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

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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.

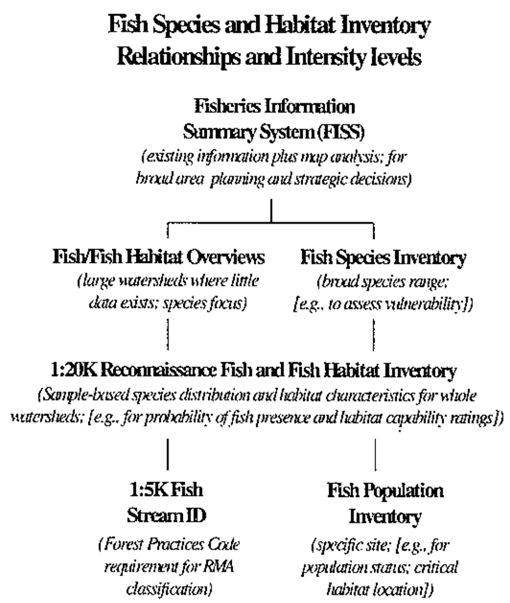

Figure 1.1. Fish species and habitat inventory relationships and intensity levels.

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

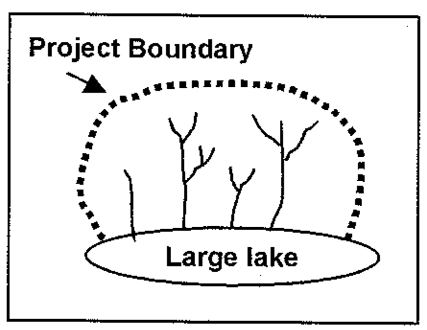
Phase 3. Development of a project plan.

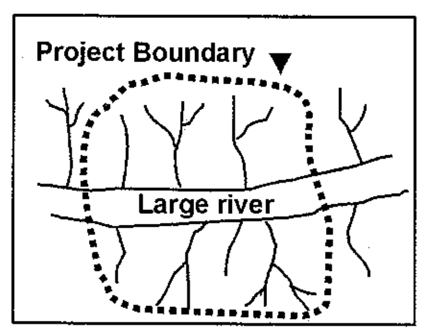
The project plan developed in Phase 3 is intended to provide a clear description of how the inventory will proceed, including the field activity, data compilation and project reporting phases. It is an important tool for project budgeting, scheduling and quality assurance.

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.

