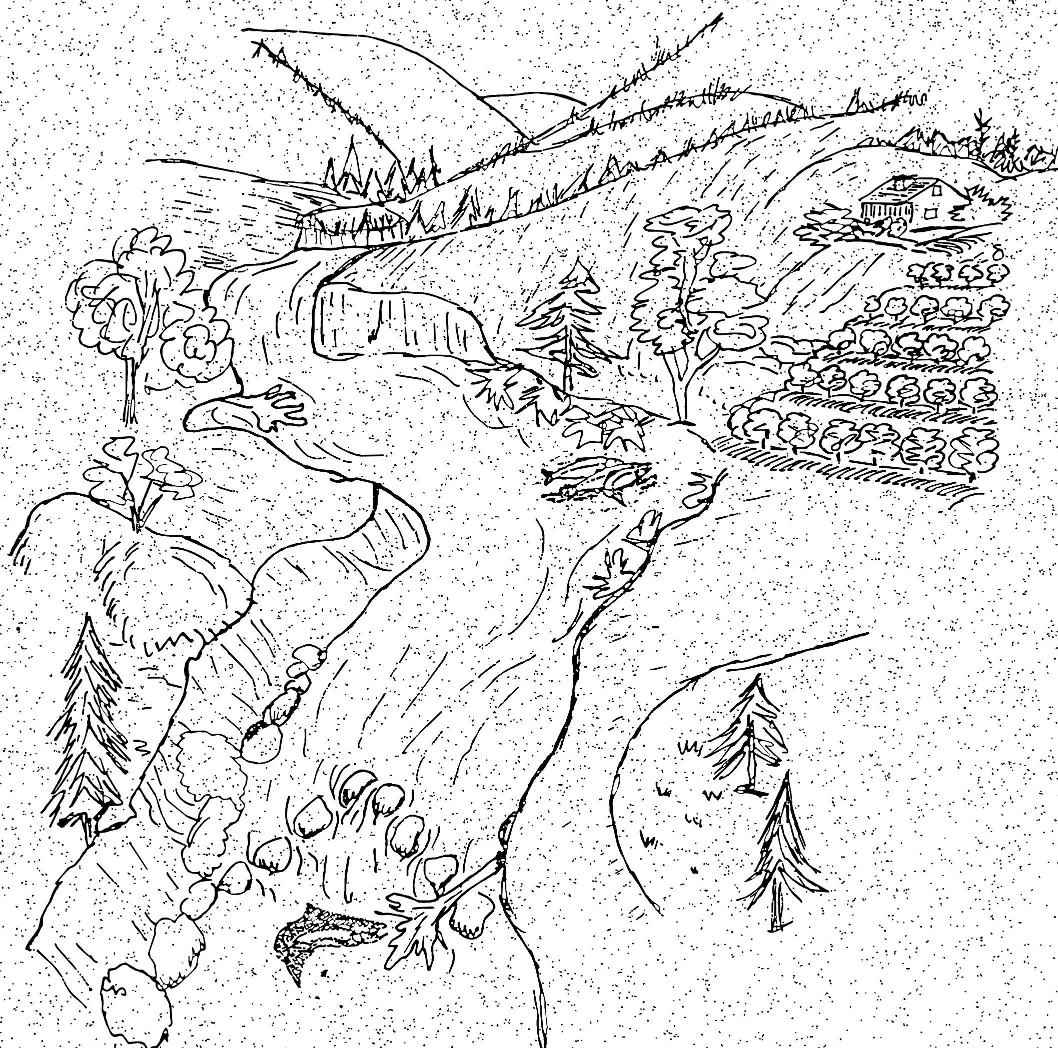
ENTIAT RIVER INVENTORY AND ANALYSIS



Chelan County Conservation District

JANUARY 6, 1998

ENTIAT RIVER INVENTORY AND ANALYSIS

TABLE OF CONTENTS

INVENTORY AND ANALYSIS

In September 1995, a stream inventory was completed on 20.1 miles of the Entiat River corridor. This resource inventory was completed as part of an interdisciplinary stream survey by a team of technical specialists with expertise in the areas of riparian ecology, stream geomorphology, fish ecology, aquatic habitat, and geology.

The Entiat River inventory included 8 reaches averaging 2.5 miles each. The inventory started at the confluence of the Columbia and Entiat Rivers and ended near river mile (RM) 20, at the boundary of the U.S. Forest Service (USFS), Wenatchee National Forest (WNF).

Riparian Inventory

Riparian areas along the Entiat River were surveyed to determine dominant overstory species, percent of canopy cover, and dominant age class of the vegetation (**Table 1**). The inventory procedures closely followed those described in Bauer and Burton (1993) for a reconnaissance-level survey. Age-class categories were from Hankin and Reeves (1988). Riparian vegetation was inventoried by "dominant plant community complex," similar to Winward and Paggett (1987) and Burton (1991). No "community-type" classification was available for the area so specific plant communities could not be classified.

TABLE 1: RIPARIAN VEGETATION

Reach	Length (miles)	Reach Description	Canopy Cover (%)	Dominant Age CLass [a]	Dominant Plant Community	Dominant Stream Classes [b]
1	2.3	End of slackwater to Firestation bridge.	0 - 10	Small Tree (8.0"-20.9"dbh).	cottonwood/ redosier dogwood	C3, F3,B3c
2	3.0	Firestation bridge to Old Hatchery Bridge.	0 - 10	Small Tree	cottonwood/redosier dogwood/erect willow	C3, B3c, F3
3	2.7	Old Hatchery Bridge to Johnson/Steven's bridge.	0 - 10	Large Tree (21.0"- 31.0" dbh)	cottonwood/ erect willow	F3, C3, B3c
4	3.0	Johnson/Steven's bridge to bridge near Mud Creek.	0 - 10	Small Tree	cottonwood/ alder	F3, B3c,C3
5	2.2	Bridge near Mud Creek to Ryan/Small bridge.	10 - 20	Small Tree	cottonwood/alder conifer/alder	F3, B3c,C3
6	2.2	Ryan/Small bridge to terminal moraine at Shorty's.	0 - 10	Shrub/Seedling and Burned Dead Tree	mixed conifer/ alder	F3, B3c,F2
7	2.2	Terminal moraine at Shorty's to USGS gaging station.	0 - 10	Shrub/Seedling Grass/Forb	river birch/ broadleaf sedge	C4,C5
8	2.5	USGS gaging station to section 14 (USFS boundary).	20 - 30	Large Tree Burned Dead Tree	cottonwood/river birch/redosier dogwood	C4, C5
Total	20.1					

[a] - From Hankin and Reeves 1988 [b] - From Rosgen 1994.

Riparian Analysis

Cottonwood was the dominant species in the lower 15.7 miles, with erect willow, redosier dogwood, and white alder as co-dominants. A mixed conifer community was dominant for 2.2 miles of Reaches 5 and 6, with occasional groves or clumps of cottonwood and redosier dogwood. River birch was dominant in Reach 7, with broadleaf sedges as the co-dominants. Conifers were a more important component of the plant community at higher elevations and in those lower elevations where the valley bottom was constricted. A list of the dominant species of riparian plants that occur along the Entiat River can be found in **Table 2** of **Appendix A**.

The "percent canopy cover" is a measure of the percentage of sunlight that is blocked from reaching the stream channel by woody vegetation and topographic features within the riparian zone. A high percent canopy cover results in well-shaded areas that help keep the stream cool in summer. This cover was determined from the ground, during the summer, using visual estimates and a few densiometer readings. These estimates were further refined by comparing them with a GPS-referenced video of the river which the USFS taped during a low-elevation helicopter flight in April, 1995.

The percent canopy cover ranged from 0 to 25 percent. Areas with the lowest percent canopy cover tended to be where agricultural land was developed and riparian trees had been removed. Although canopy cover was low in some reaches, the Entiat is not a river that you would expect a high percentage of shading, because of its relatively wide channel (averaging 90 to 110 feet at bankfull discharge). As a river increases in width, the influence of canopy cover for temperature control becomes less significant. The Entiat River, for at least the first 20 miles, approaches a size where canopy cover is not as significant for summer temperature control. However, topographic shading, as a result of the east-to-west orientation of the river and the steep, high valley walls, adds to the effectiveness of the canopy cover. The Washington Department of Fish and Wildlife (WDFW) does not consider water temperature to be a resource problem for aquatic life in the Entiat River although it has been identified by the Washington Department of Ecology (WDOE) as a "parameter exceeding state standards.

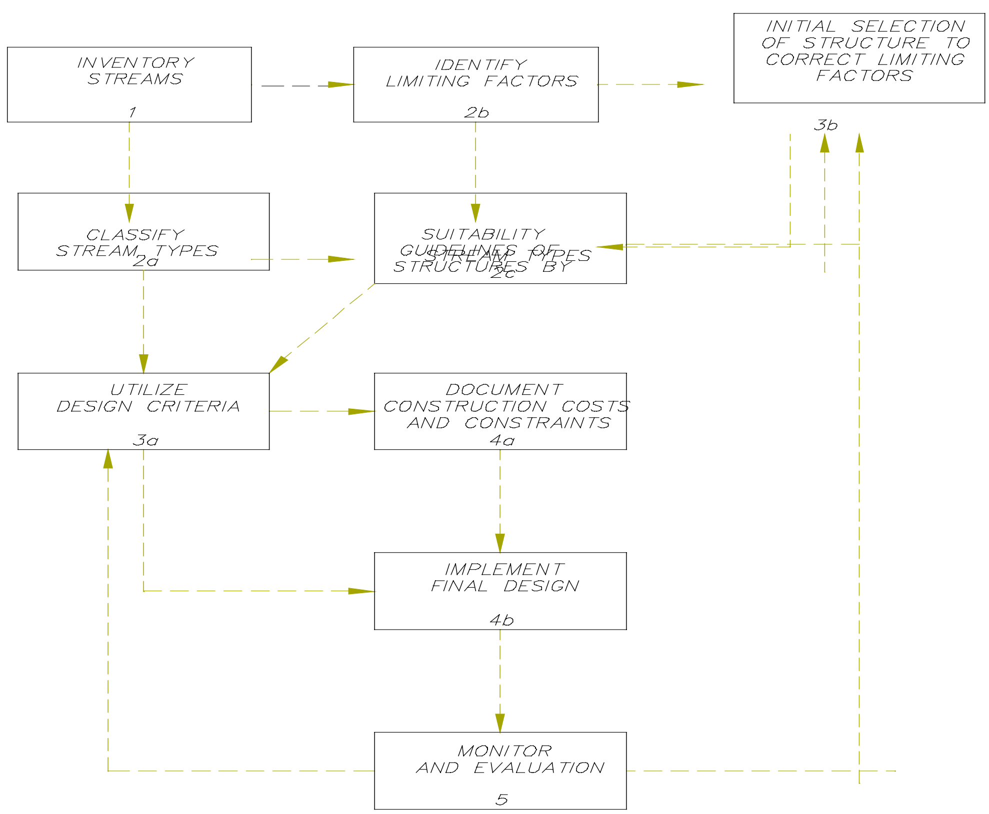
The percent of "age class structure" was determined for each stream reach. The classes were: grassland/forb, shrub/seedling, sapling/pole, small tree, large tree, mature tree, and dead/decadent tree. The shrub/seedling and dead/decadent age classes were the most common in Reaches 5 and 6, where the 1994 Tyee Fire killed most of the trees along the stream. Seedlings and shrubs have sprouted in most of these fire-damaged areas and are growing vigorously, as was evident in the shrub transects established in the inventory process. The fire also burned through Reach 8, but it was not as damaging to the large trees. In this reach, the large-tree age class was dominant with the dead (burned) tree category as a significant component. The small-tree age class was most common in the first 10.5 miles, where large trees have been systematically removed to reduce shading, competition, and pest production in orchards. The large-tree age class was most common in Reach 3.

Stream Geomorphology Inventory

Various data, including cross sections, pebble counts, hydraulic geometry and river hydrology (at the USGS gage near Stormy Creek), delineation of geomorphic stream types, and other information were generated and included as part of this fluvial geomorphic inventory. Field procedures most closely follow those described in *Stream Channel Reference Sites: An Illustrated Guide to Field Technique* (USDA 1994). Other inventory resources, such as maps, aerial photos, and a video of a GPS-referenced flight of the river corridor were used. The low-flight video coverage, provided by the USFS, Entiat Ranger District, became a valuable resource for the interdisciplinary team.

Figure 1 labeled: "Decision Framework for Habitat Structure Selection" is the process describing the flow of work used by the interdisciplinary team that completed the physical river survey. This process should not be confused with the NRCS, "nine steps of conservation planning." The procedure described in **Figure 1** would be an integral part of the resource problems, analysis, and alternative formulation in the planning process. **Table 4, Appendix A** is labeled: "Anadromous Fish Habitat Improvements for Stream Types" and is located in step **2c** of **Figure 1**.

FIGURE 1
Decision Framework for Habitat Structure Selection*



*From Rosgen and Fittante — Fish Habitat Structures — A Selection Guide Using Stream Classification (modified to show relationship between steps 2c and 3a)

The geomorphic stream classification system used for this inventory was developed by David L. Rosgen, Wildland Hydrology Consultants. The system (**Figure 6, Appendix A**). is called: “A Classification of Natural Rivers” (Rosgen 1994). The lower 20 miles of the Entiat has been classified. The first letter of the alpha-numeric code describes the physical setting of the river or stream section being classified, where:

Aa+	Very steep (greater than 10% slope, deeply entrenched, debris transport streams.)
A	Steep, entrenched, cascading, step/pool streams. High energy/debris transport associated with deposition soils. Very stable when dominated by bedrock or boulder.
B	Moderately entrenched, moderate gradient, riffle dominant channel, with frequently spaced pools. Stable plan and profile.
C	Low gradient, meandering, point-bar, riffle/pool, alluvial channels with broad, well-defined floodplains.
D	Braided channels with longitudinal and transverse bars. Very wide channels with eroding banks. Unstable.
DA	Braided but anastomosing (stable multiple channels) that are narrow and deep with expansive well vegetated floodplains and associated wetlands. Very gentle relief with highly-variable sinuosities. Stable stream banks.
E	Low gradient, meandering riffle/pool channels with low width/depth ratios and little deposition. Very efficient and stable. High meander width ratio.
F	Entrenched, meandering riffle/pool channels on low gradients with high width/depth ratios.
G	Entrenched “gully” step/pool and low width/depth ratios on moderate gradients (typical 2 to 4% slope).

The numeric character in the stream classification code describes the substrate composition by its mean diameterand is based upon the $\mathbf{d_{50}}$ value of a sample as described by Wolman (1954). This method was later modified by Rosgen (1985) to include finer-grained materials. The numeric values of the stream classification code are those described in the Wentworth particle size classification. They are:

1 bedrock
2 boulder, $d_{50} > 256$ cm or 10 inches
3 cobble, d_{50} is 64 cm or 2.5 inches to ≤ 256 cm or 10 inches
4 gravel, d_{50} is 2 mm or 0.08 inches to ≤ 64 cm or 2.5 inches
5 sand, d_{50} is 0.0625 mm or 0.002 inches to ≤ 2 mm or 0.08 inches
6 Silts or clays d_{50} is less than 0.0625 mm.

Lower case subscripted letters following the numeric character denote a steeper or gentler slope than the majority of rivers within that category (ex. B3c is a B3 type stream with less than 2% slope, see **Figure 6, Appendix A**). Many of these subscripted types exist because of alterations to natural streams by human activities.

Stream Geomorphology Analysis

Steep mountain topography is a characteristic form of most of the watershed area feeding the Entiat River system. Some areas are covered with glacial debris in the form of moraine and outwash. The differences between geomorphic stream types located in these outwash and moraine areas and those in the steeper, narrower valley areas are highly significant to this inventory and analysis because their physical characteristics help determine different methods to improve fish habitat and streambank stability.

The Potato Terminal Moraine, located at river mile 16.1 and shown on **Map 4, Appendix C** (located in back cover) is located at the McKenzie water diversion near Shorty Long's property. This is a key area that will be mentioned several times in this report because of the substantial change in stream geomorphology that occurs at this location. Management and structural applications diverge at the Potato Moraine site, where the river can be easily divided into upstream versus downstream segments. Salmonid habitat, riparian corridor, canopy cover, woody debris, streambank stability, adjacent land uses, and numerous other physical river features are discussed and incorporated in the inventory and analysis in order to generate the alternatives.

Table 3 summarizes the geomorphic stream types which will be used to plan and design practices that will address the resource problems. The primary method of restoring the stream to a more stable system that supports adequate fish habitat is by creating large pools that take up much of the energy of the stream. The number of pools for each alternative are also shown in **Table 3**. Notice the contrast between pools-per-mile in Reaches 1 - 6 and Reaches 7 - 8. The first six reaches, from the confluence, upstream to the beginning of Shorty Long's property, are severely lacking in pool habitat and other components, such as LWD (large woody debris). This first 15.4 miles of stream channel shows the result of human disturbances, such as historic flood control practices - it consists of a long series of shallow riffles and glides, with only a few large pools.

There is a relationship between C4 stream types and frequency of *Class 1* pools as shown in **Table 3** for Reaches 7 and 8. C-type stream morphologies are more prone to having deeper, larger and more numerous pools. F3 and B3c stream types are more likely to be wider and shallower at bankfull discharge than C4 or C3. **Figure 4, Appendix A** shows the proportional amount of geomorphic stream types by reach. Considerable more aquatic habitat exists in the C4 stream type.

TABLE 3

ENTIAT RIVER SUMMARY OF POOLS AND GEOMORPHIC STREAM CLASSIFICATIONS

Reach	Reach Description	Length	Dominant Stream Types	Class I * Pool Count	Class I Pools Alt 1 (present condition)	Class I Pools Alt. 2	Class I Pools Alt. 3	Class I Pools Alt. 4	Class I Pools Alt. 5 (Geomorphic)
1	Slack water to Fire Station Bridge	2.3	C3, F3, B3c	1	0.44 pools per mile 1 total	1.3 pools per mile 3 total	2.2 pools per mile 5 total	4 pools per mile 9 total	8.8 pools per mile 20 total
2	Fire Station Bridge to Old Hatchery Bridge	3.0	C3, B3c, F3	1	0.33 pools per mile 1 total	2.3 pools per mile 7 total	3.3 pools per mile 9 total	4.3 pools per mile 13 total	8.9 pools per mile 27 total
3	Old Hatchery Bridge to Johnson/Stevens Bridge	2.7	F3, C3, B3c	2	0.74 pools per mile 2 total	3.7 pools per mile 10 total	4.4 pools per mile 12 total	6 pools per mile 16 total	9 pools per mile 24 total
4	Johnson/Stevens Bridge to Bridge near Mud Creek	3.03	F3, B3c, C3	1	0.33 pools per mile 1 total	4 pools per mile 12 total	5.3 pools per mile 16 total	6.3 pools per mile 19 total	9 pools per mile 27 total
5	Bridge near Mud Creek to Ryan/Small Bridge	2.17	F3, B3c, C3	0	0.0 pools per mile 0 total	2.3 pools per mile 5 total	3.2 pools per mile 7 total	5.1 pools per mile 11 total	9.2 pools per mile 20 total
6	Ryan/Small bridge to Potato Moraine at Shorty's	2.24	F3, B3c, F2	1	0.5 pools per mile 1 total	2.2 pools per mile 5 total	3.6 pools per mile 8 total	5.4 pools per mile 12 total	9.2 pools per mile 21 total
7	Potato Moraine at Shorty's to USGS gaging station	2.17	C4, C5	11	5.5 pools per mile 11 total	6 pools per mile 13 total	6.5 pools per mile 14 total	6.5 pools per mile 14 pools	9.2 pools per mile 21 total
8	USGS gaging station to section 14 Forest Service boundary	2.5	C4, C5	17	6.8 pools per mile 17 total	8.4 pools per mile 21 total	9.2 pools per mile 23 total	9.2 pools per mile 23 total	9.3 pools per mile 23 total
Total(s		20.11		34	34 Pools	76 Pools	94 Pools	117 Pools	183 Pools

Pool frequencies are based on Class I pools. (≥ 1 meter depth, approximately 20 m^2 surface area).

Class II and III Hankin and Reeves are visual estimations. Class 1 pools were measured during inventory.

Table 5, Appendix A is a list of the most appropriate fish habitat improvements by the most dominant geomorphic stream types. Structures were chosen after analyzing interdisciplinary and suitability considerations, existing or missing habitat components, thematic overlays of the inventory data, and geomorphic compatibility of instream practices.

Fish Habitat Inventory

The type and quality of fish habitat was field-inventoried and delineated on 1:24,000 USGS quad maps. Locations of large pools, as well as potential sites for habitat improvement, were later transposed onto the Resource Inventory Maps (Themes) located in **Appendix C.** The primary fish habitat components are as follows:

1. ***Habitat Type*** - The upstream and downstream extent of each of the following habitat types was noted:

   a. pools - areas having very reduced flow velocity and increased depth compared to immediately upstream and downstream;

b. riffles - areas with water shallow enough that there is a pronounced "turbulence" on the surface as the fast-flowing water moves over gravel and cobbles;

c. glides - (also called "runs") - areas that are deeper than riffles (can be as deep as pools) but with a continuous flow, similar to that of a riffle, running through them;

d. cascades - steeper gradient areas of boulders or bedrock where the velocity increases and forms numerous "white water" pockets.

2. ***Habitat Quality*** - Only large pools were counted. Pool depths were estimated by wading into them as far as possible. In Reaches 1-6, the frequency of LWD, small woody debris (SWD) and overhanging brush and trees was determined by stopping every 30 paces (~50 ft) and noting if any of these habitat quality features were present on either bank. In Reach 7, there was generally overhanging brush along at least one side of most of the pools. Because of split channels, sharp meanders and numerous obstacles, we were forced to walk back and forth across the channel, so we stopped counting the brush at every 30 paces and only noted it for the larger pools. For Reaches 7 and 8, a general average of 10 brush units/mile (based on the first half of Reach 7) was used.

