. Depending on whether a watershed or waterbody is identified, one or both parts are used. For streams, only the watershed code is required for reconnaissance inventory purposes. For lakes, both watershed code and waterbody identifier are required.

Watershed Code is a 45-digit, 12-set array that uniquely identifies watersheds. The Watershed Code is a mandatory requirement for all aquatic data.

Waterbody Identifier is an alpha-numeric, nine-string of characters that uniquely identifies a waterbody within a watershed. It consists of five digits followed by a four-letter acronym of the parent watershed group. For the purpose of these inventories, the waterbody identifier is used for lakes and wetlands only.

Additional information on watershed/waterbody identifiers can be found in:

User’s Guide to the British Columbia Watershed/waterbody Identifier System, RIC.

or on the *Fisheries Inventory* web site.

- Interim Locational Points

The Watershed/Waterbody Identifier System is based on the aquatic features discernible at the 1:50 000 scale. While the system can be used at mapping scales of 1:20 000, many watersheds and waterbodies at this scale lack identifiers. Where an identifier is not available, assign an interim locational point (ILP) and use it until one can be generated.

Requirements for generating watershed codes and waterbody identifiers from ILPs include a 1:20 000 map and an ILP data sheet (separate sheets for lakes and streams) linked by:

1. Project Code: inventory project code obtained from the regional fisheries inventory specialist (e.g., 04-ELKR-333333333-1997).
2. ILP Map Number: The mapsheet number of the map used to assign ILP numbers.
3. ILP Number: A user defined number unique to any particular point on the map sheet (Note: This is a five-digit numeric field – e.g., 00023).

Full requirements of the ILP data sheets are presented in the reconnaissance inventory procedures below.

- Geo-referencing

Use the universal transverse mercator (UTM) coordinate to identify the location of the lake, stream or wetland, and/or the sampling site as described below. UTM coordinates are recorded as three sets of numbers: zone – easting – northing, separated by periods. Obtain UTM coordinates from the 1:20 000 map sheet or global positioning system (GPS).

  - For stream reaches, use the UTM of the upstream reach break.
  - For sampling sites in stream reaches, record the UTM coordinates of the downstream end of the site.
  - For lakes, the UTM normally refers to the location of the inlet stream on the lake. If there is more than one inlet, use the main inlet, and in cases where no inlet is present, use the UTM of the geographic centre of the lake.
  - For sampling sites in lakes, the UTM coordinates are recorded from the approximate centre of the site.
  - For features with a linear extent, the UTM is for the downstream end.

- Numeric Identifiers

Each mapped feature, including features listed in section 2.3.5, *Mapping* (i.e., reach breaks, sample sites, etc.,) must be locationally referenced. This may be done by recording the UTM of the feature, *or* by assigning a unique numeric identifier (NID) to the feature. Numeric identifiers include the mapsheet number, referred to as the NID map number and the NID. The NID map number and NID together provide a unique identifier to link locational data recorded on the interim map to attribute data recorded in the database. All NIDs must have a UTM for phase 5 and 6 deliverables. Record the NID for a mapped feature on the interim map. Record the NID and NID map number with the attribute data associated with the mapped feature. All data forms and cards (e.g., reach table, reach form, site cards) include the NID and NID map number fields. As reaches may not have yet been determined, feature information (such as height of a falls, or length of a cascade) is included on the map and later entered in the reach table once reaches have been identified. See section 2.4.4.3, *The FDIS reach table*, for details on completing the reach table.

- Determine the mainstem for ILP assignment

To determine the mainstem for ILP assignment, first check the watershed atlas and use what that gives you. If the atlas does not include your streams, assign the mainstem to the stream with the gazetted name. If the stream is unnamed, follow these rules for mainstem assignment:

  - above the stream fork, try to pick as the mainstem the branch that appears to have the greatest perennial discharge. Determine this by inspecting for the following:
    - stream forks at end of valley – pick the longest fork as the mainstem, unless there is a lake >5 ha at the head of one. If so, pick that one (unless the fork is >30% longer, or is somewhat longer and has a tributary, then pick that fork).
    - stream forks at the end of the valley, with the same length on each fork – pick as the mainstem the fork with the lake at the head, even if it is tiny.
    - stream forks at the end of the valley, with the same length on each fork – pick as the mainstem the fork whose course is closest in trend to the other streams in the valley.
    - stream forks at the end of the valley, with the same length on each fork, but one has a tributary – pick as the mainstem the one with the tributary.
    - stream forks near the end of the valley, with the same length on each fork and neither stream has a course that follows the valley trend – pick the fork with the largest watershed.

2.3.4.1 Reconnaissance inventory procedures

It is recognized that obtaining watershed/waterbody identifiers for all waterbodies on a 1:20 000 map can be a time consuming process. To reduce time requirements in the pre-field phases of the reconnaissance inventory, ILPs may be used in place of watershed/waterbody identifiers. If ILPs are used, they *must* be replaced with watershed codes prior to loading data into the standard provincial inventory databases. The procedure for using ILPs follows:

1. Create a 1:20 000 map of the project area with ILPs for streams. Two (2) copies are required; one for use as the interim map to carry on with the inventory project, and one ILP map for use in generating watershed codes.
2. Generate ILP data sheets: one for streams; and one for lakes. Take care to ensure ILPs recorded on the map are consistent with the ILP data sheets. The ILP data sheet provides a record of ILPs assigned by project for use in generating waterbody identifiers and for assigning additional ILPs as required later in the inventory project.

   On the ILP data sheets, note that for streams, the UTM in the ILP data sheet (Streams) refers to the UTM of the stream mouth. For lakes, the UTM in the ILP data sheet (Lakes) refers to the location of the outlet (use the ILP just as you would the watershed code for lakes). Refer to the *User's Guide to the British Columbia Watershed/Waterbody Identifier System,* RIC for information on the ILP data sheets.

3. Send the ILP map and ILP data sheet to the ministry contact for watershed code assignments. Note that the mandatory fields in ILP data sheets must be filled out completely.[2] This includes UTM coordinates for all ILPs.
4. Record separately ILPs assigned at later stages of the inventory. Submit these as a smaller watershed/waterbody identifier request as required.

2.3.5 Mapping

Transcribe all relevant information and features found during the data review phase to the interim maps for use during the inventory project. Relevant information includes:

1. fish sampling and distribution information – sample sites, known upstream/downstream distribution limits, etc.
2. falls that may act as obstructions to fish movement;
3. chutes or cascades that may potentially act as obstructions;
4. culverts and other stream crossings that potentially alienate fish habitats;
5. major beaver dams;
6. logjams and sediment wedges;
7. landslides or major erosional events that affect the channel;
8. evidence of subsurface flow;
9. enhancement activities; and
10. other information that may affect the sampling objectives and plan – regionally determined.

Exercise care to only transfer information that has potential importance for the current inventory program.

2.3.5.1 Interim map(s)

Interim maps are the working copy maps developed and used throughout the inventory project. Features are added as required following the inventory phases. At the conclusion of Phase 1 – Review and Analysis of Existing Data, interim maps should include the following:

1. interim locational points (ILPs);
2. known watershed code/waterbody codes for all waterbodies with information (streams, lakes, and connected wetlands); and
3. known features from data review, referenced with NID/NID map numbers.

Prepare interim maps in accordance with the mapping standards provided in the *Standards for Fish and Fish Habitat Maps,* RIC. Symbols and codes may be drawn by hand.

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[2] An electronic (Excel or compatible spreadsheet), and hard copy of the ILP table containing only those ILPs that do not have watershed codes and associated maps (1:20 000, full sheets) must be sent to the ministry contact for watershed code assignments as soon as possible. If the excel file is too large, it can be zipped using either PKZIP or WINZIP. Mandatory fields in the table include MAP#, PROJECTID, ILP#, TRIM FEAT., and any COMMENTS that will aid in locating the ILP/stream on the map. For complex areas where there may be any confusion about which stream an ILP is associated with, NAD, UTM ZONE, EASTING and NORTHING are also required. It is highly recommended that wherever possible, UTMs be included. This will decrease the time required to respond with new watershed codes.

2.4 Phase 2 – Classification and Sampling Design

Identify all lakes and stream reaches in the project area and classify and map each one using maps and air photo analysis. Using a statistical sampling design, select stream reaches that are to be sampled in the field. Add additional sample sites as required to adequately cover species distribution concerns. Figure 2.1 presents the steps in the classification and sampling design phase.

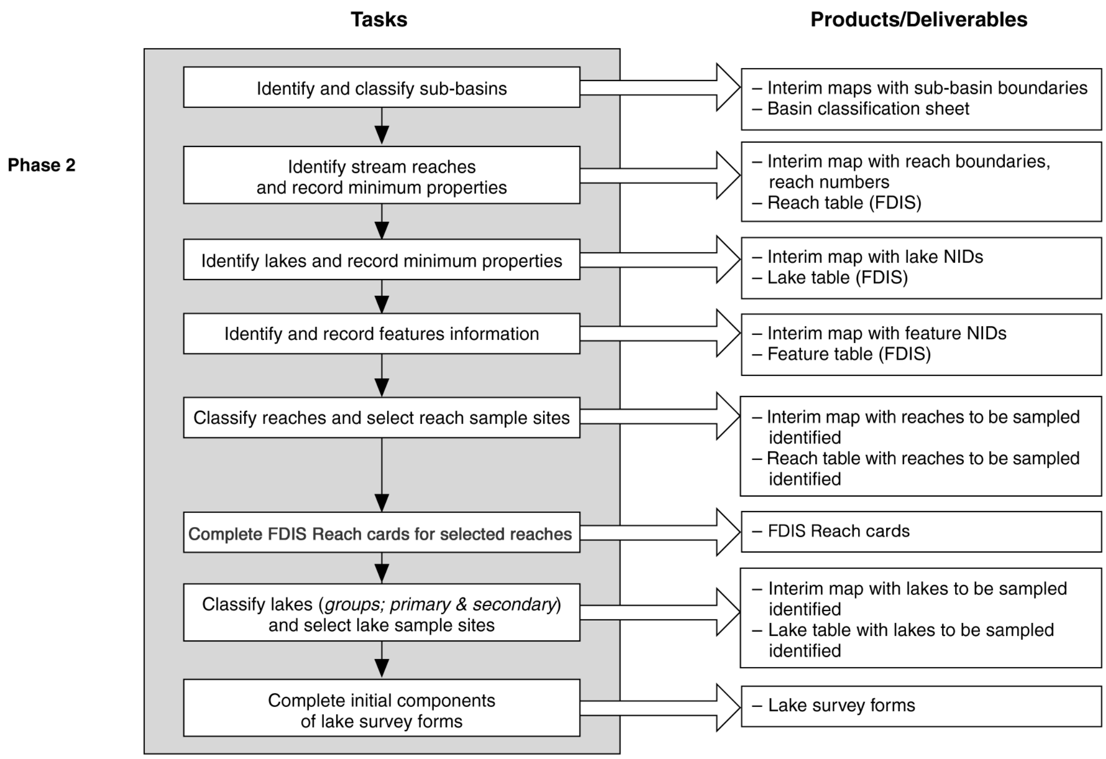

Figure 2.2. Phase 2 steps.

The inventory is intended to provide an understanding of fish distribution and habitat capability for whole watersheds. It is not often possible to sample all lakes and stream reaches in a watershed in a reconnaissance survey. Classifying and recording data on all waterbodies in the project area allows extrapolation of the collected information to unsampled reaches.

The sampling framework is designed to classify watersheds (sub-basins), lakes and stream reaches (and wetlands), and then sample within these types. It is assumed that reach channel types and associated habitat characteristics are consistent within each class. Conduct fish species distribution sampling at randomly selected sites, and at additional sites, for example, in reaches above and below barriers, and adjacent to lakes, to help characterize fish species presence and distribution limits.

Consider wetlands connected to the drainage network as either a stream (if it has confined drainage channel flowing through it), or a lake (if it is a shallow, open waterbody or has unconfined flow).

2.4.1 Maps and Air Photos

The base maps for reconnaissance fish and fish habitat inventory are 1:20 000 TRIM, and are used for planning purposes, data collection and as the base to display inventory data. Use forest cover maps, terrain maps and aquatic biophysical maps for other activities such as reach classification, determining access and planning field logistics.

Select the most recent air photograph(s) at 1:20 000 scale or larger, which should reflect the current status of the area, for lake and stream reach classification. Black and white (and some colour) air photos are available through Geographic Data BC. Also, check the *Geographic Data BC* web site for lists of maps and air photos suppliers.

Additional information regarding the use of air photos can be found in *Aerial Photography and Videography Standards: Applications for Stream Inventory and Assessment*, RIC.

Maps and air photos may not allow you to observe the channel or the full complement of reach features (e.g., some of the characteristics on the FDIS reach card). However, in the worst case scenario, the characteristics required on the reach table may be interpreted using maps and poor (or no) airphotos. When this occurs, a helicopter overflight can help you obtain the appropriate reach information. The information collected on a helicopter fly-over is useful for Phase 2 and Phase 4 activities. If required, discuss this with the project manager. See section 2.5, *Special planning requirements*, for more information regarding helicopter surveys.

2.4.2 Sub-basin Classification

Classify all sub-basins in the project area to ensure that the sampling design encompasses as many basin physiography types as possible. This is a visual procedure and no measurements are required. However, some measurement may be taken for QA purposes. Check with contract monitor for requirements. Use the following procedure to classify sub-basins:

1. Delineate (i.e., sketch) watershed boundaries in the project area on the interim maps.
2. Identify the mainstem(s) of third order and higher drainages.
3. Reaches with an order of 4 or higher may be given basin class 10 as a default.
4. Identify and delineate all third order basins.
5. Identify and delineate first and second order basins discharging directly into fourth order or higher mainstems.[3]
6. Classify delineated basins as shown in the diagrams and flow chart in Appendix 2, *Watershed classification*. Visually estimate flow chart parameters, starting at the top of Figure 1 in Appendix 2 (subjectively – by comparison to basin diagrams and using rough visual estimates of parameters).
7. Record information in the FDIS reach table when appropriate.

[3] At the discretion of the contract monitor, boundaries of first and second order basins may be left off interim maps to reduce clutter. A sample of these boundaries should be shown for QA purposes.

2.4.3 Waterbody Identification

All waterbodies within the project area must be identified as lakes, streams or wetlands. The waterbody identification forms the basis for the development of stream reach and lake tables. Consider each waterbody, including lakes and connected wetlands, a separate reach for the purposes of sampling designation.

A stream is defined as a reach , flowing on a perennial or seasonal basis having a continuous channel bed, whether or not the bed and banks of the reach are locally obscured by overhanging or bridging vegetation or soil mats, if the channel bed:

i. is scoured by water, or

ii. contains observable deposits of mineral alluvium.

The primary feature for determining whether a watercourse is a stream is the presence of a continuous channel bed. If a continuous channel bed exists, then either one of two other key features must be present demonstrating fluvial processes; that is, where flowing water has:

i. scoured the channel bed, or

ii. deposited any amount of mineral alluvium within the channel.

Water flow in the channel may be perennial, ephemeral (seasonal), or intermittent (spatially discontinuous). For further elaboration, refer to the Forest Practices Code (FPC) *Fish-stream Identification Guidebook*, 1998.

A lake is an open waterbody with a depth greater than 2 m and with less than 25% of its surface area covered with wetland vegetation. By default, any open waterbody less than 2 m deep is a wetland. In many cases it may not be possible to distinguish shallow, open wetlands from lakes using airphotos; therefore, review and complete your determination of lake/wetland status in the field.

A wetland is an area where the water table is at, near, or above the surface, or where soils are water saturated for a sufficient time so that the principle determinants of vegetation and soil development are excess water and low oxygen. List connected wetlands in the lake or stream reach tables depending on how they are to be treated for field sampling. Consider all shallow, open water wetlands part of your lake inventory. Include other wetland types, with distinct ‘channels’ flowing through them, in your stream inventory.

2.4.4 Stream Reach Sampling Design

Three of the following sections describe stream reach identification, numbering, determination of sample size, and identification of sampling sites.

Record reach characteristics for all streams in the project area. Initially, record a set of parameters sufficient for:

1. development of a sampling design, and
2. subsequent extrapolation of sampling results.

Select reaches for field sampling using a statistical sampling design (see Chapter 1, section 1.3.2.3, *Sampling design*). Increase sampling as required to cover biological (e.g., fish species distribution) and other concerns. Once selection is complete, record the detailed reach characteristics as listed on the reach form.

2.4.4.1 Stream reach identification

A stream reach is a relatively homogenous length of stream having a sequence of repeating structural characteristics (or processes) and fish habitat types (c.f., *Fish-Stream Identification Guidebook,* FPC).

For the purposes of this inventory, the minimum reach length is 100 m (0.5 cm on a 1:20 000 scale map or airphoto).[4] Delineate reaches based on all available data sources, including at a minimum, the most recent airphotos and maps at a scale no smaller than 1:20 000. Use the following key physical factors to determine reaches:

- channel pattern,
- channel confinement,
- gradient, and
- streambed and bank materials.

Stream reaches generally show uniformity in these characteristics and in discharge.

Reach boundaries usually occur at:

1. Significant changes in stream channel form or confinement (and/or coupling), such as the change from a single channel to braided, multiple channels, or at the change from a wide floodplain to a confined canyon;
2. Significant changes in gradient;
3. Significant changes in streambed and bank materials, such as a change from erodible to non-erodible materials; and
4. Significant tributary confluences.

Obstructions or potential barriers to fish distribution are reach boundaries only if they meet both the following characteristics:

1. Are less than 100 m or 10 W_b in length (if they are longer than these lengths, they are defined as a reach); and
2. Are consistent with the changes in physical criteria listed above. For example, a steep bedrock falls, approximately 50 m long, with a cascade step pool reach upstream, and an entrenched gorge with an 8% gradient downstream (the falls characteristics are different from both the upstream and downstream reaches).

Having appropriate and accurate reach identification is extremely important to the planning, implementation, and interpretation of the reconnaissance inventory. If an excessive number of reaches are described, a greater number of reaches must be sampled to satisfy random sampling requirements. If too few reaches are identified, reaches that may have significant implications for fish distribution may be missed. Examples of reaches that significantly impact fish distribution include those short sections located on valley bottoms and near confluence with larger streams and lakes. To ensure reach identification is done appropriately, it is imperative that staff members with expertise and experience in physical geography do reach identification.

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[4] The minimum reach length in fish-bearing streams may be reduced, provided there is a very distinct morphological break (e.g., very short sections of fish-bearing streams, on a valley flat, at the foot of longer, steep gradient reaches).

2.4.4.2 Stream reach numbering

A reach break marks the boundary between adjoining reaches. Each reach on a stream is assigned a unique number, the reach number, in an upstream-ascending order, the first being the reach closest to the mouth of the stream.

Like stream reaches, lakes and connected wetlands are numbered. For lakes and wetlands, assign each reach a unique number in a sequential, upstream-ascending order, consistent with the stream reach numbering system. For details on reach numbering, see *Standards for Fish and Fish Habitat Maps,* RIC and Figure 2.3.

Reach numbers start at 1 at the mouth or the downstream end of the stream in the project area and increase sequentially upstream (e.g., 1, 2, 3, …). If an additional reach is to be broken out within the existing reaches (e.g., reach 2 is broken into three reaches due to vegetation obscuring a bedrock canyon on the airphoto, but identified in the field, reach numbers should be identified using decimals (e.g., 1, 2, 2.1, 2.2, 2.3, 3, …). This will require changing only a limited number of reach numbers.

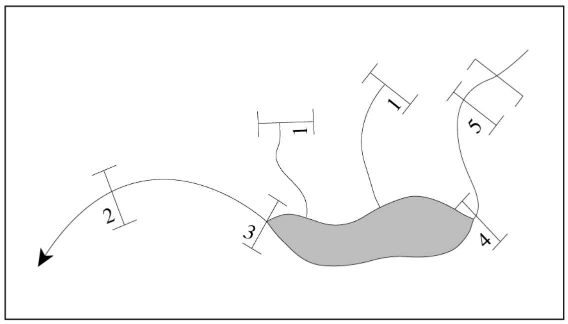


Figure 2.3. Reach numbering system.

2.4.4.3 The FDIS reach table

As indicated above, identify all stream reaches in the project area and record general physical data on the reach table. Once reaches for field sampling have been identified, complete the more detailed reach forms for reaches you plan to sample. Record features in the appropriate sections of the reach table and the reach form.

Use the reach table to record reach characteristics during the data review and map analysis stage. Use this information to determine sample size (i.e., the subset of reaches to be sampled).

Complete the following columns of the FDIS reach table[5] during the map and airphoto interpretation (Phase 2) stage:

Fill in FDIS table section for all reaches	Fill in FDIS table section for all reaches within provincial boundaries
a. project watershed code	m. order
b. watershed code	n. upstream elevation
c. ILP map number	o. downstream elevation
d. ILP number	p. length
e. NID map number	q. gradient
f. NID number	r. pattern
g. UTM (zone, easting, northing, method)	s. confinement
h. reach number	t. AN/BR
i. date	u. basin
j. map status (in, out, border, unmapped)	v. sample*
k. airphoto-line number (optional for reach table)	w. water*
l. airphoto-reference number (optional for reach table)	x. voucher*
	y. wetland
	z. gear (up to 3 types)*

* Only for sampled reaches.

Fill out a) through j) for all reaches, and k) through w) and features for all reaches within provincial boundaries.

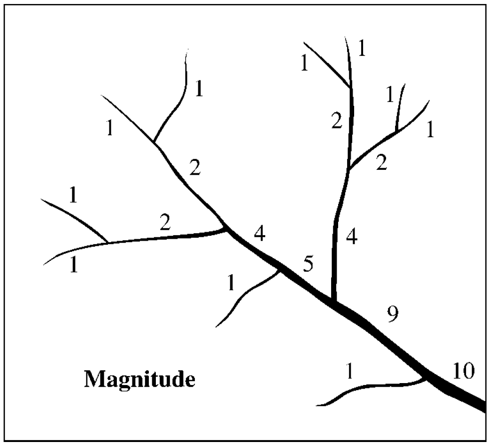
Most of the parameters listed above are described in the user notes that accompany the FDIS reach table. The referencing information (watershed code, ILP, NID, etc.) is consistent with that used on other forms and data cards. The reference number is a user-defined number to aid in the identification of reaches you plan to sample.

Order and gradient are map-derived data. Order is a method used to describe the relative size and topology of a stream in a network. The determination of order and magnitude should include all identified channels (including intermittent channels), as shown in Figure 2.4. Calculate gradient using map-based measurements of upstream and downstream elevations of a reach, and reach length.

Pattern and confinement are described in Chapter 4, *Stream Inventory*, and are interpreted from the maps and airphotos. These can be interpreted, even if the channel is not clearly visible on the airphotos or maps. If the channel is visible, and anastamosing of the stream (see Chapter 4, section 4.2.6.7, *Islands*), or braiding (multiple channels and bars) is observed, enter AN or BR in the AN/BR column of the reach table. Record the ‘basin type’ information from the basin classification sheet. Fill in the wetland column appropriately, as specified.

Complete the columns for sample type, expected fish sampling gear and comments (e.g., voucher samples, water sampling) at the project plan development stage (Phase 3), to guide the field program.

5 For descriptions of the variables, see the *Reach Information Guide*, RIC.



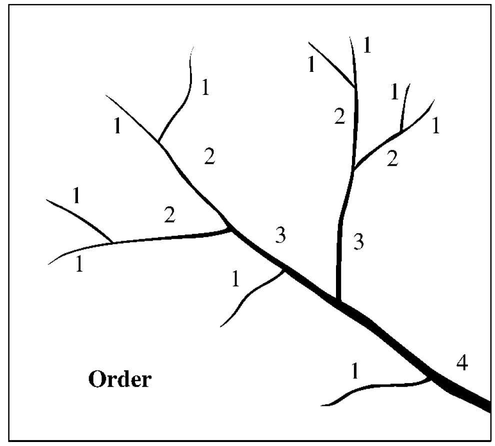


Figure 2.4. Comparison of stream magnitude and order.

2.4.4.4 Determining stream sample size and identifying sample sites

Determine the appropriate sample size for stream reaches using the following guidelines and the reach totals and sample size sheet (Table 2.1).

For the site inventory, base your sample size on the following guidelines:

- For lower gradient (<20%) and small or medium streams (third order or lower), base the sample size on the equation $y = 500\ (x^{-0.8})$, where x is the number of reaches of a certain group, and y is the sampling proportion.
- For higher gradient streams (20–30%) or large streams (fourth order or higher), the sampling size is the lower of the results of the equation listed above or 10%.
- For high gradient streams (>30%), sample when warranted (e.g., when fish are suspected to occur in a reach with a 32% gradient). Base your sampling in this group on professional judgement and/or at the discretion of the contract monitor.

In addition, observe the following standards for calculation of the minimum and maximum sample size of stream reaches:

1. For lower gradient or small/medium-sized streams, the minimum is the lower of 25%, or the result of the equation. If this results in a value less than two, then two is used as the sample size. If there is only one reach of that type, then the sample size is one.
2. For higher gradient streams (20–30%) or large streams, the minimum sample size is two, and the maximum sample size is 25.

Table 2.1. Reach totals and sample size

Reach totals:					**Sample size (project area):**				
		Size					**Size**		
Gradient	**Pattern**	***small***	***med***	***large***	**Gradient**	**Pattern**	***small***	***med***	***large***
	ST/SI	3	4	11		*ST/SI*	2	2	2
1	*IM/ME*	9	7	5	1	*IM/ME*	2	2	2
	AN/BR	0	0	0		*AN/BR*	0	0	0
	ST/SI	10	15	1		*ST/SI*	2	3	1
2	*IM/ME*	4	10	0	2	*IM/ME*	2	2	0
	AN/BR	0	0	0		*AN/BR*	0	0	0
	ST/SI	115	56	1		*ST/SI*	12	11	1
3	*IM/ME*	0	6	0	3	*IM/ME*	0	2	2
	AN/BR	0	0	0		*AN/BR*	0	0	0
	ST/SI	70	11	0		*ST/SI*	7	2	0
4	*IM/ME*	0	0	0	4	*IM/ME*	0	0	0
	AN/BR	0	0	0		*AN/BR*	0	0	0
	ST/SI	54	5	0		*ST/SI*	0	0	0
5	*IM/ME*	0	0	0	5	*IM/ME*	0	0	0
	AN/BR	0	0	0		*AN/BR*	0	0	0
Total =	397				Sample =	57			
					% =	14.4			

Classes	
Grad. class	**Gradient (%)**
1	≤4
2	>4 and ≤8
3	>8 and ≤20
4	20< and ≤30
5	>30

Size	**Order**
Small	1
Medium	2 and 3
Large	≥4

Pattern	**Description**
ST/SI	Straight, sinuous and irregular wandering type reaches
IM/ME	Irregular meandering, meandering, and tortuous meandering type reaches
AN/BR	Anastamosed or braided

Examples of sample size calculations using Table 2.1:

1. For lower gradient, medium-sized, meandering reaches:

   Total number of reaches = 7

   Equation sampling rate: $500 \times (7)^{-0.8} = 500 \times 0.21 = 105\%$

   Using a minimum of 105% or 25%, therefore

   Sample size = $(25/100) \times 7 = 1.75 = 2$

   (Minimum sample size for this group also equals 2)

2. For gradient class 4, small straight and sinuous reaches:

   Total number of reaches = 70

   Sampling rate = 10%

   Sample size = $(10/100) \times 70 = 7$

3. For gradient class 3, medium-sized, straight and sinuous reaches:

   Total number of reaches = 56

   Equation sampling rate: $500\ (56)^{-0.8} = 500 \times 0.040 = 20\%$

   Using a minimum of 20% or 25%, therefore

   Sample size = $(20/100) \times 56 = 11.2 = 11$

Once you have determined sample sizes, randomly select reaches to be sampled and identify them on the working map with a solid green line using a green highlighter.

Additional reaches may also be included in the sampling framework. Discretionary additions may include the following reaches:

- above and below barriers;
- adjacent to identified cutblocks;
- major inlets and outlets to secondary lakes;
- ~50% of all inlets and outlets to primary lakes;
- reaches surveyed to achieve connectivity within sub-basins for fish distribution and identification of upstream limits; and
- reaches that ensure all basin types and basin connectivities are adequately represented.

The minimum sample size is the random sample size identified by FDIS and discretionary reaches that address fish distribution (e.g., upstream and downstream of potential barriers), lake tributaries, inlets and outlets, and representation from all basin types.

A guideline would be to identify approximately 15 to 30% of the lower gradient reaches (less than 20% gradient) for sampling. The lower rates are more appropriate for larger project areas. The higher rates are appropriate for small project areas, and in areas of high physical complexity. For extremely large projects, FDIS sampling rates may be below 5%. When this occurs, sampling rates should be increased to 5–15%. Any concerns about sample size should be discussed with your contract monitor.

