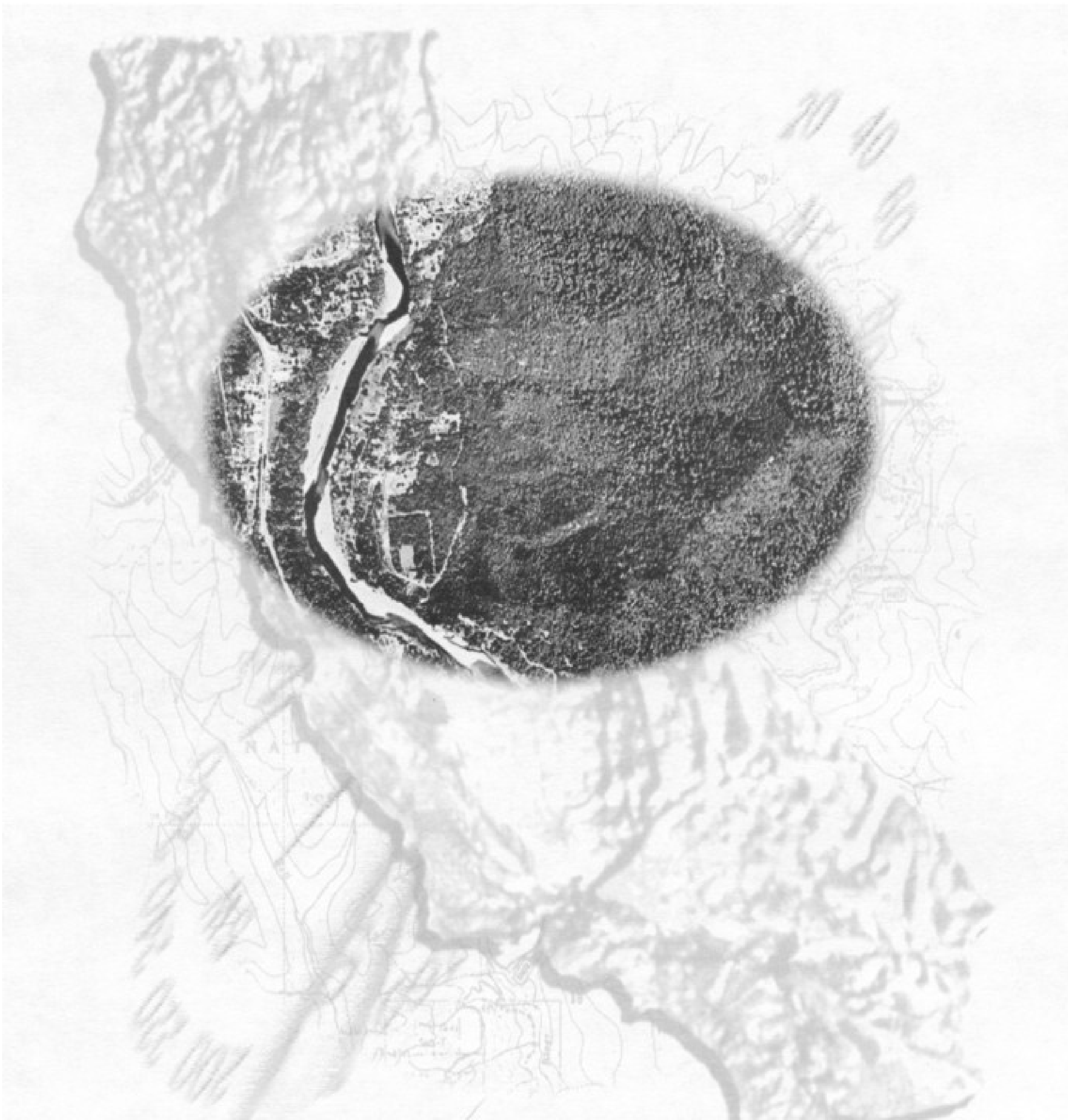
CALIFORNIA SALMONID STREAM HABITAT RESTORATION MANUAL

PART II

PRELIMINARY WATERSHED ASSESSMENT



PART II PRELIMINARY WATERSHED ASSESSMENT

To get the big picture relative to present and potential fish production in a stream or stream system it is necessary to first understand the processes at work in the watershed. Geology, topography, precipitation, soils, vegetation, and human impacts working together comprise the watershed. Watershed is defined as the total land area draining to any point in a stream, as measured on a map, an aerial photo or other horizontal plane. A watershed can also be called a catchment area, a drainage area, or a basin.

An important part of any watershed assessment includes becoming familiar with various types of maps and their uses, historical stream surveys, literature and file reports on sediment sources, hydrology, water appropriations and impoundments, timber and other resources, management practices, and with zoning or other restrictions. This should be accomplished before entering into a formal field survey.

The data gathered in the watershed assessment will:

- Provide basic information on past and present land and other natural resources management, and on present and potential fish production;
- Provide statistical information on water and fish habitat quantity and quality;
- Aid in assessing needs for additional studies;
- Provide a basis for development of fish habitat or artificial production projects and necessary project evaluation procedures.