The substrate composition of the streambed was generally noted for most of the river, but specifically measured only at a single cross-section taken in each reach. The primary habitat quality features are:

a. large pool - at least one meter deep, with a surface area (during low flows) of at least 20 square meters; referred to as *Class I* pools by Hankin and Reeves

b. overhanging vegetation - limbs of trees that hang into, or immediately over, the water surface at low flows; trunks of trees that protrude over and very close to the water surface

c. large woody debris (LWD) - dead trees, or parts of trees that are at least 35 feet long with a diameter greater than 12 inches at the small end

d. undercut banks and bedrock outcroppings - places where the thalweg (deepest part of the channel) works against the bank and erodes away the loose material, leaving a scoured pool or glide that is contained by the less erosive parts of the bank. They usually occur along the outside curve of a meander, but can also be located along straight channels. These features were only generally noted when they occurred as a component of the pool.

e. large boulders - noted only when they had a diameter of at least 4 feet and provided cover in pools, or when they were critical to poo formation

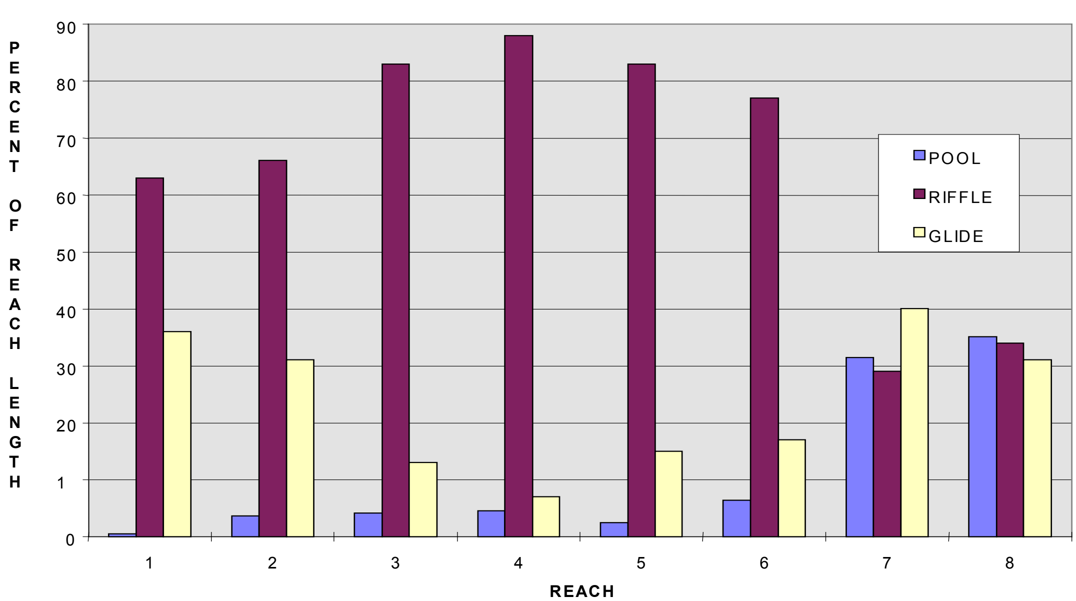
f. substrate - general abundance of spawning-size (1-3 inch diameter) gravel.

3. ***Habitat frequency*** - The percentage of habitat type (pool, riffle, glide) was determined for each reach by measuring and comparing the length between the "tic marks" which were put on the quad sheets during the survey to delineate the beginning and end of each habitat type. This information was compared with pool and riffle counts that were made independently by two fish biologists as they walked the river. These results were used to determine the pool:riffle ratio and the pool frequency for each reach. Pool frequency was determined for only large (*Class 1*) pools. Obvious sediment sources and denuded riparian areas were also noted by a riparian plant specialist during the survey.

Fish Habitat Analysis

1. ***Habitat type*** - Less than 1000 feet of cascades were noted for all of the reaches. There were no waterfalls. The length of channel that is composed of pools, riffles and glides is shown for each reach in **Figure 2**. Note that glides are fairly common throughout the survey length, but dominant only in Reach 7. Riffles are, by far, the dominant habitat type in the first six reaches. This, combined with the lack of large pools and complexity of cover (see **Figure 3**), is typical in channelized streams.

FIGURE 2 - HABITAT TYPE BY REACH



Only a few large pools were noted in the first six reaches and the majority of these were formed incidentally as a result of nearby construction activities. An example is the pool formed near the Pritchard residence, located in Reach 2, just upstream of where the Entiat River Road crosses the river the second time. This is the site of a former concrete dam that, according to Mr. Pritchard, was used to hold water for log storage and historically blocked adult fish passage. The river has created a large plunge/scour pool as it flows over and around the massive pieces of broken concrete remnants of the old dam.

Another example is the long, deep scour pool formed at the upper end of Reach 3, where very large pieces of riprap (quarried rock) have fallen from the shoulder of the adjacent road and caused the river to make a sharp turn with an erosive turbulence. An adult sockeye salmon was seen holding in this pool. Another large pool, located in Reach 4, at the defunct Ardenvoir dam/mill site, has been formed in much the same way as the one in Reach 2.

The only pool formed by bedrock outcroppings is located in the upper part of Reach 6. This was the first upstream pool where live, pre-spawning adult chinook were found. Several adult holding pools have been formed by large boulders and were found between Reaches 4 and 7. One, at the upper end of Reach 6, resulted from the placement of two rock weirs across the river by the Washington State Department of Fish and Wildlife (WDFW) in November1994. These were designed to create a permanent water diversion structure for the McKenzie irrigation ditch. Another pool was formed in Reach 4, where large boulders have fallen into the channel from the adjacent bank and become lodged across the river, forming a natural "V"-shaped weir that points upstream.

Historically, the majority of these large pools would have been created and maintained by LWD. In the first six reaches, however, the river has been inadvertently channelized for various reasons that may include: flood control, erosion control, drainage improvement, channel relocation for delineation of property lines and more uniform boundaries for easier cultivation along the river. These practices have resulted in the loss of most of the LWD in these reaches. LWD is generally removed from these areas because channelization increases the flow velocity and power to the point where LWD cannot stay in one place long enough to form stable pools. In these situations, the LWD is often carried downstream, where it tends to deposit at the first place there is a restriction, such as a bridge or water diversion. It is then removed from the channel at these locations in order to protect the integrity of the structures.

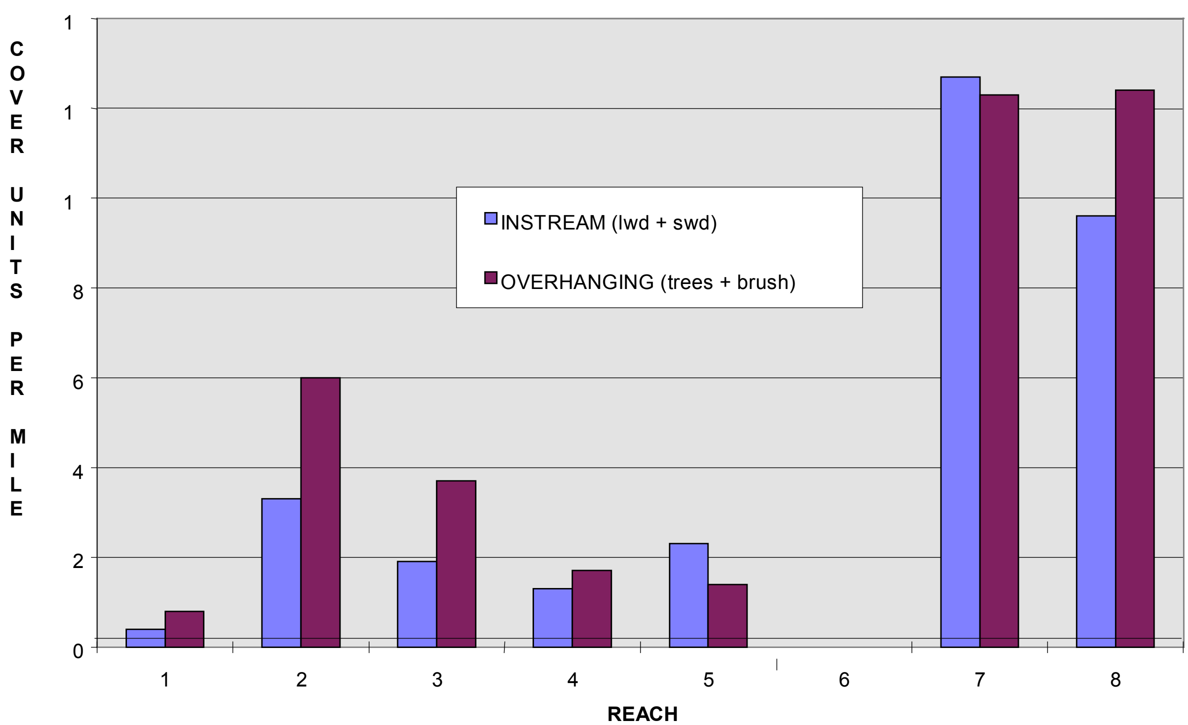
1. ***Habitat quality*** - All of the six lower reaches have been extensively channelized and the substrate consists primarily of cobbles and numerous small boulders, with some interspersed gravel. The first noticeable change in habitat quality upstream of Reach 6 is the very obvious increase in the amount of spawning-size gravel (1-3 inch diameter).

Most of the LWD has been removed from, or has been transported through, the lower six reaches (see **Figure 3**). The channel upstream of Reach 6 is more natural, with much higher sinuosity, numerous log jams (both in the channel and alongside it), undercut banks and deep pools. These features cause flowing water to lose energy periodically so that smaller-sized bedload, such as gravel, drops out of the water column and forms expansive spawning beds for salmon and trout - in fact, spawning chinook were first noted in the middle of Reach 7.

Reaches 7 and 8 contain frequent point bars (as well as a number of center bars) that consist of cobbles at the upstream end, grading to gravel in the middle and to gravel and sand at the downstream end. A certain percentage of this gravel and sand is very mobile and is periodically moved downstream where it is captured by LWD or by the next gravel bar.

The amount of cover that relates to *stream shading* is termed "percent canopy" (**Table 1**). Since this type of cover refers to the canopy of trees, it is relatively high above the channel. Cover, as it relates to *fish habitat*, can be: (1) instream - anything that breaks up the streamflow by protruding into the water at, or below, bankfull flow - either from the bottom or from the banks of the channel; or (2) overhanging - usually live vegetation that protrudes from the top or side of a bank, and over (and very close to) the low-water surface of the channel. All three forms of cover have been removed from Reach 6 due to the 1994 fire which burned most of the wood in the riparian corridor.

FIGURE 3 - FREQUENCY OF COVER



Numerous fish habitat studies have shown that the amount of instream cover (primarily LWD) is one of the primary limiting factors that determine the number of juvenile fish that a given area of stream can support. It serves two functions as cover. The most obvious is a place for both juveniles and adults to hide from predators. A less obvious function is that it creates complexity of flow and micro-habitats.

Each root or branch that protrudes from the LWD forms small vortices where the current is broken down into pockets of slower water. This is especially critical for small fish during high flows. Each root and branch also acts as a “partition” which a young fish uses to identify and separate its territory from that of its neighbors. Juvenile salmonids are very protective of their territory and will actively defend it. The more sites for territories - the more fish. Also, the fish that finds the best territory is usually the one that grows the fastest and becomes the largest.

In the channelized reaches, where velocities are generally higher, large boulders can offer some instream cover. These were not specifically addressed during the inventory except where they were arranged so that they formed weirs (low-level dams) that created large pools. Even single boulders, however, can provide a place for a few juvenile fish to define a territory. Where there are clusters of boulders, these territories can become larger and more complex. Using an electrofisher, the WDFW area habitat biologist found five juvenile chinook and several small rainbow trout (most likely steelhead) were found in shallow pools formed by a boulder cluster in Reach 5.

Overhanging cover creates a second level of protection from land and air-borne predators. Overhanging cover is usually in the form of branches from live trees and brush or dead material that rests on top of the streambank, but it can also take the form of undercut streambanks. These were not specifically documented, but they were noticeably absent in the first six reaches. This is understandable due to the channel incision, bank shaping and bank armoring that has occurred in these “streamlined” areas.

Under these conditions, woody vegetation cannot grow close to the water surface at the low-flow level and the adjacent water table generally drops below the root zone of the woody vegetation that would normally grow in a higher water table. Low-lying brush, such as snowberry, can provide overhanging cover when it is on top of an undercut bank, as long as the thalweg flows along the toe of this bank. This was a common occurrence upstream of Reach 6.

No overhanging trees were counted in the first six reaches. **Figure 3** shows that the first appearance of overhanging tree cover occurs in Reaches 7 and 8. The tree species that provides much of the observed overhanging cover in the upper reaches is water birch. Limited cover is also created by some willow species, alders and small cottonwoods.

All overhanging vegetation, such as water birch, provides habitat for adult insects, both terrestrial as well as aquatic. These insects continually fall into the stream and provide additional food for the fish. Overhanging vegetation also provides refuge from the force of water and the debris that it carries during floods. Both adults and juveniles move into the branches and behind the trunks of trees when the water rises into them.

Even though Reaches 7 and 8 contained the most overhanging cover, there were several sites where it was obvious that most of this material had been removed with the use of a power saw. These sites were generally remote and not associated with human dwellings. Bob Steele, WDFW Area Habitat Manager, suggested that the Entiat River, like many in this area, were popular for "river rafting." As such, it is not uncommon for some of these participants to carry chainsaws with them to remove obstructions, such as branches. A few rafters in other rivers have also been known to remove log jams, which, offer some of the best fish habitat and streambed stability.

3. ***Habitat frequency* -** Theoretically, a stream that is ideal for salmonid fish would have a 1:1 pool:riffle ratio, with a large pool alternating with each riffle. In the natural system, however, this would be a rare occurrence. Note that even though the ratio is essentially 1:1 in Reaches 7 and 8, pools and riffles make up only 60-70% of these reach lengths. The rest is composed of "flat water" (glides or runs). Glides are generally intermediate between pools and riffles and are some of the best rearing areas for young-of-the-year steelhead. When glides are interspersed with large boulders they also offer habitat for older juvenile chinook and trout. Glides are home to many of the aquatic insects that are important food items for fish. Glides, with slower flow and deeper water, may be more easily converted to pools than riffles when LWD is added. Glides are features that add to the complexity of habitat.

From **Table 3**, the frequency of large pools/mile (P/M) averages only 0.4 for the first six reaches, but increases at least ten-fold in the more "natural" Reach 7 (5.5 P/M) and 8 (6.8 P/M). When the location of each pool is plotted on the quad map, it becomes evident that there is a strong correlation between the number of pools and the sinuosity of the channel. For instance, within a one mile, "straight-line" distance up the river valley, beginning at the gaging station in Reach 8, the actual river channel length is two miles long, resulting in a sinuosity of 2.0. In comparison, however, the river in the next upstream "straight-line" mile is only one mile long, giving it a sinuosity of nearly1.0. There are 14 large pools in the high-sinuosity section but only 3 in the low-sinuosity part of Reach 8. The very low frequency of pools in the first six reaches corresponds with the low sinuosity ratings, which average about 1.2 in this channelized section of river.

Rivers are dynamic in both natural and unnatural states. They can go for long periods of drought and show very little change, except that woody vegetation is able to encroach closer to the low-flow elevation. One large flood can instantaneously change the number of pools, their size, and their location by widening the channel and depositing trees, logs, stumps and bedload along the entire length of the channel. Floods generally cause a greater loss of pools in an unnatural, altered stream channel that lacks a floodplain and proper sinuosity. A formerly single-thread channel can become braided within its floodplain or move and form an entirely different single-thread channel.

All of these changes create complexity in the habitat. Complexity is the key to good habitat. Good habitat is the key to healthy fish and wildlife populations (other things being equal). *Braided* channels are generally considered to be detrimental to fish life and other aquatic organisms because they are usually very unstable. A section of *split* channel, however, can have one or more stable side channels, each one with its own riparian ecosystem. All of these separate habitats combine to form a larger, more complex habitat area that will support even more fish and wildlife than a single thread channel.

RESOURCE PROBLEMS

Some of the potential resource problems in the first 20 miles of the Entiat River corridor were identified by the technical advisory (TAC) and land owner steering (LSC) committees. The resource problems identified and described in this section are the result of the more intense inventory and analysis completed on this river section.

Riparian Resource Problems

The human-caused problems associated with maintaining the riparian vegetation in the Entiat River watershed are the result of the cumulative impacts from environmental changes. These changes have occurred since early settlement and still occur with ongoing developments in the watershed. Some of the historic problems occurred in the upper watershed and include overgrazing, certain timber harvesting activities, road construction and recreation. The main influences on the vegetation in the lower part of the watershed below the USFS boundary are wildfire, agricultural encroachment on the floodplain, flood control, channel straightening, grazing (mostly in the past) and rural residential development in the floodplain.

Wildfires have been one of the greatest impacts to the riparian vegetation, both directly from burning and flooding and indirectly during flood repair and flood control projects that often follow large fires. According to the USFS: "Fires historically burned over a large percentage of the lower drainage every seven to ten years." Furthermore: "Since 1970, flooding has followed every major fire in the drainage. In addition, significant flooding occurred in the Entiat Valley in 1948, 1956, and 1974." (USDA 1996)

The trend in the vegetative condition of the riparian vegetation is generally stable or slightly upward except where it is continuing to be cleared by landowners. Younger age classes tend to be more common. Although landowners do not remove <u>all</u> trees from the riparian area they still harvest the larger species to keep them from falling into the river or from shading adjacent fruit trees. Certain species of trees are also removed because many orchardists feel that they are hosts for disease and for certain pests, such as scale insects, that can harm fruit crops. Researchers at both the Washington State University -Tree Fruit Research Station in Wenatchee, and at the Oregon State University - Mid Columbia Agricultural Research and Extension Center in Hood River, Oregon agree that native vegetation along the perimeter of an orchard may harbor some pest species but that it also supports predator species which feed on these pest species. They feel that complete removal of this vegetation will not eradicate the pest insects. The leading entomologist in the Hood River study sums his observations about insects living in the surrounding native vegetation as: “They are more beneficial for orchards than they are harmful” (Riedl 1998).

Riparian vegetation has also been removed as the result of urbanization along the stream. In some places, it has resulted in the replacement of native vegetation with introduced plants. These introduced plants are often not as effective for streambank protection as native riparian species.

Stream Geomorphology Resource Problems

Most of the first 15 miles of stream are less sinuous than its historical morphological stream type. This area was once a cobble- and gravel- dominant system with considerably more *Class 1* pools. Prior to early settlement, the lower 15 miles of stream, situated within relatively narrow valley bottom walls, had a steeper gradient than the channel above the Potato Moraine, but historically, would have had a lower width-to-depth ratio (narrower and deeper at bankfull discharge); more meander belt width; more large woody debris; and more numerous habitat features than presently exist (see **Resource Inventory Maps, 1 -4**).

Streambanks in the first six reaches are generally stable in areas where past riprap activities have occurred. Some areas are stable due to root masses from what limited streambank vegetation exists.

Some areas in Reaches 1 through 6 have the potential for severe erosion. Where softer berms have been used to control the Entiat channel direction, a greater potential for failure exists. Some streambank areas would benefit from the reintroduction of large woody-type plant species. There are opportunities to re-establishish vegetation even in areas previously treated with large rock. Implements exist today to bore spaces in between riprap in order to provide space for plant reintroduction.

Reaches 7 and 8 have some areas that need to be treated for streambank instability (see **Map 4, Appendix C**). The riverbanks along these reaches are composed of finer sand material. Large woody riparian plants are essential for stability. Rocks or boulder-type materials are generally inappropriate for revetments in Reaches 7 and 8 unless they are used to anchor rootwads into streambanks. Rootwad revetments, along with riparian planting, would be the principle mechanism for streambank stability. Rock vanes would be appropriate in specific locations based on conditions.

“There are characteristics of river channels that are so general that they must be recognized in any discussion of morphology. A straight or non-meandering channel characteristically has an undulating bed and alternates along its length between deeps and shallows, spaced more or less regularly at a repeating distance of 5 to 7 bankfulls. The same can be said of meandering channels, but this seems more to be expected because the pool or deep is associated with the bend, where there is an obvious tendency to erode the concave bank." (Leopold 1994). Leopold's statement captures the essence of the differences between the reaches below the Potato Moraine versus the reaches above. Thus, our expectations are that we will see less pools below the Potato Moraine because of channel manipulation and river types.

Table 3 has a column labeled "Geomorphic Pools." This category displays the number of pools per reach that would be anticipated in a river that has a natural, healthy pool:riffle ratio. The distance between pools is based on an average of six bankfull discharge widths. The class of pools referred to are defined by Hankin and Reeves as *Class 1*. These *Class 1* pools are deep, cool, and reoccur most years. Reach 8 maintains approximately 75% as many pools as it should in a natural condition. Reach 7 is showing some signs of a downward trend with regard to habitat and stream geomorphology. Reach 7 has approximately 60% of its natural pool potential with higher width-to-depth ratios at bankfull height.

All of the reaches below the Potato Moraine have less than 0.74 pools per mile. Reach 5 has no *Class 1* pools within its 2.2 mile length. This data supports the conclusion that alternative formulation for the Entiat River needs to include significant pool-forming measures while providing cover and streambank stability components.

The next step in the planning process is to consider the potential survivability of proposed streambank and fish habitat improvements and their impacts on the river corridor and land uses. **Tables 4** and **5** of **Appendix A** display a rating system for fish habitat practices ranging from excellent to poor, based on geomorphic stream types. This data, along with information regarding interdisciplinary input and resource problems, helps identify applicable pool-forming structures for fish habitat needs and streambank stability practices (see steps 2b and 3b in **Figure 1**). Other factors, such as streambank composition, large woody debris, present land use, riparian needs and other resources, are considered previous to structural considerations.

Fish Habitat Resource Problems

The Landowner Steering and Technical Advisory Committees, as well as fish biologists from local agencies, feel that high stream temperature is not a limiting factor for fish life in the Entiat River. It was noted, however, that the Washington Department of Ecology (WDOE) has measured water temperatures that exceeded the state class A standard (64.4^0F) on 11 different days between 1984 and 1994. For that reason, WDOE proposed water temperature as a "parameter exceeding standards" in its 303(d) list that the agency submits to EPA.

The problems identified by the Steering and Technical Advisory Committees pertain to the lack of stream complexity in the lower 20 miles. Complexity has been lost due to: lack of large woody debris for instream habitat; shortage of quality pools for juvenile rearing and adult resting; lack of suitable spawning areas; streambank erosion and sedimentation. These problems are the result of both natural and human-caused disturbances.

Among the natural disturbances are earthquakes, high intensity thunderstorms, relatively frequent wildfires, and floods (USDA 1996). The Entiat Valley lies on an active fault system. In the last 100 years, 4 earthquakes have rocked the watershed. One of these was severe enough to cause a rockslide which temporarily dammed the Columbia River. Severe summer storms can cause problems in the lower watershed. Wildfires commonly cause damage in lower, drier elevations. Since 1970, there have been six wildfires greater than 2000 acres in size. Flooding has followed many of these fires, which has contributed to stream channel adjustments, excessive erosion, high bedload deposition, and loss of suitable spawning substrate.