For all sampled reaches, complete the FDIS Reach cards.[6] This includes some of the variables from the reach table as well as:

- Biogeoclimatic zone
- Setting
- Open water
- Coupling
- Valley flat
- Islands
- Bars
- Mass movement
- Riparian vegetation
- Exposed and eroded banks and
- Land use
- Disturbance indicators
- Magnitude
- Active floodplain.

2.4.4.5 Altering sampling design

There are a variety of instances where the sampling design can be altered. However, if a reach is chosen for sampling, and then the field crew discovers a No Vis Ch. situation, this is a proper sample, and no alternative is required.

Choosing alternative sites

The random sampling design can be altered in limited cases. For example, where:

1. reaches are too dangerous to access;
2. where it is too time/cost consuming to access a reach (at the discretion of the contract monitor); or
3. where there are multiple occurrences of sampled reaches directly adjacent to each other.

In these cases, alternative sample sites must be chosen. These alternative reaches must be of the same type (pattern, gradient, order) and preferably the same:

- setting,
- confinement, and
- riparian vegetation, where possible.

In the case where no alternative sites of the same type can be located, the criteria for choosing alternative sites should be discussed with the contract monitor.

Removing samples from the sampling design

With the approval of the contract monitor, reaches can be removed from the sampling design where:

a. the random sampling rate for the project is greater than 20%, *and* removing a reach from the sample does not lower the sampling rate for that specific group to less than 25%. Priority for removing reaches should be given to 1, 2, and 3 above, and b below.

b. reaches of the same type/group have been sampled, at the discretion of the contract monitor, using an acceptable inventory procedure (e.g., recent FHIIP surveys). However, a minimum number (25 to 50% of the identified sample size) of this reach type should be sampled using the new standards. If all reaches are removed from the random sample due to previous inventories, the plan should strive to include a couple of these reach types/groups as bias samples.

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[6] For descriptions of the variables, see the *Reach Information Guide*, RIC.

2.4.5 Lakes and Wetlands Sampling Design

The following three sections describe lake and wetland reach identification, classification, determination of sample size, and identification of sampling sites. For survey purposes, consider lake and wetland boundaries, reach boundaries.

Identify and designate lakes as primary or secondary on the basis of location and connectivity within watersheds. Next, record on the lake tables, lake characteristics for all lakes in the project area. Select primary and secondary lakes for sampling.

2.4.5.1 Lake and wetland identification

A lake is an open waterbody with a maximum depth greater than 2 m and with less than 25% of its surface area covered with wetland vegetation. Open water bodies that do not fit these criteria are, by default, considered shallow, open water wetlands. Lakes and wetlands are detailed in the *Riparian Management Area* (RMA) *Guidebook,* FPC. For FRBC inventory projects, use the *RMA Guidebook* for wetland identification.

Number all reaches, including lakes and wetlands. As lakes and wetlands are considered reaches for survey purposes, they are assigned a unique number in a sequential, upstream-ascending order, consistent with the stream reach numbering system. See the *Standards for Fish and Fish Habitat Maps,* RIC and section 2.4.4.2, *Stream reach numbering* for details on reach numbering.

If the lake-type waterbody is a wetland, classify it into one of the following five classes/types (*RMA Guidebook,* FPC):

1. shallow open water,
2. marsh,
3. swamp,
4. fen, or
5. bog.

Descriptions of these categories are provided in Appendix 3, *Wetland types*.

2.4.5.2 Lakes classification

Primary versus secondary lakes and lake groups

Assign all lakes within a watershed to a lake group. Lake groups are series or clusters of interconnected lakes that permit movement of fish between them (i.e., there exists the potential for fish in one lake to populate a connected one due to the absence of major obstructions). Lakes, which are isolated because of barriers or do not have inlets or outlets, constitute one-member lake groups (Figure 2.5). Designate all lakes within a group as primary or secondary.

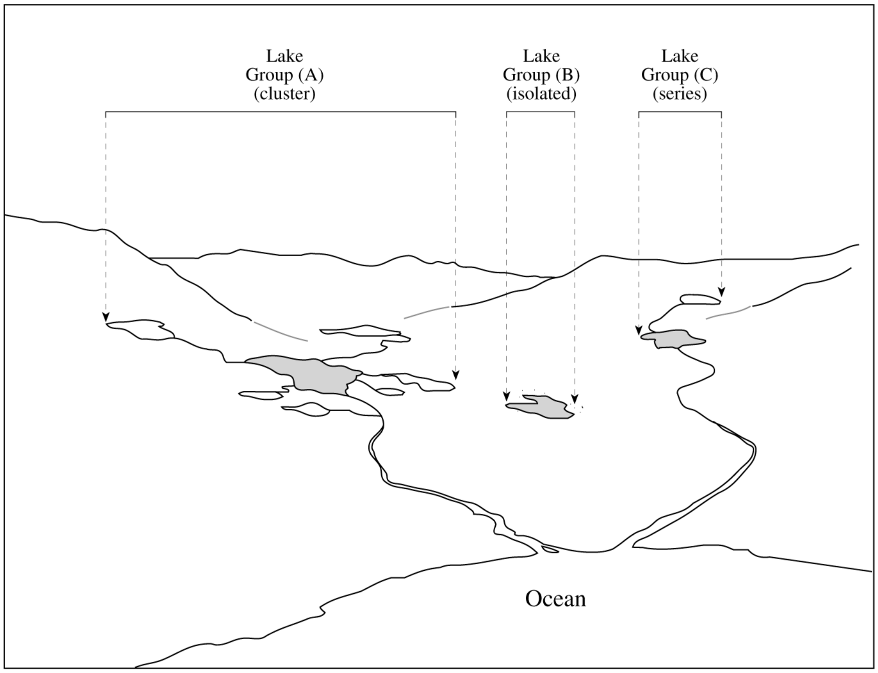

Figure 2.5. Primary and secondary lakes, and lake groups. Primary lakes are shaded in this illustration. Lake group A contains a cluster of seven lakes. Lake group B is an isolated lake. Lake group C represents a series of two lakes.

In general, primary lakes are:

1. Lakes that play a dominant role. These generally have the largest surface areas, and (or) are central in a cluster or chain of lakes.
2. Lakes that represent the physical characteristics of most of the lakes in the group.

Designate only one lake in a group as primary; designate all other lakes in the group as secondary lakes.

Note that the designation of lakes as primary or secondary is arbitrary and project specific. Once the groups are identified, assign each group a unique two-character sequence (e.g., AA, AB, AC,… BA, BC, BC,…).

The FDIS lake table (Table 2.2) is designed to facilitate the selection of lakes to be sampled in a watershed. Record the name, watershed code and waterbody identifier in the lakes table. Following this, record the basin type, group and class. Complete the sample and voucher fields at the end of the planning/sampling strategy phase, and indicate the lakes to be sampled, and the lakes from which voucher specimens will be collected.

Table 2.2. Lake table

Project WS Code	WBID	WS Code	ILP Map#	ILP	NID Map#	NID	UTM Zone	Easting	Northing	Reach #	Basin Type	Group	Class (p/s)	Genesis	Area	Magn	BGC	Wetland	Sample	Voucher

Please note that the sample table above has been condensed for display purposes and should not be used for data entry. The complete table is in FDIS and can be downloaded from the *Fisheries Inventory* web site under FDIS Tools. Descriptions of each of these parameters is available in the FDIS User Notes.

2.4.5.3 Determining lake sample size and identifying sample sites

Though the overall sample size is dependent on the time and cost associated with the number of lakes, it should conform to the following guidelines:

1. At least one lake must be sampled from each lake group identified;
2. All identified primary lakes must be sampled; and
3. At least 20% of all identified secondary lakes must be sampled.

If you do not sample a selected lake, provide appropriate justification as comments in the lakes table. Where time or cost constraints due to the large number of lakes in the project area are of consideration, use the following procedures to decrease the sample size:

1. Eliminate secondary lakes that are quite similar to other secondary lakes within the same group being inventoried;
2. Use prior knowledge, such as regional expertise or "overview" type surveys, (such as winter limnology survey data);
3. Eliminate lakes that do not have adjacent forest development planned in the near future; and
4. Eliminate lakes that may not contribute any additional fish distribution information (e.g., small, isolated lakes; lakes downstream in a watershed when fish have been identified upstream; lakes where many of the inlets and outlets are to be inventoried).

2.4.5.4 The FDIS lake survey form

After identifying the lakes to be sampled, complete the first sections of the lake survey form (one form for each lake to be sampled; this information is obtained from the lake table). Complete the balance of the form once you have field-based data.

2.5 Special Planning Requirements

While planning for the field inventory, consider the following information and logistical and regulatory factors.

2.5.1 Field Procedures

Field procedures for lake and stream inventory are presented in Chapters 3 and 4 respectively. Additional information is available in:

- *Fish Collection Methods and Standards*, RIC
- *Bathymetric Standards for Lake Inventories: Part A. Fish and Fish Habitat*, RIC
- *A Guide to Photodocumentation for Aquatic Inventory*, RIC
- *Ambient Freshwater and Effluent Sampling Manual*, RIC
- *Identification Keys to the Aquatic Plants of BC*, RIC
- *Field Key to the Freshwater Fishes of British Columbia*, RIC
- *Fish-stream Identification Guidebook*, FPC
- *Riparian Management Area Guidebook*, FPC
- *Channel Assessment Procedure Field Guidebook*, FPC
- *User's Guide to the British Columbia Watershed/Waterbody Identifier System*, version 2.1, RIC

- *Lake Survey Form Field Guide*, RIC
- *Site Card Field Guide*, RIC
- *Fish Collection Form Field Guide*, RIC

2.5.2 Access and Transportation

Determine the most suitable site access method, whether by land or by air. The mode chosen will depend on:

1. number and types of access points,
2. terrain characteristics of the site,
3. size of the crew, and
4. the objectives of the inventory project.

The choice of aircraft (fixed-wing plane, float plane or helicopter) is dictated by the budget, the desired objectives of the survey, and the availability of the aircraft. Fixed-wing aircraft may be used to conduct air-based inventories, but not as a primary transportation because of their inability to 'drop in' on desired sampling sites. Float planes overcome this problem on very large, slow moving rivers or by landing in the vicinity of a stream, but their manoeuvrability is limited, especially in mountainous terrain. As helicopters allow you to combine air and ground-based inventory methods and provide reliable, flexible transportation, they are the most commonly used air transport for fish inventory.

2.5.3 Helicopter Surveys

Air photos may not show enough detail to complete all sections of the reach table. In such cases, an initial survey of the stream(s) may also be conducted by helicopter to identify potential barriers and complete the unfilled sections of the reach table. Details of video survey procedures can be found in Appendix 4, *Videography*, and in *Aerial Photography and Videography Standards: Applications for Stream Inventory and Assessment*, RIC.

Normally you can collect two types of information during helicopter-based surveys:

1. Reach-scale information obtained from the helicopter as it flies along the stream channel; and
2. Point or zone information collected by ground crews as they are positioned and moved throughout the watershed by helicopter.

Heights of features can be estimated better if the stream is flown in an upstream direction at a slightly sideways angle, giving an unobstructed view of the channel and the valley. Keep a topographic map and/or air photos close at hand to reference locations and to aid the pilot. Also, take photographs that characterize each reach, point location, areas of significance along the channel, as well as panoramic views of the whole valley. These will help you with your data review once the field portion of the survey is completed.

Estimate helicopter survey (inventory) costs by measuring the linear distance of all streams to be flown, assume a flying speed of 80 km/hr (50 miles/hr) and then triple the results to allow for fuel stops, ferrying and crew pick-ups and drops. In mountainous terrain, adequate fuel reserves for longer low-level return routes must be maintained due to the possibility of unpredictable weather. In all cases, ferrying time to and from the inventory area from the aircrafts' base must be included.

See Appendix 4, *Videography*, if an aerial video is to be completed during the inventory.

2.5.4 Permits and Other Operational Regulations

Watershed-specific fish collection permits are mandatory for fish capture/sampling. Provincial Fish Collection Permits can be obtained from the Fisheries Section of the local BC Environment regional office. Federal permits can be obtained by contacting Fisheries and Oceans Canada. Applications should be submitted well in advance of the scheduled field activities. Note that restrictions on sampling may be set in the fish collection permit. This is discussed in Chapters 3 and 4 (lake and stream fish sampling).

Always carry the issued permit during all field activities. Each crew member participating in fish sampling (of any sort) must also possess a valid BC freshwater angling licence.

2.5.4.1 Freshwater fishing regulations

The general and specific angling regulations, detailed in the Freshwater Fishing Regulations Synopsis (BC Environment annual), do not apply to fish sampling for the purposes of aquatic surveys. However, the exemption must be officially endorsed by BC Environment, with issuance of a specific fish collection permit, as described above. In your inventory plans, always consider the most unobtrusive transgression of fishing regulations, like avoidance of weekend sampling to not offend anglers, and choosing secluded sites for handling and processing captures.

2.5.4.2 Workers' Compensation Board regulations

All government staff or private sector contractors conducting the survey must comply with the relevant Occupational Health and Safety Regulations of the Workers' Compensation Board (WCB) of British Columbia. These regulations include specific equipment requirements, crew sizes for various undertakings, and special procedures for work in isolated areas. A copy of the WCB regulations can be obtained from any WCB office in BC.

2.5.4.3 Other site-specific regulations

Waterbodies that have additional restrictions such as the use of outboard motors, boats or float planes, are identified in the Freshwater Fishing Regulations Synopsis (BC Environment). In cases where a specific location is not listed in the synopsis, address enquiries to the local office of the Conservation Officer Service.

Special restrictions may be implemented under various laws, from the municipal level (e.g., local bylaws) to the national level (e.g., *Canada Shipping Act*). In the case of private sector contractors, you may require a special permit. Make enquiries through the Conservation Officer Service, either locally, or at Enforcement Branch headquarters in Victoria. Government staff are usually exempted from such restrictions while acting within the scope of their employment. Generally, restrictions are waived if it is essential to the completion of a lake survey sanctioned by the Province of BC. However, you should register and confirm this through the local office of the Conservation Officer Service.

In all cases, you are expected to make every reasonable effort to abide by all special restrictions and to keep any requisite transgressions to the absolute minimum. For example, if a lake to be surveyed has a special restriction prohibiting gas outboards, alternative methods, such as the use of an electric motor, may be acceptable.

2.6 Phase 3 – Project Plan

Once you have completed the data review, lake and stream reach classification and sampling design development, plan the survey. In the plan, include results of the sampling design for the project area and sampling objectives recorded in the sample type, water sample and voucher fields of the reach table and the lake table. Incorporate special needs and objectives related to QA. Quality assurance of inventory data is extremely important. With the development of automated data processing (e.g., automated mapping, fish distribution modelling) it becomes even more critical that data are error free. These automated processes will not run if errors exist in critical data referencing. Also include requirements or special needs for species-level inventory on a provincial or regional scale.

Address field inventory, data compilation and reporting requirements in the project plan. These are presented in the following chapters. The project plan must also consider the following:

- All records of fish species and their distribution in all watersheds of the project area.
- Results of the air photo and map review and selection of stream reach, primary and secondary sample lakes, and lakes for which no field survey is proposed.
- Requirement for water sampling, particularly in primary lakes and in stream reaches for QA purposes only.
- Requirements for fish sampling (considering expected species and life stages present), including the use of effective sampling methods, given stream reach and lake types, and the need for samples related to species inventory needs, QA requirements, and voucher collections.
- Identification of areas where WRP fish habitat assessments and/or channel assessment methods have or will occur to eliminate redundancy of efforts.
- Considerations regarding how inventories of lake and stream habitats will be integrated, in particular, any aerial overflights and sampling of lake tributaries.
- Incorporation of any additional requirements related to other ongoing inventory initiatives and data requirements (e.g., nesting of 1:5000 fish stream identification). This includes information from the provincial Conservation Data Centre (CDC) lists, available from the *CDC* web site.
- Preparation of a detailed budget for the remaining steps in the inventory, including the field program, data compilation and final reporting. The plan must include proposed planning and scheduling based on existing knowledge, gaps and logistical factors.

2.6.1 Project Plan Deliverables

Along with the written report, the deliverables for the project plan must include:

1. An interim map showing reach boundaries, potential obstructions, existing knowledge, proposed stream reach sample sites, and primary and secondary lakes proposed for surveys. Reaches selected for sampling are marked on the interim map with a solid green line using a green highlighter. Reaches identified for discretionary sampling are indicated on the interim map with a dashed green line using a green highlighter. Also, primary lakes identified for sampling are shown using a solid green line, and secondary lakes chosen for sampling are shown using a dashed green line.
2. A reach table and a lake table (Table 2.2) indicating proposed sample sites and sampling to be conducted at each (e.g., primary lakes, secondary lakes, water sample collection and fish voucher collection), and reach/lake data.

3. A discussion of fish sampling strategy that considers habitat requirements and timing of species suspected to be present, stream reach sampling design, fish distribution sampling around the 20% gradient break, the need for fish samples (e.g., voucher specimens, tissue samples for genetic analysis), and the identification and confirmation of obstructions. The locations and physical characteristics of obstructions to fish movement are critical to the confirmation and interpretation of fish distribution. Increased knowledge of the physical characteristics and biological consequences of obstructions will improve the application of inventory data to decisions regarding potential fish presence.

   Often fish sampling at a sample site or series of sample sites does not find any fish. Confirmation of any physical feature that may be a factor in restricting fish movements can be very important evidence to provide in a non-fish bearing status report. Contractors should use their professional judgement to decide if a downstream obstruction to fish movement may exist, and attempt to confirm its existence.
4. A list of field staff and field equipment. This is for quality control purposes. Any changes to either staff or major pieces of equipment (e.g., the electrofisher, water quality meters for lakes) must be approved by the contract monitor.
5. The project plan should include a contingency plan with a list of alternate reaches to be sampled in case any in the current plan prove to be inaccessible. Also, in some instances, alternate sub-basins for sampling may need to be identified in the event that an entire area is inaccessible (e.g., where long sections of the stream are too dangerous to get to). Getting the contingency plan approved before going into the field will help in decreasing down time (i.e., in many instances, alternate sites can be chosen from the pre-approved list rather than trying to contact the contract monitor from the field to obtain approval to change a sample site location).

The project plan is submitted to the contract monitor for approval, prior to any field work. Following revisions and/or approval, a hardcopy report is prepared and submitted to the contract monitor. See *Phase 1–3 Pre-field Project Planning Report Format* below for more information.

2.6.2 Phase 1–3 Pre-field Project Planning Report

1. Cover Page
   - FRBC Multi-year Agreement Number
   - MELP Project Number
   - FRBC Project Number
   - FDIS Project Code
   - Project Name
   - Project Type: 1:20 000 Reconnaissance, Fish Stream ID, blended or other (specify)
   - Report Date:
   - Proponent:
   - Company/Agency: Name of the company or agency conducting the inventory
   - Contact Person: Name of project manager
   - Contact Phone:
   - Contact E-Mail:
   - Ministry Representative
2. Table of Contents

3. List of Digital Products
   - FDIS set-up file name
   - FDIS file names
   - Excel spreadsheet file names
   - ILP Data Sheet file names
   - Aerial video record names and tape numbers
4. Overview Map
   - Show project area location
5. Data Review
   - List of references and contacts
   - Summary of new FISS information found (provide FISS forms, FISS maps, and copies of references as appropriate)
6. ILP Data Sheets/ILP Map
   - Hard copy of the ILP data sheets and digital file on disk
   - Listing of ILP maps prepared. Provide either ILP maps or report status of ILP map processing (e.g., watershed code assignment in process at Inventory Section)
7. Interim Map
   - Listing of interim maps prepared
   - Interim maps, showing features, reach boundaries, and proposed sample sites as required for the project plan
8. Reach Table (from FDIS or Excel)
   - Hard copy of reach table for all reaches in the project area, indicating proposed sampling, and digital file on disk
9. Lake Table (from FDIS or Excel)
   - Hard copy of lakes table for all lakes in the project area, indicating proposed sampling, and digital file on disk
10. Sampling Design Sheet (from FDIS or Excel)
    - Hard copy of sampling design sheets and digital file on disk
11. Aerial Video Record (if applicable)
    - Video data as 1 original Hi-8; one VHS copy as specified in Appendix 4, *Videography* of the reconnaissance manual
    - Reference video with project code and video number (V1, V2, etc.)
12. Project Plan
    - Presentation of the project plan for completion of the inventory project, as outlined in the reconnaissance manual (Section 2.6)
    - Estimated resource requirements to complete the inventory project, including time, staff, field equipment, and budget. If the current contract is ending at Phase 3, and the remaining portion of the project is to be tendered, staff and budget can be generic.

Chapter 3.
Lake Inventory Standards and Procedures

Table of Contents

Figures

Tables

3.1 Introduction

This chapter describes the lake inventory components of the Reconnaissance (1:20 000) Fish and Fish Habitat Inventory. In Chapter 2, pre-field phases were discussed including the development of a field sampling program in the watershed context. Primary lakes, secondary lakes, as well as lakes in the watershed that were not to be sampled, were designated. This chapter describes the field requirements for an inventory of primary and secondary lakes. Steps to complete the lake inventory process, including field work, data compilation and trial report preparation, are presented in Figure 3.1.

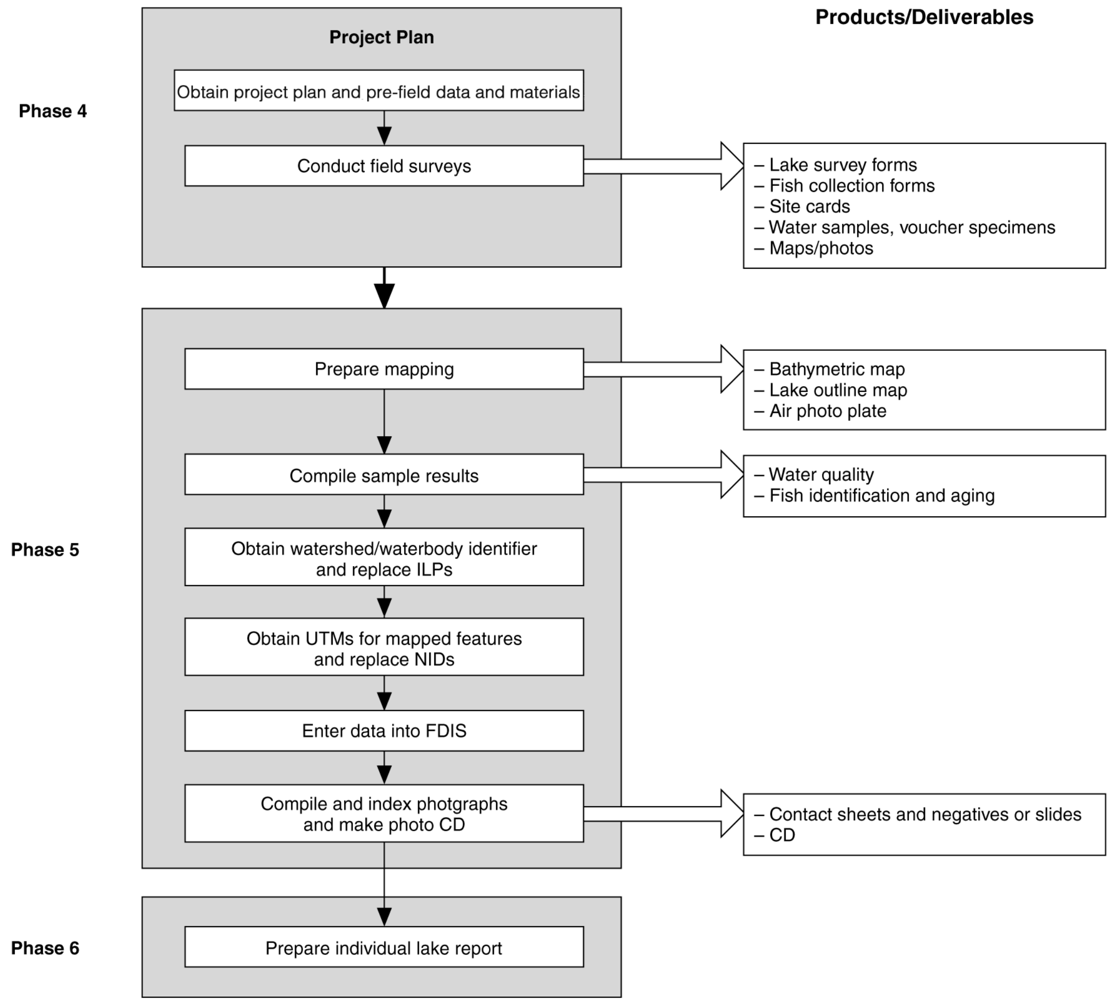

Figure 3.1. Flowchart of lake inventory activities.

3.1.1 Field Inventory Content

The field component of a full reconnaissance lake inventory includes the following tasks:

- describing terrain characteristics including lake setting, lake basin genesis (i.e., how the lake was formed), aspect, hillslope coupling and land use;
- describing shoreline characteristics including the shoreline type, shoreline cover and any recreational facilities present;
- describing and categorizing lake access;
- describing lake inlet and outlet streams including full stream survey requirements as outlined in the project plan;
- describing the fish community including fish species presence and relative abundance;
- collecting water quality information by field measurements and with a water sample analysis;
- conducting a bathymetric survey to determine mean and maximum depth, volume and the distribution of littoral areas;
- observing and recording observations of the presence and distribution of dominant aquatic flora;
- observing and recording observations of aquatic wildlife; and
- documenting physical and biological features of the lake with photographs.

The full reconnaissance primary survey includes all of these components.

3.1.2 Primary and Secondary Lake Inventory Requirements

Requirements for primary and secondary lakes differ in aspects of field data collection. Primary lakes require the full reconnaissance inventory as described above. This includes full bathymetry, water quality sampling including laboratory analysis of a water sample, tributary stream inventory and fish sampling to determine species presence, and characteristics of an adequate sample of fish. Secondary lakes, on the other hand, are intended to be quick surveys. Although secondary lakes require the same list of general requirements, the data requirements and level of effort are significantly reduced. The differences between secondary and primary lake requirements include:

- maximum depth only vs. full bathymetry;
- field water quality measurement only;
- presence of tributary streams and spawning potential vs. full stream surveys; and
- fish presence vs. fish species presence and relative abundance.

Checklists for primary and secondary lake requirements are provided in section 3.3, *Field checklists*.

3.1.3 Field Inventory Organization

Organization of the field program depends on a variety of factors, such as weather conditions, time of arrival at the lake, and the time and effort required to complete specific tasks (based on lake characteristics). The following is an example of a sequence of field activities for the primary lake survey:

1. Conduct a preliminary sounding track (an E-line) along the main axis of the lake. This will assist in the planning of transects for bathymetric mapping, in locating the best site for the limnological station, and in the placement of fish sampling gear.
2. Conduct a shoreline cruise to record various descriptions (e.g., lakeshore features, surrounding terrain, vegetation and aquatic plant distribution).
3. Install passive fish collection gear at an appropriate time to ensure standard sampling requirements are met (e.g., overnight gill-net sets).
4. Complete the bathymetric sounding transects; establish, mark and record the survey bench mark.
5. Conduct the assessment/description of associated inlet and outlet streams.
6. Complete the limnological sampling. Temperature and oxygen profiles should be done before any water samples or Secchi disk measurements are taken in order not to disturb the water column. Limnological sampling should be carried out as near to mid-day as possible.
7. Throughout the survey, take colour photographs as outlined in 3.2.10, 3.2.12.4 and Appendix 6.
8. Retrieve the fish collection gear and record sampling and fish capture data.
9. Review data forms and complete any other data collection required.

Use a similar sequence of field activities, modified to secondary lake data requirements, for secondary lakes. Install fish sampling gear upon arrival at the lake to increase the probability of obtaining fish presence information.

3.2 Standard Data Collection Procedures

Lake identification and referencing information collected during the pre-field phases of the inventory are carried through to the field data forms. Collect lake inventory field data in the field on a lake survey form and on lake outline maps. Record associated fish collection information on a fish collection form, and information on inlet and outlet streams, if surveyed, on stream site cards. If appropriate, use a lake outline map developed from an air photo enlargement to record field observations and lake bathymetry data.

Lake survey form

The lake survey form is designed to capture data collected in the pre-field and field phases of the lake inventory. Some of the data types are collected during the map and air photo analysis and are later verified in the field. Use the form to record data for primary and secondary lake surveys. Refer to the *Lake Survey Form Field Guide*, RIC.

Lake outline maps

Lake outline maps are used to record field observations during the lake inventory project. Record locations of the limnological station, fish sampling sites, photograph locations and direction, inlets/outlets, shoreline features, and significant aquatic plant communities on these maps. Also record details of any bathymetric surveys (transect locations and direction, spot depth measurements) on lake outline maps. See *Bathymetric Standards for Lake Inventories,* RIC, for information on preparing lake outline maps.

