FINAL REPORT:
TRINITY COUNTY CULVERT INVENTORY AND FISH PASSAGE EVALUATION

By

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Photo: Quinby Creek at Denny Road

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INTRODUCTION

The inventory and fish passage evaluation of road crossings within the Trinity County road system was conducted between May, 2001 and June, 2002 under contract with the Trinity County Planning Department. The primary objective was to assess passage of juvenile and adult salmonids and develop a project-scheduling document to prioritize corrective treatments to provide unimpeded fish passage at road/stream intersections. The inventory was limited to county-maintained crossings within anadromous stream reaches within the Trinity River basin known to historically and/or currently support runs of coho salmon (*Oncorhynchus kisutch*), chinook salmon (*O. tshawytscha*) and/or steelhead (*O. mykiss irideus*).

The inventory and assessment process included:

1. Locating stream crossings within anadromous stream reaches.
2. Visiting each crossing on an initial site visit to determine the type of crossing and assessment of stream channel as suitable fish habitat.
3. At county-maintained sites with culverts - collecting information regarding culvert specifications and surveying a longitudinal profile.
4. Assessing fish passage using culvert specifications and passage criteria for juvenile and adult salmonids (from scientific literature) by employing a first-phase evaluation filter and then using FishXing computer software on a subset of sites defined as partial/temporal barriers by the filter.
5. Assessing quality and quantity of stream habitat above and below each culvert.

The prioritization process ranked culvert sites by assigning numerical scores for the following criteria:

1. Presumed species diversity within stream reach of interest (and federal listing status).
2. Extent of barrier for each species and lifestage for range of estimated migration flows.
3. Quality and quantity of potential upstream habitat gains.
4. Sizing of current stream crossing (risk of fill failure).
5. Condition of current crossing (life expectancy).

The initial ranking was not intended to provide an exact order of priority, rather produce a first-cut rank in which sites could be grouped as high, medium, or low priority. Professional judgment was a vital component of the ranking process. Site-specific information that is difficult to assign a discrete numerical value was also considered.

Examples included:

1. Direct observations of attempted migration at known barriers. Treating these sites should result in a high probability of immediate utilization of re-opened habitat.

2. Fish behavior at culverts. Recent studies suggests salmonids experience migration difficulties at road crossings that exhibit hydraulic characteristics within the reported abilities of several salmonid species (Taylor 2000 and 2001; Love et al. pers. comm.).

3. Physical stress or danger to migrating salmonids. Recent studies have revealed several sites where concentrations of migrating salmonids were subjected to decades of predation by birds and mammals or poaching by humans (Taylor 2000 and 2001). Inability to enter cool-water tributaries to escape stressful/lethal mainstem water temperatures during summer months has also been observed. These factors should weigh heavily in priority ranking.

Additional physical, operational, social, and/or economic factors exist that may influence the final order of sites; but these are beyond the scope of this project.

Final Product of Culvert Inventory

Five hard copies and CD's were distributed to the Trinity County Planning Department.

Final report includes:

1. A count and location of all culverted stream crossings. Locations were identified by stream name; road name; road number; watershed name; mile marker or distance to nearest named crossroad; Trinity County road map #; USGS Quad name; Township, Range and Section coordinates; and lat/long coordinates (NAD27 datum). All location data were entered into a spreadsheet for potential database uses.

2. For each site, culvert specifications were collected, including: length, diameter, type, position relative to flow and stream gradient, amount of fill material, depth of jump pool below culvert, height of leap required to enter culvert, previous modifications (if any) to improve fish passage, and evaluate effectiveness of previous modifications. All site-specific data were entered into a spreadsheet for potential database uses.

3. Information regarding culvert age, wear, and performance was collected, including: overall condition of the pipe and rust line height. Presence or absence and condition of trash racks was also assessed. All culvert specifications were entered into a spreadsheet for potential database uses.

4. An evaluation of fish passage at each culvert location. Fish passage was evaluated by two methods. Initially, fish passage was assessed by employing a first-phase evaluation filter that was developed for Part 10 of the California Department of Fish and Game's (CDFG) *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2002). The filter quickly determines if a culvert either meets fish passage criteria for all species and life stages as defined by CDFG and NMFS for the range of migration flows (GREEN); fails to meet passage criteria for all species and life stages (RED); or is a partial/temporal barrier (GRAY). Then FishXing (a computer software program) was used to conduct in-depth passage evaluations on the GRAY sites by modeling culvert hydraulics over the range of migration

flows and comparing these values with leaping and swimming abilities of the species and life stages of interest.

5. Digital photo documentation of each culvert to provide visual information regarding inlet and outlet configurations; as well as insertion in future reports, proposals, or presentations

6. An evaluation of quantity and quality of fish habitat above and below each culvert location. Some information was obtained from habitat typing surveys previously conducted by CDFG, USFS, watershed groups, and/or timber companies. Where feasible, a first-hand inspection and evaluation of stream habitat occurred. Length of potential anadromous habitat was also estimated from USGS topographic maps. In situations where formal habitat typing surveys were not conducted and/or access to stream reaches was not permitted, professional judgment of biologists familiar with watershed conditions was utilized.