WATERSHED OVERVIEW

Often, most of the information necessary for a watershed assessment can be gathered prior to going into the field. This information can be entered on the "Watershed Overview Work Sheet," then entered into a database for analysis and storage. If a computer is to be used for storage and analysis, a dBASE IV file, Watershd.dbf, is available from Inland Fisheries Division on diskette. The database structure is described in Appendix I.

Tools and Supplies

- Maps and aerial photographs. United States Geological Survey (USGS) 7.5-minute topographic maps (quadrangles) are the minimum required.
- Planimeter
- Map measuring tool (map wheel)
- Topographic map template (dot grid overlay)
- Latitude and longitude calculator (Coordinator brand)
- Calculator
- Computer
- Watershed Overview Work Sheet

Instructions for Completing the Watershed Overview Work Sheet

1) **Date** - Enter the day's date (mm/dd/yy).

2) **Investigator** - Enter the name of the person responsible for the data on the work sheet.

3) **Stream Name** - Name of the stream as it appears on the 7.5-minute USGS quadrangle.

4) **PNMCD:** Enter the official numeric code for the stream according to the EPA River Reach File. EPA River Reach file is available by writing to:

Office of Wetlands, Oceans and Watersheds
Assessment and Watershed Protection Division
401 M Street
S.W. Washington, D.C. 20240.

5-8) **Tributary to** - Starting at the subject stream's mouth working downstream to the ocean or a terminal lake, describe the downstream tributary system. Examples: 1) Hollow Tree Creek, tributary to the South Fork Eel River, tributary to Eel River; 2) Eel River, tributary to the Pacific Ocean.

9) **County** - Record the county or counties through which the stream flows.

10) **USGS Map** - Enter the name(s) of the 7.5-minute USGS quadrangle containing the stream surveyed beginning at the mouth and progressing to the headwaters.

11) **Location** - Record township, range, and section (preferably quarter section) at the mouth of the stream, or at the lowest point of the stream reach surveyed. Also record the latitude and longitude of the survey starting point. This information can be derived from the 7.5-minute USGS quadrangle using the Coordinator tool (Appendix M).

12) **Access** - Describe the route used to access the stream or stream reach surveyed. Mention trails, roads, locked gates, who controls the gates and a phone number, if possible. List any other special access considerations. Use the other side of the sheet, if needed.

13) **Hydrologic Basin Planning Delineation** - The State Water Resources Control Board (State Board), Regional Water Quality Control Boards (Regional Boards), the Department of Water Resources, and the USGS have agreed on a standard method of delineating surface water drainage areas in California. Enter the 5 digit Hydrologic Sub Area Number (HSA) from the Water Resources Control Board hydrologic basin planning maps. See Appendix C for information on the maps and where to get copies.

14) **Aerial Photos** - Enter the photo numbers, years, and source of any available aerial photos. A list of sources for aerial photos is given in Appendix D.

15) **Stream Order** - Stream order is a classification based on the branching pattern of river systems (Strahler 1957). A first order stream is defined as the smallest un-branched tributary to appear on a 7.5-minute USGS quadrangle (1:24,000 scale) (Leopold et al. 1964). This system includes only perennial streams (i.e. those with sufficient flow to develop biota). When two first order streams join, they form a second order stream. Then, when two second order streams join, they result in a third order stream; and as streams of equal order meet they result in a stream of the next higher order (Figure II-1).