Human-caused disturbances are related to past and present flood control work. Much of the river below the WNF boundary has been channelized, riprapped and/or diked to reduce flooding. While these practices were intended to alleviate flooding problems in the lower watershed, they have inadvertently created other problems related to streambank stability, water quality, fish and wildlife habitat and the shallow water table associated with the river. These problems were exacerbated by accelerated runoff conditions in the upper watershed and removal of native riparian vegetation related to orchard management in the lower watershed. The hydrology of the watershed has been changed by overgrazing, timber harvest (and associated road construction), recreation, wildfires, and associated wildfire suppression (USDA 1996). While the conditions which led to these problems are not continuing in most areas, the vegetative condition has not fully recovered. Some of these areas continue to have resource management problems.

Instream complexity, especially in the form of quality pools, has been lost primarily due to human intervention as it relates to removal of large riparian trees. The most common way that pools are formed is when large trees fall into the river from the near bank.. These trees are then considered to be LWD. If they are large enough to stay in place, they cause the water to slow down as it attempts to get past them. Bedload and small woody debris that is being carried in the water column becomes trapped along the upstream face of this LWD. The streambed becomes locally higher, and the water flow becomes shallower and faster. This creates a stable spawning bed and a place where certain aquatic insects thrive.

As the water plunges over, under, and around the LWD, it scours a deeper pool area along, and underneath, the downstream face of the LWD. The erosive force of these “scouring” flows digs out the streambed and flushes cobbles, gravel and sand downstream of the LWD. The heavier cobbles settle out quickly. The smaller-sized gravel settles on top of, and just downstream of the cobbles. Most of the fine sediments are carried much farther downstream. The deposition of cobbles and gravels, well-sorted by the scouring flows, causes the water depth to become shallow again and the flow velocity to increase. This area of change from pool to riffle is the “tail-out” section.

This combination of fast, shallow water with slow, deep water, LWD, overhanging vegetation and loose rock substrate is the most important type of spawning and rearing habitat for the following reasons:

a. The water picks up oxygen from the air as it spills over the LWD;

b. The gravel is well-sorted and several different fish species are able to find the size that is most desirable for them;

c. The gravel is cleaner than that found on point bars;

d. The gravel does not become armored or embedded, as often happens along point bars - spawning fish can move the gravel much easier;

e. The change in depth causes the water to flow through the gravel, as well as over the surface at the tail-out, carrying the much-needed oxygen to the eggs and helping to flush out fine sediments and metabolic waste products of incubating eggs and alevins;

f. LWD provides refuge (particularly during high flows) from the exertion of swimming in a stronger current and from the debris and bedload that is being transported during high flows;

g. LWD provides cover, for protection from predators, at all flows;

h. Under the proper conditions, this combination can raise the nearby water table and create better growing conditions for riparian vegetation, eventually allowing more overhanging vegetation to establish;

i. LWD, combined with the stable, cleaner, well-oxygenated bedload accumulation, provides a complex habitat for a wider variety of aquatic insects - the food source for most fish. Juvenile salmonids feed on "drift," the aquatic insects that wash out of the gravel on the upstream side of the LWD or fall from the LWD and overhanging vegetation and float past the fish or sink in front of them as they wait in the pool on the downstream side;

j. This combination provides juvenile fish with more quality territories to occupy and defend, so that more fish can take advantage of the food source.

ALTERNATIVES AND EFFECTS

Alternatives have been developed to address limiting factors for salmonid habitat: lack of pools, lack of large woody debris, lack of streambank stability, excessive sediment in the spawning gravels and lack of suitable spawning areas. Most of the limiting factors were identified by both the Technical Advisory and Landowner Steering Committees.

Riparian Improvements

The health and amount of riparian vegetation directly influences each of these identified problems so most of the alternatives include riparian planting and management. There are six miles of streambank identified for potential riparian planting opportunities (see **Table 7**). These areas include sites where streambank erosion is causing a problem and other locations where the 1994 fire burned through the riparian types along the corridor.

TABLE 7

STREAMBANK PLANTING RECOMMENDATIONS

Reach	Length (miles)	Reach Description	Canopy Cover (%)	Potential Planting Sites (feet)	Dominant Plant Community	Minimum Recommended Planting
1	2.3	End of slackwater to Firestation bridge.	0 - 10	4700	cottonwood/ redosier dogwood	4700
2	3.0	Firestation bridge to Old Hatchery Bridge.	0 - 10	5900	cottonwood/redosier dogwood/erect willow	5900
3	2.7	Old Hatchery Bridge to Johnson/Steven's bridge.	0 - 10	3900	cottonwood/ erect willow	3900
4	3.0	Johnson/Steven's bridge to bridge near Mud Creek.	0 - 10	2900	cottonwood/ alder	2900
5	2.2	Bridge near Mud Creek to Ryan/Small bridge.	10 - 20	2000	cottonwood/alder conifer/alder	2000
6	2.2	Ryan/Small bridge to terminal moraine at Shorty's.	0 - 10	10,350	mixed conifer/ alder	10,350
7	2.2	Terminal moraine at Shorty's to USGS gaging station.	0 - 10	6600	river birch/ broadleaf sedge	6600
8	2.5	USGS gaging station to section 14 (USFS boundary).	20 - 30	3600	cottonwood/river birch/redosier dogwood	3600
Total	20.1			39,950 (7.6 miles)		39,950 (7.6 miles)

[a] - From Hankin and Reeves 1988 [b] - From Rosgen 1994.

Streambank plantings can be done with "whip" or "pole"-sized cuttings from willow, cottonwood, or dogwood species. Other species can be started from rooted plants or nursery stock. Species can be selected which are compatible with the adjacent land use. For example, along orchards where there is concern about the potential shading influence of cottonwoods on crop trees, another native species (such as erect willow or dogwood) could be used to complement the land use while improving other resource values. These species are not as tall or invasive as cottonwood trees but will still provide many of the benefits associated with cottonwood. Cottonwoods could also be planted on the south bank without shading crop trees.

Where possible, large trees which have been removed during past flood-control projects or because they were shading orchard trees should be relocated and secured in the river channel at strategic locations to provide LWD for fish habitat and/or streambank protection. Likewise, large trees which need to be removed in the future, should be used for stable LWD placement and "fish-friendly" bank protection. Many native riparian plants can also be used in urban backyard settings as landscaping and streambank plantings. Locations of potential planting sites have been identified on resource **Maps 1 - 4, Appendix C**. A list of species that could be planted is included in **Table 2, Appendix A**.

A public information program should be initiated to inform landowners of the benefits of maintaining a healthy riparian zone and vegetation. This effort should include information about riparian plants for orchard land, maintenance of effective floodplains, and riparian zones and vegetation. This is highly significant for the rapidly developing area located just within and below the National Forest boundary downstream to the Potato Terminal Moraine in stream Reach 7. This area has excellent fish habitat, in part, because it still has an effective floodplain with healthy riparian vegetation. Increased development in this floodprone area, resulting in riparian vegetation removal, will negatively impact the excellent fish habitat located above the Potato Moraine.

Other topics which should be included are: herbicide and pesticide use; vegetation planting and management techniques that benefit fish and wildlife; potential Resource Conservation and Development (RC&D) measures; streambank stability practices; and the importance of large woody debris and overhanging vegetation.

Stream Corridor, Streambank Stability, and Fish Habitat Improvements

Five alternatives, or treatment levels, were formulated to address the identified resource problems and objectives. **Table 3** shows how these alternatives would affect the number of large pools that would be created. Alternatives 2, 3, and 4 are identified site-specifically on resource **Maps 1-4**, in **Appendix C.** The types and locations of structures can be found on each map located under the subtitle: "PROPOSED INSTREAM IMPROVEMENTS BY STREAM REACH."

Alternative 1 - As a minimum, ordinary maintenance of unstable banks, which is considered to be an **Alternative 1** project ("future-without") should be built using barbs and woody material when possible because these bio-engineering practices will provide mutual improvements for landowners and salmonid habitat.

Alternative 2 - the treatment level that would address the minimal requirements for migration, spawning, resting, and rearing habitat in Reaches 1 through 6. Minimal rootwad revetments would be used in Reaches 7 and 8 to protect both streambanks and large pools where over-extended meanders have accelerated lateral migration.

Alternative 3 - the recommended alternative for addressing adequate migration, spawning, resting, and rearing habitat improvements. This alternative has approximately 40% of potential historic pools. Alternative 3 provides an average of 3 pools per mile in Reaches 1 through 6, and 8 pools per mile in Reaches 7 and 8. Alternative 3 would include significant improvement in *Class 1* pool frequency.

Alternative 4 - a more ideal restoration alternative where the amount of pools and streambank protection practices are optimal, given current land uses and stream limitations on the first 20 miles of river.

Alternative 5 - (Geomorphic Pools) - creation of the number of large pools that would have historically existed in presettlement times. If the Entiat was re-establishedished to its natural stable morphological stream type, the amount of pools in this alternative could be present. However, present land uses, roads, bridges, and other existing structures along the valley bottom are permanent. Alternative 5 would not be a practical alternative when considering present land uses.

Measures to correct salmon habitat problems and streambank stability are significantly different above and below the Potato Moraine. The Entiat River within, and upstream of, the Potato Moraine has a gentler slope with finer-textured material in both the channel bed and streambanks. The river below the Potato Moraine is steeper, coarser, more confined, with less sinuosity.

In the river reaches above the Potato Moraine, boulders have a potential to do greater damage when improperly placed in C4 and C5 stream types. The high sediment supply and highly unstable banks most often limit the effectiveness of boulders placed in the channel. Boulders must be keyed into the bank. Large woody material is more appropriate for these stream types. Rootwad revetments, properly placed in streambanks, offer both stability and habitat on these stream types.

Vortex rock weirs (low-level checks with spaces between rocks to accommodate some bedload movement) can be used on C4 stream types with limitations. C5 stream types have too high of a sediment supply, often causing high levelsof bedload deposition above the vortex rock weir. The result is a stream channel with a higher width to depth ratio than desired for fish habitat and streambank stability. Instream measures, including large rock, should be avoided or used cautiously in this area.

The river channel below the Potato Moraine can accommodate various boulder-style instream practices if properly placed. A few areas have vortex rock weirs that occur naturally. These rock formations survive well in the present river condition and dynamics which is a strong indicator that they are appropriate to address resource problems.

Table 4, Appendix A also rates vortex rock weirs as good or excellent for most stream types located below the Potato Moraine.

Large woody debris cabled to anchors including large rock would provide needed cover in these larger pools below the Potato Moraine. All vortex rock weirs, deflectors, or barbs need to be keyed into streambanks.

There is little standardization for definition of bioengineering and fish habitat improvement structures. Often, several names may be used to describe the same structure. **Appendix B** has been included to better describe the kinds of structures or bioengineering practices supported in this report. Schematic diagrams have been included in this appendix to illustrate some of the common practices recommended in the alternatives.

Figure 5, **Appendix A:** "Managing Floodprone Areas for Minimal Structural Damages or Losses" suggests a technically sound criteria for helping planners to establish safer areas for structures built in a river corridor. Because the river will continually adjust within various floodplain widths, specific areas should be identified as higher potential for damages to structures. A more complete analysis of flood stage elevations should be completed by a qualified hydrologist.

Structural developments are currently being installed in Reaches 7 and 8. Some of these structures are located on Zone A described in **Figure 5**. These are floodprone areas where damage to structures is inevitable. As flood stages will occur, solutions to seek protection of structures in these areas will also occur. The results are, most often, straightening of channels; hardening of streambanks with expensive structures; loss of numerous habitat values; and an expensive long-term operation and maintenance program to manipulate the channel.

Effects and Suitability of Alternatives

Table 6, **Appendix A:** "EFFECTS AND ANALYSIS OF PRACTICES FOR SALMON HABITAT AND OTHER CONCERNS" summarizes treatment effects and their suitability to address the identified concerns. High suitability denotes a practice that most positively effects an identified concern. Medium suitability denotes a practice that, most likely, will have positive affects on the identified concerns. Low suitability denotes a practice that would have a minimum positive effect on identified concerns. The identified concerns are those selected by the technical advisory and steering committees as high priority and/or resource problems.

There are a number of benefits that will result from re-establishingishing healthy riparian vegetation, fish habitat, and improved streambank stability on the Entiat River. Benefits include:

- Soil and streambank stability

- Water quality preservation and improvement
- Buffering and moderation of stream temperature (both summer and winter)
- Improved width-depth ratios (deeper and narrower) above Potato Moraine
- Establishment of a wider range of velocity distribution in the river channel throughout various flow stages.
- Better control of upstream lateral migration, bank erosion, and aggradation using vortex rock weir grade control structures
- Stable undercut banks with overhanging shrubs and trees
- Food input to the aquatic system
- Large woody debris supply for future instream structure
- Wildlife habitat and travel corridors
- Improved rearing habitat for young salmonids
- Improved cover, which provides protection for juveniles and adults
- Less energy used by migrating adults
- Deepened feeding areas in some of the riffle reaches of the channel
- Improved sorting of bottom substrates so that spawning-sized gravel is captured and stabilized.

Re-establishmentishment of streambank riparian vegetation is the least expensive stabilization available. Roots stabilize the soil and increase streambank resistance to erosion. Shade, produced from trees and shrubs, helps keep the water cooler in summer and may reduce the development of ice flows in the winter. Riparian vegetation helps to filter out nutrients and pesticides in runoff from the uplands. It also helps to provide a barrier between the orchards and the waterway so that pesticides from spraying practices are less likely to drift directly into the stream.

Mature riparian vegetation on a floodplain provides a “sponge effect” which helps store water in the soil profile during high flows. This moisture becomes available for return flow later in the season when water levels become critical for multiple uses. The cumulative effect is a reduced peak flood impact and an increased low flow later in the year.

Riparian vegetation also provides food sources for aquatic organisms which become food for fish. Large woody debris for pool development in the stream is recruited from the riparian zone or the floodplain. Other wildlife, including many that are considered predominately upland species, use the riparian zone extensively, both as habitat and travel corridors.

Conclusions

The introduction of instream structures and streambank stabilization practices, as well as the reintroduction of riparian woody vegetation, are compatible with the river's geomorphic process and will have long-term mutual benefits. Re-establishing meander corridor widths below Reach 7 (below Potato Moraine) would have a direct conflict with present land uses. While rivers with high sinuosity and well-vegetated streambanks are highly desirable for fish habitat and long-term stability, a more practical approach to addressing resource concerns in Reaches 1 through 6 must be used.

Reaches 7 and 8 require a different approach to both practices and management. Because these two reaches have well-developed natural floodplains and a greater resource potential, practices that impede or restrict meander development will create a significant downward trend in all resource values, as well as a greater potential for damaged structures. At a minimum, floodplains and floodways should be identified using a flood frequency and elevation analysis to help local landowners and planners make more-informed decisions about floodprone damages and loss of resource habitat. Because lateral migration (see **Figure 7, Appendix A**) is common on the stream types in Reaches 7 and 8, streambank stability is uncertain. There is high potential for damage to any structures that may be located near the banks of the river.

The greatest potential for long-term damages in Reaches 7 and 8 is the continued development of buildings and other permanent obstructions in the floodplain. Attempts to protect property from flood damage will be expensive in these floodprone areas. Undersized bridges, homes and structures built in floodprone areas, and decisions based on misunderstandings of flood recurrence intervals and their impacts will cause future resource problems and property damage.

Lack of action to correct the present condition of the Entiat will only lead to a downward trend in fish habitat, streambank stability, and property protection. Practices that address these mutual concerns are beneficial. The complexity in riparian and fish habitat is lacking; however, the Entiat River system has a great potential for improvement. Both landowners and aquatic habitat can benefit from such improvements.

These benefits address identified concerns and problems regarding the first 20 miles of the Entiat River corridor.

List of Preparers

Name	Present Title-Years	Education	Prior Experience	Other
Natural Resources Conservation Service & Chelan Co. Con. District			(Title and Years)	
Frank R. Easter	Watershed Planning Team Leader - 1	B.S. Range Science A.S. Forestry	Asst. State Cons. Programs - 5 Area Conservationist - 9 District Conservationist - 7 Soil Conservationist - 2 Range Conservationist - 2	
W. Barry Southerland	WPT Resource Cons. - 6 WPT Stream Geomorphologist	MPA Nat. Res. Mgmt B.S. Range/Soil Science A.A.Forestry	HU Project Coordinator - 3 Supr. Soil Cons. - 2 Soil Conservationist - 5 Range Cons - 2	ARCPACS-CPESC #514 Soil Erosion and Sediment Control Specialist.
Mark H. Schuller	WPT Fish Bio. 4 - 3	B.S. Fishery Science Minor, Wildlife Mgmt.	Regional Habitat Manager Washington State Dept of Fish and Wildlife - 19	
Micheal L. Burton	WPT Resource Planning Specialist - 3	M.S. Riparian Ecology B.S. Range Mgmt	Soil Conservationist - 2 Resource Cons.- 3	
David R. Brower	WPT Cartographer - 5	B.A. Geography Cartography	Pro. Supr. - 1 Univ. of Kan. Cart. Serv. - 1.5 Senior Map Ed. - 1 Johnson Co. Kan. - 1	
Bianca Streif	Regional Fish Bio. - 2 (Presently Oregon NRCS Biologist)	B.S. Conservation Bio. A.S. Nat. Res. and Wildlife Mgmt.	Watershed Planning Bio. - 6 Fisheries Bio. CSUS - 5 Sacrament Co. Park Rngr. - 5 USFS Technician - 2	American Fisheries Society
Joan Mattson	ENG Geologist - 3	B.S. Geology	Geologist - 6 Minerology Tech. - 4	
Philip J. Jones	Entiat River Watershed Project Coordinator - 2	B.S. Forestry and RangeScience	APTL Land Use Plan. USFS - 11 Ranger Dist. Res. Mgr. - 21	

REFERENCES CITED

Bauer, S.B. and T.A. Burton. 1993. Monitoring Protocols to Evaluate Water Quality Effects of Grazing Management on Western Rangeland Streams. U.S. Environmental Protection Agency. #910/R-93-017.

Burton, M.L. 1991. Relationships Between Geomorphology and Riparian Complex Types in Southern Idaho. MS Thesis. Washington State University, Pullman, WA..

Hankin, D.G. and G.H. Reeves. 1988. Estimating Total Fish Abundance and Total Habitat Area in Small Streams Based on Visual Estimation Methods. Canadian Journal of Fisheries and Aquatic Sciences 45: 834-844.

Harrelson, Cheryl C., C.L. Rawlins and John P. Potyondy, 1994. Stream Channel Reference Sites: An Illustrated Guide to Field Technique. USDA Gen. Tech. Rep. RM-245. 61 pp.

Hitchcock, C.L. and A. Cronquist. 1981. Flora of the Pacific Northwest. University of Washington Press, Seattle, WA.

Leopold, L. B. 1994. A View of the River. Cambridge, Mass. Harvard University Press.

Riedl, Helmut. 1998. entomologist doing orchard study at Oregon State University, Mid-Columbia Agricultural Research and Extension Center.

Rosgen, D. L. 1994. A Classification of Natural Rivers, Elsevier Science, Catena Journal., Vol. 22, No. 3: 169-199.

USDA Forest Service. 1994. Femat Mission Watershed Report. Unpublished Report.

USDA Forest Service, Wenatchee National Forest. 1996. Watershed Assessment, Entiat Analysis Area, Version 2.0.

USDA Forest Service. 1959. Mission Creek Watershed Protection And Demonstration Project CT. USFS R-6 Fact Sheet No. 2500-3.

Winward, A.H. and W.G. Padgett. 1987. Special Considerations When Classifying Riparian Areas. In: Proceedings-Land Classification Based on Vegetation: Applications for Resource Management. USFS Gen. Tech. Rep. INT-257.

Wolman, M. G., 1954, A method for sampling coarse river-bed material: Am. Geophys. Union Trans., v. 35, p. 951.

APPENDIX A

TABLES AND FIGURES

TABLE 2

Riparian Vegetation Species List

Scientific Name	Common Name
Acer glabrum	Rocky mtn. maple
Ainus rhombifolia[b]	White Alder
Atropa belwonna[c]	Matrimony vine
Befula occidentalis var. occidentalis	Water birch
Clematis ligusticifolia	Western clematis
Cornus sericea var. occidentalis	Redosier dogwood
Crataegus douglasii vardougwii	Douglas hawthorn
Equisetum spp.	Horsetail rush
Phalaris arundinacea[c]	Reed canarygrass
Pinusponderosa [b]	Ponderosa pine
Polygonum cuspidatum[c]	False bamboo
Popuhis balymnifera ssp. Tricocarpa[b]	Black cottonwood
Prunus virginiana	Chokecherry
Pseudotmga menziesii var. glauca[b]	Douglas fir
Roiniapsuedo-acacia[c]	Black locust
Rotippa spp[c]	Water cress
Rosa woodsii	Woods rose
Rubus parviflorus	Blackberry
Salix alba[c]	Golden willow
Salix erioccephala	Erect willow
Salix exigua var. exigua	Coyote willow
Salix lasiandra[b]	Pacific willow
Salix sitchensis	Sitka willow
Sambucus cerulea	Blue elderberry
Scirpus acutus	Hardstem buurush
Yhuja plicata[b]	Western red cedar
T)pha latifolia	Cattail
Ulmus spp[c].	Elm

a. From Hitchcock and Cronquist 1981.
b. Not recommended for streambank planting where plant height is a concern.
c. Introduced species not recommended for planting.