7. A ranked list of culverts that require treatment to provide unimpeded fish passage to spawning and rearing habitat. On a site-by-site basis, general recommendations for providing unimpeded fish passage were provided.

Project Justification

Fish passage through culverts is an important factor in the recovery of depleted salmonid populations throughout the Pacific Northwest. Although most fish-bearing streams with culverts tend to be relatively small in size with only a couple of miles or less of upstream habitat, thousands of these exist and the cumulative effect of blocked habitat is probably quite significant. Recent research regarding watershed restoration considers the identification, prioritization, and treatment of migration barriers to restore ecological connectivity for salmonids a vital step towards recovering depressed populations (Roni et al. 2002).

Culverts often create temporal, partial or complete barriers for anadromous salmonids on their spawning migrations (Table 1) (adapted from Robison et al. 2000).

Typical passage problems created by culverts are:

- Excessive drop at outlet (too high of entry leap required);
- Excessive velocities within culvert;
- Lack of depth within culvert;
- Excessive velocity and/or turbulence at culvert inlet; and
- Debris accumulation at culvert inlet and/or within culvert.

Table 1. Definitions of barrier types and their potential impacts.

Barrier Category	Definition	Potential Impacts
Temporal	Impassable to all fish some of the time	Delay in movement beyond the barrier for some period of time
Partial	Impassable to some fish at all times	Exclusion of certain species and life stages from portions of a watershed
Total	Impassable to all fish at all times	Exclusion of all species from portions of a watershed

Even if culverts are eventually negotiated, excess energy expended by fish may result in their death prior to spawning or reductions in viability of eggs and offspring. Migrating fish concentrated in pools and stream reaches below road crossings are also more vulnerable to predation by a variety of avian and mammalian species, as well as poaching by humans. Culverts which impede adult passage limit the distribution of spawning, often resulting in under seeded headwaters and superimposition of redds in lower stream reaches.

Current guidelines for new culvert installation aim to provide unimpeded passage for both adult and juvenile salmonids (NMFS 2000). However many existing culverts on federal, state, county, and private roads are barriers to anadromous adults, and more so to resident and juvenile salmonids whose smaller sizes significantly limit their leaping and swimming abilities to negotiate culverts. For decades, "legacy" culverts on established roads have effectively disrupted the spawning and rearing behavior of all four species of anadromous salmonids in California: Chinook salmon, coho salmon, coastal rainbow trout (steelhead are anadromous coastal rainbow trout), and coastal cutthroat trout (*Oncorhynchus clarki clarki*).

In recent years, there has been a growing awareness of the disruption of in-stream migrations of resident and juvenile salmonids caused at road/stream intersections. In-stream movements of juvenile and resident salmonids are highly variable and still poorly understood by biologists. Juvenile coho salmon spend approximately one year in freshwater before migrating to the ocean, and juvenile steelhead may rear in freshwater for up to four years prior to out-migration (one to two years is most common in California). Thus, juveniles of both species are highly dependent on stream habitat.

Many studies indicate that a common strategy for over-wintering juvenile coho is to migrate out of larger river systems into smaller streams during late-fall and early-winter storms to seek refuge from possibly higher flows and potentially higher turbidity levels in mainstem channels (Skeesick 1970; Cederholm and Scarlett 1981; Tripp and McCart 1983; Tschaplinski and Hartman 1983; Scarlett and Cederholm 1984; Sandercock 1991; Nickelson et al. 1992). Recent research conducted in coastal, northern California watersheds suggests that juvenile salmonids migrate into smaller tributaries in the fall and winter to feed on eggs deposited by spawning adults as well as flesh of spawned-out adults (Roelofs, pers. comm). Direct observation at numerous culverts in northern California confirmed similar upstream movements of three year-classes of juvenile steelhead (young-of-year, 1-year old and 2-year old) (Taylor 2001; Taylor 2000).

The variable life history of resident coastal rainbow trout is exhibited by seasonal movements in and out of one or more tributaries within a watershed. These smaller tributaries are where most culverts are still located since larger channels tend to be spanned by bridges.

In response to the 1994 federal listing of coho salmon as threatened in northern California, five counties (Humboldt, Del Norte, Trinity, Siskiyou, and Mendocino) formed the Five-Counties Salmon Group to examine various land-use activities conducted or permitted under county jurisdiction that may impact coho salmon habitat. Initial meetings identified causative factors of potential impacts, information gaps, and priority tasks required to obtain missing information. A high-priority task included conducting culvert inventories on county roads to evaluate fish passage and prioritize treatments.

