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FOREST SERVICE HANDBOOK
ALASKA REGION (REGION 10)
JUNEAU, ALASKA

FSH 2090.21 – AQUATIC HABITAT MANAGEMENT HANDBOOK

2090.22

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Approved: /s/ Steven A. Brink
Acting Regional Forester

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New Document	Entire Handbook	
1	2090.21-2001-1 Transmittal	3 Pages 1
2	2090.21_contents	2 Pages 2
3	2090.21_0_code	55 Pages 3
4	2090.21_10	11 Pages 4
5	2090.21_20	55 Pages 5
6	2090.21_30	39 Pages 6
7	2090.21_40	15 Pages 7
8	2090.21_50	2 Pages 8

Digest:

Zero Code – Provides legal sources and language to (1) help ensure fisheries resources are adequately represented in the interdisciplinary team process; (2) ensure a consistent Regional approach to aquatic habitat management through established standards, guidelines, and prescriptions; and (3) coordinate the management of watersheds through the interdisciplinary team process and interaction with cooperating agencies.

DIGEST—Continued

Chapter 10 – The objectives for managing aquatic ecosystems in the Alaska Region are founded on the principle that naturally functioning ecosystems (including consideration of both temporal and spatial scales) will best sustain populations of freshwater organisms. These objectives are:

1. Aquatic Habitat Management. Maintain or restore the natural range and distribution of aquatic habitat conditions on the Forests to sustain the diversity and production of fish and other freshwater organisms.

2. Riparian Area Management. Maintain riparian areas in mostly natural conditions, for fish, other aquatic life, old growth and riparian-associated plant and wildlife species, water-related recreation, and to provide for ecosystem processes, including important aquatic and land interactions.

3. Fish Habitat. Fish habitat objectives are described in terms of desired physical and biological conditions that can be measured using the aquatic inventory methods described in Chapter 20. The habitat objectives referenced in this chapter are a first approximation of scientifically based indicators of healthy, fully functioning aquatic systems.

Chapter 20 – Establishes Regional standards and a technical guide for completing aquatic inventory, and provides a Regional protocol for hydrolologic unit delineation. It combines coarse and fine-filter/scale hierarchically integrated physical, chemical, and biological characterization of the environment. Core attributes (variables) and methods for obtaining attribute data are identified. The data elements are consistent with the Forest Service Natural Resources Information System. Uses of the aquatic inventory procedures include:

- Determining and evaluating trends (monitoring) in ecological potential and conditions;
- Predicting and interpreting responses to disturbances;
- Assigning achievable desired future conditions; and
- Managing to restore and maintain ecological health.

Chapter 30 –Consolidates and clarifies management direction for riparian areas. The revised Tongass National Forest Plan (1997) defines the "riparian area" as "the area including a stream channel, lake or estuary bed, the water itself, and the plants that grow in the water and on the land next to the water." This chapter defines riparian management areas (RMA) and provides direction for their management. The RMA is the area identified during project planning that directly affects the form and function of aquatic ecosystems, stream processes and the quality and quantity of fish habitat. An RMA includes the immediate stream channel or water, the land adjacent to the water body, and upslope areas that have a direct effect on aquatic habitat. This chapter extends Tongass Forest Plan Revision riparian standards and guidelines to Regional application and updates and refines direction for fish passage at road crossings.

Chapter 40 – Describes fish habitat restoration and improvement practices, and the Alaska Region's cooperative project planning and analysis process. Fish project planning is an orderly process developed to ensure National Environmental Policy Act compliance, coordination with Alaska Department of Fish and Game and other fish enhancement cooperators, and proper phase development in the budget and contract processes.

Chapter 50 – Reserved for Regional monitoring protocols. Currently there is a brief description of the road condition survey (FSH 7709.58-98-1), which is designed to identify both general risks and site-specific problems that may have either a direct or cumulative effect on the aquatic ecosystem.

(2)

UNITED STATES DEPARTMENT OF AGRICULTURE
FOREST SERVICE

R-10 FSH 2090.21
AQUATIC HABITAT MANAGEMENT HANDBOOK

Contents

CHAPTER

3

FSH 2090.21 – AQUATIC HABITAT MANAGEMENT HANDBOOK
ZERO CODE

Table of Contents

01 - AUTHORITY

Several laws provide the authority under which fisheries and aquatic resources are managed. This section identifies those sources and comments on their significance to present management.

1. Fish and Wildlife Coordination Act (72 Stat. 563, 16 U.S.C. 661 et seq.). Provides that wildlife and fish resources will receive equal consideration with other resources in water resource development programs.

2. Multiple-Use, Sustained-Yield Act of June 12, 1960 (74 Stat. 215, as amended, 16 U.S.C. 528-531). Recognizes and clarifies Forest Service authority and responsibility to manage wildlife and fish.

3. National Environmental Policy Act, NEPA [1969]. Establishes a policy for the environment. The Act "will encourage productive and enjoyable harmony between man and his environment; to promote efforts which will prevent or eliminate damage to the environment and biosphere."

4. 40 Code of Federal Regulations [1986]. Directs federal agencies in the implementation of the NEPA. The regulations include direction to consider cumulative effects of management actions, clearly define a purpose and need for a proposed action, and discuss environmental effects of proposed actions.

5. National Forest Management Act (NFMA) [1976]. Includes direction to consider and coordinate wildlife and fish into multiple use and sustain yield activities. NFMA also requires Forest Plans to provide for diversity of plant and animal communities, and to harvest timber only where protection is provided for streams, streambanks, shorelines, lakes, wetlands, and other bodies of water.

6. 36 Code of Federal Regulations (CFR), Section 219 [1982]. Directs the Forest Service in the implementation of the NFMA. Minimum standards are set for fish in all national forests. It identifies riparian areas for special management attention and specifies the area approximately 100 feet from the streambank, and at least the recognizable area dominated by riparian vegetation to be of special significance. The Regulation states:

No management practices causing detrimental changes in water temperature or chemical composition, blockages of watercourses, or deposits of sediment shall be permitted within these areas [riparian areas] that seriously and adversely affect water conditions or fish habitat.

The Regulation also gives direction concerning maintenance of viable populations of existing native and desired non-native vertebrate species and use of management indicator species to estimate the effects of planning alternatives on fish and wildlife populations.

7. Clean Water Act [1972]. Has the objective and grants the authority to restore and maintain the chemical, physical, and biological integrity of the Nation's waters. The Act requires best management practices, defines point and nonpoint pollution, and addresses requirements for dredge and fill in wetlands (section 404 Corps of Engineer permits). The CWA contains provisions for the delegation by the Environmental Protection Agency of many permitting, administrative, and enforcement aspects of the law to state governments. In states with the authority to implement CWA programs, EPA still retains oversight responsibilities.

The State of Alaska Department of Environmental Conservation has delegated authority to implement the Clean Water Act in Alaska. Alaska Water Quality Standards include the growth and propagation of fish, shellfish and other aquatic life, and wildlife as beneficial uses of water.

8. Alaska National Interest Lands Conservation Act (ANILCA) [1980]. Permits fishery research, management, enhancement, and rehabilitation activities within National Forest wilderness and wilderness study areas. The Act gives direction to cooperatively plan fish enhancement activities with the State of Alaska and nonprofit aquaculture corporations.

9. Tongass Timber Reform Act (TTRA) [1990]. Gives specific direction to assure protection of riparian areas on the Tongass National Forest. The Act prohibits commercial timber harvest within a minimum distance of 100 feet from class I streams and class II streams that flow directly into class I streams. It gives direction to use best management practices as defined in 1990 Soil and Water Conservation handbook FSM 2509.22.

10. Recreational Fisheries Executive Order [6/7/95]. Directs federal agencies to improve the quantity, function, sustainable productivity, and distribution of United States aquatic resources for increased recreation fishing opportunities.

02 - OBJECTIVE

1. Provide legal sources and language to help ensure fisheries resources are adequately represented in the interdisciplinary team process.

2. Ensure a consistent Regional approach to aquatic habitat management through established standards, guidelines and prescriptions.

3. Coordinate the management of watersheds through the interdisciplinary team process and interaction with cooperating agencies.

03 - POLICY

The Forest Service recognizes as fish habitat any lake or stream on National Forest System (NFS) land that supports, or may potentially support, anadromous or resident fish. The Forest Service recognizes the need to consider aquatic habitat needs for all aquatic species and riparian dependent species, and that aquatic ecosystem management must include those riparian areas associated with the aquatic ecosystem. The Forest Service also realizes that the entire watershed, including trees, shrubs, riparian vegetation, and grasses is an integral component of the total ecosystems and should be managed as such.

1. The National Riparian Policy (FSM 2525.03, 12/94) responds to the National Forest Management Act.

The National Riparian Policy (FSM 2526.03, 3/86, amend. 48) states:

a. Manage riparian areas to meet various legal mandates including, but not limited to, those associated with flood plains, wetlands, water quality, dredge and fill material, endangered species, wild and scenic rivers, and cultural resources.

b. Manage riparian areas under the principles of multiple-use and sustained yield while emphasizing protection and improvement of soil, water, vegetation, and fish and wildlife resources. Give preferential consideration to riparian dependent resources when conflicts among land use activities occur.

c. Delineate and evaluate riparian areas prior to implementing any project or activity. Determine geographic boundaries of riparian areas by on-site characteristics of water, soil, and vegetation.

d. Give attention to land along all stream channels capable of supporting riparian vegetation (36 CFR 219.27e).

e. Give special attention to land and vegetation within approximately 100 feet from the edges of all perennial streams, lakes, and other bodies of water. This distance shall correspond to at least the recognizable area dominated by the riparian vegetation (36 CFR 219.27e). Give special attention to adjacent terrestrial areas to assure adequate protection for the riparian dependent resources.

2. The Regional Riparian Policy (R-10 Supplement 2526) further defines the National Riparian Policy and includes four additional policy statements. The Regional Riparian Policy states:

In order to assure protection of riparian habitat, maintain a buffer of no less than 100 feet in width slope distance on each side of all Class I streams in the Tongass National Forest, and on those Class II streams which flow directly into a Class I stream. Use Best Management Practices (BMPs), as defined in Chapter 10 of Region 10's FSH

2509.22 - Soil and Water Conservation Handbook, to assure the protection of riparian habitat on streams or portions of streams not protected by such buffers.

Forest Officers will recognize riparian dependent and associated resources and values in the day-to-day management of NFS lands. When conflicts arise, priority will be given to riparian dependent resources consistent with other laws and regulations.

Land management activities in riparian areas will be planned, implemented, and evaluated to ensure that activities are consistent with management direction in Forest Plans.

Manage riparian areas to provide for long-term conservation, productivity, biological diversity, and ecosystem integrity.

3. Regional Policy on Aquaculture in Wilderness (FSM 2300, R-10 Supplement 2300-95-2, 2323.35b). Allow manipulation of fish habitat in wilderness areas and specifies procedures for need determination.

4. Regional Recreational Fisheries Policy gives direction to provide for increased recreational fishing opportunities through the conservation, restoration, and enhancement of aquatic systems and fish populations, and by increasing fishing access, education, and outreach, and partnership opportunities.

5. Cooperative Fisheries Enhancement gives specific direction for the implementation of ANILCA section 507 (a) (cooperative planning provision). Requires annual fish enhancement coordination meeting with Alaska Department of Fish and Game, Fisheries Division, and other Divisions as appropriate.

6. Soil and Water Conservation Handbook (FSM 2509.22, 10/96) addresses requirements of the Clean Water Act to meet state water quality standards that include fish as a beneficial use. BMPs identify methods, measures, or practices to prevent or reduce water pollution including, but not limited to, structural and nonstructural controls, operation and maintenance procedures, other requirements and scheduling and distribution of activities.

7. Timber Sale Contract C-Clauses. (Reserved)

04 - RESPONSIBILITY

04.1 - Regional Forester

The Regional Forester:

1. Prescribes and implements Regional objectives, policies and responsibilities for wildlife, fish, and sensitive plant resources.

2. Develops standards for consistency and coordination between Forests and the Region with respect to: a) Recovery Plan goals; b) maintenance of viable populations; c) quantitative evaluations of habitat capability for management indicator species; d) conduct of major fish, wildlife and State and Private activities; e) RPA targets; and f) integration of Sikes Act plans with Forest plans.

04.2 - Forest Supervisor

The Forest Supervisor:

1. Establishes management direction (objectives, standards, and policies) that ensures coordination of wildlife, fish, and sensitive plant habitat objectives in Ranger District programs.

2. Maintains communications with individuals and organizations with local concerns about wildlife, fish and sensitive plant resources.

3. Coordinates implementation of Forest and project level plans with State wildlife and fish management agencies. Implements Sikes Act plans through Forest plans or as otherwise appropriate and provides for their annual updating.

4. Uses Wildlife and Fish Habitat Relationships classifications, models, and procedures to achieve integration of wildlife and fish habitat inventories, habitat capability evaluations, and resource coordination guidelines into Forest level interdisciplinary resource planning.

5. Maintains expert staff capable of: a) meeting objectives; b) developing new Forest policies, plans, and processes; c) determining the adequacy of biological evaluations; d) evaluating population viability and habitat capability; and, e) training District biologists, rangers, and other personnel in wildlife and fish management.

6. Ensures that all management activities authorized, funded or implemented do not jeopardize endangered, threatened or sensitive animal and plant species.

04.3 - District Ranger

The District Ranger:

1. Plans and implements wildlife and fish projects that are most responsive to Forest Plan goals.

2. Monitors and evaluates wildlife and fish management prescriptions to measure compliance with objectives, determine effects, and execute management adjustments when needed.

3. Uses Wildlife and Fish Habitat Relationships classifications, models, and procedures to achieve integration of wildlife and fish habitat inventories, habitat capability evaluations, and resource coordination guidelines into project level interdisciplinary resource planning and management.

4. Maintains communications with individuals and organizations concerned about fish and wildlife in the District's area of influence.

5. Encourages local fish and wildlife groups and individuals to accomplish project work through volunteer efforts.

05 - DEFINITIONS

1. Abbreviations.

AFHA - Anadromous Fish Habitat Assessment

AHMU - Aquatic Habitat Management Unit

BMP - Best Management Practices

FHMU - Fish Habitat Management Unit

RMA - Riparian Management Area

06 - COORDINATION

External coordination is always encouraged and most often required during development of fish and water projects and throughout general program management. The following Acts, agreements, and policies directly affect how the Forest Service works with other agencies and organizations to manage aquatic and riparian ecosystems.

1. Master Memorandum of Understanding (MOU) between the United States Department of Agriculture Forest Service, Alaska Region and the Alaska Department of Fish and Game.

The MOU of March 1998 defines responsibilities for both signatories, including Forest Service recognition of Alaska Department of Fish and Game (ADF&G) responsibility for the management of fish populations on National Forest system lands. Similarly, Alaska Department of Fish and Game recognizes Forest Service responsibility for the management of fish habitat.

Supplemental MOU No. 1 directs the signatories to coordinate on stream channel management issues including road crossing issues, fish passage, dredge and fill, and channel realignment requirements.

2. Tongass National Forest Cooperative Fisheries Enhancement Planning Process (TLMP Appendix H 12-21). Signed in 1993 by the Alaska Department of Fish and Game, the Southern Southeast Regional Aquaculture Association, the Northern Southeast Regional Aquaculture Association and the Forest Service, this agreement describes cooperation and coordination needed for the enhancement of fisheries in Southeast Alaska. The Planning Process clearly identifies requirements to move a project from the opportunity identification step through the monitoring and evaluation step.

3. Annual Coordination Meeting between Alaska Department of Fish and Game and the Forest Service. The Tongass National Forest Cooperative Fisheries Enhancement Planning Process recommends an annual coordination meeting of the Forest Service and the Alaska Department of Fish and Game (ADF&G). In keeping with the spirit of this fish planning process, the Chugach National Forest is also encouraged to conduct an annual coordination meeting with ADF&G and other agencies as deemed appropriate. Topics for discussion may include:

a. Discussion of identified project opportunities and feasibility analyses.

b. Review of all projects currently in development.

c. Presentation of anticipated budgets.

d. Coordination of project implementation.

e. Opportunities for cooperative funding.

f. Results of completed projects.

Annual meetings with individual Alaska Department of Fish and Game divisions may be needed to address specific needs and issues. For example, coordination of road stream crossings and fish passage issues may require annual meetings between the ADF&G Habitat Division and

Forest Service, including Engineering staff. Fish enhancement program coordination may require meetings with Habitat Division and other ADF&G Divisions. The intent is to encourage frequent and open communications between the Alaska Department of Fish and Game and the Forest Service as per the Master MOU.

4. Fish Transport Permit. Alaska Department of Fish and Game permits are required for the Forest Service to transport live fish or their reproductive products. The objective is to prevent the spread of fish pathogens and control the dispersion of fish gametes. Permit applications must be submitted to:

Salmon Rehabilitation and Enhancement Coordinator
Alaska Department of Fish and Game
Commercial Fisheries Management & Development Division
P.O. Box 2556
Juneau, AK 99802-5526

5. Fish Sampling Permit. Alaska Department of Fish and Game permits are required for the Forest Service to collect fish, shellfish, and aquatic plants for the purposes of science, education, propagation, or exhibition. Generally these permits expire on December 31 and must be renewed annually.

6. BMP Memorandum of Understanding (MOU). (Reserved).

7. Clean Water Act, Section 404, Wetland Dredge and Fill Permit (404). (Reserved).

8. Anadromous Fish Catalog Update. The Forest Service agrees to cooperate with the Alaska Department of Fish and Game (ADF&G) in the updating and mapping of anadromous fish waters (Supplemental Memorandum of Understanding No.1, 1998). The "*Catalog of Waters Important for Spawning, Rearing or Migration of Anadromous Fishes*" shows cartographic locations of specified rivers, lakes and streams having documented occupancy by anadromous fish and is the means by which the agreement between the Forest Service and Alaska Department of Fish and Game is carried out. Additionally, the catalog has legal standing in state courts as the list and location of protected anadromous fish waters. Update procedures allow current surveys to expand (or in some instances contract) the list of anadromous waters. For the National Forests, the most common change is the addition of lakes, rivers and streams that new inventories and surveys identify as anadromous habitat. Proposals for revision to the Catalog are submitted to:

Alaska Department of Fish and Game
Habitat and Restoration Division
333 Raspberry Road
Anchorage, Alaska 99518-1599

The proposed revision must include a nomination form (call your local ADF&G office) that identifies the name and location of the water body, the fish species using the water body, the date the fish were observed, the life stages and activities for which the water body is used, and any other clarifying information. The person proposing the revision must sign the nomination form. A map showing the mouth of the water body and the upper known extent of anadromous fish usage must be included for each proposed change. The water body should be located on a 1:63,360 scale USGS map (or 1:250,000 scale if 1:63,360 scale is unavailable for the area).

Species identification must be verified by a person qualified to identify the fish species found in the waters of the Alaska Region of the Forest Service (i.e., proponents of Catalog revisions may be asked to describe their qualifications). Adult anadromous fish may be identified by ocular means while identification of juvenile anadromous fish requires a "fish-in-hand."

9. Coastal Zone Management Act. Under the Coastal Zone Management Act (CZMA), any Federal project or activity that affects any land or water use or any natural resource of Alaska's coastal zone must be carried out in a manner that is consistent, to the maximum extent practicable, with the enforceable policies of the Alaska Coastal Management Program. Consult with Area or Forest Planning Staff regarding compliance with CZMA requirements.

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08 - GLOSSARY

A

Active channel[1] - Includes stream channels, secondary channels*, and braided channels*. For the Alluvial Fan Process Group, it also includes gravel outwash lobes. (Words marked by an * are defined in the glossary.)

Adfluvial fish[1] - Species or populations of fish that live in lakes and enter streams to spawn, but do not go to sea.

Aggradation[2] - The geologic process of deposition of material eroded and transported from other areas that raises streambeds and flood plains.

Alevin[3] - Larval salmonid that has hatched but not fully absorbed its yolk sac, and generally has not yet emerged from the spawning gravel.

Alluvial fan[1] - A cone-shaped deposit of organic and mineral material made by a stream where it runs out onto a level plain or meets a slower stream.

Alluvium[2] - A general term for all deposits resulting directly or indirectly from the sediment transport of streams, thus including the sediment laid down in riverbeds, flood plains, lakes, and at the foot of mountain slopes and estuaries.

Anadromous fish[1] - Fish that mature and spend much of their adult life in the ocean, returning to fresh water for reproduction; salmon and steelhead are examples.

Anadromous Fisheries Habitat Assessment[1] - An assessment conducted in 1994 within the Tongass National Forest (published in 1995) to study the effectiveness of current procedures for protecting anadromous fish habitat and to determine the need for any additional protection.

Anchor ice[2] - Ice formed below the surface of a stream, on the streambed, or upon a submerged body or structure.

Angle of repose[3] - The maximum slope at which loose or fragmented solid material will stand without sliding.

Aquaculture[1] - Maintenance, enhancement, and rehabilitation of fish stocks including rearing of anadromous fry in fresh water for release into salt water for maturation.

Aquatic ecosystem[1] - Stream channel, lake, or estuary bed, water, biotic communities, and nonliving components that occur and function collectively as a natural system.

Aquatic farm (or Aqua farming)[1] - Growing, farming, or cultivating aquatic products in captivity or under positive control. Current State of Alaska law (AS 16.40.100--16.40.199, July 1, 1990) does not allow the aquatic farming of finfish, but does allow the farming of shellfish.

Area of potential effects[1] - The geographic area or areas within which an undertaking may cause changes in the character or use of historic properties, if any such properties exist.

Arterial road[1] - Roads usually developed and operated for long-term land and resource management purposes and constant service.

B

Baffle - Wood, concrete, or metal mounted in a series on the floor and/or wall of a culvert to increase boundary roughness and thereby reduce the average water velocity in a culvert or to retain bedload within the culvert.

Bank[1] - The continuous margin along a river or stream where all upland vegetation ceases.

Bankfull discharge - Bankfull discharge occurs at the point when water just begins to overflow onto the active flood plain. This discharge has a recurrence interval of about 1.5 years (Leopold, 1994).

Bankfull depth - Average water depth at bankfull flow.

Bankfull height - Location of the water surface during bankfull flow.

Bankfull width - A measure of wetted channel width at bankfull discharge.

Barrier[1] - A vertical falls, steep cascade, or high velocity chute in a stream channel that prevents migration of anadromous species (from CTUG).

Beach fringe[1] - The area inland from salt-water shorelines that is typically forested.

Bedload[1] - The part of sediment transport not in suspension moving on or near the channel bed. The particles of this material have a density or grain size that prevents movement far above or for a long distance out of contact with the streambed under natural flow conditions.

Bedrock control[1] - A section of a stream channel composed of bedrock material. Streambed and banks consist of the underlying bedrock (from CTUG).

Bed roughness - Irregularity of streambed material that contributes resistance to stream flow. Commonly measured as Manning's roughness coefficient.

Benthic[1] - Pertaining to the sea bottom or to organisms that live on the sea bottom.

Best Management Practices (BMPs)[1] - Land management methods, measures or practices selected by an agency to meet its nonpoint source control needs. BMPs include, but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters. BMPs are selected on the basis of site-specific conditions that reflect natural background conditions and political, social, economic, and technical feasibility. BMPs are found in Forest Service Handbook 2509.22.

Biogeographic provinces[1] Twenty-one ecological subdivisions of Southeast Alaska identified by generally distinct ecological, physiogeographic, and biogeographic features. Plant and animal species composition, climate, and geology within each province are generally more similar within than among adjacent provinces. Historical events (such as glaciers and uplifting) are important to the nature of the province and to the characteristics that distinguish each province.

Biological diversity[1] - The variety of life forms and processes, including the complexity of species, communities, gene pools, and ecological functions, within the area covered by a land management plan.

Biomass[1] - The total quantity, at a given time, of living organisms of one or more species per unit area or all of the species in a community.

Blowdown[1] - See windthrow.

BMPs[1] - See Best Management Practices.

Boulders[1] - Rounded or angular rocks greater than 12 inches in size.

Braided streams or channels[1] - Braided channels are characterized by multiple channel threads that are tightly woven together and separated by shallow, unvegetated bars.

Buffer[3] - A protective strip of vegetation left essentially intact along a stream or lake during and after logging.

C

Canopy gap[1] - Natural openings created in the overstory of old-growth conifer forests from the loss of a single or small group of trees from windthrow, insects, or disease. Gaps are also created in second-growth conifer stands by cutting all of the trees in a small area to increase light penetration to the understory, thereby maintaining or increasing the growth of understory plants.

Catastrophic event[1] - Events resulting from a great and sudden calamity or disaster. In the case of forest stands such events may include windstorms, wildfire, floods, snowslides, and insect outbreaks. Whether a disturbance event is called catastrophic is dependent on the context within which the event occurs, the scale of the event, and the effects of the event.

Capability[1] - The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity.

Capital investment cost[1] - Costs generally associated with construction such as trails, roads, and physical structures.

Carrying capacity[1] - The estimated maximum number of animals that can be sustained over the long term within a specified area.

Channel[1] - A natural waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the water.

Channel bed width - Equates to the distance between the bottom of the left bank and the bottom of the right bank.

Channel entrenchment - Channel entrenchment describes valley incision depth* and vertical confinement.

Channel gradient - The change in elevation between end points of the channel segment divided by the length of the channel segment.

Channel length - The distance between the start and endpoint of the channel segment measured with a hip chain along the stream thalweg*.

Channel migration - Movement of a stream or river channel within a flood plain area (or an alluvial fan) usually over an extended period of time.

Channel pattern - The configuration of the stream as it appears from above, and is described as straight, multiple thread, braided, or meandering.

Channel sideslope[1] - The area from the stream channel to the side-slope break. Also see Side-slope break.

Channel type[1] - A means of distinguishing parts of a stream system into segments that have consistent physical and biological characteristics. For descriptions, see "Channel Type Field Guide," Forest Service publication R10-MB-6.

Class (streams)[1] - See Stream class.

Clearcut[1] - Harvesting method in which all trees are cleared in one cut. It prepares the area for a new, even-aged stand. The area harvested may be a patch, stand, or strip large enough to be mapped or recorded as a separate age class in planning.

Coarse gravel[1] - Rounded rocks generally 3/4 of an inch to 3 inches in size.

Cobbles[1] - Rounded rocks between 3 and 12 inches in size.

Colluvial[1] - Soil and material produced by the disintegration and weathering of rocks, including cliff debris, material of avalanches, and alluvium. This material accumulates at the foot of a slope.

Confined streams[1] - Streams that are confined within their channel banks; they are controlled by stream incision, geomorphic landform characteristics, and local geological conditions.

Confluence[1] - The point where two streams meet.

Connectivity[1] - A measure of the extent that forest areas between or outside reserves provide habitat for breeding, feeding, dispersal, and movement.

Control (nick) points[1] - Points in streams that are not easily erodible.

Critical habitat[1] - Specific areas designated as critical by the Secretary of Interior or Commerce for the survival and recovery of species listed as Threatened or Endangered pursuant to the Endangered Species Act.

Culvert[1] - A conduit or passageway under a road, trail, or other obstruction. A culvert differs from a bridge in that it is usually constructed entirely below the elevation of the traveled way.

Cumulative effects[1] - See Effects.

Cumulative watershed effects (CWE)[1] - The effects on a watershed's streams and lakes that result from the incremental and additive impact of many individual actions within a watershed added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative watershed effects can result from individually minor but collectively significant actions taking place over a period of time.

D

Debris flows[1] - The movement of material resulting from the decay and disintegration of rocks, earth, and other materials.

Debris slides[1] - The rapid downslope movement of a mixture of soil, rock, and forest litter with or without relatively high water content. Also known as debris avalanches.

Debris torrents[1] - Landslides that occur as a result of debris; avalanche materials that either dam a channel temporarily or accumulate behind temporary obstructions such as logs and forest debris. Debris torrents are usually confined within the stream channel until they reach the valley floor where the debris spreads out, inundating vegetation and forming a broad surface deposit.

Detritus[1] - Material, produced by the disintegration and weathering of rocks, that has been moved from its site of origin.

Discharge velocity[1] - The speed of water outflow from a stream or river over a given period of time.

Dissected landforms[1] - A physical, recognizable form or feature of the earth's surface such as a mountain, hill, or valley, has a characteristic shape that in part is the result of several shallow or deeply incised drainage channels.

Dissolved oxygen[1] - The amount of free (not chemically combined) oxygen in water.

Disturbance[1] - A force that results in changes in ecosystem structure and composition through natural events such as wind, fire, flood, avalanche, or mortality caused by insect or disease outbreaks or by human caused events (e.g., timber harvest).

Diversity[1] - See Biological diversity.

E

Ecosystem[1] - A complete, interacting system of organisms considered together with their environment (for example; a marsh, a watershed, or a lake).

Ecosystem management[1] - The use of an ecological approach to land management to sustain diverse, healthy, and productive ecosystems. Ecosystem management is applied at various scales to blend long-term societal and environmental values in a dynamic manner that may be modified through adaptive management.

Emergent[1] - A plant rooted in shallow water and having most of its vegetation above water (for example, cattails).

Endangered species[1] - Any species of animal or plant in danger of extinction throughout all or a significant portion of its range. Plant or animal species identified and defined in accordance with the 1973 Endangered Species Act and published in the Federal Register.

Enhance[1] - To improve, reinforce, enrich or strengthen the existing condition, value, or beauty of a resource.

Entrenchment ratio - Calculated as the flood-prone width divided by the bankfull channel width, this ratio describes the degree to which floods are contained by the channel.

Ephemeral channels[1] - A stream that flows in direct response to rainfall and snowmelt but not during dry seasons. Its channel is above the level of the water table.

Erosion[1] - The wearing away of the land surface by running water, wind, ice, gravity, or other geological processes.

Escapement[1] - Adult anadromous fish that escape from all causes of mortality (natural or human-caused) to return to streams to spawn.

Estuary[1] - An ecological system at the mouth of a stream where fresh water and salt water mix, and where salt marshes and intertidal mudflats are present. The landward extent of an estuary is the limit of salt-intolerant vegetation, and the seaward extent is a stream's delta at mean low water.

F

Fen - A tract of low, wet ground containing sedge peat, relatively rich in mineral salts, alkaline in reaction, and characterized by slowly flowing water. Vegetation is generally sedges and grasses, often with low shrubs and sometimes a sparse cover of trees. Sphagnum mosses are absent or of low cover. Fens contribute to stable stream flows, provide nutrient input to streams, and often contribute to fish rearing habitat.

FHAT[1] -See Fish Habitat Assessment Team.

Fines[1] - Bed material less than 4 mm (0.16 in.) in diameter.

Fish Passage[1] - The ability of both adult and juvenile fish to move both up and down stream.

Fish user day[1] - A recreation visitor day spent fishing or viewing fish.

Flash flooding[1] - A very rapidly responding, relatively high streamflow overtopping the banks in any reach of a stream.

Flood plain - That portion of the stream valley adjacent to the channel that is built by sediments of the stream and that is covered with water when the stream overflows its banks at flood stage (Schwarz et al., 1976).

Fluvial[1] - Of, or pertaining to, streams and rivers.

Foodfish[1] - Fish consumed by humans.

Footslope[1] - The inner, gently inclined surface at the base of a hill or mountain slope. The surface profile is dominantly concave, and is the transition zone between upslope erosional sites and downslope depositional sites.

Fragmentation[1] - An element of biological diversity that describes the natural condition of habitats in terms of the size of discrete habitat blocks or patches, their distribution, the extent to which they are interconnected, and the effects of management on these natural conditions. Also the process of reducing the size and connectivity of stands within a forest.

FSH[1] - Forest Service Handbook.

FSM[1] - Forest Service Manual.

FUD[1] - See Fish User Day.

Function[1] - A term in ecology referring to the interactions and influences between plant and animal species within an area (how each species uses its environment), and to natural processes of change or disturbance (such as wind or aging).

G

Geomorphology - The classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes recorded by these surface features (Bates and Jackson, 1987).

Glacial rivers and streams[1] - Rivers and streams that receive their main flow characteristics from the presence and activities of ice and glaciers and their meltwater.

Glide[1] - Very low velocity stream flow that creates a calm surface condition with water flowing smoothly and gently.

Gradient - Refers to the slope of the water surface profile.

Groundwater[1] - Water within the earth that supplies wells and springs. Specifically, water in the zone of saturation where all openings in soils and rocks are filled; the upper surface level forms the water table.

H

Habitat[1] - The sum total of environmental conditions in a specific place occupied by wildlife or plant organisms or populations.

Habitat capability[1] - The estimated maximum number of fish or wildlife that can be supported by the amount and distribution of suitable habitat in an area.

Headwaters[3] - The source of a stream: the upper slopes of a watershed.

Hollow[3] - A small valley or basin.

Horizontal distance[1] - Distance measured in a flat (horizontal) manner at a zero angle.

Hydraulic control - A channel feature within a habitat unit (e.g., pool, riffle) that controls water depth over a range of discharges.

Hydrologic cycle[1] - The complete cycle through which water passes, commencing as atmospheric water vapor, passing into liquid and solid form as precipitation, thence along or into the ground surface, and finally again returning to the form of atmospheric water vapor by means of evaporation and transpiration; also called water cycle.

Hydrophyte[1] - Plants typically found in wet habitats.

I

Incision depth - The vertical distance between the first major slope break above the bankfull stage and the channel bottom at the thalweg.

Invert - The lowest point of the internal cross section of a culvert.

Invertebrate[1] - Animals without a backbone.

K

Karst[1] - A type of topography that develops in areas underlain by soluble rocks, primarily limestone. Dissolution of the subsurface strata results in areas of well-developed, surface drainage that are sinkholes, collapsed channels, or caves.

L

Lacustrine wetland[1] - Includes permanently flooded lakes and reservoirs, intermittent lakes, and tidal lakes with ocean-derived salinities of less than 0.5 percent. Typically, there are extensive areas of deep water and there is considerable wave action.

Landslides[1] - The moderately rapid-to-rapid downslope movement of soil and rock materials that may or may not be water-saturated.

Large Woody Debris (LWD)[4] - A term used to describe logs, tree boles, rootwads*, and limbs that are in, on or near the stream channel. Current usage of the term defines LWD as wood material equal to or greater than 0.1 meters in diameter, and equal to or greater than 1.0 meter in length.

Leave strips[1] - The result of timber harvest activities where blocks of timber are left after harvest has occurred.

Littoral[1] - The relatively shallow (up to approximately 9.1 meters (30 feet) in depth) area of a lakeshore where sunlight can penetrate.

Log Transfer Facilities (LTF)[1] - Formerly referred to as Terminal Transfer Facilities, Log Transfer Facilities include the site and structures used for moving logs and timber products between land and water-based transportation.

LUD[1] - See Land Use Designation.

LWD[4] - See Large Woody Debris.

M

Macro pool - All channel depressions that meet minimum qualifying dimensions for residual pool depth* and size (length or width) relative to the channel bed width*, and have a unique hydraulic control*.

Mariculture[1] - The cultivation of plants and animals in saltwater, with no freshwater component. Mariculture does not include anadromous fish farming.

Marine systems[1] - Of, or belonging to, or caused by, the sea.

Maritime climate[1] - Weather conditions controlled by an oceanic environment characterized by small annual temperature ranges and high precipitation.

Mass-wasting[1] - A general term for a variety of processes by which large masses of earth material are moved by gravity either slowly or quickly from one place to another. Also, mass movement.

Meandering channel - Channels having a ratio of channel length to valley length of 1.5 or greater.

Memorandum of Understanding (MOU)[1] - An agreement developed through consultation between the Forest Service and others agencies that states specific measures the agencies will follow to accomplish a large or complex project. A memorandum of understanding is not a fund-obligating document.

Microclimate[1] - The temperature, moisture, wind, pressure, and evaporation (climate) of a very small area that differs from the general climate of the larger surrounding area.

Monitoring[1] - Gathering information and observing results of management activities to provide a basis for the periodic evaluation of the Forest Plan.

Multiple thread channel - Streams having two or more sidechannels* that are separate by vegetated bars or flood plain islands.

Muskeg[1] - See Peatland.

N

Natural condition - The state of the ecosystem that occurs when ecological functions and processes are within a natural range of variability on both temporal and spatial scales.

Nonpoint source (pollution)[1] - Unlike point sources of water pollution, nonpoint sources are diffuse and can come from any land area. Nonpoint sources of water pollution originate from many undefinable sources such as agricultural and urban runoff, runoff from construction activities, and runoff from forestry practices. Nonpoint source pollutants are generally carried over or through the soil and ground cover via storm flow processes. The following activities are potential nonpoint sources of pollution; reforestation and subsequent cultural treatment, thinning, prescribed burning, pest and fire control, harvest operations, surface drainage, and road construction and maintenance from which there is natural runoff. Best Management Practices are recognized as control mechanisms for nonpoint source pollution.