Table 4

ANADROMOUS FISH HABITAT IMPROVEMENTS FOR STREAM TYPES

Stream type	Low Stage Checks	Medium Stage Checks	Vortex Rock Weirs	Boulder Placement	Bank Placement Boulder	Single Wing Deflector	Double Wing Deflector	Channel Constrictor	Bank Cover	"W" Weirs	Root Wad Revetments Veg. Transp.	Gravel Trap "V" Shaped	Gravel Trap Log Sill	Gravel Placement	Vegetation stabilization Ex. Dor. Stock Plant.
B2	Exc.	Good	Good	Exc	Exc	Exc	Exc	Exc	Exc	N/A	N/A	Good	Good	Good	Fair
B3	Exc	Good	Exc	Exc	Exc	Exc.	Exc.	Exc.	Exc.	Exc.	Exc.	Good	Good	Good	Fair
B3c	Good	Fair	Good	Good	Exc.	Good	Good	Fair	Good	Exc.	Exc.	Fair	Good	Fair	Good
B4c	Fair	Poor	Good	Poor	Good	Fair	Fair	Fair	Good	Good	Exc.	Poor	Poor	N/A	Good
C3	Good	Fair	Good	Fair	Exc	Good	Good	Fair	Good	Exc	Exc.	Fair	Good	Fair	Good
C4	Fair	Poor	Good	Poor	Good	Fair	Fair	Fair	Good	Good	Exc.	Poor	Poor	N/A	Exc
F2b	Good	Fair	Exc	Fair	Good	Fair	Fair	Fair	Good	N/A	N/A	Poor	Poor	Fair	Fair
F3b	Fair	Poor	Exc	Fair*	Good	Fair	Fair	Fair	Good	Fair	Good	Poor	Poor	Fair	Exc
F3	Good	Fair	Good	Fair	Good	Fair	Fair	Fair	Good	Fair	Good	Poor	Poor	Fair	Good
F4	Fair	Poor	Good	Poor	Good	Fair	Fair	Fair	Good	Fair	Good	Poor	Poor	Fair	Good
G3c	Good	Fair	Good	Poor	Fair	N/A	N/A	N/A	N/A	Poor	Good	Poor	Poor	Poor	Fair
G4c	Fair	Poor	Good	Poor	Fair	N/A	N/A	N/A	N/A	Poor	Good	Poor	Poor	Poor	Fair
D4	Fair	Poor	Poor	Poor	Poor	Fair	Fair	Fair	Poor	Poor	N/A	N/A	Poor	Poor	Good
C5	Fair	Poor	Fair	Poor	Good	Poor	Poor	Poor	Fair	Fair	Exc.	Poor	Poor	Poor	Exc

Excellent - Little or no limitation to location of structures or special modification. (with exception of meander reconstruction).

Good - Under most conditions, very effective. Ntnor modifications of design or placement required.

Fair - Serious limitations which can be overcome by placement location, design modification, or stabilization techniques. Generally not recommended due to difficulty of offsetting potential adverse consequences and high probability of reduced effectiveness

Poor – Not recommended

Most of these practices must be completed with corresponding streambank protection. Example - A single wing log deflector must be accompanied by streambank vegetation because the opposing bank will scour as water deflects. Utilize table 4 in "Fish Habitat Structures - A Selection Guide Using Stream Classification ' Dave Rosgen and Brenda L. Fittante. Converted 1985 classification types to 1992.

Dimension, pattern (plan view) and longitudinal profile must be understood before implementing a particular practice. Practices must be compatible with the natural morphological form of a stable stream type. Fish habitat structures, in and of themselves, do not necessarily describe a stream restoration effort. Fish habitat structures are not a substitute for meander geometry. Fish habitat structures should be commensurate with flow, sediments, and morphology of a given stream type.

These guidelines are intended for application in planning and designing enhancement structures over a wide variety of streams to reduce the "error" from the trial and error method. These guidelines are intended as an initial framework for technology transfer that others will improve upon as more data are derived from ongoing monitoring and evaluation programs {Rosgen 1994, Wildland Hydrology Consultants, Applied Fluvial Geomorphology Course Manual pg. C117}.

TABLE 5

RATINGS FOR POTENTIAL FISH HABITAT FOR ENTIAT BY STREAM TYPES

08/96

STREAM TYPE	PRACTICE	RATING
C3 Utilize table 4a labeled, Limitations and discussions of various fish habitat improvement structures by stream types. (Rosgen, Revised, 1994)	Vortex Rock Weir	Good
	Bank Boulder Placement	Good
	Random Boulder Placement	Poor
	Double Wing Log Deflector	Good
	Single Wing Log Deflector	Good
	Channel Constrictor	Good
	Low Stage Checks	Good
	Medium Stage Checks	Fair
	"W" Weirs	Exc
	Log or Rock Spurs	Good
	Bank Placed Root Wads	Exc
B3 B3c	Vortex Rock Weir	Exc
	Bank Boulder Placement	Exc
	Random Boulder Placement	Exc
	Double Wing Log Deflector	Exc
	Single Wing Log Deflector	Exc
	Channel Constrictor	Exc
	Low Stage Checks	Exc
	Medium Stage Checks	Good
	"W" Weirs	Exc
	Log or Rock Spurs	Exc
	Bank Placed Root Wads	Good
F3	Vortex Rock Weir	Good
	Bank Boulder Placement	Good
	Random Boulder Placement	Fair
	Double Wing Log Deflector	Good
	Single Wing Log Deflector	Good
	Channel Constrictor	Fair
	Low Stage Checks	Fair
	Medium Stage Checks	Poor
	"W" Weirs	Fair
	Log or Rock Spurs	Good
	Bank Placed Root Wads	Good

TABLE 5 CONTINUED

RATINGS FOR POTENTIAL FISH HABITAT

Stream Type	Practice	Rating
F2	Vortex Rock Weir	N/A
	Bank Boulder Placement	N/A
	Random Boulder Placement	N/A
	Double Wing Log Deflector	Fair
	Single Wing Log Deflector	Fair
	Channel Constrictor	Fair
	Low Stage Checks	Fair
	Medium Stage Checks	Poor
	"W" Weirs	N/A
	Log or Rock Spurs	N/A
	Bank Placed Root Wads	N/A
B2	Vortex Rock Weir	N/A but usable
	Bank Boulder Placement	N/A
	Random Boulder Placement	N/A
	Double Wing Log Deflector	Exc
	Single Wing Log Deflector	Exc
	Channel Constrictor	Exc
	Low Stage Checks	Exc*
	Medium Stage Checks	Exc*
	"W" Weirs	N/A
	Log or Rock Spurs	N/A
	Bank Placed Root Wads	N/A
C4	Vortex Rock Weir	Good
	Bank Boulder Placement	Good
	Random Boulder Placement	Poor
	Double Wing Log Deflector	Poor
	Single Wing Log Deflector	Poor
	Channel Constrictor	Poor
	Low Stage Checks	Fair
	Medium Stage Checks	Poor
	"W" Weirs	Good
	Log or Rock Spurs	Good
	Bank Placed Root Wads	Exc
C5	Vortex Rock Weir	Fair
	Bank Boulder Placement	Good
	Random Boulder Placement	Poor
	Double Wing Log Deflector	Poor
	Single Wing Log Deflector	Poor
	Channel Constrictor	Gair
	Low Stage Checks	Fair
	Medium Stage Checks	Poor
	"W" Weirs	Fair
	Log or Rock Spurs	Fair
	Bank Placed Root Wads	Exc

Rosgen, D.L., Fittante, Brenda L., A Selection Guide

TABLE 6

ENTIAT - EFFECTS AND ANALYSIS OF PRACTICES FOR SALMON AND OTHER CONCERNS

Identified Concerns:

Practices:	Water Quality	Cropland	Fish Passage	Streambank Stability	Riparian Habitat	Juvenile Rearing Habitat	Adult Resting Habitat	Spawning Habitat
	Treatment Effects:							
Water Diversion Structures (BYPASSES)	2	3	3	n/a	n/a	3	3	3
Barb	n/a	n/a	n/a	2	2	2	2	1
Buffer Strip (Riparian Area Management Strip)	3	1	n/a	3	3	1	1	1
Critical Area Planting	3	1	n/a	n/a	2	1	1	3
Deflector	n/a	n/a	n/a	3	2	2	2	1
Fencing	3	3	n/a	3	3	3	2	3
Vortex Rock Weir	1	n/a	n/a	2	1	2	3	3
Large Woody Debris Placement	n/a	n/a	n/a	n/a	1	3	3	3
Log Weirs (irrigation diversions)	n/a	n/a	3	1	1	3	n/a	n/a
Pesticide Management	3	3	n/a	3	3	n/a	n/a	n/a
Ponds (off-channel)	n/a	n/a	n/a	n/a	3	3	n/a	n/a
Riparian Management	3	2	n/a	3	3	3	3	3
Root Wad Revetment	3	n/a	n/a	3	3	3	2	3
Side channel rearing (irrigation diversion)	n/a	n/a	3	n/a	3	3	n/a	n/a
Streambank Protection (vegetation)	3	3	n/a	3	3	3	3	3

<u>Suitability Index:</u> n/a - Not Applicable, 1 - Low Suitability, 2 - Moderate Suitability, 3 - High Suitablity

These practices are limited to the corridor inventory area and do not apply to uplands.

FIGURE 4

FREQUENCY OF OCCURRENCE OF GEOMORPHIC STREAM TYPE BY REACH

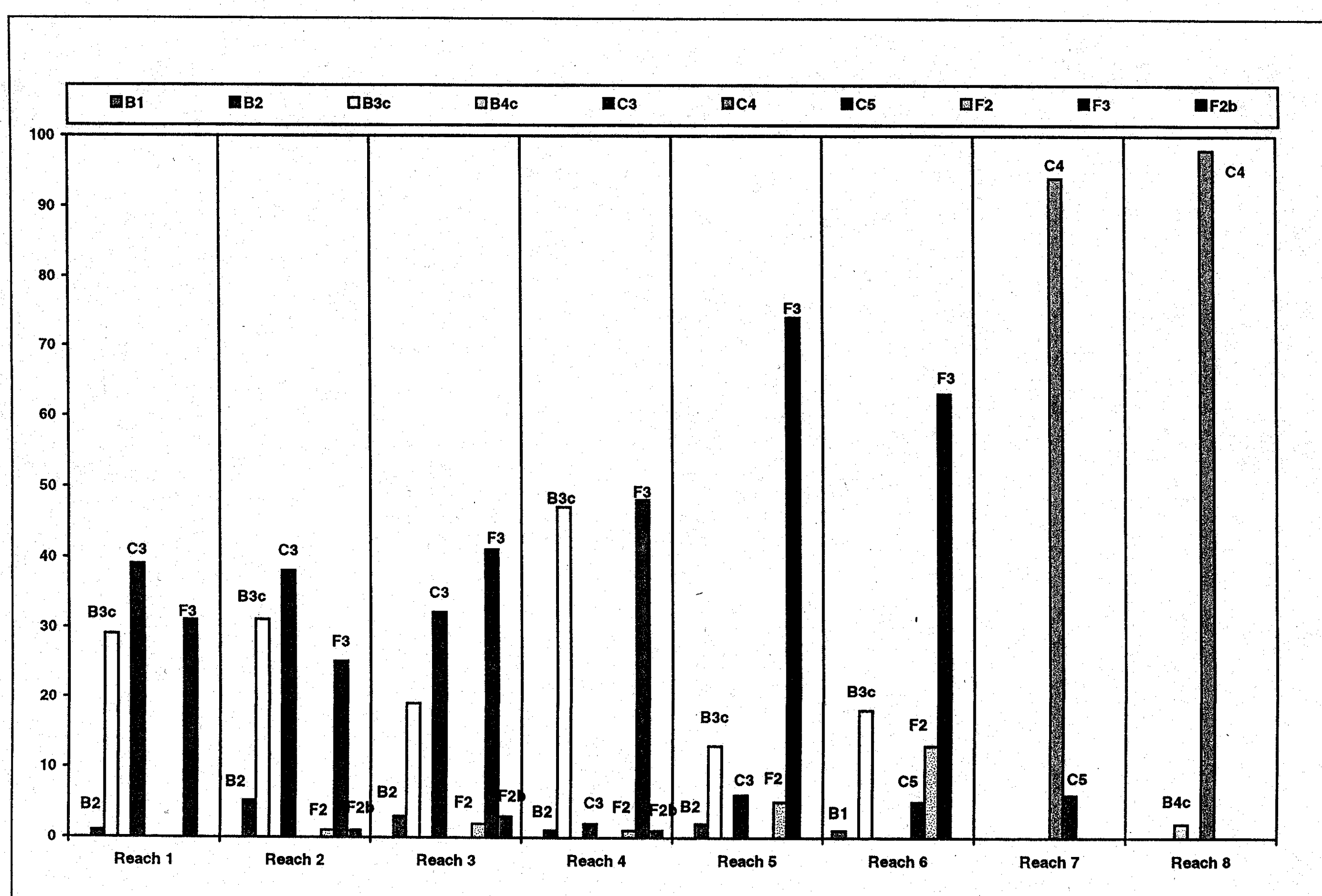
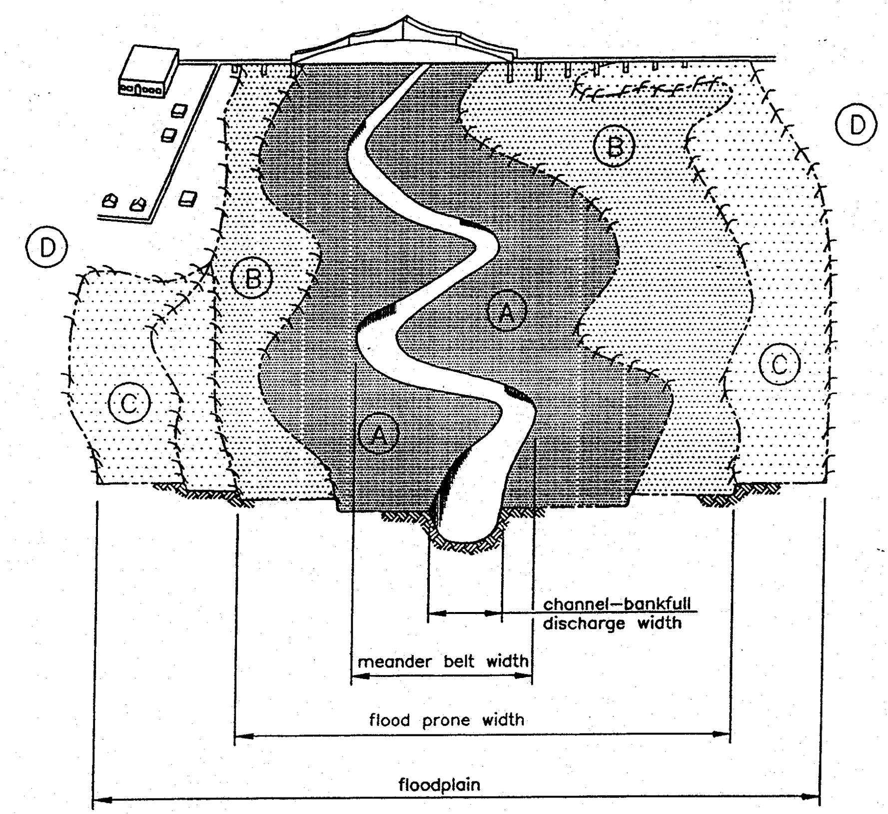


FIGURE 5

Managing Floodprone Areas for Minimal Structural Damages or Losses

These designated boundaries are based on technical–hydraulic studies that determine flood elevations, cross sectional areas and fringes.



(A) Recurrence interval of flood is frequent. Damages to structures are inevitable. Cost of channel control is high.

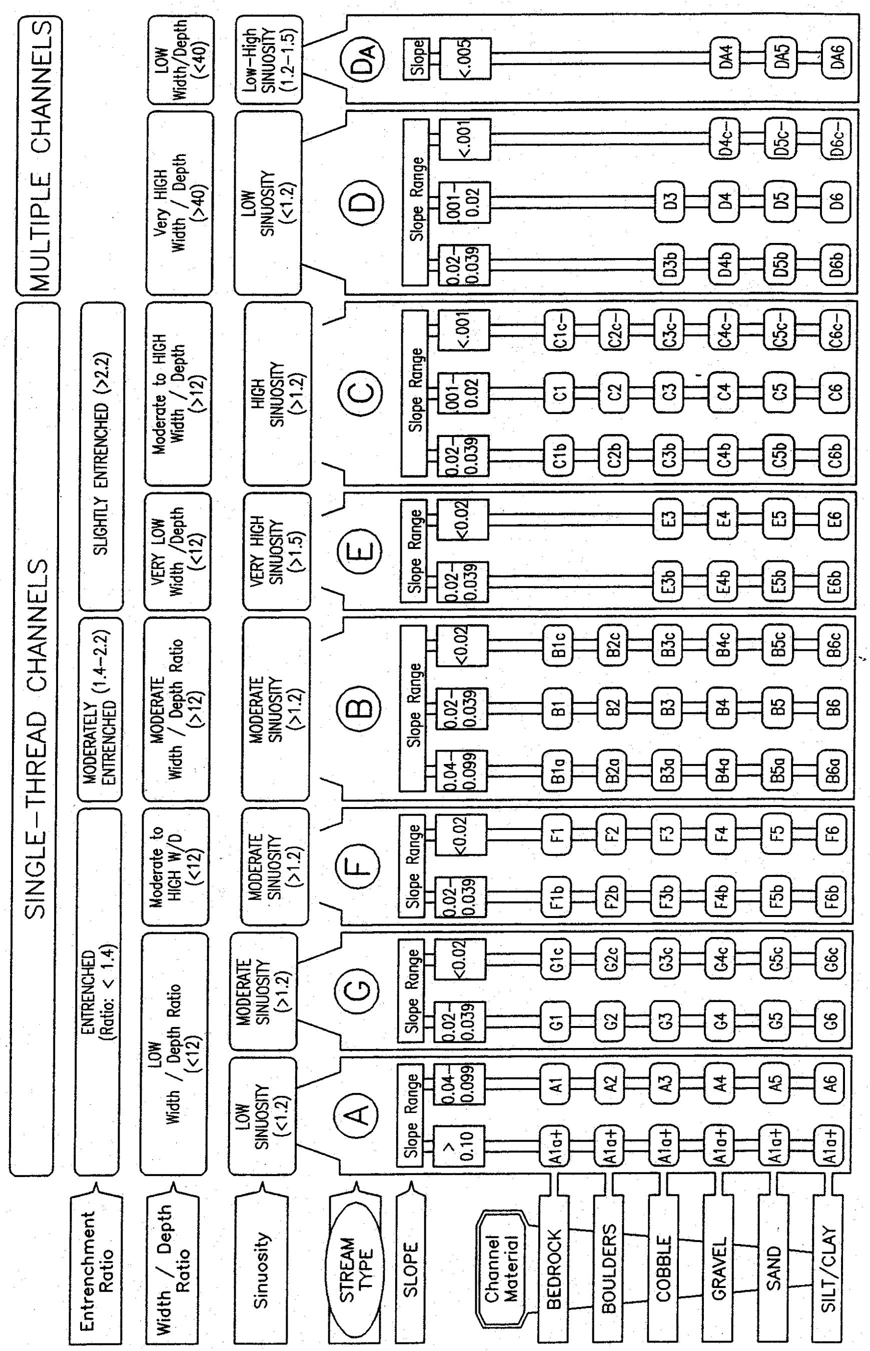
(C) Recurrence interval of flood frequency is high enough for concern. If building occurs however, alterations to structures should be incorporated.

(B) Recurrence interval of flood is still frequent enough to cause significant damages. Structures must have alterations that render them more resistant to flood damage. (Suggestion is to NOT build here).

(D) Floodway fringe, structures are not part of project flood limit. Potential to damage structures are low to none by flood.

floodpln.dwg/k yasumiishi

FIGURE 6
LEVEL II: THE MORPHOLOGICAL DESCRIPTION

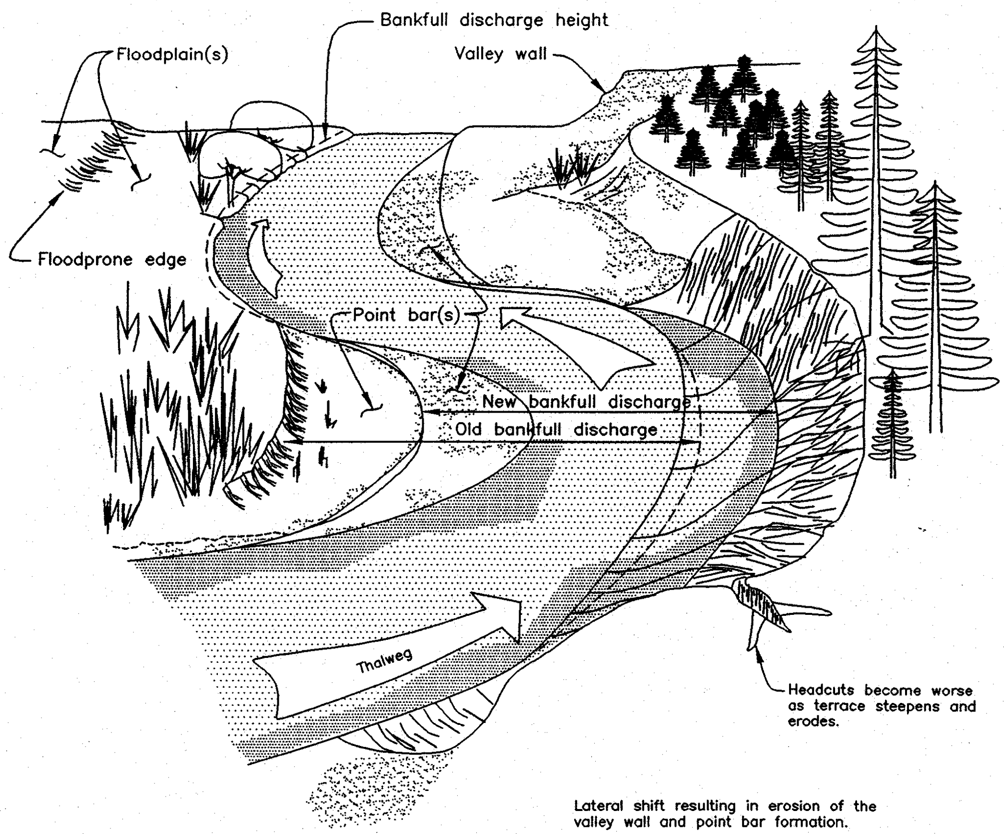


KEY to the ROSGEN CLASSIFICATION of NATURAL RIVERS. As a function of the "continuum of physical variables" within stream reaches, values of Entrenchment and Sinuosity ratios can vary by +/-0.2 units; while values for Width / Depth ratios can vary by +/-2.0 units.

ENTIAT\MORPH.DWG/k yasumiishi/w southerland

LATERAL MIGRATION

Figure 7



Lateral shift resulting in erosion of the valley wall and point bar formation.