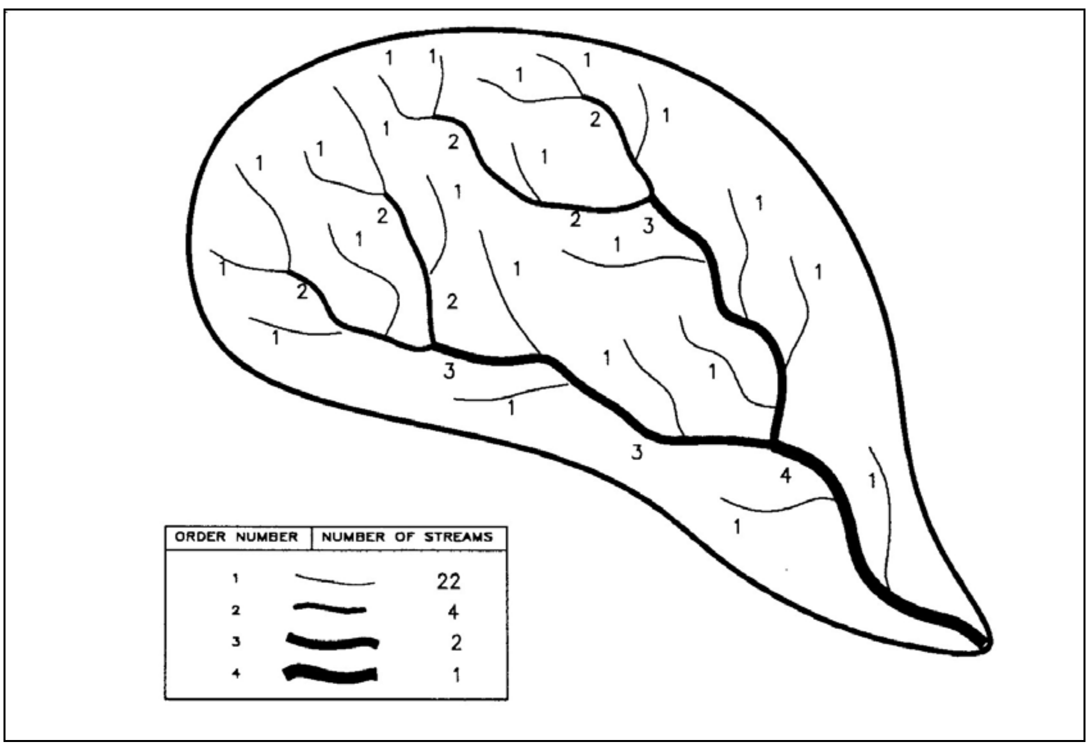


Figure II-1. Stream order designation (Strahler, 1957).

16) **Total Length** - Enter the total length of the perennial stream. This can be approximated using a map measure and a 7.5-minute USGS quadrangle.

17) **Drainage Area** - The drainage area includes all area that drains to the subject body of water. Drainage divides follow ridges and saddles and cross contour lines at right angles (Figure II-2). Compute the total drainage area in square miles using a planimeter, or a dot grid overlay, available from most drafting supply stores, and a 7.5-minute USGS quadrangle.

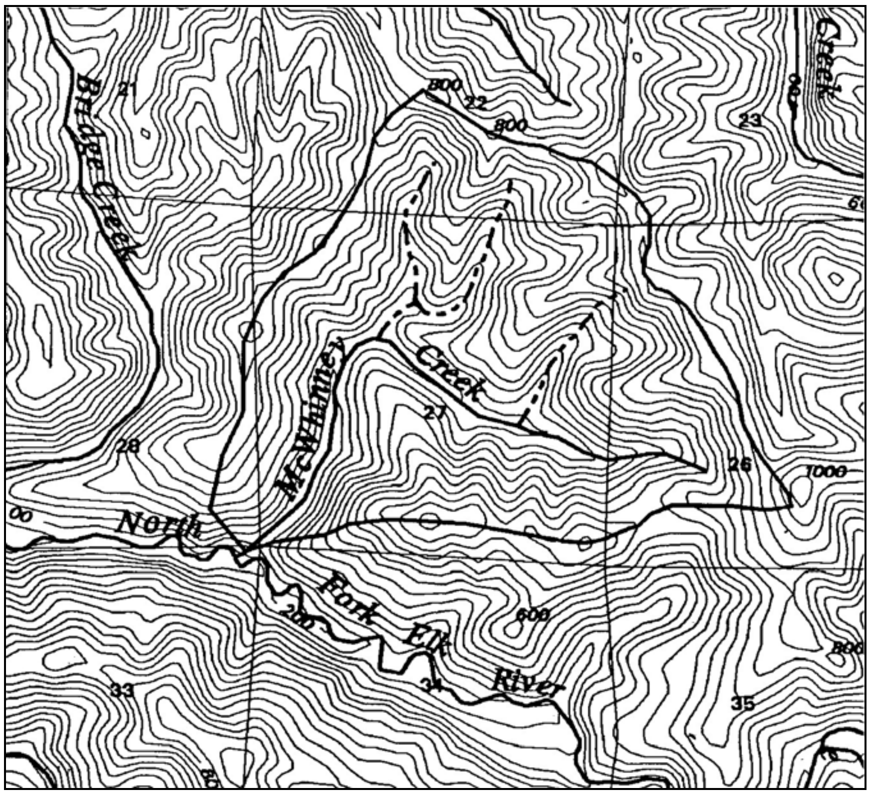


Figure II-2. Drainage area calculation.

18) **Summer Base Flow** - Summer base flow, as used here, is the lowest flow recorded in a given year. If base flow information is available, record it in cubic feet per second (cfs). Enter the source of your information; whether it was an estimate of the flow, or measured with an instrument; and the date of the sample.

19) **Elevations** - Record the elevation at the stream's mouth and the approximate elevation of the headwater areas at the basin crest. These elevations can be obtained from USGS topographic maps.

20) **Lakes in Watershed** - Record the number and square miles of lakes in the watershed (preferably using a 7.5-minute USGS quadrangle and a planimeter).

21) **Fish Species** - List the fish species known to exist in the stream using existing surveys on file with DFG, USFS, etc. This may be updated if found to be incorrect, or if conditions are found to have changed since the previous surveys. Use the abbreviations for names of fishes and invertebrates found in Appendix E. Also include data source, survey technique, and date. For example: DFG files Eureka, electrofishing, 1991.

22) **Endangered/Threatened/Sensitive Species** - Record any listed species known to exist in this watershed. Include your data source and date. The State of California "List of State and Federal Endangered and Threatened Fishes and Crustaceans," (Revised October 1996) is included as Appendix F. This list is maintained by DFG Natural Heritage Division (NHD) and is revised quarterly (January, April, July, and October). Current copies of the list may be obtained from NHD or other divisions and regional offices. In addition all species identified in "Fish Species of Special Concern of California" by Moyle, Williams, and Wikramanayake need to be considered as well as other aquatic species included on the "Special Animals" list maintained by the Natural Diversity Data Base (NDDB) in NHD.