O

Ordinary high water mark[1] - The mark along the bank or shore up to which the presence and action of the nontidal water are common and usual, and so long continued in all ordinary years, as to leave a natural line impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics. (Consult 11 AAC 53.900 -- Alaska Code.)

Overflow[1] - High runoff that overflows natural stream and river banks. Also known as flooding.

P

Parr[3] - Young salmonid, in the stage between alevin and smolt that has developed distinctive dark "parr marks" on its sides and is actively feeding in fresh water.

Palustrine wetland[1] - Includes all nontidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity from ocean derived salts is below 0.5 percent.

Parent material - The unconsolidated, and more or less chemically weathered, mineral or organic matter from which soils develop.

Peak flow[1] -The highest discharge of water recorded over a specified period of time at a given stream location. Often thought of in terms of spring snowmelt, summer, fall or winter rainy season flows. Also called maximum flow.

Perched culvert[1] - A condition in which a drainpipe outlet is elevated above the stream bottom.

Pipe arch - A culvert that has been factory-deformed from a circular shape such that the width (or span) is larger than the vertical dimension (or rise).

Point source (pollution)[1]- A point at which pollution is added to a system, either instantaneously or continuously.

Population viability[1] - Probability that a population will persist for a specified period of time across its range despite normal fluctuations in population and environmental conditions.

Pool[3] - Portion of a stream with reduced current velocity, often with deeper water than surrounding areas and with a smooth surface.

Pool tail crest depth - The deepest point where the water surface slope breaks into the downstream riffle, or plunges to a pool below the upstream pool.

Primary pool - Macro pool that extends laterally from bank to bank.

Primary stream production[1] - Results from photosynthesis by green plants. In streams, includes production from algae and aquatic plants, and from non-stream sources such as leaf litter.

Process group[3] - Channels formed and maintained by the same or similar fluvial processes. Process groups describe the interrelation between runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes.

R

Redd[3] - Nest made in gravel, consisting of a depression hydraulically dug by a fish for egg deposition (and then filled) and associated gravel mounds.

Rehabilitation[1] - Actions taken to protect or enhance site productivity, water quality, or other values for a short period of time.

Resident fish[1] - Fish that are not migratory and complete their entire life cycle in fresh water.

Residual pool depth - Equals the maximum depth minus the pool tail crest depth*, which is the depth of water over the hydraulic control.

Restoration[1] - The long-term placement of land back into its natural condition or state of productivity.

Retention[1] - The amount of commercial forest land removed from the timber base to protect other resource values.

Revegetation[1] - The re-establishment and development of a plant cover. This may take place naturally through the reproductive processes of the existing flora or artificially through the direct action of reforestation or re-seeding.

Riffles[1] - Shallow rapids in an open stream, where the water surface is broken by waves caused by wholly or partially submerged obstructions.

Riparian[3] - Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

Riparian area[1] - The area including a stream channel, lake or estuary bed, the water itself, and the plants that grow in the water and on the land next to the water.

Riparian corridor[1] - The flood plain and associated riparian soils, vegetation, and wetlands.

Riparian ecosystem - Land next to water where plants that are dependent on a perpetual source of water occur.

Riparian management area[3] - Land areas delineated through land management planning (or watershed analysis) to provide for the management of riparian resources. Specific standards and guidelines, by stream process group, are associated with riparian management areas.

Riverine wetland[1] - A category in wetland classification that includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens; and (2) habitats with water containing ocean-derived salts in excess of 0.5 percent.

Rootwad - The root mass at the butt end of the tree.

RPA Assessment and Program[1] - The RPA Assessment is prepared every ten years and describes the potential of the nation's forests and rangelands to provide a sustained flow of goods and services. The RPA Program is prepared every five years to chart the long-term course of Forest Service management of the National Forests, assistance to State and private landowners, and research. They are prepared in response to Sections 3 and 4 of the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) (16 U.S.C. 1601).

Rubble[1] - Streambed material ranging in size from 6.09-25.4 cm (2.4 to 10 inches) in diameter.

Run[1] - A group of fish migrating in a river (most often on a spawning migration) that may comprise one or many stocks.

S

Secondary channel[1] - Lateral channel with an axis of flow roughly parallel to the mainstem and fed by the mainstem.

Secondary stream production[1] - Results from consumption by animals of materials produced in primary production in streams; this includes production of macroinvertebrates and some fish species.

Sediment[1] - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sediment transport[1] - The movement of sediment through the stream, from the source area to a point of deposition.

Seral stage - A sere is the collection of successional stages from bare ground to climax forest, while seral refers to the position of a vegetation community along a sere.

Side channel - Lateral (secondary) channel with an axis of flow roughly parallel to and fed by the main stem. Side channels generally rejoin the main channel.

Side-slope break[1] - The abrupt change (usually decreases) in slope gradient defining the upper limit of channel incision.

Sinuosity - The dimensionless ratio between the channel thalweg* length and the valley floor length*. Straight channels* are defined as having sinuosity less than 1.5. Channels having a ratio of channel length to valley length of 1.5 or greater are considered meandering* (Leopold, Wolman and Miller, 1964).

Site-potential tree height[1] - The average height of a given species of tree when mature on a site of specified productivity potential.

Slope distance[1] - Distance measured along the contour of the ground.

Slough[1] - A section of an abandoned river channel containing stagnant water and occurring on a flood plain or delta.

Smolt[3] - Juvenile salmonid one or more years old that has undergone physiological changes to cope with a marine environment.

Straight channel - Channels having sinuosity less than 1.5.

Streambed[1] - The substrate plane bounded by the streambanks, over which the water column moves. Also called the stream bottom. (From CTUG)

Streambank[1] -The portion of the channel cross section that restricts lateral movement of water at normal water levels. The bank often has a gradient steeper than 45 degrees and exhibits a distinct break in slope from the stream bottom. An obvious change in substrate may be a reliable delineation of the bank.

Stream class[1] -A means to categorize stream channels based on their fish production values. There are four stream classes on the Tongass National Forest.

Stream crossing[3] - The intersection of a road with a stream channel, such as a bridge, pipe arch, culvert, or ford.

Streamflow[1] - The discharge of water from a watershed that occurs in a natural stream channel.

Stream order - First order streams are the smallest unbranched tributaries; second order streams are initiated by the point where two first order streams meet; third order streams are initiated by the point where two second order streams meet, and so on.

Stream order - A numerical system (usually 1-6, ranking from headwaters to river terminus) designating the relative position of a stream or stream segment in a drainage basin. First order streams have no discrete tributaries; the junction of two first order streams produce a second order stream, and so forth. (Meehan, 1991).

Subspecies[1] - An aggregate of similar populations of a species generally inhabiting a geographic subdivision of the range of the species and differing phenologically (for example, different size or color) from other populations of the species.

Substrate - The mineral and/or organic material that forms the bed of the stream.

Suspended sediment[1] - The very fine soil particles that remain in suspension in water for a considerable period of time without contacting the stream or river channel bottom.

Swale[1] - A slight, marshy depression in generally level land. A depression in glacial ground moraine.

T

Temporary roads[1] - Low-level roads constructed for a single purpose and short-term use. Once use of the road has been completed, it is obliterated and the land it occupied is returned to production.

Thalweg - Line connecting the deepest parts of a stream channel.

Total stream discharge[1] - Total water outflow from a stream or river.

TTRA[1] - Tongass Timber Reform Act of 1990.

Turbidity[1] - An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a water sample. Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms.

U

Unconfined streams[1] - Streams without geomorphic landform characteristics or local geologic conditions that cause incision. Such streams overflow their banks, change flow into other channels, and establish new channels during flood conditions.

Unprogrammed timber harvest[1] - Timber harvest that occurs on unsuitable forested lands and is not chargeable to (does not contribute to) the allowable sale quantity.

V

Valley floor length - The straight-line distance between the start and end of the segment measured on an orthophoto.

Viable population[1] - For forest planning purposes a fish or wildlife population that has the estimated number and distribution of reproductive individuals to insure its continued existence is well distributed in the National Forest.

V-notch ravine[1] - A very steep (greater than 15 percent gradient), deeply incised stream channel usually situated on steep mountain slopes or hillslopes.

W

Watershed[1] - The area that contributes water to a drainage or stream. A portion of the forest in which all surface water drains to a common point. Watersheds can range from tens of acres that drain a single small intermittent stream to many thousands of acres for a stream that drains hundreds of connected intermittent and perennial streams. Third order watershed - a watershed where there are (generally) two major branches to the mainstream of the watershed. (Also see Stream order.) Fourth order watershed - a watershed that contains at least two third order watersheds.

Watershed analysis[1] - A systematic procedure for characterizing and evaluating ecological processes within a watershed, for use in ecosystem management and project planning; Forest Plan Appendix J characterizes watershed analysis from an aquatic perspective.

Watershed condition[3] - A description of the health of a watershed in terms of the factors that affect soil productivity and the ability of the watershed to sustain favorable conditions of flow (such as for fish habitat.)

Water table[1] - The upper surface of the ground water or that level below which the soil is saturated with water.

Windfirm[1] - Trees not likely to be blown over by the wind. These are usually trees that have been exposed to the wind throughout their life and have developed a strong root system or trees that are protected from the wind by terrain features or other trees.

Windthrow[1] - The act of trees being uprooted by the wind.

Windthrow management area[1] - A managed area designed to minimize windthrow within an adjacent no-harvest area.

Z

Zone1 - The wetted portion of the stream.

Zone 2 - The portion of the stream within the bankfull width, above the wetted height, and below the bankfull height.

Zone 3 - The portion of the stream within the bankfull width and above the bankfull height.

Zone 4 - Area outside the bankfull width or height.

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[1]Source: Tongass National Forest Land and Resource Management Plan, 1997.

[2]Source: American Fisheries Society. Aquatic Habitat Inventory Glossary and Standard Methods, 1985.

[3]Source: Anadromous Fish Habitat Assessment, 1995.

A

Active channel[1] - Includes stream channels, secondary channels*, and braided channels*. For the Alluvial Fan Process Group, it also includes gravel outwash lobes. (Words marked by an * are defined in the glossary.)

Adfluvial fish[1] - Species or populations of fish that live in lakes and enter streams to spawn, but do not go to sea.

Aggradation[2] - The geologic process of deposition of material eroded and transported from other areas that raises streambeds and flood plains.

Alevin[3] - Larval salmonid that has hatched but not fully absorbed its yolk sac, and generally has not yet emerged from the spawning gravel.

Alluvial fan[1] - A cone-shaped deposit of organic and mineral material made by a stream where it runs out onto a level plain or meets a slower stream.

Alluvium[2] - A general term for all deposits resulting directly or indirectly from the sediment transport of streams, thus including the sediment laid down in riverbeds, flood plains, lakes, and at the foot of mountain slopes and estuaries.

Anadromous fish[1] - Fish that mature and spend much of their adult life in the ocean, returning to fresh water for reproduction; salmon and steelhead are examples.

Anadromous Fisheries Habitat Assessment[1] - An assessment conducted in 1994 within the Tongass National Forest (published in 1995) to study the effectiveness of current procedures for protecting anadromous fish habitat and to determine the need for any additional protection.

Anchor ice[2] - Ice formed below the surface of a stream, on the streambed, or upon a submerged body or structure.

Angle of repose[3] - The maximum slope at which loose or fragmented solid material will stand without sliding.

Aquaculture[1] - Maintenance, enhancement, and rehabilitation of fish stocks including rearing of anadromous fry in fresh water for release into salt water for maturation.

Aquatic ecosystem[1] - Stream channel, lake, or estuary bed, water, biotic communities, and nonliving components that occur and function collectively as a natural system.

Aquatic farm (or Aqua farming)[1] - Growing, farming, or cultivating aquatic products in captivity or under positive control. Current State of Alaska law (AS 16.40.100--16.40.199, July 1, 1990) does not allow the aquatic farming of finfish, but does allow the farming of shellfish.

Area of potential effects[1] - The geographic area or areas within which an undertaking may cause changes in the character or use of historic properties, if any such properties exist.

Arterial road[1] - Roads usually developed and operated for long-term land and resource management purposes and constant service.

B

Baffle - Wood, concrete, or metal mounted in a series on the floor and/or wall of a culvert to increase boundary roughness and thereby reduce the average water velocity in a culvert or to retain bedload within the culvert.

Bank[1] - The continuous margin along a river or stream where all upland vegetation ceases.

Bankfull discharge - Bankfull discharge occurs at the point when water just begins to overflow onto the active flood plain. This discharge has a recurrence interval of about 1.5 years (Leopold, 1994).

Bankfull depth - Average water depth at bankfull flow.

Bankfull height - Location of the water surface during bankfull flow.

Bankfull width - A measure of wetted channel width at bankfull discharge.

Barrier[1] - A vertical falls, steep cascade, or high velocity chute in a stream channel that prevents migration of anadromous species (from CTUG).

Beach fringe[1] - The area inland from salt-water shorelines that is typically forested.

Bedload[1] - The part of sediment transport not in suspension moving on or near the channel bed. The particles of this material have a density or grain size that prevents movement far above or for a long distance out of contact with the streambed under natural flow conditions.

Bedrock control[1] - A section of a stream channel composed of bedrock material. Streambed and banks consist of the underlying bedrock (from CTUG).

Bed roughness - Irregularity of streambed material that contributes resistance to stream flow. Commonly measured as Manning's roughness coefficient.

Benthic[1] - Pertaining to the sea bottom or to organisms that live on the sea bottom.

Best Management Practices (BMPs)[1] - Land management methods, measures or practices selected by an agency to meet its nonpoint source control needs. BMPs include, but are not limited to structural and nonstructural controls and operation and maintenance procedures. BMPs can be applied before, during and after pollution-producing activities to reduce or eliminate the introduction of pollutants into receiving waters. BMPs are selected on the basis of site-specific conditions that reflect natural background conditions and political, social, economic, and technical feasibility. BMPs are found in Forest Service Handbook 2509.22.

Biogeographic provinces[1] Twenty-one ecological subdivisions of Southeast Alaska identified by generally distinct ecological, physiogeographic, and biogeographic features. Plant and animal species composition, climate, and geology within each province are generally more similar within than among adjacent provinces. Historical events (such as glaciers and uplifting) are important to the nature of the province and to the characteristics that distinguish each province.

Biological diversity[1] - The variety of life forms and processes, including the complexity of species, communities, gene pools, and ecological functions, within the area covered by a land management plan.

Biomass[1] - The total quantity, at a given time, of living organisms of one or more species per unit area or all of the species in a community.

Blowdown[1] - See windthrow.

BMPs[1] - See Best Management Practices.

Boulders[1] - Rounded or angular rocks greater than 12 inches in size.

Braided streams or channels[1] - Braided channels are characterized by multiple channel threads that are tightly woven together and separated by shallow, unvegetated bars.

Buffer[3] - A protective strip of vegetation left essentially intact along a stream or lake during and after logging.

C

Canopy gap[1] - Natural openings created in the overstory of old-growth conifer forests from the loss of a single or small group of trees from windthrow, insects, or disease. Gaps are also created in second-growth conifer stands by cutting all of the trees in a small area to increase light penetration to the understory, thereby maintaining or increasing the growth of understory plants.

Catastrophic event[1] - Events resulting from a great and sudden calamity or disaster. In the case of forest stands such events may include windstorms, wildfire, floods, snowslides, and insect outbreaks. Whether a disturbance event is called catastrophic is dependent on the context within which the event occurs, the scale of the event, and the effects of the event.

Capability[1] - The potential of an area of land to produce resources, supply goods and services, and allow resource uses under an assumed set of management practices and at a given level of management intensity.

Capital investment cost[1] - Costs generally associated with construction such as trails, roads, and physical structures.

Carrying capacity[1] - The estimated maximum number of animals that can be sustained over the long term within a specified area.

Channel[1] - A natural waterway of perceptible extent that periodically or continuously contains moving water. It has a definite bed and banks that serve to confine the water.

Channel bed width - Equates to the distance between the bottom of the left bank and the bottom of the right bank.

Channel entrenchment - Channel entrenchment describes valley incision depth* and vertical confinement.

Channel gradient - The change in elevation between end points of the channel segment divided by the length of the channel segment.

Channel length - The distance between the start and endpoint of the channel segment measured with a hip chain along the stream thalweg*.

Channel migration - Movement of a stream or river channel within a flood plain area (or an alluvial fan) usually over an extended period of time.

Channel pattern - The configuration of the stream as it appears from above, and is described as straight, multiple thread, braided, or meandering.

Channel sideslope[1] - The area from the stream channel to the side-slope break. Also see Side-slope break.

Channel type[1] - A means of distinguishing parts of a stream system into segments that have consistent physical and biological characteristics. For descriptions, see "Channel Type Field Guide," Forest Service publication R10-MB-6.

Class (streams)[1] - See Stream class.

Clearcut[1] - Harvesting method in which all trees are cleared in one cut. It prepares the area for a new, even-aged stand. The area harvested may be a patch, stand, or strip large enough to be mapped or recorded as a separate age class in planning.

Coarse gravel[1] - Rounded rocks generally 3/4 of an inch to 3 inches in size.

Cobbles[1] - Rounded rocks between 3 and 12 inches in size.

Colluvial[1] - Soil and material produced by the disintegration and weathering of rocks, including cliff debris, material of avalanches, and alluvium. This material accumulates at the foot of a slope.

Confined streams[1] - Streams that are confined within their channel banks; they are controlled by stream incision, geomorphic landform characteristics, and local geological conditions.

Confluence[1] - The point where two streams meet.

Connectivity[1] - A measure of the extent that forest areas between or outside reserves provide habitat for breeding, feeding, dispersal, and movement.

Control (nick) points[1] - Points in streams that are not easily erodible.

Critical habitat[1] - Specific areas designated as critical by the Secretary of Interior or Commerce for the survival and recovery of species listed as Threatened or Endangered pursuant to the Endangered Species Act.

Culvert[1] - A conduit or passageway under a road, trail, or other obstruction. A culvert differs from a bridge in that it is usually constructed entirely below the elevation of the traveled way.

Cumulative effects[1] - See Effects.

Cumulative watershed effects (CWE)[1] - The effects on a watershed's streams and lakes that result from the incremental and additive impact of many individual actions within a watershed added to other past, present, and reasonably foreseeable future actions, regardless of what agency or person undertakes such other actions. Cumulative watershed effects can result from individually minor but collectively significant actions taking place over a period of time.

D

Debris flows[1] - The movement of material resulting from the decay and disintegration of rocks, earth, and other materials.

Debris slides[1] - The rapid downslope movement of a mixture of soil, rock, and forest litter with or without relatively high water content. Also known as debris avalanches.

Debris torrents[1] - Landslides that occur as a result of debris; avalanche materials that either dam a channel temporarily or accumulate behind temporary obstructions such as logs and forest debris. Debris torrents are usually confined within the stream channel until they reach the valley floor where the debris spreads out, inundating vegetation and forming a broad surface deposit.

Detritus[1] - Material, produced by the disintegration and weathering of rocks, that has been moved from its site of origin.

Discharge velocity[1] - The speed of water outflow from a stream or river over a given period of time.

Dissected landforms[1] - A physical, recognizable form or feature of the earth's surface such as a mountain, hill, or valley, has a characteristic shape that in part is the result of several shallow or deeply incised drainage channels.

Dissolved oxygen[1] - The amount of free (not chemically combined) oxygen in water.

Disturbance[1] - A force that results in changes in ecosystem structure and composition through natural events such as wind, fire, flood, avalanche, or mortality caused by insect or disease outbreaks or by human caused events (e.g., timber harvest).

Diversity[1] - See Biological diversity.

E

Ecosystem[1] - A complete, interacting system of organisms considered together with their environment (for example; a marsh, a watershed, or a lake).

Ecosystem management[1] - The use of an ecological approach to land management to sustain diverse, healthy, and productive ecosystems. Ecosystem management is applied at various scales to blend long-term societal and environmental values in a dynamic manner that may be modified through adaptive management.

Emergent[1] - A plant rooted in shallow water and having most of its vegetation above water (for example, cattails).

Endangered species[1] - Any species of animal or plant in danger of extinction throughout all or a significant portion of its range. Plant or animal species identified and defined in accordance with the 1973 Endangered Species Act and published in the Federal Register.

Enhance[1] - To improve, reinforce, enrich or strengthen the existing condition, value, or beauty of a resource.

Entrenchment ratio - Calculated as the flood-prone width divided by the bankfull channel width, this ratio describes the degree to which floods are contained by the channel.

Ephemeral channels[1] - A stream that flows in direct response to rainfall and snowmelt but not during dry seasons. Its channel is above the level of the water table.

Erosion[1] - The wearing away of the land surface by running water, wind, ice, gravity, or other geological processes.

Escapement[1] - Adult anadromous fish that escape from all causes of mortality (natural or human-caused) to return to streams to spawn.

Estuary[1] - An ecological system at the mouth of a stream where fresh water and salt water mix, and where salt marshes and intertidal mudflats are present. The landward extent of an estuary is the limit of salt-intolerant vegetation, and the seaward extent is a stream's delta at mean low water.

F

Fen - A tract of low, wet ground containing sedge peat, relatively rich in mineral salts, alkaline in reaction, and characterized by slowly flowing water. Vegetation is generally sedges and grasses, often with low shrubs and sometimes a sparse cover of trees. Sphagnum mosses are absent or of low cover. Fens contribute to stable stream flows, provide nutrient input to streams, and often contribute to fish rearing habitat.

FHAT[1] -See Fish Habitat Assessment Team.

Fines[1] - Bed material less than 4 mm (0.16 in.) in diameter.

Fish Passage[1] - The ability of both adult and juvenile fish to move both up and down stream.

Fish user day[1] - A recreation visitor day spent fishing or viewing fish.

Flash flooding[1] - A very rapidly responding, relatively high streamflow overtopping the banks in any reach of a stream.

Flood plain - That portion of the stream valley adjacent to the channel that is built by sediments of the stream and that is covered with water when the stream overflows its banks at flood stage (Schwarz et al., 1976).

Fluvial[1] - Of, or pertaining to, streams and rivers.

Foodfish[1] - Fish consumed by humans.

Footslope[1] - The inner, gently inclined surface at the base of a hill or mountain slope. The surface profile is dominantly concave, and is the transition zone between upslope erosional sites and downslope depositional sites.

Fragmentation[1] - An element of biological diversity that describes the natural condition of habitats in terms of the size of discrete habitat blocks or patches, their distribution, the extent to which they are interconnected, and the effects of management on these natural conditions. Also the process of reducing the size and connectivity of stands within a forest.

FSH[1] - Forest Service Handbook.

FSM[1] - Forest Service Manual.

FUD[1] - See Fish User Day.

Function[1] - A term in ecology referring to the interactions and influences between plant and animal species within an area (how each species uses its environment), and to natural processes of change or disturbance (such as wind or aging).

G

Geomorphology - The classification, description, nature, origin, and development of present landforms and their relationships to underlying structures, and of the history of geologic changes recorded by these surface features (Bates and Jackson, 1987).

Glacial rivers and streams[1] - Rivers and streams that receive their main flow characteristics from the presence and activities of ice and glaciers and their meltwater.

Glide[1] - Very low velocity stream flow that creates a calm surface condition with water flowing smoothly and gently.

Gradient - Refers to the slope of the water surface profile.

Groundwater[1] - Water within the earth that supplies wells and springs. Specifically, water in the zone of saturation where all openings in soils and rocks are filled; the upper surface level forms the water table.

H

Habitat[1] - The sum total of environmental conditions in a specific place occupied by wildlife or plant organisms or populations.

Habitat capability[1] - The estimated maximum number of fish or wildlife that can be supported by the amount and distribution of suitable habitat in an area.

Headwaters[3] - The source of a stream: the upper slopes of a watershed.

Hollow[3] - A small valley or basin.

Horizontal distance[1] - Distance measured in a flat (horizontal) manner at a zero angle.

Hydraulic control - A channel feature within a habitat unit (e.g., pool, riffle) that controls water depth over a range of discharges.

Hydrologic cycle[1] - The complete cycle through which water passes, commencing as atmospheric water vapor, passing into liquid and solid form as precipitation, thence along or into the ground surface, and finally again returning to the form of atmospheric water vapor by means of evaporation and transpiration; also called water cycle.

Hydrophyte[1] - Plants typically found in wet habitats.

I

Incision depth - The vertical distance between the first major slope break above the bankfull stage and the channel bottom at the thalweg.

Invert - The lowest point of the internal cross section of a culvert.

Invertebrate[1] - Animals without a backbone.

K

Karst[1] - A type of topography that develops in areas underlain by soluble rocks, primarily limestone. Dissolution of the subsurface strata results in areas of well-developed, surface drainage that are sinkholes, collapsed channels, or caves.

L

Lacustrine wetland[1] - Includes permanently flooded lakes and reservoirs, intermittent lakes, and tidal lakes with ocean-derived salinities of less than 0.5 percent. Typically, there are extensive areas of deep water and there is considerable wave action.

Landslides[1] - The moderately rapid-to-rapid downslope movement of soil and rock materials that may or may not be water-saturated.

Large Woody Debris (LWD)[4] - A term used to describe logs, tree boles, rootwads*, and limbs that are in, on or near the stream channel. Current usage of the term defines LWD as wood material equal to or greater than 0.1 meters in diameter, and equal to or greater than 1.0 meter in length.

Leave strips[1] - The result of timber harvest activities where blocks of timber are left after harvest has occurred.

Littoral[1] - The relatively shallow (up to approximately 9.1 meters (30 feet) in depth) area of a lakeshore where sunlight can penetrate.

Log Transfer Facilities (LTF)[1] - Formerly referred to as Terminal Transfer Facilities, Log Transfer Facilities include the site and structures used for moving logs and timber products between land and water-based transportation.

LUD[1] - See Land Use Designation.

LWD[4] - See Large Woody Debris.

M

Macro pool - All channel depressions that meet minimum qualifying dimensions for residual pool depth* and size (length or width) relative to the channel bed width*, and have a unique hydraulic control*.

Mariculture[1] - The cultivation of plants and animals in saltwater, with no freshwater component. Mariculture does not include anadromous fish farming.

Marine systems[1] - Of, or belonging to, or caused by, the sea.

Maritime climate[1] - Weather conditions controlled by an oceanic environment characterized by small annual temperature ranges and high precipitation.

Mass-wasting[1] - A general term for a variety of processes by which large masses of earth material are moved by gravity either slowly or quickly from one place to another. Also, mass movement.

Meandering channel - Channels having a ratio of channel length to valley length of 1.5 or greater.

Memorandum of Understanding (MOU)[1] - An agreement developed through consultation between the Forest Service and others agencies that states specific measures the agencies will follow to accomplish a large or complex project. A memorandum of understanding is not a fund-obligating document.

Microclimate[1] - The temperature, moisture, wind, pressure, and evaporation (climate) of a very small area that differs from the general climate of the larger surrounding area.

Monitoring[1] - Gathering information and observing results of management activities to provide a basis for the periodic evaluation of the Forest Plan.

Multiple thread channel - Streams having two or more sidechannels* that are separate by vegetated bars or flood plain islands.

Muskeg[1] - See Peatland.

N

Natural condition - The state of the ecosystem that occurs when ecological functions and processes are within a natural range of variability on both temporal and spatial scales.

Nonpoint source (pollution)[1] - Unlike point sources of water pollution, nonpoint sources are diffuse and can come from any land area. Nonpoint sources of water pollution originate from many undefinable sources such as agricultural and urban runoff, runoff from construction activities, and runoff from forestry practices. Nonpoint source pollutants are generally carried over or through the soil and ground cover via storm flow processes. The following activities are potential nonpoint sources of pollution; reforestation and subsequent cultural treatment, thinning, prescribed burning, pest and fire control, harvest operations, surface drainage, and road construction and maintenance from which there is natural runoff. Best Management Practices are recognized as control mechanisms for nonpoint source pollution.

O

Ordinary high water mark[1] - The mark along the bank or shore up to which the presence and action of the nontidal water are common and usual, and so long continued in all ordinary years, as to leave a natural line impressed on the bank or shore and indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics. (Consult 11 AAC 53.900 -- Alaska Code.)

Overflow[1] - High runoff that overflows natural stream and river banks. Also known as flooding.

P

Parr[3] - Young salmonid, in the stage between alevin and smolt that has developed distinctive dark "parr marks" on its sides and is actively feeding in fresh water.

Palustrine wetland[1] - Includes all nontidal wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens, and all such wetlands that occur in tidal areas where salinity from ocean derived salts is below 0.5 percent.

Parent material - The unconsolidated, and more or less chemically weathered, mineral or organic matter from which soils develop.

Peak flow[1] -The highest discharge of water recorded over a specified period of time at a given stream location. Often thought of in terms of spring snowmelt, summer, fall or winter rainy season flows. Also called maximum flow.

Perched culvert[1] - A condition in which a drainpipe outlet is elevated above the stream bottom.

Pipe arch - A culvert that has been factory-deformed from a circular shape such that the width (or span) is larger than the vertical dimension (or rise).

Point source (pollution)[1]- A point at which pollution is added to a system, either instantaneously or continuously.

Population viability[1] - Probability that a population will persist for a specified period of time across its range despite normal fluctuations in population and environmental conditions.

Pool[3] - Portion of a stream with reduced current velocity, often with deeper water than surrounding areas and with a smooth surface.

Pool tail crest depth - The deepest point where the water surface slope breaks into the downstream riffle, or plunges to a pool below the upstream pool.

Primary pool - Macro pool that extends laterally from bank to bank.

Primary stream production[1] - Results from photosynthesis by green plants. In streams, includes production from algae and aquatic plants, and from non-stream sources such as leaf litter.

Process group[3] - Channels formed and maintained by the same or similar fluvial processes. Process groups describe the interrelation between runoff, landform relief, geology, and glacial or tidal influences on fluvial erosion and deposition processes.

R

Redd[3] - Nest made in gravel, consisting of a depression hydraulically dug by a fish for egg deposition (and then filled) and associated gravel mounds.

Rehabilitation[1] - Actions taken to protect or enhance site productivity, water quality, or other values for a short period of time.

Resident fish[1] - Fish that are not migratory and complete their entire life cycle in fresh water.

Residual pool depth - Equals the maximum depth minus the pool tail crest depth*, which is the depth of water over the hydraulic control.

Restoration[1] - The long-term placement of land back into its natural condition or state of productivity.

Retention[1] - The amount of commercial forest land removed from the timber base to protect other resource values.

Revegetation[1] - The re-establishment and development of a plant cover. This may take place naturally through the reproductive processes of the existing flora or artificially through the direct action of reforestation or re-seeding.

Riffles[1] - Shallow rapids in an open stream, where the water surface is broken by waves caused by wholly or partially submerged obstructions.

Riparian[3] - Pertaining to anything connected with or immediately adjacent to the banks of a stream or other body of water.

Riparian area[1] - The area including a stream channel, lake or estuary bed, the water itself, and the plants that grow in the water and on the land next to the water.

Riparian corridor[1] - The flood plain and associated riparian soils, vegetation, and wetlands.

Riparian ecosystem - Land next to water where plants that are dependent on a perpetual source of water occur.

Riparian management area[3] - Land areas delineated through land management planning (or watershed analysis) to provide for the management of riparian resources. Specific standards and guidelines, by stream process group, are associated with riparian management areas.

Riverine wetland[1] - A category in wetland classification that includes all wetlands and deepwater habitats contained within a channel, with two exceptions: (1) wetlands dominated by trees, shrubs, persistent emergent, emergent mosses or lichens; and (2) habitats with water containing ocean-derived salts in excess of 0.5 percent.

Rootwad - The root mass at the butt end of the tree.

RPA Assessment and Program[1] - The RPA Assessment is prepared every ten years and describes the potential of the nation's forests and rangelands to provide a sustained flow of goods and services. The RPA Program is prepared every five years to chart the long-term course of Forest Service management of the National Forests, assistance to State and private landowners, and research. They are prepared in response to Sections 3 and 4 of the Forest and Rangeland Renewable Resources Planning Act of 1974 (RPA) (16 U.S.C. 1601).

Rubble[1] - Streambed material ranging in size from 6.09-25.4 cm (2.4 to 10 inches) in diameter.

Run[1] - A group of fish migrating in a river (most often on a spawning migration) that may comprise one or many stocks.

S

Secondary channel[1] - Lateral channel with an axis of flow roughly parallel to the mainstem and fed by the mainstem.

Secondary stream production[1] - Results from consumption by animals of materials produced in primary production in streams; this includes production of macroinvertebrates and some fish species.

Sediment[1] - Solid material, both mineral and organic, that is in suspension, is being transported, or has been moved from its site of origin by air, water, gravity, or ice and has come to rest on the earth's surface either above or below sea level.

Sediment transport[1] - The movement of sediment through the stream, from the source area to a point of deposition.

Seral stage - A sere is the collection of successional stages from bare ground to climax forest, while seral refers to the position of a vegetation community along a sere.

Side channel - Lateral (secondary) channel with an axis of flow roughly parallel to and fed by the main stem. Side channels generally rejoin the main channel.

Side-slope break[1] - The abrupt change (usually decreases) in slope gradient defining the upper limit of channel incision.

Sinuosity - The dimensionless ratio between the channel thalweg* length and the valley floor length*. Straight channels* are defined as having sinuosity less than 1.5. Channels having a ratio of channel length to valley length of 1.5 or greater are considered meandering* (Leopold, Wolman and Miller, 1964).

Site-potential tree height[1] - The average height of a given species of tree when mature on a site of specified productivity potential.

Slope distance[1] - Distance measured along the contour of the ground.

Slough[1] - A section of an abandoned river channel containing stagnant water and occurring on a flood plain or delta.

Smolt[3] - Juvenile salmonid one or more years old that has undergone physiological changes to cope with a marine environment.

Straight channel - Channels having sinuosity less than 1.5.

Streambed[1] - The substrate plane bounded by the streambanks, over which the water column moves. Also called the stream bottom. (From CTUG)

Streambank[1] -The portion of the channel cross section that restricts lateral movement of water at normal water levels. The bank often has a gradient steeper than 45 degrees and exhibits a distinct break in slope from the stream bottom. An obvious change in substrate may be a reliable delineation of the bank.

Stream class[1] -A means to categorize stream channels based on their fish production values. There are four stream classes on the Tongass National Forest.

Stream crossing[3] - The intersection of a road with a stream channel, such as a bridge, pipe arch, culvert, or ford.

Streamflow[1] - The discharge of water from a watershed that occurs in a natural stream channel.

Stream order - First order streams are the smallest unbranched tributaries; second order streams are initiated by the point where two first order streams meet; third order streams are initiated by the point where two second order streams meet, and so on.

Stream order - A numerical system (usually 1-6, ranking from headwaters to river terminus) designating the relative position of a stream or stream segment in a drainage basin. First order streams have no discrete tributaries; the junction of two first order streams produce a second order stream, and so forth. (Meehan, 1991).

Subspecies[1] - An aggregate of similar populations of a species generally inhabiting a geographic subdivision of the range of the species and differing phenologically (for example, different size or color) from other populations of the species.

Substrate - The mineral and/or organic material that forms the bed of the stream.

Suspended sediment[1] - The very fine soil particles that remain in suspension in water for a considerable period of time without contacting the stream or river channel bottom.

Swale[1] - A slight, marshy depression in generally level land. A depression in glacial ground moraine.

T

Temporary roads[1] - Low-level roads constructed for a single purpose and short-term use. Once use of the road has been completed, it is obliterated and the land it occupied is returned to production.

Thalweg - Line connecting the deepest parts of a stream channel.

Total stream discharge[1] - Total water outflow from a stream or river.

TTRA[1] - Tongass Timber Reform Act of 1990.

Turbidity[1] - An expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through a water sample. Turbidity in water is caused by the presence of suspended matter such as clay, silt, finely divided organic and inorganic matter, plankton, and other microscopic organisms.

U

Unconfined streams[1] - Streams without geomorphic landform characteristics or local geologic conditions that cause incision. Such streams overflow their banks, change flow into other channels, and establish new channels during flood conditions.

Unprogrammed timber harvest[1] - Timber harvest that occurs on unsuitable forested lands and is not chargeable to (does not contribute to) the allowable sale quantity.

V

Valley floor length - The straight-line distance between the start and end of the segment measured on an orthophoto.

Viable population[1] - For forest planning purposes a fish or wildlife population that has the estimated number and distribution of reproductive individuals to insure its continued existence is well distributed in the National Forest.

