CHAPTER 1
WORKING IN THE WATERSHED

All of the rivers and streams drain from an area called a watershed. What happens in each watershed affects the quality of the streams and the fish habitat they provide. This chapter gives a basic background about how watersheds work and what stream habitat salmon and steelhead (and other species) need. Finally, basic road treatment principles are listed – how to protect water quality and stream habitat while maintaining safe county roads for the traveling public.

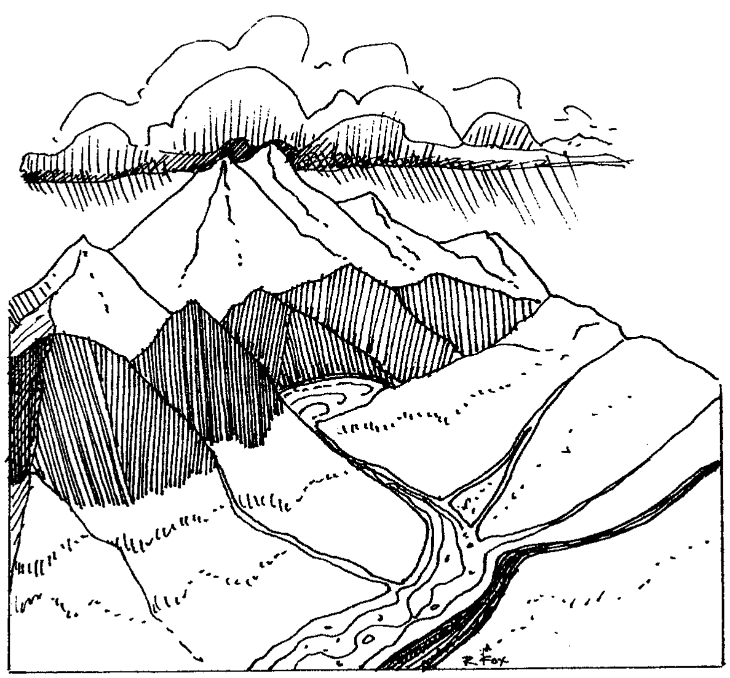
Photo of Navarro River, Mendocino County: Copyright © 1991 Dr. Oren Pollak

1-A WATERSHED BASICS

Northwestern California is often described by its spectacular rivers - like the Klamath, Trinity, Smith, and Eel. From the largest rivers to the smallest creeks, these streams are each part of a drainage basin or watershed. Understanding the basics of how watersheds work in affecting water quality and stream habitat is the purpose of this chapter. These basics can then be translated into principles for treating county roads.

1-A Watershed Basics

- Watershed Approach
- What is a Watershed?
- Watershed Processes
- Water Quality



1-A WATERSHED BASICS

THE WATERSHED APPROACH

Watersheds and watershed management represent a useful approach to solving local road-related problems because:

1. Salmon & steelhead species in northwestern California watersheds are now listed, or proposed to be listed, as threatened or endangered under the federal Endangered Species Act, leading to new legal restrictions on watershed activities.
2. Almost all of the streams in the region are listed under the federal Clean Water Act as "impaired" by excessive sediment & temperature, triggering a requirement for "TMDL" pollution limits for each stream system (which includes the watershed).
3. Inadequate staffing and funding are available at the county level to meet all county road maintenance needs.
4. Since water moves downstream in a watershed, and road work and other watershed activities can affect water quality at locations downstream, it takes a "Big Picture" watershed view to make sure the human-caused problems are solved.
5. Solutions need to address the causes and not just the symptoms of stream and fish conditions – and watersheds provide a way to do this.

WHAT IS A WATERSHED?

The basic definition of a watershed is fairly simple:

Watershed – an area of land which drains water, sediment, and dissolved materials into waterways; defined by the ridges of the hills or mountains that divide them.

Other terms often used to mean the same thing include: basin, drainage, or catchment. While technically the term 'watershed' can refer to any size of an area, there is less confusion if terms are consistently used and defined by size. A system of terms exists for subdividing large watersheds into smaller ones based on relative watershed size:

River Basin – A river system or a group of streams composing a coastal drainage area.
Examples: Eel River Basin, Klamath River Basin, Northern California Coastal Basin.

Subbasin - A geographic area representing part or all of a surface drainage area, a combination of drainage areas, or a distinct hydrologic feature. Almost all subbasins are larger than 700 square miles in size, though some in Northern California are smaller.
Examples: Middle Fork Eel River, Scott River, Mattole River.

Watershed – The next smallest subdivision of a subbasin.
Examples: Mill Creek, Moffett Creek, Honeydew Creek

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Subwatershed – A logical subdivision of an area within a watershed, based on geography (major tributary) or a distinctive feature or use (municipal water supply).
Examples: Upper Mill Creek, McAdams Creek, East Fork Honeydew Creek

Drainage – An area within a subwatershed based on the development of the stream channel network, including draws and swales.
Examples: Unnamed Creek, Upper McAdams Creek, Lower East Fork Honeydew Creek

While most people find it difficult to be consistent in using these terms as defined, communication is improved when the words are properly applied.

Water Bodies

Water flows through channels having many different names also: river, stream, creek, gulch, ditch, and estuaries. Water is also stored on the surface in different types of water bodies – lakes, lagoons, reservoirs, and ponds. Together, all of these flowing and stored surface water bodies are called **watercourses**. In contrast, the standing body of water stored beneath the surface of the ground is called **groundwater.** Most of this groundwater is surface water that has seeped down into the earth.

Stream Order

Stream channels connect like the veins on a leaf. This network of increasingly larger streams, as tributaries connect, has several numbering systems. The stream "order" system refers to numbering tributaries starting in the headwaters.

1. First-order streams (Order 1) have no tributaries;
2. Second-order streams (Order 2) have as tributaries only first-order channels, or are where two first-order streams come together;
3. A third-order stream is formed by the joining of two second-order streams; and so on.

Using the USGS topographic maps at 1:24,000 scale (also called 7.5 minute scale), most watershed streams (as defined above) would be fourth-order while subwatershed streams would be third-order. However, smaller scale maps (such as 15 minute scale) would show fewer streams and the stream order would likely be different.

1-A WATERSHED BASICS

WATERSHED PROCESSES

Understanding the physical processes that shape a watershed's condition can help in making better decisions about road management practices. The quality of the stream and its fish habitat is directly influenced by these watershed processes.