3.2.1 Waterbody Information

Transfer to the lake survey form, waterbody identification and referencing information, and general lake properties recorded during the pre-field phase on the lakes table, for all primary and secondary lakes to be sampled in the field. Complete all additional waterbody data fields on the lake survey form not collected during phases 1–3. Waterbody information includes all points listed under the following four headings:

Identification and referencing

- Lake name (gaz.) – gazetted lake name;
- Lake name (local) – local name or alias;
- Watershed code;
- Waterbody identifier;
- Reach number – sequential reach number consistent with the reach numbering system assigned in pre-field phase 2;
- ILP map number – the mapsheet number of the map used to assign ILPs;
- ILP number – an interim locational point number assigned when no watershed code/waterbody identifier is available;
- NID map number – the NID map number is the mapsheet number of the map used to assign NIDs to the features (e.g., 92L.005); and
- NID – each feature identified on a mapsheet is assigned a five-digit number, unique to that mapsheet, such as 00001, 00002;
- Project code – inventory project code obtained from the regional fisheries inventory specialist.

Air photo and mapping references

- Air photo reference number (and any comments);
- TRIM map number(s) (if the lake extends over more than one mapsheet); and

Lake properties

- Magnitude – magnitude of the lake as identified from the interim map drainage network (i.e., the total number of first order streams contributing to the drainage area);
- Surface area – lake surface area (in hectares) (record data source and method used);
- Elevation – lake surface elevation (in metres) (record data source and method used); and
- Biogeoclimatic zone – the biogeoclimatic zone of the study area as identified from the 1:2 000 000 BGC map[1] (e.g., alpine tundra [AT], bunchgrass [BG]).

[1] Title and date for BGC map.

Waterbody type

A check box is provided to record whether the waterbody is a lake or a wetland. Verify initial observations from the air photo interpretations with field data to determine the appropriate classifications. These include depth and wetland vegetation cover criteria as discussed in Chapter 2, *Pre-field Phases*.

3.2.2 Terrain Characteristics

Record the physical characteristics of the terrain surrounding the lake from map and air photo interpretation, and verify them in the field. Terrain data categories, including lake setting, lake basin genesis, aspect, hillslope coupling and land use, are discussed in greater detail below.

3.2.2.1 Setting

The lake setting describes the general area in which the lake occurs in the landscape, such as a mountain plateau, in a valley, or on a plain. See Appendix 5, *Terrain characteristics*, for descriptions of the various types of settings. Record the lake setting using one of the following codes.

Type	Description
VF	Valley floor
VW	Valley wall
HV	Hanging valley
MP	Mountain plateau
PN	Plain/large plateau
PD	Piedmont

3.2.2.2 Lake basin genesis

Lake basin genesis describes the origin of the lake. For example, was the lake formed by glacial action on a valley floor, by valley blockage, or is it formed by beaver dams or plant growth? Determine lake genesis from air photos and from actual examination of the site. Record the lake basin genesis using one of the sub-codes given in the following table. If sub-codes are not known, use the general codes listed. If a combination of the following lake origin categories is determined, only the two dominant ones are recorded. See Appendix 5, *Terrain characteristics,* for a description of the various types.

Also see Hutchinson, G.E. (1957) A Treatise on Limnology. Volume 1: Geography, Physics and Chemistry. John Wiley & Sons, Inc. New York, N.Y. (1015 pp.) for a more detailed discussion.

Type	Code	Sub-code	Description
Volcanic	VD	–	Volcanic dam lakes
Landslide	LL	–	Landslide dam lakes
Glacial	GL	GI	Glacial ice lakes
		GS	Glacial scour lakes
		GC	Glacial cirque
		GF	Glacial fjord-like
		GP	Glacial piedmont
		GM	Glacial moraine
		GK	Glacial kettle
		DC	Dead ice complex
Solution	SL	–	Solution lakes
Fluvial	FL	FA	Abandoned fluvial channel lakes
		FD	Alluvial fan dam lakes
		LV	Levee lakes
		OX	Oxbow lakes
Shoreline	BL	–	Barrier lakes
Organic	OL	PH	Phytogenetic lakes
		BV	Beaver dam lakes
Anthropogenic	AL	RV	Reservoir lakes
		AQ	Anthropogenic quarries

3.2.2.3 Aspect

Aspect of the lake refers to the orientation of its longitudinal axis and flow direction to the geographic north. Aspect is recorded using the eight point compass (i.e., north, northeast, east, southeast, south, southwest, west or northwest). These are coded as N, NE, E, SE, S, SW, W and NW respectively. A lake oriented NW–SE, with the outlet near the northwest end, would have a NW aspect (see Figure 3.2). In case the shape of the lake is ambiguous and no outlet can be determined, the most plausible aspect is recorded.

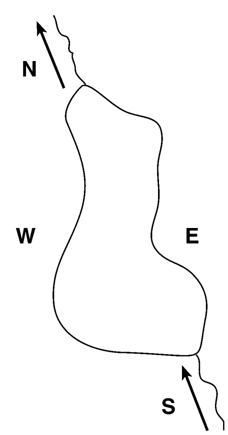

Figure 3.2. A lake with NW–SE orientation and NW aspect.

3.2.2.4 Hillslope coupling

Hillslope coupling is a subjective assessment of sediment transfer from hillslopes to stream channels or lakes. It identifies the importance of the valley flat as a buffer to sediment transfer (*CAP Guidebook*, Forest Practices Code). Record hillslope coupling using one of the following three categories:

1. Decoupled (DC): A waterbody is considered decoupled from a hillslope when sediment mobilized on the hillslope by a landslide does not enter the waterbody.
2. Partially coupled (PC): A waterbody is considered partially coupled to a hillslope when only a portion of the sediment mobilized on the hillslope by a landslide enters the waterbody.
3. Coupled (CO): A waterbody is considered coupled to a hillslope when the bulk of the sediment mobilized on the hillslope by a landslide directly enters the waterbody.

These hillslope coupling categories are used to characterize the lake and not the associated streams directly (see Figure 4.8 in Chapter 4, *Stream Inventory Standards and Procedures*).

3.2.2.5 Land use

Land use refers to the existing use of the land around the lake. Identify and record the land use using codes from the following table, and the relative percentage of each category.

Code	Description	Code	Description
NO	None/Natural*	MI	Mining
AG	Agriculture	PR	Developed park/recreation
FB	Logging, to banks	UD	Urban development
FR	Logging, with reserves	OT	Others

* Natural includes undeveloped (natural) parks

3.2.3 Shoreline Characteristics

The shoreline characteristics of the lake include shoreline type, shoreline cover and the recreational attributes present around the lake. Record the shoreline characteristics using the descriptions under the following three headings:

3.2.3.1 Shoreline type

Identify and record the shoreline type(s) and record the approximate percentage to the nearest 10% of the total shoreline, in the corresponding fields. The following shoreline types are categorized:

Type	Description
i	Sand or gravel beach
ii	Low, rocky shore
iii	Cliffed or bluff shore
iv	Wetland shore
v	Vegetated shore

3.2.3.2 Shoreline cover

Shoreline cover refers to the debris and overhanging vegetation present at the shoreline and one metre above the water**.** Estimate and record to the nearest 10% of the lakeshore perimeter.

3.2.3.3 Recreational facilities

Three types of recreational facilities are recorded on the lake survey form. These are:

- Resorts;
- Campsites; and
- Boat launches.

Record the approximate number of each of these recreational facilities that are present around the lake. Mark their locations on the lake outline map.

3.2.4 Inlet/Outlets

Lake inlet and outlet streams are identified and referenced in the pre-field phases of the watershed based reconnaissance inventory, and data are recorded in the reach table. Many of these streams will contain reaches selected as field sampling sites and will be presented in the project plan. The project plan must discuss how stream inventory of lake tributaries will be integrated with lake inventory.

The stream inventory requirements associated with an individual lake inventory are discussed below for primary and secondary lakes. For primary lakes, visit each tributary in the field and record data on a stream site card and on a fish collection form as required. Follow the procedures outlined in Chapter 4. For secondary lakes, record an indication of the number of inlets/outlets present and the availability of stream fish spawning habitat. Note the location of all inlets/outlets on the lake outline map.

1. **Primary lakes**
   The watershed codes or ILP numbers of all inlets and outlets are recorded on the lake survey form for cross reference purposes. Survey the first reach of each tributary (lake inlet and outlet) stream in order to identify streams or stream reaches that may be used by lake fish populations during various life stages. Carry out the field survey beyond the first reach on systems where the stream is directly influenced by the lake (e.g., beyond the low gradient section). Extend the tributary survey 500 m immediately upstream (or downstream) of the lake. On inlet streams, where an impassable barrier occurs before the 500 m mark, consider the obstruction the upper boundary of the survey. Note dry streams and provide in your description their possible seasonal use by lake fish.
2. **Secondary lakes**
   For all secondary lakes, determine and record the number of inlets, permanent inlets, and the number of outlets. Also, make a subjective, visual assessment to determine the availability of a stream habitat that could sustain fish populations.

3.2.5 Survey Information

Survey information refers to the field inventory component of the lake survey. The following information is required:

Date – record the start and end dates of the survey;

Agency – code for the agency conducting the inventory project; and

Crew – initials of the crew conducting the survey.

3.2.6 Access

Record access to the lake by specifying the closest community, the mode(s) of transport used to arrive at the lake, and the distances. Record detailed access descriptions in the comments field. The following three subsections provide details for completing the access fields.

3.2.6.1 Mode of transport/distance

Record the normal method of transport used to access the lake. Where the final mode of access to the lake is by off-road vehicles or by foot, record how close you can drive to the lake under "auto distance" in km. Record whether a trail exists (Y or N) for foot or ATV access. Also record the off-road distance and trail distance, as appropriate. Use the following codes to describe the mode of transport:

Code	Method	Code	Method
FW	Fixed-wing plane	FT	Foot
H	Helicopter	ATV	All-terrain vehicle
FP	Float plane	B	Boat
V2	Two-wheel drive	HO	Horse
V4	Four-wheel drive		

If other modes are required, list in comments as appropriate.

3.2.6.2 Closest community

Record the name of the closest community to the lake.

3.2.6.3 Comments

Record detailed access descriptions in the comments field;

- For road access, include descriptions of all turns, distance between turns, road types and conditions, commencing from the nearest community and proceeding to the lake. Surface materials (e.g., paved, smooth gravel, rough gravel) and associated vehicle requirements, or constraints (e.g., four-wheel drive), should be indicated over the entire distance. The entire driving distance should be reported, as should any restrictions to the use of any associated roads, or sections thereof (e.g., time restrictions on industrial roads, gates).
- For hike-in destinations, record trail conditions and distances in addition to any road access comments.
- For fly-in destinations without other access, the direction, distance and approximate flying time to the lake from the air base is reported. If any aircraft restrictions apply to the lake, these should also be indicated. Where air transport has been adopted for a lake

with other access options (e.g., trails), survey the flightpath (in and/or out) to the extent permitted by flying conditions and safety.

3.2.7 Bathymetric Survey

Lake bathymetry is required for all primary and secondary lake inventories. For primary lakes, conduct a full bathymetric survey and produce a bathymetric map. Conduct bathymetric statistics such as mean depth, maximum depth, volume, littoral area, from the bathymetric map.

For secondary lakes, employ less intensive methods to obtain maximum depth and littoral area estimates. *Bathymetric Standards for Lake Inventories,* RIC describes the procedures for bathymetry. The following three subsections provide more detail for completing these fields.

3.2.7.1 Type of survey

Record the type of bathymetric survey conducted on the lake survey form as:

Type	Description
FL	Full – bathymetry available for entire waterbody.
EL	E-line – one transect, along the long axis of the lake.
SS	Spot sounding
NO	None – bathymetry not available/conducted.

3.2.7.2 Field procedures for primary lakes

- **Type of survey** – a full bathymetric map is a standard requirement; circle FL.
- **Maximum depth** – record the maximum depth of the lake as observed from the full bathymetric survey.
- **Benchmark** – establish a benchmark and record its description and location. Record the benchmark height above the current water level. Benchmarks are usually placed 2 m above the existing waterline.
- **Littoral area** – record the percentage of littoral area. Littoral area is defined as the shallow shoreward region of a lake in which the water is less than 6 m deep. It usually has light penetration to the bottom and is often occupied by rooted macrophytes. For primary lakes, determine the approximate percentage of the littoral area from the 6 m contour on the bathymetric map.
- **Maximum water level** – determine and record the maximum water level of the lake. Maximum water level is the difference in height between the high water mark and the water level at the time of survey. It can be determined by examining the surrounding area for evidence of the following:
  - wave cut terrace;
  - evidence of erosion;
  - pollen and driftwood deposition;
  - mudline;
  - ice damage on tree trunks; and
  - presence of lichen of rocks.

3.2.7.3 Field procedures for secondary lakes

- **Type of survey** – indicate the method of depth recording used.
- **Maximum depth** – record the maximum depth determined in the lake.
- **Benchmark** – no benchmark is required for a secondary lake survey.
- **Littoral area** – visually estimate the percent littoral area to the nearest 25%.
- **Maximum water level** – determine and record the maximum water level of the lake relative to the water level at the time of survey.

3.2.8 Aquatic Wildlife Observations

Record any important observations of aquatic wildlife. Record any observation or sign of wildlife that may directly affect the fish and the fish habitat (e.g., beaver activity). Give special attention to reptiles, amphibians and mammals listed on the Conservation Data Centre (CDC) tracking lists. The CDC lists for the province can be obtained through the *CDC* web site. Ensure that all relevant reference material is provided as part of the survey crew's field equipment.

Record the group of animals associated with the observations (**inv**ertebrates, **rep**tiles, **amp**hibians, **bir**ds and **mam**mals), and species/comments on the lake survey form.

3.2.9 Aquatic Flora

Record the dominant emergent and submergent aquatic plant species, and an approximate percentage of their coverage of the lake's surface area. Identify plants to the genus level, or the species level if possible. Record the dominant species on the lake survey form in a descending order of abundance. Also mark the dominant plant beds on the lake outline map. If required, a representative specimen of all unidentifiable plant species may be collected, preserved and submitted to the contract monitor. Mount the collected specimens in the field and label them using the appropriate lake data sample number and the watershed code. The *Identification Keys to the Aquatic Plants of BC,* RIC provides information on collection, preservation and field identification of aquatic plants of BC.

3.2.10 Photodocumentation

Take the following colour photographs during lake inventories:

- Panoramic view of surrounding area;
- Shoreline and riparian conditions;
- Inlet and outlet streams;
- Representative fish captured in the lake;
- Any unidentified or diseased fish;
- Aquatic plant communities;
- Benchmark (*if set*); and
- Any other important and relevant features.

Record photographic documentation on the lake survey form. Record photograph locations, including NID numbers and NID map numbers, and direction on the lake outline map.

3.2.11 Water Quality

Collect water quality information at a limnological station in all primary and secondary lakes surveyed. Locate the deepest spot in the lake and, if possible, anchor the boat in place. Otherwise, use the nearest point where the boat can be anchored or collect samples when there is no wind and the boat will not drift. Surface and bottom water samples are collected with a vertical water sampler. Make field measurements of pH, colour, conductivity and hydrogen sulphide. For primary lakes, collect surface and bottom water samples for laboratory analysis. Collect a temperature/oxygen profile and record the Secchi depth. Primary and secondary lake requirements differ only in the collection of water samples for laboratory analysis (see list below).

Water quality requirements for primary and secondary lakes:

1. For all lakes, record the following information:
   - Secchi depth (m);
   - Water colour;
   - pH (surface and bottom);
   - Conductivity (surface and bottom);
   - Dissolved oxygen profile;
   - Temperature profile; and
   - Hydrogen sulphide detection/measurement.
2. For all primary lakes, record the following additional information:
   - Water samples for laboratory analysis; and
   - Metals package.

The following eight subsections provide greater detail on completing the water quality component.

3.2.11.1 Limnological station

A limnological station is the site for water quality sampling and is set in the deepest part of the lake. In lakes having more than one distinct basin, or with morphologically distinct major portions, set a station in each area. However, for most lake surveys this is viewed as an option and should not be at the expense of other stipulated field components.

Once established, record the UTM coordinates and environmental monitoring system (EMS) (previously called SEAM) number for (each) limnological station. Obtain the EMS number from the regional fisheries inventory specialist. Mid-day sampling is recommended for water quality parameters.

3.2.11.2 Secchi depth

A Secchi disc is a circular metal or plastic plate, 20 cm in diameter, painted in black and white quadrants. It is suspended from a weighted line and used to indicate water transparency. Lower the disc into the water until it is no longer visible; record the depth. Next, lower the disc beyond this depth and gradually pull it back up until it reappears; record this depth. The Secchi depth (extinction depth) is the average of these two readings, recorded in metres. Do not take readings less than two hours after dawn or before dusk. Also, conduct Secchi depth determinations after the dissolved oxygen/temperature profiles have been conducted so that the water column is not disturbed.

3.2.11.3 Water colour

Determine the colour of the water visually by holding a sample up to a white sheet of paper and record the closest match from Table 3.1.

Table 3.1. Standard water colour descriptions for lake surveys in BC

Code	Colour	General Indications
GR	Green	– Due to phytoplankton blooms; likely indicative of higher productivity
BR	Brown	– Staining from tannic acid; may also be zooplankton or solids
RD	Red	– Could reflect high iron content and associated plankton and bacteria
BL	Blue	– Indicates marl deposits on the bottom and /or water of lower productivity
PU	Purple (or pink)	– Bottom samples only; the presence of purple sulphur bacteria and high hydrogen sulphide.
		CAUTION: this water is very toxic and corrosive; rinse equipment well
MP	Milky/ Pale blue	– Often results from the influence of glacial meltwater; may also be a marl lake or having relatively low productivity
NC	Colourless	– No particular condition other than low productivity

3.2.11.4 pH

pH is a measure of the hydrogen–ion concentration in water. It operates on a scale of 0 (highly acidic) to 14 (highly basic), with pH of 7 being neutral. Fisheries impacts occur outside of a fairly narrow pH range of about 6.5–9 (CCREM). Measure pH in the field using a hand-held pH meter (*a low ionic strength electrode and calibration standards may be required*).

3.2.11.5 Dissolved oxygen and temperature profile

Take vertical dissolved oxygen (DO) and temperature profiles simultaneously, as your meter (e.g., YSI, HydroLab) will provide a temperature reading for every depth at which the DO is measured. Take two sets of readings at each depth interval: one during descent and the other during ascent, to minimize bias due to adjustment of the meter to the water conditions at the subsequent depths.

Dissolved oxygen is a measure of the concentration of oxygen dissolved in water expressed in mg/L, or in parts per million (1 mg/L is equivalent to 1 ppm). For optimal survival, salmonid species require DO concentrations above 6.5 mg/L, however they can survive lower concentrations for short periods of time or at specific intervals in their life stage (CCREM).

3.2.11.6 Conductivity *(preferred to "specific conductance")*

Make conductivity measurements from lake surface and bottom samples. Electrical conductivity (EC) is dependent on the total dissolved salts concentration (TDS) in the water; the higher the conductivity, the higher the salt (e.g., sodium, calcium, sulphate) concentration.

Measure EC in the field using a portable conductivity meter (e.g., YSI, HydroLab). Most conductivity meters automatically convert conductivity measurements to 25°C. If your meter does not automatically standardize to 25°C, record the water temperature at the same time as conductivity and use a conductivity nomograph to convert the reading to 25°C. Also measure the EC value for the water sample to be sent to the laboratory, so the values can be compared.

3.2.11.7 Hydrogen sulphide

When DO values are very low, and the characteristic 'rotten egg' smell and can be detected easily, measure hydrogen sulphide (H_2S) in the bottom water samples. Make field measurements using a Hach kit.

Since H_2S is volatile and easily oxidized, complete tests using the Hach hydrogen sulphide test kit quickly. Care must be taken not to aerate the sample by agitation. If an excessive sample is taken, lightly flick the test sample container to remove small quantities of water until the desired amount is reached.

If H_2S is present, it can 'poison' the DO membrane and electrode. Therefore, take care in lowering the probe. In such cases, do not drop the probe below the 0.5 ppm oxygen level.

3.2.11.8 Water samples

Primary lake surveys require water samples be collected and sent to an accredited laboratory for analysis. Samples are not normally collected for secondary lake surveys.[2] For lakes less than 6 m deep, collect one 'surface' water sample. For lakes deeper than 6 m, collect one surface and one bottom water sample. A second bottom water sample is required if the metals package is requested.

Take the 'surface' water sample from a depth of 0.5 m using a vertical water sampler. Take care not to collect any surface film contaminant. Collect the bottom water sample 1 m above the lake bottom using a vertical water sampler. Take care not to overshoot the depth, as disturbance of the sediments would necessitate moving to another site. Use both surface and bottom water samples (as required) for pH field measurements. Also use the bottom water sample to measure hydrogen sulphide if the characteristic 'rotten egg' smell is apparent on decanting the water sample.

Clearly label all water sample bottles with the following, in water-proof ink:

1. Date (and time) of sample collection;
2. Lake name and station number;
3. EMS (previously SEAM) number;
4. Sample depth (optional); and
5. Name of contracting firm (optional).

Send water samples to a laboratory with Environmental Data Quality Assurance (EDQA) lab certification for analysis. Contact the laboratory before the survey to obtain their sampling protocol requirements. This includes time frames, sample quantities, preservation protocols and hold time criteria that may vary for different analyses. Store water samples in specially cleaned, standard sample collection bottles, and add preservatives as required to ensure chemical reactions do not occur in the sample prior to laboratory analysis. The laboratories may provide the appropriate bottle types and preservatives provided arrangements are made prior to initiating any field sampling. Obtain ice packs and coolers from the laboratory for

[2] Occasionally, acid rain studies or background contamination studies may require water samples from some secondary lakes.

transporting samples. The laboratory must transfer all water sample analysis data to the EMS database.

A total metals package analysis is required from one primary lake per watershed (usually a downstream lake). Where total metals is specified, a *separate* sample must be collected and preserved in the field. Guidelines for all such procedures, and contingencies, are explained in the *Ambient Freshwater and Effluent Sampling Manual,* RIC.

Parameter checklist for laboratory analysis of water sample (as per Standard Environment Canada Laboratory Form):

Acidity: pH 4.5	pH
Acidity: pH 8.3	Phosphorus: Total dissolved
Alkalinity: Total pH 4.5	Phosphorus: Total
Nitrogen: Ammonia	Residue: Filterable (TDS)
Nitrogen: Nitrate	Specific Conductance
Nitrogen: Nitrite	Metals package (if required)*
Nitrogen total	

* Contact your ministry representative for details of the metals package.

Description of parameters

Total alkalinity Total alkalinity provides a measure of the water's buffering capability (i.e., the capability to withstand rapid changes in the water's pH level). It is expressed in mg/L $CaCO_3$ equivalent, and is measured in the laboratory. Prior to initiating field sampling, obtain the appropriate sample container from the laboratory. Maximum sample holding time is 72 h at 4°C.

Total dissolved solids Related to electrical conductivity (previous section), total dissolved solids (TDS) is a measure of the concentration of dissolved salts in the water. TDS is expressed in mg/L, and is measured in the laboratory. Prior to initiating field sampling, obtain the appropriate sample container from the laboratory. Maximum sample holding time is 72 h at 4°C.

TDS is often referred to as filterable residue (FR), or total filterable residue (TFR). Electrical conductivity can be roughly converted to total dissolved solids by multiplying conductivity by approximately 0.65.

Total nitrogen and dissolved phosphorus Total nitrogen and dissolved phosphorus are nutrients used by aquatic algae and macrophytes for growth. Levels of nitrogen and phosphorus thus provide information that can be used to estimate natural productivity and identify reaches subject to enrichment from human activities.

Total nitrogen and dissolved phosphorus are both expressed in mg/L and are measured in the laboratory. Prior to initiating field sampling, obtain the appropriate sample container from the laboratory. Also ask the laboratory for their filtering requirements for the dissolved phosphorus sample. Maximum sample holding time is 72 h at 4°C.

Low level nutrients, nitrate-N and ortho-P Low-level nutrient concentrations provide information for estimating stream productivity in lakes where nutrient levels are near or below the detection level of conventional analytical methods.

Low level nutrients include low-level nitrate-nitrogen and low-level ortho-phosphate. These two variables are both expressed in mg/L (or µg/L) and are measured in the laboratory. Prior to initiating field sampling, obtain the appropriate sample container from the laboratory. Also ask the laboratory for their filtering requirements for the dissolved phosphorus sample. Maximum sample holding time is 72 h.

3.2.12 Fish Inventory – Lakes

Fish are collected in primary lakes for reconnaissance level fish and fish habitat inventories to determine:

- the species assemblage; and
- the relative abundance of fish in the lake.

For successful sampling, fishing effort must cover the range of habitats available in the sampling area, using a variety of sampling techniques appropriate to the habitat types and fish species (and life stages) that may be present. Reasonable effort should be made to ensure that all species present are represented in the catch.

For secondary lakes, minimal fish sampling effort is sufficient to determine:

- fish presence; and
- the numerically dominant fish species.

Complete species lists are generally not obtained from secondary lakes as this information is later interpreted from the fish fauna of primary lakes and the connectivity among lakes within the drainage basin. While secondary lake fish sampling is not intended to provide an indication of fish absence, every effort should be made to confirm that fish are present in the lake. This may include inspection of tributary streams for evidence of fish presence.

All fish sampling must be conducted with minimum impact to the fish population. Gear selection and monitoring must be considered with respect to harmful effects. The rare-and-endangered species list for the study area, available through the Conservation Data Centre (CDC) web site, must be consulted prior to planning a fish sampling program. Under normal circumstances, it is extremely difficult to deplete a population in a single bout of sampling with standard gear such as gill-nets placed semi-randomly in lakes. Exceptions include situations where most of the population of a given species is aggregated at a single location. These may be spawning aggregations, overwintering aggregations, or any situation where a species is only found in a habitat type of restricted occurrence within a waterbody. Very small lakes also present a concern. Under such conditions, fish sampling should be conducted with caution. Only the minimum sample size should be taken, using non-lethal sampling on live fish and, if abundance is known to be low, taking fewer than the minimum sample size (refer to section 3.2.12.3 *Fish sampling and data recording*). **It is imperative that regional fish/habitat inventory specialists and/or regional fisheries management staff be consulted during the project planning stage to identify any concerns or sampling issues relating to the survey area**.

3.2.12.1 Gear selection and monitoring

Fish sampling gear is discussed in the *Fish Collection Methods and Standards,* RIC. For lake sampling, a combination of gear types must be employed across the range of all available habitats to ensure that a representative sample of each species is captured. If rare or threatened species are expected to be present, an attempt should be made to confirm their presence.

For primary lakes, where a full species list and statistically valid estimates of some fish size data are required, the standard sampling effort for a reconnaissance survey includes two standard gill-nets (one floating, one sinking), set overnight, and six minnow traps, set overnight. Species composition requires large samples sizes especially if the fish community is diverse. Results from overnight sampling efforts provide data useful for broader potential application. The standard gill-nets consist of six panels as described in *Fish Collection Methods and Standards,* RIC. Other sampling methods appropriate to species and habitats present are encouraged.

Because of the variability in fish population density across the province, there must be flexibility in applying the two overnight gill-nets standard. Some coastal lakes may require greater sampling effort to obtain an adequate fish sample (e.g., three or more nets). In some interior lakes, standard two-net overnight sets result in excessive captures, causing unnecessary over-sampling of the fish population and significant logistical problems for field crews. Sampling effort on an individual lake must establish a balance between these two extremes. The field biologist should use professional judgement based on experience gained from sampling early in the project and discussions with regional fisheries staff. All variations from the standard must be justified. Where reduced effort is deemed appropriate, primary lake netting effort may be reduced to a minimum of one overnight net.

For secondary lakes, where the objective is to determine fish presence only, sampling gear is not standardized and sampling effort is minimal. The intent is to collect several fish in a short period of time. Sampling includes short-duration gill-net sets that are appropriate for the size of the lake and consistent with the time required to collect the other information.

If fish sampling is conducted in a lake that has been identified as potentially supporting rare, threatened or aggregated fish, sampling effort should be applied cautiously at first and sampling gear should be monitored to ensure minimal damage is inflicted on the fish population. For example, a gill-net gang can be set when the survey crew arrives at the lake and catch monitored throughout the day. These results should be considered for any justifiable variations to the standard sampling effort.

3.2.12.2 Site concept for fish sampling in lakes

A ‘site’ is a portion of a reach where sampling is carried out. This is *not* a point location but the whole area selected for sampling. Within each site, any combination or number of gear types can be used. Each gear type is referred to as ‘Method’ on the fish collection form and is assigned a unique sequential number within each site. In the following example (Figure 3.3), electrofishing was conducted in *Reach*-4 *Site*-2, and thus is recorded as EF1. *Reach*-4 *Site*-3 has a gill-net and three minnow traps. These are recorded as GN 1, MT 1, MT 2 and MT 3, respectively. *Reach*-4 *Site*-4 has a beach seine net, recorded as SN 1.