V-notch ravine[1] - A very steep (greater than 15 percent gradient), deeply incised stream channel usually situated on steep mountain slopes or hillslopes.

W

Watershed[1] - The area that contributes water to a drainage or stream. A portion of the forest in which all surface water drains to a common point. Watersheds can range from tens of acres that drain a single small intermittent stream to many thousands of acres for a stream that drains hundreds of connected intermittent and perennial streams. Third order watershed - a watershed where there are (generally) two major branches to the mainstream of the watershed. (Also see Stream order.) Fourth order watershed - a watershed that contains at least two third order watersheds.

Watershed analysis[1] - A systematic procedure for characterizing and evaluating ecological processes within a watershed, for use in ecosystem management and project planning; Forest Plan Appendix J characterizes watershed analysis from an aquatic perspective.

Watershed condition[3] - A description of the health of a watershed in terms of the factors that affect soil productivity and the ability of the watershed to sustain favorable conditions of flow (such as for fish habitat.)

Water table[1] - The upper surface of the ground water or that level below which the soil is saturated with water.

Windfirm[1] - Trees not likely to be blown over by the wind. These are usually trees that have been exposed to the wind throughout their life and have developed a strong root system or trees that are protected from the wind by terrain features or other trees.

Windthrow[1] - The act of trees being uprooted by the wind.

Windthrow management area[1] - A managed area designed to minimize windthrow within an adjacent no-harvest area.

Z

Zone1 - The wetted portion of the stream.

Zone 2 - The portion of the stream within the bankfull width, above the wetted height, and below the bankfull height.

Zone 3 - The portion of the stream within the bankfull width and above the bankfull height.

Zone 4 - Area outside the bankfull width or height.

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[1]Source: Tongass National Forest Land and Resource Management Plan, 1997.

[2]Source: American Fisheries Society. Aquatic Habitat Inventory Glossary and Standard Methods, 1985.

[3]Source: Anadromous Fish Habitat Assessment, 1995.

(4)

Table of Contents

11 - INTRODUCTION

Aquatic ecosystems include oceans, estuaries, steams, lakes, and wetlands. Management of these ecosystems requires management of the adjacent riparian lands and uplands that directly influence these waters. Management of these ecosystems also requires an understanding of interactions among biotic and abiotic components at multiple temporal and spatial scales (USDA 1993). Temporal scales may be short (greater than 10 years) when considering biotic populations or communities or long (greater than 10 years) when considering geologic processes and disturbance regimes. The ranges of spatial scales considered at various planning levels are explained in the Forest Service publication “A Hierarchical Framework of Aquatic Ecological Units in North America (Nearctic Zone), (General Technical Report NC-176).” The watershed scale is the most useful spatial scale for project specific planning. Generally watersheds in the Alaska Region are defined as forth order or lower watersheds, with some exceptions.

Watershed characteristics including geology, soils, topography, climate, hydrology and vegetation interact to produce aquatic habitats (Meehan 1991). Management of aquatic habitats requires understanding of these characteristics, including spatial and temporal aspects. The quality and quantity of aquatic habitats, including fish habitats, are defined by the stream channel processes, which in turn are functions of watershed process.

Lakes and streams are linked to the upland areas of the watershed by biotic and physiochemical properties of the riparian zone (Naiman 1992). This zone (the riparian ecosystem) is defined as “the land extending from the edge of the water body toward the uplands and having vegetation and microclimate influenced by the perennial or intermittent water associated with high water tables, and by the ability of soils to hold water (Naiman 1992).”

The term “riparian” may also refer to terrestrial land interactions with, and effects on, the water body. Management considerations may be included to broaden this definition. For the purposes of this Handbook, “riparian” is broadly defined to include the riparian ecosystem itself and the transition to upland forest where vegetation still influences the stream under some conditions (Gregory 1991). The connectivity of water bodies within a watershed is well recognized. Murphy and Meehan (1991) state:

The physical and chemical features of an ecosystem’s structure provide the framework for development of the biological community and its resources. A stream’s physical habitat is determined mainly by associated hill slopes and riparian vegetation (Sullivan et al. 1987). The principal factors that control channel morphology are water discharge, sediment load, solid elements such as woody debris, bedrock, and boulders, and bank characteristics…. The stream and terrestrial ecosystems are closely linked. The flow of water, sediment, nutrients, and organic matter from the surrounding watershed shapes physical habitats and supplies energy and nutrient resources for the stream community. Riparian vegetation strengthens streambanks, contributes woody debris, and governs the influx of light and organic matter to the stream.

Management of aquatic ecosystems for specific objectives, such as highly productive fish habitats, requires consideration of numerous parameters and relationships extending beyond the fish stream and even beyond the streambanks. It is important to also recognize that the freshwater aquatic ecosystems of the Alaska Region connect to estuarine ecosystems managed by the State.

Disturbance processes form most natural habitats. Examples include windthrow, mass soil movement, snow avalanche, flooding, erosion, deposition, and fire. The natural range of aquatic habitat conditions is determined in part by spatial and temporal patterns of natural disturbances. Disturbance processes can also be associated with land management activities such as timber harvest, road construction, and hydroelectric development. The two primary differences between natural disturbance processes and those associated with land management activities are the periodicity or temporal scale of the disturbances and the extent of the disturbances. Generally, land management activities involve disturbance processes that are frequent and of low intensity whereas natural disturbance processes are infrequent but greater intensity (Reeves 1995).

Maintenance of biodiversity is an important principle in the management of aquatic ecosystems. The Forest Service is directed by NFMA to provide for diversity of plant and animal communities by NFMA. Biological diversity includes "the variety and variability among living organisms and the ecological complexities in which they occur (Bission 1995)." Important values associated with biological diversity include the adaptation and genetic variation of existing populations and the potential for further evolution (Committee on Protection and Management of Pacific Northwest Anadromous Salmonids 1996). The following objectives for aquatic habitat management stress the importance of maintaining naturally functioning aquatic ecosystems as a basis for maintaining biological diversity on the National Forests in Alaska.

11.2 - Objectives

The objectives for managing aquatic ecosystems in the Alaska Region are founded on the principle that naturally functioning ecosystems (including consideration of both temporal and spatial scales) will best sustain populations of freshwater organisms. These objectives are:

1. Aquatic Habitat Management. Maintain or restore the natural range and distribution of aquatic habitat conditions on the Forests to sustain the diversity and production of fish and other freshwater organisms.

2. Riparian Area Management. Maintain riparian areas in mostly natural conditions, for fish, other aquatic life, old growth and riparian-associated plant and wildlife species, water-related recreation, and to provide for ecosystem processes, including important aquatic and land interactions.

3. Fish Habitat. Achieving the broad objectives for aquatic habitat management requires that additional objectives be identified for specific habitat parameters. The Anadromous Fish Habitat Assessment establishes fish habitat objectives in terms of desired physical and biological conditions that can be precisely measured and described. These habitat objectives, as stated in AFHA, "are a first approximation of scientifically based indicators of healthy, fully functioning aquatic systems on the Tongass National Forest." Initially developed on the Tongass National Forest, these objectives also serve as interim Regional objectives that will be adjusted as new information (e.g., additions to the resource data base) and improved understanding of habitat relationships and disturbance processes become available.

a. Large Woody Debris. Established as density of large wood pieces per 1,000 meter2 of stream, this objective varies by channel type, size, and process group (Exhibit 01). Channel area rather than length was selected as the reference unit because stream segment lengths may not be accurately determined from basin-wide survey data. Large woody debris is defined as woody material greater than or equal to 10 cm in diameter and greater than or equal to 1 m long that protrudes into the active stream channel area. Large woody debris, an indicator of riparian community structure and health, is a key factor influencing aquatic habitat diversity and productivity in forest streams. Large woody debris is critical in many streams for maintaining habitat cover and complexity for salmonids and aquatic invertebrates that provide an important food source for fish (Bisson et al. 1987 and Maser and Sedell 1994). Recent studies show that large woody debris provides structure for retention of salmon carcasses that contribute nutrients to many streams (Wipfli et al. 1998). Large woody debris structure, recruitment, and depletion can be greatly influenced by management activities. Large woody debris is also a good indicator of both short-term and long-term effects of riparian management activities.

b. Pool Area (Percentage). Pool area (11.2 - Exhibit 01) is used rather than pool frequency because of difficulties in scaling individual pool units and determining consistent stream segment length from basin-wide survey data. Pools are characterized by lower surface current velocity and greater depth compared to other portions of the stream. Changes in the number of pool units can indicate shifts in the balance between sediment input and transport associated with changes in fluvial erosion or streamflow regime. Pools may be correlated with channel roughness elements such as pieces of large woody debris. Pools are very important in providing habitat for rearing juveniles, cover for adults, and optimal spawning sites at pool tails-outs. Changes in pool area often reflect long-term changes in habitat condition and can be indicators of cumulative watershed effects.

c. Stream Width-to-Depth Ratio. Desired bankfull channel width-to-depth values have been established for the flood plain (FP) and moderate gradient, mixed control (MM) channel types (Exhibit 01). Bankfull stream stage is roughly equivalent to the stream level for a 2-year return-interval flood. Width-to-depth ratio is a general index of channel stability in alluvial channels—predominately streams in the flood plain—and moderate-gradient, mixed-control process-group channels. Channel segments with consistently high width-to-depth ratios indicate increased sediment storage and aggradation. Sediment aggradation in alluvial channels may be correlated with reduced flow depths, loss of pool area and volume, dewatering of spawning habitat, and loss of macro-invertebrate habitat. Other indirect effects may include changes in stream temperature ranges and increased formation of anchor ice in winter.

11.2 - Exhibit 01

Tongass Fish Habitat Objectives

Habitat Objective	Channel Type or Process Group	Interim Tongass Habitat Standards (percentiles)			Sample Size
		25th	50th	75th	
Large wood debris,	FP3	10	32	54	11
(pieces/1,000m2)	FP4	8	24	34	11
	FP5	4	5	6	3
	HC	16	35	65	4
	LC	6	15	22	22
	MC	27	45	82	7
	MM1	33	35	44	5
	MM2				
Pool area, percentage	FP	27	49	61	37
of total stream area	HC	14	26	40	8
	LC	8	20	27	12
	MC	11	22	39	19
	MM	20	35	52	15
	FP3	20	53	76	15
	FP4	35	47	59	17
	FP5	47	51	60	5
	MM1	28	40	52	13
	MM2	2	22	39	7
Stream width-to-depth	FP3	8	13	18	67
ratio, (dimensionless)	FP4	16	25	35	62
	FP5	30	45	70	70
	MM1	9	12	18	52
	MM2	17	24	33	25

Stream class

12 - STREAM VALUE CLASS

The Alaska Region stream value classification is based on subsistence, recreational, and economic fish harvest considerations. The value classes do not imply either ecological importance or prioritization of fish harvest over maintenance of watershed function. Stream classes are as follows:

1. Class I. Streams and lakes with anadromous or adfluvial fish or fish habitat; or, high quality resident fish waters, or habitat above fish migration barriers known to provide reasonable enhancement opportunities for anadromous fish.

2. Class II. Streams and lakes with resident fish or fish habitat and generally steep (6 to 25 percent or higher) gradients where no anadromous fish occur, and otherwise not meeting class I criteria.

3. Class III. Streams are perennial and intermittent streams that have no fish populations or fish habitat, but have sufficient flow or sediment and debris transport to directly influence downstream water quality or fish habitat capability. For streams less than 30 percent gradient, special care is needed to determine if resident fish are present. Streams are class III streams if they have:

Bankfull width greater than 1.5 meters (5 feet) **and**
Channel incision greater than 5 meters (15 feet)

Streams that do not meet the above criteria may be classified as class III streams based on a professional interpretation of stream characteristics. The following list contains characteristics that may indicate a class III stream:

a. Steep side-slopes containing mobile fine sediments, sand deposits, or deep soils

b. Very steep gradient (greater than 35 percent slope)

c. Recently transported bedload or debris (especially if deposited outside high water mark)

d. Recent channel erosion or scour

e. Absence of moss or other vegetation in channel

f. Bedload rounded and bright (as opposed to angular and dull)

g. High water width greatly exceeds current wetted width

h. Sediment deposits stored amongst debris that could be readily transported if debris shifts.

4. Class IV. Other intermittent, ephemeral, and small perennial channels with insufficient flow or sediment transport capabilities to directly influence downstream water quality or fish habitat capability. Class IV streams do not have the characteristics of class I, II or III streams, and have a bankfull width of at least 0.3 meters (1 foot). Incision depth (meters) may be determined from side-slope angle and length (22.32 - Exhibit 01). Incisions from 3 to 5 meters in depth may be categorized as either class III or class IV streams depending on the other stream characteristics.

5. Nonstreams. Rills and other watercourses, generally intermittent and less than 1 foot in bankfull width, showing little or no incision into the surrounding hillslope or evidence of scour.

12.1 - Channel Type

Stream channel types provide a means to distinguish between aquatic ecosystems in management planning activities. Nine process groups inclusive of channel types, describe the interrelationships of watershed runoff, landform relief, geology, and glacial or tidal influences with fluvial erosion and deposition processes (R10-TP-26). These physical processes (abiotic components) create habitats for the aquatic organisms (biotic component) of the aquatic ecosystem.

12.11 - Process Groups, Lakes, and Ponds

The channel types can be grouped according to their formative geomorphic, hydrologic and vegetative processes. Lakes and ponds are included even though a classification system has not yet been developed for the Region. The process groups described in the Channel Type User Guide (USDA 1992) are:

1. Alluvial fan (AF1, AF2 and AF8 Channels). Alluvial fan channels flow directly over the alluvial fan landform. These dynamic, multi-branched channels periodically change course within the landform. Stream gradient ranges from 1 to 3 percent on the lower half of the alluvial fan and increases toward the fan apex. The alluvial fan channel is associated with high gradient contained channels; therefore, streamflow is dependent on mountain slope runoff. Groundwater discharge is also significant. Surface flow may be intermittent above a substrate of sand to cobble size material. During low flow periods, streamflow may run subsurface in the middle section of the alluvial fan and emerge on the lower section. Aggradation of material is the dominant process on the alluvial fan and fine sediment may be deposited in the low gradient

section. The active channels on alluvial fans often include multiple high flow channels and unvegetated gravel or cobble outwash lobes with ill-defined channel banks. Alluvial fans typically support large spruce with diameters (DBH) greater than 30 inches, and have average site-potential tree heights of 140 feet. Downed wood serves as nurse logs for regeneration.

2. Estuarine (ES1, ES2, ES3, and ES4, Channel Types). Estuarine channels occur at the mouths of watersheds, along inlets and deltas at the heads of bays. Water level fluctuations, channel morphology, sediment transport, and water chemistry are influenced to some degree by saltwater inundation in these channel types. Riparian areas consist of saltwater marshes, meadows, mudflats, and gravel deltas that are depositional environments. Estuarine channels are usually single to multiple thread channels, shallowly entrenched, and poorly constrained. Currents and wave action easily erode stream substrates of fine textured alluvium. Much of the sediment produced from any given watershed is ultimately deposited in or along the estuarine channel types; consequently, these channels are highly sensitive to upstream disturbances. Sedge and grass communities dominate the riparian vegetation. The amount of stream migration and channel braiding vary with bank and bed materials and upstream erosion and sediment transport regimes. Riparian areas are normally greater than 100 feet wide and may reach widths of several hundred feet on large river deltas.

3. Flood plain (FP1, FP2, FP3, FP4, and FP5 Channel Types). Flood plain channels are associated with the valley bottom flood plain landform. This process group contains low gradient sinuous singular or anabranched channels. Mountain slope runoff and groundwater discharge control streamflow in the flood plain process group, and peak flows occur in the spring and fall. Sediment deposition is the dominant process. Substrate material ranges from sand to cobble size material.

Flood plains commonly support standing old-growth spruce with heights of up to 130 feet. Downed wood provides nurse logs for regeneration, sediment retention, and infiltration. Flood plain widths may exceed 200 feet on FP4 and FP5 channels, but are generally less than 200 feet on FP3 channels. These areas are typically highly productive for fish. Large wood and off channel rearing areas are of particular significance as habitat features.

4. Glacial Outwash (GO1, GO2, GO3, GO4, and GO5 Channels). Glacial outwash channels are associated with the valley bottom flood plain landform. This process group contains low gradient sinuous singular or anabranches channels. Braided channels are prevalent in the glacial outwash process group, and streamflow is controlled by glacial melt. Peak flows occur in the summer. Large wood and off channel rearing areas are of particular significance as habitat features. Sediment deposition is the dominant process, and substrate material ranges from sand to cobble size material. Early successional forest species, such as black cottonwood, are common.

5. High Gradient Contained (HC1, HC2, HC3, HC4, HC5, HC6, HC8 and HC9 Channels). High gradient contained channels are located on mountain slopes. These are singular straight incised channels with steep slopes and channel gradients greater than 6 percent. Streamflow is dependent upon mountain slope runoff and may be intermittent. Sediment is readily transported through these channels. Substrate material ranges from cobble to bedrock. Riparian Management Areas include incised channel side-slopes. The western hemlock series dominates vegetation although spruce is also common. Typical site-potential tree height is 120 feet. Some streams have intermittent flows. Steep gradients (greater than 6 percent) limit fish capability.

6. Large Contained (LC1 and LC2 Channels). Large contained channels are associated with canyons or sloping lowlands. These are low gradient (less than 3 percent), singular, straight and entrenched channels with gravel to bedrock substrate. Sediment regime balances input with output. Streamflow is dependent upon mountain slope or lowland runoff. Habitat is often limited by a scarcity of stable large wood structure. Riparian vegetation communities are varied. Riparian width, including flood plain and side-slope breaks, reaches 150 feet (LC1) to 190 feet (LC2). Site index for potential tree growth is 100 feet.

7. Moderate Gradient Contained (MC1, MC2 and MC3 Channels). Moderate gradient contained channels are associated with sloping or rolling lowlands. Stream gradient ranges from 2 to 6 percent for these singular, straight, and entrenched channels. Streamflow is dependent upon mountain slope runoff. Sediment is transported through these channels. Substrate is dominated by cobble, boulder and bedrock material. Habitat is often limited by availability of stable large wood structures. Riparian vegetation communities are varied. Riparian width, including flood plain and side-slope breaks, reaches 60 to 70 feet. Site index of potential tree growth is 100 feet.

8. Moderate Gradient/Mixed Control (MM1, MM2, and GO4 Channels). These channels are commonly found in transition zones between high gradient contained streams and flood plain channels. They are located in narrow valleys, footslopes or sloping and rolling lowlands. Stream channel gradients range from 2 to 6 percent. Channel containment is variable, as structural control may be intermittent or only along one bank. Overall channel pattern is straight. Streamflow is dependent upon mountain slope runoff and the sediment regime is balanced (input equals output). Channel substrate ranges from coarse gravel to boulder size material. Typical site index tree is 120 feet.

9. Palustrine (PA1, PA2, PA3, PA4 and PA5 Channels). Palustrine channels are associated with lowland landforms and wetlands. Channel gradients are less than 1 percent. Palustrine channels are singular and sinuous. Streamflow is dependent on peat lands and lowland runoff. Sediment storage is the dominant process. Substrate material ranges from fine organic material to coarse gravel. Riparian vegetation includes mixed conifer, shore pine, and nonforest. Site index is generally less than 85 feet.

10. Lakes and Ponds. Lakes and ponds can be located throughout a watershed from near sea level to the alpine. Very high elevation lakes (greater than 1,000 feet) are often frozen much of the year. Low elevation lakes are often high quality fish rearing habitat providing for many species of wildlife (especially beaver, loons, eagles, swans, and other water birds). Lakes and ponds function to mitigate downstream flooding during large precipitation events, and are important for surface-groundwater exchange and moderating water temperatures. Low elevation and fish-abundant lakes are commonly used for customary and traditional subsistence harvests, sport fishing, and recreational camping. Small ponds, particularly beaver ponds, can be highly productive. Riparian and near-lake vegetation can often be a mixed mosaic including old-growth forest, hardwoods (for example: alder or cottonwood), shore pine, and nonforest. Wetlands often occur as a component of lake and pond riparian and are important for the natural function of the lake and pond ecosystem.

S

FSH 2090.21 – AQUATIC HABITAT MANAGEMENT HANDBOOK
CHAPTER 20 – FISH AND AQUATIC STREAM HABITAT SURVEY

Table of Contents

This handbook establishes standard techniques for fish biologists, hydrologists, and aquatic ecologists conducting fish and aquatic stream habitat surveys in coastal Alaska. Compiled from published literature, the techniques and data parameters are consistent with core data standards for the National Forest System and enable development of a single Regional database. The database can help managers to quantify the characteristics of fish and aquatic habitat, set objectives for habitat protection and enhancement, and develop standards and guidelines for achieving those objectives. Stream surveys may be used to:

1. Inventory streams and assess riparian habitat conditions.

2. Assess status of aquatic populations.

3. Support design of in-stream structures.

4. Monitor effects of forest management practices on stream and riparian conditions.

5. Plan watershed restoration to achieve a desired condition based on forest plan objectives

Efforts to combine Alaska Region stream data sets and identify high quality habitat were hindered by past inconsistencies in survey protocols (USDA 1995a). The hierarchical approach presented in this handbook is flexible and can be used for either a quick inventory or a detailed watershed analysis.

Effective monitoring can be accomplished by developing an appropriate experimental design and statistical test. The protocols in this Chapter define standards for data collection, but do not include an effectiveness monitoring strategy. A recent analysis of statistical power for stream survey data parameters (Coghill 1996) suggests that the usefulness of stream habitat surveys as a monitoring tool, even when conducted to the standards described herein, is limited by sample size and stratification. While studies designed to monitor changes in stream habitats should use the techniques described in this document, the study design must account for variability associated with the spatial scale of observation (site, reach, and watershed) and the frequency of conditions encountered outside a particular range (Wimberly et al. 2000, Mulder et al. 1999).

This stream survey protocol should be used for species and habitat data needs as described in the *Alaska Region Watershed Analysis Handbook* (USDA 1997a). Watershed analysis is a procedure for assessing important riparian and aquatic habitat values and geomorphic processes within a watershed. It describes key aquatic and riparian resources, with associated habitat conditions and trends.

21 – HIERARCHICAL APPROACH

A hierarchical approach ensures that all habitat surveys, from the most superficial to the most detailed, are based on the same framework and thus are compatible in a single database. Although measurement requirements for a given attribute may vary in level of detail or frequency of measurement between survey levels or tiers, information collected at various tiers can be lumped or aggregated. For example, large wood may be counted in one tier, but tallied by size categories in another tier. In either case, data can be aggregated to achieve a total count of large wood. Such compatibility requires consistent units of measurement and definitions.

1. The Tier One survey provides reconnaissance information to apply Forest-wide standards and guidelines for fish habitat and water quality. These data are used to update the streams layer of the ARC-INFO database. Outputs provide information required to determine site-specific Best Management Practices and apply Forest-wide standard and guidelines associated with channel type process groups and stream class (USDA 1997b).

2. The Tier Two survey provides consistent, quantitative estimates of habitat parameters necessary to evaluate the condition of a stream relative to basic riparian habitat management objectives (RHMO). Metrics include macro pool frequency, total count of large woody debris, width-to-depth ratios, and others for comparison to standards for each channel type. The Tier Two survey protocol uses variables that can be measured efficiently with a two-person survey crew. Habitat units are defined and discrete categories established to minimize observer bias, reduce measurement error, and enable replication and comparison of data.

3. The Tier Three survey provides additional detail over the Tier Two survey. Habitat parameters are subdivided into meso or optional micro levels for collection of additional data on riparian habitat(Bryant et al. 1992). Habitat unit are measured to obtain areas. Channel morphology measurements are replicated, and fish populations assessed. The additional outputs may be used to develop or refine RHMO. These surveys may be appropriate for evaluation of fish enhancement proposals, determination of restoration needs, or studies of habitat utilization by fish.

4. The Tier Four survey, which provides finer detail and more replication, is appropriate for intensive surveys of small areas. Data can be aggregated into the same database used for Tier Two or Three data. Within this hierarchical framework, survey objectives dictate the level of detail needed for any parameter. Meso or micro-habitat measurements are used to tailor the survey to the information need. The key is to ensure that data collection is conducted in accordance with the criteria and definitions identified in Tier Two.

5. Any categories added beyond the Tier Four survey, must be subunits of Tier Four units that can be aggregated into the categories identified in the protocol. All survey information should be entered into the Alaska Region Aquatic Database (NRIS Water Module when available to Alaska), with appropriate spatial coverage updates to the Forest GIS streams layer.

21.1 – Database Management and Aquatic Data Structure

Data collected in a consistent manner, with common definitions, can be pooled into databases. Pooling of survey data allows the natural range of variability for stream survey metrics to be determined for that channel type and spatial scale, then stratified by ecological section or subsection as described by Nowacki et al. (2001). Data collected for each of the four tiers of the survey protocol can be entered into the Alaska Region and National Resource Information System (NRIS) database.

When recording data to paper or electronic forms, enter missing data as not available (NA) rather than a blank space.

21.11 – Watershed Numbering System

The USGS hydrologic unit code (HUC) is a nationwide hierarchical watershed numbering system. The code has four levels, each with a two-integer field. The first level HUC is termed the region. Region19 represents all of Alaska. The second level HUC is the subregion. The Alaska Region is subdivided into six subregions (21.11 – Exhibit 01). Southeast Alaska is Subregion 01 and includes the coastal forelands from Cape Fairweather to the Bering Glacier. South-central Alaska is Subregion 02. The third level HUC, the basin, subdivides the subregions. The fourth level HUC, or sub-basin, subdivides basins. Eleven USGS hydrologic units on the Tongass National Forest, and six on the Chugach National Forest, describe the region, subregion, basin, and sub-basins of Alaska Region National Forests. These identifying numbers correspond to two-digit USGS hydrologic unit code fields one through four (21.11 – Exhibit 02). A hydrologic unit map of the Chugach National Forest (21.11 – Exhibit 03) that delineates the 6 fourth level HUC. A hydrologic unit map of the Tongass National Forest (21.11 – Exhibit 04) that delineates the 11 fourth level HUC. Alaska Region hydrologic boundaries have been further delineated according to protocols established by NRCS (1995) and USGS (1998). A summary of the hydrologic levels and criteria is shown in 21.11 – Exhibit 05. The national standard USGS hydrologic units and regionally-defined drainage information coding are incorporated in 21.11 – Exhibit 06. Alaska Region watershed terms and GIS watershed attributes are based on Maxwell et al. (1995) and McCammon (1994).

Due to the unique physiography of coastal Alaska watersheds, fifth level watershed units are delineated as "associations" of discrete watersheds. Grouping true watersheds into associations was necessary to maintain the size of sixth level hydrologic units within the national standard size range of 10,000 to100,000 acres. Similarly, at the sixth level (that is, sub-watershed), most hydrologic units at this scale are delineated as "true" watersheds.

A fifth level watershed association subdivides cataloging units into polygons containing groups of contiguous watersheds. Watershed associations were defined using ECOMAP sub sections and watershed physiography as templates for grouping similar "true" watersheds. The fifth level HUC polygons were numbered sequentially from the northern tip of the sub-basin to the southern tip, and from west to east. The fifth level HUC consists of two integers (01 to 99). Generally, each subbasin was subdivided into 10 or fewer watershed associations. The lower portions of the Alsek, Stikine, and Taku Rivers are delineated as fifth level hydrologic units. These trans-boundary rivers should be delineated at the basin scale (third level), since they are greater than 6,000 square miles in drainage. The Forest Service is developing recommendations to USGS to modify existing basin and sub-basin boundaries.

A sixth level HUC divides the fifth level watershed associations into true watersheds, third order and greater. This watershed level also uses a two-integer code. The sixth level watershed numbering sequence follows the same convention as the cataloging unit: generally north to south and west to east. For true watersheds, the sixth level code will be a two-integer field with codes greater than "00." For all other polygons (for example a polygon that envelops a group of low order drainages that flow directly into salt water), the sixth field value will default to "00."

The seventh level HUC identifies and codes sub-watershed polygons that will be delineated on a project level basis. The seventh field is a two-integer field, and numbering follows the same convention used for the cataloging unit: generally north to south and west to east. The default value is "00."

The eighth level HUC identifies and codes all the other polygons that are not true watersheds (T or W feature types). These may envelop a group of low order drainages (McCammon 1994) flowing to saltwater or noncontributing areas, most frequently "A" and "Z" type features. The eighth level watershed numbering sequence follows the same conventions as the other fields. The default value is "00." The eighth field can also be used to code sub-watershed drainages that are delineated for project needs.

The ninth field has been added to describe various watershed types or drainage features and facilitate GIS applications such as stream routing. These alpha modifiers are described in 21.11 – Exhibit 06The listing order of watershed type codes coincides with the order of priority for assigning the codes (that is, a watershed with both an unidentified saltwater outlet and a lake system would be coded with the "U" code only). 21.11 – Exhibit 07 shows Admiralty Island fifth level watershed associations, and complete watershed coding for the Northwest Admiralty Association.

21.11 – EXHIBIT 01 IS A SEPARATE DOCUMENT

21.11 – Exhibit 02
USGS Hydrologic Unit Code for the Alaska Region Forests

Tongass NF	Chugach NF	
19010101	19010301	19010402
19010102	19010302	19020104
19010103	19010303	19020201
19010201	19010401	19020202
19010202		19020302
19010203		19020401
19010204		

19 = region
01 = subregion
02 = basin
03 = sub-basin

21.11 – EXHIBIT 03 IS A SEPARATE DOCUMENT

21.11 – EXHIBIT 04 IS A SEPARATE DOCUMENT

21.11 – Exhibit 05
Summary of Hydrologic Unit Criteria and Terminology

HUC Term	GIS Attribute Item	Field of Watershed Number/Definition	Polygon Size (acres)	Stream order
Sub-basin	Hydrologic Unit Code	Fields 1 thru 4: USGS hydrologic unit	10^5–10^6	NA
Watershed Association	Watershed Association Code	5th field: A group of associated watersheds.	10^4–10^5	NA
Watershed	Watershed Code	6th field: Area in which all surface waters flow to a common point, also called "true order watershed."	10^3–10^5	$\geq 3^{rd}$ order
Subwatershed	Subwatershed Code	7th field: Subwatersheds delineated on a project basis	10^2–10^4	$\leq 3^{rd}$ order
Drainage	Drainage Code	8th field: Single or group of small order drainages and noncontributing areas or order subwatershed	10^2–10^4	$\leq 3^{rd}$ order
Watershed Type	Watershed Type	9th field: Watershed or drainage feature type. Alpha code	NA	NA

21.11 – Exhibit 06
Watershed Identification Coding

Field	Descriptor	Feature	Codes
1	Region	Defined by USGS	19
2	Subregion	Defined by USGS	01-02
3	Basin	Defined by USGS	01-04
4	Subbasin	Defined by USGS	01-04
5	Watershed Association	Defined locally with aid of ECOMAP	01-26
6	Watershed	3rd order or greater true watersheds flowing to saltwater; All other polygons	01-99 00
7	Subwatershed	3rd order or reater subwatersheds All other polygons	01-99 00
8	Drainage	2nd order or other type of drainage	01-99
9	Feature type	Area (polygon) with no mappable streams	Z
		Single or group of small associated drainages (<3rd order stream)	A
		Karst feature, identified saltwater outlet	K
		Karst feature, unidentified saltwater outlet	U
		True watershed, 3rd order or greater flowing to saltwater and ≥ 3,000 acres in area	T
		True watershed, 3rd order or greater flowing to saltwater and < 3,000 acres in area	W
		Lake system with unidentified saltwarer outlet	L
		Small island watershed < 100 acres	I

21.11 – EXHIBIT 07 IS A SEPARATE DOCUMENT

21.12 – Location Coding

Watersheds are broad scale units used to catalog information about streams and other water bodies. Within watersheds, the location of stream features will be based on a unique stream route identifier. NRIS will use the national hydrography data set (NHD) developed by USGS to identify and spatially locate the stream reach. Survey reach lengths should be a minimum of 20-channel bed widths to adequately detect the range of variability.

21.13 – Survey Positional Accuracy

Survey segments identified during the office phase of the survey should begin and end at clearly identifiable points along the stream course. Examples include the mouth of a tributary visible on anair photo, or an obvious change in landform, channel pattern, or gradient. These distinct features often coincide with channel type mapping unit boundaries. The NHD stream reach identifier will automatically be linked to stream survey segment locations through the NRIS Water Module—GIS interface. Fish habitat data can be linked to the GIS data only if surveyors accurately record a starting point and distances of habitat units from that point. Latitude and longitude readings from a global positioning system (GPS) unit may be used to supplement the above procedures if position accuracy can be assured (+/- 10 meters). Accuracy is dependent on the availability and signal strength of satellites to fix the position, and data processing techniques. Canopy cover, masking terrain, satellite position, sensitivity of the GPS unit to weak signals, and the ability of the GPS unit to track and select multiple signals all affect performance. With suitable equipment, user ability, satellite signal and processing, GPS fixes can be extremely accurate. GPS coordinates must also be rectified for a given GIS map projection to accurately display stream segment node locations.

The following methods, listed in order of decreasing positional accuracy, may be used to fix the survey location:

1. Location based on GPS (assumes accurate fix).

2. Location based on an orthophoto/GIS stream cover overlay.

3. Location based on manual transfer of standard photography to GIS stream cover.

22 – TIER ONE SURVEY

The Tier One survey provides reconnaissance information to enable application of Forest-wide standards and guidelines for fish habitat and water quality. The primary use is to update the stream database spatial coverage. This improved coverage provides information necessary to establish site-specific best management practices as described in the Soil and Water Conservation Handbook – FSH 2509.22 (USDA 1996a), and to facilitate implementation of riparian management prescriptions associated with channel type process groups. Surveys should allow identification of appropriate riparian buffers, wind-firm management zones, and streams needing protection under timber contract provisions and State and Federal law. More detailed survey data may be needed for some site-specific management activities, such as identifying the appropriate road drainage structure to achieve concurrence under the 1997 Supplemental Memorandum of Understanding between the Forest Service and Alaska Department of Fish and Game. This survey may complement a proper functioning condition survey of response reaches within a watershed.

The Tier One survey includes the following measurements or observations:

1. Verify or identify channel type at least to process group.

2. Add previously unmapped streams to the GIS spatial database.

3. Verify or identify fish value class as I, II, III, or IV (USDA 1997b).

4. Note management concerns or issues.

5. Record channel morphology attributes including: gradient, average bankfull width, bankfull maximum depth (optional), incision depth, and characterize substrate composition. If the banks area symmetrical, record the incision depth on the steeper or longer slope; that which is most likely to directly influence water quality.

6. Record fish presence/absence by species and fish barrier data on stream morphology data card (22.5 – Exhibit 01).

7. Record LLID (optional)

22.1 – Identify Channel Type Process Group

Identify the channel type at least to process group level (that is, flood plain, estuarine, palustrine, alluvial fan, and so forth), or verify the existing GIS channel type code for the stream segment by completing morphology measurements. Use the channel type field cards or key to Alaska Region stream process groups (22.1 – Exhibit 01) for this purpose.

22.1 – EXHIBIT 01 IS A SEPARATE DOCUMENT

22.2 – Classify Unmapped Streams

Locate and classify unmapped channels as class I, II, III, or IV. Update the GIS spatial database according to procedures established by GIS specialists and resource data stewards.

22.3 – Verify Stream Classes

Verify or determine the stream class as I, II, III, IV or nonstream as described in chapter 10 of this Handbook. To consistently ascertain whether a nonfish stream is class III or class IV:

1. Determine whether activities can affect the downstream beneficial uses (that is, are there intervening depositional zones?).

2. Use the incision depth chart (22.55 – Exhibit 01) to determine incision depth.

22.4 – Identify Management Concerns

Identify areas or concerns that warrant special consideration during management activities (for example, off-channel habitat, spawning gravel, depositional areas or debris loading at road crossing sites, historical windthrow, average tree height and spacing, unstable slopes, presence and direction of blowdown, temperature concerns, fish passage needs, and so forth). Identified issues may later drive a watershed analysis (Forest Service 1997b).

22.5 – Channel Morphology

At a minimum rate of once per channel type, record:

1. Bankfull stream width (meters).
2. Bankfull maximum depth (meters).
3. Gradient using water surface elevation (percent slope to nearest degree).
4. Channel incision depth (meters).
5. Dominant substrate composition.

Record the information on the habitat survey stream morphology data card (22.5 – Exhibit 01).