23) **Endemic Stocks** - Endemic stocks are defined as "only historic naturally reproducing fish originating from the same stream or tributary." If the stream is known to have an endemic stock, specify the fish species and the data source and date.

24) **Fishery Management Concepts** - Record the management which best describes the stream. In some cases there may be more than one. This information is available by contacting the DFG District Biologist.

- Cold Water: All cold water non-anadromous fish species.
- Anadromous: Any fish species that migrates upstream from the ocean to spawn.
- Warm Water: All warm water fish species.
- Natural Production: Naturally reproducing stocks from the drainage or from stocks outside the basin of which the stream is part.
- Mixed Production: Stocks include natural production and hatchery produced fish from streams within or from outside the basin.
- Other: If there is a special circumstance that does not fit into any of the above categories. Be specific.

25) **Stream Flow Data** - If flow data has been collected enter **T** for true or, if not enter **F** for false. A list of gauging stations is available from the Department of Water Resources. Other potential sources for flow data include the USGS, USFS, DFG, local water districts, power authorities, and private consulting firms. Enter the source and date of your information.

26) **Water Quality Data** - Enter **T** if data has been collected, or **F** if it has not been collected on that watershed. If true enter the source and date of your information.

27) **Ownership - Federal, State, Private** - Measure and enter the total stream miles that are federal, state, or privately owned. This information can be obtained from the county parcel maps at the county courthouse. Add any pertinent information such as "the entire watershed is under ownership of one timber company," or "there are multiple private landowners," etc.

28) **Major Land Uses in Watershed** - Enter major uses with the codes listed below in parentheses. More than one code can be used. These codes correspond with entry fields in the DFG Watershd.dbf database, described in Appendix I.

- (1) Road development
    - (1a) Paved roads
    - (1b) Unpaved roads
    - (2) Timber harvest
    - (3) Mining
    - (3a) Open pit
    - (3b) Hard rock
    - (3c) Suction dredge
    - (4) Agriculture
    - (4a) Livestock grazing
    - (4b) Land under cultivation

- (5) Wilderness
    - (5a) Federal wilderness area
    - (5b) State park or wilderness area

- (6) Water developments
    - (6a) Large hydroelectric facility
    - (6b) Small hydroelectric facility
    - (6c) Diversion
        - (6c1) Water exported out of basin
        - (6c2) In basin

! (7) Developed recreation
    - (7a) Ski areas
    - (7b) Campgrounds

- (8) Dispersed recreation
    - (9) Urbanization
    - (10) Off highway vehicle area

- (11) Other, explain in additional information

29) **Comments** - Enter comments required to clarify any entries.

WATERSHED OVERVIEW WORK SHEET

Date ________/________/________ **Investigator** ______________________________
Stream Name ______________________ **PNMCD** ______________________
Tributary to ______________________ **Tributary to** ______________________
Tributary to ______________________ **Tributary to** ______________________
County ______________________ **USGS Quad** ______________________

Location T _____ R _____ S _____ **Latitude** ______________ **Longitude** ______________

Access Via ____

Hydrologic Boundary Delineation ______________________________

Aerial Photos (Source) ____
____

Stream Order ______________________ **Total Length** ________________ miles

Drainage Area ________________ sq. mi. **Summer Base Flow** ________________ cfs

Elevations Mouth ________________ feet Headwaters ________________ feet

Lakes in Watershed Number ____________ Surface Area ________________ sq. mi.

Fish Species (Data Source) ____,
______________________________, ______________________________,
______________________________, ______________________________,

Endangered / **Threatened** / **Sensitive Species** (Data Source)
______________________________, ______________________________,

Endemic Stocks (Data Source) ____

Fishery Management Concept
Cold Water: Natural Production ______________________
Mixed Production ______________________
Anadromous: Natural Production ______________________
Mixed Production ______________________
Warm Water: ______________________________
Other: ______________________________

Stream Flow Data (Source) ____
____

Water Quality Data (Source) ____
____

Ownerships in Stream Mi. Federal ______.______ State ________.________ Private ________.________
Additional Information ____

Major Land Uses in the Watershed: __________, __________, __________, __________, __________
Additional Information ____

Comments ____
____

MAPS AND THEIR USES

Maps are among the most basic sources of watershed information. There are many types of maps, each depicting its own set of information on a watershed. The more useful types include geologic, topographic, soils and vegetation, land use, and isohyetal maps.

Geological survey maps show the general geologic and other significant land form and landmark features in a watershed. They are available directly from USGS. University libraries usually have a good selection of USGS maps, both topographic and geological.

Topographic maps use elevation contours, which are lines joining areas of equal elevation to show total relief, slopes, and drainage patterns. Topographic maps, such as the USGS 7.5 and 15 minute series, also indicate streams, lakes, and major human features such as roads, railroads, and settlements.