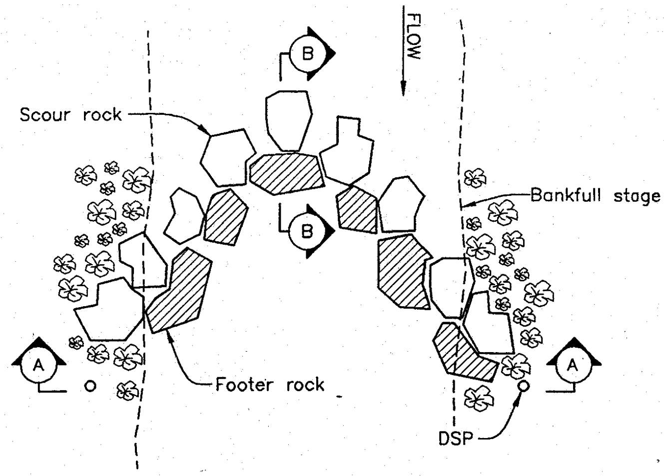
PTBAR2.DWG/k yasumiishi

DRAWING NOT TO SCALE

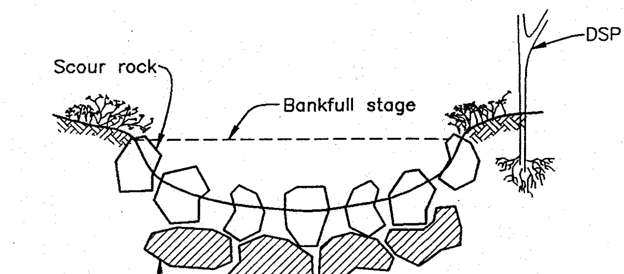
APPENDIX B

SCHEMATIC DIAGRAMS

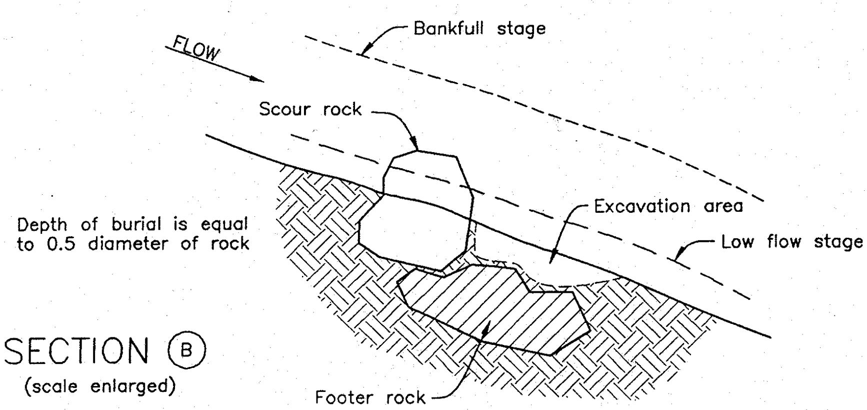
DIAGRAM 1 – VORTEX ROCK WEIRS



PLAN VIEW



SECTION Ⓐ

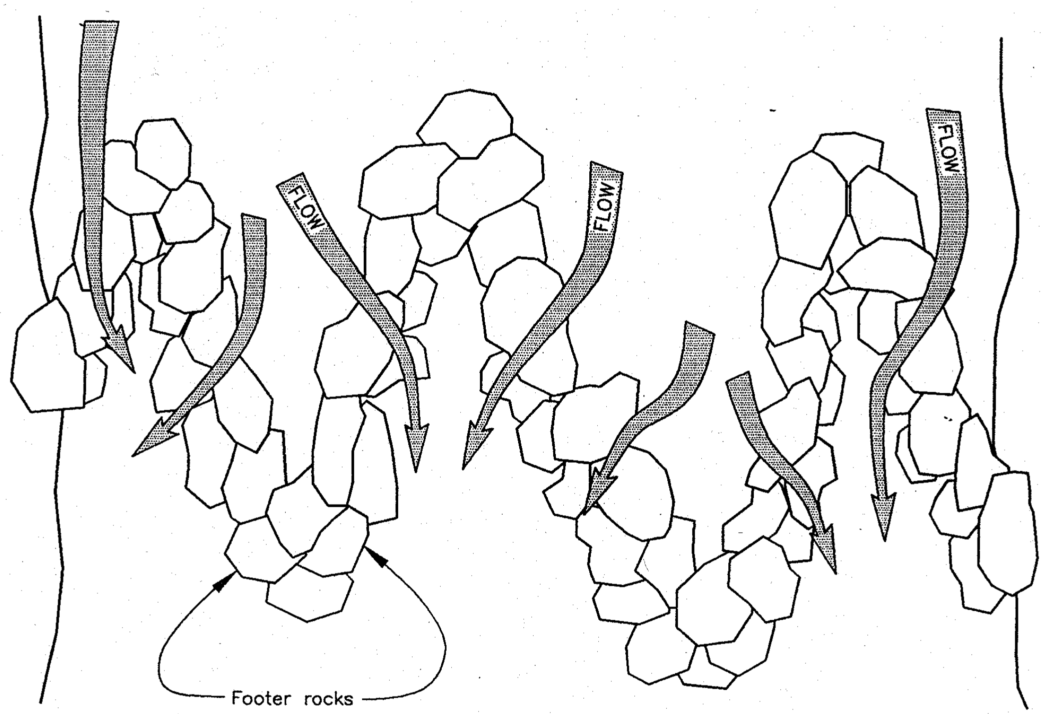


SECTION Ⓑ
(scale enlarged)

NOTE: DRAWING NOT TO SCALE

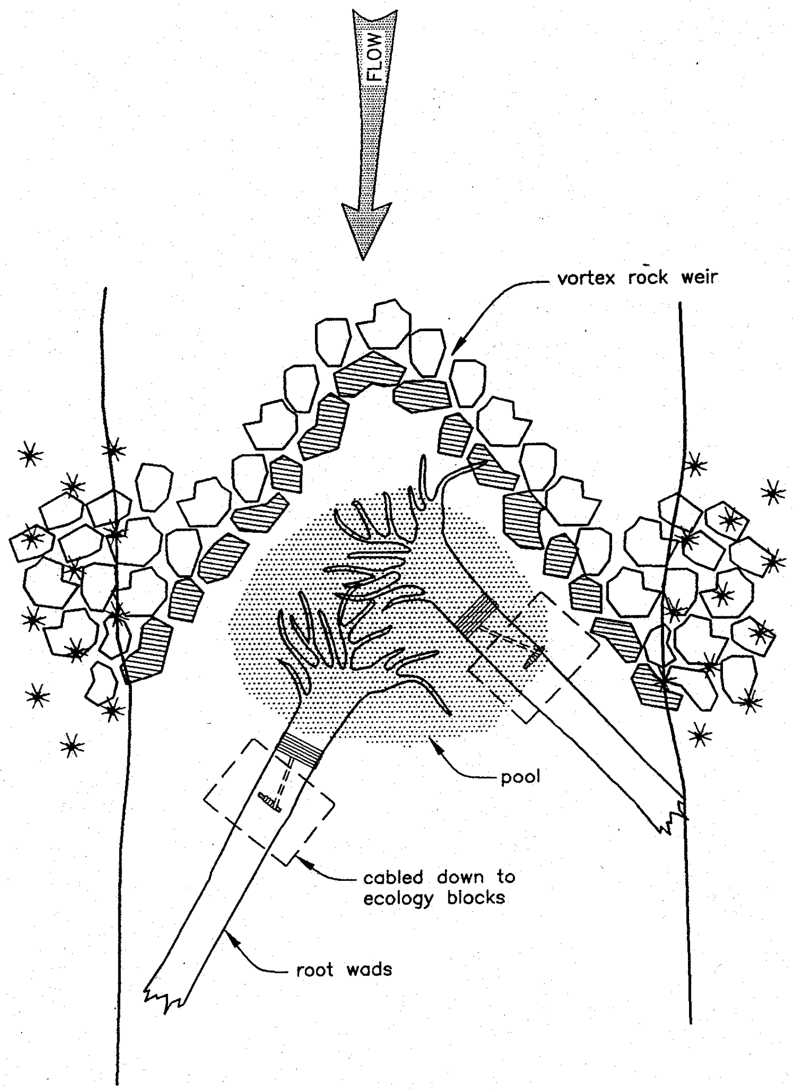
ENTIAT\ROCKWEIR.DWG/k yasumiishi/w southerland

DIAGRAM 2 – "W" ROCK WEIR



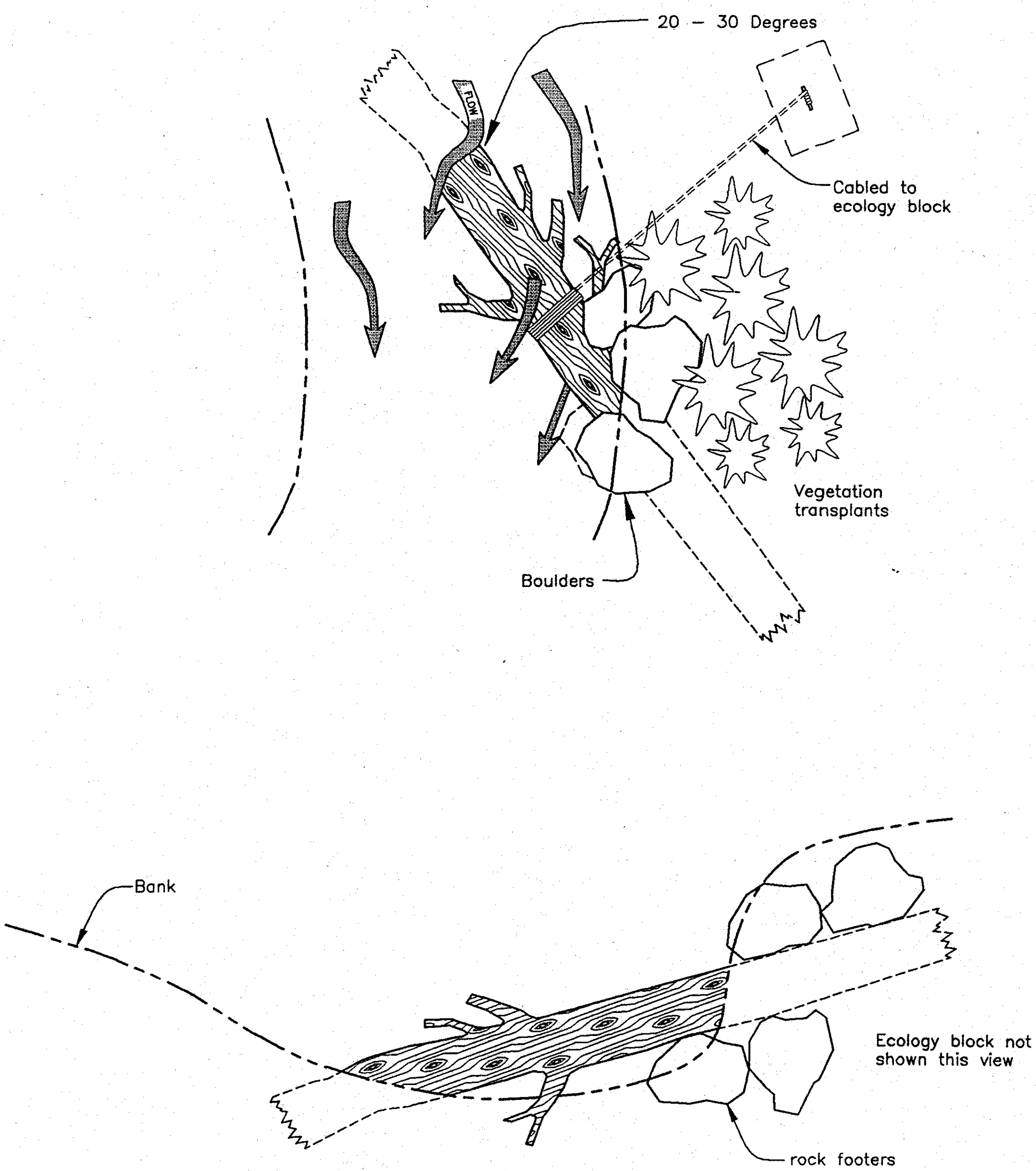
INTIAT\W_WEIR.DWG/k yasumiishi/w southerland

DIAGRAM 3 – VORTEX ROCK WEIR LOG COVERS



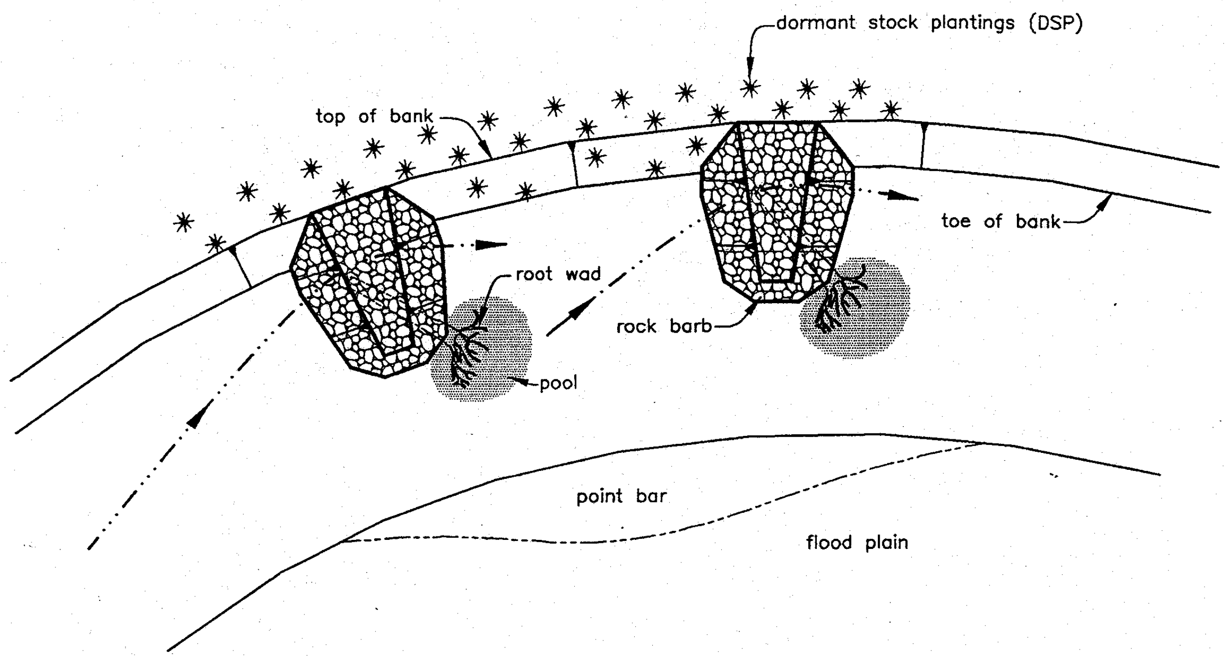
INTIAT.VRLOGCOV.DWG/k yasumiishi/w southerland

DIAGRAM 4 – LOG–SPUR

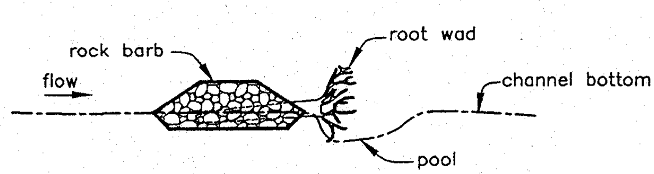


ENTIAT\LOGSPUR.DWG/k yasumiishi/w southerland

DIAGRAM 5 – BANK BARB



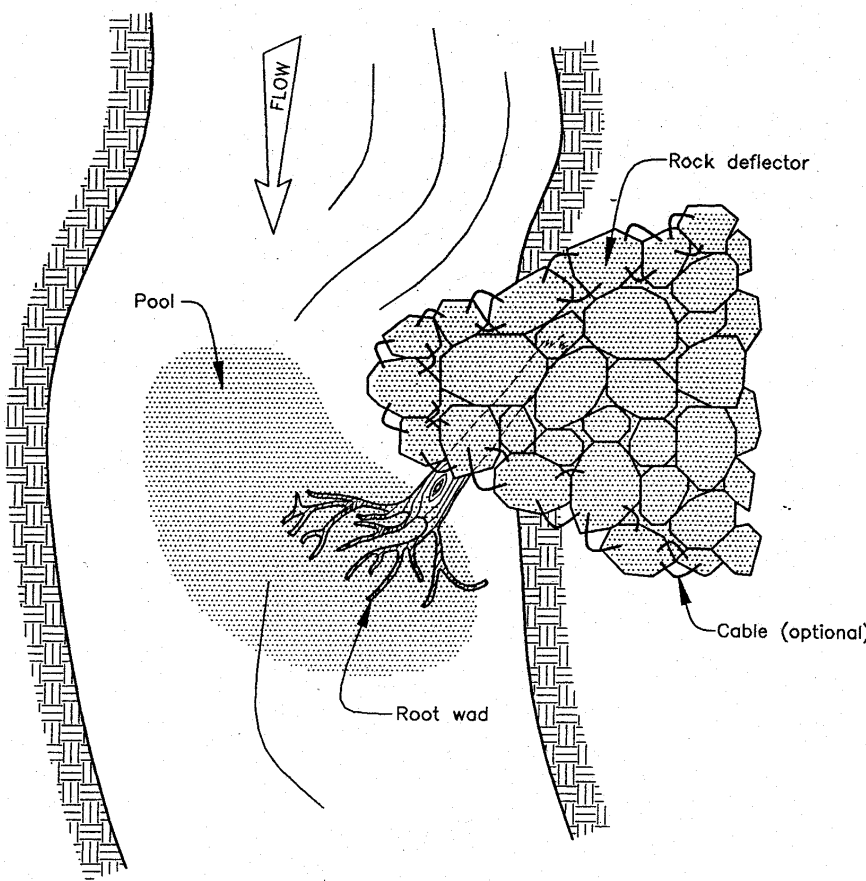
PLAN VIEW



CROSS SECTION OF BARB

ENTIAT\BARB.DWG/k yasumiishi/w southerland

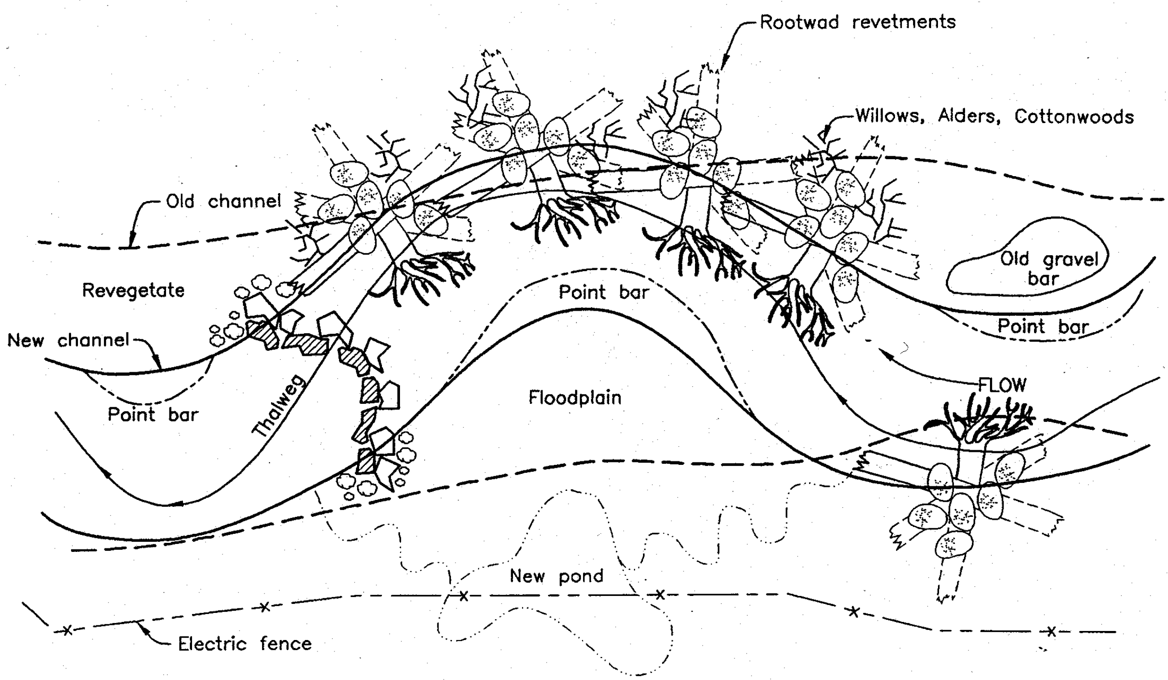
DIAGRAM 6 – ROCK DEFLECTOR



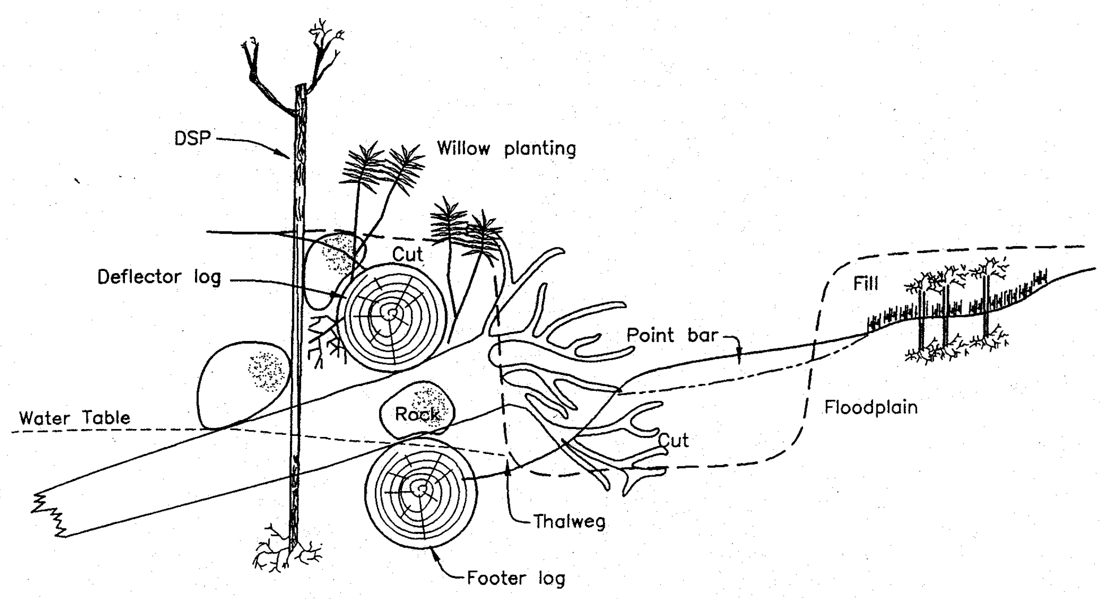
ENTIAT\DEFLECT.DWG/k yasumiishi/w southerland

DIAGRAM 7 – ROOTWAD REVETMENT

ROOTWAD REVETMENTS ARE EFFECTIVE STREAMBANK PROTECTION WHEN RE-ESTABLISHING MEANDER PATHS OR PROTECTING DOWNSTREAM SCOUR AREAS INDUCED BY PROPOSED POOLS