22.5 – EXHIBIT 01 IS A SEPARATE DOCUMENT

22.51 – Channel Measurements

Channel morphology measurements should be made at a single thread riffle section, or where no significant side channels are present (generally greater than 20 percent of the bankfull flow). If a single thread channel cannot be found, as is often the case in large flood plain channels, then cross-sectional stream measurements should be extended across the major side channels. Harrelson et al. (1994) suggested the following for locating cross sections:

1. A straight reach between two meander bends.
2. Clear indicators of the flood plain or bankfull discharge.
3. Presence of one or more terraces.
4. Channel section and form typical of the stream.
5. A reasonably clear view of geomorphic features.

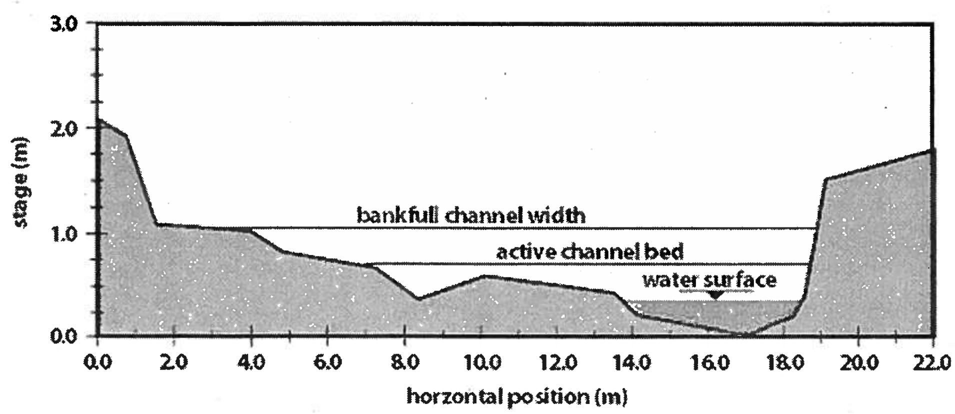
The steep vertical bank at meander bends, large woody debris accumulations, undercut banks, or slumping banks should be avoided.

22.52 – Bankfull Width

Bankfull width is a measure of wetted channel width at bankfull discharge. It is measured as the horizontal distance, perpendicular to the channel thalweg, between corresponding bankfull height locations on opposite channel banks. Bankfull discharge occurs at the point where water just begins to overflow onto the active flood plain. The active flood plain is that portion of the stream valley adjacent to the channel which is built by sediments of the stream and which is covered by water when the stream overflows its banks at flood stage (Schwarz et al. 1976). This discharge has a recurrence interval of about 1.5 years (Leopold 1994).

The primary indicator of bankfull level is the edge of the flat depositional surface in alluvial, low gradient channels. Topographical changes (that is, horizontal to vertical slope changes) are the next best indicators. Other less reliable indicators are a change in vegetation or the perennial vegetation line, the top of point bars, and a change in size or size-distribution of the bank material. The perennial vegetation line consistently occurs below the bankfull stage in the temperate rain forests of southeast and southcentral Alaska. Using the top of point bars as an indicator will generally underestimate the bankfull stage. The bankfull stage is the water flow elevation at which flooding begins (22.52 – Exhibit 01), and is significant as the flow stage where most channel forming processes occur (that is, sediment transport, scour, and deposition) Bankfull discharge is the flow that over time carries the most sediment and plays an important part in maintaining the channel and channel features, such as pools and riffles, essential for maintaining good fish habitat. Flows exceeding bankfull build the flood plain, provide the periodic disturbance and scour required to regenerate and maintain many riparian species, and are important in the design of structures (for example, 50-year flood).

22.52 – Exhibit 01
Channel Cross Section Profile
From WinXSPRO Channel Cross Section Analyzer



22.53 – Bankfull Maximum Depth (optional)

Bankfull maximum depth is the difference between the elevation at bankfull width and the elevation of the deepest point along the width transect. It is recorded as vertical distance to nearest 0.1 meters. The information is used to complete site-specific design criteria for road cards.

22.54 – Gradient

Channel gradient is the change in water surface elevation between end points of a channel segment. Measure the reach gradient over at least 20 channel widths to approximate water surface slope near bankfull stage. When measuring slope over shorter distances, called a local gradient, bankfull slope can be approximated by measuring slope from one distinct channel feature to a similar one upstream, such as from the top of a riffle to the top of the next riffle. Clinometers may be very imprecise, although a clinometer is adequate for the Tier 1 survey, provided the instrument is tested for accuracy. Abney or hand levels are preferred, and should be used with a staff or pole to give a constant instrument height.

22.55 – Incision Depth

Use the habitat survey stream morphology data card (22.5 – Exhibit 01) to record incision depth category and record both the left and right banks (facing downstream). Incision depth is the vertical distance (meters) between the first major slope break above bankfull stage and the channel bottom at the thalweg. Use the incision depth chart (22.55 – Exhibit 01) to determine incision depth. For stream classification on asymmetrical banks, select the steeper or longer slope; that which is most likely to directly influence water quality.

22.55 – EXHIBIT 01 IS A SEPARATE DOCUMENT

22.56 – Substrate Composition

Record the substrate composition which best typifies the entire reach segment: bedrock, mixed, or alluvium.

1. Bedrock: Channels contained within rock walls or with extensive outcropping along the banks and bed (greater than 15 percent of the reach length).

2. Mixed: Channels contained within a mixture of colluvial, alluvial, and bedrock materials with consistent, but not extensive, bedrock occurrence within the banks or bed (2–15 percent of the reach length).

3. Alluvium: Channels cut into alluvium with very infrequent bedrock occurrence in the banks and bed (less than two percent of the reach length).

Use the habitat survey stream morphology data card (22.5 – Exhibit 01) to record morphology data for each of the four survey tiers, and to record fish migration barrier information.

22.6 – Record Fish Presence/Absence

Note fish presence by species (direct observation), and record information on fish migration barriers on the stream morphology data card (22.5 – Exhibit 01).

The adult salmonid migration blockage table (22.6 – Exhibit 01) provides a guide for suspected but unconfirmed fish barriers. The State of Alaska Science and Technology Committee used a variety of sources to develop the table, including field observations and controlled studies. Unless there is evidence to the contrary, observers may presume that a fish migration blockage occurs for a given species when physical conditions exceed the criteria on the table. . Physical measurements on suspected juvenile (Hunter and Leslie 1986) or adult migration barriers are recorded in the space provided on the stream morphology data card (22.5 – Exhibit 01). Measurements include the type of barrier, maximum height, maximum pool depth, and gradient.

22.6 – Exhibit 01
Adult Salmonid Migration Blockage Table

	Species					
Criterion	**Coho**	**Steelhead**	**Sockeye**	**Chinook**	**Pink/Chum**	**Dolly Varden**
Max. Fall height A blockage may be presumed if fall height exceeds:	11 feet (3.35m)	13 feet (3.96m)	10 feet (3.05 m)	11 feet (3.35 m)	a) 4 feet (1.22 m) with deep plunge pools not flooded at high tide. b) 3 feet (0.91m) without pools.	6 feet (1.83m)
Pool depth A blockage may be presumed if pool depth is less than the following, and the pool is unobstructed by boulders or be bedrock:	1.25 x jump height, except that there is no minimum pool depth for falls: (a)<4 feet (1.2,) in the case of coho and steelhead; and (b)<2 feet (0.6m) in the case of other anadromous fish species.					
Steep channel A blockage may be presumed if channel steepness is greater than the following without resting places for fish:	>225 feet (68.6m) @ 12% gradient >100 feet (30.5m) @ 16% gradient >50 feet (15.2m) @ 20% gradient				>100 feet (30.5m) @ 9% gradient	>50 feet (15.2m) @ 30% gradient

To determine waterfall height, measure the additive height of falls only if there is no resting pool between them.

22.7 – Reference Point Data to a Latitude/Longitude Identifier (optional)

Survey reference points and special features associated with lakes and streams should have coordinates established either from GPS or the ArcView latitude/longitude extension. Once NHD routed hydrography is completed, a unique address for spatial location will be created automatically thorough the ArcView interface in the NRIS water module.

23 – TIER TWO SURVEY

The Tier Two survey was designed to provide consistent, quantitative estimates of habitat parameters necessary to evaluate the condition of a stream relative to forest riparian habitat management objectives (RHMO). The Tier Two survey protocol identifies variables that can be measured efficiently by a two-person survey crew. Habitat units are defined and discrete categories established to minimize observer bias, reduce measurement error, and enable replication and comparison of data across time and space. These habitat objectives will help define the natural variation for key indices of channel condition and fish habitat, and are the basis for describing the desired condition of healthy, fully functioning stream ecosystems.

The Tier Two survey includes the following measurements, explained in detail below:

1. Channel Morphology Measurements
2. Stream Survey
    a. Record GPS coordinates of starting and end survey point
    b. Length
    c. Channel Bed Width (measured at a distance of every fifth approximate average channel bed width)
    d. Pool Count
    e. Beaver Pond Area
3. Large Wood
4. Disturbance
5. Stream Buffer
6. Side Channel
7. Fish presence by species and Migration Barrier

23.1 – Channel Morphology Measurements

Conduct a minimum of one channel morphology survey per channel type. Channel types generally should be classified to a minimum length of 100 meters. Record:

1. Hip chain station (distance) relative to a known geographical point
2. Channel incision depth*
3. Entrenchment ratio (optional calculated)*
4. Flood-prone width (optional)*
5. Bankfull width*
6. Average channel bed width (to scale macro pool and key piece wood counts at beginning of each survey segment)
7. Bankfull depth (mean and maximum)*
8. Channel gradient (measured at the water surface)*
9. Channel pattern
10. Channel sinuosity*
11. Channel substrate*
12. Stream discharge estimate (optional)

* National core attribute for aquatic habitat inventory

There is tremendous complexity and geomorphic variability among and within forested streams (Woodsmith and Buffington 1996). Discharge, gradient, topography, geologic control, glacial influence, and substrate are just a few factors that influence the stream channel. Measurement error can compound the difficulty of accounting for natural variability. The channel morphology measurements adopted for the survey protocol, and recorded on the stream morphology data card shown in 22.5 – Exhibit 01, consume more time but yield more precise data than visual estimates. Careful stratification of reach map units into channel types (Maxwell et al. 1995 and Paustian et al. 1992), and identification and isolation of physical anomalies, will reduce between stream variation and improve the power to detect statistically significant differences between groups of streams when in fact a difference exists (Coghill 1996). Any survey data added to the regional database must be assigned to a channel type.

Although the channel type classification system uses discrete categories to describe average stream morphology, streams occur along a continuum, and may exhibit overlap in parameter values (Rosgen 1996). One or more morphological characteristics used to classify channels may overlap the normal range of two discrete channel types. How then do you classify channels with a morphological variable that overlaps channel types (that is, at the tail of the range of distribution)? As a rule-of-thumb, the highest value habitat and most sensitive management areas should receive preference when assigning channel type in the streams database (23.1 – Exhibit 01).

The flood plain, estuarine and palustrine channel types have very high ecological values. These types, and alluvial fans having high sensitivity to management activities should be mapped as accurately as possible. A channel that is a mixture of process groups, or transitional between process groups should be assigned to the more variable (less homogenous) category. Channels may include short sections that differ from habitat upstream or downstream. Survey objectives and the extent of the anomaly should be considered to determine if such inclusions should be mapped as a separate channel types. The channel type mapping resolution is usually a minimum segment length of 100 meters.

Criteria used to define stream reaches and compare between valley segment or reach level stream classes include sinuosity, channel entrenchment, bankfull channel width, stream gradient, channel pattern, and substrate particle size distribution. Measure these geomorphic parameters at a minimum rate of one location per mapped channel type. Additional sites may be needed to capture variability. Conduct morphology measurements at least every 1,000 meters when a single channel type covers a very long segment of stream.

As a Tier Two survey progresses upstream, new channel types may be encountered. To stratify correctly, you must identify and distinguish actual channel type transitions and breaks from small inclusions. The Alaska Region channel type key 22.1 – Exhibit 01 provides an overview of the channel types. Paustian et al. (1992) provides a very detailed description and photographs of each channel type. The *Channel Type Field Key of the Tongass National Forest* is a good field reference for channel type identification and classification.

All of the measurements listed below must be taken and recorded separately at each channel morphology survey site.

<u>23.1 – Exhibit 01</u>
<u>Channel Type Process Group Homogeneity From Most to Least Homogenous.</u>

Flood Plain, Estuary and Palustrine > Alluvial Fan, Glacial Outwash and Low Gradient Contained > Moderate Gradient–Mixed Containment, Moderate Gradient Contained, and High Gradient Contained

23.11 – Channel Incision Depth

Record the incision depth (in meters) for the left and right bank. Record left and right bank side-slope length (in meters) and side-slope angle. [Note: This measurement is optional for low relief landforms.]

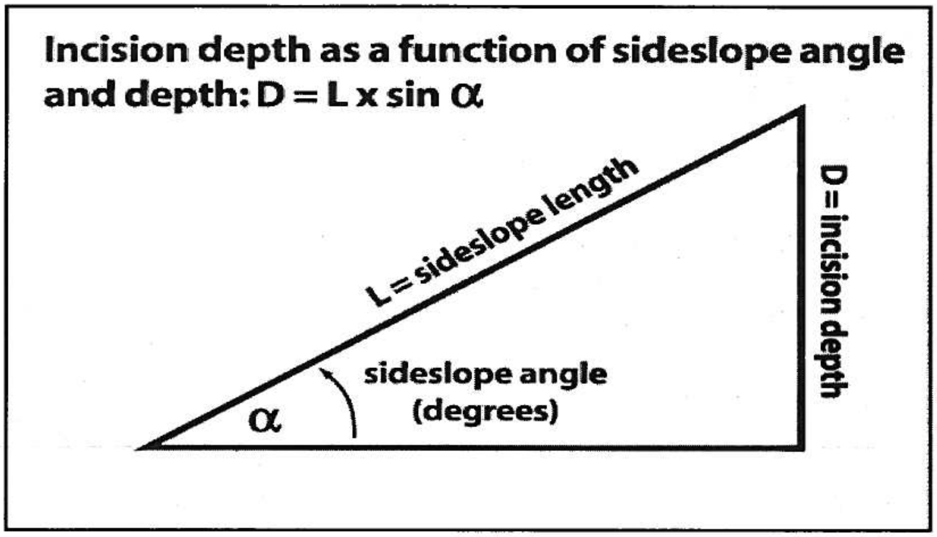
Incision depth together with entrenchment ratio describes the degree of channel confinement and containment. These attributes measure the ability of the stream channel to contain large flow events within the channel area. They also indicate the limits of fish distribution within the drainage because tributaries to steeply incised channels often have waterfalls that are barriers to fish passage. Channel containment influences stream energy, and hence transport and storage of sediment and large wood. Streambank erosion, mass wasting, and shallow wasting potential are influenced by entrenchment. Incision depth, the metric used for channel entrenchment, is the vertical distance (meters) between the first landform slope break above bankfull stage and the channel bottom at the thalweg. If the streambanks are asymmetrical, base the incision depth on the steeper or longer slope, whichever is most likely to influence water quality. Two methods are provided on the stream morphology data card (22.5 – Exhibit 01) to record this parameter within the appropriate range. The depth of incision could be measured or classified into one of several ranges. Incision depth as a function of side-slope angle and length are shown in 23.11 – Exhibits 01 and 02, which can be measured to derive the incision depth from trigonometrically.

Calculations for many commonly encountered combinations of slope length and angle are provided in an incision depth chart (22.55 – Exhibit 01).

The side-slope length and angle, used to calculate incision depth, also describes the potential for sediment and debris recruitment from the landforms immediately adjacent to a channel. These landforms are measured along the slope distance using a clinometer and hip-chain or laser range finder, perpendicular to a representative portion of the sample channel type. Survey objectives should dictate which method is used. Estimation is quicker, but is increasingly difficult to accurately gauge side-slope characteristics as the channel entrenchment increases. A record of side-slope length and angle with derived incision depth provides useful information when classifying streams, evaluating slope stability risk, or designing road crossing and drainage structures.

These typical cross section profiles (23.11 – Exhibit 02) show the relationship between depth and flood-prone width for shallow and deep channel entrenchment. Incision depth can be calculated if the side-slope angle and side-slope length are known.

23.11 – Exhibit 01
Incision Depth as a Function of Side-slope Angle and Length



23.11 – EXHIBIT02 IS A SEPARATE DOCUMENT

23.12 – Entrenchment Ratio

Entrenchment ratio is used to describe the degree to which floods are contained by the channel. The ratio is the flood-prone width divided by the bankfull channel width (Rosgen 1994). Flood-prone width is measured at an elevation of two times the maximum bankfull depth, using a level or clinometer, stadia rod and metric tape. This measurement can be difficult to obtain when the side-slope angle is low, particularly when vegetation obscures the rod. If the flood-prone distance on one bank exceeds the bankfull width, you may optionally record the flood-prone distance as greater than 2.5 times the bankfull width. The exception may be asymmetrical channel profiles. The flood-prone width is an approximation of the 50-year flood plain width (Rosgen 1996). This coincides with design criteria for Alaska Region system roads as discussed in BMP 14.17, bridge and culvert design and installation (USDA 1996a).

23.13 – Bankfull Stream Width and Depth

Record bankfull channel width (meters) measured with a surveyor's tape strung across the channel perpendicular to the streambank.

Bankfull stream width (m) is the distance from bank-to-bank at the elevation of bankfull flow (Dunne and Leopold 1978). Rosgen (1996) comprehensively discusses field procedures to determine bankfull stage. The WinXSPRO (USDA 1996b) software package may be used to graphically display the bankfull point (22.52 – Exhibit 01), obtain stage discharge estimates, and generate channel summary statistics such as the dimensionless bankfull channel width-to-depth ratio.

Channel cross section sites should occur at riffle sections. Select a straight and narrow section of riffle, free of undercut banks and obstructions such as large woody debris accumulations. The tape should be stretched across the channel to a point well beyond the bankfull point. The objective is to capture not only the bankfull stage, but also the lower angle. On wide channels, a stadia rod and survey instrument should be used to obtain accurate measurements. On narrow channels, it may be possible to obtain accurate measurements by measuring from the stream bottom to a tape stretched parallel to the water surface. Clinometers or hand levels should be checked for accuracy before use since errors in calibration are common.

Depth and distance measurements should be made from the left bank to right bank facing downstream (23.18a – Exhibit 02), and include the following locations:

Left bank pin - LBP	Right edge of water - REW
Left bankfull - LBF	Bottom of right bank - BRB
Top left bank - TLB	Top right bank - TRB
Bottom of left bank -	BLB Right bankfull - RBF
Left edge of water - LEW	Right bank pin - RBP
Thalweg - T*	

*The thalweg is the deepest section of the channel.

20 percent distance intervals from BLB to BRB

Bankfull mean depth is cross-sectional area divided by channel width. This value is approximated by summing the depths then dividing the sum of the depth by (n + 1), where n is the number of measurements. The (n + 1) divisor incorporates the edges of the channel that have zero depth. Mean depths computed by dividing by n are greater that the true correctly computed mean depth (crosssectional area/width). Mean depth computed by dividing by n + 1 are also greater than the true computed mean depth, but the difference between the true and the n + 1 divided mean depth result tends to be reduced with an increased number of depth measurements (Platts et al. 1983). Measure at least 10 equally spaced depth measurements between the LBF and RBF in place of making additional depth measurements at significant changes in slope features for irregular channels.

From the cross-sectional profile several other parameters can be derived: bankfull maximum depth, bankfull width-to-maximum depth ratio, wetted width-to-depth ratio, bankfull width-to-average depth ratio, and channel bed width.

23.14 – Average Channel Bed Width

Channel bed width is independent of the current water level, and equates to the distance between the bottom-of-the-left-bank (BLB) and bottom-of-the-right-bank (BRB) (23.18a – Exhibit 02). The bottom-of-bank should be identified on the basis of channel geometry whenever possible. Some rules of thumb can help in identifying the edge of the channel bed in an alluvial channel when bed and bank gradually blend (Woodsmith 1999):

1. "Bed" means the active streambed.

2. The stream channel bed is the site of temporary storage of active bedload sediment, transported by ordinary streamflow of sufficient magnitude. In contrast, streambank material commonly consists of soil, rock, roots and other vegetation with stronger cohesive forces. This contrast can be used to identify the break between channel bed and banks.

3. There is usually a break in slope at the edge of the bed, where the bed ends and the streambank begins. This is the bottom-of-bank, BLB to BRB (23.18a – Exhibit 02).

4. There is usually a break in slope at the top-of-bank, where the bank ends and the floodplain or side slope begins.

5. The break between established vegetation and the active bed material usually occurs between the bottom and top of bank.

The qualifying size for key pieces of large wood and macro pools changes with channel size. In order to count key piece wood or macro pools, an approximate average channel bed width must be determined and recorded prior to surveying each stream segment. Calculation of approximate average channel bed width begins with an initial measurement near the beginning of the survey segment followed by two additional width measurements (upstream and downstream respectively from the initial one), at distances of 5 times the width of the initial measurement. The initial measurement should be taken far enough upstream such that the downstream measurement fits within the survey segment. Record the average of the three measurements as an approximate channel bed width, and use that figure to scale macro pool and key piece wood counts.

Average channel bed width over the length of the stream segment is derived from channel bed width measurements taken at distance intervals equal to 5 times the approximate channel bed width. For example, if the approximate channel bed width averaged 10 meters, record the measured channel bed width (to the nearest 0.5 meters) at 50-meter intervals. At meander point bars, where the break in slope from bottom to top of bank is not apparent, measure the edge of the channel bed at the margin of established vegetation.

23.15 – Channel Gradient

Measure at the water surface and record to nearest 0.5 percent slope.

Channel gradient (reach gradient) is the change in water surface elevation between end points of a channel segment. Measure the reach gradient using a survey level, tape and stadia rod over at least 20 channel widths to approximate water surface slope near bankfull stage. When measuring slope over shorter distances, bankfull slope can be approximated by measuring the slope from one distinct channel feature to a similar one upstream, such as from the top of a riffle to the top of the next riffle.

Slope is a very sensitive parameter, especially when applied to Manning's equation. Therefore, slope should be recorded to three significant digits (0.001 as a dimensionless units, or 0.1 percent).

23.16 – Stream Channel Pattern

Record the prevalent channel pattern for the channel segment as single or multiple.

The stream morphology data card (22.5 – Exhibit 01) contains fields to record stream channel pattern as single or multiple. For large streams, channel pattern can be derived from an air photo. When combined with observations on channel morphology (that is, gradient, substrate, width/depth ratio), channel pattern provides insights on sediment regime, flood plain condition, and channel stability.

A single pattern stream has only one channel. A multiple pattern stream has more than one channel. Multiple channel patterns include streams that divide into two or more distinct channels that do not reconnect to the original channel (for example, Alluvial Fan process group), and multiple interlaced channels that are separated by bars (for example, Flood Plain and Glacial Outwash process groups).

Multiple channels, such as the flood plain (FP5) segment of the Katlian River shown in 23.16 – Exhibit 01, are complex systems. Habitats are complex, including vegetated and unvegetated bars along the main channel and several large secondary channels or side channels. All habitat units should be recorded for any given segment of channel surveyed. Arbitrarily ignoring habitat within a side channel, however insignificant relative to the whole channel segment, will bias the sample.

The width and length of side channels and separating channels are factors that affect data recording procedures. Data from habitat units that are separated by short bars (for example, small islets) or short diversions around debris jams within the bankfull width of the channel should be lumped with the larger channel. Data for side channels should be kept separate from data attributed to main channels. To reiterate, the minimum qualifying sizes of macro pools and key pieces of wood must be scaled to the average channel bed width of the channel or side channel in which they are located.

23.16 – EXHIBIT01 IS A SEPARATE DOCUMENT

23.17 – Channel Sinuosity

Channel sinuosity is a dimensionless ratio between the channel thalweg length and the valley floor length. Channel sinuosity provides an indication of how the stream channel maintains a balance between sediment load and discharge. Highly sinuous channels dissipate energy along the streambanks. Low sinuous channels have higher bedload transport.

Channel length is the distance between the start and endpoint of the channel segment measured with a hip chain along the stream thalweg. Valley floor length is defined as the straight-line distance between the start and end of the segment measured on an orthophoto. Straight channels are defined as having sinuosity less than 1.5, and are often influenced by structural controls that limit lateral bank erosion. Meandering channels are sinuous, and have a ratio of channel length to valley length of 1.5 or greater (Leopold et al. 1964). Meandering channels may have regular or irregular meander bends, and are generally alluvial channels.

23.18 – Substrate

The objectives of the pebble count are to characterize the bed material within a riffle section through a particle size class analysis. Substrate data are used for:

1. Channel type classification.
2. Characterization of the natural range of variability for substrate material within channel types.
3. Indirect index of the channel roughness, stream velocity, and power.
4. Indicator of biological productivity/diversity.
5. Monitoring indicator, particularly percent fines.

23.18a – Sampling Procedure

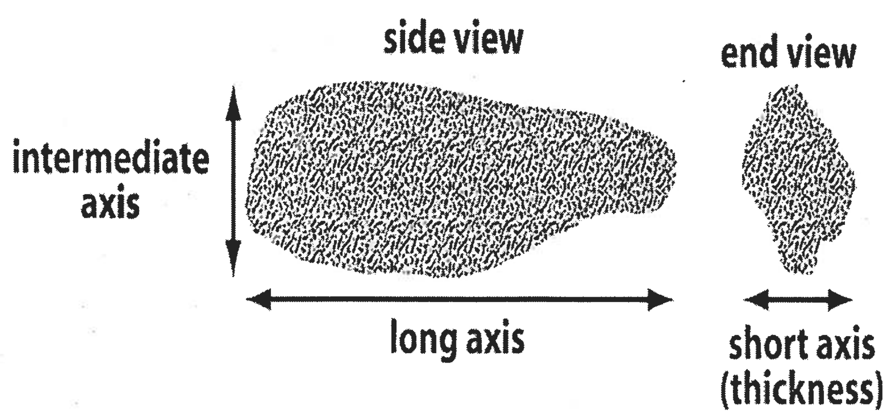
Streambed materials are characterized by a pebble count (Wolman 1954), which consists of a random selection and measurement of particles from the streambed. A point at the boot-tip is used to locate and select individual particles encountered along a transect (23.18a – Exhibit 01). Two sources of observer bias can significantly influence data precision and repeatability: (1) biased selection by particle size, and (2) errors in measurement of particles (Marcus et al. 1995). The tendency is to select larger rocks. To minimize this source of error, observers should point to the substrate directly in front of a mark at the tip of their boot, objectively selecting the first particle that touches the tip of the index finger. Consistent measurement of particles is assured by the use of calipers or gravel templates. The use of gravel templates is recommended for classifying each sampled particle into a size class. However, if calipers are used, measurements should be taken along the intermediate axis (23.18a – Exhibit 01). Measure the length of streambed particles along the intermediate axis. The intermediate axis of the substrate particle equates to the controlling size for sieved particles.

Establish 5 pebble count transects at each morphology survey site. Take 20 boot-tip samples along each transect for a total of 100 particle samples. Transects should be perpendicular to the stream (parallel to the cross section), and extend across the channel bed to the point coinciding with the bottom-of-bank, BLB and BRB (23.18a – Exhibit 02). One transect should be along the taped cross section. Two transects should be made upstream from the tape, and two transects downstream from the tape. If the riffle is large enough, transects should be located in 5 meters increments away from the tape. The objective is to sample proportionately across the entire channel bed (not just the wetted bottom), and to capture within-site variability along the longitudinal profile.

In general, pebbles should be selected at a uniformly spaced interval obtained by dividing the measured channel bed width by 5 to determine the distance between samples. Some latitude is allowed in spacings so that each particle is independent of the previous one to avoid problems with serial correlation. Serial correlation can be avoided by establishing a sampling interval that is at least as far apart as the largest dominant size of material in the reach (something around the d95 size, that is, not necessarily the largest rocks found in the section). Avoid measuring individual particles more than once, and have individual particles far enough apart so as not to influence each other. Reaches with bedrock will often violate this guideline.

Substrate sample measurements are made along the intermediate axis of the substrate particle (23.18a – Exhibit 01), and particles are classified and tallied within one of twelve size classes on the morphology data card (22.5 – Exhibit 01). Alternatively, individual substrate particle measurements may be recorded to the nearest millimeter.

23.18a – Exhibit 01
Substrate Sample Measurements



23.18a – EXHIBIT02 IS A SEPARATE DOCUMENT

23.18b – Particle Size Analysis

Sediment particle size data can be plotted to develop a particle size distribution curve (23.18b – Exhibits 01 and 02). The median particle size "d50" is the diameter where 50 percent of the substrate sample size distribution is finer, and 50 percent coarser. The d50 is useful for modeling sediment transport and the transport capacity of the channel (Knighton 1987). The d50 metric also provides some insight into the biological capability of that stream. Channels dominated by d50 that correspond to sands or silts generally have a lower diversity of aquatic macroinvertebrates. Fine sediments tend to have lower productivity of salmonids unless an abundance of macrophytes are present. Shifting sands afford poor food conditions and attachment sites for aquatic invertebrates (Merritt and Cummins 1996). Fissures and interstitial spaces in the substrate may provide rearing habitats for insects and small fish.

The "d84" is used in WinXSPRO stage discharge estimates as an indirect indicator of channel roughness. To quickly determine the d50 and d84 values, draw a line from the 50 and 84 percent cumulative frequency distributions on the Y-axis line to the plotted cumulative frequency curve. At the intersection, draw another down to the substrate class on the X-axis (23.18b – Exhibit 02). Interpolate if the lines fall between two size classes, and use the median value for that size class.

Surface particle size data can provide an assessment of the impacts of management-related disturbances. Differences between disturbed and undisturbed areas may be traced back to sediment sources such as eroding banks, road fill failures, timber harvest-initiated landslides and debris torrents, or mine tailings. Statistically significant changes to the d50 size, a measure of central tendency, using standard statistics are difficult to demonstrate partly due to the naturally large range of sizes included in the distribution. Furthermore, most management-related sediment issues are related to introduction of fine sediment into streams. A change in the percentage of a selected reference size (for example, less than 4 mm) has been shown to be a more sensitive measure of changes to substrate composition than measures of central tendency. Changes to the percent reference size can be analyzed using contingency tables and the Chi-square statistic (King and Potyondy 1993).

Repeated measurements of particle size distributions through time can reveal changes and effects influenced by land management activities. For example, if the substrate size distribution at a particular section decreases through time, a review of activities in the watershed may indicate a correlation with a road failure located upstream. Similarly, a heavy accumulation of logging slash may trap fine sediments and lead to changes in substrate characteristics.

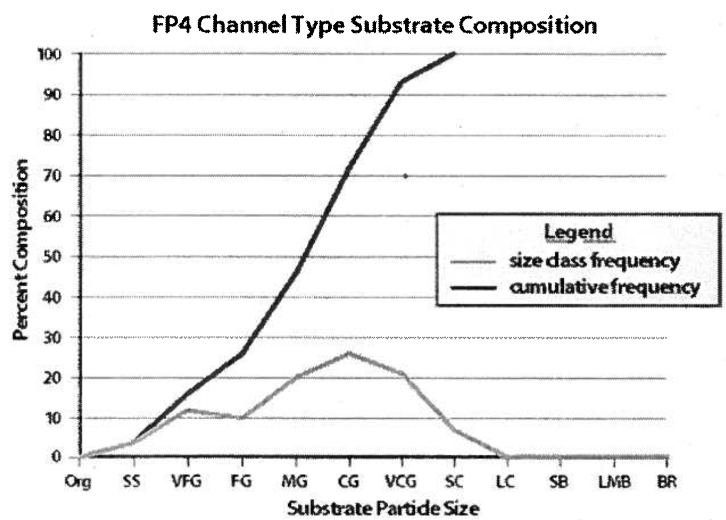
23.18b – Exhibit 01

Example of Substrate Composition Data from a Flood Plain Channel (FP4)

Substrate	Code	Size Class	% Composition
Organic	ORG	Organic	0
Sand/Silt	SS	< 2mm	4
Very Fine Gravel	VFG	2-3.9mm	12
Fine Gravel	FGR	4-7.9mm	10
Medium Gravel	MGR	8-15.9mm	20
Coarse Gravel	CGR	16-31.9mm	26
Very Coarse Gravel	VCG	32-63.9mm	21
Small Cobble	SC	64-127.9mm	7
Large Cobble	LC	128-255.9mm	0
Small Boulder	SB	256-512mm	0
Lg/Med Boulder	LMB	>512 mm	0
Bedrock	BR	Bedrock	0

23.18b – Exhibit 02

Frequency Distribution for Substrate Composition Data
Collected at a Morphology Site in a Flood Plain Channel Type (FP4)



23.19 – Discharge Estimate (optional for Tiers Two and Three)

Discharge can be measured directly or derived from channel morphology measurements (for example, stream gradient, cross section, and particle size). The precision of the indirect method (WinXSPRO Analyzer), sensitive to channel conditions, is best suited for streams with uniform flow.

Direct discharge measurement by the float method (Harrelson et al. 1994).

1. Measure and mark two points, two to three channel widths apart near the cross section.

2. Toss a float into the channel and record the time required to travel the measured distance.

3. Repeat the procedure several times at different distances from the bank to get an average surface velocity.

4. Multiply the average by 0.85 to calculate a mean velocity, then multiply the mean velocity by the cross-sectional area to calculate discharge ($Q = V * A$).

For measurements requiring greater accuracy, surveyors should follow the techniques outlined in *Discharge Measurements at Gaging Stations* (Buchanan and Somers 1969). Floats should be dense and float at least halfway under the surface of the water so as to be transported by the current, but unaffected by wind yet still visible at the surface.

The indirect method uses the WinXSPRO Channel Cross Section Analyzer. The program can be used to calculate discharge estimates for different stages using data collected for the morphology surveys. Accuracy of the analysis depends upon the stream reach conditions. Marked changes in channel geometry and discontinuities in flow (that is, steps, falls, hydraulic jumps, pools and backwaters) should be avoided.

23.2 – Stream Survey

23.21 – Length of Stream Surveyed

Record the length of stream surveyed for each channel type.

For each habitat survey, record the length of stream surveyed for each channel type. Evaluations of habitat quality will be based on the number of pools and of pieces of large wood per unit length of stream. It is generally not possible to sum all the habitat units to determine survey length. Habitat units often lie parallel within a length of stream, not in a strictly linear arrangement. Consequently, summing the unit lengths can greatly over-estimate the survey length. During the survey, run a hip chain up the center line of the channel (midway between the banks) to keep track of the distance of stream covered by the survey.

23.22 – Channel Bed Width

Record channel bed width measured at a distance of every fifth approximate average channel bed width (see section 23.13 – Average Channel Bed Width).

23.23 – Pool Count and Record of Residual Depth

Record the number of macro pools per channel type and record the maximum pool depth and pool tail crest depth of each qualifying macro pool.

Three criteria must be met before a habitat unit can be recorded as a macro pool. Habitat units that meet all three criteria, including beaver ponds, must be counted as macro pools, even if they don't "look" like what the surveyor considers to be a pool. By adhering to these rules, pool counts will be more consistent and repeatable. The criteria that define macro pools are described as follows:

1. Residual Pool Depth. Residual pool depth equals the maximum depth minus the pool tail crest depth, which is the depth of water over the hydraulic control. The depth at the pool tail crest is taken at the deepest point where the water surface slope breaks into the downstream riffle, or plunges to a pool below the upstream pool (23.23a – Exhibit 01).

2. Minimum Pool Length or Width. Macro pools must meet minimum size criteria relative to the channel size. The channel bed width is used to determine macro pool qualifying dimensions. Average channel bed width is estimated at the beginning of each stream survey segment and used as a standard measure throughout that segment.

3. Hydraulic Control. Hydraulic control is a channel feature that controls the depth of a stream at a habitat unit for a given range of discharges. Examples might include the pool tail crest, a log, or a boulder.