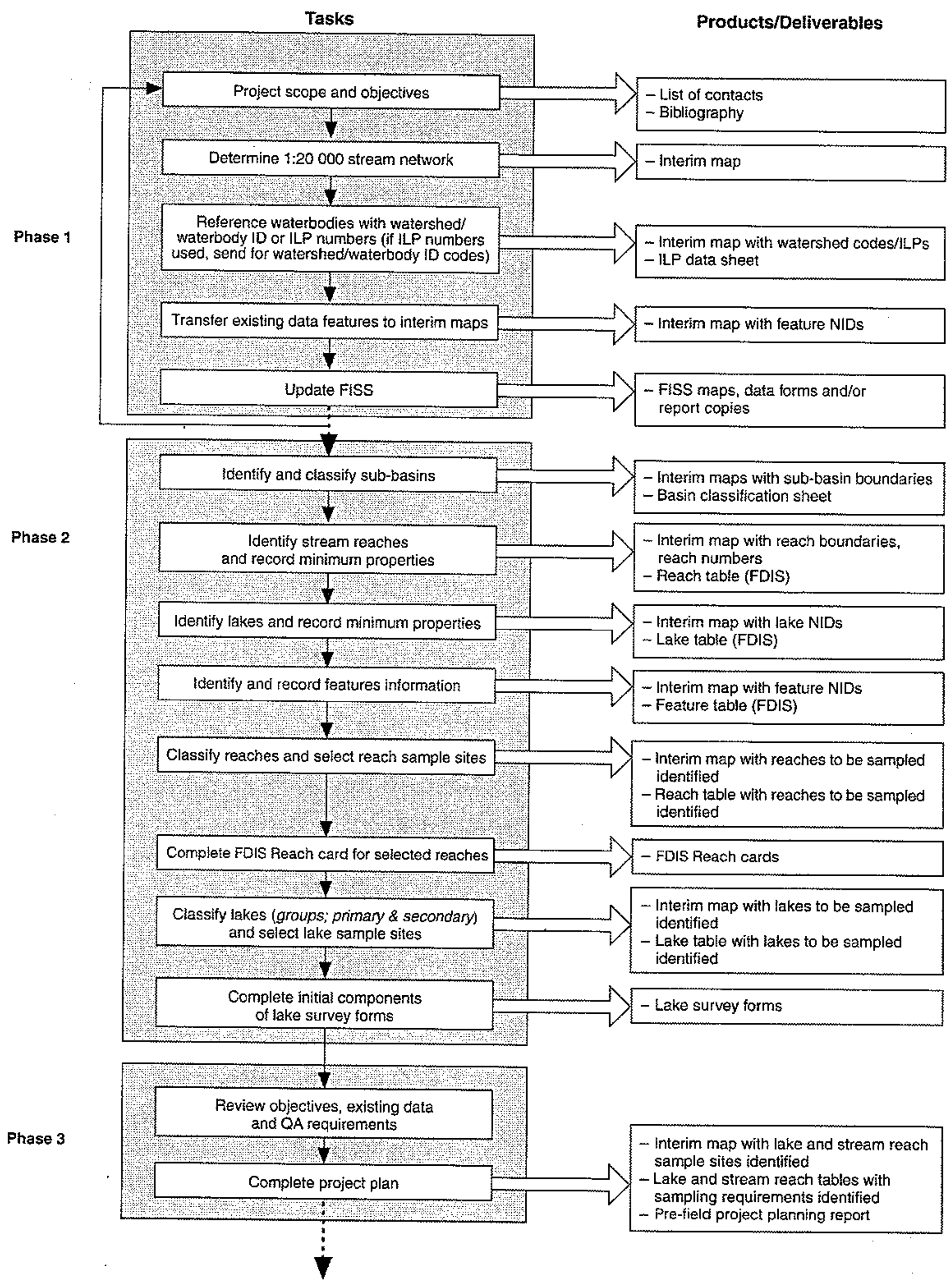


Figure 2.1. Flowchart of tasks and products for phases 1, 2 and 3.

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.

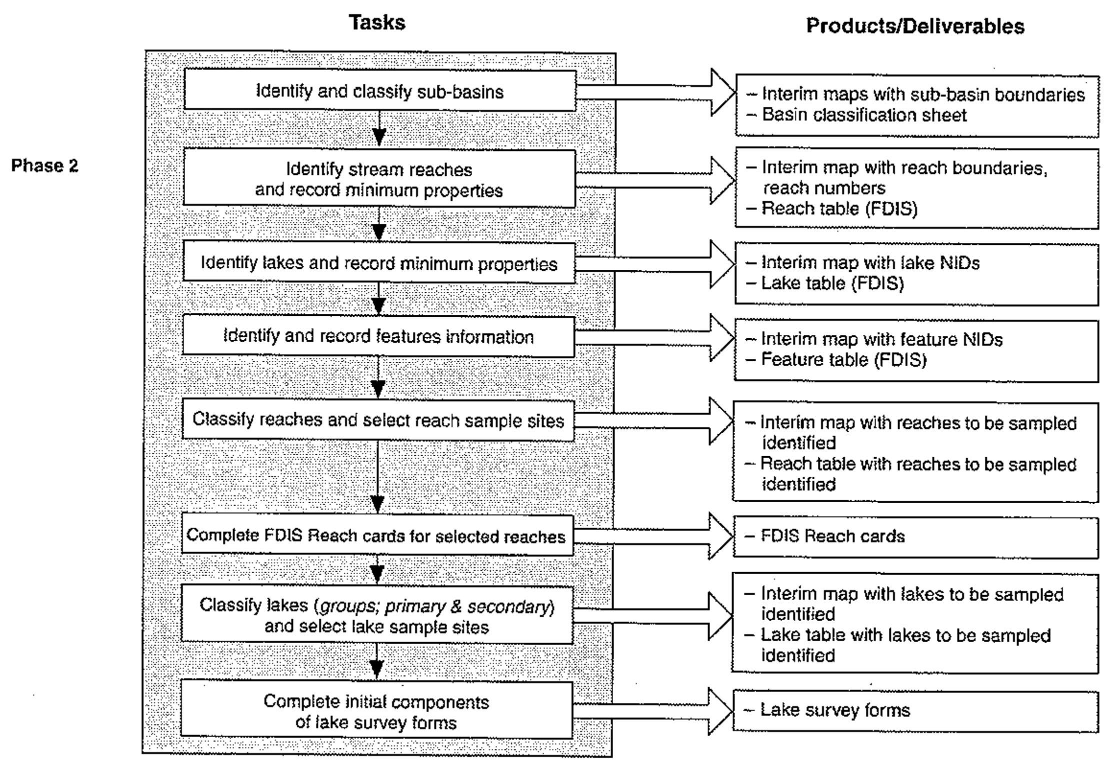

Figure 2.2. Phase 2 steps.

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.

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[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.

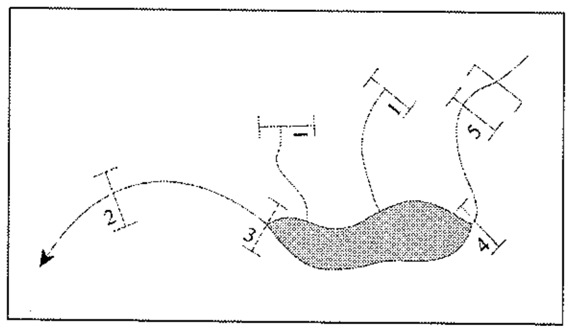

Figure 2.3. Reach numbering system.

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.