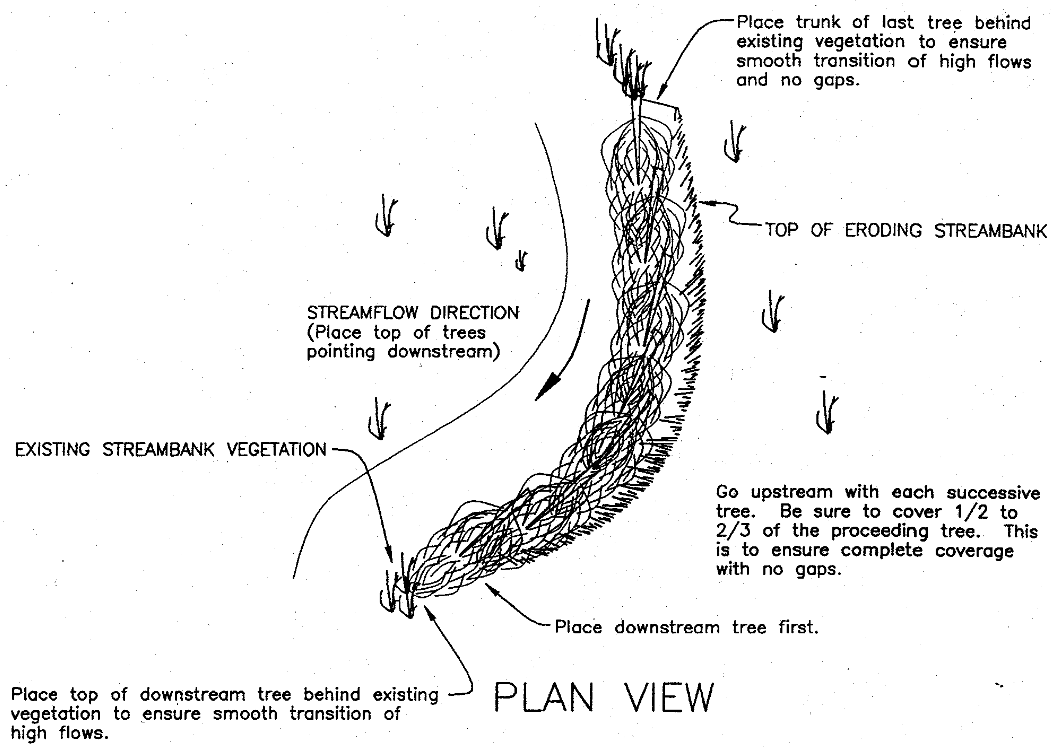
PLAN VIEW



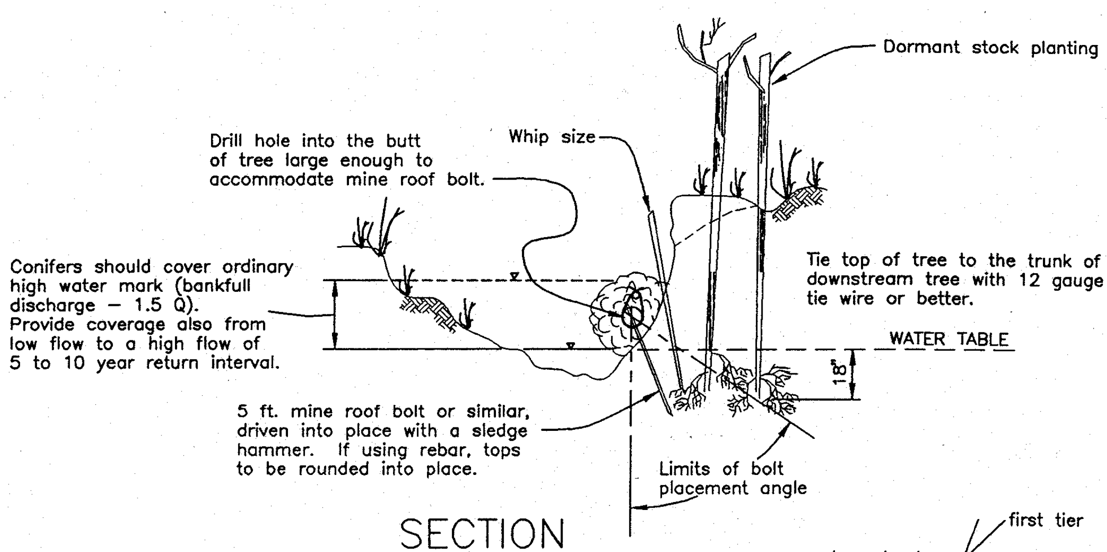
ROOTWAD REVETMENT CROSS SECTION

ENTIAT\ROOTWAD.DWG/k yasumiishi/w southerland

DIAGRAM 8 – CONIFER STREAMBANK TREATMENT
(using cut conifer trees)



PLAN VIEW



SECTION

If one tier of conifers is not enough, place additional tiers on top of the previous tiers at increasing angles as shown. Place upper tiers in the same manner as the lower tiers, except be sure to also tie the upper tiers to the lower tiers with wire.

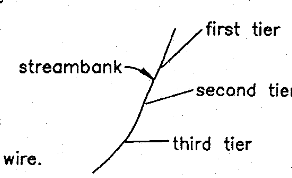
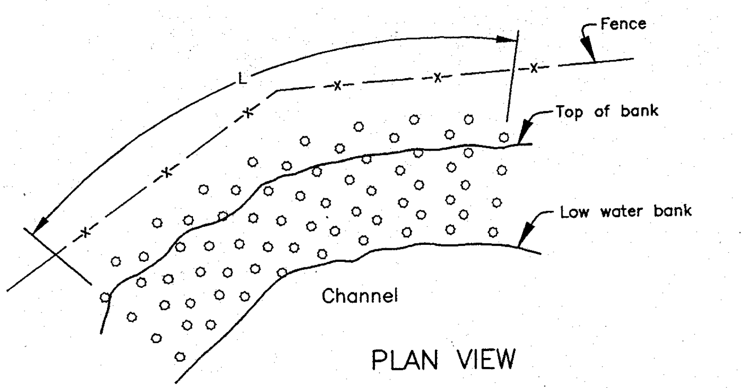
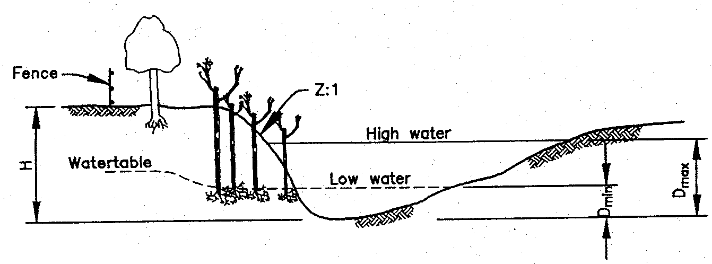


DIAGRAM 9 – DORMANT STOCK PLANTING



PLAN VIEW



SECTION

DIMENSIONS

Water Depth

D_{min} = ________ ft.

D_{max} = ________ ft.

Bank

H = ________ ft.

L = ________ ft.

Z = ________

PLANTINGS

Species ________

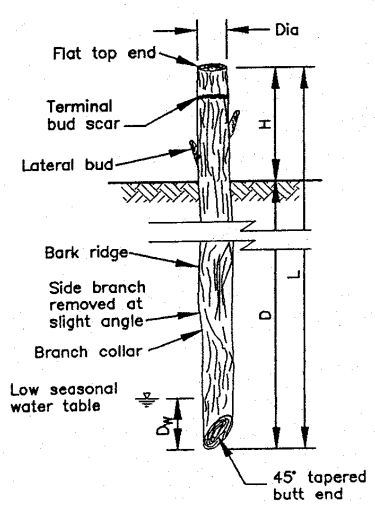
Dia ________ in.

Length ________ ft.

Spacing

______ X ______ ft.

No. of rows ____



NOTES:

1. All lateral branches shall be trimmed to avoid damage.
2. A minimum of two lateral buds shall be above the planting depth.

WOODY PLANT MATERIAL SPECIES

DIMENSIONS:

Dia. = ________ inches

D = ________ inches

H = ________ inches

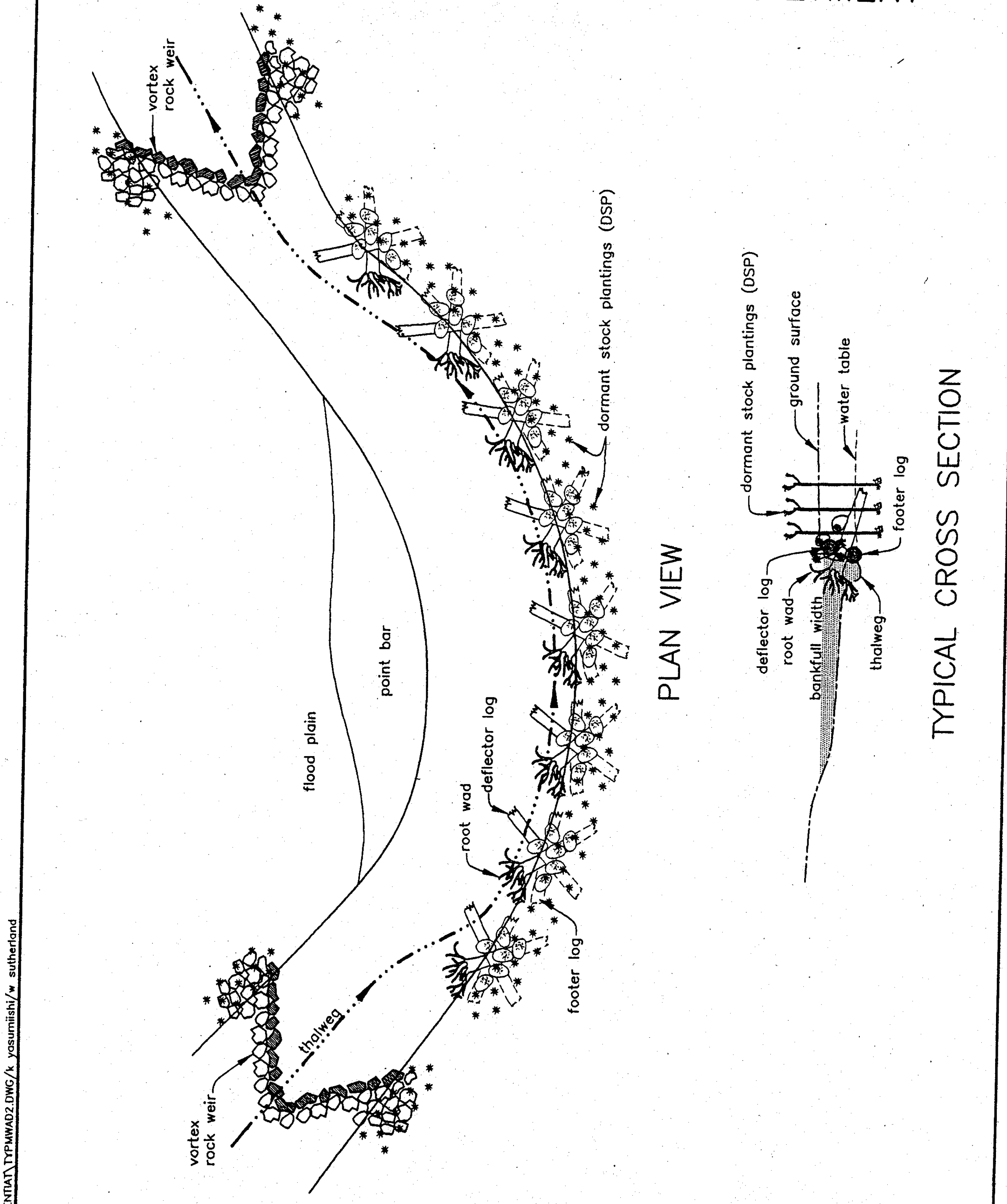
L = ________ inches

D_W = ________ inches

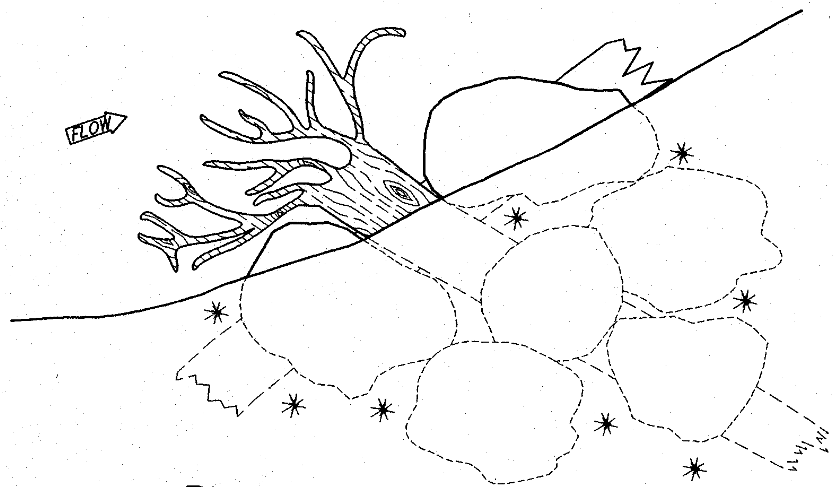
NOTE: DRAWING NOT TO SCALE

ENTIAT\STOKPLNT.DWG/k yasumiishi/w southerland

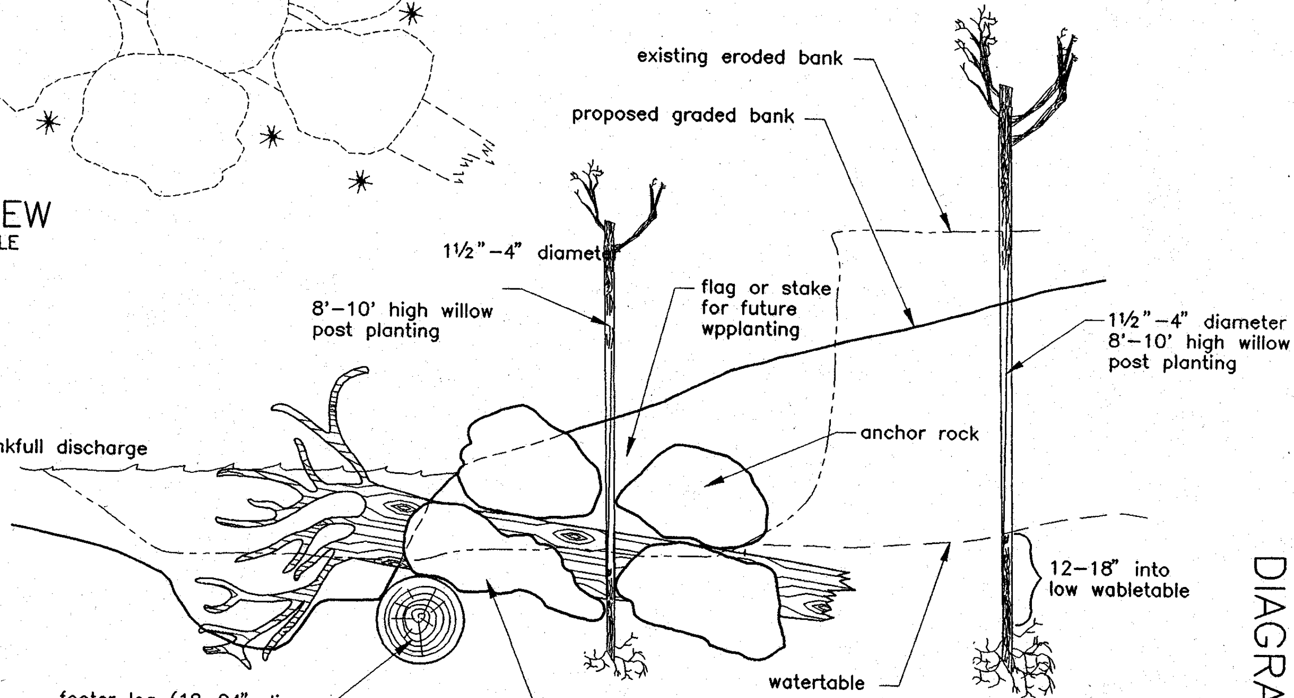
DIAGRAM 10
TYPICAL MEANDER ROOT WAD REVETMENT



CONCEPTUAL DESIGN



PLAN VIEW
NOT TO SCALE



SECTION VIEW
NOT TO SCALE

DIAGRAM 11

Notes:
1. Bankfull discharge defined by dominant channel shaping flow, not top of bank.
2. Rootwads are typically 12–15 feet in length and placed 15–20 feet on center depending on curvature flow, streambank stratigraphy and root ballsize.

R BRASCH W SOUTHERLAND

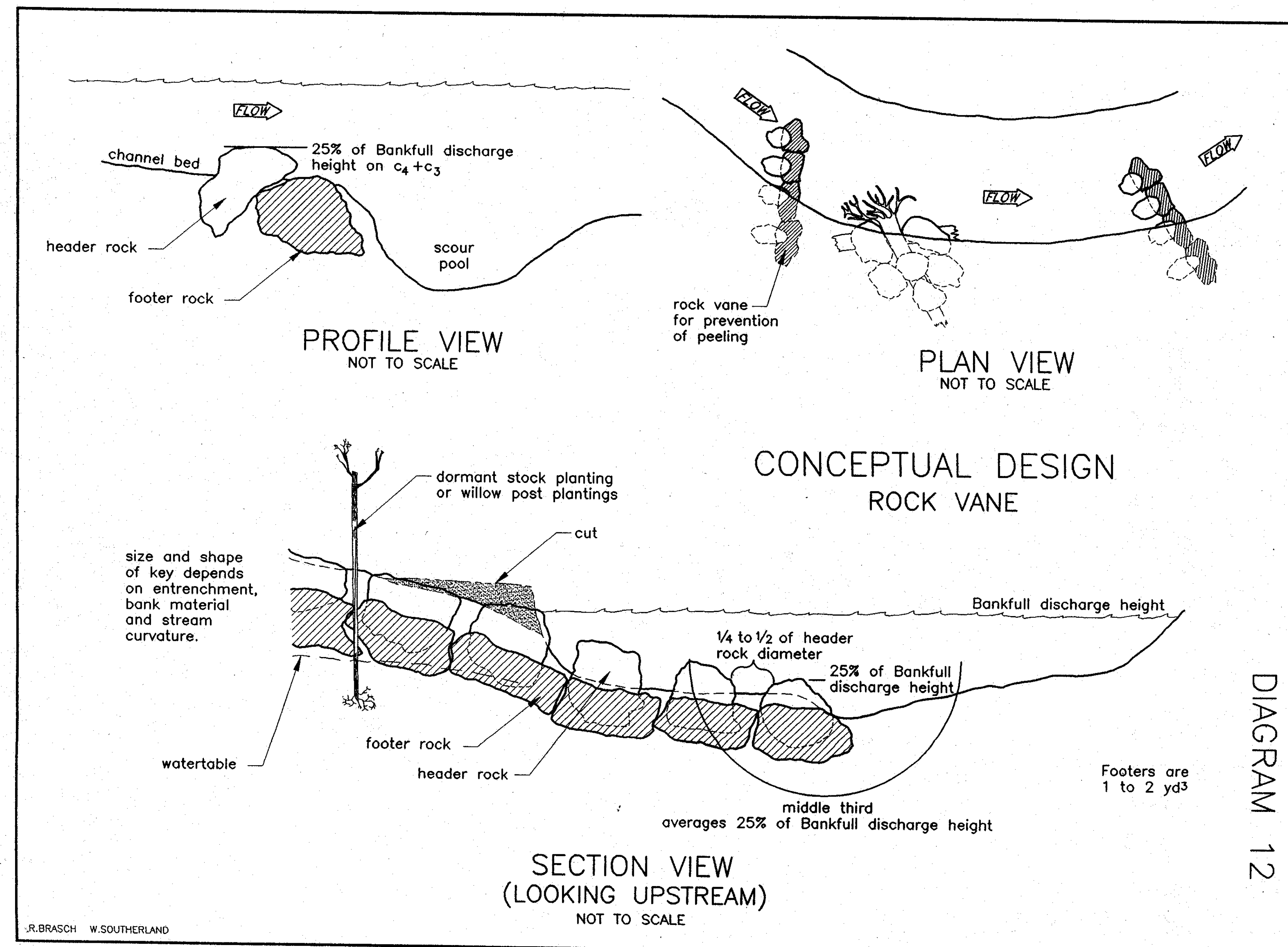


DIAGRAM 12
FLOW
channel bed
25% of Bankfull discharge height on $c_4 + c_3$
header rock
footer rock
scour pool
PROFILE VIEW
NOT TO SCALE
FLOW
FLOW
FLOW
rock vane for prevention of peeling
PLAN VIEW
NOT TO SCALE
CONCEPTUAL DESIGN
ROCK VANE
dormant stock planting or willow post plantings
cut
size and shape of key depends on entrenchment, bank material and stream curvature.
Bankfull discharge height
1/4 to 1/2 of header rock diameter
25% of Bankfull discharge height
watertable
footer rock
header rock
middle third averages 25% of Bankfull discharge height
Footers are 1 to 2 yd^3
SECTION VIEW
(LOOKING UPSTREAM)
NOT TO SCALE
R.BRASCH W.SOUTHERLAND