23.23a – Residual Pool Depth

The concept of residual pool depth, originally described by Bathurst (1981), is a method of measuring pool depth independently of discharge. Pool morphology and measurement of residual depth were explained in *Monitoring Protocol for the Upper Columbia River Basin* (Chen 1994):

> **A pool begins where there is a noticeable change in bed elevation caused by the pool-forming element(s). The head of a pool is defined as the location where the effect of scour creates a change in bed elevation resulting in increased depth. Downstream of the scour, hydraulic forces decline so that deposition occurs, and the bed elevation slopes upward. The pool then enters a shallow, sometimes long, pool tail area with a more gradual bed slope. The pool ends at the pool tail crest…where the bed elevation is greatest (that is, shallowest depth)…**
>
> **…Determination of residual depth requires a measurement of maximum pool depth and the pool tail crest depth. The pool thalweg (defined as the longitudinal axis that follows the deepest contour of the pool) is first located. Surface-to-bottom depth measurements are taken along the thalweg with a graduated rod and the greatest depth is recorded as the maximum depth. The pool tail crest depth is determined by locating the tail crest…and then measuring the surface-to-bottom depth at this point.…**
>
> **To calculate the residual depth for a pool, the pool tail crest depth is subtracted from the maximum depth. The residual depth represents the hypothetical depth of the pool if flow was reduced so that the stream became a series of standing, nonconnected pools…**

The relative importance of different sized pools depends on the size of stream in which they are located. For example, a pool with residual depth of 17 centimeters may be important fish habitat in a stream 2 meters wide. However, in a stream 30 meters wide, this pool would be insignificant. Therefore, minimum residual pool depth is scaled to channel width using a formula adopted from the Washington Forest Practices Board (1993).

((Average Channel Bed Width)*(0.01)) + 0.15 meters = Minimum Residual Pool Depth

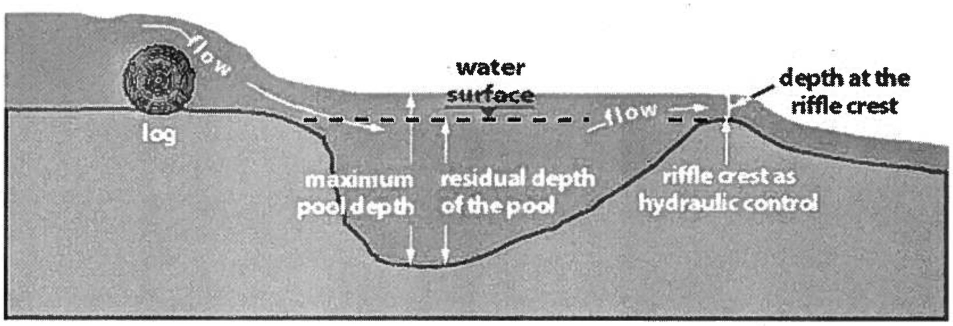
A pool to qualifies as a macro pool if it equals or exceeds the minimum residual depth. Record the average channel bed width and corresponding residual pool depth, established as the minimum qualifying depth, for use in identifying macro pools.

Residual pool depth is equal to the difference between the pool's maximum water depth and the pool tail crest water depth (23.23a – Exhibit 01). Because residual depth is independent of stream stage, measurements taken in a given pool at both high and low flows will yield the same residual depth.

In some cases, it will not be possible to measure the water depth at the pool tail (for example, debris jams or beaver dams where multiple pieces of wood or debris function as the hydraulic control). Some Palustrine channels, characterized by long, low velocity troughs, may also have no discernible hydraulic control. In these cases, count the habitat unit as a pool if minimum residual depth and area standards are met.

23.23a – Exhibit 01
Residual Pool Depth

$$\text{Residual pool depth} = \left(\text{Maximum pool depth}\right) - \left(\text{Depth at the riffle crest}\right)$$



23.23b – Minimum Pool Length or Width

The minimum pool length or width must be greater than or equal to 10 percent of the average channel bed width to prevent inclusion of numerous pool-like depressions formed by localized scour (Woodsmith and Buffington 1996). Smaller habitat units do not qualify as a macro pool.

Macro pool length or width = 0.10 * average channel bed width

23.23c – Hydraulic Control

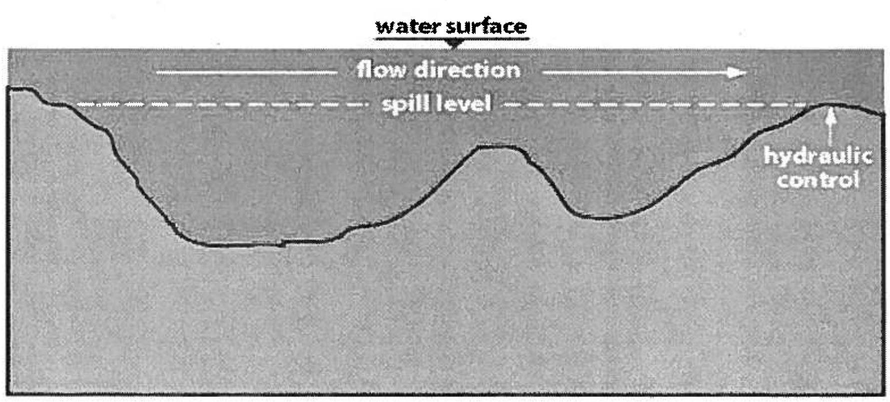
The hydraulic control of a pool can be understood by envisioning the water shut-off. Water would spill until level with the low point in the basin. The low point would be the pool tail crest, and would be the hydraulic control for that pool. The remaining wetted surface would be the residual pool area. Residual pool area is independent of flow stage. Uneven relief of the stream bottom can make it difficult to determine if irregular shaped basins are a single pool or two or more pools side-by-side. Basins that share the same hydraulic control should be counted as a single macro pool. If adjoining pools each have their own hydraulic control, they must be counted as individual macro pools (provided they meet minimum criteria for residual depth and dimension). An example of a hydraulic control is shown in 23.23c – Exhibit 01 (Lisle 1987).

To find the hydraulic control (pool tail crest), start at the deepest part of the pool and follow the thalweg downstream. Take spot measurements to determine the deepest point in the pool and the depth at the pool tail crest. Look not only for the shallowest point, but also for transitions in surface flow conditions (for example, tranquil to turbulent). A change in gradient can also indicate the pool tail crest. In very low gradient channels, a hand level may be needed to distinguish between more than one possible tail.

There may be ridges or high spots in the bed of a pool. Take care to distinguish those ridges from a true tail crest. Calculate residual pool depth between the deepest point and the ridge. If the calculated residual depth is great enough to qualify the unit as a pool, then that lump may or may not be the pool tail crest. In 23.23c – Exhibit 01, it may appear reasonable to identify the mid-pool high spot as a pool tail crest and to conclude that the picture depicts two pools. To test whether this is correct, consider whether the two proposed pools each have their own hydraulic control, or if they share a single control. If they each have their own hydraulic control, then they must be counted as two pools (providing they each meet the criteria of minimum residual pool depth and minimum pool area). If they both share the same hydraulic control, then they must be lumped together as a single large pool.

Make the final determination of the hydraulic control by picturing what would happen if stream discharge were reduced. Remember that the pool tail crest (hydraulic control) is where water flows out of the pool. As the water level goes down, the pool tail crest should be the last place still connecting the pool to the rest of the stream before the water drops so low that the pool becomes an isolated basin. Looking again at the example (23.23c – Exhibit 01), you will see that as the water level drops, the hydraulic control becomes exposed before the mid-pool high point. There is a single hydraulic control for the entire unit. Consequently, this should be recorded as one pool.

23.23c – Exhibit 01
Longitudinal Profile of a Pool With One Hydraulic Control

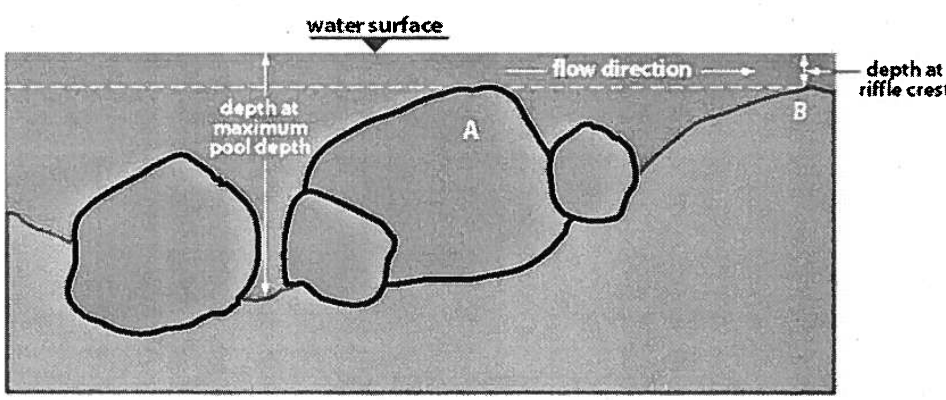


23.23d – Boulders in Pools

A special case occurs when a pool contains large boulders (23.23d – Exhibit 01). In some circumstances, it may appear that the shallow point over the boulders is the pool tail crest. To determine whether or not these shallow spots constitute a true pool tail crest, envision what would happen if the stream surface level decreased. The pool tail crest should be the last place still connecting the pool to the rest of the stream before the water drops so low that the pool becomes an isolated basin. If the water receded, would the boulders resemble islands? Or, would they become part of the perimeter of the basin? If they become islands, they are not pool tail crests. If they become part of the perimeter, then they might be the pool tail crest, but only if they are the final connection to the rest of the stream. Scour or irregular shapes around the base of the boulders often leave channels for water to flow downstream, even though the top of the boulders may be shallower than the pool tail crest depth.

Boulders or logs within a pool may or may not be the hydraulic control. In 23.23d – Exhibit 01, if the boulder ponds water and functions as a basin perimeter, then it would form a pool with a tail crest at the top of boulder "A." If water could flow around the boulder, then the pool tail crest would be at the high point "B."

23.23d – Exhibit 01
Boulders or Logs Within a Pool



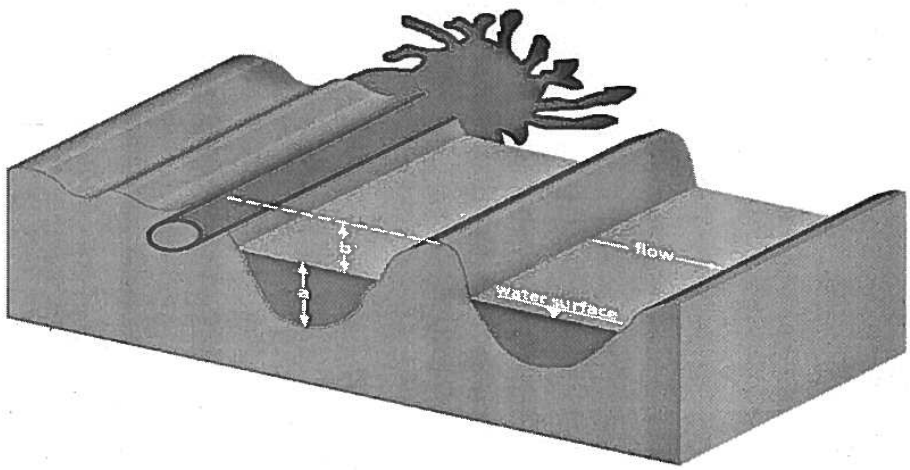
23.23e – Connected Pools

Sometimes a pool will appear longitudinally divided into two parallel pools separated by a shallow area (often sand or fine gravel). It can be difficult to determine if there is one big pool with a high point running down the center of it, or if it is actually two pools. If the water level dropped, would the pool be split down the middle forming two pools that are connected to the stream? Or, would it become isolated from the rest of the stream first, with the lump still under the water? If it first becomes split, then it is two pools and you should be able to locate two hydraulic controls. If it first becomes isolated, then it is only one pool and will have only one hydraulic control.

23.23f – Isolated Pools (no surface outflow)

Occasionally you will find a pool that is deep and big enough to qualify as a pool, but it will be isolated with no apparent surface flow connecting it to the rest of the stream. If it lies within the bankfull margins then it must be counted. The residual pool depth is still the elevation difference between the deepest point of the pool and the pool tail (23.23f – Exhibit 01).

23.23f – Exhibit 01
Isolated Pools



Isolated pools are unconnected to surface flow at the stage encountered. Determine residual pool depth by adding the depth at a, the deepest point of the pool, to b, the vertical distance from the pool tail crest to the water surface.

23.24 – Beaver Pond

Estimate the area of beaver ponds (average length times width in square meters) and record the location of beaver ponds as left bank, right bank, or main channel.

Beaver ponds are often large, complex, and difficult to circumnavigate. Use a tape or range finder to estimate the pond surface area. Include all ponds that would be connected to the stream during bankfull flow, and estimate the average length and width in meters. Do not include beaver dams built on flood terraces above the bankfull zone. For both main channels and side channels, record the location of beaver ponds as left bank, right bank, or main channel. Aerial photos should be used to supplement the beaver pond data obtained during surveys. In channels with a series of beaver ponds (for example, PA5), it is usually not possible to get an accurate count of LWD in either the pond or dam.

23.3 – Large Wood

For the Tier Two survey, count all pieces that meet minimum qualifying dimensions and that are within the bankfull width of the stream zones one and two (23.33 – Exhibit 01) such that the total count includes key pieces. Identify, and tally separately, how many of those qualifying pieces are key pieces (23.32 – Exhibit 01). Do not count wood in beaver ponds or dams.

23.31 – Minimum Qualifying Dimensions

Count all pieces of wood (including rootwads) that meet the following minimum dimensions:

Diameter = 0.1 meters (measured at widest point) and length = 1 meter

23.32 – Key Pieces of Large Wood

Large wood plays an important role in stabilizing banks, moderating the transport of sediments, providing cover, and in forming pools. The functional role of wood in a stream depends on its size relative to the size of the stream. In very large rivers, a small piece of wood does not stay in place as long as a big piece or a cluster of pieces, and is not likely to play as important a role in channel forming processes. Wood pieces that are large relative to the channel size have important geomorphic functions, and are termed key pieces. The minimum dimensions of key pieces are described for ranges of average channel bed width (23.32 – Exhibit 01).

When conducting the count of all qualifying pieces (that is, total pieces), do not count any piece of wood twice even if it spans more than one habitat unit, or zone, or also qualifies as a key piece stem and/or rootwad. Key pieces of wood simply represent a special subset of qualifying pieces. For Tier Two surveys, there should be two data fields: one to tally qualifying pieces of LWD, and one to tally qualifying key pieces. A single piece of large wood (for example, tree) may have both a rootwad and stem that meet minimum qualifying dimensions for key pieces. Tally such a tree as a single key piece.

Example: While surveying a stream, Fred Fishsqueezer encounters a spruce tree lying across the stream within zones one, two, three, and four. At least one meter of the tree lies within portions of two macro pools, a riffle, and a beaver pond. Fred uses professional judgment, and assigns the tree to one of the two pools. He does not include the tree in the other habitat units, since he has already counted it with the pool. The entire tree counts as a single LWD piece.

Fred's tree also qualifies as a key piece. Both the rootwad and stem exceed minimum qualifying dimensions for a key piece, but it is still tallied as a single key piece.

Large woody debris tallies provide a useful metric to describe stream habitat characteristics. Perhaps more important than the quantity of LWD, however, is the presence of large pieces to anchor accumulations that create complex habitat, and to interact with flow in channel formation. Long-term stability is a function of channel size and power, the shape and size of the wood, the proportion of wood that lies in the flood plain, orientation with respect to streamflow, and the degree to which the wood is anchored or bedded into the streambed or streambank (Bilby 1984). Bilby and Ward (1989) showed a strong positive relation between the length and diameter of stable debris and channel width. Stable wood pieces are assumed to provide persistent fish habitat. Such large stable wood is termed key pieces. Minimum key piece diameter and stem length dimensions are identified according to average channel bed width (23.32 – Exhibit 01). Murphy and Koski (1989) determined key piece dimensions for southeast Alaska.

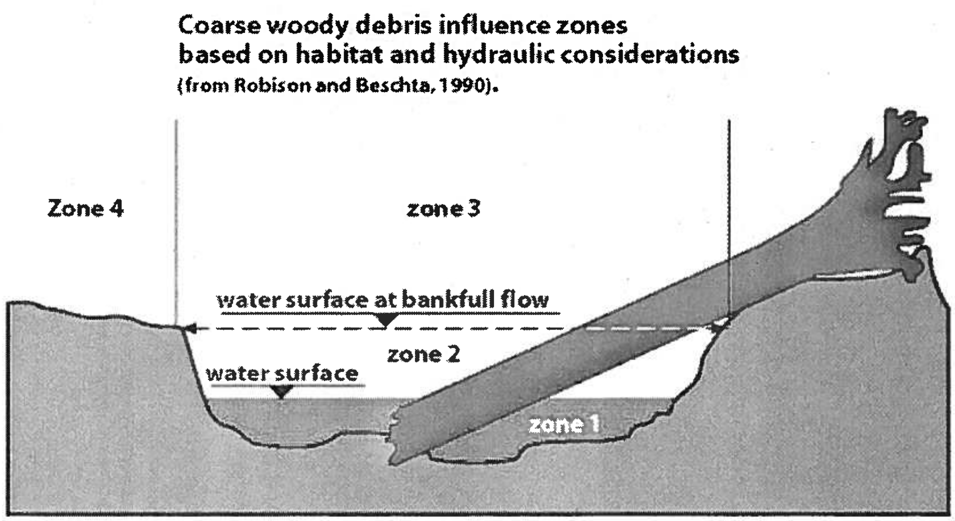
23.32 – Exhibit 01
Large Wood Key Piece Dimensions by Average Channel Bed Width

Average Channel Bed Width	Key Piece Diameter	Key Piece Stem Length	Rootwad Diameter
0-4.9 meters	0.3 meters	>3 meters	>1 meter
5-9.9 meters	0.3 meters	>7.6 meters	>3 meters
10-19.9 meters	0.6 meters	>7.6 meters	>3 meters
≥20 meters	0.6 meters	>15 meters	>3 meters

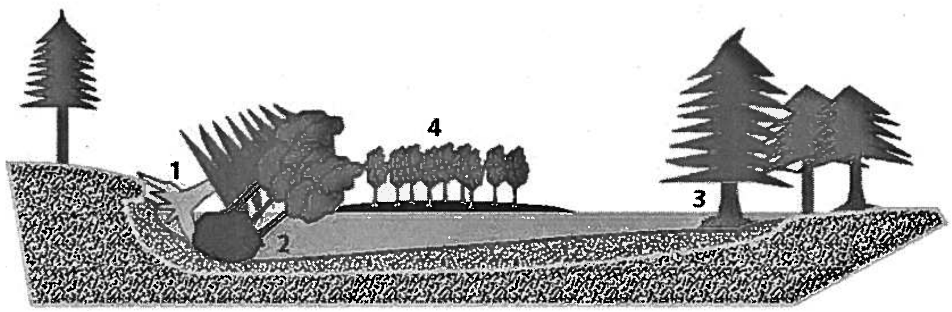
23.33 – Zones and Special Cases

There are four zones of influence for large woody debris (23.33 – Exhibit 01) (Robison and Beschta 1990). Zone one is within the wetted width. Zone two is the area within the bankfull width that is above wetted height and below the bankfull height. Zone three is the space within the bankfull width and above the bankfull height. Zone four is everything that occurs outside the bankfull width. All qualifying boles and rootwads with at least one meter within zones one or two must be counted (no matter how many zones the large wood occurs in, count as only one piece). All qualifying dead wood should be included in the count, regardless of orientation (that is, standing, down or leaning). Qualifying living trees may be included if they contribute to the formation of pools. That would normally not include Sitka alder branches that arch out over the water, red alder on vegetated bars, or trees on flood plains that may be swept by high flows, unless they contribute to pool formation (23.33 – Exhibit 02). Wood positioned within the bankfull width but elevated above the bankfull height is in zone three. Those pieces are normally not included in large wood counts unless 1 meter or more of that piece extends into zone two. The exception is for wood stacked in a pile from the streambed (as opposed to wood suspended from a bank). In cases where wood is stacked from the streambed, count all pieces including those with less than 1 meter within zone two.

23.33 – Exhibit 01
Large Wood Zones of Influence (Robison and Beschta, 1990)



23.33 – Exhibit 02
When Standing or Partially Standing Trees Qualify as Large Woody Debris



1. **Live tree on sloughing bank forming rootwad pool. Tally as LWD.**
2. **One or more live or dead trees with a single root wad mass. Consider each qualifying bole as a single piece to determine if a key piece.**
3. **Live standing tree with roots in active channel. Tally as LWD if rootwad pool is present.**
4. **Live or dead alder on vegetated bar. Not tallied as LWD.**

23.4 – Disturbance

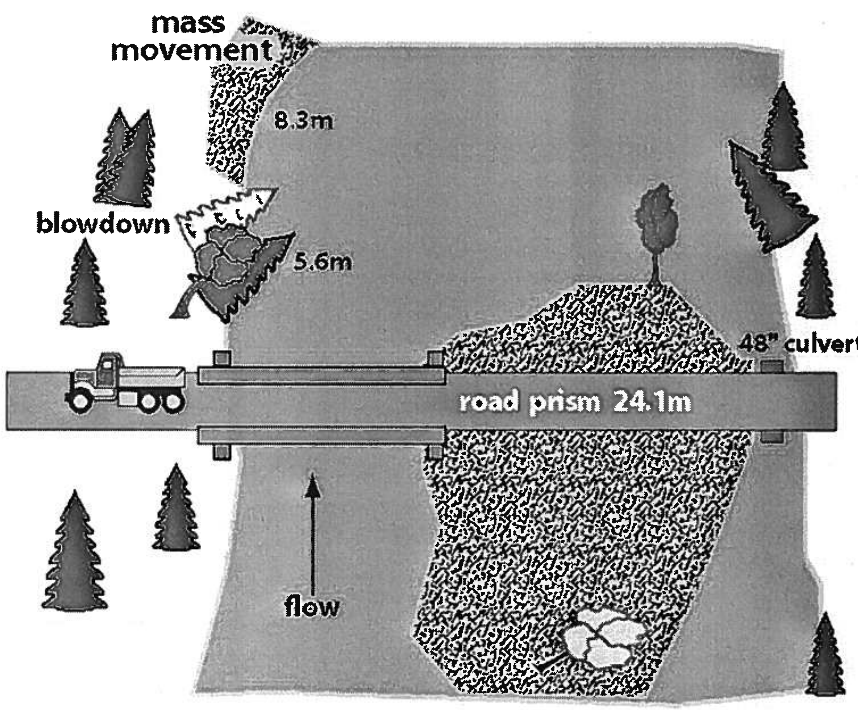
Measure and record the length and type of disturbed streambank and record the streambank location. The disturbance should originate at or above the bankfull elevation.

Streambank erosion is a key indicator of channel condition or stability. Stable banks maintain or help restore low width-to-depth ratios and provide favorable habitat for aquatic and riparian dependent wildlife. A change in the measure of disturbance to a streambank may indicate a shift in equilibrium within a stream, and trigger a more intensive search for the source.

For both the right and left banks, record the length of stream (in meters) that is disturbed and greater than 1 meter in length. Also record the type of disturbance. Only record the length of disturbance at the source (that is, do not estimate downstream impacts). For example, if the disturbance is blowdown or mass movement, it is likely that logs or sediment from the disturbance will be deposited along the bank downstream. Do not include this downstream area in your measurement. Roads should be within two channel bed widths and affect the stream if they are to be counted. Restrict the length of disturbance to those portions of the bank where the impact entered the stream (23.4 – Exhibit 01).

Measure and record the length and type of disturbed streambank and record the streambank location. Disturbance type may be identified as one of the following categories: mass movement (MM), road (RD), blowdown (BD), or other (OT).

23.4 – Exhibit 01
Streambank Disturbance That Directly Impacts the Stream



23.5 – Stream Buffer

Measure and record the length (m) of streambank bordered by timber harvest, classify the average buffer width, and record streambank location (orientation facing downstream).

Measure and record the length of each bank that is bordered by timber harvest. Include all ages of clearcut through the stem exclusion phase of regeneration. Estimate and record the average width of the stream buffer perpendicular to the stream within one of five categories: no harvest, no buffer, 1 to 29 meters, 30 to 60 meters, or greater than 60 meters. Buffer width should be determined from the edge of the bankfull channel or side channel to the stump. Blowdown within the buffer or large spacing between trees (for example, palustrine channel type) should not affect the buffer width estimate. Record the streambank location of each buffer as left bank, right bank, or both banks oriented facing downstream. While this information will provide a general record of harvest activity, for monitoring purposes follow the procedures outlined in *Buffer Effectiveness Monitoring Protocol* (Kelliher 1999).

23.6 – Side Channel Measurements

Measure and record the following:

1. Measure and record the length of all side channels.
2. Record the streambank location (left or right bank) and distance of side channel inlet and outlet relative to an LLID or GIS segment node.
3. Record approximate average channel bed width of side channel.
4. Record minimum required residual pool depth.
5. Record channel bed width measured at a distance of every fifth approximate average channel bed width.
6. Record whether the channel is flowing, intermittent, or dry.
7. Record the number of qualifying macro pools.
8. Record the number of qualifying pieces of large wood.
9. Record the number of key pieces scaled to the average channel bed width of the side channel.
10. Record maximum pool depth and pool tail crest depth.

Side channels can provide extensive fish rearing habitat and refuge from floods, particularly in large flood plain channels. Arbitrarily bypassing a side channel during a survey will give an erroneous indication of habitat complexity and quality. Include all side channels across a valley regardless of size or current flow stage.

To distinguish a side channel from a braid, consider the stability of the intervening island with respect to size and permeability. The intervening island should be at least as long as the bankfull width of the channel. Given that rule-of-thumb for size, permanent vegetation or cohesive soil between the channels, and lack of interconnections other than a bankfull flows, denotes a side channel. For all side channels that appear active at some time during the year, measure length and average channel bed width.

A field-derived average channel bed width is needed to assess macro pool and LWD key piece qualifying criteria, and to establish intervals to measure channel bed width throughout the channel. Calculate the approximate average channel bed width from three width measurements taken at distances equal to approximately 5 times the first channel bed width measurement. Measurements should occur at every fifth channel bed width throughout the channel to enable more accurate calculation of channel bed width for the entire side channel. Side channel lengths must be kept separate from the main survey length.

Channel bed width and length provide a measure of potential habitat area, but flow stage also influences the availability of that habitat. Record flow stage as flowing (continuous), intermittent, or dry. Channels with discontinuous flow or isolated pools should be recorded as intermittent. Dry channels have no pooled or standing water.

The location of the upstream and downstream ends of the side channel should be recorded with respect to both distance from major tributary or channel type change, and left or right bank alignment. Record distance measurements at the center of the side channel where it joins the main channel.

23.7 – Fish Distribution

Note fish presence by species at the end of each stream segment. Record latitude and longitude or other location indicator of upstream limit of fish in-hand of Alaska Catalog of Anadromous Waters.

Check for presence of fish in Class III and Class IV stream reaches. Record at least once per stream class. Note that lack of detection does not conclusively preclude the presence of fish.

23.71 – Fish Migration Barriers

Complete fish barrier information on the morphology data card (22.5 – Exhibit 01). Record the location of the barrier (latitude/longitude and/or hip chain distance, distance from a major tributary mouth).

The adult salmonid migration blockage table (22.6 – Exhibit 01) provides objective criteria to evaluate fish migration barriers. A morphology data card (22.5 – Exhibit 01) should be completed for barrier falls that cause a change in the stream classification, or that present an enhancement opportunity. This is in addition to stream morphology data recorded at least once per channel type at a representative riffle.

Accurately locate each fish barrier and record the following information:

1. Barrier type (beaver, debris dam, vertical falls, chute/cascade, culvert, boulder, man-made dam, other).

2. Temporal nature (ephemeral or permanent).

3. Maximum height of falls or biggest single step if cascading (m).

4. Maximum depth of plunge pool (m).

5. Chute/cascade gradient and length (m).

6. Culvert perch height relative to the hydraulic control (if applicable)

Some hydro-geomorphic blockages may persist for decades, yet ultimately are ephemeral (Wiedmer 1999). A draft State of Alaska barrier classification system discusses these as ephemerally fixed, hydro-geomorphically dynamic barriers. In such cases, current upstream migration appears blocked by hydrological or geomorphic conditions, although landscape-scale conditions are in flux over brief geologic time. Examples may include mass wasting, responses to tectonic disturbance, glacial advance or retreat, and dynamic channel formation.

Additional portions of the morphology data card (22.5 – Exhibit 01) may be pertinent, depending on survey objectives. For example, if a fish ladder has enhancement potential, then stream gradient, a cross-sectional profile, and boot-tip substrate surveys can provide information useful to design engineers.

24 – TIER THREE SURVEY

The Tier Three survey consists of the Tier Two survey plus additional measurements, explained in detail below.

1. Channel Morphology Measurements.

2. Channel Bed Width. Record channel bed width measured at a distance of every fifth approximate average channel bed width.

3. Stream Survey.

    a. Length of stream survey.

    b. Identify habitat units by meso category.

    c. Record dominant substrate class by habitat unit.

    d. Pools (record length and average wetted width and record maximum depth and pool tail crest depth).

    e. Beaver pond (no change).

    f. Fast water (record average wetted width).

4. Large Wood. Count by qualifying pieces, key pieces, and by cluster category for each habitat unit.

5. Disturbance. (No change)

6. Stream Buffer. (No change)

7. Side Channel. Identify habitat units to meso level, record side channel length, pool length and average wetted width; count qualifying LWD, key pieces, and cluster category.

8. Undercut Bank (or Bank Condition).

9. Fish. For each stream reach, record fish catch per unit effort (CPUE) by species, stream class, and migration barriers.

24.1 – Channel Morphology

Increase effort over the Tier Two minimum of one channel morphology survey per channel type. Record riparian vegetation and forest seral stage data, and measure stream discharge or estimate it from cross section data (22.5 – Exhibit 01)

Channel cross section sites for morphology surveys should begin at a randomly chosen point within a single thread riffle as described for the Tier Two surveys. Increase the frequency of this survey when stream characteristics are not consistent over the entire length of the channel type. Consider taking additional morphology survey data in cases of loss or gain of a significant tributary or changes in channel type phase (for example, forest to shrub or muskeg, change in gradient or dominant substrate size).

24.11 – Riparian Vegetation and Forest Seral Stage

Record the category of riparian vegetation and seral stage as required for morphology measurements (25 – Exhibit 09). Consider riparian vegetation adjacent to the representative reach selected for the morphology survey. List the type among the eleven choices for both the left bank (DL) and the right bank (DR) when facing downstream.

A "sere" is the continuum of successional stages from bare ground to climax forest, whereas "seral" refers to the position of a vegetation community along a sere (Martin et al. 1995). There are five forest seral stage categories in this protocol: shrub-seedling, sapling pole, young saw-timber, mature timber, and old-growth forest (25 – Exhibit 09).

24.2 – Stream Survey

24.21 – Length

Record the following:

1. Record the length and location of stream surveyed.

2. Identity of all habitat units by meso categories (24.24 – Exhibit 01).

3. Maximum length and average wetted width of each fast water unit.

4. Length, maximum depth and pool tail crest depth, and average wetted width of each pool (average residual pool width is optional).

5. Dominant size class of substrate for each habitat unit.

Each habitat survey must identify the length of stream surveyed, measured along the thalweg, for each channel type. Base evaluations of habitat quality on the number of pools and the number of pieces of large wood per length of stream. Habitat units often lie parallel within a length of stream, not in a strictly linear arrangement. Consequently, summing the unit lengths can greatly over-estimate the survey length. A hip chain is an easy way to keep track of the distance of stream covered by the habitat survey.

Identify habitat units to meso category level as described in 24.24 – Exhibit 01 and *Hierarchy for Habitat Units* (Bryant et al. 1992). Measure and record the length for each unit. Divide the habitat unit into thirds and measure and record the wetted width across the center of each third (average residual width may be recorded for macro pools in addition to average wetted width). Calculate and record the average wetted width. Record the maximum depth and pool tail crest depth.

If ocular length and width estimates are used, then every fifth unit must also be measured after the ocular estimate has been recorded (Hankin and Reeves 1988). Both values (ocular and measured) must be recorded so that a correction factor can be calculated. The correction factor will be unique to the individual making the estimate; therefore one person must make all the ocular estimates. If a different person is assigned to make the ocular estimates, this must be clearly noted so that a new correction factor can be calculated for that individual.

For each Tier Three habitat unit, record the dominant substrate size class as listed in 25 – Exhibit 06.

24.22 – Pools

Record the following:

1. Pool type to meso category (that is, backwater, scour, or slough).

2. Pool length, three wetted pool widths, and the calculated average wetted width (residual width may be recorded in addition to wetted width).

3. Maximum depth and pool tail crest depth.

Macro pools have a unique hydraulic control and meet criterion for residual depth and size according to the formulae:

> Minimum residual pool depth = (average channel bed width) * (0.01)) + 0.15 meters
> Minimum macro pool length or wetted width = 0.10 times average channel bed width.

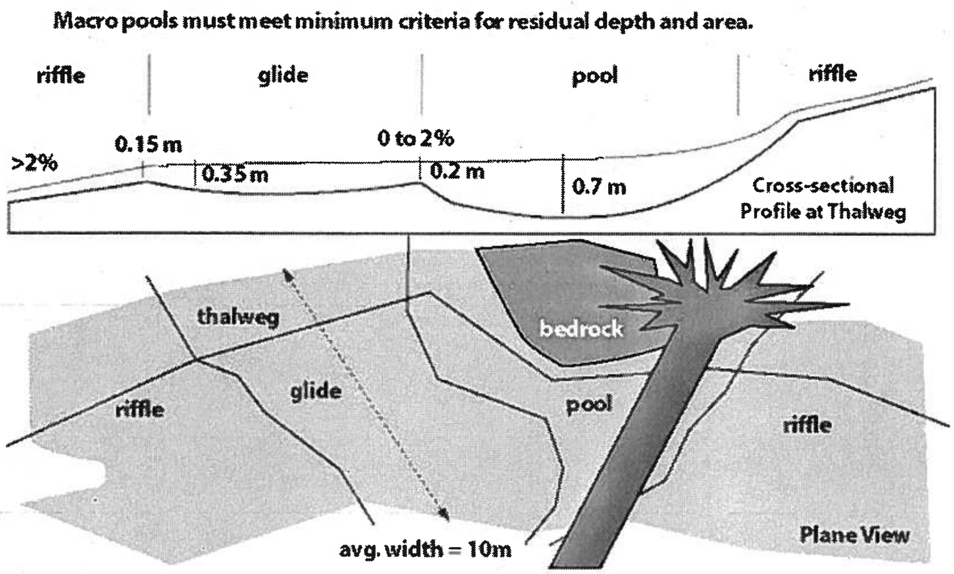
Bryant et al. (1992) developed a method that identifies and defines habitat types at increasing levels of detail ("macro", "meso" and "micro" categories). "*Hierarchy for Habitat Units*" (Bryant 1998) contains an explanation of this hierarchical method of pool identification. In palustrine channel types, "slough" can also be used as a meso category.

The Tier Three survey requires recording of the wetted pool area to conform to NRIS Water Module core attributes for aquatic habitat inventory. Measure the maximum length of the pool from the hydraulic control at the tail crest to the first slope break above the pool. Judgment is required to distinguish the slope break from surface disturbance at the head end of the pool. The outer margins of the pool are located where the water surface plane is uniform. The average wetted pool width should be calculated from three measurements of wetted width. Multiply the length by the average wetted width to obtain pool area. Record the maximum depth and pool tail crest depth.

The average residual width may be recorded in addition to the required wetted width. To determine residual width, consider the depression in the stream bottom as a basin. The surface of that basin is a horizontal plane at the elevation of the hydraulic control. When flow conditions are such that the pool water surface is maintained at the elevation of the pool tail crest, then the residual width and wetted width are equivalent. Measure residual width at the perimeter of the basin at the elevation of the pool tail crest. The average residual pool width should be calculated from three measurements of residual width.

Distinguishing between a pool with a long tail out and a glide in the classification of channel units. Macro pools must have a hydraulic control and meet minimum qualifying dimensions for residual pool depth and length or width dimensions (24.22 – Exhibit 01).

24.22 – Exhibit 01
Macro Pool Cross-sectional for Residual Depth and Area



24.23 – Beaver Pond

Tier Three requirements: See Tier Two (no difference).

24.24 – Fast Water Habitat

Identify fast water habitat type to meso category (that is, glide, riffle, and cascade) and record the length and average wetted width (m) of fast water habitat units. Habitat unit subdivisions of pool and fast water macro habitat are shown is 24.24 – Exhibit 01. Micro habitat unit categories may be substituted for meso categories (25 – Exhibit 02).

Macro	Meso
Pool	Backwater Scour Slough
Fast Water	Glide (gradient 0-2 percent) Riffle (gradient 2-4 percent) Cascade (gradient >4 percent)

24.3 – Large Wood

Count the following:

1. All pieces that meet minimum qualifying dimensions (greater than or equal to 0.1 meters in diameter and greater than or equal to 1.0 meter length).