Soils and vegetation maps are available from the United States Natural Resources Conservation Service (NRCS). A knowledge of soil types in a watershed will help understand and evaluate infiltration, runoff, slope stability, and soil susceptibility to erosion. Vegetation found in an area depends on soil type, climate (precipitation and temperature), topography, and natural or human surface disturbances. The combination of geology, topography, soils, climate, vegetation, and disturbance determines slope stability. Modification of vegetation by fire, logging, ranching, road building, or other disturbances can increase erosion and have severe consequences to soils, runoff, and groundwater storage capacity in a watershed.

Land use and ownership maps can help identify human activities which may have major impacts on a watershed. National Forest maps indicate boundaries between federally owned forest land and private land or other lands. BLM also can provide very good land ownership maps. Common human activities that can disturb a watershed include mining, grazing, timber harvest, agriculture, recreation, and urbanization. Knowing land uses in a basin will provide general comprehension of the present and probable future human impacts on the drainage. Ownership maps will indicate parties responsible for management of land within the watershed, and the initial contact for access permission for field surveys or restoration project construction.

Isohyetal maps depict average yearly precipitation rates for specific areas within a watershed. Lines on the map join areas of equal precipitation and basic human and geographic features are usually shown. Used in conjunction with precipitation charts for a weather station in or near the watershed, it is possible to estimate the total amount, intensity and seasonality of precipitation. This data can then be used to predict the timing and magnitude of normal annual stream discharge, or normal frequency of exceptionally high or low flows in any given time period.

USGS publishes an index to topographic and other map coverage. This index and the different types of maps published by USGS may be obtained from:

Western Mapping Center
U.S. Geological Survey
345 Middlefield Road
Menlo Park, CA 94025

AERIAL PHOTO INTERPRETATION: HISTORICAL SEQUENCE

Aerial photographs (air photos) present the view looking straight down from an aircraft to the ground. Orthophotoquads are black-and-white photo images prepared from air photos that have been adjusted to eliminate image displacement.

Image displacement is caused by distortion of distances near the edge of air photos. This distortion occurs because the center of the photo is directly underneath the camera in the airplane but the edges of the photo are not. This causes a slight distortion of the distances at the edge of the photo (they appear slightly longer as compared to distances at the center of the photo). Therefore, there is a slight difference in the scale at the edge of the photo compared to the center.

Orthophotomaps are multicolor orthophotoquads which have had extensive cartographic treatment including contours, lettering, and some symbols. Orthophotoquads, orthophotomaps, and aerial photographs are especially valuable when used in conjunction with topographic maps, soils and vegetation maps, and geologic maps.

Historical photo sequences from earliest to most recent can provide an important perspective and greatly add to understanding present conditions in a watershed. By inspecting photo sequences of an area from the oldest to the most recent, a careful observer can obtain an overview of natural or human induced land disturbances, and of changes in land uses and vegetation. Stereo images which can be produced optically by viewing overlapping photos through a stereoscope are especially good for observing topography, mass erosion sites and riparian areas.

Significant factors or possible resource problems that can be revealed through review of aerial photos include large burned areas, dams and diversions, urbanization, roads, stream crossings, landslides and their possible causes, other major erosion areas, timber management practices, riparian vegetation, stream channels, estuarine areas, and altered drainage patterns. These and other observed phenomena can have major impacts on a fishery resource. A review of this kind can suggest possible fishery restoration or production priorities before ever stepping into the field. However, field review is certainly a necessary next step to verify suspected watershed problems before any prioritization or design can occur.

USFS and private timber companies with large land holdings keep up to date inventories of air photos covering their lands. Private air photo companies, county planning departments, municipal water districts, CDF, DFG, city and county planning departments, Indian reservations, local colleges and universities, NRCS, BLM, and other natural resource agencies are all potential sources of air photos. See Appendix D for a list of aerial photographic sources.

HISTORICAL STREAM SURVEY REVIEW

After completing a map and air photo assessment, a thorough review of previous surveys that have been conducted on the project stream is in order. This review will summarize information currently available from various agencies on the history of the stream and will provide important background for development of a restoration or enhancement plan.

Most state and federal agencies that manage fisheries have a file of old stream surveys for every stream in their jurisdiction. These surveys can have a variety of formats and may be confusing to the inexperienced person. In most cases useful information can be obtained from them. For example, virtually all surveys include a rough description of the fish habitat accessibility and availability, usually in the form of migration barrier locations and a pool to riffle (P:R) ratio. In addition, surveys usually give an indication of the species and sizes of fish that occupy a stream and their relative abundance. These are typically very rough estimates and it should not be assumed that all stream surveys are accurate. However, they can be useful indicators of what to expect during the stream inventory.

Many stream surveys have a hand-drawn or photocopied map included with them on which various physical stream characteristics are located. Some items which can prove to be important and should be carefully noted are survey access points, tributary confluences, and other land features which can provide location points. Other physical features which are often included on the map or in the text of the survey, and which are important to note are: fish migration barriers, road crossings, water diversions, major landslides, log debris accumulations, dams, etc. The condition and size of the features as well as the date of the survey on which they were first identified should be noted. Information from previous surveys can be very useful for purposes of comparison when the stream inventory is conducted. Some previously reported problems, especially fish migration barriers, could be high priority treatment sites for habitat restoration activity and should be verified during the habitat survey.