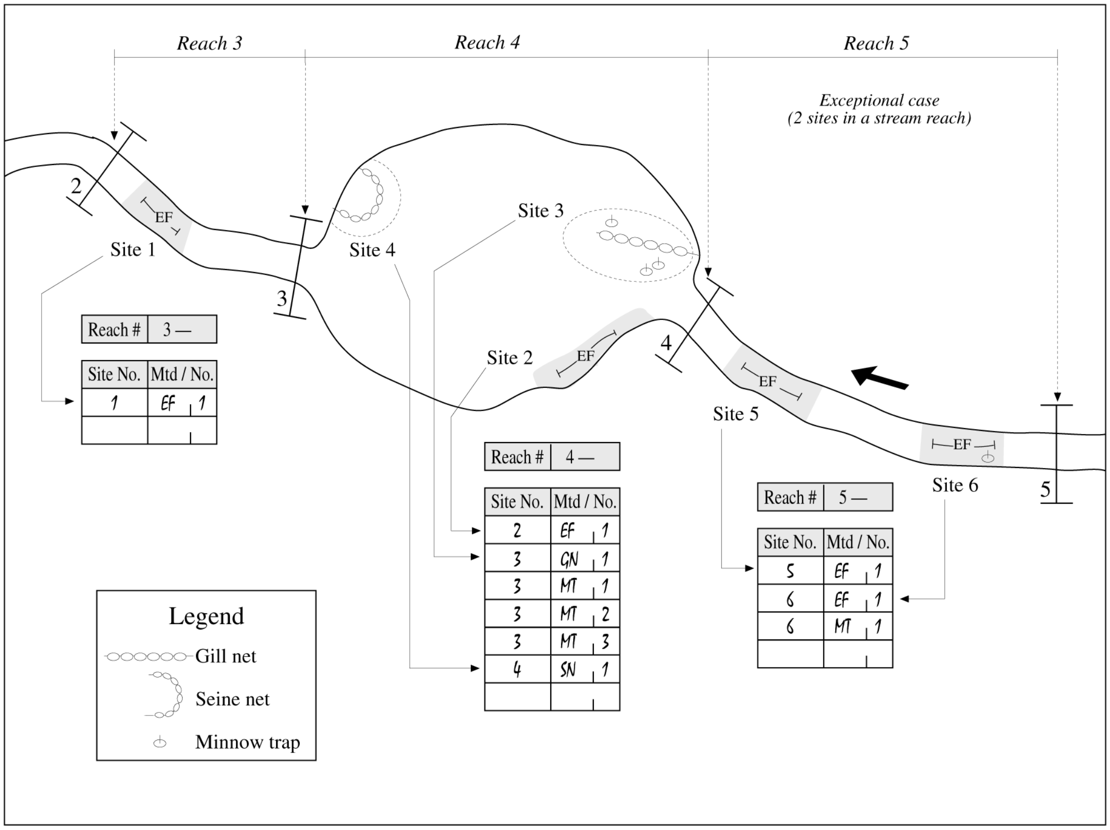

Figure 3.3.[3] Site/method recording procedure.

The following assumptions are followed for lake, stream or wetland inventories and for filling out the fish collection form:

- Each lake, wetland or stream reach constitutes an individual reach within a drainage network
- Stream reaches are typically assigned one sampling site whereas a lake will generally have more than one sampling site. However, extremely long stream reaches may have more than one site.
- In all cases, sampling sites are chosen to cover all different habitat types in lakes (e.g., shoal, deep water areas), and in streams (e.g., riffles, pools).
- In stream reaches, a sampling site has a defined area, usually at least 100 m long or a length equivalent to 10 W_b, whichever is greater. However, no standards exist to determine the minimum size of a sampling site in lakes.
- One fish collection form should contain information for one reach only (i.e., one stream reach, one lake, or one wetland). Thus, in the given example (Figure 3.3), three fish collection forms will be completed.

[3] Figure 3.3 shows electrofishing in a shoal area of the lake. This is not a common practice but is shown as one possible method of choice in a specific case.

3.2.12.3 Fish sampling and data recording

All field data are recorded on the fish collection form. The *Fish Collection Methods and Standards,* RIC must be consulted prior to field work for all fish handling procedures including the use of anaesthetics, recovery and release of fish, standard codes, and protocols. Refer to the *Fish Collection Form Field Guide*, RIC.

Sampled fish

All fish captured must be identified to species level. Information is recorded as individual fish data and as a fish summary recording total captures by sampling "event."

Fish summary

Often data about every single fish captured or observed is not recorded. For example, an electrofishing site could capture 87 rainbow trout fry, 125 longnose dace, and 47 coho fry. Individual fish measurements would be made only on a sample for each species/age group, leaving out the information on how many fish were actually captured at that electrofishing site. This total number of each species captured in each sampling "event" is recorded in the fish summary section of the fish collection form. Sampling "events" are referenced by site, method and number (e.g., Site =1, Method = EF, No. = 1). Recording by Haul #/Pass #, Stage or age group within species is allowed but is not required for standard reconnaissance sampling.

Individual fish data

Individual fish information is recorded for a sample of all species captured in the site in the Individual fish data section of the fish collection form. The sample for each species captured must cover the range of individual fish captured, and must be sufficient to provide results appropriate to the survey objectives.

1. **Species:** Accurately identify and record all fish sampled using the *Field Key to the Freshwater Fishes of British Columbia,* RIC, and the appropriate fish species codes. If a fish species cannot be identified, enter 'SP' as the species code, and write in the comment field that a voucer specimen of the unidentified species has been collected and submitted. General group names or possible identifications can also be entered in the comment field, and will be especially important if there are two or more species that are in question. Voucher specimens should also be submitted if there is any doubt about the identification. Error rates by field crews are currently running at about 20–30%, even for salmonids. This error rate can only be reduced through diligent use of the voucher specimen program.
2. **Sample sizes:**

   Primary survey (for each species):

   Sport fish:

   If N>200, randomly select 200 (measure all if N <200) for length only,
   count the rest.

   Select 60 individuals (or all if N<60) that represent as a wide range of sizes and sample for: weight, sex, maturity and age (check list of length categories can be used to do this).

   Non-game species:

   If N>30, randomly select 30 for length and weight; count the rest. For the selected 30, sex, maturity and age should only be recorded if specifically requested.

Secondary Survey (for each species):

Sport fish:

If N>30, randomly select 30 (measure all if N <30) for measure length, weight, sex, maturity and age; count the rest.

Non-game Species:

If N>20, randomly select 20 for length only; count the rest. For the selected 20, weight, sex, maturity and age should only be recorded if specifically requested.

3. **Length:** Record the fork length (FL) or the total length (TL), in mm, of each fish sampled. Fork length is the length of a fish (in mm) from nose tip to fork of tail (median caudal fin rays), and is measured only for fish with forked tails (e.g., salmonids). Total length is the distance from the most anterior part of the head to the tip of the longest caudal fin ray and is measured only for fish that do not posses a forked tail.
4. **Weight:** Weight is sampled to describe a length/weight relationship. Record the weight of each fish sampled in grams (to the nearest 1.0 g).
5. **Sex:** Determine and record the gender of each fish sampled, if possible. If the fish is ripe and ready to spawn, sex may be easily determined by secondary (phenotypic) sexual characteristics. If the sex cannot easily be determined by external examination, internal examination will be required only of those specimens already sacrificed for other reasons (i.e., voucher specimens).
6. **Maturity:** Maturity represents the determined life stage of the fish and is visually estimated as ‘immature,’‘maturing,’‘mature,’‘spawning,’ or ‘spent.’
7. **Aging structure:** Aging structures from several representatives of each size group of each sport species is recommended. Samples should be taken over the range of fish sizes and to separate age groups. The body structure used for determining fish age is numbered (age sample number) and preserved. Scales or fin ray clippings are the required aging structures. Otoliths, cleithrum and operculum can be collected from an individual fish only if it fish dies during the capture, measurement, or release procedures.
8. **Age (structure) sample number:** A unique identification must be assigned by the crew to each body structure that is used to determine fish age.
9. **Age:** Determine and record the age of the fish using the aging structure collected. Note that this is a post-survey exercise; the age is recorded on the form after age data are complied. The age of the fish will be verified, using the aging structure submitted by the crew, as a part of the QA procedures.
10. **Voucher number:** The crew must assign a unique identifying number to each voucher specimen collected.
11. **Genetic structure:** Certain body structures may be required for the purposes of genetic classification of species and will be specified by the contract monitor.
12. **Genetic sample number:** The crew must assign a unique identifying number to each genetic sample, if collected. Record this number on the form.

Visually observed fish

In situations where visual observations, made while snorkeling, for example, are the only feasible means of determining fish presence, the Data Summary section of the Fish Collection Form is completed. All codes and data recording protocols are provided in the *Fish Collection Methods and Standards,* RIC. The following information should be determined:

1. **Species:** Identify all observed fish, as accurately as possible, using the *Field Key to the Freshwater Fishes of British Columbia,* RIC, and recording on the form using the appropriate fish species codes.
2. **Life stage:** Observe the life stage of the majority of fish of each species and record as 'fry,' 'parr,' 'juvenile,' or 'adult.'
3. **Total number, minimum, and maximum length:** Record an estimate of the total number of fish of each species, and their average, minimum, and maximum length (where possible).
4. **Fish activity:** Record the activity exhibited by the majority of the observed fish as 'migrating ,' 'incubating,' 'spawning,' or 'rearing (feeding or resting).'

3.2.12.4 Fish Photodocumentation

Colour photographs of one representative fish of each species collected from the lake must be taken and documented. Representatives of any fish that the crew is unable to identify, or of any diseased or parasitized fish must be photographed as well. The quality of these photographs should enable verification of fish species identifications. Each photograph must include an object of scale, such as a ruler, to indicate the relative size of the fish. Photographs including all species captured, with one representative fish per species are acceptable.

3.2.12.5 Voucher specimens

Voucher specimens may be required from the fish sample. Reference voucher collections require a representative selection of each species group encountered in the sample. The need for reference voucher collections will be known and incorporated at the project planning stage. Additional collection of representative specimens of any fish that the crew is unable to identify in the field, as well as of any diseased fish, fish showing signs of parasitism or of hazardous environmental impact, may also be required. Voucher specimen requirements and restrictions, including fixation, preservation and submission of specimen protocols are discussed in the *Fish Collection Methods and Standards,* RIC.

3.3 Field Checklists

3.3.1 Primary Lake Survey Field Requirements Checklist

Field Lake Survey

- ❑ waterbody location and referencing
- ❑ survey information
- ❑ access
- ❑ terrain characteristics
- ❑ shoreline characteristics

Bathymetry

- ❑ conduct full bathymetric survey
- ❑ benchmark
- ❑ maximum depth (from bathymetry)
- ❑ high water level
- ❑ % littoral area (from bathymetry)

Limnological Sampling

- ❑ establish limnological station
- ❑ location on map and UTM
- ❑ station number
- ❑ date and time
- ❑ EMS number

Record field measurements:

- ❑ dissolved oxygen profile
- ❑ temperature profile
- ❑ Secchi depth
- ❑ water colour
- ❑ pH (surface and bottom)
- ❑ conductivity (surface and bottom)
- ❑ hydrogen sulphide detection

Collect water samples for lab. analysis:

- ❑ number of samples
- ❑ collection depth(s)
- ❑ requisition number
- ❑ metals package (if required)
- ❑ label sample bottles

Fish Sampling

Representative sample of species present:

- ❑ identify and record on fish collection form
- ❑ collect additional fish samples (if required)
- ❑ collect voucher specimens (if required)

Lake Inlets and Outlets

- ❑ identify tributaries, outlet locations
- ❑ survey first reach of each tributary/ outlet

Wildlife

Record observations specific to:

- ❑ rare and endangered species *(non-fish)*
- ❑ aquatic species *(non-fish)*
- ❑ comment on wildlife activities

Aquatic Flora

Identify/ record dominant aquatic flora:

- ❑ species level
- ❑ voucher specimens

Photographic Documentation

Colour photographs:

- ❑ panoramic view of surrounding area
- ❑ shoreline and riparian conditions
- ❑ inlet and outlet streams
- ❑ representative fish captured in the lake
- ❑ any unidentified or diseased fish
- ❑ aquatic plant communities
- ❑ benchmark
- ❑ any important and relevant features
- ❑ record location/direction on outline map

3.3.2 Secondary Lake Survey Field Requirements Checklist

Field Lake Survey

- ❑ waterbody location and referencing
- ❑ survey information
- ❑ access
- ❑ terrain characteristics
- ❑ shoreline characteristics

Bathymetry

- ❑ E-line survey
- ❑ maximum depth
- ❑ high water level
- ❑ % littoral area

Limnological Sampling

- ❑ establish limnological station
- ❑ location on map and UTM
- ❑ station number
- ❑ date and time

Record field measurements:

- ❑ dissolved oxygen profile
- ❑ temperature profile
- ❑ Secchi depth (m)
- ❑ water colour
- ❑ pH (surface and bottom)
- ❑ conductivity (surface and bottom)
- ❑ hydrogen sulphide detection

Fish Sampling

Sample for fish presence only:

- ❑ identify and record on fish collection form

Lake Inlets and Outlets

- ❑ identify tributaries, outlet locations
- ❑ comment on fish spawning potential

Wildlife

Record observations specific:

- ❑ rare and endangered species *(non-fish)*
- ❑ aquatic species *(non-fish)*
- ❑ comment on wildlife activities

Aquatic Flora

Identify/record dominant aquatic flora:

- ❑ species level
- ❑ voucher specimens

Photographic Documentation

Colour photographs of:

- ❑ panoramic view of surrounding area
- ❑ shoreline and riparian conditions
- ❑ inlet and outlet streams
- ❑ representative fish captured in the lake
- ❑ any unidentified or diseased fish
- ❑ aquatic plant communities
- ❑ benchmark (*if set*)
- ❑ any important and relevant features
- ❑ record location/direction on outline map

Chapter 4.
Stream Inventory Standards and Procedures

Table of Contents

4.1 Introduction

This chapter describes the stream site inventory for fish and fish habitat. Use the procedures and standards described in this document to conduct a reconnaissance field program. This will ensure collection of good quality data and proper interpretation of results. Clearly document any unavoidable departures in methodology. Strict adherence to standards (e.g., units of measurement) must not vary. However, if required, there can be some flexibility in the procedures used to collect data (e.g., fish sampling methodology).

4.1.1 Field Inventory

The project leader must adopt and follow a standardized field plan to maximize the efficiency of the time spent in the field. The plan should include contingency options that address possible field conditions (e.g., survey lakes first if streams are high). Every crew member must know their role and the sequence of the sampling activities. Project timing must take into account that biophysical information is to be collected at the lowest stream flows. To minimize disturbance to fish and water quality, complete water and fish sampling before the physical inventory.

The field portion of the Reconnaissance Fish and Fish Habitat Inventory is comprised of:

1. channel measurements;
2. cover inventory;
3. features identification;
4. description of water conditions;
5. morphology characterization;
6. habitat quality assessment;
7. wildlife observations;
8. photography; and
9. fish sampling.

For wetland reaches, the minimum information required is site referencing, cover (cover estimates), water characteristics (temperature, pH, conductivity, turbidity), photos, and habitat quality characterization. Other data fields on the site card should be completed if applicable.

4.2 Standard Data Collection and Procedures

4.2.1 Site Card

Use the site card to capture data collected in the field. As part of your pre-field site referencing, transcribe reach referencing information to the site card. See *Site Card Field Guide*, RIC.

4.2.2 Site Referencing and Measurements in the Field

A site is defined as a section (segment) of a stream or wetland reach where the field sampling is conducted. Site referencing includes:

- Site UTM: the UTM coordinates of the downstream end of the site;
- Site length: the total length of the field site as measured in the field (by metre tape, hip-chain, etc.) along the stream course (thalweg). The site must be at least the greater of 100 m or 10 times the bankfull width (W_b). In some instances, the site length may be increased to adequately capture habitat sequences, etc. (e.g., when pool or riffle units are longer than 100 m or 10 W_b).
- Site number: a unique three-digit number assigned to all sites within a project.

Reference additional header information on the site card as stated in Chapter 3, *Lake Inventory Standards and Procedures.*

4.2.3 Channel

4.2.3.1 Channel width

The channel width (also called bankfull width [W_b]) is the width of the bankfull flood stage of the stream channel. A number of criteria can be used to determine the W_b in the field (*Fish-stream Identification Guidebook*, *Channel Assessment Procedure Field Guidebook,* Forest Practices Code). Use only those criteria relevant to the particular field site. The following should be considered:

- a change in vegetation (>2 years old) from bare ground, with no trees, to vegetated ground with trees, from no moss to moss covered ground, or from bare ground to grass-covered ground, particularly in range lands (i.e., where rooted, terrestrial vegetation begins);
- a topographic break from vertical to flat floodplain;
- a topographic break from steep bank to more gentle slope;
- the highest elevation below which no fine woody debris (needles, leaves, cones or seeds) occurs; and
- a change in texture of deposited sediment (e.g., from clay to sand, or sand to pebbles, or boulders to pebbles).

To measure the width of a channel stream:

- Include all unvegetated gravel bars in the measurement (see Figure 4.1). These generally show signs of recent scouring or deposition.
- Where multiple channels are separated by one or more vegetated islands, the width is the sum of all the separate channel widths. The islands are excluded from the width measurement.
- Measure the widths at a minimum of six sites, taken at equally spaced intervals. The six channel/wetted widths can be measured using a spacing of the bankfull width (from the first measurement), or they can be equally spaced over the site. For example, for a stream with a bankfull width of 4 m, the measurements could be taken every 4 m or every 20 m (six measurements over the 100 m site length), but the latter should be used as it is more representative. For small streams it is suggested the measurements be taken equally spaced over the site; for larger streams, choose the method that is most representative of the site.

- Generally, do not take stream widths near stream crossings, unusually wide or narrow areas (e.g., impoundments), or disturbances (see the *Fish-stream Identification Guidebook,* Forest Practices Code). However, outline width estimates for these areas in the comments section of the site card.

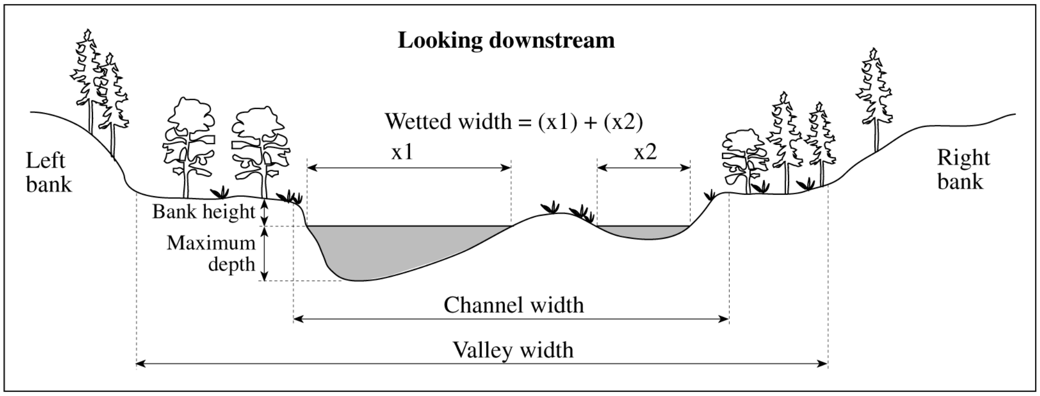

Figure 4.1. Measuring channel bankfull widths.

4.2.3.2 Wetted width

The “wetted width” is the width of the wetted portion of the stream channel. If multiple channels occur, then the separate widths should be added together, as illustrated in Figure 4.1 (also refer to *Riparian Management Area Guidebook,* Forest Practices Code, and *Fish-stream Identification Guidebook,* Forest Practices Code. For wetted width spacing intervals, use the same procedure as for channel width (see 4.2.3.1).

4.2.3.3 Residual pool depth

The residual pool depth is the difference between the maximum pool depth and the riffle crest depth (or pool outlet depth). Record residual pool depths for a minimum sub-sample of six pools. Make every attempt to select representative pools for measurement while also recording depths for the deepest pools encountered within the site.

4.2.3.4 Gradient

Gradient is the slope or rate of vertical drop per unit of land of the channel bed. Measure gradient along the longest sighting within the site. This section should be at least 60 m long and preferably longer. However, sighting distances along small streams with thick riparian vegetation may be 30 m or less. Where visibility is restricted, take sightings in both upstream and downstream directions from a given point to maximize the length of stream used to calculate gradient. Take at least two gradient measurements at the site. The use of an Abney level or a more accurate measuring device is suggested where accurate measurements are required, such as where gradients are less than 3% and where gradients fall between 18 and 22% (20% is a critical Forest Practices Code gradient break). Methods used for measurements must be recorded on the respective site card.

4.2.3.5 Depth at channel bankfull

Depth at channel bankfull is the depth of the channel at bankfull flow. Measure the depth of the bankfull discharge, with a calibrated rod to the nearest 10%. Depending upon the channel morphology, measure this depth at a step-pool break (immediately upstream of a step), or at a riffle-pool crest (immediately upstream of a riffle) (see Figure 4.2).

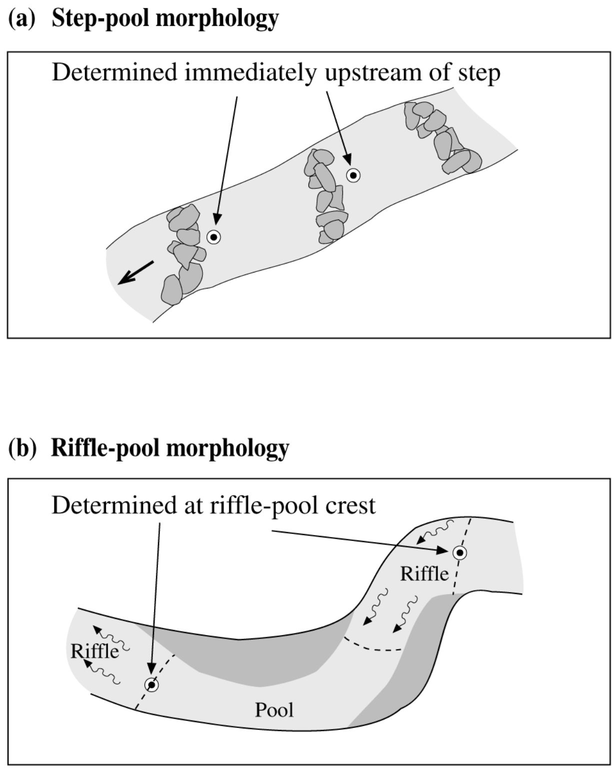

Figure 4.2. Locating depth measurement.

4.2.3.6 Stage

This is the stage of the current discharge. Stream discharge is the amount of water passing through the channel at the time of survey. Visually estimate water height as a percentage of W_b depth at the same site where W_b was determined. Classify stage as (L) low flow: 0–30% of W_b depth; (M) medium flow: 30–90% of W_b depth; or (H) high flow: >90% W_b depth.

1. Observe the amount of water in the channel in relation to the bankfull depth.
2. Look for the low flow indicators including
   - Distinct sequence of riffles and pools or steps and pools.
   - High bank tops.
   - Wetted width significantly smaller than channel width.
   - Dry, unvegetated channel bars.
   - Debris and jam pile ups well above water surface.
3. Look for high flow indicators including:
   - Distinction between riffles and pools or steps and pools is difficult to determine.
   - Water level at or over bank tops.
   - Wetted width similar to or greater than channel width.
   - No bars or bank sides visible.
   - Debris movement in channel.
   - Submerged riparian vegetation.
   - Flood channels full of water.

4.2.3.7 No channel visible (No Vis. Ch.)

Where site assessment in the field reveals no visible channel, this could signify one of two situations:

1. the mapping was incorrect and there was no channel in the field where the map identified one; or
2. the channel may flow subsurface (in the field, running water may be heard under a moss/vegetated area).

If no channel is present, place a check mark (√) in the appropriate box. Take a photo for verification for either situation. Gather other information where possible (e.g., riparian vegetation).

4.2.3.8 Dry channel (Dry/Int)

A dry channel is any stream channel found to be void of water or having separated pools along the channel at the time of the field survey. This definition encompasses both ephemeral and intermittent streams as defined by the *Fish-stream Identification Guidebook,* FPC.

Where flow is seasonal in a channel (i.e., intermittent), flow may occur for several months each year but will seldom occur during the dry season. The dry channel is assessed visually and recorded, if present, as a check mark (√) in the appropriate box.

4.2.3.9 Dewatered channel (DW)

Dewatering is typically associated with increased sediment loads. Sediment accumulation has elevated the channel bed above the water's surface, and there is usually a wetted channel upstream and downstream of this section, and subsurface flow through the bed material. The presence of channel dewatering is assessed visually and recorded, if present, as a check mark (√) in the appropriate box.

Note: Choose only one of dewatered channel or dry channel—whichever describes the situation best. For both types, fill in the card as much as possible (i.e., do not record water-related parameters such as conductivity, total cover—including amount and location—and wetted width). Also record as many site characteristics (e.g., bank shape, riparian vegetation) as possible.

4.2.3.10 Tributaries (Tribs.)

This is used to identify that there are many (more than a few) tributaries significant to fish habitat (values) which can be defined as a stream and are not identified on the base maps. If there are tributaries that are important to locate/georeference, identify these tributaries in the features section.

4.2.4 Cover

4.2.4.1 Stream cover (Cover)

Cover is any structure in the wetted channel or within 1 m above the water surface that provides hiding, resting, or feeding places for fish. Stream cover estimates are obtained from a visual assessment of the type and amount of in-channel covers available for fish. Cover types are described in Table 4.1 and an example of cover estimates is shown in Figure 4.3.

Table 4.1. Stream cover descriptions

Type	Description
Small woody debris (SWD)	Woody debris smaller than LWD.
Large woody debris (LWD)	LWD is any large piece of relatively stable woody material having a minimum diameter greater than 10 cm. Root wads are included.
Boulder (B)	Stream substrate particles >256 mm or 10 inches in diameter that block stream flow to provide surface turbulence, shade and escape from higher velocity and predation.
Undercut (U)	Cover that consists of stream bank that has had its base cut away by the water or has been man-made and overhangs part of the stream.
Deep pool (DP)	A portion of the stream with reduced current velocity at low flow, deeper than the surrounding area, and usable by fish for resting or cover (therefore containing some surface cover of flow turbulence).
Overstream vegetation (OV)	Any vegetation that projects over the stream that is less than 1 m above the water surface.
Instream vegetation (IV)	Vegetative materials such as attached, filamentous algae or other aquatic plants that provide protection for fish.

Because percentage estimates are quite subjective, classify/rank the characteristics that follow.

For cover total:
None: no cover of this type exists at the site (e.g., shallow bedrock gorge);

Trace: a small amount of cover (less than 3 to 5%) (e.g., shallow bedrock gorge with a few boulders to provide a bit of cover);

Moderate: cover accounts for between 5 to 20% of the site;

Abundant: more than 20% of the site is considered covered.

The following example illustrates how cover is recorded.

Cover: Total: Moderate

Type	SWD	LWD	B	U	DP	OV	IV
Amount	N	S	N	N	D	T	N
Location		P, O			P	P, O	

Where “Total” = **N**one, **T**race, **M**oderate, **A**bundant; “Amount” = **N**one, **T**race, **S**ubdominant, **D**ominant; and where “Location” = **P**rimary, **S**econdary, **O**ff (there can be multiple choices; refer to Figure 4.10, page 4:24).

Amount and location are assessed independent of each other. In this example, LWD is the subdominant cover type. It occurs in both the primary channel and off-channel areas—the LWD may only exist in trace amounts in the off-channel area, but in total at the site it is assessed as subdominant.

If you have two codes, record each (e.g., P, S), but if all categories are selected, record “All.”

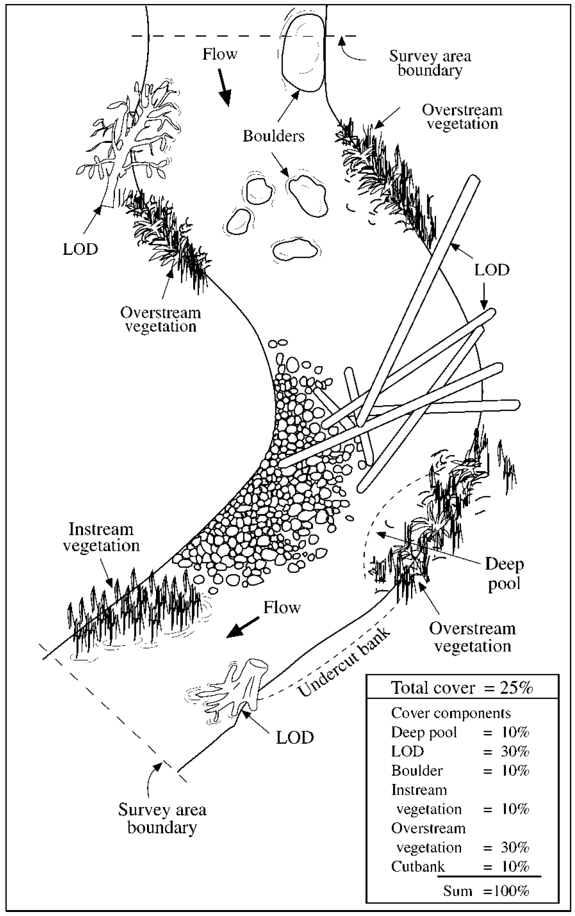

Figure 4.3. Stream cover.