Rainfall, Streamflow, And Runoff

- **Hydrologic cycle** is the term used to describe the continuous circulation of the Earth's waters from the ocean to the atmosphere to the land and then back to the ocean. **Hydrology** is the science of water, or the study of water and its environment in the hydrologic cycle.

- Water falling to earth, or **precipitation,** can be in the form of rainfall or snow. Rainfall or snowmelt entering a stream channel becomes stream flow.

- **Runoff** occurs when the ground in the watershed is no longer capable of absorbing the precipitation.
  - Some soils absorb water from rainfall more easily than others, so runoff occurs less rapidly.
  - Vegetation can affect the rate of runoff, with more runoff usually coming off bare areas. Urban or paved areas speed the movement of water and shorten the time between rainfall and runoff.

- **Precipitation** affects runoff based on the following aspects:
  - Intensity of rainfall – measured in inches per hour – varies from low to high; high intensity rainfall leads to large amounts of runoff.
  - Duration of rainfall, together with intensity, affects the runoff – the longer the rain storm, the greater the amount of water to runoff.
  - Frequency of rainstorms during a period of time – multiple storms over a short period of time creates the greater runoff than single storms or those spread out over a long period of time.
  - Type of precipitation – rain or snow – controls the timing of runoff; snowpack spreads out the effects of storms, leading to delayed runoff in warmer months.

Geology and Soil Landscape

- **Geology** is the science of the earth. A more specific study is geomorphology, or the study of the physical features of the surface of the earth. Understanding the regional landscape of northwestern California requires reference to these sciences.

- The Northwestern Region's watersheds are underlain by three major geologic landscapes:

  - <u>Coast Range</u> - These mountain ranges and valleys are parallel to the coast and subparallel to the San Andreas Fault, running in a northwesterly direction. Most of the rocks in the north are dominated by the Franciscan Formation, which is a "wild, messy" assortment of rocks. Muddy sandstone, or graywacke, is the most common rock type. Being naturally unstable, more landslides are associated with the Franciscan than any other geologic formation.

- Klamath Mountains – These rugged mountains in Siskiyou and Trinity counties (and southwestern Oregon) are a single, extremely complex, block of the earth's crust. Originally at the northern end of the Sierra Nevada, the Klamath block's rocks get older moving from west to east. The youngest region is adjacent to the Coast Range. Granitic rocks can be found in separate masses or plutons. Metamorphic rock is the other common rock type.
- Cascade Range – A chain of volcanic cones, this range includes Siskiyou County from Shasta Valley to the east and south. Mt. Shasta is the highest point. Basalt is the dominant and oldest rock, followed by andesite as typified by Mt. Shasta.

♦ Soils are weathered rocks mixed with some other materials. The stability of soils in the region vary by type, and is closely associated with the qualities of their underlying rocks. Two soil types known for their high tendency for erosion are:
  - "Blue goo"soils in the Coastal Franciscan formation; these soils are derived from incompetent schist high in clay content and tend to act very "slippery" on steep slopes. Slopes composed of this type of soil are often hummocky and grass-covered.
  - Decomposed granite (or "DG") soils in the Klamath Mountains region; these soils do not stick together well (are "non-cohesive") due to high sand and low silt and clay content.

Soil Erosion and Sedimentation

♦ **Erosion Processes**
  - ♦ Soil erosion is mainly caused by water (though wind is also a factor).
  - ♦ Erosion is a natural process linked to the hydrologic cycle.
  - ♦ Not all soil that is eroded enters the stream or drainage system.
  - ♦ Streams do work by eroding, transporting, and depositing material (silt, sand, gravel, cobbles, boulders). Examples of this process include streambank erosion, muddy streams, and new gravel bars.

♦ **Types of erosion,** and examples of their causes, include:
  - Gully – An erosion channel formed by concentrated runoff, usually larger than one foot deep and wide. Gullies often form where road surface or ditch runoff is directed onto unprotected slopes.
  - Sheet & Rill – Sheet erosion is the loss of soil in thin layers of soil across a large surface area, while Rill erosion is a small erosion channel (larger channels are called gullies). Rill erosion can be seen where rainfall and surface runoff is concentrated on unprotected fillslopes, cutbanks, and ditches.
  - Dry Ravel – On steeper slopes, gravity can bring dry soil downhill. Frost heaves can create this condition also. Raveling is most obvious along bare, steep road cuts.

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- Landslides - The downslope movement of a mass of earth caused by gravity. Examples include debris slides, torrents, rock falls, debris avalanches, and soil creep. They may be caused by natural erosional processes, natural disturbances (such as earthquakes, floods, fires), or human disturbances.

♦ **Sedimentation**
- Soil erosion that enters the stream channel or drainage system (ditches, storm water drains, etc.) becomes sediment.
- Natural levels of sediment in a stream system are referred to as "background levels".
- Excessive levels of sediment are those amounts above background, and can cause habitat problems when pools and spawning gravels are filled with fine sediment.
- High levels of sediment suspended in the stream flow cause cloudy water, or turbidity. Persistent muddy appearance is usually due to high silt and clay content.
- Sediment becomes deposited in the stream channel when the flows slow down, such as in gravel or sand bars, pools, or other areas of the stream bed. Floods can cause sediment to deposit outside of the channel in the flood plain.

Stream Channel and Floodplains

♦ Stream channels carry runoff flows from precipitation in the watershed. The channel is carved by the flowing water, but it takes its shape from the sediment carried.

♦ Too much sediment for a stream's capacity to move sediment becomes deposited in a stream channel, which will cause it to fill or aggrade. Too little sediment, compared to what the stream was historically carrying, can cause the channel to downcut or degrade in elevation. When either of these conditions happen, the stream channel must adjust upstream and downstream. Streambank erosion, channel widening, and headcut erosion (in the headwaters of a stream) are some of the symptoms of this readjustment to a new equilibrium condition.

♦ Stream crossings on roads, particularly bridges, can be seriously impacted by the changes in stream channel depth and width.

♦ **Connectivity** is a term that refers to the physical connection between tributaries and the river, between surface water and groundwater, and between wetlands and water sources. Roads can also be connected to the stream system when runoff flows along the road system before entering the stream network (also called "hydrologically connected road")(Fig.1-2).