2. Wood with 1 meter or more in zones one and two, or wood stacked in streambed(23.33 – Exhibit 01), in these categories:

   a. live or dead (section 23.33 – Zones and Special Cases),

   b. vertical or horizontal.

3. Number of key pieces of wood (section 24.32).

4. Structure in these categories:

   a. clusters of 5–9 pieces of large wood,

   b. clusters of more than 10 pieces.

24.31 – Count All Qualifying and Key Pieces

As in the Tier Two survey, count all qualifying pieces of wood that meet the length, diameter and zone criteria (except LWD in beaver dams). Key pieces must also be identified and counted. In some instances, either the stem or rootwad will qualify as a key piece, but not both. In cases, both may meet minimum qualifying dimensions for key LWD. To enable a total count of key pieces without duplication, record key piece data as either (1) stem alone qualifies, but rootwad is too small (2) rootwad alone qualifies, but stem is too small, or (3) rootwad and stem qualify. If you are counting large wood according to the size categories listed in 25 – Exhibit 03, the key pieces will correspond to the Tier Four size categories. Key pieces are also subject to all the zone rules.

It is usually impossible to accurately count wood pieces within a beaver dam or lodge. This is particularly true of PA5 channels, which occur in association with a series of beaver dams, often with extensive ponds.

24.32 – Zones and Special Cases

This is the same as for Tier Two. At least 1 meter of the piece must lie within the designated zone in order for it to be counted. The exception to this rule being wood stacked in the streambed. The designated zone consists of the portion of the stream that would be filled with water during bankfull flow (the combined zones one and two in 23.33 – Exhibit 01). All qualifying boles and rootwads within zones one or two must be counted. Qualifying living trees may be included if they contribute to the formation of pools, regardless of horizontal or vertical orientation (23.33 – Exhibit 02). Wood positioned within the bankfull width but elevated above the bankfull height is in zone three and will not be included in Tier Three counts unless 1 meter or more of that piece extends into zone two.

If a qualifying piece of wood lies in two habitat units, only count it once. The assignment of habitat unit should be based first on function, and secondarily on the percentage length within the unit. For example, a large tree with a rootwad and bole may lay within both a pool and riffle. The rootwad may be associated with the pool, while the bole may lie over the riffle. Assign the entire tree (that is, one LWD piece) to the pool if the rootwad appeared instrumental in the pool forming process, even though the greater portion of the piece may lie within the riffle. If survey objectives require additional information, then use comments to note which other habitat units also contain that piece. Never count a LWD piece twice.

If a cluster of wood encompasses more than one habitat unit, treat the cluster as a single entity and assign it to a single habitat unit.

24.33 – Cluster Categories

All qualifying pieces of wood (those which meet the dimension and zone criteria) will be used to identify clusters. If a piece does not qualify according to dimension, do not count it as part of the cluster. Pieces must actually be touching at least one other piece of wood to be part of a cluster.

Record the frequency of occurrence of each of the following categories for each channel type:

1. Clusters of 5–9 pieces of large wood.
2. Clusters of 10 or more pieces ("debris jams").

24.4 – Disturbance

Tier Three requirements: See Tier Two (no difference).

24.5 – Stream Buffer

Tier Three requirements: See Tier Two (no difference).

24.6 – Side Channel Habitat

Record the following:

1. Measured length of all side channels.
2. Average channel bed width of all side channels, and minimum required residual pool depth.
3. Channel bed width measured at a distance of every fifth channel bed width.

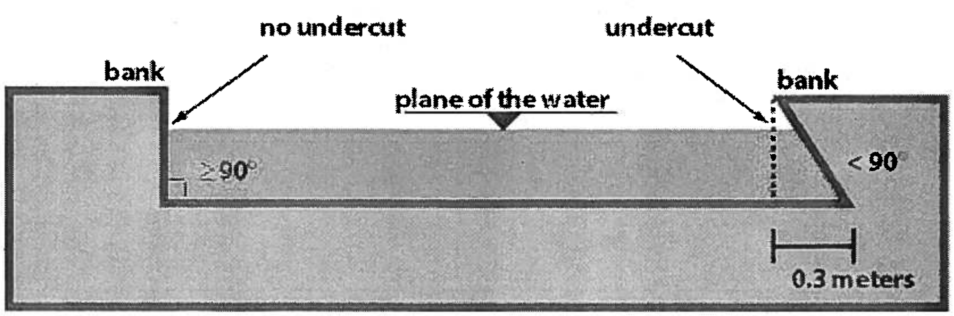
4. Streambank location (left or right bank) and distance along the stream.
5. Identity of all habitat units (including fast water) by meso category.
6. Length and calculated average wetted width of pools.
7. Length and calculated average wetted width of fast water units.
8. Maximum depth and pool tail crest depth of pools.
9. Large wood pieces.
10. Key pieces and clusters of LWD.
11. Whether the channel is flowing, intermittent, or dry.

24.7 – Undercut Bank (or Bank Condition)

Record the length of streambank that is undercut at bankfull stage. The minimum size requirements for undercut bank are length greater than or equal to 1.0 meter and depth greater than or equal to 0.3 meters.

For both banks, record the length of bank that is undercut. Undercut exists whenever the angle between the bank and the plane of the water less than 90 degrees and the minimum size criteria above are met (24.7 – Exhibit 01). When measuring length of undercut bank, include any undercut portion of the bank that is within zone one and two (the portion of the streams that would be filled with water during bankfull flows), even if it is above the current water level.

24.7 – Exhibit 01
Undercut Bank From Cross-sectional View of Stream



24.8 – Fish

Record the following:

1. Fish catch per unit effort (CPUE) by species, for each stream segment.

2. Data on fish migration barriers using the stream morphology data card, 22.5 – Exhibit 01.

3. Location of fish barriers using the morphology data card, 22.5 – Exhibit 01.

4. Results of population sampling using minnow traps or dive survey.

Sample a variety of pool and fast water habitats to determine which if any fish species are present (24.8 – Exhibit 01). Recording presence by species will verify stream class and species distribution within the watershed. Sample the population using minnow traps, dive surveys, and so forth, rather than rely on surface observation, to increase the chance of identifying all species present.

Check for presence of fish in mapped class III streams by sampling. Note that lack of detection does not conclusively preclude the presence of fish.

As in Tier Two, fish migration barrier data should be recorded on the morphology data card (22.5 – Exhibit 01). The data should include the life stage and species affected, the type and estimated longevity of barrier, the maximum height of the falls and residual depth of plunge pool, chute or cascade gradient and distance, and culvert perch height relative to the hydraulic control of the plunge
pool (if applicable).

24.8 – Exhibit 01
Species Codes for Fish Found in Freshwater in Region 10

Genus and Species*	Common Name	Species Code	ADF&G NMFS Code
Salvelinus malma	Anadromous Dolly Varden	AD	531
Salvelinus malma	Dolly Varden char	DV	532
Salvelinus alpinus	Arctic char		
Oncorhynchus mykiss	Steelhead	SH	540
Oncorhynchus mykiss	Rainbow trout	RB	541
Oncorhynchus clarki	Cutthroat trout	CT	560
Oncorhynchus clarki	Anadromous cutthroat trout	AC	561
Oncorhynchus clarki	Land-locked cutthroat trout	LC	562
Oncorhynchus gorbuscha	Pink salmon	PK	440
Oncorhynchus keta	Chum salmon	CM	450
Oncorhynchus kisutch	Coho salmon	CO	403
Oncorhynchus tshawytscha	Chinook salmon	CK	410
Oncorhynchus nerka	Sockeye salmon	SE	420
Oncorhynchus nerka	Kokanee	KO	-
Salmo salar	Atlantic salmon		
Esox lucius	Northern pike	NP	-
Salvelinus fontinalis	Brook trout	BT	-
Thymallus arcticus	Arctic grayling	AG	610
Gasterosteus aculatus	Stickleback	SB	661
Cottus spp.	Sculpin	SC	160
Platichthys stellatus	Starry flounder	SF	129
Thaleichthys pacificus	Eulachon		
	No Fish Found	NF	-
	Unknown	UN	-

*American Fisheries Society Special Publication No. 20.

25 – TIER FOUR SURVEY

The Tier Four survey offers additional detail for population assessment or characterization of habitat. Components of the Tier Four survey may be substituted into the Tier Two or Three surveys to meet specific survey objectives. For example, if surveyors desire very detailed large wood information, but don't have resources to conduct a complete Tier Four survey, one option would be to conduct a Tier Two survey and count wood according to the Tier Four specifications.

To avoid redundancy in this manual, Tier Four specifications are simply presented in Exhibits 01 through 09. Discharge estimates should be made following Buchanan and Somers (1969), a USGS publication entitled *Discharge Estimates at Gaging Stations*. A longitudinal channel slope profile is developed from differential elevation measurements of the channel bed at distinct slope breaks between cross section station. Measurement techniques are presented in General Technical Report RM-245 *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* by Harrelson, Rawlins, and Potyondy (1994).

25 – EXHIBIT 01 IS A SEPARATE DOCUMENT

25 – Exhibit 02
Stream Survey Units

Record	2	3	4	Category	Codes
Survey Length	X	X	X		Continuous hip chain entire survey (meters)
Channel Bed Width	X	X	X		Record channel bed width at a distance = 5X average channel bed width
Pools	X	X	X		Count qualifying macro pools
	X	X	X		Record minimum required residual pool depth
		X	X		Record length (m)
	X			**Macro**	Pool = (PL)
		X		**Meso**	Backwater = (PL-Bw) Scour = (PL-Sr) Slough = (SL-sl)
			X	**Micro**	Backwater--Dammed = (PL-dm); Eddy = (PL-ed) Scour--Plunge = (PL-pp); Lateral = (PL-lsc); Mid-channel = (PL-mcs) Slough--Slough = (SL-sl)
		X	X		Record average wetted width (m)
	X	X	X		Record maximum depth and pool tail crest depth
Fast Water		X		**Meso**	Glide = (GL) Riffle = (RF) Cascade = (CS)
			X	**Micro**	Glide--Glide = (GL-gl); Cobble = (GL-cb); Boulder = (GL-bd) Riffle--Riffle = RF-rf); Cobble = (RF-cb); Boulder = (RF-bd) Cascade--Slip-face = (CS-sf); Chute = (CS-ch); Rapids = (CS-rp); Step-pool = (CS-sp); Fall = (CS-fl)
		X	X		Record average wetted width (m)
		X	X		Record length (m)
Beaver Pond	X	X	X		Visually estimate beaver pond area connected to channel at bankfull flows
	X	X	X		Record streambank location (DL, DR, MC)
Side Channel	X	X	X		Record Side channel length.
	X	X	X		Stream bank location.
	X	X	X		Record hip chain distance of inlet/outlet relative to LLID or GIS node.
	X	X	X		Record approx. average channel bed width at start of survey segment.
	X	X	X		Channel bed width (every 5th approx. avg. channel bed width).
	X	X	X		Count qualifying macro pools.
	X	X	X		Record minimum required residual pool depth.
	X	X	X		Record maximum & pool tail crest depth (*Wet Channels Only*).
	X	X			LWD tally.
			X		Count LWD by size categories.
	X	X	X		LWD key piece tally.
		X	X		LWD clusters in two categories.
	X	X	X		Flow (flowing, intermittent, or dry).
		X			Habitat units (*Meso*).
			X		Habitat units (*Micro*).
		X	X		Measure average wetted width and length of habitat units (*Wet Channels Only*).

25 – Exhibit 03
Large Wood

Record	2	3	4	Category	Codes		
Large Wood	X	X	X	***Total Count***	Count all pieces that qualify as large wood (Length > 1 m and Diameter > 0.1 m)		
	X	X	X	***Key Pieces***	Count of key pieces (root wad and stem)		
				Stem	Channel bed width	Piece Diameter	Piece Length
					0.0 - 4.9 meters	0.30 meters	> 3.0 meters
					5.0 - 9.9 meters	0.30 meters	> 7.6 meters
					10.0 - 19.9 meters	0.60 meters	> 7.6 meters
					> 20.0 meters	0.60 meters	> 15 meters
				Root wad	Channel bed width	Root wad diameter	
					0.0 - 4.9 meters	> 1 meters	
					5.0 - 9.9 meters	> 3 meters	
					10.0 - 19.9 meters	> 3 meters	
					> 20.0 meters	> 3 meters	
	X	X	X	***Zone of Location***	Zone 1 and 2 combined		
			X		Zone 3 (keep separate)		
		X	X	***Cluster Category***	1 = 5-9 pieces touching		
		X	X		2 =10 or more pieces touching		
			X	***Size Class***	LW1 =1 < log < 3 meter long; 0.1 to < 0.3 meter diameter LW2 =1 < log < 3 meter long; 0.3 to < 0.6 meter diameter LW3 =1 < log < 3 meter long; > 0.6 meter diameter LW4 = 3 < log < 7.6 meter long; 0.1 to < 0.3 meter diameter LW5 = 3 < log < 7.6 meter long; 0.3 to < 0.6 meter diameter LW6 = 3 < log < 7.6 meter long; > 0.6 meter diameter LW7 = 7.6 < log < 15 meter long; 0.1 to < 0.3 meter diameter LW8 = 7.6 < log < 15 meter long; 0.3 to < 0.6 meter diameter LW9 = 7.6 < log < 15 meter long; > 0.6 meter diameter LW10 = log > 15 meter long; 0.1 to < 0.3 meter diameter LW11 = log > 15 meter long; 0.3 to < 0.6 meter diameter LW12 = log > 15 meter long, > 0.6 meter diameter RW1 = 0.1 to 1.0 meter diameter without bole RW2 = > 1.0 to 2.9 meter diameter without bole RW3 = > 3 meter diameter without bole		

25 – Exhibit 04
Disturbance

Record For Survey Tier	2	3	4	Codes
Disturbance **Record both banks**	X	X	X	(Length of stream) DR - downstream right bank DL - downstream left bank BB - Both banks MM = Mass Movement BD = Blow Down RD = Road OT = Other MM = Mass Movement

25 – Exhibit 05
Stream Buffer

Record For Survey Tier	2	3	4	Category/Codes
Stream Buffer **Record for both banks**	X	X	X	*(Length of stream)* DR - downstream right bank DL - downstream left bank BB - Both banks No Harvest Buffer Width: No Buffer <30 m 30-60 m >60 m

25 – Exhibit 06
Substrate

Record	2	3	4	Size (mm)	Codes
Substrate	X	X	X		**Recorded on the morphology data card**
				Bedrock	BR = Bedrock
				>512	LMB = Large/Medium Boulder
				256-512	SB = Small Boulder
				128-255.9	LC = Large Cobble
				64-127.9	SC = Small Cobble
				32-63.9	VCG = Very Coarse Gravel
				16-31.9	CGR = Coarse Gravel
				8-15.9	MGR = Medium Gravel
				4-7.9	FGR = Fine Gravel
				2-3.9	VFG = Very Fine Gravel
				<2	SS = sand/silt
				Organic	ORG = Organic
		X	X		Dominant substrate/habitat unit
			X		% Dominant substrate/habitat unit

25 – Exhibit 07
Cover

Record For Survey Tier	2	3	4	Codes
Cover			X	Tree Bole = TB
				Rootwad = RW
				Slash = SL
				Debris Jam = DJ
				Bedrock = BR
				Large/Medium Boulder = LMB
				Small Boulder = SB
				Large Cobble = LC
				Undercut Bank = UB
				Depth = DE
				Bridge/culvert* = BC
				Weir = W
				Log Structures = HL
				Boulder Structures = HB
				Overhanging Vegetation = OV
				Aquatic Vegetation = AV
				Other Human = HU
				Insufficient or no cover = IC
			X	Percent Cover

** Some bridges or culverts, particularly log structures, may provide cover.*

25 – Exhibit 08
Channel Pattern Categories

Record For Survey Tier	2	3	4	Codes
Stream Segment Channel Pattern	X	X	X	*(Record data on Channel Morphology Survey)* M = Multiple S = Single

25 – Exhibit 09
Riparian Vegetation

Record For Survey Tier	2	3	4	Codes
Riparian Vegetation Type		X	X	*(Record data on Channel Morphology Survey)* CFC = Conifer Forest – Closed CFO = Conifer Forest – Open BFC = Broad leaf Forest – Closed BFO = Broad leaf Forest – Open NSW = Nonforest-Shrub – Willow NSA = Nonforest-Shrub – Alder NSO = Nonforest-Shrub – Other NHE = Nonforest-Herbaceous – Estuarine NHB = Nonforest-Herbaceous – Bog NHF = Nonforest-Herbaceous – Fen NHO = Nonforest-Herbaceous - Other
Forest Seral Stage		X	X	(Record data on Channel Morphology Survey) SS = Shrub-Seedling SP = Sapling Pole (early 2nd growth lacking understory vegetation) YS = Young Saw-timber (> 9 inches DBH, even-aged canopy) MT = Mature Timber (uniform canopy, some understory development) OG = Old Growth Forest (multiple canopy, > 150 years old, developed understory vegetation)

Fish Pass

Table of Contents

31 - PLANNING

The Aquatic Habitat Management Handbook (AHMH) consolidates and clarifies management direction for riparian areas. The FSH 2609.24 Aquatic Habitat Management Handbook (AHMH 1986) stated that fisheries goals were based on fish habitat management units (FHMU), defined as "that portion of land including the stream channel and banks defined for the protection of stream habitat and maintenance of stream productivity." Using language consistent with the National Forest Management Act (NFMA) rule (36 CFR 219), AHMU directed managers to "give special consideration to that area at least 100 feet on either side of the stream." AHMU then broadened the objective for fish habitat management to include management of riparian-dependent wildlife and recreational opportunities by emphasizing "integrated resource management along streams."

The Tongass Timber Reform Act gave the Tongass National Forest additional direction to protect riparian areas. The Act prescribes a streamside buffer "of no less than 100 feet" to assure protection of riparian habitat. Like NFMA, the Tongass Timber Reform Act expands management focus from fish habitat to the aquatic ecosystem by recognition of the riparian area.

The revised Tongass National Forest Plan (1997) defines the "riparian area" as "the area including a stream channel, lake or estuary bed, the water itself, and the plants that grow in the water and on the land next to the water." The Plan provides direction for management of riparian areas by defining riparian management areas (RMA) as "the land area to be considered for the management of both aquatic ecosystems and the terrestrial organisms directly dependent on aquatic ecosystems."

31.1 - Riparian Management Areas

The RMA is the area identified during project planning that directly affects the form and function of aquatic ecosystems, stream processes and the quality and quantity of fish habitat. An RMA includes the immediate stream channel or water, the land adjacent to the water body, and upslope areas that have a direct effect on aquatic habitat. A determination of "direct effect" is based on criteria that are specific to channel process groups. RMA delineation is necessary before management prescriptions can be developed for projects such as timber sales and road construction.

31.11 - Stream Channels and Lakes

Stream channels and lakes with developed flood plains (FP, MM, PA, and some GO channel types) require an RMA determination based on site features such as riparian classified soils and plants, wetlands, the horizontal distance equal to the site-potential tree height and, where appropriate, the 100-year flood plain.

Alluvial fan stream channels (AF channel types) require an RMA determination based on site features such as riparian classified vegetation. The minimum width of the RMA on nonfish high gradient channels is the width from the streambank to the break in the side-slope.

31.12 - Riparian Soils

Riparian soils include hydric soils and soils of fluvial origin.

31.13 - Riparian Plant Communities

Riparian plant communities occupy sites that are just above the water table and frequently flooded. Shrubs and herbs such as red alder (*Alnus rubra*), Sitka alder (*Alnus sinuata*), Pacific red elder (*Sambucus racemosa*), blueberry (*Vaccinium* spp.), willow (*Salix sitchensis*) and salmonberry (*Rubus spectabilis*) are predominating riparian vegetation.

Riparian management areas have varying minimum widths as measured in distances from the lake or streambank.

Management beyond the RMA aims to provide a windfirm boundary for the RMA. The distance to be managed for wind will vary in width and management prescription depending on site-specific conditions, such as predominant wind direction, history of windthrow in the area, and topography.

32 - DIRECTION

For most applications the terms riparian management area and aquatic habitat management unit are similar concepts. Both terms have the objective to define the area of land that directly influences the streams and lakes on national forest lands. The aquatic habitat management unit definition includes the lake or stream itself and the land area adjacent to the water body. The riparian management area includes streamside areas, lake or pond margins, and the water body itself. (32 - Exhibit 01).

32 - Exhibit 01
Riparian Management Area Definitions by Process Group

Process Group	Riparian Management Area
Alluvial Fan (AF)	The greater distance of the active portion of alluvial fan or one site potential tree height from the active portion of the channel (140 feet).
Flood Plain (FP)	The greater distance of one site potential tree height (130 feet), the 100-year flood plain, riparian vegetation or soils, or the riparian associated wetland fens.
High Gradient Contained (HC) stream class I & II	The greater distance of 100 feet or to the top of the V-notch (side-slope break).
High Gradient Contained (HC) stream class III	Within the V-notch to the break in the side-slope.
Low Gradient Contained (LC) stream class I & II	The greatest distance of the area within 100 feet of the stream or to the top of the side-slope break.
Low Gradient Contained (LC) stream class III	Area from the stream to the side-slope break.
Moderate Gradient Contained (MC) stream class I & II	The greatest distance of the area within 100 feet of the streambank or the channel side-slope break.
Moderate Gradient Contained (MC) stream class III	The area within the channel side-slope break.
Moderate Gradient Mixed Control (MM)	The greatest distance of one site potential tree height (120 feet), the 100-year flood plain, riparian vegetation or soils, or riparian associated wetland fens.
Palustrine (PA) stream class I and II (direct)	The greater distance of 100 feet from the streambank, the 100-year flood plain, the extent of riparian vegetation, riparian soils, or riparian associated wetland fens.
Palustrine (PA) stream class II (non-direct)	The greatest distance of the 100-year flood plain, the extent of riparian vegetation or soils, or riparian associated wetland fens.
Lakes and Ponds, class I & II (greater than or equal to3 acres)	The greatest distance of 100 feet from the shoreline, the riparian vegetation, or associated wetland fens.

(Buffers of at least 100 feet are required on all Class I streams and Class II streams that flow directly into Class I streams).

33 - STREAM CHANNEL AND LAKE MANAGEMENT OBJECTIVES AND PRESCRIPTIONS FOR ACTIVITIES

Management objectives for aquatic ecosystems are developed for specific channel process groups. Prescriptions for management activities, such as timber harvest and road and facility construction, are developed based on the objectives for each channel process group. Road prescriptions are based on the Region 10 best management practices (Soil and Water Handbook, R-10 Amendment, 10/31/96), and are generally similar between channel process groups.

1. Timber Harvest. Maintenance of naturally functioning aquatic ecosystems requires strict adherence to prescribed stream and lake riparian protection measures. Effective application of riparian protection measures requires that stream class and channel type must be correctly established. It is often difficult, however, to determine fish presence or use of ephemerally available habitat in habitats with low fish populations. In cases where sampling cannot establish presence of fish, professional judgment must consider habitat accessibility and quality when determining potential to support fish.

2. Road Management. Roads may adversely affect aquatic organisms and water quality by disrupting hydrologic connectivity and movements. A road is considered hydrologically connected when surface flows are continuous between roads and streams (Furniss et al. 2000). Under these conditions the relatively impermeable road surface, cut slopes, and ditches become part of the stream network, accelerating runoff, sedimentation, and chemical pollution. When the capacity of stream drainage structures is exceeded, roads may capture or divert streams. The magnitude of physical consequences depends on flow, the volume and character of road fill, soil characteristics, and the overflow pathway (Furniss et al. 1997). Subsurface flow impacts may include road prisms, which depress the water table downslope from the road and create either a bulge or draw down of groundwater near the ditch (Kahklen and Moll 1999).

Effective long-term strategies that address hydrologic connectivity, diversion potential, and fish passage issues should incorporate both watershed-scale and site-specific needs into the planning, design, construction, and maintenance of forest road transportation systems.

Roads may be hydrologically connected to streams through:

1. subsurface flow interception,
2. surface flow on the road,
3. flow routing along ditches to stream channels,
4. sediment sources, and
5. sediment sinks (for example: barriers to bedload).

33.1 - Process Groups

33.11 - Alluvial Fan

Alluvial fan (AF0, AF1, AF2 and AF8 channels).

1. Objectives. Maintain near natural quantities of large wood by assessing the site's old-growth type and managing for the natural frequency and size distribution of large, downed wood and standing trees on the fan. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publication R10TP28.) In the stream channel, maintain the natural range of aquatic habitat features for large wood size and distribution as described in *Alaska Anadromous Fisheries Habitat Assessment* (Forest Service publication R10MB279, Appendix C.1.) on fish habitat objectives.

2. Desired Condition. Stream systems relocate naturally in unpredictable patterns across the alluvial fan. Large wood distributed across the fan functions to retain and meter sediment into stream systems and creates pools for fish rearing habitat. Availability of large wood is adequate wherever the stream may be located on the fan. Fluvial processes on the fan may excavate wood.

3. Stream Class/Activity. Apply the following management direction at the project level to streams in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Implement BMP 13.9. Provide for natural fish migration. Do not divert stream channels.

b. Timber Harvest. No programmed commercial timber harvest may occur within the riparian management area, which is defined as the greater of the active portion of the alluvial fan or 140 feet (the height of one site-potential tree) from the current channel(s). Manage across the remainder of the fan such that no more than 10 percent of the fan harvested in a 30-year period. The objective is to leave large trees within the stand for future recruitment to stream channels. No commercial timber harvest may occur within 100 feet of class I streams and class II streams that flow directly into class I streams.

c. Harvest Controls. Yard in a manner to minimize exposure of mineral soil and to prevent new human-caused channelization from occurring across the entire alluvial fan. The objective is to minimize alder growth and formation of new channels (ref. BMP 13.9). Where trees are removed, leave utility/cull logs distributed across the alluvial fan.

d. Roads, Borrow Pits, and Drainage Structures. Discourage use as borrow sources. Do not allow borrow pits on active fans. Avoid road crossing of fans where possible; otherwise cross alluvial channels in the narrowest, most stable locations (BMP 14.2). If culverts are used, install vented fords to control overflow and minimize downstream disturbance. Develop stream course protection plans whenever stream crossings are necessary. The objective is to maintain fish movement and avoid diverting stream channels.

33.12 - Estuarine

Estuarine (ES1, ES2, ES4 and ES8 channels).

1. Objectives. Maintain near-natural rates of sediment deposition and quantities of large wood by assessing the condition of the watershed for the natural rates of erosion and the size distribution for large, downed wood and standing trees in the riparian management area.

Minimize increases in deposition of fine sediments by applying BMP 13.16 (channel protection) and BMP 14.17 (bridge design and implementation). Minimize impacts to stream channels (BMP 14.14).

Maintain intertidal wetland functions associated with these channels including sediment retention, shoreline stabilization, nutrient cycling, and wildlife and fish habitats. The natural rates of sediment deposition and volume and frequency of freshwater and tidal flooding are key processes that maintain these estuarine functions.

Maintain the integrity and structure of sensitive streambanks. Keep stream substrate particle size distributions within the natural range for channel types in similar geophysical areas.

Estuarine associated riparian management areas have high values for many wildlife species and are important for rearing marine fishes. Minimum 1,000-foot buffers are required for these streams.

2. Desired Condition. Natural processes dominated by diurnal and seasonal tidal flooding and fluvial sediment deposition sustain estuary wetland functions and habitat. Streambank condition and function and substrate composition exist within natural ranges. Upstream and riparian input of allocthonous organic material and large woody debris are maintained at natural rates. Channel condition (width to depth ratio, pool frequency, and depth) and large woody debris (density, recruitment rate, and size distributions) meet process group habitat objectives.

3. Stream Class/Activity. Maintain streambank structure and wetland functions and values.

Apply the following management direction at the project level to streams in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest. No commercial timber harvest may occur within 1,000 feet of the estuary, defined as the landward extent of salt tolerant vegetation. Where estuarine channels occur other than in association with a defined estuary, no commercial timber harvest is allowed in the riparian management area (32 - Exhibit 01). Manage beyond the no harvest zone to provide for a reasonable assurance of a windfirm boundary along the riparian management area, with special attention given to the area within one site-potential tree height of the riparian management area.

b. Harvest Controls. Consider no-harvest (or limited harvest) areas to benefit water quality or estuarine associated wildlife species.

c. Roads, Borrow Pits, and Drainage Structures. Give special attention to wetland functions and fish passage when locating roads. Road design and construction should minimize erosion and sedimentation and ensure that lateral channel migration patterns are maintained. Borrow pits are not appropriate for this channel process group.

33.13 - Flood Plain

Flood plain (FP0, FP1, FP2, FP3, FP4, and FP5, channel types).

1. Objectives. Maintain near-natural quantities of large wood by assessing the site's old-growth type and managing for the natural frequency and size distribution of large, downed wood and standing trees on the flood plain. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publications R10-TP-28.) In the stream channel, maintain the natural range of large wood size and distribution, pool size and abundance, and channel morphometry. (Consult the *Alaska Anadromous Fisheries Habitat Assessment*, Forest Service publication R10-MB-279, Appendix C.1. on fish habitat objectives.)

2. Desired Condition. Flood plain channels are highly productive as fish and wildlife habitat. Natural flood plain functions include flood mitigation, surface groundwater exchange, water temperature moderation, and formation of streams providing off-channel fish habitat. Large wood is distributed across the flood plain, except where nonforest or early successional species naturally dominate. Old-growth forest provides high quality habitat for riparian associated wildlife species.

3. Stream Class/Activity.

a. Timber Harvest. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams. Further, no commercial timber harvest is allowed in the flood plain beyond the 100-foot buffer until the completed watershed analysis indicates this is acceptable. No programmed commercial timber harvest may occur in the riparian management area (32 - Exhibit 01). Manage an appropriate distance beyond the no harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

b. Harvest Controls. Yard in a manner to minimize exposure of mineral soil (less than 1 percent) and prevent channelization from occurring across the flood plain. The objective is to minimize alder growth and formation of new channels (BMP 13.9).

c. Roads, Borrow Pits, and Drainage Structures. Avoid locating roads in flood plains (BMP 14.2). Avoid braided channels whenever possible; otherwise, cross flood plain channels at the narrowest, most stable location and design roads to maintain the function of the 100-year event flood plain (BMP 14.2 and 14.3). Maintain natural fish movement patterns between the main channel and overflow, ephemeral, and intermittent channels located within the flood plain. Develop stream course protection plans whenever stream crossings are necessary. Do not develop borrow pits within the active flood plain. The objective is to maintain fish passage and access to all available habitats and to avoid diversion of surface drainage channels.

33.14 - Glacial Outwash

Glacial outwash (GO1, GO2, and GO3 channel types).

1. Objectives. Maintain near-natural quantities of large wood by assessing the site's old-growth type and managing for the natural frequency and size distribution of large, downed wood and standing trees on the flood plain. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publications R10-TP-28.) In the stream channel, maintain the natural range of large wood size and distribution, pool size and frequency, and channel morphometry. (Consult the *Alaska Anadromous Fisheries Habitat Assessment*, Forest Service publication R10-MB-279, Appendix C.1. on fish habitat objectives.)

2. Desired Condition. Glacial outwash plains range from low to highly productive fish and wildlife habitat. Fine sediments may limit spawning. Natural flood plain functions such as flood mitigation, surface groundwater exchange, water temperature moderation, and stream formation provide off-channel fish habitat. Areas of off-channel spawning and rearing may be highly productive where areas of upwelling occur. Large wood is distributed across the flood plain, except where nonforest or early successional species dominate naturally.

3. Stream Class/Activity.

a. Timber Harvest. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams and, no commercial timber harvest is allowed in the flood plain beyond the 100-foot buffer until a completed watershed analysis indicates this is acceptable. No programmed commercial timber harvest may occur in the riparian management area (32 - Exhibit 01). Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

b. Harvest Controls. Yard in a manner to minimize exposure of mineral soil (less than 1 percent) and prevent channelization from occurring across the flood plain. The objective is to minimize alder growth and formation of new channels (BMP 13.9).

c. Roads, Borrow Pits, and Drainage Structures. Avoid locating roads in flood plains (BMP 14.2). Avoid braided channels whenever possible; otherwise, cross flood plain channels in the narrowest, most stable locations and design roads to maintain the function of the 100-year event flood plain (BMP 14.2 and 14.3). Maintain natural fish movement patterns between the main channel and the overflow, ephemeral, and intermittent channels within the flood plain. Develop stream course protection plans whenever stream crossings are necessary. Do not develop borrow pits within the active flood plain. The objective is to maintain fish passage and access to all available habitats and to avoid diversion of surface drainage channels.

33.15 - High Gradient Contained

High gradient contained (FS0, HC0, HC1, HC2, HC3, HC4, HC5, HC6, HC8 and HC9 channels).

1. Objectives. Activities should not accelerate side-slope surface erosion or mass wasting. Maintain instream large wood structure to supply downslope channel processes at natural rates over time, such as for natural debris torrents.

2. Desired Condition. Natural integrity of channel side-slopes is maintained. Sediment is "metered out" to downstream reaches by large wood structure. Over the long term, high gradient contained streams act as conduits to move large wood and gravel into downstream fish-bearing streams during debris flow events.

3. Stream Class/Activity. Retain natural drainage patterns and minimize changes to the natural rates of sediment transport.

Design, install, and maintain stream crossings to pass flow, bedload, and wood debris from peak events with minimal impacts to stream channel and road integrity.

Apply the following management direction at the project level to streams in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest Stream Class I and II. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams. No programmed commercial timber harvest is allowed within the riparian management area, defined as within 100 feet of the stream or to the top of the V-notch (side-slope break), whichever is greater. Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

b. Timber Harvest Stream Class III. No programmed commercial timber harvest within the riparian management area, defined as the V-notch (side-slope break). Following watershed analysis, riparian management areas that become available for timber harvest will be converted from nonsuitable to suitable forested lands. (On a forestwide basis, it is anticipated that this change will occur along 25 percent of the class III streams in this process group.) Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area (pay special attention to the area within one site-potential tree height of the riparian management area).

c. Harvest Controls. Minimize yarding corridors within the riparian management areas.

d. Roads, Borrow Pits, and Drainage Structures. Generally, slopes with a high frequency of V-notch channels should be avoided (BMP 14.2). Road and road crossings should be designed and constructed to minimize soil runoff to the channel, retain natural drainage patterns, and minimize changes to the natural transport rates of sediment and organic material. Borrow pits are not appropriate.

33.16 - Low Gradient Contained

Low gradient contained (LC1 and LC2 channels).

1. Objectives. Maintain near-natural quantities of large wood by assessing the site's old-growth type and managing for the natural frequency and size distribution for large, downed wood and standing trees. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publication R10TP28.) In the stream channel, meet the natural range of aquatic habitat features for large wood size and distribution, and pool size and

abundance. (Consult the *Alaska Anadromous Fisheries Habitat Assessment*, Forest Service publication R10MBd279, Appendix C.1. on fish habitat objectives.)

2. Desired Condition. Natural integrity of channel side-slopes is maintained. Large wood is recruited and retained in the stream channel. Riparian vegetation provides shade and is a source of organic inputs to the stream. Old-growth forest provides high quality habitat for riparian associated wildlife species.

3. Stream Class/Activity. Allow no increase over natural rates of channel side-slope surface erosion or mass wasting.

Minimize changes to the natural rates of sediment transport. Assure fish passage for all Class I & II streams.

Apply the following management direction at the project level to streams in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest Stream Class I and II. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams. No programmed commercial timber harvest is allowed within the riparian management area, defined as within 100 feet of the stream or to the top of the side-slope break, whichever is greater. Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

b. Timber Harvest Stream Class III. No programmed commercial timber harvest is allowed within the riparian management area, defined as the side-slope break. Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

c. Harvest Controls Stream Class I and II. Fully suspend trees over the full width of the stream and banks when yarding. Minimize yarding corridors within the riparian management area. Yard in a manner to prevent delivery of sediment from channel side-slopes and to minimize exposure of mineral soil to less than 1 percent. Ensure that channelization does not occur across the flood plain.

d. Roads, Borrow Pits, and Drainage Structures. Road and road crossings should be designed and constructed to retain natural drainage patterns and minimize changes to the natural transport rates of sediment and organic material. Minimize erosion and sedimentation associated with road crossing approaches. Fish migration or movement should not be impeded by road crossings. Do not develop borrow pits within the gorge (BMP 14.9).

33.17 - Moderate Gradient Contained

Moderate gradient contained (MC0, MC1, MC2 and MC3 channels).