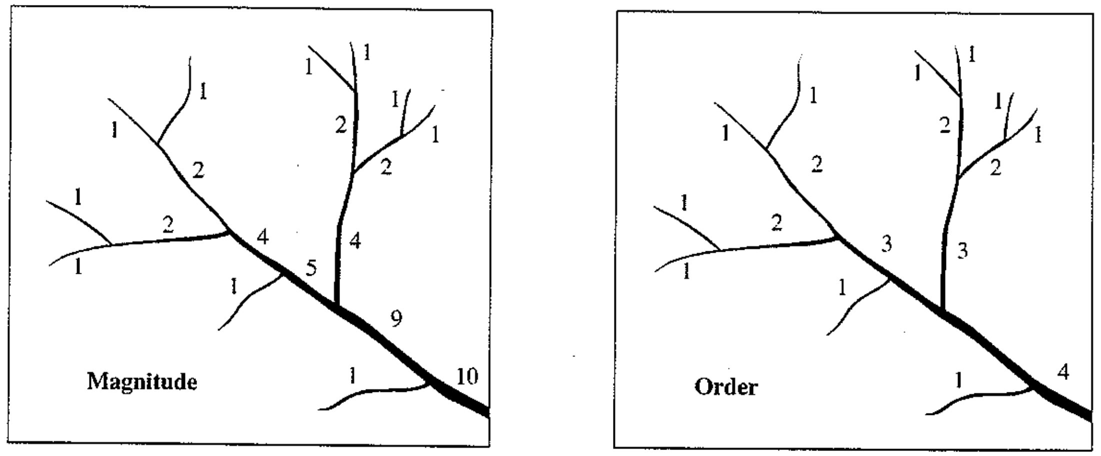

Figure 2.4. Comparison of stream magnitude and order.

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:

Gradient	Pattern	Size small	Size med	Size large
1	*ST/SI*	3	4	11
	IM/ME	9	7	5
	AN/BR	0	0	0
2	*ST/SI*	10	15	1
	IM/ME	4	10	0
	AN/BR	0	0	0
3	*ST/SI*	115	56	1
	IM/ME	0	6	0
	AN/BR	0	0	0
4	*ST/SI*	70	11	0
	IM/ME	0	0	0
	AN/BR	0	0	0
5	*ST/SI*	54	5	0
	IM/ME	0	0	0
	AN/BR	0	0	0
Total =	397			

Sample size (project area):

Gradient	Pattern	Size small	Size med	Size large
1	*ST/SI*	2	2	2
	IM/ME	2	2	2
	AN/BR	0	0	0
2	*ST/SI*	2	3	1
	IM/ME	2	2	0
	AN/BR	0	0	0
3	*ST/SI*	12	11	1
	IM/ME	0	2	2
	AN/BR	0	0	0
4	*ST/SI*	7	2	0
	IM/ME	0	0	0
	AN/BR	0	0	0
5	*ST/SI*	0	0	0
	IM/ME	0	0	0
	AN/BR	0	0	0
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.

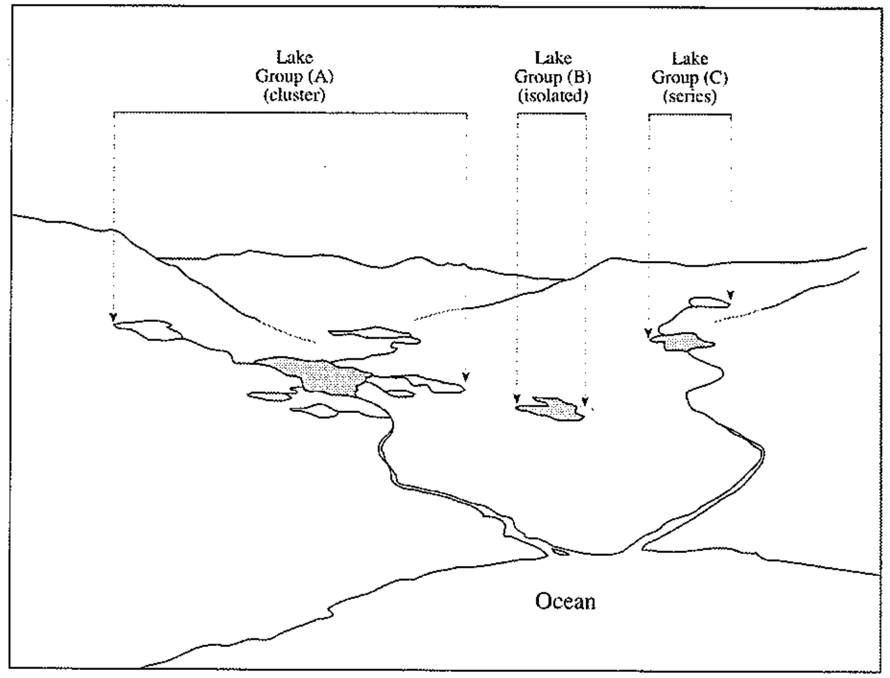

Figure 2.5. Primary and secondary lakes, and lake groups. Primary lakes are shaded in this illustration. Lake group A contains a cluster of seven lakes. Lake group B is an isolated lake. Lake group C represents a series of two lakes.

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
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