4.2.4.2 Crown closure

The crown closure consists of the stream-side riparian vegetation that projects over the stream channel and is higher than 1 m above the water surface. The percentage of channel area covered by crown closure is estimated visually during the ground survey.

4.2.4.3 Large woody debris (LWD FNC) and distribution

Large, woody debris cover estimates include the presence and the amount of functional LWD within the channel (bankfull width). Functional LWD is defined as being greater than 10 cm in diameter and attached or embedded in the stream or bank (at least partly within the bankfull area). Functional in this instance is used in its geomorphological sense—"functionality" as habitat, is assessed in the total cover section. Also classify the following as functional LWD:

- rootwads embedded in the stream or bank; and
- large pieces of LWD that create pools or scour.

Describe the abundance of LWD as:

- none (N);
- few (F) – fewer than one piece per W_b; or
- abundant (A) – more than one piece of functional LWD per W_b.

Characterize the distribution of LWD (if present) as:

- clumped (C); or
- evenly distributed (E).

Estimate these measurements visually.

4.2.4.4 Instream vegetation

Instream vegetation describes the presence of vascular plants (V), mosses (M) or attached (filamentous) algae (A) within the wetted stream width. The appropriate code is circled on the site card to indicate presence. More than one choice is acceptable.

4.2.4.5 Bank characteristics

Left bank, right bank (LB, RB)

The left and the right bank refer to the stream bank being described when the observer is facing downstream.

Shape (Shp)

Shape refers to the shape or form of the identified channel bank according to the following selections:

- V – v-shaped (steep sloping or vertical);
- S – sloping (gradual or shallow slope);
- O – overhanging bank; and
- U – undercut (similar to overhanging, but undercut has water or “wetted channel” underneath the overhanging portion of the bank).

Texture

Texture refers to the dominant size class of material of the identified channel bank. These are defined as: fines (F); gravels (G); cobbles (C); boulders (B); bedrock (R); and anthropogenic (A) (includes rip-rap, dikes, etc.). See section 4.2.6.1, *Bed material* for size-class descriptions. Choose up to two dominant bank materials.

Riparian zones (Rip)

Riparian zones are defined under the B.C. Forest Practices Code as the land adjacent to the normal high water line in a stream, river, lake or pond and extending to the portion of land that is influenced by the presence of the adjacent ponded or channelled water.

Riparian vegetation at the reconnaissance inventory level is recorded for the dominant vegetative cover adjacent to the waterbody. Riparian classes include:

N – none	D – deciduous forest
G – grass	M – mixed forest
S – shrub	W – wetland
C – coniferous forest	

Choose the dominant (one) riparian class.

Vegetation stage (Stg)

Stage refers to the level of maturity and structure of the dominant riparian vegetative cover adjacent to the sampled waterbody. See *Fish Habitat Assessment Procedure* (Johnston and Slaney, 1996). Riparian stages include:

- Initial (INIT) – non-vegetated or initial stage following disturbance (less than 5% cover);
- Shrub (SHR) – shrub/herb stage, less than 10% tree cover;
- Pole-sapling stage (PS) – pole-sapling stage, with trees overtopping shrubs. The standard age is usually less than 15–20 years;
- Young forest (YF) – young forest, self thinning is evident and the forest canopy is differentiated into distinct layers, stand age is 30–80 years; and
- Mature forest (MF) – mature forest with canopy gaps and a well-developed understory.
- Not applicable (NA) – use when riparian vegetation is absent, grass, or wetland.

4.2.5 Water

4.2.5.1 Flood signs

Flood signs are visually assessed signs of flooding within the local area such as rafted debris, recent scarring of trees or other vegetation, fluvial sediments newly deposited on the surface of the forest floor, tree trunks, or other vegetation (e.g., sediments deposited 30 cm up tree trunk on bank).

4.2.5.2 Requisition number (Req. #)

This is the requisition number of the form(s) completed for any water samples sent for laboratory analysis.

4.2.5.3 Environmental Monitoring System number (EMS)

The EMS[1] number (previously called SEAM) applies to the number of any water-quality sampling site(s). Requirements for water quality sampling are project-specific and subject to the discretion of the contract monitor.

Water samples and laboratory analyses

Generally, water samples are required for quality assurance purposes. However, water samples may also be taken to clarify information regarding fish presence, theoretical fish densities, or where fish are diseased or otherwise abnormal. Collect all water samples from the downstream end of a site, when required.

Guidelines for all such procedures, and contingencies, are fully explained in the *Ambient Freshwater and Effluent Sampling Manual*, RIC. Water samples must be sent to a EDQA-certified laboratory for analysis. The laboratory must be contacted prior to field sampling for their analysis requirements and sampling protocol. These may include time frames, sample quantities, preservation requirements and sample hold time criteria, which may vary for

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[1] EMS is the provincial database system. The EMS number is pre-determined and assigned by the Water Management Branch. It must be obtained prior to conducting the inventory for those sites requiring water-quality sampling.

different analyses. All water samples need to be stored in specially cleaned, standard sample collection bottles, and some require the addition of preservatives to ensure that chemical reactions do not alter the sample prior to laboratory analysis. Laboratories will provide the appropriate bottle types and preservatives, but arrangements must be made prior to initiating any field sampling. Obtain ice packs and coolers for transporting samples from the laboratory.

4.2.5.4 Temperature (Temp)

This is the water temperature of the stream, as measured using a standard (e.g., mercury) or digital thermometer. Record temperature to the nearest 1°C.

4.2.5.5 pH

This is a measure of the hydrogen ion concentration of the water and is measured in the field using a hand-held pH meter. Record the pH to the nearest tenth (e.g., 7.1).

4.2.5.6 Conductivity (Cond.) (preferred to "specific conductance")

Electrical conductivity (EC) is a measure of the total concentration of dissolved salts in water; the higher the conductivity, the higher the salt (e.g., sodium, calcium, sulphate) concentration. Measure EC in the field using a portable or hand-held conductivity meter. Most conductivity meters automatically adjust conductivity measurements to 25°C. If the meter does not automatically standardize to 25°C, record the water temperature at the same time as conductivity, convert the EC reading to the 25°C standard using a conductivity nomograph.

4.2.5.7 Turbidity (Turb.)

Turbidity indicates the concentration of suspended sediments and particulate matter in water. It is subjective and is estimated visually. Turbidity may be defined as:

- turbid (T) – muddy, brown water with visibility restricted to a few centimetres;
- moderately turbid (M) – 'muddy,' water with increased visibility in shallow areas; general shapes on bed surface can be discerned, but deeper areas are not visible;
- lightly turbid (L) – features can be distinguish in shallow areas, and limited visibility in slightly deeper pools (~>1.5 m); and
- clear water (C) – excellent visibility except in very deep areas.

Note: Turbidity should not be confused with water colour. Any comments about colour should be noted in the comment section.

4.2.6 Morphology

4.2.6.1 Bed material

The streambed materials or substrates may include a range of different sized material. The dominant (most abundant) and subdominant groups of materials are estimated visually according to Table 4.2 and recorded on the site card.

4.2.6.2 D_{95}

D_{95} represents the diameter of the bed material particle that is larger than 95% of the total substrate. This measurement, similar to other bed material measurements, is an important indicator of fish habitat quality. At each inventory site, select a particle that is larger in size than 95% of the bed material and measure the intermediate diameter (B diameter) (Figure 4.4) using a calibrated rule (e.g., ruler, metre tape).

Table 4.2. Bed material (substrate) size distribution

Class	Size	Description*
Fines (F)	<2 mm	Smaller than ladybug size.
Gravels (G)	2–64 mm	Ladybug to tennis ball size.
Cobbles (C)	64–256 mm	Tennis ball to basketball size.
Boulders (B)	>256 mm	Larger than a basketball.
Rock (R)	>4000 mm	Includes boulders and blocks larger than 4 m, and bedrock.

* Size descriptions from Kaufmann and Robison (1993)

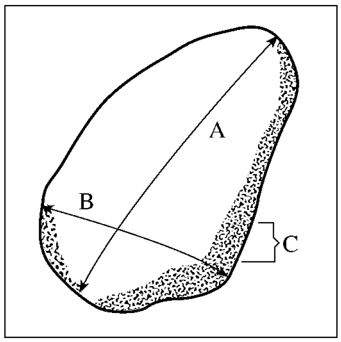


Figure 4.4. Bed material showing D_{95} measurement.

4.2.6.3 D

'D' refers to the size of the largest, moveable (by flowing water), sediment particle on the channel bed (see *Channel Assessment Procedure Field Guidebook,* Forest Practices Code). Typically, the largest movable particle:

- Does not include large lag boulders deposited during periods with very different streamflow regimes (e.g., immediately post glacial) or boulders that have fallen into the channel from surrounding glacial moraines, or colluvial fans and cones.
- Should not be covered in old moss and organic stains and should be rounded or sub-rounded, but not angular.
- Should have evidence of movement by flowing water during the past decade, for example, it should be incorporated into the channel bed (i.e., other sediment knitted around the larger stones) and not be an isolated stone, distinctly different from all others in the vicinity (i.e., with several bankfull widths, upstream or downstream).

Note: In extremely stable cobble-pool or step-pool morphologies (i.e., where the channel has not reformed within the last century), the entire stream bed may be covered in moss.

4.2.6.4 Channel morphology classification

Channel morphology classification is a visual assessment based on Table 4.3, and on Figure 6 of the *Channel Assessment Procedure Field Guidebook*, FPC.

Table 4.3. Classification of channel morphology

Morphology	Code	Sub-code	Bed material	LWD
Riffle-pool	RP	RP_g-w	Gravel	Functioning
Riffle-pool	RP	RP_c-w	Cobble	Functioning
Cascade-pool	CP	CP_c-w	Cobble	Present-minor function
Cascade-pool	CP	CP_b	Boulder	Absent
Step-pool	SP	SP_b-w	Boulder	Present, minimal function
Step-pool	SP	SP_b	Boulder	Absent
Step-pool	SP	SP_r	Boulder-block	Absent
Large channel	LC	—refer to notes on the Fisheries Inventory web site—		

Record on the site card the code that best describes channel morphology.

4.2.6.5 Disturbance indicators

Disturbance indicators are field indicators of:

- channel degradation and aggradation;
- changes in sedimentological characteristics, related to both sediment supply and transport limitations;
- bank impacts related to recent erosion as evidenced by collapsing or freshly removed materials;
- morphological features primarily relating to the relative abundance of pools and steps or riffles; and
- large woody debris.

Banks	Large woody debris
B1 – Abandoned channels	D1 – Small woody debris
B2 – Eroding banks	D2 – Large woody debris
B3 – Avulsions	D3 – Recently formed LWD jams

Sedimentation	Morphology
S1 – Homogeneous bed texture	C1 – Extensive riffles or cascades
S2 – Sediment fingers	C2 – Minimal pool area
S3 – Sediment wedges	C3 – Elevated mid-channel bars
S4 – Extensive bars	C4 – Multiple channel or braids
S5 – Extensively scoured zones (stream bed)	C5 – Disturbed stone lines

Organic
O1 – Beaver dams

For additional descriptions or clarifications, refer to the *Channel Assessment Procedure Guidebook*, FPC.

Many of these are frequently occurring (e.g., eroding banks). Check them only if they dominate the channel or when interpreting morphology/habitat.

4.2.6.6 Pattern

Pattern describes the path of the channel banks in relation to a straight line. Stream channel pattern is an important factor in determining channel stability. Assess channel patterns visually in the field and classify each site as one of the types shown in Figure 4.5 (after Church, 1992).

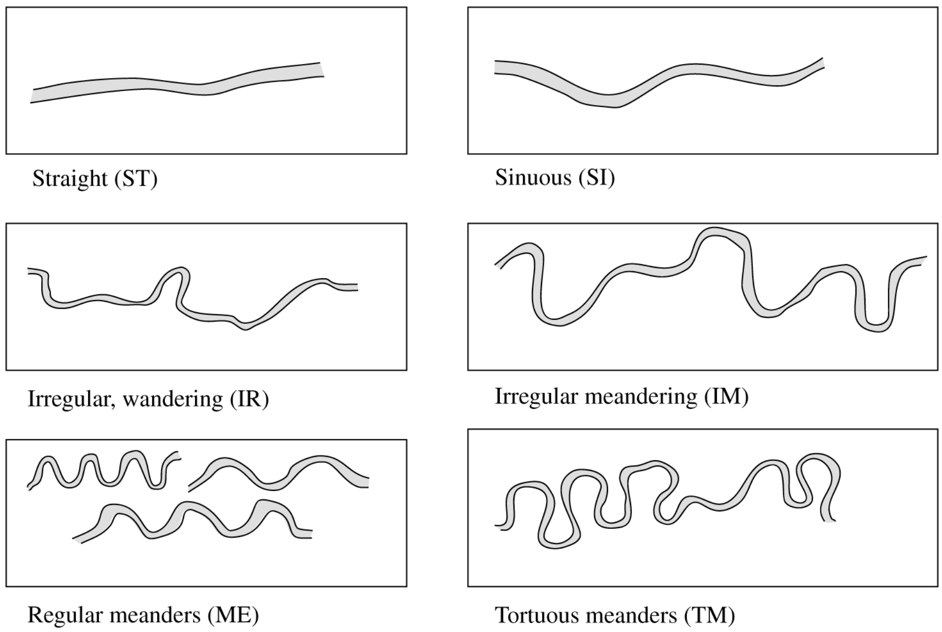
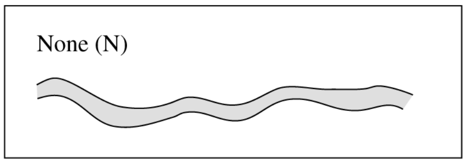


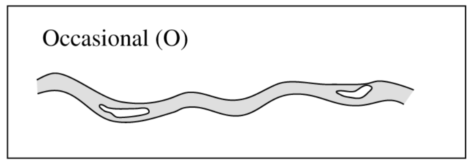
Figure 4.5. Stream channel patterns.

4.2.6.7 Islands

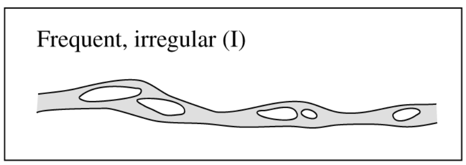
Islands in the stream channel are closely related to channel pattern, in terms of channel sensitivity to disturbances. Islands are permanently vegetated bedrock (support perennial vegetation over at least one half of the sample area and appear relatively stable—not likely to be eroded during the next high flow), or sediment, deposited within the channel. Identify the predominant island type during the field survey. Visually assess each site and assign one of the following (Figure 4.6) island descriptors (after Church, 1992):



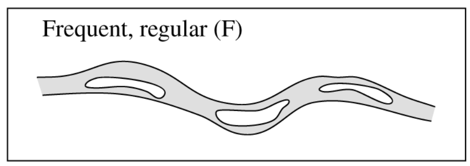
No islands in channel.



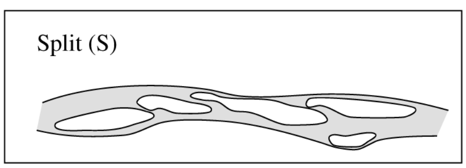
No overlapping of islands, average spacing being ten or more W_b.



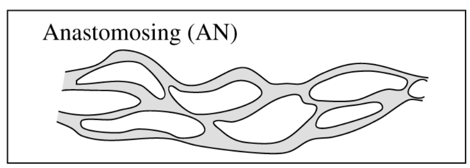
Infrequent overlapping, with average spacing less than ten W_b.



Not overlapping, average spacing less than ten W_b.



Islands overlap frequently or continuously; usually two or three flow branches.



Continuously overlapped islands, with multiple flow branches.

Figure 4.6. Stream channel islands.

4.2.6.8 Bars

Stream bars consist of exposed bed materials deposited by stream flow within the stream channel. Bars are sparsely vegetated to moderately vegetated and are distinct from islands, which are heavily vegetated and more stable. Bar type may be used to estimate stream stability. Determine the dominant bar type for each site visually and designate as illustrated in Figure 4.7. More than one type is acceptable.

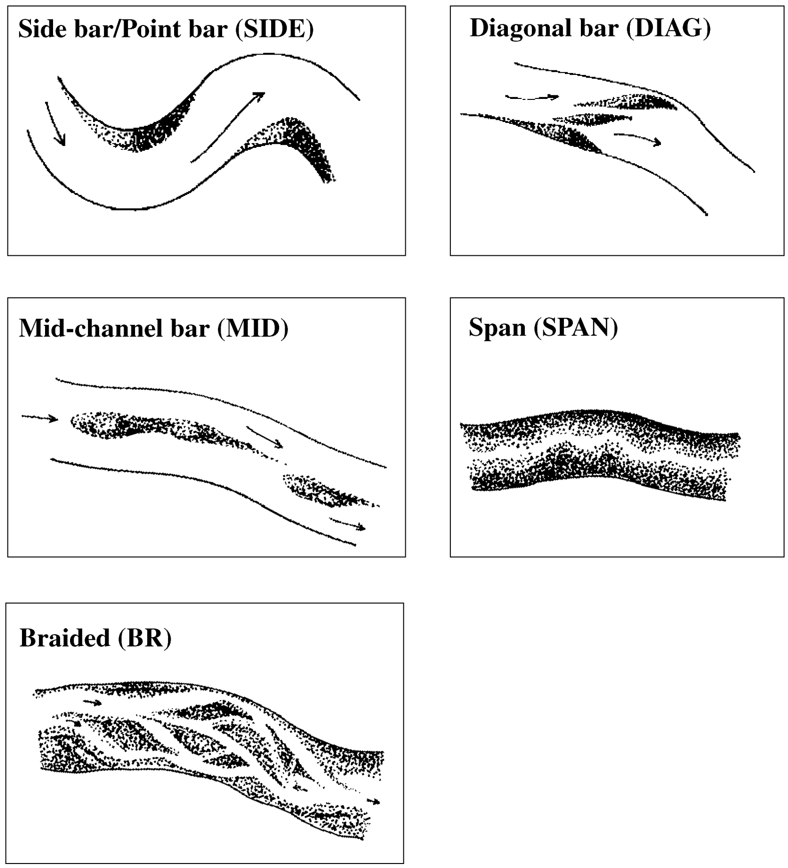


Figure 4.7. Stream bars.

4.2.6.9 Coupling

Coupling is a subjective assessment of sediment transfer routes from hillslopes to stream channels (Figure 4.8). Generally, the degree of coupling describes the short-term response of the stream channel to events that occur on the hillslope and the importance of the valley flat as a buffer to sediment transfer. Degrees of coupling include:

- Decoupled (DC) – A channel is considered decoupled from a hillslope when sediment mobilized on the hillslope by a landslide would not normally enter the stream channel (at any point—either side).
- Partially Coupled (PC) – A channel is considered partially coupled to a hillslope when a portion of the sediment mobilized on the hillslope by a landslide may directly enter the stream channel.
- Coupled (CO) – A channel is considered coupled to a hillslope when sediment mobilized on the hillslope by landslide activity will directly enter the stream channel (on either side).

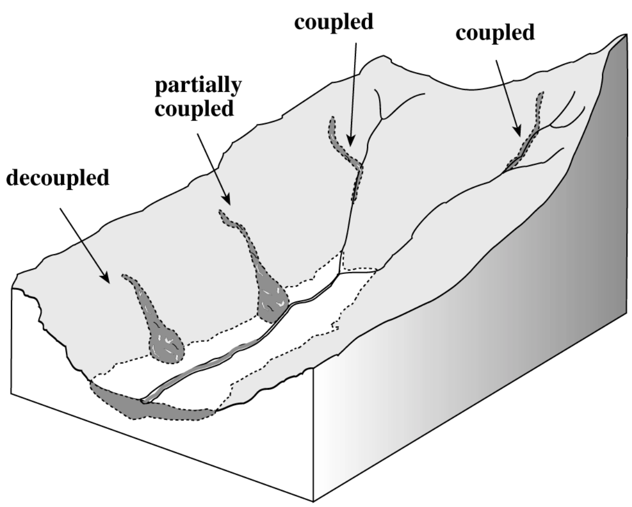


Figure 4.8. An illustrated description of coupling (from *Channel Assessment Procedures Guidebook*, 1996)**.**

4.2.6.10 Confinement

Confinement is a visual assessment of the degree to which the lateral movement of a river channel is limited by relic terraces or valley walls, as illustrated in Figure 4.9.

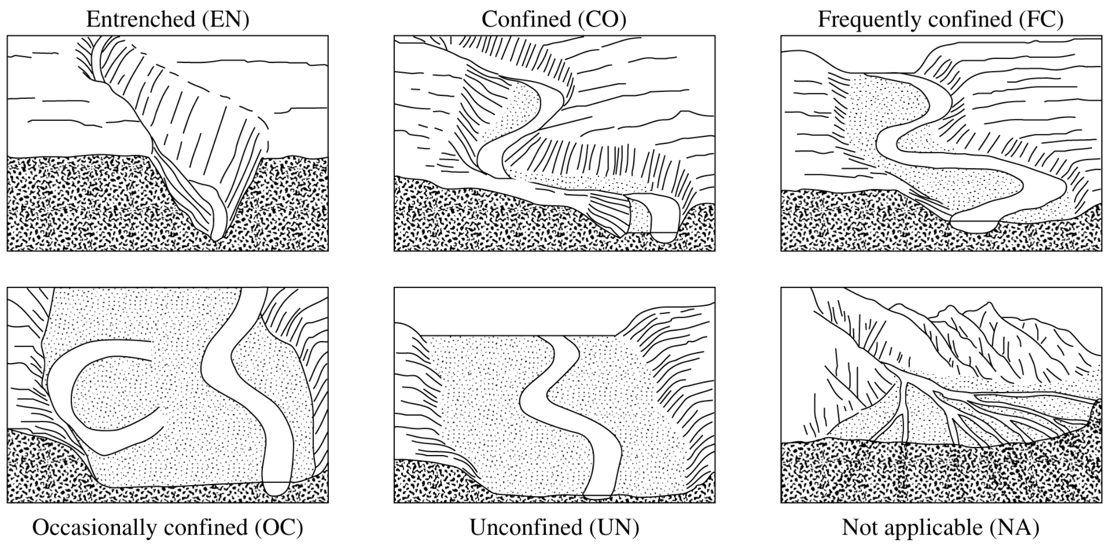


Figure 4.9. Types of channel confinement.

4.2.7 Features

Features of concern to fish populations, fish habitat, or the inventory (e.g., obstructions to fish passage, culverts, effluent outfalls) are to be identified on the site card. A list of such features is provided in Table 4.4. If width or gradient are deemed important for the feature, record these characteristics in the feature comment section.

Table 4.4. Stream feature types and codes

Code	Description	Code	Description
BD	Beaver dam	F	Falls
BG	Crossing, general	FD	Ford
BR	Bridge	FLD	Dewatering
C	Cascade or chute	FSB	Subsurface flow
CN	Canyon	FSZ	Fisheries sensitive zone
CV	Culvert	GE	Groundwater, field evidence
D	Dam, general	HCE	Erosion/sedimentation
X	LWD jam	HD	Hydro dam
ECAC	Spawning channel	LS	Landslide or bank sloughing
ECAH	Hatchery	TRB	Tributary
EOF	Fishway	VB	Velocity barrier
E	Enhancement, general unspecified	XW	Wedge

4.2.7.1 NID number

NIDs are assigned to identify features on a mapsheet. Each feature identified on a mapsheet is assigned a five-digit number, unique to that mapsheet, such as 00001 or 00002. The mapsheet number followed by this feature identifier number forms a complete NID reference code, unique to the project. Only the unique, five-digit feature identifier is marked on the mapsheet, adjacent to each feature. However, both the mapsheet number and the feature identifier are recorded on the data forms in their respective, corresponding columns. An example of the NID number entry is 00012.

4.2.7.2 NID map number

The NID map number is the mapsheet number of the map used to assign NIDs to the features (e.g., 92L.005).

4.2.7.3 Type

Record the type of feature using codes provided in Table 4.4.

4.2.7.4 Height/Length (HT/LG)

Measure or estimate the height, if applicable, and/or the length of features that have a linear upstream/downstream extent (e.g., 100 m long cascades) and record them in metres. If gradient and width are important characteristics, record these in the feature comment section.

4.2.7.5 Photo

Take a photograph for each feature described and record the roll and photo number.

4.2.7.6 Comments

Record comments related to described features.

4.2.7.7 UTM

This is the UTM coordinates of the feature and the associated method code. For linear features, record the UTM for the downstream point.

4.2.8 Fish/Habitat Comments

A fish/habitat comments section is available on the site card. Completion of this section is optional. Any significant comments related to the observation of fish and/or habitat that are not captured by site card data or section-specific comments should be included here. To be useful, comments must be accurate and concise. For example, if fish are observed spawning or distinct spawning sites are found, this information can be recorded in the fish/habitat comments section.

Site card data are intended to provide information that helps in forming a "picture" or understanding of what the habitat is like. Measurements provided in the channel, cover, water, morphology and features sections, along with photographic documentation, provide this picture. Habitat features characteristic of channel types and states are described in the *Channel Assessment Procedure* (CAP) *Guidebook* and field guide (FPC). CAP types are captured on the site card as morphology and are used to assist in the interpretation of habitat features and habitat capability from site data.

There are some standard coding and wording rules to follow to make searching of these comments more efficient:

- all references to fish species should use approved fish codes (see Table 4.5) in single quotation marks (e.g., 'CH' spawning sites located).
- the following words are limited to their use only in reference to fish habitat:

OFF (channel)	LWD
PRIMARY (channel)	DAM
SECONDARY (channel)	OBSTRUCTION
SPAWN	BARRIER
OVERWINTER	POOL
REAR	RIFFLE
MIGRATE	GRAVEL (spawning)
SIDE (channel)	FSZ
BACK (channel)	

Note that comments such as 'PRIMARY COVER TYPE IS LWD' should not be used, as PRIMARY refers to the primary channel. Choose alternative phrasing such as 'DOMINANT COVER TYPE IS LWD.' These words may be used in various tenses/forms (e.g., spawn, spawned, spawning).

Table 4.5. General fish species codes (to be used for fish/habitat comments only)

Code	Description	Code	Description
SP	Unidentified species	SB	Stickleback (general)
AO	All salmon	SG	Sturgeon (general)
BS	Bass/sunfish (general)	SU	Sucker (general)
BH	Catfish (general)	TR	Trout (general)
CBC	Chub (general)	WF	Whitefish (general)
DC	Dace (general)	L	Lamprey (general)
SA	Salmon (general)	C	Minnow (general)
CC	Sculpin (general)	P	Perch (general)
SM	Smelt (general)		

4.2.8.1 Fisheries sensitive zone (FSZ)

A fisheries sensitive zone is a flooded depression, pond, or swamp (but not a stream, wetland, or lake) which either perennially or seasonally contains water, and which is seasonally occupied by a species listed in the definition of fish-stream under the Forest Practices Code.

If a FSZ exists at the site, check the box.

4.2.9 Photodocumentation

4.2.9.1 Required photographs

Take one upstream-oriented and one downstream-oriented photograph at each site to show general stream characteristics including channel morphology, riparian vegetation, obstructions, and major disturbances.

Photos are required of any identified features, as well as representative[2] or diseased fish. Record fish photographs on the fish collection form.

4.2.9.2 Roll number (Roll #)

This is the film roll number corresponding to each photograph.

4.2.9.3 Frame number (#)

This is the negative frame number corresponding to each photograph.

4.2.9.4 Focal length (Foc Lg)

This is the focal length of the lens used to take each photograph. This is recorded as **Std** (standard, 35 mm), **Wd** (wide angle, <35 mm), or **Te** (telescopic/zoom, >50 mm).

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[2] Representative of the watershed/project area. Fish photos are not required at every site.

4.2.9.5 Direction (Dir.)

This is the general direction of each photograph with respect to the site from which the photograph was taken: **U** (upstream), **D** (downstream), **X** (across the stream), or **Bd** (towards the stream bed).

4.2.9.9 Comments

Record any relevant comments about the photograph. These should be descriptive enough and concise enough to provide a caption for the photograph.

4.2.10 Wildlife Observations

Throughout the course of field survey, crew members should remain alert to observations or signs of aquatic wildlife in addition to fish. Special attention must be given to the identification of species listed on the Conservation Data Centre (CDC) tracking lists.

Record any observations or signs of aquatic wildlife that may directly affect the fish and fish habitat. The survey crew should be familiar with various wildlife signs (e.g., nest types, tracks) or be equipped with relevant reference material in the field.