1. Objectives. Maintain quantities and supplies of large wood by assessing the site's old-growth type and managing for the natural abundance and size distribution of large, downed wood and standing trees. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publication R10TP28.) In the stream channel, maintain the natural range of large wood size and distribution, and pool size and frequency. (Consult the *Alaska Anadromous Fisheries Habitat Assessment*, Forest Service publication R10MB279, Appendix C.1. on fish habitat objectives.)

2. Desired Condition. Natural integrity of channel side-slopes is maintained. Large wood is recruited and retained in the stream channel. Riparian vegetation provides shade and is a source of organic inputs to the stream.

3. Stream Class/Activity. Allow no increase over natural rates of channel side-slope surface erosion or mass wasting.

Minimize changes to the natural rates of sediment transport. Assure fish passage for all Class I & II streams.

Apply the following management direction at the project level to streams in this process group. Complete a NEPA document that includes a watershed analysis before making site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest Stream Class I and II. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams. Programmed commercial timber harvest is not allowed within 100 feet or within the channel side-slope break, whichever is greater. Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area (pay special attention to the area within one site-potential tree height of the riparian management area).

b. Timber Harvest Stream Class III. No programmed commercial timber harvest is allowed within the riparian management area, defined as the side-slope break. Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the Riparian Management Area.

c. Harvest Controls. Fully suspend trees over the full width of the stream and banks when yarding. Minimize yarding corridors within the riparian management area. Yard in a manner to minimize delivery of sediment from channel side-slopes.

d. Roads, Borrow Pits, and Drainage Structures. Where road crossings are required, minimize erosion and sedimentation associated with road crossing approaches within the inner gorge. Road and road crossings should be designed and constructed to retain natural drainage patterns and minimize changes to the natural transport rates of sediment and organic material. Maintain fish passage at road crossings and avoid diverting surface drainage channels. Borrow pits are generally not appropriate.

33.18 - Moderate Gradient/Mixed Control

Moderate gradient/mixed control (MM0, MM1, MM2, and GO4 channels).

1. Objectives. Maintain quantities and supplies of large wood by assessing the site's old-growth type and managing for the natural abundance and size distribution of large, downed wood and standing trees. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publication R10TP28.) In the stream channel, maintain the natural range of large wood size and distribution, pool size and frequency, and channel morphometry. (Consult the *Alaska Anadromous Fisheries Habitat Assessment*, Forest Service publication R10MB279, Appendix C.1. on fish habitat objectives.)

2. Desired Condition. Large wood is recruited and retained in the stream channel. Riparian vegetation provides shade and organic inputs to the stream, and maintains dynamic flood plain processes. Large wood is distributed across the flood plain. Old-growth forest provides high quality habitat for riparian associated wildlife species.

3. Stream Class/Activity. Minimize soil disturbance and the formation of new channels (BMP 13.9). Maintain fish migration where needed and maintain natural surface drainage patterns for flood plain areas.

Apply the following management direction at the project level to streams in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams. No programmed commercial timber harvest is allowed in the riparian management area (32 - Exhibit 01). Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

b. Harvest Controls. Fully suspend trees over the full width of the stream and banks when yarding. Minimize yarding corridors within the riparian management area. Yard in a manner to limit exposure of mineral soil (less than 1 percent) and prevent flood plain channelization. The objective is to minimize surface soil disturbance and formation of new channels (BMP 13.9).

c. Roads, Borrow Pits, and Drainage Structures. Road and road crossings should be designed and constructed to retain natural drainage patterns and minimize changes to the natural transport rates of sediment and organic material. Minimize erosion and sedimentation associated with road crossing approaches. Special road construction techniques may be required to ensure fish passage. The objective is to maintain fish passage and access to upstream habitats and avoid diversion of surface drainage channels. Borrow pits are generally not appropriate.

33.19 - Palustrine

Palustrine (PA0, PA1, PA2, PA3, PA4 and PA5 channels).

1. Objectives. Maintain quantities and supply of large wood (primarily for cover habitat) by assessing the site's vegetation type and managing for the natural frequency and size distribution of large, downed wood and standing trees. (Consult *Ecological Definitions for Old-growth Forest Types in Southeast Alaska*, Forest Service publication R10TP28.) In the stream channel, maintain the natural range of large wood size and distribution. (Consult the *Alaska Anadromous Fisheries Habitat Assessment*, Forest Service publication R10MB279, Appendix C.1. on fish habitat objectives.)

2. Desired Condition. Highly complex stream and riparian systems provide canopy shading, instream organic recruitment for food and cover, and habitat diversity for rearing salmonids. Undercut banks are often present. Old-growth forest provides high quality habitat for riparian associated wildlife species.

3. Stream Class/Activity. Maintain streambank structure and wetland functions and values.

Apply the following management direction at the project level to streams in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest Stream Class I and II. No commercial timber harvest is allowed within 100 feet of class I streams and class II streams that flow directly into class I streams. No programmed commercial timber harvest is allowed in the riparian management area (greatest in flood plain, riparian vegetation or soils, and riparian associated wetland fens). Manage an appropriate distance beyond the no-harvest zone to provide for a reasonable assurance of windfirmness of the riparian management area. Pay special attention to the area within one site-potential tree height of the riparian management area.

b. Timber Harvest Stream Class III. Consider no harvest (or limited harvest) areas to benefit water quality or palustrine associated wildlife species.

c. Harvest Controls. Fully suspend trees over the stream and banks when yarding. Minimize width and number of yarding corridors within the riparian management area. Yard in a manner to minimize delivery of sediment from channel side-slopes. Use wetland guidelines.

d. Roads, Borrow Pits, and Drainage Structures. Wetland functions and fish passage receive special attention in locating roads. Road design and construction should minimize erosion and sedimentation.

33.21 - Lakes and Ponds

1. Objectives. In forested areas, maintain near-natural quantities of large wood for near-shore lake habitat and for lake and riparian associated wildlife.

2. Desired Condition. Low elevation lakes and ponds provide high quality fish rearing, wildlife habitat, and recreation. In forested areas, riparian areas provide canopy shading, organic recruitment for food and cover, and habitat diversity for fish. Old-growth forest surrounding lakes and ponds provides high quality habitat for lake and riparian associated wildlife species. Lakes offer scenic diversity and attract recreationists for both consumptive and nonconsumptive pursuits.

3. Lake Class/Activity. Maintain lakeshore character, including vegetation, bank conditions, and near-shore substrate, excepting local areas developed for recreation or other conforming uses. Maintain hydrologic and wetland function and values. Because lakes and ponds are variable in their physical and biological characteristics, additional objectives should be set on a project-by-project basis.

Apply the following management direction at the project level to lakes in this process group. Complete a watershed analysis before making project site-specific adjustments to process group direction. Deviate from this direction only if the objectives of the process group can be met.

a. Timber Harvest Lake Class I and II. This direction pertains to Class I lakes having anadromous fish or high value resident fisheries, and Class II lakes having lower value resident fisheries or 3 acres or greater in size. No programmed commercial timber harvest is allowed within 100 horizontal feet of the lake margin or within the riparian management area (32 - Exhibit 01). Consider restricting harvest beyond the no programmed commercial timber harvest area to benefit lake associated scenic quality, wildlife species (e.g., spotted frogs, Vancouver Canada geese, tree nesting ducks), and recreation, subsistence, and visitor uses. Typically, larger lakes in lesser development LUDs with higher resource values should have wider additional buffers than smaller lakes in the more highly developed LUDs with lower resource values. Manage an appropriate distance beyond any no-harvest zone to provide for a reasonable assurance of windfirmness of the desired standing timber. Pay special attention to the area within one site-potential tree height of the no-harvest zone.

b. Timber Harvest Lake Class II and III. This direction pertains to Class II lakes having lower value resident fisheries or less than 3 acres, and Class III lakes. Consider no harvest (or limited harvest) areas to benefit lake associated scenic quality, wildlife species and recreation, subsistence, and tourism uses.

c. Harvest Controls. Yard in a manner to minimize exposure of mineral soil (less than 1 percent) and prevent channelization in areas that would drain into a lake, pond or wetland.

d. Roads, Borrow Pits, Drainage Structures, and Facilities. Give special attention to wetland/riparian functions and values. As a rule, locate roads and borrow pits outside the commercial timber harvest area. Roads, trails, and other facilities that are dependent on, or make specific use of, the lake or pond may be located at the lake edge.

33.3 - Small Scale Channel Types

The Alaska Region channel type classification system described in Paustian et al. (1992) has been expanded to include small-scale, previously unmapped channel types. The new "0't" channel types, which range in size from 0.3 meters to 2.0 meters, are generally undetectable on 1:12,000 aerial photographs. Channel types have been added to the alluvial fan, flood plain, high gradient contained, moderate gradient contained, moderate gradient/mixed control, and palustrine process groups. There are two additional channel types within the high gradient contained process group. The FS0 is a small-scale footslope channel with stream gradient ranging from 6 to 15 percent. The HC0 is associated with mountain slope or hill landforms, and has a stream gradient greater than 15 percent.

34 - FISH PASSAGE AT ROAD CROSSINGS

This section provides guidance for compliance with fish passage requirements of the Clean Water Act, Forest Plan standards and guidelines, and applicable State statutes. Blockage of fish constitutes the elimination of a beneficial use of a water body as defined in the Alaska Water Quality Standards (18 AAC 70). Alaska Statute 16.05.840 (Fishway Act) requires that an individual or governmental agency notify and obtain authorization from the Alaska Department of Fish and Game (ADF&G) for activities within or across a stream used by fish if the Department determines that such uses or activities could represent an impediment to the efficient passage of fish. As per a Supplemental Memorandum of Understanding between the Forest Service and Alaska Department of Fish and Game (March 17, 1998), culvert installation; stream realignment or diversions; dams; low-water crossings; and construction, placement, deposition, or removal of any material or structure below ordinary high water all require concurrence from the Alaska Department of Fish and Game.

Blockage of fish passage is inconsistent with the best management practices under section 404(f) of the Clean Water Act. Section 33, Code of Federal Regulations 323.3(b), Clean Water Act (1987) states that "the design, construction and maintenance of the road crossing shall not disrupt the migration or other movement of those species of aquatic life inhabiting the water body." The Tongass Forest Plan Standards and Guidelines direct managers to "maintain, improve, and restore the opportunities for fish migration" in Class I and II streams.

This handbook provides tools and direction to implement longstanding policy established in the Southeast Alaska Area Guide (USDA 1977), that "Fish passage must be assured at all locations where roads cross fish streams." The Guide supported this policy with the following explanation:

> **Adult and juvenile salmonids must have unhampered access to all fish habitat. Coho, steelhead, cutthroat and Dolly Varden tend to spawn in headwater areas and their fry disperse downstream to fully utilize all habitat, while juvenile fingerlings move about considerably as rearing populations adjust themselves to carrying capacities. Juveniles also move in significant numbers to overwinter in small tributaries where temperatures are moderated by groundwater sources.**
>
> **Road crossing structures such as round culverts can cause increases in water velocity when improperly designed, often resulting in scouring at the downstream end during periods of high runoff. The scouring of gravel below culverts results in streambed instability and in culvert outlets elevated above the water level. Since the jumping ability of juveniles is limited, and their swimming capabilities in high velocity currents are restricted, fishery biologists recommend the use of crossing structures which maintain the natural stream gradient, width and bottom material. Culvert and bridge installations must not cause water velocity to exceed 40 cm/second (1.3 feet/second) and must allow passage of fish as small as 50 mm (2 inches) at normal and low flows. These requirements are best met by using small bridges or full arch culverts.**

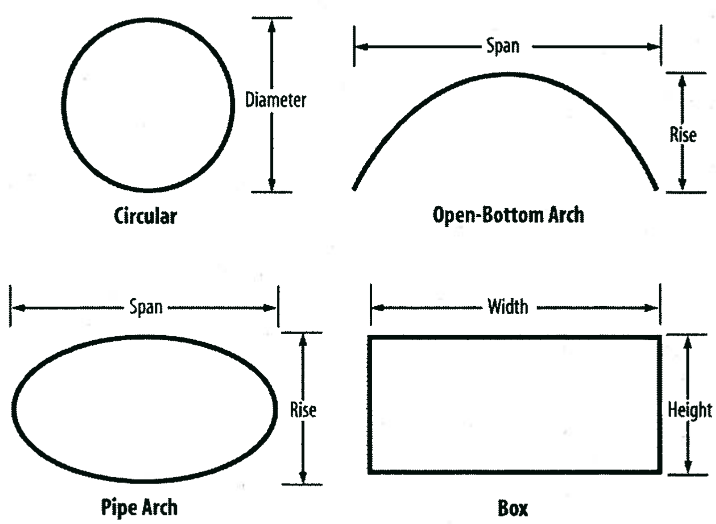
Robison and others (1999) described some consequences of failing to provide fish passa

1. The loss of genetic diversity in an upstream reach for resident fish.
2. The loss of range for juvenile anadromous and resident fish that migrate seasonally.
3. The loss of nutrients from the carcasses of anadromous spawning adults to reaches upstream of passage blockages.
4. Changes in fish genetics or community assemblages upstream of fish passage impediments due to differential swimming ability.
5. The loss of resident fish on small streams after extreme flood or drought.

34.1 - Road Crossing Structures

Two basic types of structures pass water through road prisms: culverts and bridges. The four basic culvert shapes are round or circular, elliptical pipe arch (squash), open-bottom arch, and box (Exhibit 01). These diagrams are reprinted from *Explanations and Instructions for Inventory and Assessment of Culverts on Fish Bearing Streams Draft,* September 1999 (USDA Forest Service 2000).

34.1 - Exhibit 01
End-sections of Common Culvert Types



The height, rise, or diameter (measured vertically) of the culvert is measured from inside of the corrugations.

34.11 - Culverts

Corrugated culverts are preferred for fish passage rather than smooth-walled culverts, and large corrugations tend to provide better fish passage conditions than small corrugations. Juvenile fish use the relatively low-velocity boundary layer along the culvert corrugations to move upstream through the culvert barrel. Small fish will often swim from one corrugation to another, resting between to conserve energy.

1. Box. The open-bottom box is a variation of the open-bottom arch culvert. These structures, used when headroom is limited, have a wide opening with low rise. Either a low clearance bridge or a box culvert is a good option when it is important to minimize the spread of road subgrade, such as on palustrine channels. Box culverts, bridges, and open bottom arches have similar ability to maintain the natural stream channel when sized to span the bankfull channel width.

2. Circular. Circular culverts, being relatively inexpensive to purchase and install, are the most commonly used structures on Alaskan forest roads. Frequently used on small fish streams, they provide conditions suitable for fish passage when properly designed, installed, and maintained. Because they reach maximum diameter at 50 percent of the rise dimension, they must be bedded deeper than other culvert styles to achieve desired bedded width.

Circular culverts are constructed of galvanized steel, aluminum, or plastic (polyethylene). Most culverts used on the forest are galvanized steel although the use of plastic is increasing. Plastic culverts are manufactured with a lined interior (smooth) or unlined interior with corrugations exposed. Corrugations increase roughness and contribute to a boundary layer of reduced velocity, which in turn improves fish passage conditions. Plastic culverts may outlast steel culverts under acidic water conditions.

3. Pipe-arch. Pipe-arches, also known as "squash pipes," are flattened vertically to produce an elliptical cross section of reduced height and lower profile. Often used on fish streams in preference to round culverts, their wide base conforms well to many channels and causes less channel constriction for the same cross-sectional area of culvert. When properly sized and installed, the corrugations and the substrate that accumulate over the bottom of the culvert provide areas of reduced velocity and fish passage conditions similar to the natural streambed.

4. Structural Plate-Arch. The structural plate-arch culvert is a multiplate arch composed of galvanized sections bolted together. Often it is attached to concrete, steel or wood footings. The structural plate-arch is used when size limitations for the pipe-arches are exceeded. The open bottom configuration is advantageous when it is important to retain the natural character and productivity of the streambed (e.g., spawning habitat).

34.12 - Bridges

Bridges, while generally the best structures for passing aquatic organisms, are also the most expensive in the short term. Modular bridges that may be reassembled in new locations provide a cost efficient option for fish passage and should be considered when roads are scheduled for temporary use. Properly sized and installed, bridges minimize loss of stream and riparian habitat from sediment inundation, benthos covered by nonembedded culverts, and loss of flood plain and riparian habitat due to the structure or road fill (Harper and Quigley 2000).

One maintenance cost associated with bridges that is not incurred with culverts is periodic replacement of decks.

1. Log stringer. The log stringer is a bridge built by cabling logs together, and setting them on log abutments. The use of log stringers may be limited locally by availability of wood of sufficient size and strength to safely span a crossing. Wood decay limits their safe use to relatively short-term applications (approximately 15 years), but they provide for fish passage, and even after collapsing into the stream, may continue to provide fish habitat as large woody debris. Log stringers may be installed and removed with little instream modification; thus they provide an economical and environmentally sound alternative for providing short-term fish passage on temporary roads scheduled for closure.

34.2 - Approaches to Providing Fish Passage Through Road Drainage Structures

Commonly used techniques to provide fish passage through culverts include:

1. Maintaining the natural streambed through use of bottomless arch culverts or bridges.

2. Stream simulation approach in which culverts are installed to maintain the natural stream width, gradient, and substrate.

3. Fishway designs within the culverts (roughened channel or weir/baffle structures).

4. The "no slope" culvert design, should only be used on very low gradient sites.

The guidelines on culvert design for juvenile fish passage reflect interim strategies for the Tongass National Forest. Fish passage design is a continuing evolutionary process. Guidelines may change as we accumulate knowledge and understanding of biological processes and fish performance.

34.21 - Maintain the Natural Streambed

The best solution for fish movement is generally to maintain the natural channel and streambanks in an undisturbed condition. Bridges that span the bankfull channel width, and that are installed according to applicable best management practices (BMP), should maintain channel integrity and existing fish movement.

Open bottom culverts maintain the natural streambed within the pipe, but generally encroach on the flood plain. All structures that restrict the channel at peak flow should have riprap aprons and rock or timber weirs to backwater the culvert and control outlet elevation. On soft subgrades, the relatively rigid footings of open bottom culverts are prone to settlement and erosion. For long-term structures, install open bottom culverts on grades at or near bedrock or, with due consideration of the power of the stream, other suitable nonerosive material. The design should consider the width of channel necessary to retain protective rock around the footings, and compaction of material beneath the footings (Porior 2001). In lower energy streams, scour resistant beds may be constructed using riprap and geotextile material.

A common practice during road construction is to divert small drainages along the upslope ditch short distances to the next larger channel to reduce the number of cross drainages. If such rerouting occurs into a fish stream, the culvert design must compensate for the increased flow and stream power.

34.22 - Stream Simulation

The stream simulation approach attempts to maintain natural stream processes from the inlet, through the culvert, and into the downstream channel. Inlets should minimize turbulence, and the outlet should be in a backwater condition to facilitate juvenile fish passage. Culvert diameters are selected to match the average bankfull width of the stream reach, or ordinary high water (OHW) width on non-adjusting channels. Culverts are then installed at the same grade as the stream. OHW is defined by the mark along the bank or shore up to which the presence and action of the non-tidal water are common and usual, and present in all ordinary years, such that a natural line is impressed on the bank or shore. This mark is indicated by erosion, shelving, changes in soil characteristics, destruction of terrestrial vegetation, or other distinctive physical characteristics (11 AAC 53.900 - Alaska Code).

Structures designed at a width less than bankfull/ordinary high water should be the exception, following consultation and approval of Alaska Department of Fish and Game in the Supplemental Memorandum of Understanding concurrence process.

Elliptical squash pipes or pipe arch culverts are preferred over round culverts for stream simulation because their shape more closely conforms to the channel shape. The inlet and outlet of the squash pipe or arch pipe are bedded to a minimum depth of 20 percent of the culvert rise dimension, or 1.5 feet below the stream bottom, whichever is greater. The bedding depth of the outlet should consider the elevation of the stable outlet control, or pool tail crest.

To retain substrate, rock should be sized for a Q50 storm and then backfilled into the culvert. Gravel retention baffles should be used to retain sediment. Outlet aprons should be constructed to control the outlet elevation and to backwater the culvert. The engineered fill will ensure substrate coverage throughout the culvert to the desired depth.

If round culverts are used, countersinking should be increased to 40 percent of the culvert rise dimension or 2 feet, whichever is greater. For all stream simulation culvert installations, adequate end area must remain after countersinking to pass anticipated flow, bedload, and debris. Deposition at either inlet or outlet may reduce flow capacity.

The stream simulation strategy is effective in maintaining fish passage in low gradient (0 to 2 percent) installations. This strategy may be effective at gradients up to 6 percent when 100 percent of the culvert bottom is covered with rock.

The stream simulation technique is generally not appropriate where bedrock or large boulders limit the depth to which the culvert may be sunk, or where an upstream channel constriction accelerates flows and scours substrate within the culvert.

34.23 - Fishway Designs

A variety of weir/baffle designs have been attempted on steeper grades to provide conditions conducive to fish passage by reducing water velocity within the barrel. As with the stream simulation approach, fishway culverts should be designed to span the bankfull/ordinary high water channel width. In addition, the design must account for the reduction in culvert capacity and hydraulic efficiency associated with increased roughness created by the weirs. The complex hydraulics associated with weir and baffle placement within culverts require expert design.

Fishway designs provide a series of interconnected pools where fish rest, and plunging flow to gain elevation (see exhibit 01). A downstream control weir provides a backwater condition at the outlet. Weir/baffle fishways should not be installed in areas with known high bedload and debris movement. They should be designed with removable plates or some other mechanism to clean the pools of bedload.

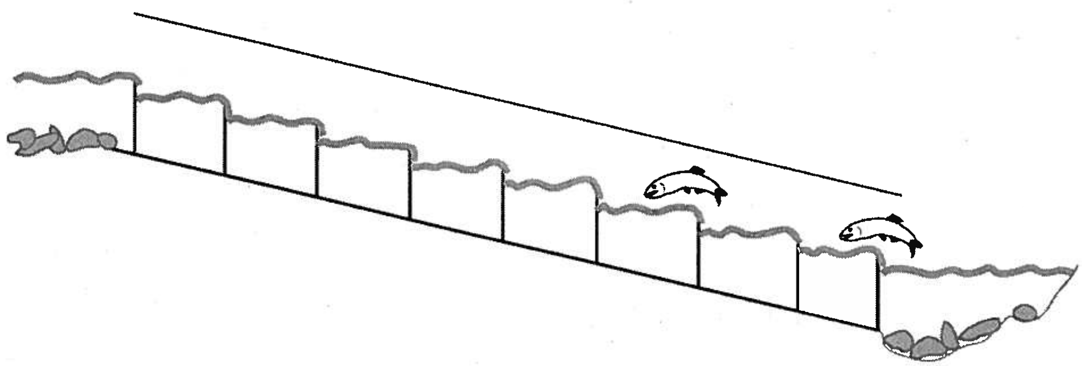
A pool immediately above the culvert provides good exit conditions for migrating fish. However, if there is insufficient water depth below the weir, a weir with a center notch may present a velocity barrier to juvenile salmon. For juvenile fish passage, weirs should be constructed to provide a series of step pools, with no more than 3 inches in elevation between the tops of each weir. Water should be pooled from the outlet control through each step. Center slots, if used, should not drain pools at low flows.

Juvenile fish ascend a culvert by seeking the path of least resistance. Kane and others (2000) documented the tendency for juvenile coho, Dolly varden, and trout to move up the sides of culverts, resting in the relatively still water between corrugations as they migrate. When ascending culverts with baffles, juvenile fish preferred to pass through slots next to the culvert wall and baffle rather than jump the baffle. Culverts with center slots designed to facilitate adult passage should include slots on the walls to provide better conditions for juvenile ascent as shown in Exhibit 02 (Porior 2001).

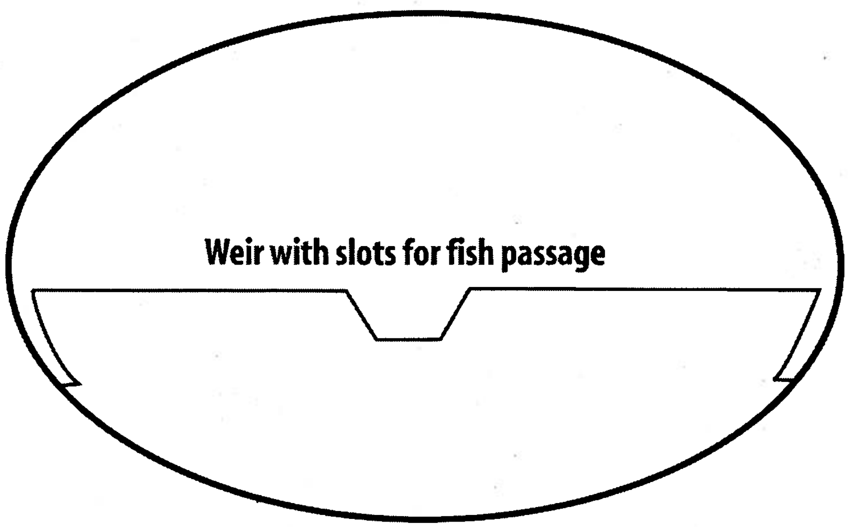
Weir/baffle installations have been used successfully on grades up to 7.5 percent. However, even moderate gradient installations should only be attempted where there is ready access to equipment for maintenance and retrofits to insure proper functioning after initial high flows. These structures are not as effective as the other methods at passing bedload and debris. As with fish ladder designs, there is an element of art in working from a theoretical design to an installed structure that provides conditions for juvenile fish passage at design flows. At gradients approaching or exceeding 6 percent, inlet velocities may impede juvenile fish passage. Even a small acceleration at the inlet could result in head cutting and create a barrier. Very large interlocked rock is needed at the outlets to prevent scour and to dissipate stream energy so that a barrier does not form downstream. Insufficient size of the outlet pool or loss of outlet control may result in extensive down cutting and require reestablishing streambed grade for a substantial distance downstream.

Weir/baffle structures can provide fish passage at an initially cheaper cost than a bridge. They may be the only practical method of restoring passage to a site where the natural channel has been lost from down cutting. The initial cost, risk of failure, and annual maintenance costs should be compared with the cost of a bridge. Weir/baffle installations are not recommended for small isolated road systems with infrequent maintenance.

34.23 - Exhibit 01
Fishway Baffle Design



34.23 - Exhibit 02
Schematic of a Baffled Culvert With Slots at the Edges and Center

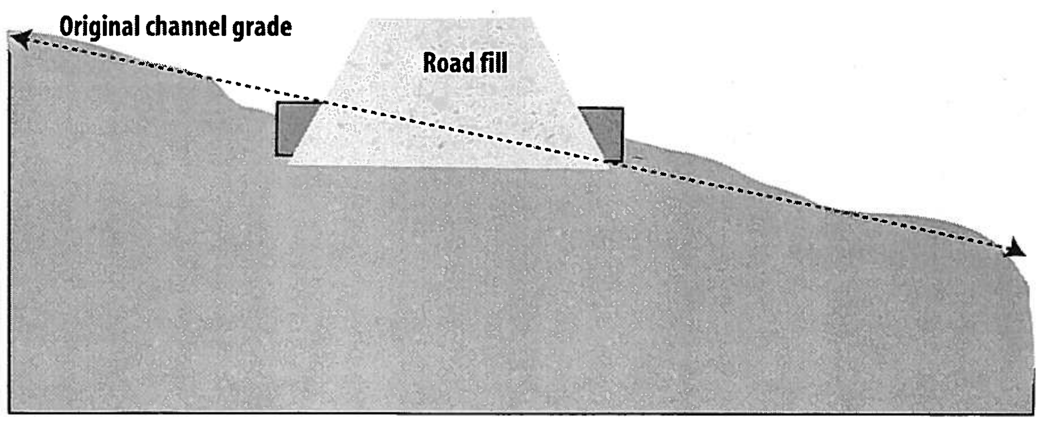


34.24 - "No Slope" Method

A widely used practice to provide fish passage in the Alaska Region was to countersink culverts and install them at a grade of 0.5 percent or less, regardless of stream grade. Generally the culverts were bedded 12 inches or more below the stream surface to collect substrate. In theory, the culverts were sized to compensate for inlet depression and still retain end area for storm flows, but culvert widths generally did not span the bankfull/ordinary high water channel width. Instead, the preferred method of stream simulation should be used, as described in section 34.23. Exceptions might be made for very low gradient palustrine channels with pooled water or, for estuary channels where there is tidally influenced backwater, provided the sites are not spawning areas.

Minor adjustments in stream channels are a naturally continuing process. Bedding a culvert at a grade less than the stream may have unintended impacts that vary depending on the bed material and longitudinal profile of the stream. Deeply bedding the inlet may induce head cutting, thereby creating a fish passage problem upstream. The reduction in grade may increase deposition at the inlet and reduce the effective end area. Outlet scour may lower the outlet control elevation and leave the culvert outlet perched. The schematic in Exhibit 01 is typical of many 0 percent grade installations.

34.24 - Exhibit 01
Profile View of Culvert at 0 Percent Grade
and a Stream Channel With Higher Overall Gradient



34.3 - Fitting the Crossing Structure to the Stream is Key for Attaining Fish Passage Objectives

Culverts that constrict the natural stream channel may be capable of passing flood flows and still be impassable to juvenile fish. This occurs because the constriction can increase water velocity or create a rapid change in water surface profile at the inlet. At the culvert outlet, the energy released by the accelerated water can erode and lower the channel, leaving the end of the barrel perched. Perched culverts may make the passage of adults difficult and the passage of juveniles impossible.

Culverts can block fish passage by increasing water velocity within the culvert barrel, creating jumps associated with perched outlets and head cutting, decreasing water depth within the barrel caused by the loss of the channel thalweg or water seepage through the road prism, and physically blocking passage in the case of crushed culverts or accumulated bedload or debris. The inlet should provide a smooth transition from the stream to the culvert barrel. Water surface elevation changes, flow constrictions from the natural stream channel, and the change from the relatively rough streambed to smooth metal pipe can result in velocity increases at the culvert inlet. Improperly bedded culverts may sag or buckle causing velocity barriers within the barrel. Culvert outlets best achieve fish passage when back-watered by downstream hydraulic control.

The hydraulic forces that act against migrating fish within a culvert can be evaluated in computer models. A software application called FishXing (for example: Fish Crossing) helps integrate biology, hydrology and hydraulics for analysis of fish migration through culverts (USDA Forest Service 2000). The model enables comparison of fish swimming capability and culvert hydraulics across a range of streamflows (Furniss et al. 2000). The data attributes required to model fish passage for a given culvert design using FishXing are listed below. Drop-down menus provide a range of preprogrammed choices on shapes, dimensions, and appropriate units, or for some fields, allow user defined inputs.

Hydraulic Inputs Culvert shape (circular, box, open-bottomed arch, pipe arch)
Culvert span x rise (inches)
Culvert length (feet)
Culvert slope (percent)
Corrugation size (inches)
Inlet configuration (projecting, mitered, headwall, wingwall)
Installation at grade or sunken (depth in feet)
Roughness coefficient for culvert (Manning's n)
Inlet and outlet bottom elevation (feet)
Stream Inputs
Inlet and outlet bottom elevation (feet)
Outlet pool (surface elevation, max depth, tail crest depth in feet)

Substrate (percent coverage, particle size classification)
Fish passage design flow (low and high passage flow in cfs)
Manning's coefficient for stream
Tailwater channel bed width and bankfull width (feet)
Biological Inputs
Target fish species and size (mm)
Swimming speed (burst and/or prolonged in feet/s)
Minimum water depth for migration (feet)
Time to exhaustion (min)

34.4 - Design Flow

The fish passage design flow differs from the flood flow, or maximum stream discharge, that the structure must safely accommodate during its design life. The fish passage design flow provides a standard to evaluate the hydraulic conditions within a culvert relative to the sustained swimming performance of the design fish.

The Tongass Forest Plan states that passage in Class I streams may be delayed by high water velocity for up to four days. However, the Alaska Region and State of Alaska have adopted an interim criterion that culverts be designed to maintain conditions conducive to fish passage at all flows up to the Q2 2-day flow (a two day delay from the mean annual flood).

Bridges, open-bottomed culverts and stream simulation designed structures that maintain the natural channel bankfull width, gradient, and substrate characteristics should not impede existing fish movement. A design flow must be stipulated to analyze fish passage conditions when the natural stream bottom is altered or constricted; however, the Clean Water Act does not contain a provision to delay migration due to high discharge.

Low flows may also hinder fish passage within culverts when water depth is inadequate. Low flow, or base flow, is the runoff or discharge during long periods when no precipitation or snowmelt occurs. It is composed of groundwater runoff and delayed subsurface runoff. Extreme low flows are often expressed as the average 7-day low flow with a two-year recurrence interval. Depending on the location, extreme low flows in southeast and south-central Alaska may occur in mid-winter or late summer. Maintaining depth of flow is moot when the natural channel is maintained, as occurs when a bridge or open-bottom arch is installed.

Design factors that mitigate low flow passage problems include the following:

1. Maintain the culvert outlet in a backwater condition,

2. Backfill with large substrate within the culvert to provide channel roughness elements that trap and retain bedload material and establish a thalweg,

3. Bed the culvert on a relatively impermeable, compact surface below the natural thalweg grade.

34.5 - Guidelines for Fish Passage Culvert Installations

Ongoing research and adaptive management are providing new tools and insight into fish passage design. All designs for fish passage structures and culvert installations larger than 48 inches in diameter (or pipe arch equivalent) should have review by a hydraulic engineer.

Guidelines are provided for smaller installations that require fish passage, to achieve hydraulic forces within the acceptable range for juvenile fish. These guidelines facilitate the concurrence reviews stipulated in the Supplemental Memorandum of Understanding between the Forest Service and Alaska Department of Fish and Game. The general guidelines include:

1. At least 20 percent of the diameter or 18 inches, whichever is greater, of each elliptical or arch type culvert should be buried at both the inlet and outlet of the culvert below the natural thalweg. Round culverts should be buried at least 40 percent of the rise dimension (diameter) or 24 inches, whichever is greater. This guideline is not applicable to bottomless culverts.

2. Culverts should have engineered fills sized for retention in a Q50 storm. Gravel retention weirs may be used to further retain fill.

3. Culvert outlets should terminate on materials that will not readily erode or degrade. Riprap outlet aprons and rock or timber weirs should be used to backwater the culverts and control outlet elevation.

4. Culverts should be designed to carry the anticipated levels of streambed load and debris up to and including the design discharge.

5. Bridges or open bottomed pipe arches should be used in areas where fish spawn or in high value rearing habitat.

6. In general, culverts should be installed and aligned with the hydraulic gradient and parallel to the water flow of the natural stream. The assumption is that replicating the stream conditions (i.e., gradient, channel width and substrate) within the culvert barrel will provide passage equivalent to the natural stream. Exceptions should be designed structures (e.g., use of skewed alignment to enhance fish passage characteristics).

7. Culverts should be sized such that the bedded width is equal to the bankfull/ordinary high water channel width.

8. A single large culvert is preferable to two or more smaller culverts.

9. Culverts should be regularly inspected and maintained to ensure that they continue to provide unobstructed fish passage (see TLMP Fish Passage at Road Crossings Monitoring Protocol).

10. Permanent structures should be designed to accommodate streamflows that meet or exceed 50-year recurrence intervals (BMP 14.17).

Proper design, installation, and maintenance are all essential to structure function. Blockage by debris or bedload is common, especially in small diameter culverts (Cariello 2000). Periodic inspections conducted during critical migration periods are likely to provide more accurate condition assessments.

34.6 - Access to Short Stream Reaches

A Supplemental Memorandum of Understanding between the Forest Service and Alaska Department of Fish and Game (March 17, 1998), while resolving the State's issues and procedural concerns about instream activities, does not fully address procedural requirements of the Clean Water Act.

The Tongass Forest Plan provides for blockage of fish passage in limited cases. A question that often arises is: What is the minimum amount of fish habitat for which the added expense of providing access is justified? The Clean Water Act, Section 404(f) exemption for roads requires that any adverse effect on the aquatic environment has been minimized, and that all applicable BMPs have been met. A Corps of Engineers 404 permit is required for road construction or maintenance if any applicable BMPs are not met. In addition, consultation and concurrence are required from the Alaska Department of Environmental Conservation (ADEC) and Alaska Department of Fish and Game to disrupt fish migration or movement. Such exemptions, if allowed, would consider each case on merit.