WATER

The most basic habitat requirement for salmonids is water. As the human population of California increases, there is a growing demand for water for human needs. Even in rural watersheds the number and degree of water extractions from streams or ground water can impact flows needed to sustain fish. Landowners and managers can "own" water rights granted by the State Water Resources Control Board. A water right can be in the form of deeded access to a spring, for example, or an impoundment, a "riparian" water right, or an agricultural stream diversion. They are granted in terms of pipe flow, cubic feet per second, or even in acre feet per year. Additionally, in some areas of rural California, a considerable amount of water is taken from small streams without a water right.

All these extractions have an effect on the aquatic system (in some cases de-watering small streams in summer) so it is important to determine the extent of water use within a watershed. The California Department of Water Resources (DWR) maintains impoundment and diversion records, which are available in report, database, or Geographical Information System (GIS) formats. The Water Resources Control Board grants water rights and maintains those records. The State and Regional Water Quality Control Boards are also useful sources of watershed information.

RIPARIAN ZONE

The riparian zone borders the stream and is the transition area to the upper watershed. The zone interacts with the channel and bears strongly on the structure and function of the aquatic ecosystem. The structure and composition of the riparian zone can be affected by the stream type and its active channel, as well as by geologic and topographic features (Figure II-3).

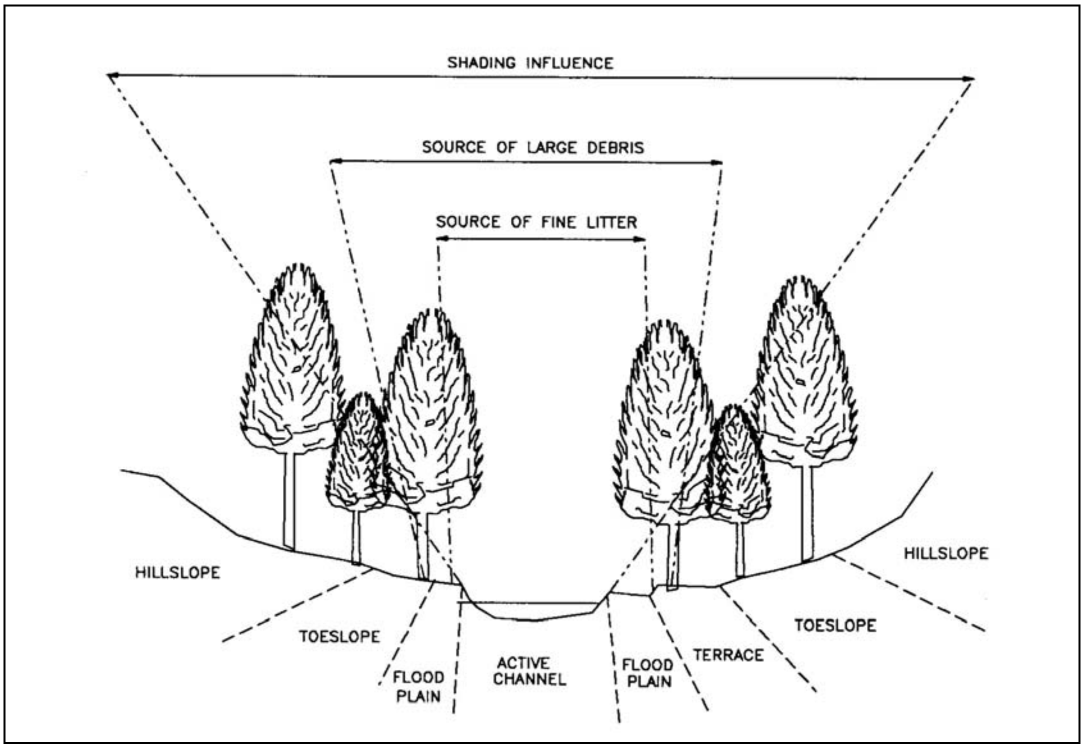


Figure II-3. Diagrammatic representation of functional roles of riparian zones (Lamberti and Gregory, 1989).

Functions of the riparian zone include:

- Controlling the amount of light reaching the stream which affects temperature and productivity.
- Providing litter and invertebrate fall.
- Providing stream bank cohesion and buffering impacts from adjacent uplands.
- Providing large woody debris.

For most practical purposes the riparian zone can be considered the terrestrial component of the stream environment. Riparian zones are typically subject to partial or complete flooding and riparian vegetation is adapted to the particular climatic and topographic attributes of the zone. Riparian zones are the links between the terrestrial and aquatic ecosystems. An extremely close relationship exists between the riparian zone, the fluvial processes of the channel, and fish habitat.

Management of streams for fisheries resources must include the riparian zone as a vital part of the stream ecosystem. In addition to Fish and Game Code Section 1600 rules (Part VI), the importance of this near-stream zone has led the Board of Forestry (BOF) to designate it as a Watercourse and Lake Protection Zone (WLPZ). The BOF has developed protection rules that regulate near-stream timber harvest activities. These rules are subject to periodic review, evaluation, and revision.