4.2.11 Additional Comments

Record additional comments and reference them by comment numbers.

4.2.12 Fish Inventory

The objective of fish sampling in a reconnaissance level fish and fish habitat inventory is to determine species diversity and relative abundance of fish in the stream reaches being sampled. Results of site sampling are then extended to make inferences about fish distributions and populations in remaining, unsampled reaches within the project area.

In order to achieve representative results, sampling efforts in streams must be systematic and must cover the range of habitats present in each stream reach, with techniques appropriate to the habitats, fish species and life stages that may be present. Reasonable effort must be made to ensure that all species present are represented in the catch. Collect information on individual fish, including fish aging structures, from a sample of all fish captured. Collect samples, including voucher specimens and tissues for genetic analysis, where identified in the project plan.

Conduct all fish sampling with minimum impact to the fish population. Gear selection and monitoring must be considered with respect to harmful effects. Consult the rare-and-endangered species list for the study area, available through the *CDC* web site) prior to selecting fish capture gear.

4.2.12.1 Sampling locations

Fish sampling is conducted at sites within stream reaches selected for sampling. All sample sites must correspond to sites recorded on the site cards. The minimum length of stream to be sampled at each location is the greater of 100 m or 10 W_b (e.g., minimum sample site length in a 30 m wide stream is 300 m). Select individual sites to ensure all habitat types are sampled in all sections of the primary, secondary and off-channel stream zones (see Figure 4.10). In some instances, the site length may be increased to adequately capture habitat sequences (e.g., long pool-riffle sequences).

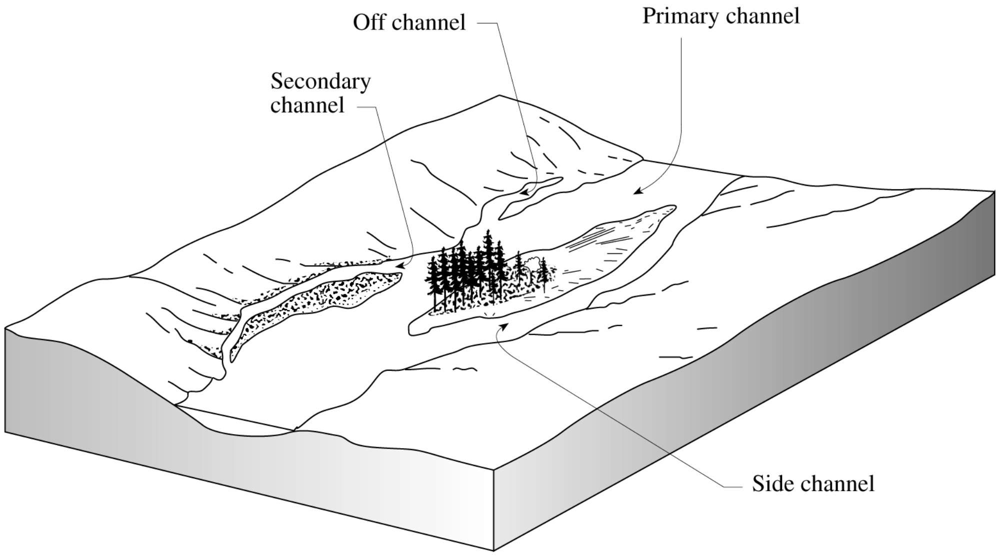

Figure 4.10. Stream zones.

4.2.12.2 Gear selection and sampling effort

Fish sampling gear is discussed in the *Fish Collection Methods and Standards,* RIC. Employ a variety of gear types suitable to the habitats being sampled across all available habitat types to ensure that a representative sample of each species present is captured. The majority of reconnaissance sampling effort in streams consists of electrofishing. However, in many cases, electrofishing is not feasible due to factors such as water depth or debris jams. Therefore, alternate primary sampling methods must be employed. Because the reconnaissance inventory covers a range of stream sizes, other techniques may be more appropriate in certain stream reaches. For example, visual observations made while snorkelling may be the most appropriate technique for large, clear streams. Trapping, seining, netting, or angling may be appropriate in other cases. Consider expected conditions and sampling gear requirements at the project planning stage.

To ensure that fish sampling covers the range of habitats present in each stream reach, with techniques appropriate to the habitats, fish species and life stages that may be present, the use of two sampling methods is required for the standard reconnaissance sample site, However, in some cases, the use of two methods is not appropriate and secondary methods need not be applied. Examples of situations where this may be the case include:

- very small streams where it can be demonstrated that the range of habitats can be effectively sampled using a single method (e.g., electrofishing).
- field situations where logistically the use of two methods causes significant time/cost implications. At sample sites where two methods are appropriate, but for logistic reasons a second method adds significantly to the cost, the second method at that site may be dropped.

This will undoubtedly bring up the question of quality control and what is the minimum that must be done in order that a fish sampling program will be accepted. The ministry acknowledges it is difficult to set definitive rules and therefore difficult to assess in terms of quality assurance. The approach to quality assurance will consider sampling in the context of the whole watershed, where it must be demonstrated that sufficient effort was applied.

Flexibility and common sense must be applied on both parts: professional judgements of the contract biologist and in ministry review.

For electrofishing, the sampling effort required is based on the length of stream fished and the time considered appropriate for the conditions of the stream. Minimum sample-site length is 100 m or 10 W_b, whichever is greater. **Sample all habitat types within the site.** (Note: The sampling-length criterion is the minimum length acceptable.) In certain cases, it may be necessary to increase the length of stream sampled (e.g., where repeating pool-riffle sequences contain extremely long pool or riffle units), and the sampled portion of stream only incorporates one unit. Where the number of fish captured in a sample site exceed the requirements of a reconnaissance survey (e.g., vast numbers of juvenile fish), use professional judgement to limit the sampling effort to reduce the impact on the fish population. This reduction must not occur at the expense of detecting less abundant species.

As an example of how to continue sampling in this situation, one would simply not sample in the habitats where the vast numbers of a particular species were initially captured. Efforts would be channeled towards other habitats present within the sampling site (the greater of 10 bankfull channel widths or 100 m).

Stop nets installed downstream at the site are recommended to aid in fish capture while electrofishing, especially where visual observation and capture of fish is impaired by turbidity, excessive water velocity, or turbulence. Barrier nets are very effective in intercepting fish escaping from a sample site that may otherwise not be seen. Also, where fish presence or absence is an issue, the use of downstream nets may be required.

Record each method used to capture fish at a given sample site along with the gear specifications on the fish collection form.

4.2.12.3 Fish sampling and data recording

Record all field data on the fish collection form. Consult the *Fish Collection Methods and Standards*, RIC prior to field work. It contains information on all fish handling procedures including the use of anaesthetics, recovery and release of fish, standard codes, and protocols.

Sampled fish

All fish captured must be identified to species level. Information is recorded as individual fish data and as a fish summary recording total captures by sampling "event."

Fish summary

Often data about every single fish captured or observed is not recorded. For example, an electrofishing site could capture 87 rainbow trout fry, 125 longnose dace, and 47 coho fry. Individual fish measurements would be made only on a sample for each species/age group, leaving out the information on how many fish were actually captured at that electrofishing site. This total number of each species captured in each sampling "event" is recorded in the fish summary section of the fish collection form. Sampling "events" are referenced by site, method and number (e.g., Site =1, Method = EF, No. = 1). Recording by Haul #/Pass #, Stage, or Age group within species is allowed but is not required for standard reconnaissance sampling.

Individual fish data

Individual fish information is recorded for a sample of all species captured in the site in the Individual fish data section of the fish collection form. The sample for each species captured must cover the range of individual fish captured, and must be sufficient to provide results appropriate to the survey objectives.

1. **Species:** Accurately identify and record all fish sampled using the *Field Key to the Freshwater Fishes of British Columbia,* RIC and the appropriate fish species codes. If a fish species cannot be identified, enter SP as the species code, and write in the comment field that a voucher specimen of the unidentified species has been collected and submitted. General group names or possible identifications can also be entered in the comment field, and will be especially important if there are two or more species that are in question. Voucher specimens should also be submitted if there is any doubt about the identification. Error rates by field crews are currently running at about 20–30%, even for salmonids. This error rate can only be reduced through diligent use of the voucher specimen program.
2. **Sample sizes:** The intent of individual fish sampling in streams is to determine the characteristics of the fish population. Results from individual sample sites can be combined to create population-level statistics. For individual sample sites, the following sample sizes are recommended for each species.
   - Sport fish species:

   If N>60, randomly select 60 (measure all if <60) for length only; count the rest.

   Select individual fish that represent a range of sizes and age classes and sample for age and sex and maturity (if possible). In streams, distinct age groups may be obvious from the fish captures. Collect enough scale samples to permit age class separation, but do not oversample (a checklist of length categories or a length-frequency tally can be used to do this). If sample sites within a stream are in close proximity, fish age samples taken at one site may be applicable to the other, reducing the number of samples required.
   - Non-game species:

   If N>30, randomly select 30 for length; count the rest. For the selected 30, record sex, maturity, weight and age if specifically requested.
3. **Length:** Record the fork length (FL) or the total length (TL), in mm, of each fish sampled. Fork length is the length of a fish (in mm) from nose tip to fork of tail (median caudal fin rays), and is measured only for fish with forked tails (e.g., salmonids). Total length is the distance from the most anterior part of the head to the tip of the longest caudal fin ray and is measured only for fish that do not posses a forked tail.
4. **Weight:** In stream sampling, fish weight is usually not required. If required, or if the fish caught is of interest (e.g., larger individual, unusual occurrence), it should be recorded in grams to the nearest 1.0 g.
5. **Sex:** Determine and record the gender of each fish sampled, if possible. If the fish is ripe and ready to spawn, sex may be easily determined by secondary (phenotypic) sexual characteristics. If the sex cannot easily be determined by external examination, internal examination will be required only of those specimens already sacrificed for other reasons (i.e., voucher specimens).
6. **Maturity:** Maturity represents the determined life stage of the fish and is visually estimated as ‘immature,’ ‘maturing,’ ‘mature,’ ‘spawning,’ or ‘spent.’

7. **Aging structure:** Aging structures from several representatives of each size group of each sport species is recommended. Samples should be taken over the range of fish sizes and to separate age groups. The body structure used for determining fish age is numbered (age sample number) and preserved. Scales or fin ray clippings are the required aging structures. Otoliths, cleithrum and operculum can be collected from an individual fish only if it fish dies during the capture, measurement, or release procedures.
8. **Age (structure) sample number:** A unique identification must be assigned by the crew to each body structure that is used to determine fish age.
9. **Age:** Determine and record the age of the fish using the aging structure collected. Note that this is a post-survey exercise; the age is recorded on the form after age data are complied. The age of the fish will be verified, using the aging structure submitted by the crew, as a part of the QA procedures.
10. **Voucher number:** The crew must assign a unique identifying number to each voucher specimen collected.
11. **Genetic structure:** Certain body structures may be required for the purposes of genetic classification of species and will be specified by the contract monitor.
12. **Genetic sample number:** The crew must assign a unique identifying number to each genetic sample, if collected. Record this number on the form.

Visually observed fish

In situations where visual observations, made while snorkeling, for example, are the only feasible means of determining fish presence, the Data Summary section of the Fish Collection Form is completed. All codes and data recording protocols are provided in the *Fish Collection Methods and Standards,* RIC. The following information should be determined:

1. **Species:** Identify all observed fish, as accurately as possible, using the *Field Key to the Freshwater Fishes of British Columbia,* RIC and recording on the form using the appropriate fish species codes.
2. **Life stage:** Observe the life stage of the majority of fish of each species and record as ‘fry,’ ‘parr,’ ‘juvenile,’ or ‘adult.’
3. **Total number, minimum, and maximum length:** Record an estimate of the total number of fish of each species, and their average, minimum, and maximum length (where possible).
4. **Fish activity:** Record the activity exhibited by the majority of the observed fish as ‘migrating ,’ ‘incubating,’ ‘spawning,’ or ‘rearing (feeding or resting).’

4.2.12.5 Photodocumentation

Take and document colour photographs of at least one representative fish of each species in the inventory project area. Representatives of any fish that the crew is unable to identify, or of any diseased or parasitized fish must be photographed as well. The quality of these photographs should enable verification of fish species identifications. Each photograph must include an object of scale, such as a ruler, to indicate the relative size of the fish. Photographs including all species captured, with one representative fish per species are acceptable. Post-field photodocumentation standards are described in Appendix 6.

4.2.12.6 Voucher specimens

Voucher specimens may be required from the fish sample. Reference voucher collections require a representative selection of each species group encountered in the watershed. The need for reference voucher collections will be known and incorporated at the project planning stage (see Chapter 2, *Pre-field Phases*). Additional collection of representative specimens of any fish that the crew is unable to identify in the field, as well as of any diseased fish, fish showing signs of parasitism or of hazardous environmental impact, are also required. Voucher specimen requirements and restrictions, including fixation, preservation and submission of specimen protocols are discussed in the *Fish Collection Methods and Standards*, RIC. This document also provides information on additional sampling and collection of tissue for age determination and genetic analysis, which may be required for some projects.

Chapter 5.
Reporting and Mapping

Table of Contents

5.1 Data Compilation and Reporting for Watershed Surveys

This section describes data compilation and report preparation for watershed reconnaissance surveys. Individual lake survey requirements are given in 5.2. Information gathered from individual lake surveys must be incorporated into the watershed reporting process where appropriate. Deliverable checklists are provided in 5.3.

5.1.1 Watershed Codes/Waterbody Identifiers

The correct watershed code for all lakes and streams, and waterbody identifier for each lake must be determined and recorded for all data collected. Replace any ILP numbers used during the project. In the event watershed codes are not available at the end of the project, submit the ILP reference map and ILP tables with the project report.

The correct watershed code for all lakes and streams, and waterbody identifier for each lake must be determined and recorded for all data collected. Replace any ILP numbers used during the project. In the event watershed codes are not available at the end of the project, submit the ILP reference map and ILP tables with the project report.

5.1.2 NIDs and UTMs

If used throughout the project, NIDs must be used diligently to identify where data points occur on the maps. These will allow the GIS and FDIS data sets to be linked to provide fully functioning digital mapping. All NIDs must have a UTM. All mapped features must be georeferenced by UTMs in the final data set. Update field obtained UTM data, through digital mapping, so that points are within 10m of source line work on 1:20,000 scale maps. Where FDIS allows, retain both field obtained and final UTM data.

5.1.3 Conflicting Information

Where reach information is found to conflict with site information (e.g., a pattern was identified as SI at the reach level, but ST at the site level), the reach information should not be corrected to coincide with the site information. The data should be left as is to show differences in interpretation at the different levels. Where a clear error occurred (due to transcription or misinterpretation), the appropriate data should be corrected.

5.1.4 Post-field Analysis Results

Compile and prepare results from any post-field sample analysis for entry into electronic databases. These include:

- **Fish identification** – incorporate verification of fish identification into the fish collection results. Any changes that result from verified samples must be incorporated into the fish collection forms prior to electronic data entry.
- **Fish age analysis** – incorporate results of fish aging into the fish collection forms prior to electronic data entry.
- **Water quality results** – water sample analysis results are electronically stored in the EMS database. For lake inventory projects, compile hard copy results into an appendix to accompany the individual lake survey report. The requirement to enter data into the FDIS is currently under discussion. Stream water sample analysis results must be appended to the fish and fish habitat inventory report.

- **Aquatic organism identifications** – incorporate results of any taxonomic verifications requested into the data set. This includes aquatic plants and any aquatic wildlife observations. Aquatic plant species lists may be attached to individual lake survey reports as an appendix.

5.1.5 Photographic Documentation

Photographs can be delivered in the following general groups:

- Photos for FDIS reach/site Summary;
- All photos taken for project inventory.

See Appendix 6 for details of photodocumentation and scanning deliverable requirements.

The field forms must be submitted with completed photodocumentation sections.

5.1.6 Databases

After field work is complete, enter data from all data forms and cards into the FDIS databases. Incorporate the results of post-field sample analysis, including fish identifications and aging. Provide electronic FDIS databases with correct watershed codes, waterbody identifiers, and UTM locations for all data collected during the project. Further information on FDIS and procedures to import watershed codes and enter post field analysis results can be found on the *Fisheries Inventory* web site.

5.1.7 FISS Updates

Provide updated hard copy FISS data forms as necessary. Also include hard copy maps annotated with new FISS data. For further information refer to*: Fisheries Information Summary System: Data Compilation and Mapping Procedures,* RIC.

5.1.8 Standard Maps

Three maps are required as deliverables; the Fisheries Overview, Fisheries Project and Fisheries Interpretive maps. Mapping associated with the Reconnaissance Inventory is described in detail in the *Standards for Fish and Fish Habitat Maps* RIC . This standard must be consulted to confirm mapping content, symbology, labelling, map layout, codes, and legends. A general description of the three required maps follows.

Project Overview Map – this map will show the entire project area (with boundary lines), and include:

- TRIM/Forest Cover (FIC) aquatic features as background;
- Location of all sample sites;
- 8.5" × 11" size, or 11" × 17" for larger project areas. For very large areas, use larger plots rather than several small maps;
- Inset map showing project location in relation to region or province.

Fisheries Project Map – this map is intended to summarize all *new* information collected under the inventory project. The map must be displayed at a scale of 1:20 000, and if required, several maps may be joined together by eliminating those portions of maps outside the project area. “E”-sized plots are used. New information such as watershed codes (ILPs), stream features, and reach, site and lake data are presented using the TRIM/FIC aquatic features as the base. The intent is to provide information on the map for all reaches and lakes, with a “link” to associated attribute database information.

Fisheries Interpretive Map – this map is intended to illustrate the results of classifications or interpretations. It is not generated directly from attributes stored in a database but from conclusions based on a synthesis of various data. It may not be requested in all cases. Build interpretive maps using “E”-size plots and at a scale of 1:20 000, but as with the project map, several sheets can be combined.

5.1.8.1 Automated Mapping

An automated mapping program has been developed to assist in the preparation of the standard maps. The Fish Inventory Mapping system (FishMap) is an ArcView extension designed to be used with FDIS. Further information and user guide for Fish Map is available from the *Fisheries Inventory* web site.

5.1.8.2 Hard Copy Map Deliverables

Provide a hard copy of each Project Overview, Fisheries Project and Fisheries Interpretive map. Full size maps should be of sufficient scale and size to allow clear interpretation of information, labelling, and other features. For further desriptions of these maps see *Standards for Fish and Fish Habitat Maps,* RIC.

5.1.8.3 Digital Format Map Deliverables

Digital files to provide associated with the standard maps include:

- the Mapping Symbol File exported from FDIS (Fish and Fish Habitat Map Features Table);
- digital files of the hardcopy maps. Adobe Acrobat (*.pdf files) are encouraged. See 5.1.11 Fish and Fish Habitat Inventory Report Index);
- digital metadata table.

Ensure that the format of the digital products conform to the specifications detailed in *Standards for Fish and Fish Habitat Maps*, RIC.

5.1.9 Watershed Report

An example watershed report can be obtained from the *Fisheries Inventory* web site. Refer to the example report for specific descriptions of report content. Each report should conform to the following example:

1. Cover page

A sample title page follows.

2. Table of Contents

A sample table of contents follows.

Reconnaissance (1:20 000) Fish and Fish Habitat Inventory
of
Buba Creek Watershed
WSC: 400-033300

Prepared for:

Little Tree Forest Ltd.
Arrow Lakes Timber Division
Box 12
Anytown, BC
V1L 4K3

Prepared by:

Big Fish Consulting Ltd.
Box 21
Anytown, BC
V1L 4K3

Approved by:

____

Klipp Finn, R.P. Bio

February 24, 1997

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5.1.9.1 Project-specific Reporting

Some inventory projects may require including in the reports details or analysis concerning specific aspects of the inventory project. These requirements are project-specific and should be discussed with the contract monitor at the project planning phase. Examples are:

- Analysis of fish-related information (e.g., length–weight relations);
- Non-fish bearing reach (streams and lakes) reports; and
- Suggested riparian management area classification.

Refer to the example reports on the *Fisheries Inventory* web site for specific details.

5.1.9.2 Hard Copy Report Format

Prepare the report text single-spaced. Fonts such as Times Roman are suggested. Provide appropriate margins for binding the report. Number all pages.

5.1.9.3 Digital Report Format

Fish and Fish Habitat Inventory (FFHI) reports are required in digital format. Specific digital formats [e.g. Adobe acrobat (*.pdf files)] will facilitate improved access to the reports, and may reduce the number hardcopies required. See *Fish and Fish Habitat Inventory Report Index* 5.1.11.

Current specifications are:

- MS Word or Adobe Acrobat (*.pdf files);
- All diagrams and data tables must be embedded within the word file (e.g., do not submit excel tables separate from the word file). Do not separate different sections/chapters into different files;
- All report photographs need to be linked or embedded to the electronic version of the report;
- All maps that are referred to in the report discussion, need to be linked to the electronic version of the report.

5.1.10 Quality Assurance

QA procedures as described in the QA manual should be followed. Automated procedures within FDIS must be run to ensure the data is of high quality. The FISHQA tool should be run on the digital Mapping Symbol File exported from FDIS before any standard maps are produced. FDIS, FishMap and the Fish QA Tool are designed to work together. Manual procedures are described in the *Reconnaissance (1:20 000) Fish and Fish Habitat Inventory: Quality Assurance Procedures,* RIC.

5.1.11 Fish and Fish Habitat Inventory Report Index

The number of copies of all deliverables is project specific, to be discussed with the project proponent. The FFHI Report Publishing System has been developed to allow convenient access to FFHI reports over the internet. Some of the benefits of this system are improved public and Ministry access to report data and reduced contractor expenses through reduction of hardcopy requirements. Report and map products delivered in Adobe Acrobat (*.pdf) file format will enable efficient publication in the FFHI Report Publishing System. The Ministry publishes the reports on the *Fish Inventory* web site where they can be accessed through the *Fish and Fish*

Habitat Inventory Report Index. Information on the FFHI Report Publishing System, including a User's Guide and templates, is available on the *Fisheries Inventory* web site.

5.2 Data Compilation and Reporting for Individual Lake Surveys

When individual lake surveys are part of a Watershed project survey, information gathered from individual lake surveys must be incorporated into the watershed reporting process where appropriate. The following data compilation and reporting steps described for the Watershed reporting (Chapter 5.1) apply to individual lake surveys:

Watershed Codes/Waterbody Identifiers	5.1.1
NIDs and UTMs	5.1.2
Conflicting Information	5.1.3
Post-field Analysis Results	5.1.4
Databases	5.1.6
FISS Updates	5.1.7
Project-specific Reporting	5.1.9.1
Hard Copy Report Format	5.1.9.2
Digital Report Format	5.1.9.3
Quality Assurance	5.1.10

Additional items for individual lake surveys are described below. A deliverable checklist for individual lake surveys is provided in 5.3.

5.2.1 Photographic Documentation

Photographs can be delivered in the following general groups:

- Photos for FDIS reach/site (Tributary) summary;
- Photos referred to in report discussion;
- All photos taken for project inventory
- See Appendix 6 for details of potodocumentation and scanning requirements.
- The field forms must be submitted with completed photodocumentation sections.

5.2.2 Post-field Analysis Results

- **Lake bathymetric statistics –** bathymetric statistics are calculated and recorded on the bathymetric map. Record statistics such as volume and mean depth in FDIS.

5.2.3 Lake Outline Map

Prepare a final lake outline map for each lake surveyed. See *Bathymetric Standards for Lake Inventories,* RIC. The map must show the location of the following:

- Benchmark;
- Bathymetric transect and spot depths;
- All inlet and outlet streams including any reaches surveyed;
- Limnological station;
- Prominent recorded shoreline features;

- Fish sampling sites;
- Dominant aquatic macrophyte beds; and
- Photographic sites and direction of photographs.

5.2.4 Lake Aerial Photograph

One aerial photograph enlargement of each lake surveyed should be appropriately marked to identify the following locations:

- Benchmark;
- High water mark;
- Limnological station;
- All fish sampling sites; and
- Inlet and outlet streams.

5.2.5 Bathymetric Map

A bathymetric map must be prepared for each primary lake surveyed. The map must follow the standards given in *Bathymetric Standards for Lake Inventories,* RIC. Calculate and record bathymetric statistics on the map and update FDIS. Provide hardcopy bathymetric mapping both as a full size map of an appropriate scale and in 8.5"×11" format. Digital bathymetric maps are also required. For digital map specifications, see *Bathymetric Standards for Lake Inventories*, RIC.

5.2.6 Individual Lake Report

An individual lake report is required for each lake surveyed and must be referenced in the Watershed Report. This section describes the layout and format of individual lake inventory reports. An example product can be obtained from the *Fisheries Inventory* web site. Refer to the example report for specific descriptions of report content. Each report should conform to the following examples:

1. Cover page

A sample title page follows.

2. Table of Contents

A sample table of contents follows.

Reconnaissance (1:20 000) Fish and Fish Habitat Inventory
of
Buba Lake
WSC: 400-033300

Prepared for:

Little Tree Forest Ltd.
Arrow Lakes Timber Division
Box 12
Anytown, BC
V1L 4K3

Prepared by:

Big Fish Consulting Ltd.
Box 21
Anytown, BC
V1L 4K3

Approved by:

____

Klipp Finn, R.P. Bio

February 24, 1997

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[1] **Resource Information**: This requires a brief summary of **previous and concurrent survey** information, and information on any landuse and development issues that have or may impact the lake.

1. If appropriate, these may be listed in the report under the following sections:
2. First Nations issues and interests in the study area.
3. Development and land use: logging, mining, recreation
4. Other developments, concerns or points of interest
5. Impacts and uses by wildlife
6. Identify any existing water quality data
7. Previous presence of fish (list species and dates)
8. Data pertaining to inlets and outlets of the lake should be included here

[2] **Methods:** Identify the standards used (e.g., Reconnaissance [1:20 000] Fish and Fish Habitat Inventory: Methods and Standards, 1998; Bathymetric Standards for Lake Inventories, 1999) and describe any deviations from the standards, giving reasons, primarily for:

1. Bathymetry
2. Limnology
3. Stream fish capture
4. Lake fish capture
5. Fish age and growth
6. Photodocumentation
7. Site sampling
8. Digital mapping

5.3 Final Deliverable Checklist

Draft materials must be provided for a QA review prior to completion of final deliverables. All requested changes must be incorporated into final deliverables.

All deliverables must incorporate data and results for the entire project area, whether conducted under the current contract or not, including all data and mapping produced during pre-field (phases I to III), field (phase IV) and post field results (phases V and VI).

The final deliverable checklist is intended as a list of items that may be required as final deliverables for Fish and Fish Habitat Inventory Surveys. Some items may be contract specific.