Flood Frequency and Floodplain Size

Stream channels can contain within their banks flows of only modest size. Bankfull stage is when the water fills the channel to the level of the floodplain, which occurs about twice each year. Flows in excess of the channel's capacity are floods. Floods are natural events and should be expected. Most rivers overflow their banks every 2 or 3 years. However, catastrophic floods may occur any year. The probability of occurrence of a particular size flood, based on the years of record, is often used to predict the frequency of floods for planning purposes. Potential frequency of 25, 50, and 100 year flood events are commonly used.

The overflow onto the floodplain makes this area part of the channel during unusual storms. Floodplains occur in large river valleys and also in the valleys of creeks just a few feet wide, but are usually not present along most headwater tributaries. Structures that encroach onto this floodplain – such as roads and buildings – are encroaching on the stream and may be damaged or destroyed when floods occur. The "100-year floodplain" represents the area potentially inundated for an unusual but possible flood event with the probability of occurring once every 100 years on the average. This potential 100-year flood scenario is being used more and more for engineering designs for any structures within a stream channel or floodplain.

<u>Flood Frequency & Size Concepts:</u> (Mount, 1995)

1. The probability that a 100-year flood will strike a river in California is the same every year, regardless of how long it has been since the last 100-year flood.
2. It is not a certainty that the 100-year event will occur sometime in the next 100 years (although it is pretty likely).
3. In California, where historic data sets are small, the 100-year floodplain is likely to grow following a major flooding event.
4. It is a virtual certainty that the defined 100-year floodplain is not the actual 100-year floodplain.

Stream Categories

Streams are often identified by their flow condition:

- <u>perennial</u> – those streams which carry water the year round, except for infrequent and extended periods of severe drought.
- <u>ephemeral</u> – streams consisting of a dry channel throughout most of the year, bearing water only during or immediately after a rain..
- <u>intermittent</u> – stream channels which carry water only part of the year and are dry the other part, but which receive flow from the groundwater table when it is high enough.

These stream types are indicated on topographic ("topo") maps of the U.S. Geological Survey (USGS), with perennial streams identified by solid blue lines ("blue line streams") and intermittent streams by dash-dot blue lines. However, these USGS map indications were only estimates made at the date of the original map development, and should not be used as a substitute for more accurate descriptions of current conditions – especially for smaller creeks.

Stream Class: Another way to categorize streams is by the water's use, such as for aquatic species or domestic water supply. The terms below are also commonly used, particularly by the California Dept. of Forestry and Fire Protection (CDF) and the Dept. of Fish and Game (DFG) to help define the degree of state forestry regulations:

1-A WATERSHED BASICS

Class I Watercourse: A stream (or lake) that is used for a domestic water supply (including springs) on the site and/or within 100 feet downstream of the operations area; and/or fish always or seasonally present onsite, including habitat to sustain fish migration and spawning. (It typically flows year round, but may flow seasonally.)

Class II Watercourse: A stream (or lake) that has fish always or seasonally present offsite within 1000 feet downstream, and/or aquatic habitat for nonfish aquatic species; excludes Class III waters that are tributary to Class I waters. (These streams may flow year round or seasonally; many springs and wetlands are also included.)

Class III Watercourse: A stream channel (or lake) with no aquatic life present but showing evidence of being capable of sediment transport to Class I or II waters under normal high water flow conditions.

Class IV Watercourse: Man-made watercourses, usually downstream, for established domestic, agricultural, hydroelectric supply or other beneficial use.

Other stream terms are often based on legal definitions from one or more laws. The Clean Water Act refers to “Waters of the U.S.”, and “Ordinary High Water Mark”, both of which are defined under the Act in Chapter 2 of this manual.

VEGETATION

All plants affect the amount and pattern of runoff in the watershed.

Upland:

- Vegetation on the slopes helps to slow runoff, which allows better seepage of rainfall into the soils and groundwater and better water storage for summer streamflows.
- Plant roots hold soil in place, with deeper-rooted trees helping to prevent deeper erosion like landslides.
- Plant litter, like dead leaves, needles and branches, provides a protective layer over the soil from the erosive impacts of rainfall and snowmelt.
- Loss of vegetation, such as from fires, disease, logging, grazing, or urbanization, can increase soil erosion and increase the rate of runoff (usually temporarily).

Riparian:

- Streamside vegetation provides many benefits to a healthy stream:
    - Shade to the stream, to help cool the water;
    - Food for fish from insects, leaf litter and organic material falling into the stream;
    - Bank protection from erosion through root strength;
    - Structure for instream habitat when trees fall into the stream (also known as Large Woody Debris, or LWD), creating scour pools and trapping sediment for slow release during storms;
    - Filter for surface sources of erosion, minimizing sedimentation;

- During floods, slows the energy of the flow and causes sediment to deposit in the floodplain instead of in the channel.

♦ In turn, the stream provides both surface and underground water to the riparian vegetation.
♦ This narrow plant zone offers habitat for many animal species dependent on its unique features.

Wetlands:

♦ These areas generally include, but are not limited to, marshes, bogs, estuaries, and similar areas. Some are near or directly connected to the stream channel system.
♦ Wetland plants aid in trapping sediment and filtering excess nutrients, which can cause water quality problems.
♦ Wetlands help slow floodwaters and function to recharge groundwater areas, or aquifers.
♦ Many wildlife species are dependent upon wetlands for their habitat.

WATER QUALITY

Clean water means good water quality. Water quality is not so good, for example, when a stream is too muddy (or turbid) or too warm to support the natural and human uses dependent on the water – "beneficial" uses like recreation, drinking water, or cold water fish. Control of the sources of water pollution is a major focus of state and federal laws.

Types of Water Pollution

Pollution from sewage and industrial wastes – usually entering the water from pipes – is known as point source pollution. Runoff or indirect pollution – from a variety of less obvious sources – is called nonpoint source (NPS) pollution. Rural roads and road maintenance activities have the potential to contribute to nonpoint pollution – the major type of water pollution problem in California today. Road maintenance yards and other "industrial" type facilities, if not managed well, can be the source of runoff or "storm water" pollution and even hazardous waste contamination of the surface (stream) and ground waters.

Water Quality Protection and Improvement

A watershed approach looks at both point and nonpoint sources of pollution and looks for solutions across all land ownerships. Ways can be found to prevent, reverse, and eliminate damage caused by both types of pollution. Sometime the solutions – especially for runoff sources – need to be quite creative as the traditional pollution treatment plants will not work. Prevention is always the first and best approach – and the cheapest.