Recruitment of large trees into stream systems as structural elements is becoming less commonplace and is cause for concern for the future of this vital fish habitat component. Reduction of riparian vegetation can also result in decreased stream bank stability and increased channel width. The result can be widening and braiding of the channel, loss of channel structure and fish habitat, and subsurface flow during the summer low flow season. It is imperative to recognize the importance of the riparian zone and include it in any stream habitat restoration effort.

SEDIMENT SOURCES

Sediment is an important and vital component of instream fish habitat. Salmonids are dependent upon sorted and well distributed gravel reaches to spawn successfully. The gravel must be reasonably free of fine sediment in order for eggs and embryo to survive and emerge as fry. Young fry further depend on gravel and cobble interstices for escape cover.

In an undisturbed watershed, the stream sediment budget exists in dynamic equilibrium. Human activity in a watershed usually disturbs the natural supply rate of sediment from its sources, as well as the rapidity with which sediments move through a stream system. Dam construction, for example, reduces the supply of sediment to a stream and can limit transport flows. Poor road construction and maintenance usually increase rates of sediment delivered to streams and increase runoff rates.

Human land use activities, especially roads, as well as natural geologic and soil conditions, affect sediment production and can have a major impact on the floodplain and stream channel form and flow pattern. Channel form and pattern are key factors affecting fish habitat. Increased sediment yield to streams, if not scoured by seasonal flows, can result in streambed aggradation and development of severe stream bank instability. As sediments are deposited, the stream channel is forced to widen as the substrate surface level rises. When the channel width increases, the stream shallows and the surface area exposed to the sun increases in relation to the volume of water. Solar heating is increased and higher water temperatures result. This causes changes in habitat suitability, species composition and aquatic biomass.

In an active streambed, gravel, cobble, boulders, and organic debris that form critical components of fish habitat must be continuously replenished from upland or near stream sources since they are transient and move through the stream system during transport flows. It is possible to determine the dominant sediment sources in a watershed by a combination of aerial photograph analysis and field inspection of road and stream bank conditions. Geologic and soil maps can also be very useful in this determination.

Sediment is derived from three primary sources in a watershed: 1) mass wasting (or landslides) in which soil, rock, and other debris are moved down slope by gravity; 2) surface erosion in which finer materials are transported by wind or overland flow of water when precipitation exceeds the infiltration capacity of the soil; 3) stream bank and stream channel erosion in which erosion products are washed from the streambed, banks, or overflow areas by stream flow.

Mass Wasting

Mass wasting may be categorized as either shallow or deep seated, and is often triggered by an undercut of a slope and/or a buildup of soil-water pressure during heavy rains. The stability of a slope can be reduced by expansion and contraction from periodic freezing or supersaturation, ground disturbance, or changes in vegetation. The location of historic, active, and potential landslides can often be determined from aerial photographs. Ground reconnaissance can determine the volume and stability of landslides as well as the dominant particle size originating from the slide.

There are many types of mass movement, any of which might be called a landslide. Landslides come in all sizes and shapes, and their movement may be sudden and extremely rapid occurrences, or they may be imperceptible except for the debris deposition at their toe. These slow moving, long-term landslides take many forms but are often slumps or earth avalanches that can be identified by curved head wall scarps, crooked or "jackstrawed" trees, or cracks in the soil. Mass wasting can be greatly accelerated by human land use within a watershed, particularly in relationship to road systems and other earth disturbance activities.

Surface Erosion

Diversion or capture of streams and storm runoff by roads or other disturbed or excavated areas can cause greatly accelerated erosion in the form of rills, gullies, landslides, enlarged stream channels, or even new stream channels. Extensive study has determined that the majority, in some cases as much as 70 percent, of eroded sediment is caused by watershed road systems. For example, blocked culverts are a common feature that can divert water onto a road, or into its inboard ditch until it breaks across the roadway, often causing massive erosion on the road and both the uphill and downhill slopes it encounters. Surface erosion from unconsolidated sources such as overland flow during very heavy downpours or rapid melting of hail or snow, or strong wind usually results in movement of sand-sized or smaller sediments in a form called sheet erosion. Altered drainage patterns and widening of storm runoff channels can be identified from analysis of a sequence of air photos taken over a number of years and from ground inspection of drainage patterns where they are intercepted by roadways or other disturbance.

Heavy grazing, fire, or other surface disturbance can also accelerate surface erosion. Because this erosion tends to be more uniformly distributed over the land surface, it is often difficult to recognize or quantify.

Stream and Channel Erosion

Erosion is the natural process that cuts stream channels, and can form river canyons and create river valleys. The rate of erosion is generally determined by the stream gradient and the resistance of the channel material. Obstructions to flow in the channel can accelerate stream bank erosion as flows are redirected. Mass side slope erosion is typically triggered by stream bank erosion undercutting unstable slopes and can add substantially to bedload.

The erosion process is continuous and self-renewing from the uppermost slopes down through the valley floors and estuaries. Down cutting, meander, aggradation and deposition are all natural erosion processes that must be given careful consideration as part of a fish habitat inventory or evaluation.