5.3.1 Final Deliverables for Watershed Reports

Final watershed report with Appendices and Attachments including:

- Hard copy written report (text, figures, tables, etc.) including:
  - Project Overview Map
- FDIS summary
  - FDIS Reach/Site card printouts
  - Fish Data Collection Form
- Photographs (See Appendix 6 for specifics)
- Maps
  - Fisheries Project Map
  - Fisheries Interpretive Map
- Pre-field Planning document
- Field notes, forms, and maps
- Fish ageing structures
  - Actual structures
  - Labelled Photocopies
- Fish samples and vouchers
  - Table: Vouchers collected
  - Table: DNA collected
  - Actual Fish Vouchers
  - Evidence of expert fish ID
- Photodocumentation (See Appendix 6 for specifics)
  - Photodocumentation Form 1
  - Binder with indexed slides or negatives (with photograph contact sheet)
  - Indexed copies of photographs in digital CD format
- Digital Data
  - Pre-field Planning documentation
  - Table of vouchers collected
  - Table of DNA collected

  - Photo summary report (See Appendix 6 for specifics)
  - Written report (text, figures, tables, etc.)
  - Electronic FDIS databases including:
    - ~ Correct watershed codes,
    - ~ Waterbody identifiers
    - ~ UTM locations for all data collected during the project.
    - ~ Data entry of post-field sample analysis results as required.
  - Maps
    - ~ Project Overview Map
    - ~ Fisheries Project Map
    - ~ Fisheries Interpretive Map
    - ~ Metadata Table
    - ~ Map Symbol File from FDIS (Fish and Fish Habitat Map Features Table)
- Fiss Update materials
- Aerial Photography
  - Purchased original Aerial photos
  - Aerial video tape

5.3.2 Final Deliverables for Individual Lake Reports

Final Individual Lake Report with Appendices and Attachments including:

- Hard copy written report (text, figures, tables, etc.) including:
  - Location (Overview) Map
  - Outline Map
  - Enlarged annotated air photo
- Lake Survey Form
- Water Chemistry Data
- Fish Collection Form (Lake)
- FDIS Reach/Site (Tributary) Summary
  - FDIS Reach/Site card printouts
  - Fish Data Collection Form (Tributary)
  - Photographs (See Appendix 6 for photograph specifics)
- Report Photographs (See Appendix 6 for specifics)
- Bathymetric Map
- Photodocumentation (See Appendix 6 for specifics)
  - Photodocumentation Form 1
  - Binder with indexed slides or negatives (with photograph contact sheet);
  - Indexed copies of photographs in digital CD format
- Digital Data
  - Pre-field Planning documentation
  - Table of vouchers collected
  - Table of DNA collected
  - Photo summary report (See Appendix 6 for specifics)

- Written report (text, figures, tables, etc.) including:
  - ~ Location Map
  - ~ Outline Map
  - ~ Enlarged annotated air photo
- Electronic FDIS databases including:
  - ~ Correct watershed codes
  - ~ Waterbody identifiers
  - ~ UTM locations for all data collected during the project
  - ~ Data entry of post-field sample analysis results as required
- Bathymetric Map

- Fiss Update materials
- Field notes, forms, and maps
- Echo sounding data (continuous paper trace sounder rolls)
- Aerial Photography
  - Purchased original Aerial photos
  - Aerial video tape
- Fish samples and vouchers
  - Table: Vouchers collected
  - Table: DNA collected
  - Actual Fish Vouchers
  - Evidence of expert fish ID

References

Resource Inventory Committee (RIC) References

The following documents can be found on the RIC Standards Aquatic Ecosystems web site:

Aerial Photography and Videography Standards: Applications for Stream Inventory and Assessment, RIC (1996)

Ambient Freshwater and Effluent Sampling Manual, RIC (1997)

Bathymetric Standards for Lake Inventories: Fish and Fish Habitat, RIC (1999)

Field Key to the Freshwater Fishes of British Columbia, RIC (1994)

Fish Collection Methods and Standards, Version 4.0, RIC (1997) and *Errata #1,* RIC (March 1999)

Fisheries Information Summary System: Data Compilation and Mapping Procedures, RIC (1997)

Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: *Lake Survey Form Field Guide,* RIC (1999) and *Errata,* RIC (March 2000)

Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: *Fish Collection Form Field Guide,* RIC (1999) and Errata RIC (March 2000)

Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: *Site Card Field Guide,* RIC (1999) and *Errata* RIC (March 2000)

Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: *Reach Information Guide.* Version 1.0, RIC (2000)

Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: *Quality Assurance Procedures.* Version 1.0, RIC (2000)

Reconnaissance (1:20,000) Fish and Fish Habitat Inventory: *Users Guide to the Fish and Fish Habitat Assessment Tool (FHAT20)* Version 1.0, RIC (2000)

Standards for Fish and Fish Habitat Maps Version 2.0, RIC (1998) and *Errata* RIC (April 1999) and *Errata #2* RIC (March 2000)

User's Guide to British Columbia's Watershed/Waterbody Identifier System, Version 2.1, RIC (2001)

The following document can be found on the RIC Background Documents Aquatic Ecosystem web site:

Identification Keys to the Aquatic Plants of BC, RIC (1994)

Forest Practices Code Publications

The following documents can be found on the Forest Practices Code Guidebooks web site:

Province of British Columbia. 1996. Channel Assessment Procedure Guidebook. Forest Practices Code, Guidebook. B.C. Min. For., Victoria, B.C.

Province of British Columbia. 1998. *Fish-stream Identification Guidebook* Second Edition. Forest Practices Code Guidebook. B.C. Min. For., Victoria, B.C.

Province of British Columbia. 1999. Managing Identified Wildlife: Procedures and Measures: Volume 1 Forest Practices Code. B.C. Min. For., Victoria, B.C.

Province of British Columbia. 1995. *Riparian Management Area Guidebook. Forest Practices* Guidebook. B.C. Min. For., Victoria, B.C.

Forest Renewal Publications

Johnston, N.T. and P.A. Slaney. 1996. *Fish habitat assessment procedures.* B.C. Min. Environ., Lands and Parks, and B.C. Min. For., Victoria, B.C. Watershed Restoration Tech. Circ. No. 8.

Non Provincial Government Publications

Allaby, A. and M. Allaby. (eds.) 1991. The Concise Oxford Dictionary of Earth Sciences. Oxford University Press, New York, N.Y.

Anonymous. 1985. Gazetteer of Canada for British Columbia

American Public Health Association (APHA). 1989. Standard methods for the examination of water and wastewater. 17th Edition. Washington, D.C.

Canadian Council of Resource and Environment Ministers (CCREM – currently renamed Canadian Council of Ministers of the Environment [CCME]). 1987. Canadian water quality guidelines. Ottawa, Ont.

Church, M. 1992. Channel morphology and typology. In The rivers handbook: Hydrological and ecological principles. C. Callow and G. Petts (eds.). Basil Blackwell, Oxford, UK. pp. 126–143.

Church, M. and D. Jones. 1982. Channel bars in gravel-bed rivers. In Gravel-bed rivers. R. Hey, J. Bathurst, and C. Thorne (eds.). John Wiley and Sons, Chichester, UK. pp. 291–336.

Hutchinson, G.E. 1957. A Treatise on Limnology. Volume 1: Geography, Physics and Chemistry. John Wiley & Sons, Inc. New York, N.Y. (1015 pp.)

Kaufmann, P. and F. Robison. 1993. A quantitative habitat assessment protocol for field evaluation of physical habitat in small wadable streams: Mid Appalachian version. For. Engin. and Fish and Wildl. Dep., Oregon State Univ. in Cooperation with U.S. EPA ERL, Corvallis, OR.

Mitchell, A. and R.P. Agnew. 1996. Stream, wetland and lake classification business requirements. Business Design Branch, BC Min. For., Victoria, BC.

Web Sites

BC Fisheries: http://www.bcfisheries.gov.bc.ca/

Conservation Data Centre: http://www.env.gov.bc.ca/rib/wis/cdc/

Fisheries Inventory: http://www.bcfisheries.gov.bc.ca/fishinv/

Forest Practices Code Guidebooks:
http://www.for.gov.bc.ca/tasb/legsregs/fpc/fpcguide/guidetoc.htm

Geographic Data B.C.: http://home.gdbc.gov.bc.ca/

RIC Standards Aquatic Ecosystems: http://www.for.gov.bc.ca/ric/PUBS/Aquatic/Index.htm

RIC Background Documents Aquatic Ecosystem:
http://www.for.gov.bc.ca/ric/o_docs/Aquatic/Index.htm

Appendix 1.
Information Resources

Information Sources for Existing Data Review and Project Planning

Internet Access to Data

Access to fisheries information is available over the Internet through **FishInfo BC** on the *BC Fisheries* web site.

The **FishWizard** is a simple map-based Internet tool for finding and viewing fisheries-related information in government databases. It is intended primarily for public use and currently links to datasets that include the Fisheries Information Summary System (FISS), species distribution, escapement records and stocking records. The 1:50 000 Watershed Atlas is used as the digital base map. Because the FishWizard directly accesses databases that are continuously being updated, the most recent data is available to users.

The **Fisheries Project Registry** (FPR) is a map-enabled database management system, accessible on the Internet, which tracks minimum data about the existence, general nature, location and key contacts for fisheries-related projects. The Registry contains projects approved by funding agencies or sponsoring organizations, giving other individuals and groups the ability to quickly and easily get basic information about projects in any watershed or within any stream reach, lake, wetland or marine statistical area. The Registry is managed by Fisheries and Oceans Canada and can be accessed through FishInfo BC or through the Fisheries and Oceans Canada web site.

The FishWizard and the Fisheries Project Registry are joint provincial-federal information sharing initiatives under the Canada-BC Agreement on the Management of Pacific Salmon Fishery Issues.

A third component of FishInfo BC is the **Fisheries Inventory** web site. This site provides access to detailed fisheries information available in the provincial Fisheries Data Warehouse, including the Watershed Dictionary (watershed code information), FISS, Fish stocking records, Stream survey data and Lake Survey data.

Fisheries Information Summary System

Most available information on fish and fish habitat has been compiled into the Fisheries Information Summary System (FISS) and should be the starting point for data review. FISS contains information previously available in the Stream Information Summary System (SISS) catalogues, and any other information available when the compilation was undertaken. FISS is updated on a continuous basis.

FISS information is available from the Internet sources listed above. General or specific questions regarding the nature and/or content of FISS data, geographic status reports, or information about references may be directed to:

FISS Data Manager
BC Fisheries
email: FishDataIssues@Victoria1.gov.bc.ca

Hard copies of the FISS maps are available at a cost from:

Archetype Print
459–409 Granville Street
Vancouver, B.C. V6C 1T2
phone: (604) 602-0282; fax: (604) 602-0283

Please note that Archetype Print is not responsible for map content. Queries about content should be directed to BCFisheries.

Other Information Sources

Information from recent projects or significant sources that may have been missed in FISS should be sought. Some of these may include:

- Results of an IWAP or CWAP, and/or the results of any fish habitat assessment procedures (FHAPs) done through the FRBC Watershed Restoration Program Watershed assessment procedure reports; Fish habitat assessment procedure reports
- Other government agencies (e.g., DFO), and specialist reports and studies.
- Fish stream and riparian area classification maps done for forest companies.

Information Types and Contact Agencies

Contact lead agencies regarding additional information that may be required.

- Fisheries project information: BC Fisheries (Victoria); BC Environment regional fisheries sections.
- Salmon Escapement and related information: Fisheries and Oceans Canada
- Water quality: BC Environment; Environment Canada
- Hydrology: BC Environment; Environment Canada
- Forestry/Forest Practices Code-related sources: BC Environment and Ministry of Forests regional and district offices.

Appendix 2.
Watershed Classification

Illustrated Watershed Types

Illustrated Watershed Types

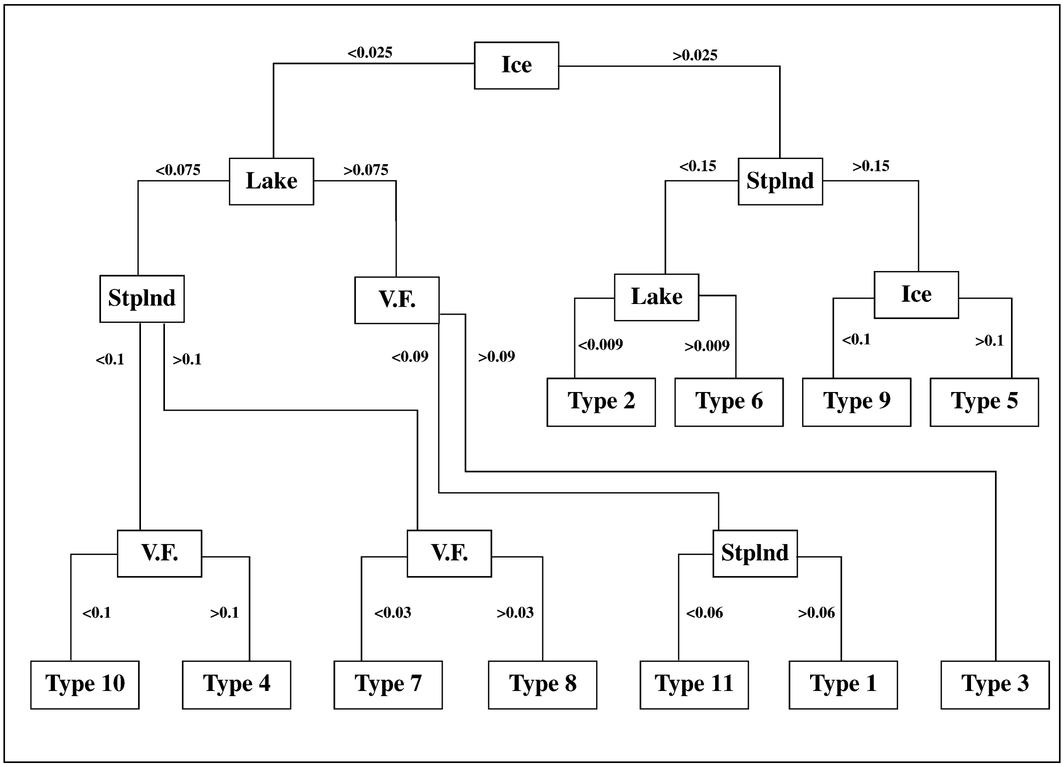


Figure 1. Classification flow chart. Values represent proportions of total watershed area. For example, at the highest level in the flowchart, if the ice covers less than 2.5% of the watershed area, follow the left limb.

Ice – the proportion of permanent ice and snow covering the watershed.

Lake – the proportion covered in lakes/open water bodies.

Stplnd – the proportion of steepland (>60% gradient).

V.F. – the proportion of valley flat (<7% gradient, connected to the channel network).

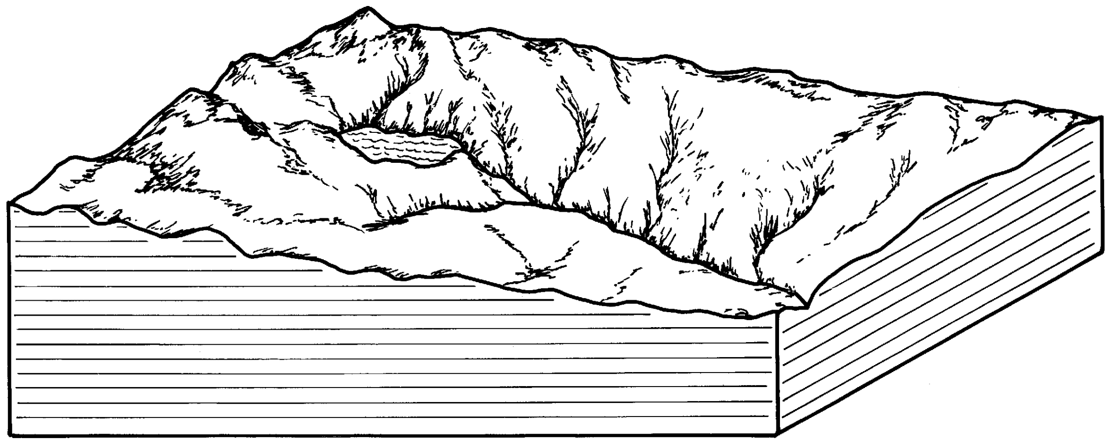


Figure 2. Type 1: Relatively low proportions of ice and valley flat, high proportions of lake and steepland.

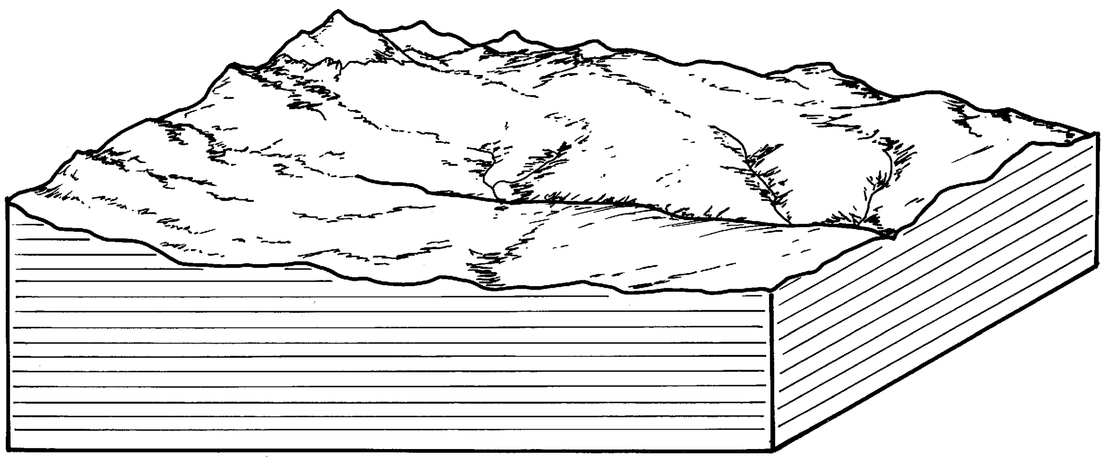


Figure 3. Type 2: High proportions of ice, low proportions of lake and steepland.

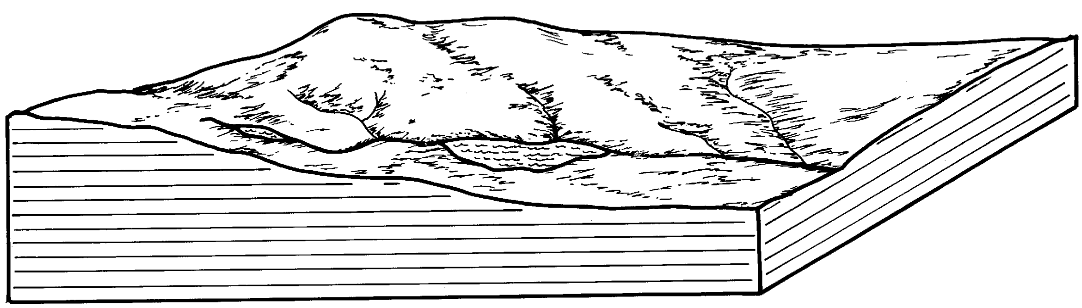


Figure 4. Type 3: Low proportions of ice and high proportions of lake and valley flat.

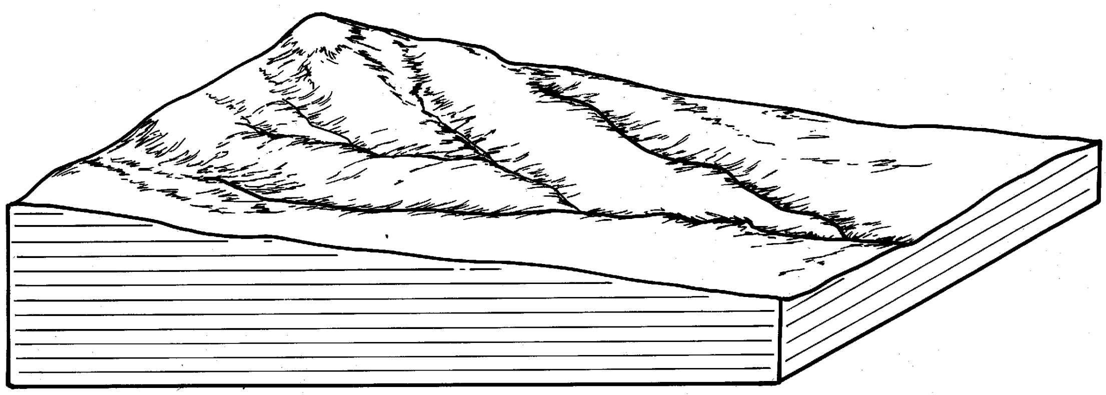


Figure 5. Type 4: Low proportions of ice, lake, and steepland and high proportions of valley flat.

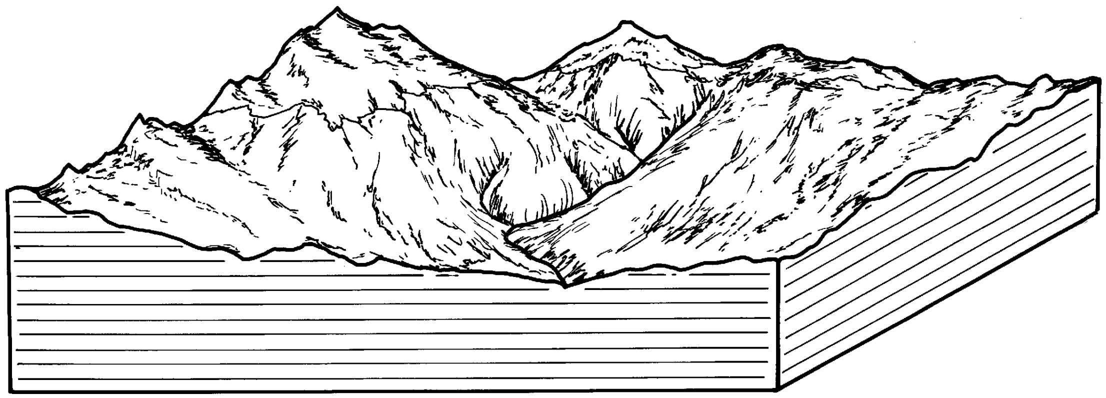


Figure 6. Type 5: Quite high proportions of ice and relatively large amounts of steepland.

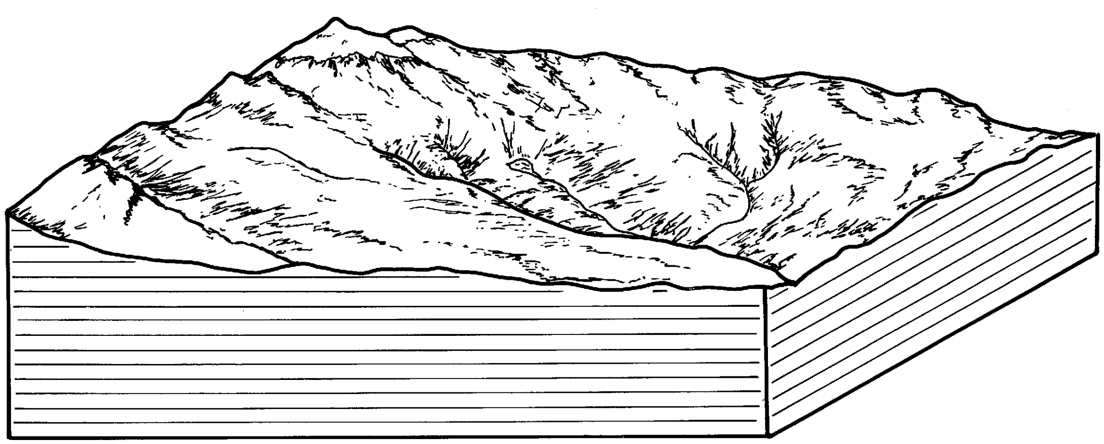


Figure 7. Type 6: High proportions of ice, low proportions of steepland and lake.

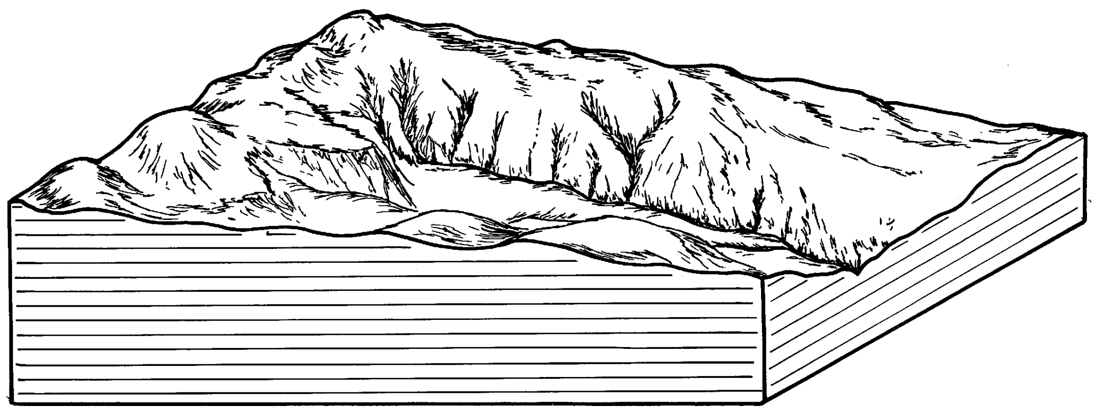


Figure 8. Type 7: Low proportions of ice, lake, and valley flat with a relatively large amount of steepland.

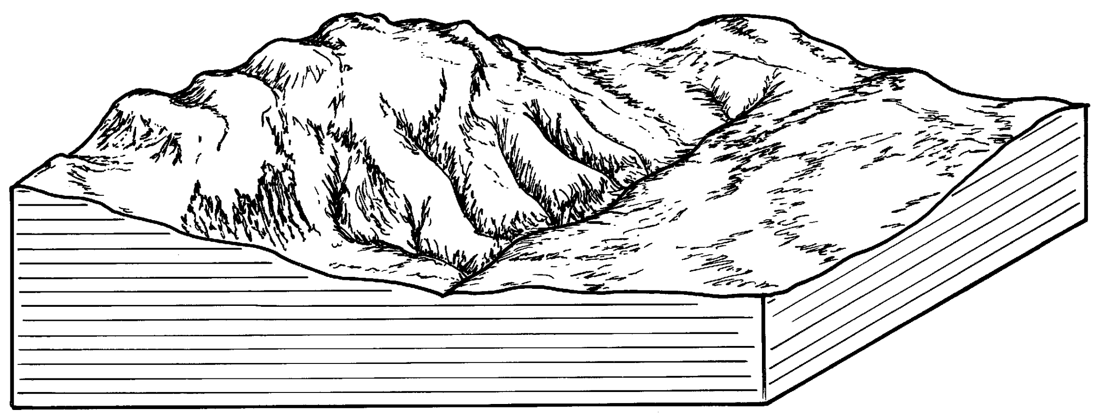


Figure 9. Type 8: Low proportions of ice and lake cover, and relatively large extents of steepland and valley flat.

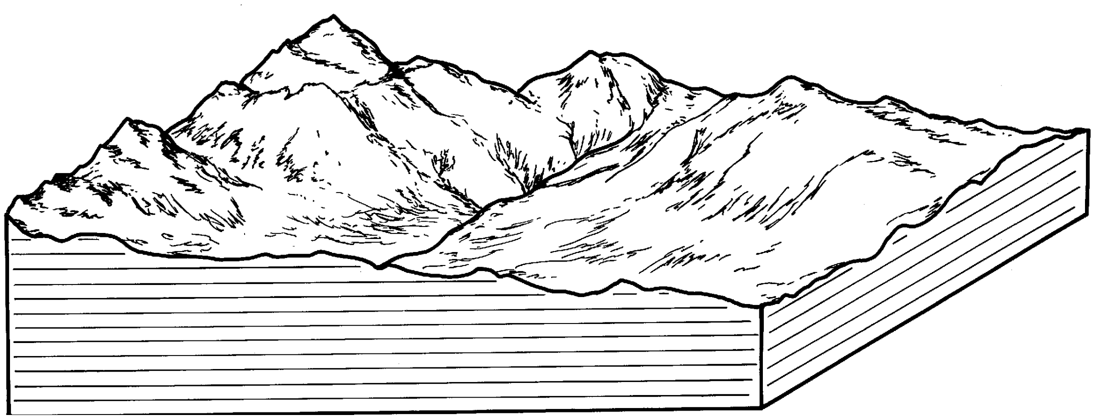


Figure 10. Type 9: High proportions of ice and steepland.

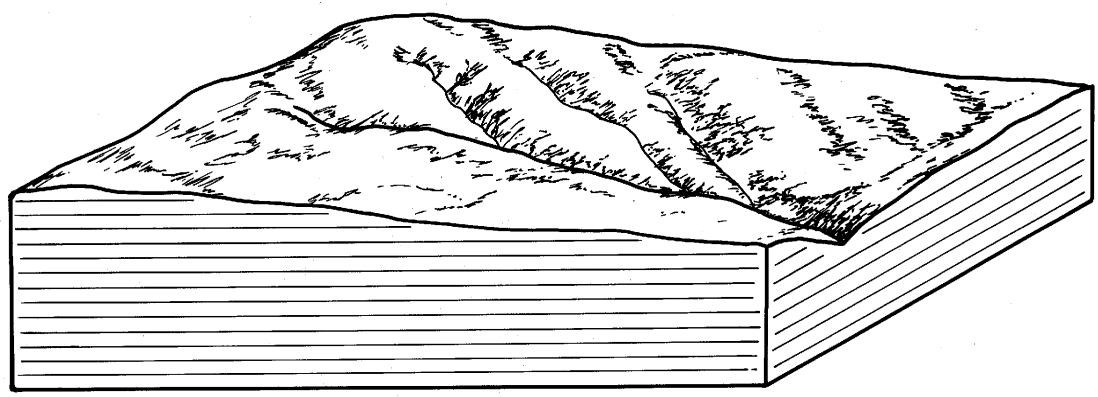


Figure 11. Type 10: Low proportions of ice, lake, steepland, and valley flat.

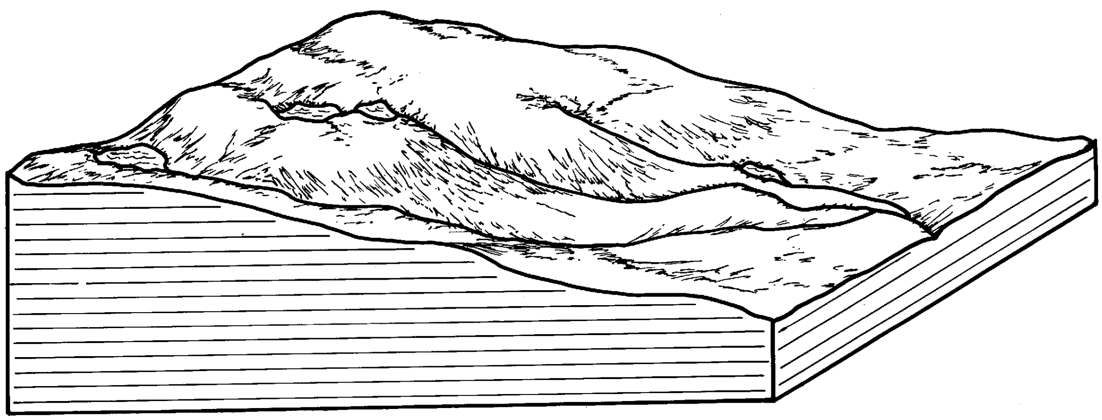


Figure 12. Type 11: Low amounts of ice, valley flat, and steepland, high proportions of lake.