Water quality protection laws and programs seek to prevent pollution or to clean it up. For this region, water quality objectives are set and beneficial uses are stated for each water body in the North Coast Basin Plan adopted by two state agencies – the North Coast Regional Water Quality Control Board (RWQCB) and the State Water Resources Control Board (SWRCB). These objectives are for many water quality factors, such as: temperature, sediment, turbidity, oil and grease, bacteria, toxicity, pesticides, and specific chemicals. Most of the waters of northwestern California are much cleaner than these quality objectives.

Finding cooperative ways to protect and restore watershed "health" among all of the owners and users of a watershed is becoming a common aspect of the "watershed approach". Community-based watershed groups form and seek common solutions to the watershed's problems. Often, a watershed assessment of the current and historic conditions is performed, followed by a jointly prepared strategy or plan for solving identified problems. For county road issues, this cooperative approach can be of benefit when other road ownerships are part of the problem, or when non-county upslope or upstream sources create erosion or runoff problems on county roads. One example of a successful watershed partnership with county road department involvement is the French Creek Watershed Advisory Group in Siskiyou County. This sediment-control effort developed a Road Management Plan for the decomposed granite (DG) problem areas of the watershed and implemented it together. Within several years, water quality improvement in French Creek (as measured by deeper pools) was significant.

TMDLs – Coming to a River Near You!

TMDL = Total Maximum Daily Load = pollution limits by stream & by source

When a river does not meet state and federal water quality standards, it usually becomes earmarked for a remedial strategy under the federal Clean Water Act. The state has identified streams that are polluted with various pollutants. This list of "impaired water bodies" was adopted by the two state water quality agencies (see above) in 1998 and is referred to as the "303(d) list", which refers to a section of the Clean Water Act. Also mandated by the act is the establishment of Total Maximum Daily Loads (TMDLs) as a means to address each pollutant.

The amount and sources of each pollutant are identified and a strategy is developed for restoring the stream to state standards. In California, a lawsuit settlement (or consent decree) required that the Environmental Protection Agency (EPA) and the North Coast Regional Water Quality Control Board (RWQCB) complete TMDLs on a 13-year schedule for the listed streams in the region. This list and timetable is found in Table 1-1 below. For some rivers, EPA is the lead agency for developing the TMDL targets for the listed pollutants while others have the RWQCB as the lead.

Since roads are a known source of sediment, each of the sediment TMDLs will be addressing limits to the amount of erosion and sediment that will be allowable from roads: both public and private. The methods will be outlined in an Implementation Plan. Getting ahead of the curve in meeting this challenging regulation will benefit counties and county road managers.

1-A WATERSHED BASICS

Table 1-1. Rivers Scheduled for a TMDL Pollutant Target

River Name	County Location	Listed Pollutant	Due Date
Albion River	Mendocino	Sediment	12/01
Big River	Mendocino	Sediment	12/01
Eel River – Delta	Humboldt	Sediment & Temperature	12/06
Eel R. – Middle Fk	Mendocino	Sediment & Temperature	12/03
Eel R. – Middle Main	Mendocino	Sediment & Temperature	12/05
Eel R. – North Fk.	Mendocino / Trinity	Sediment & Temperature	12/02
Eel R. – South Fk	Mendocino/ Humboldt	Sediment & Temperature	12/99
Eel R. – Upper Main	Mendocino	Sediment & Temperature	12/04
Elk River	Mendocino	Sediment	12/09
Freshwater Creek	Humboldt	Sediment	12/10
Garcia River	Mendocino	Temperature / Sediment	12/00
Gualala River	Mendocino/Sonoma	Sediment	12/01
Klamath River – all	Siskiyou /Humboldt / Del Norte	Nutrients & Temperature	4/04
Klamath - mainstem	Siskiyou /Humboldt / Del Norte	Low Dissolved Oxygen	12/04
Mad River	Humboldt / Trinity	Sediment & Turbidity	2/07
Mattole River	Mendocino/ Humboldt	Sediment & Temperature	12/02
Navarro River	Mendocino	Sediment & Temperature	12/00
Noyo River	Mendocino	Sediment	12/99
Redwood Creek	Humboldt	Sediment	12/98
Russian River	Mendocino/Sonoma	Sediment	12/11
Scott River	Siskiyou	Sediment & Temperature	4/05
Shasta River	Siskiyou	Low DO & Temperature	9/05
Ten Mile River	Mendocino	Sediment	12/00
Tomki Creek	Mendocino	Sediment	12/04
Trinity River	Trinity/ Humboldt	Sediment	12/01
Trinity R.-South Fk.	Trinity/ Humboldt	Sediment	12/98
Trinity R.-South Fk.	Trinity/ Humboldt	Temperature	12/08
Van Duzen River	Humboldt	Sediment	12/99

For more information on the TMDL efforts above, see RWQCB website at: //www.swrcb.ca.gov/rwqcb1

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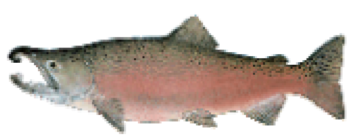
1-B STREAM HABITAT NEEDS

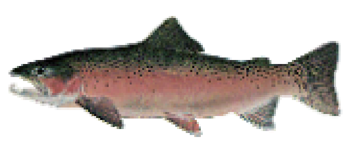
In the last section, the basics of how watersheds affect water quality and stream habitat were described. Here the focus is on fish within the watersheds – primarily salmon and steelhead. These fish use the streams that county roads cross or affect. Understanding what the fish need in our county's streams will help in performing better road maintenance practices.

1-B STREAM HABITAT NEEDS

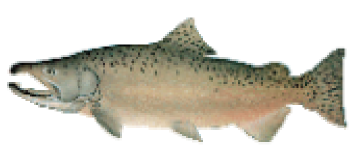
- What Fish?
- Salmon & Steelhead Life Cycles
- Salmon & Steelhead Habitat Needs
- Locations of Salmon and Steelhead
- Threatened and Endangered Status
- Other Aquatic or Riparian Species of Concern



coho salmon – male



steelhead - male



chinook salmon - male

1-B STREAM HABITAT NEEDS

There's lots of talk about salmon and steelhead these days – usually about their low numbers and what can be done to help restore their populations. Road workers are among those who like to fish these streams (and even more so in their retirement years). But what do salmon and steelhead need to thrive in our county's streams? Here is some basic salmon information to help everyone's common understanding.