35 - FISH HABITAT PASSAGES REQUIREMENTS

Pink, chum, and coho salmon and Dolly varden populate most streams with access to the sea. Steelhead, sockeye salmon, and anadromous cutthroat trout are found in varying abundance in many coastal streams. Their passage requirements are usually met by meeting the needs of weaker swimming species (Behlke et al. 1991). Resident (nonanadromous) populations of Dolly varden and coastal cutthroat trout are common in smaller streams and cohabitat larger streams with salmon. Their instream movements to meet life history needs are not fully known, although movements to spawning, rearing and over-wintering areas are documented. Little information is available about instream movement and distribution of nongame fish species such as sculpin, or other aquatic organisms in Alaska.

The following excerpt from Vinyard and Dunham (1994) discusses impacts of isolating small populations of fish:

Fragmentation of formerly continuous fluvial salmonid habitat results in loss of total available habitat and reductions in total population size. This process may precipitate both ecological and genetic impacts within the remaining population. Genetic effects may include loss of genetic variability within remnant fragments and greater genetic divergence among population fragments. These results may be from the isolation of a small population which is subject to bottleneck and genetic drift effects, and by the failure of reproductive individuals to move among population remnants.

Ecological impacts from the isolation of small populations in remnant habitats may include increased dispersal rates among populations and reduced recolonization following local extinctions, leading to further loss of populations. The consequences of localized environmental events may also be enhanced because smaller or more isolated populations may be more vulnerable to localized perturbation. Small isolated population fragments are also more subject to random fluctuations and less likely to be recolonized if local extinction occurs.

35.1 - Verifying Fish Presence

Verification of fish presence is generally easiest from May through September because fish tend to be actively feeding away from cover. Steelhead, cutthroat trout, and Dolly varden however, may be absent from tributaries, particularly headwater streams, except from fall to spring. Suspended sediments and high flow make observation difficult in fall, and limit use of minnow traps as a capture technique. During cold weather, fish may seek shelter in the crevices of the streambed or under banks, and may not be observable or accessible to normal capture techniques. During summer months, baited minnow traps and electroshocking have been popular sampling methods. Although electroshocking is very efficient in small streams, it can kill or injure fish and should be used prudently.

Winter is the time of greatest ecological stress on stream dwelling fish (Mason 1976); thus, access to winter habitat is critical. Cederholm and Scarlett (1981), Peterson (1982), Tschaplinski and Hartman (1983), and Swales et al. (1986) discussed redistribution of fish in autumn from large streams to winter habitat on sloughs, ponds, and off-channel areas. At the site level, fish display distinct habitat preferences. At the reach level, however, fish do not necessarily know the location of or seek out the best habitat. Access should be maintained to all habitats throughout the year. Dolloff (1987) concluded, "The probability that a particular type of habitat will be entered and occupied is a function of the amount and quality of that habitat type, its accessibility and its distribution relative to the spawning areas or other concentrations of fish."

35.2 - Migration Timing and Swimming Performance

Migration timing varies not only by life stage and species, but also by region and among stocks within a region. There are gaps in swimming performance information, particularly for juvenile fish and for Dolly varden char. Nonetheless, the best available information on migration timing and swimming performance are needed to determine the design flow. The tables on migration timing (35.22 - Exhibit 01) and swimming performance (35.23 - Exhibit 01) represent a normal range for species encountered. Local escapement counts should be used when available to determine the migration timing.

Culverts should be designed, installed, and maintained to prevent the creation of water velocity or height barriers at the outlet, and to allow upstream passage of juvenile fish. Swimming performance varies by fish species, life stage, water temperature, and oxygen saturation. Culvert design should be based on the requirements of the weakest swimming species and life stage of fish present.

35.21 - Timing and Performance by Various Species

35.21a - Pink and Chum Salmon

Bell (1973) tested adult pink and chum salmon swimming ability. Of the salmonids, they had the slowest prolonged and burst speeds tested. Upstream passage must only be provided during adult spawning migrations, which occur from mid-July through September.

Pink salmon migrate directly to the ocean upon emergence from the gravel. As shown in 35.22 - Exhibit 01, the pink salmon smolt emigration occurs from March through May.

Like pink salmon, chum salmon emerge from the gravel as smolt. The smolting period is from early March through May. The timing of spawning migration varies from early July through November depending on the region and stream system. The timing for individual stocks may be compressed within a much smaller portion of that period.

35.21b - Coho Salmon

Coho salmon have a more complex life history than pink or chum salmon. Adults enter streams to spawn from as early as July for some streams on Prince of Wales Island, through November elsewhere, often under high flow conditions. Fry emerge from the gravel beginning in April and rear in natal streams during summer. With the first fall freshets and falling water temperatures (Taylor 1988 and Peterson 1982), fry seek refuge in boulders and woody debris on large streams, before moving into tributaries and off-channel pools, rich fen streams, and palustrine channels (Bramblett et al. 1997; Tschaplinski and Hartman 1983; Bustard and Narver 1975; Peterson 1982; and Skeesick 1970). Some wintering habitats dry out in summer (Brown and Hartman 1988), providing only a small percentage of the habitat in a watershed. Low stream velocity in winter refuge habitat demands minimal energy expenditure by fish, and moderates water temperatures to prevent freezing. This habitat has been called "survival habitat" because it results in higher rate of survival (Bustard and Narver 1975) and, in some instances, enables growth during winter (Swales et al. 1986).

Only a portion of the fry produced locate suitable wintering habitat and survive to contribute to the adult population (Crone and Bond 1976 and Mason 1975). Many surviving fish rear for another summer, again seeking refuge in the fall. They over-winter in freshwater for one to four years (Drucker 1972) before out-migrating as smolt, having physiologically adapted to the marine environment. The mean freshwater age is greater for lake smolts than stream or river smolts (Halupka et al. 2000). Most coho return to spawn after 16 months in saltwater, and rarely up to 28 months.

35.21c - Dolly Varden

Dolly varden char have multiple life history forms including resident, freshwater migratory (e.g., adfluvial), and anadromous forms (Rieman and McIntyre 1993). Anadromous stocks may enter many streams before wintering in a lake system, and migrate long distances into lakes to over-winter (Armstrong 1971 and Armstrong and Morrow 1980). Despite the seeming random dispersion of summer saltwater movement, spawners exhibit strong homing tendencies to natal streams (Scott and Crossman 1979). Within streams, Dolly varden exhibit selectivity for both spawning and wintering sites (Martin 1988).

Resident and anadromous forms can move to spawning streams as early as late spring or early summer, and usually spawn in October. Juveniles of anadromous stocks may rear in freshwater for two to four years (Armstrong 1970). In autumn, juveniles move into spring fed areas or small tributaries where they remain throughout the winter (Armstrong and Elliott 1972; Blackett 1968; and Elliott and Reed 1974). Swimming performance measures (i.e., sustained or burst swimming speeds) are not available in the literature for Dolly varden. Dolly varden are generally considered low or medium performance swimmers (Behlke et al. 1991 and Poulin and Argent 1997). However, quantitative measures of swimming performance are lacking in the published literature.

35.21d - Cutthroat Trout

Coastal cutthroat trout exist in both resident and anadromous forms. They have a diverse life history with various adaptations to marine and freshwater environments. Both forms spawn from April to early June (ADF&G 1994). For anadromous populations, smolt migration peaks in May. Many if not all anadromous cutthroat re-enter streams to winter in freshwater (Trotter 1997). Although nonspawning fish may winter in a stream other than their natal stream, spawners exhibit a high degree of homing precision. Repeat spawning is common (Trotter 1997).

Jones (1997) found cutthroat spawning and rearing in very small tributaries. Resident forms move from lakes, ponds and deep stream pools into stream riffles to spawn. Resident juveniles rear in natal streams for two years and anadromous forms up to four years (Trotter 1989 and Jones 1976). The range of movement can be large, as with the anadromous form, or very restricted as with resident populations above barriers.

Small, isolated populations of resident coastal cutthroat trout that reside above migration barriers are at a greater risk of extirpation than populations with larger numbers (Williams et al. 1998). Low numbers of individuals and low straying rates in coastal cutthroat populations, coupled with high genetic variability among populations in Alaska, increases the risk that the loss of an individual population could result in a proportionately large loss of genetic diversity to the subspecies (Williams et al. 1998).

35.22 - Timing Restrictions for Instream Activities

Timing restrictions for instream activities are among strategies discussed to control nonpoint source pollution. Road construction or maintenance activities that have the potential to increase sediment within the stream should be scheduled to coincide with periods of lowest probability for erosion, sedimentation, or damage to fish habitat quality. Restricted periods are times when instream activity should not occur. The Soil and Water Conservation Handbook (FSH 2509.22) discusses best management practices to protect water-related beneficial uses.

Instream construction activities and the use of equipment on fish streams should be restricted when there is high risk of damage to fish and their habitat quality; that is, when eggs or alevin are in the gravel.

Timing restrictions for Class III streams should be evaluated on individual characteristics. At a minimum, consider the following:

1. The species residing at and downstream from the construction site.

2. Distance to downstream fish habitat.

3. The ability of the stream to transport sediment to downstream fish habitat. For example, intervening beaver ponds may prevent delivery of sediment to downstream fish habitat.

4. Timing when eggs and alevin of the downstream species will be in the gravel.

5. The amount of channel disturbance anticipated at the construction site.

Exhibit 01 presents the general timing table for instream construction activities for selected salmonids in Alaska streams. In consultation with Alaska Department of Fish and Game biologists, timing windows should be fine-tuned when site-specific information is available. When multiple species are present, timing windows are combined to define a period during which instream work can be conducted. For example, if both pink salmon and steelhead were present in a Ketchikan area stream, the resultant timing window would extend from July 18 to August 7.

In every instance where some instream activity is planned, take care to minimize streambed disturbance and sediment generation. Minimize downstream inputs through such precautions as minimizing stream crossing by heavy equipment, minimizing ground disturbance during periods of heavy precipitation, using of silt fences or hay bales during construction and avoiding discharge of fine textured soils into moving water (USDA Forest Service 1996).

Where site-specific information is available, restrictions should be adjusted to reflect local spawn timing. For instance, sockeye salmon at Chilkat Lake spawn as early as July 15, and in Chilkoot Lake as early as July 1. Sockeye stocks in southeast Alaska sockeye generally spawn after August 15.

Timing windows should be developed in consultation with the Alaska Department of Fish and Game. Variance proposals to work outside of established timing windows should be evaluated on a case-by-case basis, and should include specific mitigation measures. All variances should include a provision for instream work to be completed during low-flow conditions.

35.22 - Exhibit 01
Generic Timing Table For Instream Construction Activities

	Alaskan Forest Region			
Species	South-central	Northern southeast	Central southeast	Southern southeast
Coho	June 15--July 15	June 1--July 15	June 1--Sept 15	June 15--Sept 1
Pink/chum	June 1--July 15	June 1--July 15	May 15--Aug 1	June 1--Aug 3
Sockeye	June 15--Aug 15	June 15--July 20	No General Timing Window	July 18--Aug 15
Steelhead/ Cutthroat	Apr 15--Aug 1	No General Timing Window	July 18--Aug 15	July 18--Aug 15
Dolly varden	No General Timing Window	No General Timing Window	No General Timing Window	No General Timing Window

When the risk of damage to fish or their habitat is reduced, and instream activities are allowed when conducted in accordance with all applicable BMP).

35.23 - Swimming Performance

Swimming performance increases with fish size, and decreases with increasing water temperature. Fish may use a combination of burst and sustained swimming speeds to enter and move through culverts. Sustained (prolonged) speed is powered by red muscle working aerobically, and is characterized by slow caudal movements of large amplitude (Behlke 1991). Burst (darting) speed is the speed a fish can maintain for a very short period, generally 5 to 10 seconds without gross variation in performance and a period of recovery. Burst speed is powered by white muscle working anaerobically, and is employed, for example, to negotiate a difficult hydraulic situation (Behlke 1991). Culvert hydraulic forces can be evaluated relative to swimming performance capability using fish passage models to determine if the conditions are within a range conducive to fish passage.

In Exhibit 01, the swimming performance of selected Alaskan fish species are provided from Hunter et al. (1986). The equations are time decay swimming velocity curves that summarize available swimming performance data for each species.

35.23 - Exhibit 01
Swimming Performance of Alaskan Fish Species

Species	Length Range (mm)	Water Temp. (C)	Burst (m/s)	Sustained (m/s)	Original Data Source
Juvenile Salmon	n/a	n/a	0.638 * (L * 0.0254)-0.0172		Barber & Downs (1996)
Coho	40--178	8--12		3.02 * L0.52 * t-0.1	Glova & McInerney (1977); Davis et al. (1963); Flagg et al. (1983); and Howard (1975)
Coho	40--133	13--15		5.67 * L0.7 * t-0.1	Glova & McInerney (1977); Davis et al. (1963); Flagg et al. (1983); and Howard (1975)
Coho	40--120	18--20		5.87 * L0.7 * t-0.1	Glova & McInerney (1977); Davis et al. (1963); Beamish (1978); and Dahlberg et al. (1968)
Coho	356--510	10--19	13.3 * L0.52 * t-0.65		Weaver (1963) and Beamish (1978)
Pink	494--607	20		4.08 * L0.55 * t-0.08	Brett (1982)
Sockeye	n/a	2		3.31 * L0.6294 * t-0.1	Brett and Glass (1973)
Sockeye	n/a	5		3.63 * L0.6243 * t-0.1	Brett and Glass (1973)
Sockeye	n/a	10		4.46 * L0.6294 * t-0.1	Brett and Glass (1973)
Sockeye	n/a	15--18		5.21 * L0.06345 * t-0.09	Brett and Glass (1973) and Brett (1982)
Sockeye	n/a	18--20		4.99 * L0.6293 * t^0.09	Brett and Glass (1973) and Brett (1982)
Sockeye	77--539	15		4.42 * L0.5 * t-0.1	Brett (1965a)
Sockeye	126--611	10--15		5.47 * L0.89 * t-0.07	Brett (1964, 1967, and 1982)
Chinook	508--965	19	11.49 * L0.32 * t-0.5		Weaver (1963)
Cutthroat	n/a	n/a	6 feet/sec	2.5 feet/sec	Bell (1991)
Rainbow	103--280	n/a	7.16 * L0.77 * t-0.46		Bainbridge (1960)
Rainbow	103--813	7--19	12.8 * L1.07 * t-0.48		Bainbridge (1960); Weaver (1963); and Beamish (1978)
Rainbow	610--813	7--19	12.3 * L0.52 * t-0.51		Weaver (1963) and Beamish (1978)
Rainbow	30--300	n/a	15.88 * L0.81 * t-0.5		Webb (1977)
Rainbow	60--200	10		3.28 * L0.37 * t-0.1	Fry and Cox (1970)
Arctic Char	70--420	9--10	Apply juvenile salmon	3.74*L^0.606*t^-0.13	Welch (1979) and Beamish (1980)
Arctic Char	70--420	9--10	Apply juvenile salmon	2.69*L^0.606*t^-0.08	Welch (1979) and Beamish (1980)

Where L equals total length of fish in meters and t equals the duration of the swimming effort in seconds.

35.3 - Spawning Habitat and Road Crossing

Install bridges or open-bottom culverts to protect and maintain known spawning sites. Disturbance of the stream bottom should be minimized. Gravel substrates associated with pool tail crests are preferred spawning areas. Flood plain, palustrine, estuary, and moderate gradient-mixed control channel types often contain extensive sections of gravel where spawning may occur. It is critical to maintain all available spawning habitat where fish abundance is limited by suitable spawning habitat.

Where spawning may occur but has not been observed, mitigation should be considered in the culvert design. The concurrence process described in the Supplemental Memorandum of Understanding should be used to identify mitigation measures for stream crossings requiring protection of spawning gravels.

Table of Contents

Projects to restore or improve aquatic habitats may be implemented at the site level or watershed level. However, all projects should initially consider the broader watershed scale early in the planning process; for example, by considering how existing conditions of upstream and upslope areas may affect conditions at the site level. Broad understanding of erosion processes, hydrology, channel morphology, water quality, species distribution, biotic community composition, and human uses of the watershed will support informed decision making at the project level.

41 - FISH HABITAT IMPROVEMENT PRACTICES

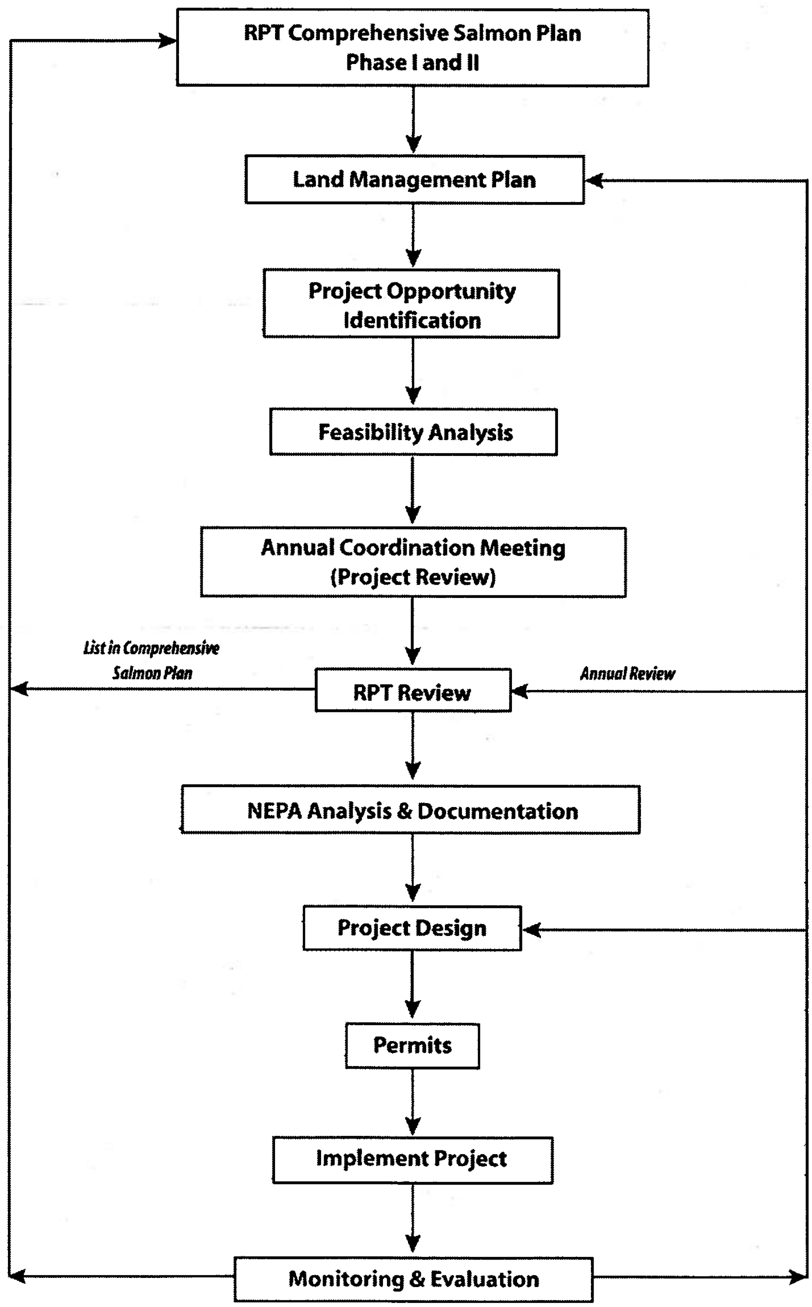
Fish habitat enhancement projects are generally designed to increase production of a specific fish population in a specific location. Enhancement activities generally aim to provide fish for harvest opportunities in the common property fishery, although individual fisheries may be targeted. For example, managers may conduct lake fertilization to boost sockeye salmon production for a subsistence fishery, or enhance chum salmon habitat in an important brown bear feeding area. Examples of projects that are not contributors to the common property fishery are recreational fishing projects and projects designed to enhance threatened, endangered or sensitive fish such as northern pike in Yakutat's Pike Lakes.

The majority of the fish habitat enhancement projects implemented in the Alaska Region are cooperative projects involving multiple agencies and organizations. The costs of the projects are shared in a variety of ways depending on such factors as budget levels and priorities, availability of personnel and equipment, fish brood stock availability at various hatcheries, and proximity of other projects to the proposed project location. Project success requires coordination and commitment at all levels of participating agencies and organizations.

41.1 - Project Planning

Fish project planning is an orderly process developed to ensure National Environmental Policy Act compliance, coordination with Alaska Department of Fish and Game and other fish enhancement cooperators, and proper phase development in the budget and contract processes 41.1 - (Exhibit 01). The process is described in the *Tongass National Forest Cooperative Fisheries Enhancement Planning Process* (1993 revision). Its purpose is to establish a consistent, Regionwide, process for planning fish projects (41.1 - Exhibit 01).

41.1 – Exhibit 01
Fish Project Planning



41.11 - Project Opportunity Identification

Fisheries enhancement opportunities are proposed on the Fisheries Project Opportunity Identification Form (41.11 - Exhibit 01), and then reviewed by the Forest Fish Biologist and by appropriate groups or agencies including the Alaska Department of Fish and Game. This review is the basis for the next step, the feasibility analysis.

41.11 – Exhibit 01
Fisheries Project Opportunity Identification Form

Date:	
Proponent:	
Organization:	
Project Name:	Type of Project:
Describe Location:	ADF&G Stream No.:
Access to the Site:	
Attach Map of Project Location:	
Briefly describe the opportunity including the purpose, benefiting species, potential user groups, and projected amount and type of habitat to be improved. Attach schematics maps/photos of proposed project, if appropriate; Describe relationship to any of the projects.	
Land Ownership, Status, and Classification:	
Habitat surveys and watershed condition surveys presently available (list):	
Available data on indigenous species and stock status:	

41.11 – Exhibit 01--Continued

Specialists in the following disciplines and/or representatives of the indicated organizations should review and comment on the proposed projects.

Alaska Department of Fish and Game		USDA Forest Service	
	Commercial Fish Division		Ecology
	FRED Division		Archaeology
	Habitat Division		Fish
	Sport Fish Division		Geology
			Hydrology
Aquaculture Association			Recreation
	Northern Southeast		Soils
	Southern Southeast		Subsistence
			Timber
			Wilderness
			Wildlife
			FS District Office (if not the initiator of the project)

Comments:

41.12 - Feasibility Analysis

The project proponent and cooperators prepare a feasibility study, usually to determine factors that might preclude project development. The following areas should be examined:

1. Does the project have physical limitations?

2. Are there any significant biological problems?

3. Are there social or political considerations?

4. Is the project economically feasible?

5. Is the project compatible with the forest planning process, Forest Service policy, and other agency and organization plans or policies?

6. What is the land status/classification of the project area? As examples:

   a. Is the proposed project in a special use authorization area?

   b. Are there rights-of-way, encumbrances or restrictions?

   c. Is the area within a designated or recommended Wild and Scenic River or a study river (See FSM 2354.7 Procedure for Evaluation of Water Resources Projects)?

   d. Is the land designated as wilderness? (See FSM 2323.3 for further information on developing a fish project in a designated wilderness area or wilderness study area.)

7. What are the potential benefits to users and the potential conflicts between user groups?

Considerable feasibility information can be obtained through formal and informal consultations with individuals or groups. Level of support for a project can often be determined in advance through these contacts.

41.2 - Fish Enhancement Project Types

The types of fish habitat improvement (or fish enhancement) projects implemented in the Alaska Region during the past 20 years include:

41.21 - Small Instream Structures (large woody debris (LWD), gabions, and so forth)

Small structures are sometimes constructed in stream channels to improve rearing habitat for salmon. Juvenile coho, chinook and sockeye salmon and steelhead trout usually require 1-4 years of rearing in freshwater before migrating to saltwater where they mature. Instream structures, often constructed of logs or rock, provide cover to protect fish from predators, increase water depth during summer and winter low flow periods, and provide shelter from high streamflows. This helps salmon and steelhead fry and char to survive better and increase the numbers of juveniles migrating to the ocean.

Although individual structure costs can be low, large numbers of structures may be needed to significantly change the habitat. Structures have a design life ranging from 5 to 25 years.

41.22 - Fishways

Fishway structures are constructed at stream barriers to allow salmon and trout passage to upstream spawning and rearing habitat. Barriers can be partial, with some adult salmonids passing during specific water flows, or the barriers may be total, blocking salmon migration at all water flows. The exact number of barriers on streams throughout the Tongass National Forest is unknown. However, fisheries habitat managers believe there could be more than a thousand unidentified barriers on streams on the Tongass National Forest. As barriers are identified, site-specific analyses are conducted to determine feasibility and cost effectiveness of fishway construction and any potential negative effects to fish already resident in the stream. Many barriers have been identified on streams that have too little available habitat upstream to justify investment in a fishway structure.

Most fishways built since 1980 have survived high flow periods and pass fish as designed. Fishways often require modifications following initial construction to ensure fish passage. Periodic maintenance is required to remove debris from the ladders and jump pools. Most fishways are constructed with an average design life of 25 years. Fishways are generally expensive to construct but can have benefit/cost ratios as high as 13:1 when favorable salmon and steelhead trout spawning and rearing habitats exist above the barrier.

Bioenhancement is sometimes associated with fishway construction. Salmon eggs taken from below the barrier or from nearby streams are incubated in hatcheries, and the resulting juvenile fish are released into the stream and/or lake habitat above the newly constructed fishway. Bioenhancement promotes establishment of runs of adult spawners.

41.23 - Barrier Modification

Falls modification is the means by which either a partial or total barrier to salmon migration is altered to enhance fish passage. This is usually accomplished by creating small pools in the falls or high velocity chutes. These pools may be created in the natural bedrock or by construction of low concrete walls. Monitoring of salmon passage under various flow conditions is often needed to determine if the falls modification has been successful or if further modification is needed. Bioenhancement is sometimes required to ensure early establishment of runs of adult spawners.

41.24 - Spawning Channels

Spawning channels are constructed to provide stable spawning and rearing habitat for salmon. The most common approach in Southeast Alaska is to excavate a channel adjacent to a stream such that the channel provides fish access to the main stream. Intercepted ground water, in areas of upwelling, provides flowing water for the constructed spawning channels. Spawning channels can be low cost projects with benefit/cost ratios as high as 8:1.

Spawning channels may receive bioenhancement in the form of adult salmon transfers into the channel. Blocking the spawning channel connection to the mainstream usually results in the transferred salmon spawning in the channel.

Spawning channels can be a cost-effective method to improve egg-to-fry survival of salmon, but require thorough hydraulic, biotic, and hydrologic analysis and precise engineering.

41.25 - Rearing Ponds/Off-Channel Rearing

Rearing ponds can increase quantity and often quality of rearing habitat for juvenile salmon compared to natural stream systems. Ponds are constructed near a stream system and connected to the stream by ditches or channels. Juvenile salmon rearing in the stream move into the more favorable pond habitat.

The cost of rearing-pond construction varies considerably. Some ponds are constructed during road gravel excavation projects, while other ponds are constructed solely for the purpose of rearing salmon.

Rearing ponds may provide a cost-effective means of increasing the size and number of juvenile coho salmon produced. Rearing-ponds require continuous monitoring using quantitative techniques to accurately determine the contribution of pond reared salmon to the common property fishery. However, pond depth, cover, flow regime, oxygen, inlet and outlet control, and access are among factors that influence seasonal survival rates of salmon in constructed ponds.

41.26 - Bioenhancement (stocking)

41.26a - Barren Lake Stocking

Barren lake stocking consists of release of immature salmon in lakes that do not have natural runs of salmon because of barriers. The stocked juvenile salmon rear in the lakes until emigrating to saltwater where they mature. Total harvest of these salmon is intended since natural reproduction is not possible. Generally the barriers do not prevent the out migration of salmon smolts. Survival of juvenile salmon in lakes can be as high as 65 percent or as low as 1 percent depending on the lake, the species released, and disease associated with the species and the lake.

41.26b - Cooperative Fish Stocking

Stocking of lakes and streams generally seeks to augment other enhancement projects by seeding new habitat with young salmon. The objective is to establish self-perpetuating wild runs of salmon.

41.26c - Incubation Boxes

Incubation boxes are used in remote locations to incubate Chum salmon eggs. These devices are similar to incubation systems used in fish hatcheries but operate with little maintenance. Unlike incubation systems in hatcheries, salmon fry emerge from the incubation boxes into a stream or lake. Use of incubation boxes increases egg-to-fry survival over levels commonly observed in stream gravel.

Incubation boxes can be moderately expensive. However, survival of salmon eggs to fry is about 70 percent and maximum production has been measured at 98 percent. Benefit/cost ratios can be as high as 20/1.

41.26d - Lake Fertilization

Some lakes exhibiting low levels of fertility and high potential for salmon production may be enriched by commercial fertilizers. The objective of lake fertilization is to enhance primary food production and increase the size and survival of salmon fry. Enriching lake nutrient levels may measurably increase the number and/or size of out-migrating juvenile salmon, resulting in increased availability of adult salmon for harvest. Lakes self-fertilize as large adults bring nutrients from the sea. Lake fertilization, a relatively expensive enhancement technique, requires detailed pre and post-fertilization monitoring. However, large increases in salmon production are often realized. Benefit/cost ratios can be as high as 4:1. Bioenhancement (stocking of salmon fry) is often conducted in association with lake fertilization.

41.27 - Debris Removal

Debris removal was used extensively during the 1970s to remove possible barriers to upstream migration of adult salmon and to increase available spawning habitat. Unfortunately, debris removal eliminated much beneficial large woody debris (structure) from stream channels. This work may have provided short-term benefit to pink and chum salmon because their young leave the stream ecosystem immediately upon emerging from the gravel substrate. In contrast, salmon species requiring instream-rearing habitat during the early portion of their life cycles probably declined as a result of debris removal practices. Studies show that large woody debris adds diversity to stream ecosystems and in most instances is beneficial to the production of salmon in those systems. Wood is an integrate component of stream ecosystems and recruitment of wood instrumental to channel forming processes. Clusters of wood may form persistent barriers to fish movement.

Accumulations of debris at the outlets of lakes have blocked migration into the lake and the associated habitat in the streams above the lake. Removal of the blockage restored salmon access throughout the watershed. Benefit/cost ratios in such exceptions are calculated to be as high as 100:1.

41.28 - Weir/Stock Assessment

This activity evaluates the success of previously completed projects by establishing the common property harvest of fish produced by completed projects. In addition, this activity can support fisheries subsistence management and develop trend information of escapement and production of indicator streams.

42 - RESTORATION PRACTICES

42.1 - Watershed Restoration

Watershed restoration is the process of improving the existing condition of watersheds. It is completed using the ecosystem approach to forest management and addresses maintenance of biological diversity and maintenance of long-term productivity and sustainable levels of renewable resources. As stated in Alaska Region Best Management Practice 12.3, the purpose of watershed restoration is "to improve degraded watershed conditions, to minimize soil erosion, and to improve water availability and quality."

A watershed analysis should precede watershed restoration project planning. Information acquired during watershed analysis will guide the design of the restoration measures.

Important elements of watershed restoration include:

1. Restoration of form and process in tributary (headwater) streams that deliver sediment and LWD to larger channels.

2. Stabilization and revegetation of slope erosion, including areas of mass movement.

3. Control and prevention of road-related runoff and sediment production.

4. Stream channel structural habitat improvement.

5. Management of the structure and composition of vegetation to restore riparian function.

Some of these elements, such as control of road sediment production, may be addressed individually as site-specific projects. However an ecosystem approach to land management requires a comprehensive watershed restoration program based on a thorough understanding of the functions and processes occurring in specific watersheds.

42.11 - Slope Erosion. (Reserved)

42.12 - Road Sediment. (Reserved)

42.13 - Stream Channel Structural Habitat Improvement

Log and rock placement in stream channels has proven to be an effective tool in restoring fish habitat within stream channels. These structures are commonly installed to provide increased pool density and depth, to provide refugia from fast streamflow, and to provide hiding cover. However, it is critical that structures are designed to conform to site hydrologic conditions.

42.14 - Riparian Rehabilitation

Riparian rehabilitation projects manipulate vegetation to accelerate seral stage development. Emphasis is often to accelerate growth of large conifers for future sources of large woody debris by thinning to release selected conifers from sunlight and nutrient competition.

Take care to maintain a vegetative species mix that includes deciduous trees, particularly in close proximity to the streambank. The deciduous trees are important sources of detritus, providing allocthonous inputs for aquatic invertebrate productivity and important sources of terrestrial invertebrates eaten by juvenile salmonids (Whipfli et al. 1997). Alder is highly regarded for its nitrogen contribution to the aquatic ecosystem. Cottonwood can also be important for providing large wood to the stream channel more quickly than conifers for a given diameter tree. Additional work can include microsite development, planting of conifers, and road treatments.

Large wood plays an important role in stabilizing banks, moderating the transport of sediments downstream, and forming pools. How a piece of wood functions in a stream depends on its size relative to the size of the stream. In very large rivers, a small piece of wood may not stay in place as long as a big piece or a cluster of pieces, and is not likely to play as important a role in bank stabilization and pool formation. Large wood pieces big enough to have important geomorphic functions are called key pieces. The size of a key piece depends on the size of the stream in which it is found (42.14 - Exhibit 01).

42.14 - Exhibit 01

Large Woody Debris "Key Piece" Minimum Size Criteria
by Stream Channel Width

Average Channel Bed Width	Diameter	Stem Length	Rootwad Diameter and Length
(meters)	(meters)	(meters)	(meters)
0 - 4.9	0.3	> 3	> 1
5 - 9.9	0.3	> 7.6	> 3
10 - 19.9	0.6	> 7.6	> 3
≥ 20	0.6	> 15	> 3

43 - PROJECT PLANNING AND HABITAT CAPABILITY

Coho salmon are used as indicators of habitat potential production or "capability." Coho smolt production estimates by channel type (43 - Exhibit 01) are based on survey data and are useful for estimating fish enhancement and watershed restoration potential outputs.

Project life expectancy is based on monitoring of existing projects (43 -Exhibit 02). Life expectancy estimates, while useful for calculating project cost/benefit ratios, should not replace local knowledge and experience. Actual life of a project may vary over a range of time depending on site-specific conditions and design criteria.

43 - Exhibit 01

Coho Model Production Co-efficient Estimates

Channel Type by Process Group	**Coho Coefficient** *(smolts/ft)*	**Channel Type by Process Group**	**Coho Coefficient** *(smolts/ft)*
Estuarine		**Alluvial Fan**	
ES1	0.00	AF1	0.02
ES2	0.00	AF2	0.00
ES3	0.00	AF8	0.00
ES4	0.00		
ES8	0.00		
Palustrine		**Low Gradient Contained**	
PA1	0.52	LC1	0.20
PA2	0.51	LC2	0.19
PA3	0.96		
PA4	1.60		
PA5	4.83		
Flood Plain		**Moderate Gradient Mixed Control**	
FP1	0.19	MM1	0.04
FP2	0.33	MM2	0.10
FP3	0.19	**Moderate Gradient Contained**	
FP4	0.45	MC1	0.03
FP5	0.29	MC2	0.05
		MC3	0.00
Glacial Outwash		**High Gradient Contained**	
GO1	0.00	HC1	0.01
GO2	0.00	HC2	0.01
GO3	0.00	HC3	0.01
GO4	0.00	HC4	0.01
GO5	0.00	HC5	0.00
		HC6	0.00
		HC8	0.00
		HC9	0.00

43 - Exhibit 02

Project Life Expectancy

Project type	Project life (yrs)
Stream rehabilitation, stabilization	10
Barrier modification	25
Fishway	
Alaska steeppass (high bedload)	25
Alaska steeppass (low bedload)	0
Major construction fishway	25
Major construction fishway	50
Barren lake habitat utilization	3
Spawning channel	10
Rearing ponds/off channel rearing	50
Lake fertilization	annual

8

Table of Contents

51 - ROAD CONDITION SURVEY

Road construction, presence and maintenance can negatively affect the function of downslope aquatic ecosystems and the quality of the fish habitats provided by the aquatic ecosystem. The *Anadromous Fish Habitat Assessment* report expressed concern about the negative effects of road construction and maintenance on fish habitat. Roads can potentially create areas of hillslope instability resulting in landslide generation, contribute fine sediment from surface erosion, block fish migration, and alter surface and subsurface water flow patterns.

The road condition survey (FSH 7709.58-98-1, chapter 12.5) is a monitoring tool for determining potential risk to aquatic ecosystems within the watershed. Application of the road condition survey will identify both general risks and site-specific problems that may have either a direct or cumulative effect on the aquatic ecosystem.

51.1 - Fish Passage Monitoring (Reserved)

52 - HABITAT IMPROVEMENT MONITORING (Reserved)