Appendix 3.
Wetland Types

(Definitions adapted and modified from the *Riparian Management Area Guidebook*, Forest Practices Code (1995).)

Shallow Open Water

Shallow open water wetlands are intermittently or permanently flooded areas with open expanses of standing or moving water up to 2 m deep. Open water, with no emergent vegetation, covers 75% or more of the wetland surface.

Marsh

Marsh wetlands have mineral and sometimes well-decomposed peat soils. When peat soils are present, they are often enriched with mineral materials. Waters are nutrient rich with near neutral to basic pH. Surface water levels typically fluctuate seasonally with declining levels exposing matted vegetation or mudflats. Emergent vegetation includes grasses, cattails, sedges, rushes, and reeds which cover more than 25% of the wetland surface.

Swamp

Swamp wetlands have mineral or occasionally peat soils with a water table at, or near the surface. There is a pronounced internal water movement from adjacent mineral areas, making the water nutrient-rich. If peat is present, it is mainly well-decomposed wood and occasional sedges. The vegetation is typically dominated by coniferous or deciduous trees or dense shrubs and herbaceous species.

Fen

Fen wetlands have organic soils and a water table at or above the surface. Soils are primarily moderate to well-decomposed sedge and non-sphagnum moss peats. Waters are mainly nutrient rich with a near neutral to slightly acidic pH. The vegetation consists primarily of sedges, grasses, reeds, mosses, and some shrubs. Scattered trees may be present.

Bog

Bog wetlands have organic soils with a water table at or near the surface. Soils are predominantly composed of poorly to moderately decomposed sphagnum moss peats. The bog surface is usually unaffected by groundwaters and thus waters are generally acidic and low in nutrients. Bogs are usually covered with sphagnum mosses and ericaceous (belonging to or similar to heath family, genus *Erica*) shrubs, and may be treed or treeless.

Appendix 4.
Videography

Standards for Reconnaissance Aerial Videography in Inventory Planning

In the event that aerial videography is used as a device to corroborate decisions regarding map layout and sample design at the reconnaissance level, the contractor shall deliver the product of the video work to the ministry representative as detailed in the following guidelines and criteria:

1. Original video data shall be supplied as Hi-8™. One VHS copy will also be provided. The video should be referenced with a code in the following format:

   Project code – year – V1, where V1 represents the first video,
   V2 represents the second, etc.

   A copy of the data log sheet, *Aerial Photography and Videography Standards: Applications for Stream Inventory and Assessment*, RIC, Figure 7, must also be included.
2. Video equipment shall either be mounted externally to the helicopter or be held in such a manner to ensure that the video image is clear and stabilized.
3. Video records shall be:
   - Continuous along the stream network with voice annotation of significant features; and
   - Recorded as discrete portions of the stream network to include voice annotations of all significant features.
4. Voice annotation will be recorded either through a connection with the helicopter's communication system or through an independently wired audio link.
5. Significant features will be cross-referenced to the map base in such a manner as to allow expedient referencing of the video and map base by a third party. Referencing will be based on:
   - Preliminary reach break identification;
   - GPS – Universal Transverse Mercator (UTM) coordinates; and
   - Other means if required or approved in advance by the contract monitor.
6. Significant features to note on the video recording include:
   - Reach break verification;
   - Potential barriers to fish migration;
   - Changes in the stream network that are not identified on the map base;
   - Stream complexes that are not adequately represented on the map base;
   - Significant habitat alterations due to resource extraction activities;
   - Points of access; and
   - Other features of interest that should be noted in the planning process.

7. Delays due to weather or equipment malfunction will be paid at a rate specified in Schedule B. The contract monitor reserves the right to cancel this phase of the contract should delays prove to be too costly and inefficient.
8. The contract monitor reserves the right to reject the video product if it is deemed unusable in the planning process due to poor quality. In such instances, payment for the videography phase of this contract will be forfeited.

Appendix 5.
Terrain Characteristics

Setting Descriptions

Valley Floor (VF)

A lake or stream that is situated on a valley floor is generally on the local erosional base level or close to it. Major rivers run in a valley floor for most of their length (e.g., Fraser, Skeena, Bulkley, Columbia, Kootenay), and most major lakes in B.C. are valley floor lakes (e.g., Pitt, Harrison, Arrow, Kamloops).

Valley Wall (VW)

A stream or lake situated between a valley crest (i.e., the ridgeline of the hills or mountains flanking a valley) and (but not on) the valley floor. In mountainous areas, the bulk of the small first and second order stream reaches are on valley walls. Valley wall lakes are much rarer, and were usually formed by glacial meltwater running beside valley glaciers. They are usually small, steep-sided, oriented in the direction of the valley orientation, and have bedrock basins and outlet controls (Cougar Lake, north of Merritt, on 92I/7 is an example of a valley wall lake. Others are Leviathan on 82F/15, Monroe and Mineral above Moyie Lake on 82G/5, and Sukunka, north of a gas plant on 93P/5).

Hanging Valley (HV)

This code is used when a lake or stream is in a hanging valley or cirque (a cirque may also be called a cwm or corrie). If the bulk of the cirque is not all lake, there may be some low gradient stream on the valley floor. This valley floor will be short, and there will be a steep gradient (often with many waterfalls) down to the main valley floor. Lakes in cirques are often called *tarns*. For a good selection of tarns and streams in hanging valleys between the upper Stein River and Lillooet Lake, see 92J/1. In fact, the headwaters of Lizzie Creek show a series of hanging valleys. Lizzie Lake is in a hanging valley, overlooked by Haven Lake, Long Lake, Whisky Lake and Arrowhead Lake, also all in hanging valleys. Then, above these, there are yet higher hanging valleys or cirques with lakes (tarns) and streams. Examples of these are Shields Lake above Haven Lake; the Crystal Tarns, Snake Lake, and Rainbow Lake above Long Lake; and Heart Lake above Arrowhead Lake. By looking at the smaller high altitude lakes along any mountain range in the province, one can locate hanging valleys with cirque lakes or tarns in them.

Mountain Plateau (MP)

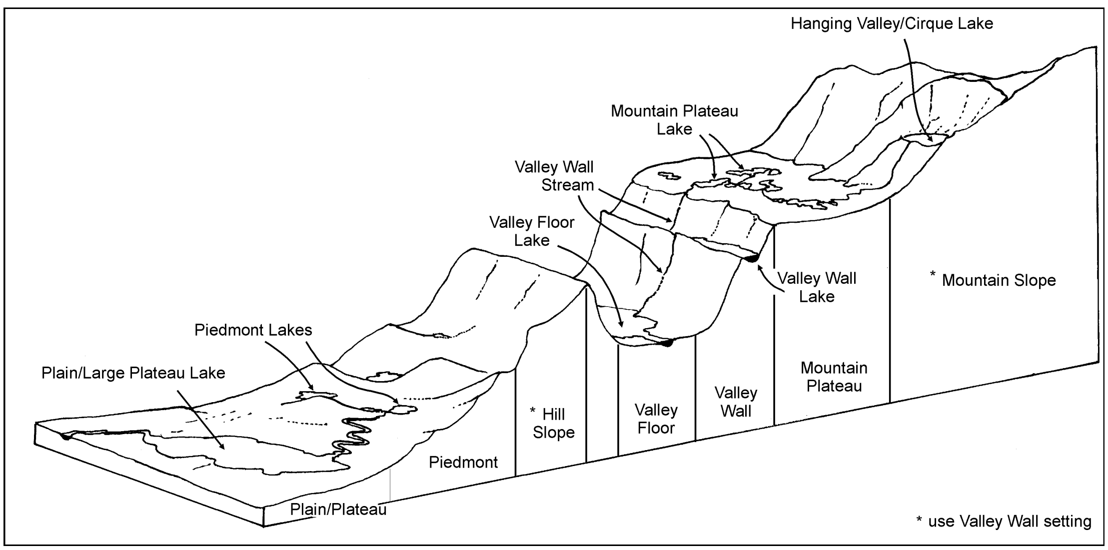
There are many small to medium sized lakes and streams on high plateaux in B.C. Typically, the streams draining a mountain plateau exhibit an abrupt change of gradient, and become much steeper down the scarp (the steep, sometimes clifflike edge of the plateau). The streams down the scarp are probably best classified as being in a valley wall setting. On the plateau itself, there can be a complex interwoven set of lakes and ponds connected by a very irregular stream network. The setting designation applies to the streams, lakes, and ponds on the raised plateau surface. Examples of mountain plateaux are found in St. Mary's Alpine, 82F/16; Forbidden Plateau, 92F/11; around Kasalka Butte, 93E/11; around Kawdy Mountain, 104J/14; Kawdy Plateau, 104O/3 & 6; and Spatsizi Plateau, 104H/10. It should be noted that in these plateaux, the settings of some lakes and streams may be in hanging valleys or on valley floors, and streams in the plateau area may be set on valley walls.

Plain/Large Plateau (PN)

Large areas of B.C. are occupied by broad plateaux which may, but usually do not, have an abrupt slope break at their edges. Examples of these areas are the Fraser Plateau, 92O, 92P, and 93B; the Nechako Plateau, 93F and 93K; the Liard Plateau, 94N; the Liard Plain, 94M; and the Eshto Plateau, 94P. The edge of the Alberta Plateau is an example of a plain, and covers much of the northern border area with Alberta. A large part of the east coast of Vancouver Island is a coastal plain, the Nanaimo Lowland, as is the east coast of Graham Island (the northernmost of the Queen Charlotte Islands), the Argonaut Plain. Also, a strip of the west coast of Vancouver Island is the Estevan Coastal Plain.

Piedmont (PD)

The streams and lakes of a piedmont area are found adjacent to mountain ranges, but are in a hilly area, with a lower relief than the mountain range, but higher than that found on large plateaux. They are at a lower elevation than the mountain plateaux, and do not have a scarp. Piedmont areas are found along the eastern side of the Rockies, in the Rocky Mountain foothills, and the eastern side of the coast range, from the western edge of the Nechako and Fraser plateaux. The Sunshine Coast, the Georgia Lowland, is largely piedmont.



Lake Genesis Descriptions

Volcanic Lakes (VD)

Lava-dammed lakes (Hutchinson's Type 19 and 19a) (e.g., Ray, Clearwater, Kostal, Stevens, and Murtle lakes in Wells Gray Provincial Park, Tuya Lake in the Dease Lake area).

Landslide Lakes (LL)

Lakes formed by mass movement dams. These lakes are often seen in steep sided mountain valleys in which the surface flow may be discontinuous. (Hutchinson's Type 20, 20a, Type 20b, 20c, 21, and 22) (e.g., Foley Lake in the Chilliwack area, and Cerulean Lake in Strathcona Provincial Park).

Glacial Lakes (GL)

There are many different types of lakes found in glaciated areas. Common ones found in B.C. follow.

Glacial Ice Lakes (GI)

Lakes in direct contact with ice (e.g., Summit and Tide lakes on the Bowser River) or dammed by moraines in direct contact with ice. (Hutchinson's Type 23, 23a, 23b, 23c, 24, 24a, 24b, 24c, 24d, 24e, 25, and 25a).

Glacial Scour Lakes (GS)

Lake formed in basins scoured into rock. They are usually very irregular and have several basins. (Hutchinson's Type 26) (e.g., Helen Mackenzie and Kwai lakes on Forbidden Plateau, Roche and Sheridan lakes in the Cariboo).

Cirque Lakes (GC)

A cirque (also called 'Cwm' or 'Corrie') is a half-open, steep-sided hollow in a mountain region that has been or is being glaciated (*Oxford Dictionary of Earth Sciences*, 1991). Cirque lakes are lakes situated in a cirque (Hutchinson's Type 27, 27a, 27b, 28, and 28a) (e.g., Widgeon Lake near Mission, Lake Louise in Banff National Park, and Sunrise Lake in Strathcona Provincial Park).

Fjord-like Lakes (GF)

Fjord-like lakes are usually long, sinuous valley floor lakes that run to bedrock valley walls on either side. They are often extremely deep with a low ratio of littoral area and are over 400 ha in size. (Hutchinson's Type 28b) (e.g., Adams, Kinaskan, Tum-Tum, Brown, Buttle, Upper Campbell, and Azure lakes).

Piedmont Lakes (GP)

Lakes located along the face of mountain ranges or on coastal plains formed when the large valley glaciers spread out from their feeder valleys are piedmont lakes (Hutchinson's Type 28c) (e.g., Ruby Lake near Sechelt, Kennedy Lake on the west coast of Vancouver Island).

Moraine, Esker, and Outwash Lakes (GM)

These are lakes formed by unconsolidated, glacially derived materials (e.g., esker, moraine) that are deposited in a narrow point, in a valley or other depression and act as a dam (also include outwash lakes) (Hutchinson's Type 30, 30a, 30b, 31, 32a, 32b, and 33). An example of a moraine lake is Empheron Lake at the snout of the Tellot Glacier, example of an esker lake is Esker Lake on the Yukon border, and an example of outwash lake is Barney Lake on the Yukon border.

Ground Moraine Lakes (DB)

Lakes filling basins created on the till surface by continental glaciers. (Hutchinson's Type 34) (e.g., Swan Lake near Dawson Creek).

Glacial Kettle Lakes (GK)

Glacial kettle lakes, often known as 'pothole' lakes, are formed when outwash (gravels and sands) deposited around a large block of glacial ice forms a basin after the ice has melted. Though breakup of the ice-block could have resulted in the formation of more than one basin, the kame terrace is at the same general level around the lake (Hutchinson's Type 35, 36, 37, 39, and 40) (e.g., Crater, Alleyne, and Kentucky lakes near Aspen Grove).

Dead Ice Complex Lakes (DC)

These are lakes formed as a large section of continental or very large section of valley glacier melts. However, compared to kettle lakes, the kame terrace surrounding the lake may be of more variable height, and they may have eskers running across them and they always have multiple basins (e.g., Jennings Lake).

Solution Lakes (SL)

Solution lakes are created when dissolution of limestone, gypsum, or salt from the substrate forms basins. A solution lake will be in a comparatively soluble bedrock basin (Hutchinson's Type 43, (43a, 43b), 44, 45, 46, and 47 *some types*) (e.g., Devil's Punchbowl near Victoria Lake on Vancouver Island).

Fluviatile Lakes (FL)

Alluvial Fan Dam Lakes (FD)

Alluvial fan dam lakes are formed when stream deposits an alluvial fan across a valley, damming it to form a lake (Hutchinson's Type 49, 50, and 51) (e.g., Estero Basin on the coast, Canty in the Rockies north of Mackenzie, and Upper Tuchodi north of Kwadacha Park).

Abandoned Fluvial Channel Lakes (FA)

Fluvial channels, most of them outwash channels left by glacial meltwater during deglaciation, often have small lakes in them. Some of these channels are in valley walls, as the main part of the valley was occupied by ice at the time of their formation. If the lake basin and immediate surroundings appear to be part of an old river system, a check of the aerial photography should clarify whether the lake is in an abandoned riverbed or not. For stream surveyors, these are very easy to recognise. Normally, the only difficulty is in grasping the huge scale of these rivers.

Levee Lakes (LV)

Levee lakes are formed when a levee deposit, along the banks of the main channel, traps water (Hutchinson's Type 52, 53, (53a, 53b), 54, 58, and 59) (e.g., Duck and Leach lakes adjacent to the Kootenay River near Creston).

Oxbow Lakes (OX)

Oxbow lakes are formed when an avulsion cuts off a portion of the meandering channel between two bends (Hutchinson's Type 55, 56, and 57) (e.g., Hatzic Slough near Mission).

Shoreline or Barrier Lakes, Lagoons (BL)

These are lakes formed by spits, tombolos, or barrier beaches and are always beside a larger body of water with a gravel and sand berm separating the barrier lake from the larger body. If by the sea, there may be saltwater intrusions (Hutchinson's Type 64, 65, 66, 67, and 68) (e.g., Sherwood Pond, Albert Head Lagoon, both near Victoria).

Organic Lakes (OL)

Phytogenetic lakes, beaver dams, and coral lakes. There are no coral lakes in B.C. The other two categories are:

Phytogenetic Lakes (PH)

Phytogenetic lakes are found in the north-eastern BC, in coastal areas of high rainfall, and in alpine areas. Most of these water bodies will be wetlands and are formed as a result of damming by vegetation. (Hutchinson's Type 47 (most of the B.C. examples), Type 69, 70, and 71) (e.g., Parker Lake, near Fort Nelson).

Beaver Dam Lakes (BV)

Lakes formed as a result of beaver dams. (Hutchinson's Type 72) (e.g., Foley Creek Pond).

Anthropogenic Lakes (AL)

Lakes formed as a result human action.

Reservoir Lakes (RV)

These are lakes formed when areas are dammed, for example, for electric power or water supply for industry, agriculture, domestic use, or wildlife (Hutchinson's Type 73) (e.g., Koocanusa, McNaughton, Williston, and Capilano lakes).

Quarry Lakes (AQ)

These are lakes formed when retired gravel, sand, and rock quarries fill with water and are large and deep enough to be called lakes (Hutchinson's Type 74) (e.g., Kingzett Lake near Cobble Hill, Allan Lake in the Fraser Valley, and the borrow pits Alpha, Delta, Gamma, etc., along the Alaska Highway near Fort Nelson).

For more information, see:

Hutchinson, G.E. (1957). A Treatise on Limnology. Volume 1: Geography, Physics and Chemistry. John Wiley & Sons, Inc. New York, N.Y. 1015 pp.

Example of various genesis – type

Lake genesis	Lake setting	Lake name	Water body ID	Watershed codes
Fjord-like (GF)	Valley Floor (VF)	Adams	00583ADMS	128-453400
Shoreline/Barrier (BL)	Piedmont (PD)	Albert Head Lagoon	00352VICT	920-031900
Quarry(AQ)	Piedmont (PD)	Allan	00773LFRA	100-058500-84700
Glacial Kettle (GK)	Valley Floor (VF)	Alleyne	01915NICL	120-246600-51000-34100-0230
Outwash (GM)	Piedmont (PD)	Barney	00002ULRD	210-643700-97000
Alluvial Fan Dam (FD)	Valley Floor (VF)	Canty	00003PARA	230-900100
Reservoir (RV)	Valley Floor (VF)	Capilano	00891SQAM	900-071100
Volcanic Dam (VD)	Valley Floor (VF)	Clearwater	00658CLWR	129-360400
Fluvial, abandoned (FA)	Valley Wall (VW)	Cougar	00626GUIC	120-246600-29600-32400
Esker (GM)	Valley Floor (VF)	Esker	00001ULRD	210-643700-97000-83500
Landslide (LL)	Valley Floor (VF)	Foley	00043CHWK	100-065700-09700-45800
Beaver Dam (BV)	Valley Floor (VF)	Foley Creek Pond	Missing	100-065700-09700-45800
Glacial Scour (GS)	Mountain Plateau (MP)	Gump	00447GUIC	120-246600-29600-54200
Fjord-like (GF)	Valley Floor (VF)	Harrison	00081HARR	110-000000
Oxbow (OX)	Valley Floor (VF)	Hatzic Slough	00887LFRA	100-058500
Dead Ice Complex (DC)	Valley Floor (VF)	Jennings Lakes	00875SWIR	818-579500
Piedmont (GP)	Piedmont (PD)	Kennedy	01168CLAY	930-306400
Ground Moraine (DB)	Plain/Large Plateau (PN)	Kotcho	00174KCHL	220-671000
Phytogenetic (PH)	Valley Floor (VF)	Parker	00172LMUS	212-580800-06900-46700-2170
Glacial Scour (GS)	Plain/Large Plateau (PN)	Roche	00763STHM	128-123700-73700-41000
Shoreline/Barrier (BL)	Piedmont (PD)	Sherwood Pond	00361VICT	920-021600
Ground Moraine (DB)	Plain/Large Plateau (PN)	Swan	00784LPCE	230-690000-64400
Alluvial Fan Dam (FD)	Valley Floor (VF)	Upper Tuchodi	0036MMUS	212-580800-40300
Cirque Lake (GC)	Hanging Valley (HV)	Widgeon	00422LFRA	100-026700-19300-49200

Appendix 6.
Photodocumentation and Scanning: Deliverable Requirements

A6.0 Photo-documentation and Scanning Requirements for Fish and Fish Habitat Inventory Projects

This appendix describes the requirements for the photographic deliverables for Fish and Fish Habitat Inventory Projects.

- All photographic images delivered must be of high quality for archival purposes.
- In order for a slide, print or negative to be useful, it must be properly referenced and labelled with useful information.
- Only high quality digital cameras capable of producing images that will meet reconnaissance inventory standards will be accepted.
- Required field photographs for lake and stream surveys, are described in Chapter 3 and Chapter 4.

A6.1 Photo-documentation Requirements for Fish and Fish Habitat Inventory Projects

The following describe the requirements for photo-documentation deliverables and photo-referencing for Fish and Fish Habitat Inventory Projects.

A6.1.1 Photo-documentation (Survey) Form 1

Record camera equipment details on Photo Survey Form 1, Equipment Details, records equipment details for up to two cameras used in a photo survey; if more than two cameras are used, attach a second copy of the form and change the camera number(s) accordingly. This Form will accommodate images from film cameras, digital cameras, and still video. Instructions for completing the form follows:

Survey Start and End Dates:

Enter the start and end dates for the photo survey in the format “yyyymmdd.”

Agency :

Record the agency code for the agency, group or company that completed the photo survey form.

Crew:

Record the initials of up to three crew members using a maximum of three letters per member.

Camera Information:

For each camera used, indicate the make, model and format: 135 mm film, other film (specify format), digital or still video. If only one camera is used, circle “n/a” for camera #2.

Circle the letter(s) corresponding to the lens information, below. If the camera has a built-in lens, circle the appropriate letter, and write “fixed lens” and the focal length in the lens table.

For digital and still video cameras, indicate the image resolution and the output file type.

PHOTO SURVEY FORM 1 - EQUIPMENT DETAILS

Survey start date (yyyymmdd): __|__|__|__|__|__|__|__ **Agency:** |____|
Survey end date: __|__|__|__|__|__|__|__ **Crew:** ____|___|___

CAMERA #1

Make & model:				**Lenses:** A B C D E F
Format:	135mm film	Other film: ________	Digital	Still video
Resolution (for digital and video cameras):				
Output file type (for digital and video cameras):				

CAMERA #2

n/a **Make & model:**				**Lenses:** A B C D E F
Format:	135mm film	Other film: ________	Digital	Still video
Resolution (for digital and video cameras):				
Output file type (for digital and video cameras):				

LENSES

Focal length (mm)	Focal length (mm)
A	D
B	E
C	F

ROLL AND/OR BATCH DETAILS

Roll# or Batch#	Camera #	Output medium	For film cameras: Film type	ISO
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	
		neg slide file	color B&W other: ________	

Lens Information:

- For each lens, provide the focal length opposite a letter in the “lenses” box, then circle the appropriate lens letter associated with each camera. If the lens is used with a converter, indicate this as well (e.g., 50 mm ×2).
- For zoom lenses, indicate the range of focal length.
- If the lens is built-in, write “fixed” and the focal length in the “lenses” box.

Roll and/or Batch Details:

- Number the rolls and/or batches sequentially, so that each number is used only once.
- For each roll or batch, circle the output medium: negative, slide or file.
- For film cameras, indicate colour, black-and-white (B&W), or other (specify, for example, colour infrared, black-and-white infrared), and ISO film speed.

A6.1.2 Photo-documentation for Watershed and Individual Lake Reports

The following describe the deliverables for the Watershed and Individual Lake Reports. See example product reports on the *Fisheries Inventory* web site.

A6.1.2.1 FDIS Reach/Site Summary Photographs for Watershed Reports and FDIS Reach/Site (Tributary) Summary Photographs for Individual Lake Reports

For each FDIS Reach/Site Summary attach at least 1 and as many as four photos, with an associated caption, to the reverse side of the summary. Alternatively, place them on the next page if you do not wish to double-side photocopy. Treat the photos as an integral part of the site, referring to them in your comments:

- The most representative of the sample site is best, but a view of the site looking downstream is preferred. The minimum requirement is a downstream or upstream shot of the site, but other photos of important features and typical fish are also appropriate;
- Draft reports copies are to contain halftone or grayscale photos, where all final report copies photos are to be in color.

A6.1.2.2 Photodocumentation Appendixes and Attachments for Watershed and Individual Lake Reports

The following photo-documentation deliverables are associated with the Watershed and Individual Lake Reports. Some of the deliverables may be contract specific.

Binder with:

- Indexed slide or negatives. All negatives contained in 8.5 × 11 plastic sleeves and uniquely labelled. Include photograph contact sheet;
- Photo summary report printout from FDIS. CD image #s included in FDIS for each roll and frame;
- Photo CD containing project photos. For further CD requirements, see A6.1.3 and A6.2. Include a very high quality colour photocopy of each thumbnail reference in each CD jacket;
- All photographic prints that have been developed. Prints should be contained in plastic sleeves and labelled for reference. The same information should be included on the back of each print and on the enclosure for each negative. Do not develop additional prints simply to provide in this deliverable.

Individual Lake reports may also contain an appendix with additional photos embedded into the report and treated as an integral part of the report discussion.

A6.1.3 Photo-referencing

Photo-referencing is used to identify photos or scanned photo images.

There are two types of photo-referencing:

1. CD photo-referencing

A digital table on the CD can be used to cross-reference the image file name to the photo referencing information.

- For those projects using FDIS 7.3 (or newer): The photo-documentation file is exported (use the Excel format option) and stored on the CD (remember to enter the photo CD number and image number into FDIS before the export is completed).
- For projects using older versions of FDIS, an Excel table should be created to cross-reference the image file name to the photo-referencing information.

  Example:

Filename	Photo Reference
BubbaCreek001.tif	R3, F15, 123-123456-12345, Reach 3, Site 1

NOTE: IF FDIS 7.3 (or newer) is used, storing the photodoc file on the CD is mandatory.

2. Photo labelling

It is also recommended that labeling be incorporated into the photos. There are two options as follows:

- Include a whiteboard with referencing information in the photograph when the picture is taken.
- Use a software/graphics package to label the image before it is stored on CD. If adding a label to the photograph, the label should not be placed directly on the digital image. The label should be added to some white space above or below the photo image.

A6.2 Scanning Requirements

The following describes the scanning requirements for project photographs. All photographs must be colour, of high quality, and the scaling should be 100%.

Hardware:

A good quality flatbed scanner with an optical resolution of at least 1200 dpi should be used. Many scanners that offer a 1200 dpi resolution, actually have an optical resolution of 600 dpi, and achieve higher resolutions through interpolation schemes. These should be avoided. The colour depth has to be at least 24 bit colour for prints, negatives and slides.

File type:

Only PCD (*.pcd) and TIFF (*.tiff or *.tif) file formats are acceptable. Do not submit *.jpg files as a primary product. The TIFF files can be compressed with a lossless scheme, such as “run length encoding,” RLE. RLE is also known as “recurrence encoding.”

CD Type:

The preferred product is the Kodak Photo CD, also known as the Kodak Photo CD Master. These files are in *.pcd format, in the following formats (in pixels): 128×192, 256×384, 512×768, 768×1024, 1024×1536, and 2048×3072. Although the 1024 by 1536 picture file is considered “adequate,” and is the minimum requirement, the 2048×3072 is usually part of the package. The Kodak Pro Photo CD is also quite acceptable, but the 4096×6144 file is not required and should not be asked for if 35 mm slides or negatives were used. See <*http://home.earthlink.net/~ritter/tiff/*> for more information regarding TIFF file formats.

DO NOT USE THE KODAK PICTURE CD *or* THE KODAK PICTURE DISK. These products may go up to the minimum requirement of 1024 by 1536 pixel resolution, in the case of the Picture CD, but the files are JPEG files. The Kodak Picture Disk gives 400 by 600 pixel images in JPEG format. In this case, neither the resolution nor the format is acceptable for the reconnaissance inventory.

Resolution:

- Slides: 1200 dpi

Since there is some loss in going from slide to print, it is better to scan the slide directly. This should be done at a minimum of 1200 dpi, to give the same size of image file (1200 by 1800 pixels) in TIFF format. As noted, these TIFF files can be compressed using loss-less algorithms such as RLE.

- Photographs (4"×6"): 300 dpi

Scan 4 by 6 inch prints at a minimum of 300 dpi (dots per inch) to give a 1200×1800 pixel image file in TIFF format. For this to be successful, the scanner has to be of good quality and the photographic print must be of excellent quality.