WHAT FISH?

More than one species of fish in the salmon and trout family are presently of concern due to their dwindling numbers in our region's streams:

Common Name	Genus & species
➢ Coho ("Silver") Salmon	*Oncorhynchus kisutch*
➢ Chinook ("King") Salmon	*Oncorhynchus tshawytscha*
➢ Steelhead	*Oncorhynchus mykiss iredeus*
➢ Coastal Cutthroat Trout	*Salmo clarki clarki*

These species and others in the salmon and trout family are referred to by biologists as salmonids. However, "salmon" generally refers to all ocean-migrating forms of these fish.

SALMON & STEELHEAD LIFE CYCLES

Salmon, steelhead and coastal cutthroat trout must use streams and rivers during a part of their life cycle. They are all born in freshwater, move to the ocean, and return to their native stream to spawn (Figure 1-1). Their river-to-ocean, ocean-to-river life cycle makes them anadromous fish.

Anadromous (a-nad'-ru-mus) **fish** - Fish which migrate between fresh and salt water during a species' life span; literally, "running upward".
Juvenile fish – Young salmon and steelhead that include the stages from: emergence from the egg with yolk sac (**alevin**), to instream **fry** stage, to **smolt** phase as they start migrating to the ocean.
Redd – The nest depression constructed by spawning adults in stream gravels in which the eggs are laid.

Timing of Salmon & Steelhead Runs & Habitat Use

All chinook and coho salmon die soon after spawning, while a small percentage of steelhead and cutthroat trout will live to return to spawn the next year. When the fish enter our streams for spawning depends on the specific river system – it differs on coastal streams from inland ones, and from one major river to another. Timing also depends on runoff conditions and whether the sandbars at the mouths of streams have been breached yet by high flows.

Table 1-2 gives the range of months when these species can be found in our streams. Besides their spawning period, the fish use the stream for months to years during the juvenile rearing

1-B STREAM HABITAT NEEDS

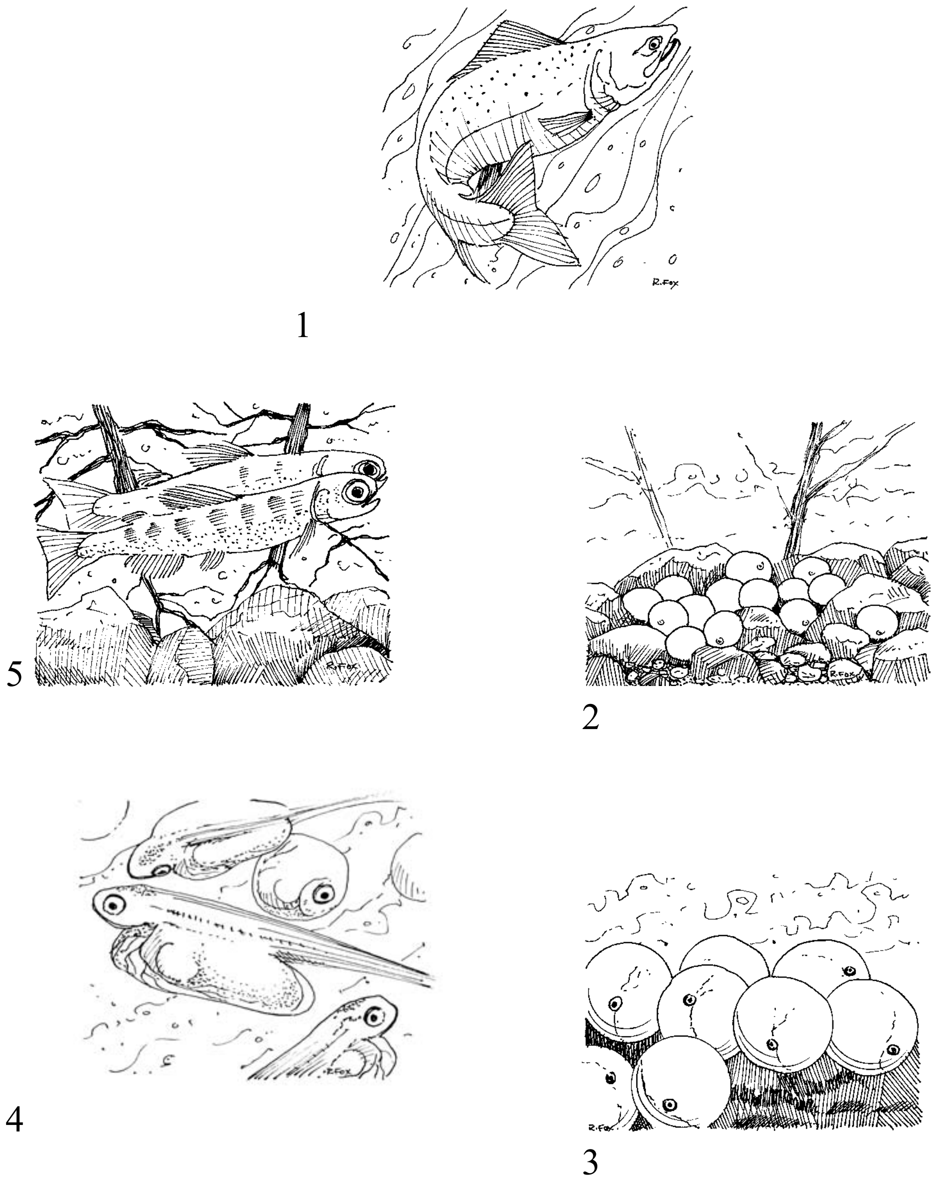


Figure 1-1. Life cycle of the Pacific salmon.

1) Adults move from ocean into freshwater for upstream spawning migration to their original homes – 2) Spawning and egg laying in redds – 3) Incubation of eggs in redd – 4) Hatched fish (fry) have attached yolk sac for initial food – 5) Juvenile fish live and grow in fresh water before transforming into a smolt for the saltwater phase. Salmon and steelhead grow into adults during the ocean phase. Immature adults may also return to the streams of their birth.

(Artwork by Richard Fox

)

phase. These young then move downstream during their out-migration phase to the estuaries and the ocean at various months of the year.