APPENDIX C

QUADRANGLE MAPS OF ENTIAT

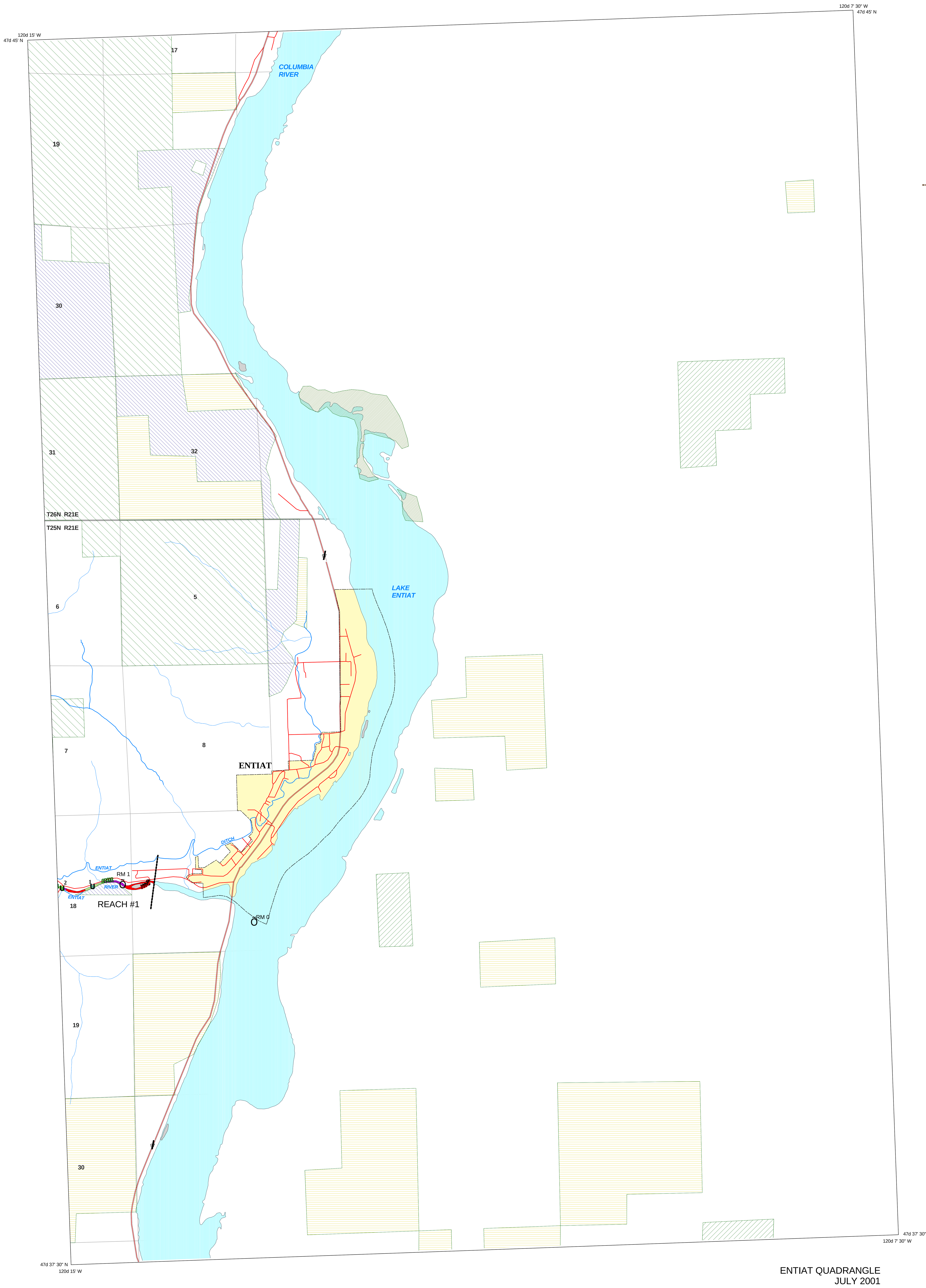
RIVER INVENTORY

MAPS 1-4

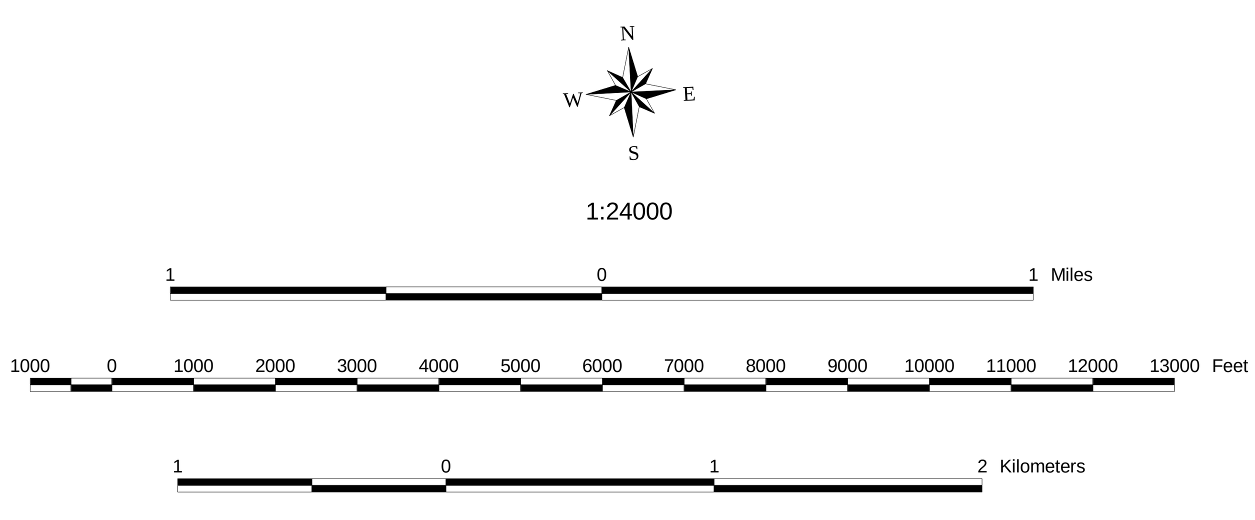
UNITED STATE
DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

MAP 1 NRCS SO
ENTIAT QUADRANGLE

CHELAN, WA
7.5 MINUTE SERIES



ENTIAT QUADRANGLE
JULY 2001



Proposed Alternatives for River Restoration and Fish Habitat

- Alternative 2 Structures and/or Improvements
- Alternative 3 Structures and/or Improvements
- Alternative 4 Structures and/or Improvements
- Dormant Stock Planting/Vegetation Establishment
- Spring Chinook Salmon Redds
- Unstable Banks Needing Rootwad Revetments W/ Dormant Stock Plantings

Symbols in the above legend for Alternatives 2, 3, and 4 are located on the map along the Entiat River where the proposed improvements are to be placed. Each symbol has a number corresponding to the list below. Each number in the list describes the type of improvement to be placed at that location on the map.

PROPOSED INSTREAM IMPROVEMENTS
BY STREAM REACH

REACH #1
1 - VORTEX ROCK WEIR (ALT. 4)
2 - VORTEX ROCK WEIR (ALT. 3)
3 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
4 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
5 - VORTEX ROCK WEIR (ALT. 4)
6 - BARBS (ALT. 3)
7 - VORTEX ROCK WEIR (ALT. 4)
8 - VORTEX ROCK WEIR (ALT. 2)

REACH #2
9 - VORTEX ROCK WEIR (ALT. 2)
10 - VORTEX ROCK WEIR (ALT. 2)
11 - VORTEX ROCK WEIR (ALT. 3)
12 - IRRIGATION CHECK DAM (ALT. 2)
13 - VORTEX ROCK WEIR (ALT. 4)
14 - LOW-STAGE LOG CHECK DAM (ALT. 4)
15 - VORTEX ROCK WEIR (ALT. 4)
16 - LOG CHECKS ON IRRIGATION CHANNEL (ALT. 2)
17 - VORTEX ROCK WEIR (ALT. 2)
18 - VORTEX ROCK WEIR (ALT. 4)
19 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
20 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 2)

REACH #3
21 - VORTEX ROCK WEIR (ALT. 2)
22 - BARBS (ALT. 4)
23 - VORTEX ROCK WEIR (ALT. 2)
24 - VORTEX ROCK WEIR (ALT. 3)
25 - VORTEX ROCK WEIR (ALT. 4)
26 - LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 4)
27 - VORTEX ROCK WEIR (ALT. 2)
28 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 2)
29 - VORTEX ROCK WEIR (ALT. 2)
30 - VORTEX ROCK WEIR (ALT. 4)
31 - VORTEX ROCK WEIR (ALT. 2)
32 - VORTEX ROCK WEIR (ALT. 3)
33 - ROOT WAD REVETMENT W/DORMANT STOCK PLANTING (ALT. 2)
34 - VORTEX ROCK WEIR (ALT. 2)

REACH #4
35 - VORTEX ROCK WEIR (ALT. 2)
36 - VORTEX ROCK WEIR (ALT. 3)
37 - VORTEX ROCK WEIR (ALT. 2)
38 - VORTEX ROCK WEIR (ALT. 3)
39 - VORTEX ROCK WEIR (ALT. 2)
40 - VORTEX ROCK WEIR (ALT. 3)
41 - VORTEX ROCK WEIR (ALT. 2)
42 - BARBS (ALT. 4)
43 - VORTEX ROCK WEIR (ALT. 2)
44 - VORTEX ROCK WEIR (ALT. 2)
45 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
46 - VORTEX ROCK WEIR (ALT. 2)
47 - VORTEX ROCK WEIR (ALT. 4)
48 - VORTEX ROCK WEIR (ALT. 2)
49 - VORTEX ROCK WEIR (ALT. 2)
50 - VORTEX ROCK WEIR (ALT. 2)
51 - BARBS W/ROOTWADS (ALT. 4)
52 - VORTEX ROCK WEIR (ALT. 2)

REACH #5
53 - VORTEX ROCK WEIR (ALT. 3)
54 - VORTEX ROCK WEIR (ALT. 2)
55 - VORTEX ROCK WEIR (ALT. 4)
56 - VORTEX ROCK WEIR (ALT. 2)
57 - VORTEX ROCK WEIR (ALT. 4)
58 - VORTEX ROCK WEIR (ALT. 2)
59 - BARBS (ALT. 4)
60 - VORTEX ROCK WEIR (ALT. 3)
61 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 4)
62 - VORTEX ROCK WEIR (ALT. 2)
63 - VORTEX ROCK WEIR (ALT. 2)

REACH #6
64 - VORTEX ROCK WEIR (ALT. 3)
65 - VORTEX ROCK WEIR (ALT. 2)
66 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
67 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
68 - VORTEX ROCK WEIR W/PLANTINGS (ALT. 2)
69 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
70 - VORTEX ROCK WEIR (ALT. 3)
71 - VORTEX ROCK WEIR (ALT. 4)
72 - VORTEX ROCK WEIR (ALT. 2)
73 - VORTEX ROCK WEIR (ALT. 4)
74 - VORTEX ROCK WEIR (ALT. 2)

REACH #7
75 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
76 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
77 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
78 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

REACH #8
79 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
80 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
81 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
82 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

LEGEND

EXISTING POOLS
- Pools 1: > 1 meter
- Pools 2: .5 - 1 Meter
- Pools 3: < .5 Meter

GEOMORPHIC STREAM CLASSES
- B1
- B2
- B3C
- B4C
- C3
- C4
- C5
- F2
- F2B
- F3
- Open Water (Not Inventoried)

- Perennial Streams
- Intermittent Streams
- Stream Reach Boundaries
- Township and Range
- Sections
- Highways
- Secondary Roads
- Private Lands
- Wenatchee National Forest
- Bureau of Land Management
- Washington State Department of Fish and Wildlife
- Washington State Department of Parks and Recreation
- Washington State Department of Natural Resources
- Rivermiles
- Cross Section Locations
- USGS Gage

WATERSHED PLANNING STAFF
WASHINGTON STATE OFFICE, SPOKANE
RESOURCE INVENTORY

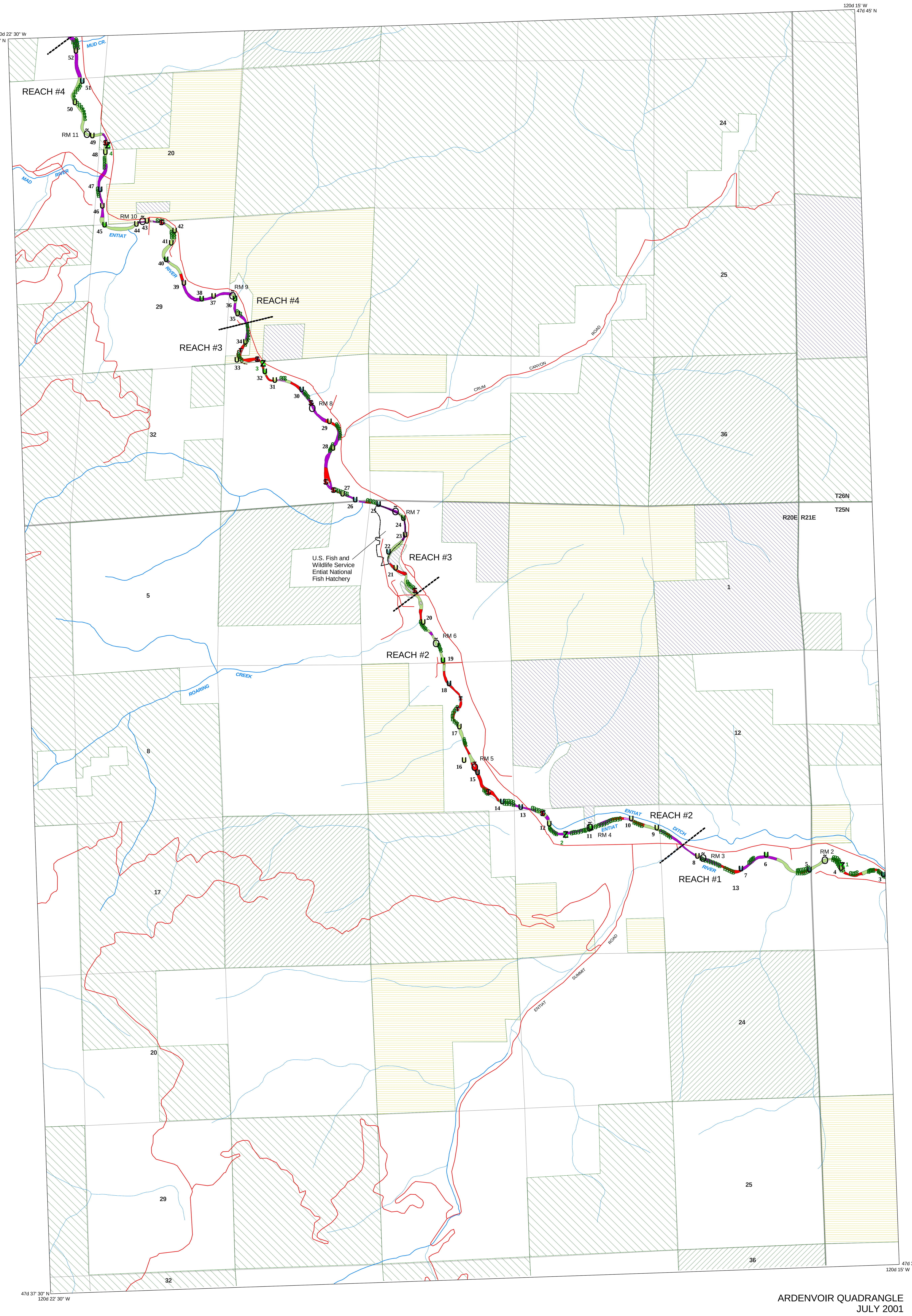
Sources:
USGS 7.5' Quadrangles (1:24,000 Scale): Entiat, Ardenvoir, Baldy Mtn., Tyee mtn,. for streams and PLS. Ownership information from WDNR Public Lands database. U.S. Census Bureau TIGER data (1:100,000 scale) for roads information. USDA NRCS field inventories for stream geomorphology and pool locations. Alternatives compiled from aerial photography and video, stream surveys, and interdisciplinary correlations.

NOTE:
The information shown on this map was intended for general planning purposes only. Decisions should be based upon site specific information. BOUNDARIES AND LOCATIONS ARE APPROXIMATE.

UNITED STATE
DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

MAP 2 NRCS SO
ARDENVOIR QUADRANGLE

CHELAN, WA
7.5 MINUTE SERIES



Proposed Alternatives for River Restoration and Fish Habitat

- U Alternative 2 Structures and/or Improvements
- U Alternative 3 Structures and/or Improvements
- U Alternative 4 Structures and/or Improvements
- ß Dormant Stock Planting/Vegetation Establishment
- Spring Chinook Salmon Redds
- -------- Unstable Banks Needing Rootwad Revetments W/ Dormant Stock Plantings

Symbols in the above legend for Alternatives 2, 3, and 4 are located on the map along the Entiat River where the proposed improvements are to be placed. Each symbol has a number corresponding to the list below. Each number in the list describes the type of improvement to be placed at that location on the map.

PROPOSED INSTREAM IMPROVEMENTS
BY STREAM REACH

REACH #1
1 - VORTEX ROCK WEIR (ALT. 4)
2 - VORTEX ROCK WEIR (ALT. 3)
3 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
4 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
5 - VORTEX ROCK WEIR (ALT. 4)
6 - BARBS (ALT. 3)
7 - VORTEX ROCK WEIR (ALT. 4)
8 - VORTEX ROCK WEIR (ALT. 2)

REACH #2
9 - VORTEX ROCK WEIR (ALT. 2)
10 - VORTEX ROCK WEIR (ALT. 2)
11 - VORTEX ROCK WEIR (ALT. 3)
12 - IRRIGATION CHECK DAM (ALT. 2)
13 - VORTEX ROCK WEIR (ALT. 4)
14 - LOW-STAGE LOG CHECK DAM (ALT. 4)
15 - VORTEX ROCK WEIR (ALT. 4)
16 - LOG CHECKS ON IRRIGATION CHANNEL (ALT. 2)
17 - VORTEX ROCK WEIR (ALT. 2)
18 - VORTEX ROCK WEIR (ALT. 4)
19 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
20 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 2)

REACH #3
21 - VORTEX ROCK WEIR (ALT. 2)
22 - BARBS (ALT. 4)
23 - VORTEX ROCK WEIR (ALT. 2)
24 - VORTEX ROCK WEIR (ALT. 3)
25 - VORTEX ROCK WEIR (ALT. 4)
26 - LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 4)
27 - VORTEX ROCK WEIR (ALT. 2)
28 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 2)
29 - VORTEX ROCK WEIR (ALT. 2)
30 - VORTEX ROCK WEIR (ALT. 4)
31 - VORTEX ROCK WEIR (ALT. 2)
32 - VORTEX ROCK WEIR (ALT. 3)
33 - ROOT WAD REVETMENT W/DORMANT STOCK PLANTING (ALT. 2)
34 - VORTEX ROCK WEIR (ALT. 2)

REACH #4
35 - VORTEX ROCK WEIR (ALT. 2)
36 - VORTEX ROCK WEIR (ALT. 3)
37 - VORTEX ROCK WEIR (ALT. 2)
38 - VORTEX ROCK WEIR (ALT. 3)
39 - VORTEX ROCK WEIR (ALT. 2)
40 - VORTEX ROCK WEIR (ALT. 3)
41 - VORTEX ROCK WEIR (ALT. 2)
42 - BARBS (ALT. 4)
43 - VORTEX ROCK WEIR (ALT. 2)
44 - VORTEX ROCK WEIR (ALT. 2)
45 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
46 - VORTEX ROCK WEIR (ALT. 2)
47 - VORTEX ROCK WEIR (ALT. 4)
48 - VORTEX ROCK WEIR (ALT. 2)
49 - VORTEX ROCK WEIR (ALT. 2)
50 - VORTEX ROCK WEIR (ALT. 2)
51 - BARBS W/ROOTWADS (ALT. 4)
52 - VORTEX ROCK WEIR (ALT. 2)

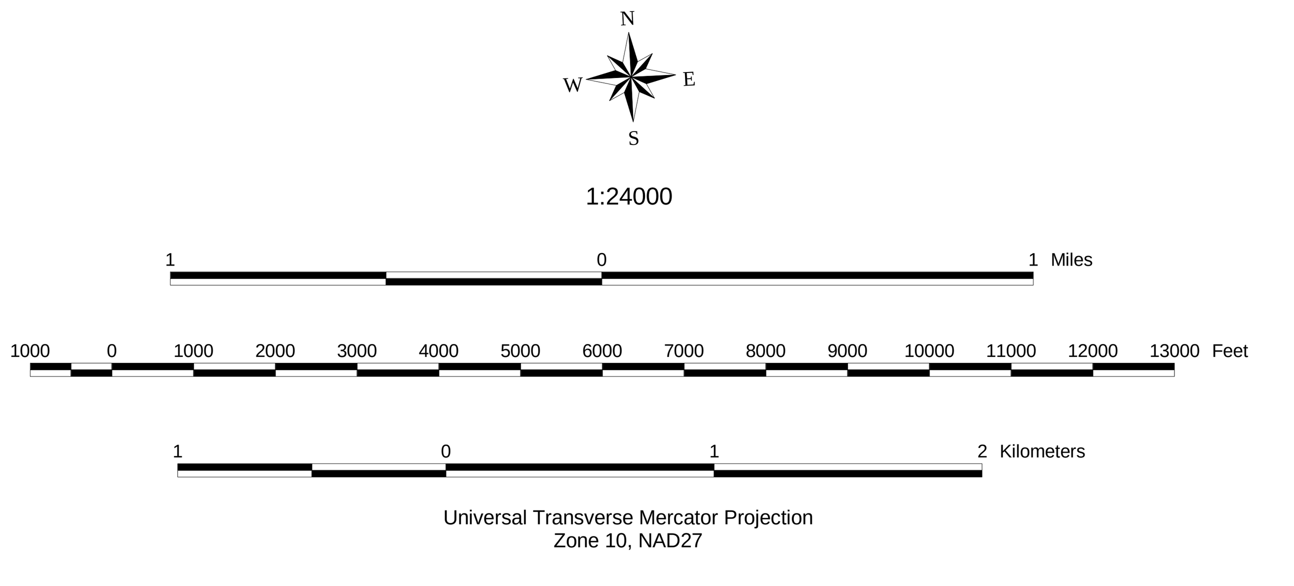
REACH #5
53 - VORTEX ROCK WEIR (ALT. 3)
54 - VORTEX ROCK WEIR (ALT. 2)
55 - VORTEX ROCK WEIR (ALT. 4)
56 - VORTEX ROCK WEIR (ALT. 2)
57 - VORTEX ROCK WEIR (ALT. 4)
58 - VORTEX ROCK WEIR (ALT. 2)
59 - BARBS (ALT. 4)
60 - VORTEX ROCK WEIR (ALT. 3)
61 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 4)
62 - VORTEX ROCK WEIR (ALT. 2)
63 - VORTEX ROCK WEIR (ALT. 2)

REACH #6
64 - VORTEX ROCK WEIR (ALT. 3)
65 - VORTEX ROCK WEIR (ALT. 2)
66 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
67 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
68 - VORTEX ROCK WEIR W/PLANTINGS (ALT. 2)
69 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
70 - VORTEX ROCK WEIR (ALT. 3)
71 - VORTEX ROCK WEIR (ALT. 4)
72 - VORTEX ROCK WEIR (ALT. 2)
73 - VORTEX ROCK WEIR (ALT. 4)
74 - VORTEX ROCK WEIR (ALT. 2)

REACH #7
75 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
76 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
77 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
78 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

REACH #8
79 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
80 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
81 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
82 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

ARDENVOIR QUADRANGLE
JULY 2001



Universal Transverse Mercator Projection
Zone 10, NAD27

LEGEND

EXISTING POOLS
- S Pools 1: > 1 meter
- Pools 2: .5 - 1 Meter
- S Pools 3: < .5 Meter