HYDROGRAPHS

For all gauged streams a hydrograph can be generated. A hydrograph is a graph showing, for a given point on a stream, the discharge, stage, velocity, or other property of water with respect to time. A hydrograph may be made for daily, monthly, or annual discharges. Depiction of long periods such as an annual hydrograph can be used to determine low flow, summer base flow, winter base flow, and flood discharges (Figure II-4). A list of stream flow gauging stations is available from the California Department of Water Resources. Gauging station data is usually available in university libraries as well.

Salmonids are dependent upon different flows during various life stages, and their presence, absence, and movements are influenced by flows. Therefore, hydrographic data are useful for fisheries assessment. Low summer flows, for example, affect the ability of fisheries personnel to conduct habitat and biological assessment activities. Winter and spring spawning surveys must be timed according to adult access flows. Scheduling for these surveys, as well as calibrating the survey results can be facilitated by reviewing hydrographic data.

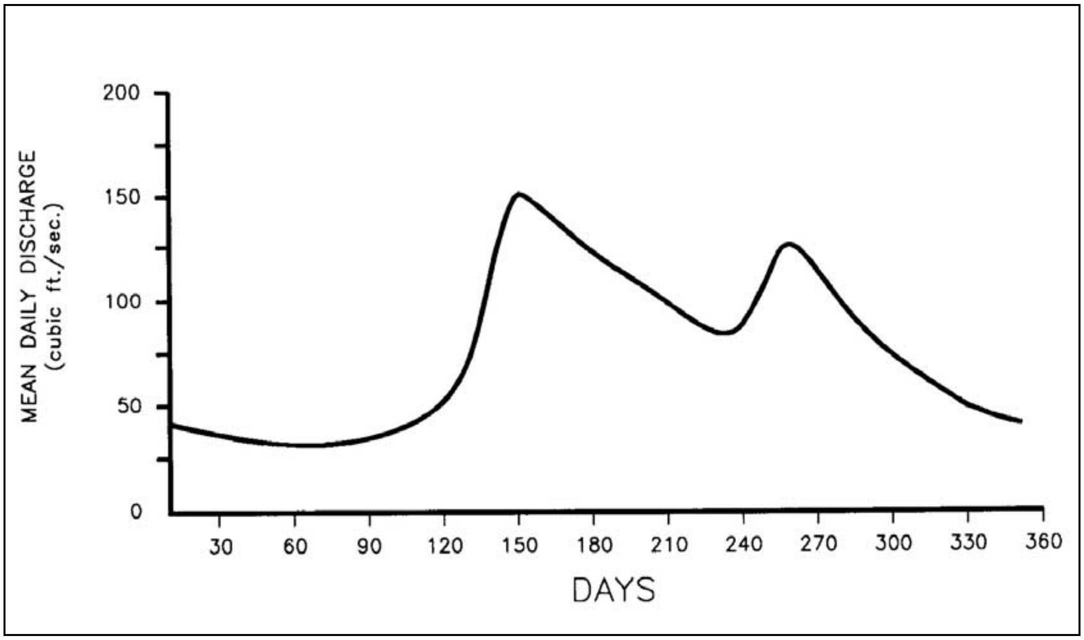


Figure II-4. Hydrograph.

For streams without a gauging station a hydrograph can be constructed by relating the un-gauged stream to a nearby gauged stream of similar drainage area, aspect, and rainfall. If the information is used for comparison with a gauged stream, flow in the un-gauged stream is assumed to vary in a manner similar to the gauged stream. For most purposes a simple transformation of the data can be made by applying a correction factor. For example, if the discharge of the gauged stream (stream A) is measured at 100, 80 and 60 cfs on different days, and the discharge on the un-gauged stream (stream B) is 120, 96, and 72 cfs on those same days, the correction factor (ratio of flow in stream B to stream A) would be 1.2 (i.e., to estimate the discharge on stream B on any day, multiply the discharge of stream A on that day by 1.2). It is preferable to develop correction factors for several different ranges of flow.

Another way of comparing the stream discharges and extrapolating the discharge of the un-gauged stream is to express the discharge per unit area. For example, the drainage area of stream A is 200 square miles and of stream B is 215 square miles (Part II, "Watershed Overview Work Sheet Data Entry Instructions" for a description of how to calculate drainage area). Stream A would have discharges of 100)200=0.50 cfs/sq. mi., 80)200=0.40 cfs/sq. mi., and 60)200=0.30 cfs/sq. mi. At the discharges stated, stream B would have discharges of 120)215=0.56 cfs/sq. mi., 96)215=0.45 cfs/sq. mi., and 72)215=0.33 cfs/sq. mi. The correction factors would be 0.56)0.50 =1.12, 0.45)0.40= 1.13, and 0.33)0.30= 1.10. The average correction factor would be (1.12+1.13+1.10))3= 1.12.

This method of extrapolating discharge per unit area is suitable for high flows, but under low-flow situations it is less useful because the numbers get very small for most streams. For low-flow situations a simple extrapolation on flow may be more useful.

By applying the correction factor to prior years' data it is possible to compute the discharges in un-gauged streams and construct annual hydrographs for the selected years. Armed with these hydrographs, the habitat restoration planner can roughly estimate future flows.

The correlation between two streams is seldom very close or reliable in any single year and reliance on a correction factor should be undertaken with caution.

REFERENCES

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