Table 1-2. General Salmonid Life Cycle Timing in NW California Streams[1]

Species	Spawning	Rearing	Out-Migration	Time in Freshwater
Chinook Salmon				
Fall-run	Sept - Feb	all year	Mar - Sept	1- 15 months
Spring-run	mid Sept – mid Oct	all year	April - Oct	1 – 15 months
Coho Salmon	Oct - Mar	all year	Mar - May	1+ yr
Steelhead				
Winter-run	Nov - June	all year	Mar - Nov	1+ to 2 yrs
Summer-run	Mar - June	all year	Mar - Nov	1+ to 2 yrs
Coastal cutthroat trout	Dec - May	all year	Only some migrate to ocean	1+ to 4-6 yrs

1/ Sources: Ross Taylor, consultant; Al Olson, Klamath National Forest; Greg Bryant, NMFS

SALMON AND STEELHEAD HABITAT NEEDS

- **Access** to stream habitat – upstream for adults and up/downstream for juveniles
- **Clean gravels** in riffles and runs where adults can build nests (redds) in which to lay their eggs, juveniles can rear, and stream insects (macro-invertebrates) can produce to provide food for the fish
- **Pools** that are cool and deep where young can rear and adults can rest
- **Instream shelter** (created by large woody debris (LWD), boulders, undercut banks) where fish can hide from predators or avoid being swept downstream
- **Overhead cover** to provide shade and sources of insect food
- **Sidechannels and smaller tributaries** for over-wintering use
- **Cool, flowing water** free of pollutants, with good clarity, and sufficient dissolved oxygen
- **Estuary space_**, where salt and fresh water mix, for adjustment by adults moving upstream, and juveniles (smolts) moving into the ocean

Another way to look at salmon habitat needs is to remember the "**Four C's**":

- **Cold**
- **Clean**
- **Complex**
- **Connected**

1-B STREAM HABITAT NEEDS

COLD: Water that is too warm (>60° F) for a prolonged time can be stressful to the health of these coldwater fish, while water that is too hot (>73-79° F) will kill them.
CLEAN: Water, pools and gravels should be clean and not be polluted from excess sediment or nutrients or any chemicals.
COMPLEX: A stream should not be cleaned or altered significantly of its naturally complex structure, such as large wood, overhanging riparian vegetation, meanders, flow patterns, and floodplain connections.
CONNECTED: Fish must be able to get from the ocean to their spawning areas and juveniles to the ocean, with no manmade, impassable barriers preventing this migration.

SALMON & STEELHEAD LOCATIONS

Salmon and steelhead use stream systems from the top to the bottom. Adults will go up as high in the system as they can physically reach, which depends upon the species. Steelhead tend to go higher up in the drainages than coho, which are found higher than chinook. Steelhead can also use streams that only flow seasonally (winter & spring) during a part of their life cycle. Coastal cutthroat trout will often spawn in very small streams of Del Norte and Humboldt counties.

Barrier Forms:
1) Physical Barriers (too tall or long)
2) Flow Barriers (too little, too fast)
3) Thermal Barriers (too hot)

Types of Physical Barriers:
- Natural waterfalls
- Water diversion dams and weirs (without fish ladders)
- Flood debris dams (without fish ladders)
- Water storage dams (without fish ladders)
- Landslides in stream ⇐ SOMETIMES ROAD-RELATED
- Culverts & other types of stream crossings ⇐ ROAD-RELATED (See: Ch. 4)

When are they barriers?
- Seasonally, during low – or very high - flow periods
- Temporarily – if alteration is not completely successful
- Permanently – if not altered

Sources of Information on Local Salmon Habitat & Barrier Locations

Not all of the streams crossed by County roads provide habitat for salmon and steelhead. Some may have natural barriers while others may be too steep for upstream migration. If you want to know specific stream areas of use by salmon and steelhead, here are some useful references:

1-B STREAM HABITAT NEEDS

1) NMFS Salmon & Steelhead Habitat Distribution Tables – by County & Stream – website (//swr.nmfs.noaa.gov)
2) California Dept. of Fish and Game (DFG) Fishery Biologists & Wardens – each county
3) "County Culvert Fish Migration Barrier Inventory for the Five Counties" – 2001-02 – prepared by Ross Taylor & Associates (available at each county DPW/DOT office.)

NOTE: Upper reaches of streams may still be home to other coldwater fish, such as resident rainbow trout, as well as other sensitive aquatic species (Table 1-3). Barriers to migration may not be their problem, but clean water is still needed.

THREATENED OR ENDANGERED STATUS

Not all salmon and steelhead are equal when it comes to getting listed as "threatened" or "endangered" under the federal Endangered Species Act (ESA). The National Marine Fisheries Service (NMFS) adopted the concept of an "evolutionarily significant unit" (ESU) to define distinct population segments of the anadromous Pacific salmon and trout species. The intent is to conserve the genetic diversity of these species and the ecosystems they inhabit. Northwestern California encompasses 8 different ESUs for the 3 species, each with a different listing status under the ESA (see Table 1-3 below).

Endangered species – Any species which is in danger of extinction throughout all or a significant portion of its range.
Threatened species – Any species which is likely to become an endangered species within the foreseeable future throughout all of a significant portion of its range.

Table 1-3. Status of ESA Listings of Salmon & Steelhead in the Five County Region[1]

Species / ESU	Listing Status[1]	ESU Area	Counties in NW Calif.
COHO SALMON			
So. Oregon / Northern California	Threatened / Interim 4(d) rule	Elk River, OR to Mattole River / Klamath & Trinity Basins	Del Norte / Humboldt / Mendocino / Trinity / Siskiyou
Central Calif. Coast	Threatened /4(d) rule	Punta Gorda to San Lorenzo River	Mendocino / Sonoma / others south
CHINOOK SALMON			
Calif. Coastal	Threatened	Redwood Creek through Russian River basin	Humboldt / Mendocino / Sonoma
Upper Klamath / Trinity	Not listed	Klamath /Trinity basins, above confluence with Trinity River	Siskiyou / Trinity / Humboldt
Southern Oregon / Northern California	Not listed	Cape Blanco south to lower Klamath R. downstream of Trinity River	Del Norte/ Humboldt/ Mendocino
STEELHEAD			
Central Calif. Coast	Threatened /4(d) rule	Russian R. thru Aptos Cr.	Mendocino /Sonoma /others
No. Calif. Coast	Threatened	Redwood Cr. through Gualala River	Mendocino/ Humboldt

1-B STREAM HABITAT NEEDS

Species / ESU	Listing Status[1]	ESU Area	Counties in NW Calif.
Klamath Mountains Province	Not listed	Cape Blanco, OR to South Fork Trinity Basin	Del Norte / Humboldt / Siskiyou / Trinity
COASTAL CUTTHROAT TROUT **-** status reviewed, not warranted for ESA listing			

1/ As of 12/01; Species status updates can be found at NMFS website: //www.nwr.noaa.gov

OTHER AQUATIC OR RIPARIAN SPECIES OF CONCERN

In addition to the species listed under the federal Endangered Species Act are those animal species identified under the California Endangered Species Act (CESA) as threatened and endangered. Often these species are on both state and federal lists, but occasionally some are only on the state list or only on the federal list. The implications of these two lists in getting road maintenance projects performed are described in Chapter 2 – Getting the Permits.