GEOMORPHIC STREAM CLASSES
- B1
- B2
- B3C
- B4C
- C3
- C4
- C5
- F2
- F2B
- F3
- Open Water (Not Inventoried)

- Perennial Streams
- Intermittent Streams
- Stream Reach Boundaries
- Township and Range
- Sections
- Highways
- Secondary Roads
- Private Lands
- Wenatchee National Forest
- Bureau of Land Management
- Washington State Department of Fish and Wildlife
- Washington State Department of Parks and Recreation
- Washington State Department of Natural Resources
- Rivermiles
- Cross Section Locations
- USGS Gage

WATERSHED PLANNING STAFF
WASHINGTON STATE OFFICE, SPOKANE
RESOURCE INVENTORY

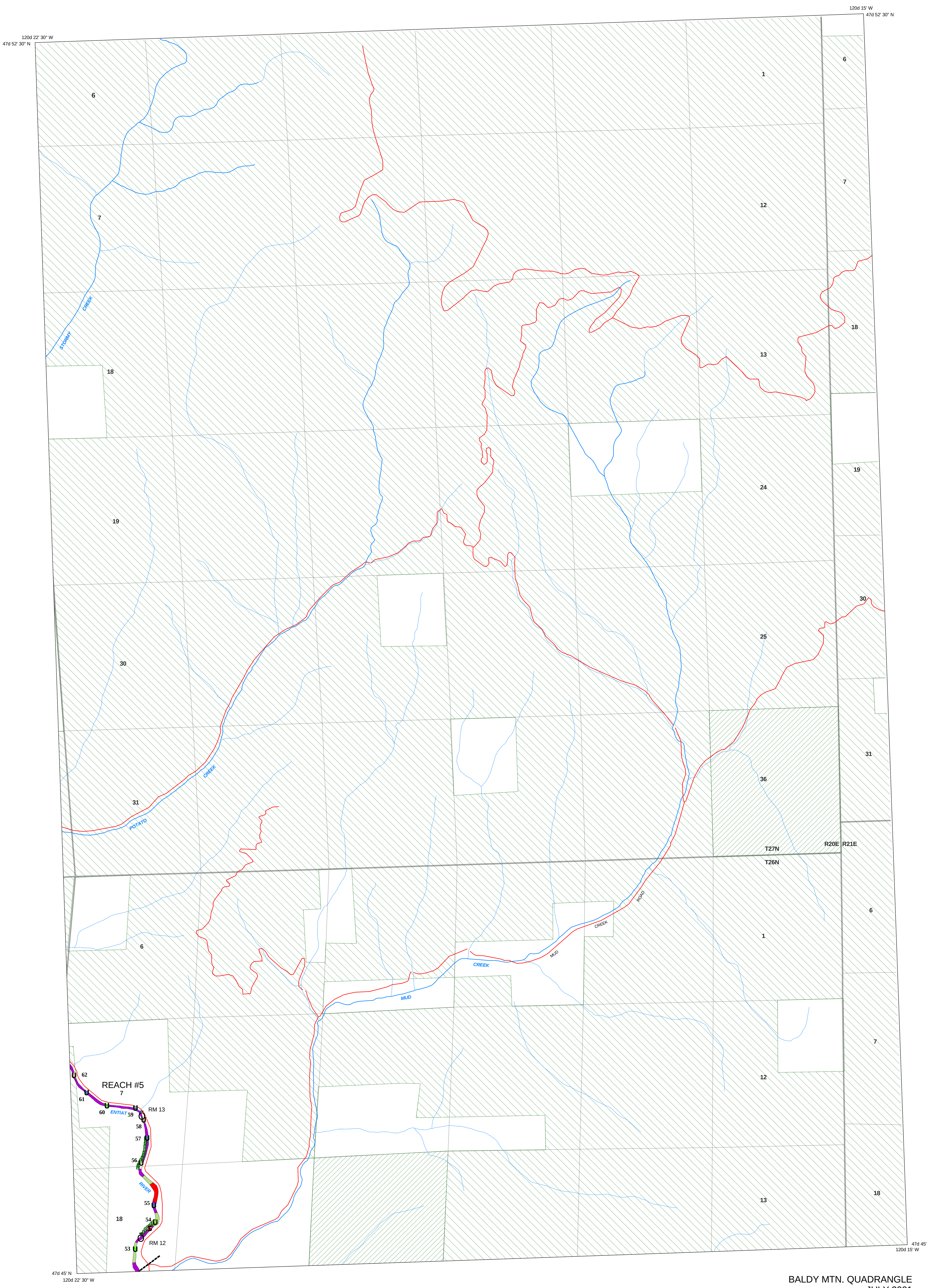
Sources:
USGS 7.5' Quadrangles (1:24,000 Scale): Entiat, Ardenvoir, Baldy Mtn., Tyee mtn,. for streams and PLS. Ownership information from WDNR Public Lands database. U.S. Census Bureau TIGER data (1:100,000 scale) for roads information. USDA NRCS field inventories for stream geomorphology and pool locations. Alternatives compiled from aerial photography and video, stream surveys, and interdisciplinary correlations.

NOTE:
The information shown on this map was intended for general planning purposes only. Decisions should be based upon site specific information. BOUNDARIES AND LOCATIONS ARE APPROXIMATE.

UNITED STATE
DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

MAP 3 NRCS SO
BALDY MTN. QUADRANGLE

CHELAN, WA
7.5 MINUTE SERIES



Proposed Alternatives for River Restoration and Fish Habitat

U Alternative 2 Structures and/or Improvements
U Alternative 3 Structures and/or Improvements
U Alternative 4 Structures and/or Improvements
ß Dormant Stock Planting/Vegetation Establishment
Spring Chinook Salmon Redds
-------- Unstable Banks Needing Rootwad Revetments W/ Dormant Stock Plantings

Symbols in the above legend for Alternatives 2, 3, and 4 are located on the map along the Entiat River where the proposed improvements are to be placed. Each symbol has a number corresponding to the list below. Each number in the list describes the type of improvement to be placed at that location on the map.

PROPOSED INSTREAM IMPROVEMENTS
BY STREAM REACH

REACH #1
1 - VORTEX ROCK WEIR (ALT. 4)
2 - VORTEX ROCK WEIR (ALT. 3)
3 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
4 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
5 - VORTEX ROCK WEIR (ALT. 4)
6 - BARBS (ALT. 3)
7 - VORTEX ROCK WEIR (ALT. 4)
8 - VORTEX ROCK WEIR (ALT. 2)

REACH #2
9 - VORTEX ROCK WEIR (ALT. 2)
10 - VORTEX ROCK WEIR (ALT. 2)
11 - VORTEX ROCK WEIR (ALT. 3)
12 - IRRIGATION CHECK DAM (ALT. 2)
13 - VORTEX ROCK WEIR (ALT. 4)
14 - LOW-STAGE LOG CHECK DAM (ALT. 4)
15 - VORTEX ROCK WEIR (ALT. 4)
16 - LOG CHECKS ON IRRIGATION CHANNEL (ALT. 2)
17 - VORTEX ROCK WEIR (ALT. 2)
18 - VORTEX ROCK WEIR (ALT. 4)
19 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
20 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 2)

REACH #3
21 - VORTEX ROCK WEIR (ALT. 2)
22 - BARBS (ALT. 4)
23 - VORTEX ROCK WEIR (ALT. 2)
24 - VORTEX ROCK WEIR (ALT. 3)
25 - VORTEX ROCK WEIR (ALT. 4)
26 - LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 4)
27 - VORTEX ROCK WEIR (ALT. 2)
28 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 2)
29 - VORTEX ROCK WEIR (ALT. 2)
30 - VORTEX ROCK WEIR (ALT. 4)
31 - VORTEX ROCK WEIR (ALT. 2)
32 - VORTEX ROCK WEIR (ALT. 3)
33 - ROOT WAD REVETMENT W/DORMANT STOCK PLANTING (ALT. 2)
34 - VORTEX ROCK WEIR (ALT. 2)

REACH #4
35 - VORTEX ROCK WEIR (ALT. 2)
36 - VORTEX ROCK WEIR (ALT. 3)
37 - VORTEX ROCK WEIR (ALT. 2)
38 - VORTEX ROCK WEIR (ALT. 3)
39 - VORTEX ROCK WEIR (ALT. 2)
40 - VORTEX ROCK WEIR (ALT. 3)
41 - VORTEX ROCK WEIR (ALT. 2)
42 - BARBS (ALT. 4)
43 - VORTEX ROCK WEIR (ALT. 2)
44 - VORTEX ROCK WEIR (ALT. 2)
45 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
46 - VORTEX ROCK WEIR (ALT. 2)
47 - VORTEX ROCK WEIR (ALT. 4)
48 - VORTEX ROCK WEIR (ALT. 2)
49 - VORTEX ROCK WEIR (ALT. 2)
50 - VORTEX ROCK WEIR (ALT. 2)
51 - BARBS W/ROOTWADS (ALT. 4)
52 - VORTEX ROCK WEIR (ALT. 2)

REACH #5
53 - VORTEX ROCK WEIR (ALT. 3)
54 - VORTEX ROCK WEIR (ALT. 2)
55 - VORTEX ROCK WEIR (ALT. 4)
56 - VORTEX ROCK WEIR (ALT. 2)
57 - VORTEX ROCK WEIR (ALT. 4)
58 - VORTEX ROCK WEIR (ALT. 2)
59 - BARBS (ALT. 4)
60 - VORTEX ROCK WEIR (ALT. 3)
61 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 4)
62 - VORTEX ROCK WEIR (ALT. 2)
63 - VORTEX ROCK WEIR (ALT. 2)

REACH #6
64 - VORTEX ROCK WEIR (ALT. 3)
65 - VORTEX ROCK WEIR (ALT. 2)
66 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
67 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
68 - VORTEX ROCK WEIR W/PLANTINGS (ALT. 2)
69 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
70 - VORTEX ROCK WEIR (ALT. 3)
71 - VORTEX ROCK WEIR (ALT. 4)
72 - VORTEX ROCK WEIR (ALT. 2)
73 - VORTEX ROCK WEIR (ALT. 4)
74 - VORTEX ROCK WEIR (ALT. 2)

REACH #7
75 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
76 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
77 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
78 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

REACH #8
79 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
80 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
81 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
82 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

BALDY MTN. QUADRANGLE
JULY 2001

N W E S

1:24000

1 0 1 Miles

1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 Feet

1 0 1 2 Kilometers

Universal Transverse Mercator Projection
Zone 10, NAD27

LEGEND

EXISTING POOLS
S Pools 1: > 1 meter
Pools 2: .5 - 1 Meter
S Pools 3: < .5 Meter

GEOMORPHIC STREAM CLASSES
B1
B2
B3C
B4C
C3
C4
C5
F2
F2B
F3
Open Water (Not Inventoried)

Perennial Streams
Intermittent Streams
Stream Reach Boundaries
Township and Range
Sections
Highways
Secondary Roads
Private Lands
Wenatchee National Forest
Bureau of Land Management
Washington State Department of Fish and Wildlife
Washington State Department of Parks and Recreation
Washington State Department of Natural Resources
Õ Rivermiles
Z Cross Section Locations
Z USGS Gage

WATERSHED PLANNING STAFF
WASHINGTON STATE OFFICE, SPOKANE
RESOURCE INVENTORY

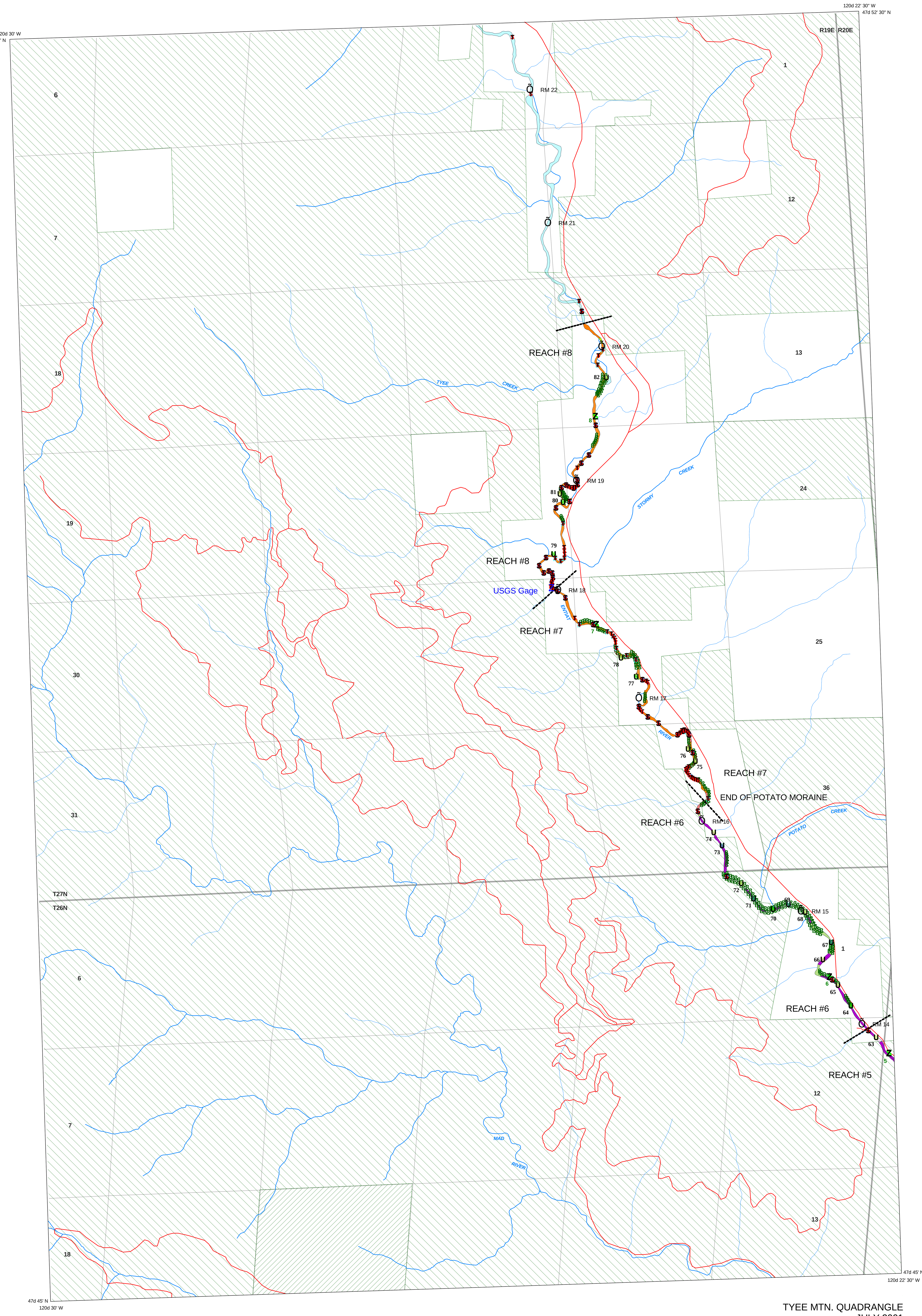
Sources:
USGS 7.5' Quadrangles (1:24,000 Scale): Entiat, Ardenvoir, Baldy Mtn., Tyee mtn,. for streams and PLS. Ownership information from WDNR Public Lands database. U.S. Census Bureau TIGER data (1:100,000 scale) for roads information. USDA NRCS field inventories for stream geomorphology and pool locations. Alternatives compiled from aerial photography and video, stream surveys, and interdisciplinary correlations.

NOTE:
The information shown on this map was intended for general planning purposes only. Decisions should be based upon site specific information. BOUNDARIES AND LOCATIONS ARE APPROXIMATE.

UNITED STATE
DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

MAP 4 NRCS SO
TYEE MTN. QUADRANGLE

CHELAN, WA
7.5 MINUTE SERIES



TYEE MTN. QUADRANGLE
JULY 2001

Proposed Alternatives for River Restoration and Fish Habitat

- Alternative 2 Structures and/or Improvements
- Alternative 3 Structures and/or Improvements
- Alternative 4 Structures and/or Improvements
- ß Dormant Stock Planting/Vegetation Establishment
- Spring Chinook Salmon Redds
- -------- Unstable Banks Needing Rootwad Revetments W/ Dormant Stock Plantings

Symbols in the above legend for Alternatives 2, 3, and 4 are located on the map along the Entiat River where the proposed improvements are to be placed. Each symbol has a number corresponding to the list below. Each number in the list describes the type of improvement to be placed at that location on the map.

PROPOSED INSTREAM IMPROVEMENTS
BY STREAM REACH

REACH #1
1 - VORTEX ROCK WEIR (ALT. 4)
2 - VORTEX ROCK WEIR (ALT. 3)
3 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
4 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
5 - VORTEX ROCK WEIR (ALT. 4)
6 - BARBS (ALT. 3)
7 - VORTEX ROCK WEIR (ALT. 4)
8 - VORTEX ROCK WEIR (ALT. 2)

REACH #2
9 - VORTEX ROCK WEIR (ALT. 2)
10 - VORTEX ROCK WEIR (ALT. 2)
11 - VORTEX ROCK WEIR (ALT. 3)
12 - IRRIGATION CHECK DAM (ALT. 2)
13 - VORTEX ROCK WEIR (ALT. 4)
14 - LOW-STAGE LOG CHECK DAM (ALT. 4)
15 - VORTEX ROCK WEIR (ALT. 4)
16 - LOG CHECKS ON IRRIGATION CHANNEL (ALT. 2)
17 - VORTEX ROCK WEIR (ALT. 2)
18 - VORTEX ROCK WEIR (ALT. 4)
19 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
20 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 2)

REACH #3
21 - VORTEX ROCK WEIR (ALT. 2)
22 - BARBS (ALT. 4)
23 - VORTEX ROCK WEIR (ALT. 2)
24 - VORTEX ROCK WEIR (ALT. 3)
25 - VORTEX ROCK WEIR (ALT. 4)
26 - LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 4)
27 - VORTEX ROCK WEIR (ALT. 2)
28 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM W/ROOTWADS (ALT. 2)
29 - VORTEX ROCK WEIR (ALT. 2)
30 - VORTEX ROCK WEIR (ALT. 4)
31 - VORTEX ROCK WEIR (ALT. 2)
32 - VORTEX ROCK WEIR (ALT. 3)
33 - ROOT WAD REVETMENT W/DORMANT STOCK PLANTING (ALT. 2)
34 - VORTEX ROCK WEIR (ALT. 2)

REACH #4
35 - VORTEX ROCK WEIR (ALT. 2)
36 - VORTEX ROCK WEIR (ALT. 3)
37 - VORTEX ROCK WEIR (ALT. 2)
38 - VORTEX ROCK WEIR (ALT. 3)
39 - VORTEX ROCK WEIR (ALT. 2)
40 - VORTEX ROCK WEIR (ALT. 3)
41 - VORTEX ROCK WEIR (ALT. 2)
42 - BARBS (ALT. 4)
43 - VORTEX ROCK WEIR (ALT. 2)
44 - VORTEX ROCK WEIR (ALT. 2)
45 - VORTEX ROCK WEIR OR LOW-STAGE LOG CHECK DAM (ALT. 3)
46 - VORTEX ROCK WEIR (ALT. 2)
47 - VORTEX ROCK WEIR (ALT. 4)
48 - VORTEX ROCK WEIR (ALT. 2)
49 - VORTEX ROCK WEIR (ALT. 2)
50 - VORTEX ROCK WEIR (ALT. 2)
51 - BARBS W/ROOTWADS (ALT. 4)
52 - VORTEX ROCK WEIR (ALT. 2)

REACH #5
53 - VORTEX ROCK WEIR (ALT. 3)
54 - VORTEX ROCK WEIR (ALT. 2)
55 - VORTEX ROCK WEIR (ALT. 4)
56 - VORTEX ROCK WEIR (ALT. 2)
57 - VORTEX ROCK WEIR (ALT. 4)
58 - VORTEX ROCK WEIR (ALT. 2)
59 - BARBS (ALT. 4)
60 - VORTEX ROCK WEIR (ALT. 3)
61 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 4)
62 - VORTEX ROCK WEIR (ALT. 2)
63 - VORTEX ROCK WEIR (ALT. 2)

REACH #6
64 - VORTEX ROCK WEIR (ALT. 3)
65 - VORTEX ROCK WEIR (ALT. 2)
66 - VORTEX ROCK WEIR W/ROOTWADS (ALT. 2)
67 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
68 - VORTEX ROCK WEIR W/PLANTINGS (ALT. 2)
69 - SINGLE-WING DEFLECTOR W/ROOTWADS (ALT. 4)
70 - VORTEX ROCK WEIR (ALT. 3)
71 - VORTEX ROCK WEIR (ALT. 4)
72 - VORTEX ROCK WEIR (ALT. 2)
73 - VORTEX ROCK WEIR (ALT. 4)
74 - VORTEX ROCK WEIR (ALT. 2)

REACH #7
75 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
76 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
77 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
78 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

REACH #8
79 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
80 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 3)
81 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)
82 - ROOT WAD REVETMENT W/PLANTINGS (ALT. 2)

N
W E
S

1:24000

1 0 1 Miles

1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 Feet

1 0 1 2 Kilometers

Universal Transverse Mercator Projection
Zone 10, NAD27

LEGEND

EXISTING POOLS
- Pools 1: > 1 meter
- Pools 2: .5 - 1 Meter
- Pools 3: < .5 Meter

GEOMORPHIC STREAM CLASSES
- B1
- B2
- B3C
- B4C
- C3
- C4
- C5
- F2
- F2B
- F3
- Open Water (Not Inventoried)

- Perennial Streams
- Intermittent Streams
- Stream Reach Boundaries
- Township and Range
- Sections
- Highways
- Secondary Roads
- Private Lands
- Wenatchee National Forest
- Bureau of Land Management
- Washington State Department of Fish and Wildlife
- Washington State Department of Parks and Recreation
- Washington State Department of Natural Resources
- Rivermiles
- Cross Section Locations
- USGS Gage

WATERSHED PLANNING STAFF
WASHINGTON STATE OFFICE, SPOKANE
RESOURCE INVENTORY

Sources:
USGS 7.5' Quadrangles (1:24,000 Scale): Entiat, Ardenvoir, Baldy Mtn., Tyee mtn,. for streams and PLS. Ownership information from WDNR Public Lands database. U.S. Census Bureau TIGER data (1:100,000 scale) for roads information. USDA NRCS field inventories for stream geomorphology and pool locations. Alternatives compiled from aerial photography and video, stream surveys, and interdisciplinary correlations.

NOTE:
The information shown on this map was intended for general planning purposes only. Decisions should be based upon site specific information. BOUNDARIES AND LOCATIONS ARE APPROXIMATE.