Another designation used by the California Department of Fish and Game (DFG) is California Special Concern (CSC) species: these vertebrate species have declining population levels, limited ranges, and/or continuing threats that have made them vulnerable to extinction. Also, there is the Federal Special Concern (FSC) species list. Some of these species may soon reach the point where they meet the criteria for listing as threatened or endangered under the State and/or Federal Endangered Species Acts. [However, these CSC and FSC listed species do not have the legal protections of the ESA and CESA listed ones.]

Table 1-4. Status of Other Aquatic & Riparian Animal Species Listed under the Federal or California ESA, or as Special Concern Species

Common Name	Status[1]	NW County Locations[2]
➢ Point Arena Mountain Beaver	Endangered (F) / CSC	M
➢ Trinity Bristle Snail	Threatened (S)	T
➢ Siskiyou Mountains Salamander	Threatened (S)	DN, S
➢ Coho Salmon	Endangered/ Threatened (S)	DN, S, H, T, M
➢ Coastal Cutthroat Trout	CSC	DN, H
➢ Klamath River Lamprey	CSC	DN, H, S
➢ Green Sturgeon	CSC / FSC	DN, H, S, T
➢ Eulachon	CSC	DN, H
➢ Del Norte Salamander	CSC / FSC	DN, S, H, T
➢ Southern Seep (Torrent) Salamander	CSC / FSC	DN, S, H, T, M
➢ Northern Red-legged Frog	CSC / FSC	DN, H, M
➢ Tailed Frog	CSC / FSC	DN, H, S, T, M
➢ Foothill Yellow-legged Frog	CSC / FSC	DN, S, H, T, M
➢ Cascades Frog	CSC / FSC	S, T
➢ Northwestern Pond Turtle	CSC / FSC	DN, S, T, H, M

1/ (S) State-listed under California Endangered Species Act; (F) Federally listed under ESA; CSC = California Special Concern species; FSC = Federal Special Concern species; 2/ County initials used as abbreviation. Sources: Jennings & Hayes (1994), Amphibian and Reptile Species of Special Concern in California, Calif. Dept. of Fish and Game (CDFG), Sacramento; CDFG (2001) "State and Federally Listed Endangered and Threatened Animals of California", 10 p.; "Special Animals", 46 p. [See website for updated status: www.dfg.ca.gov/whdab/html/lists.html]

1-C ROAD TREATMENT PRINCIPLES

All county roads need to be maintained to ensure they remain open and safe to the traveling public. They also need routine maintenance and upgrading to meet environmental standards, such as TMDLs. Proper practices, upgrading techniques, and "storm-proofing" routines should also significantly lower the long-term maintenance requirements and costs of county roads.

1-C ROAD TREATMENT PRINCIPLES

- Goals of Treating County Roads
- Road Problem Identification
  - Sources of Road Sediment & Runoff Problems
  - "Big 3" Road Maintenance Problems
- Ten Principles for Treating County Roads

1-C ROAD TREATMENT PRINCIPLES

GOALS OF TREATING COUNTY ROADS

The goals of treating maintenance problems on county roads are to:

- ⇒ **Maintain public safety and open roads.**
- ⇒ **Prevent or minimize delivery of sediment and chemicals to streams.**
- ⇒ **Prevent or minimize the interruption of normal runoff into streams.**
- ⇒ **Protect aquatic and riparian habitat.**
- ⇒ **Restore access for fish movement at stream crossings.**

One can accomplish this goal by creating:

- ♦ Low impact solutions
- ♦ Low cost solutions
- ♦ Permanent solutions
- ♦ Self-maintaining roads

ROAD PROBLEM IDENTIFICATION

Recognizing the major sources of road problems and how they might impact streams is essential to understanding the Principles for treating county roads.

SOURCES OF ROAD SEDIMENT AND RUNOFF PROBLEMS: [See Figure 1-2]

- ♦ A **gully** is very efficient at delivering sediment to the hillslope and to the stream channel.

- ♦ **Fillslopes** are very efficient deliverers of sediment to sites below the roads, especially on very steep slopes. Some roads are so close to streams that the fillslope encroaches on the stream (as at road-stream crossings).

- ♦ **Cutbank** slope failures deliver sediment to the road, which can be cleaned off or delivered to ditches and the stream. Cutting into the toe of the cutslope during cleaning can cause more bank sloughing, especially in granitic soils.

- ♦ Large, deep-seated **landslides** "take the road for a ride" and can contribute huge amounts of sediment during a single event. Landslide scars or rock outcrops can also create a surface flow path from the road to an adjacent channel.

- ♦ **Inboard ditches** deliver to a road-stream crossing, or to a cross-drain where sufficient discharge is available to create a gully, sediment plume, or both, that extends to a stream channel. They also capture subsurface and surface runoff and can redirect it from established channels to form a new one.

1-C ROAD TREATMENT PRINCIPLES

- Other **cross-drainage features**, such as waterbars, dips or cross-drains, can discharge sufficient water to create a gully, sediment plume, or both, that extends to a stream channel. Adding water from roads into sidehill channels can increase the amount of water they normally carry and cause the channel to adjust by eroding its banks.

- **Culverts** that are improperly placed, undersized, or poorly maintained are a major cause of erosion when plugged, causing loss of the road and/or diversion of the stream onto and across the road.

"BIG 3" ROAD MAINTENANCE PROBLEMS Most Often Affecting Stream Quality In Northwestern California: (Bill Weaver, Pacific Watershed Associates; Greg Bryant, NMFS)

1. Road surface drainage – including roadside ditches – can contribute to chronic erosion and sediment delivery as well as alter the timing and volume of streamflow by diverting water from one watercourse to another;

2. Storm-related stream crossing failures, which can wash large sections of road into the stream below;

3. Road-related landslides, which are mostly fillslope failures, that can contribute large amounts of sediment directly into the stream.

TEN PRINCIPLES FOR TREATING COUNTY ROADS

Remembering and practicing the following ten road treatment principles should go a long ways toward protecting water quality and stream habitat. Of course, ensuring that roads are open and safe to the traveling public remains the number one priority for the county. These principles are demonstrated in the specific Best Management Practices (BMPs) that follow in later chapters of this manual.

1. Prevention of erosion is better and cheaper than trying to control erosion.

- It is more expensive to fix up mistakes. Environmental damage = expensive costs to repair.
- Primary erosion control costs are cheaper than the cost of removing sediment. Less erosion = lower maintenance costs.
- The cost of potential legal fines for water quality violations needs to be included in the prevention cost.

2. Treat the cause - <u>not</u> the symptom - of erosion.

- Treat active, rather than inactive, sources of sediment. Look upslope and upstream first before deciding on the cause of an erosion problem and its best solution.
- If you don't change anything, it's just going to happen again (such as chronic flood damage).

1-C ROAD TREATMENT PRINCIPLES

3. **Disconnect the road from the stream channel.** (See Fig. 1-2)
    - Do not allow drainage from a road directly into a stream channel, or from a stream directly onto a road.
    - Upgrade drainage systems to prevent the potential for these direct connections.

4. **Protect the riparian zone.**
    - Streamside vegetation provide a buffer for filtering pollutants, a shade canopy for cooling stream temperature, and a source of food and habitat for aquatic and other sensitive species.
    - Replacing riparian plants can be difficult and expensive.

5. **Keep existing vegetative cover wherever possible.**
    - Plant cover provides your cheapest form of effective erosion control.
    - Grasses, shrubs and trees help stabilize cut and fill slopes; native species are best.
    - Exception is made for invasive plants and noxious weeds, which should be removed.

6. **Direct runoff away from bare soil or disturbed areas.**
    - Erosion is sure to occur when drainage washes over bare ground.

7. **Keep runoff velocities low, using energy reduction or control measures where possible.**
    - Rapid runoff has more erosive force than slow runoff.
    - If runoff is carrying sediment, cross drains or velocity controls are needed.

8. **Each solution should not create more problems than it is solving.**
    - Look before you leap & anticipate possible effects of a proposed solution.

9. **Connect the stream channel for fish passage at stream crossings.**
    - No stream crossings should block the upstream or downstream migration of salmon and steelhead.
    - Stream crossings should be sufficiently sized and placed to allow for normal stream processes.

10. **Work within the limitations of the existing county road system as best you can while keeping the roads open and safe to the traveling public.**
    - The county road system was developed over the past 150 years based on local, public transportation needs. Some road sections are not "ideally" located from a watershed quality perspective, but they cannot be relocated - for practical and financial reasons.
    - Balancing the public's need for safe and open roads with the environment's need for clean water and healthy streams can be challenging but is not impossible.

1-C ROAD TREATMENT PRINCIPLES

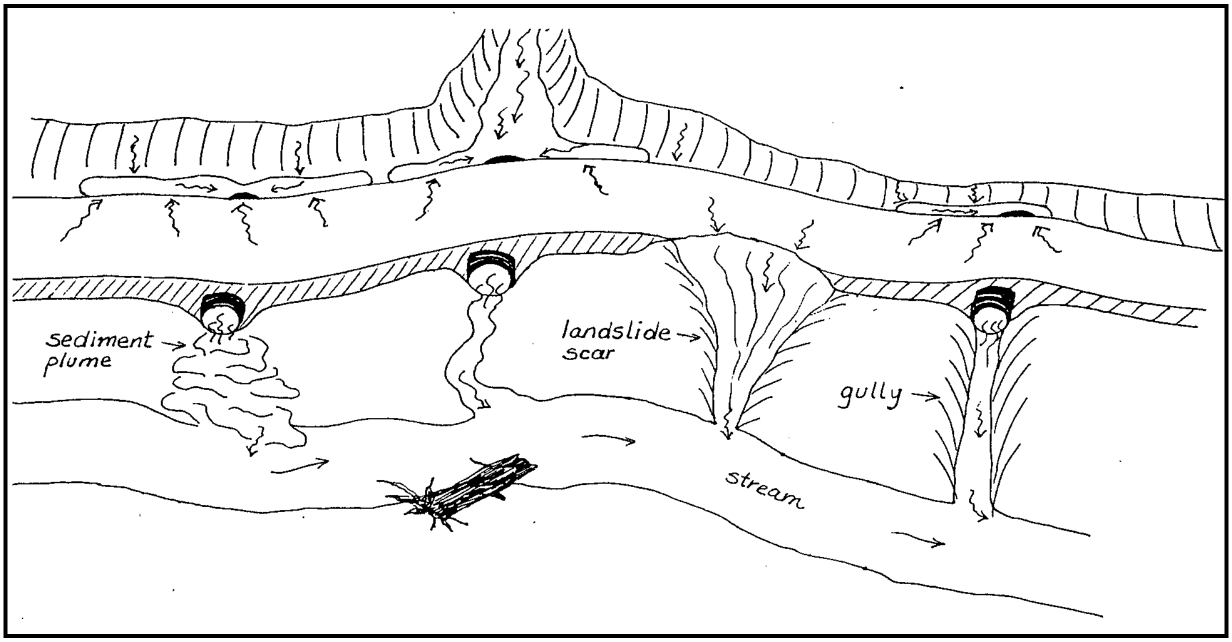


Figure 1-2. How roads can be connected to streams.

Inboard ditches, gullied cross-drain discharges, sediment plumes below cross-drain discharges, and road-stream crossings create connected surface flowpaths between roads and natural stream networks. Disconnecting roads from streams involves limiting the concentration of surface discharge and using permeable soils on the natural ground and road fill slopes to infiltrate runoff and convert it to subsurface flow before it can reach a stream.

(Source: Furniss, M., Flanagan, S., and B. McFadin. 2000. "Hydrologically-connected Roads". Stream Systems Technology Center, Stream Notes (July 2000), pp. 5-7)