Anadromous salmonids will benefit from this planning effort because the final document provides Trinity County's Planning Department with a prioritized list of culvert locations to fix that will provide unimpeded passage for all species (and life stages) of salmonids. Report information will assist in proposal development to seek State and Federal money to implement treatments. The inventory will also provide the County with a comprehensive status evaluation of the overall condition and sizing of culverts within fish-bearing stream reaches, providing vital information to assist the County's general planning and road's maintenance needs.

METHODS AND MATERIALS

Methods for conducting the culvert inventory and fish passage evaluation included eight tasks; accomplished generally in the following order:

1. Location of stream crossings.
2. Initial site visits and data collection.
3. Estimation of tributary-specific hydrology and design flows for presumed migration period.
4. Data entry and passage analyses. Passage was first evaluated with a first-phase evaluation filter referred to as the "Green-Gray-Red" filter. Sites determined to be "Gray" then required an in-depth evaluation with FishXing – a computer modeling software.
5. Site visits for migration observations during fall/winter migration flows.
6. Collection and interpretation of existing habitat information.
7. Prioritization of sites for corrective treatment.
8. Site-specific recommendations for unimpeded passage of both juvenile and adult salmonids.

Location of Culverts

Preliminary project scoping included examination of Trinity County road system maps and counting road/stream intersections on known (current and historic) anadromous stream reaches. The National Marine Fisheries Service (NMFS) coho salmon stock questionnaire list was used to identify and locate coho and steelhead streams on the Trinity County road maps. NMFS's list of current and historic coho streams was based heavily on a compilation of field and survey reports produced by Brown and Moyle (1989).

Approximately 70 county stream crossings were initially identified on anadromous stream reaches. Because the use of maps was considered a rough, first-cut at locating potential stream crossings, additional sites were also investigated once the project started.

Initial Site Visits

The objective of the initial site visits was to collect physical measurements at each crossing to utilize with the first-phase evaluation filter and with FishXing passage evaluation software. Notes describing the type and condition of each culvert, as well as qualitative comments describing stream habitat immediately above and below each culvert were also included. Photographs of the outlet and inlet were taken at each site.

Culvert Location

The location of each culvert was described by: Trinity County road system map # ; road name and number; stream name; watershed name; name of USGS quad map; Township, Range, and Section; latitude and longitude; and mile marker or distance to nearest named cross-road. If more than one county road culvert crossed single stream, a number was assigned to the stream name with the #1 culvert located farthest downstream (numbering then proceeded in an upstream direction). Lat/long coordinates were determined using Terrain Navigator (Version 3.01 by MapTech), a geo-referenced mapping software program; or in the field with a handheld GPS unit. For data entry and analyses purposes, all lat/long coordinates were provided in the North American 1927 datum (NAD27).

Longitudinal Survey

A longitudinal survey was shot at each culvert to provide accurate elevation data for FishXing passage analyses. We utilized an auto-level (Topcon AT-G7) with an accuracy of ± 2.5 mm, a domed-head surveyor's tripod, and a 25' leveling rod in 1/100' increments. All data and information were written on water-proof data sheets with a pencil. Data sheets were photocopied to provide back-ups in case of loss or destruction of originals.

Once a site was located in the field by the two-person survey crew, bright orange safety cones with signs marked "Survey Party" were placed to warn oncoming traffic from both directions. Bright orange vests were also worn by the survey crew. Vests increased one's visibility to traffic, and decreased suspicions of nearby property owners to our unannounced presence in the roadside stream channel. If sites were close to private residences, we attempted to contact the property owners to inform them of our survey of the county-maintained road crossing.

To start the survey, a 300-foot tape (in 1/10' increments) was placed down the approximate center of the stream channel. The tape was started on the upstream side of the culvert, usually in the riffle crest of the first pool or run habitat unit above the culvert. This pool or run was considered the first available resting habitat for fish negotiating the culvert. The tape was set to follow any major changes in channel direction. The tape was set through the culvert and continued downstream to at least the riffle crest (or control) of the pool immediately downstream of the culvert outlet. If several "stair-stepped" pools led up to the culvert inlet, then the tape was set to the riffle crest of the lower-most pool. Extreme caution was used when wading through culverts. A hardhat and flashlight were standard items used during the surveys.

The tripod and mounted auto-level were set in a location to eliminate or minimize the number of turning points required to complete the survey. If possible, a location on the road surface was optimal, allowing a complete survey to be shot from one location. The leveling rod was placed at the thalweg (deepest point of channel cross-section at any given point along the center tape) at various stations along the center tape, generally capturing visually noticeable breaks in slope along the stream channel.

At all sites, five required elevations were measured (Figure 1):

1. culvert inlet,
2. culvert outlet,
3. maximum pool depth within five feet of the outlet,
4. outlet pool control, and
5. active channel margin between the culvert outlet and the outlet pool control. An active channel discharge is less than a bank-full discharge and is often identified by several features, including (Figure 2):

- Edge of frequently scoured substrate.
- Break in rooted vegetation or moss growth on rocks along stream margins.
- Natural line impressed on the bank.
- Shelving.
- Changes in soil character.

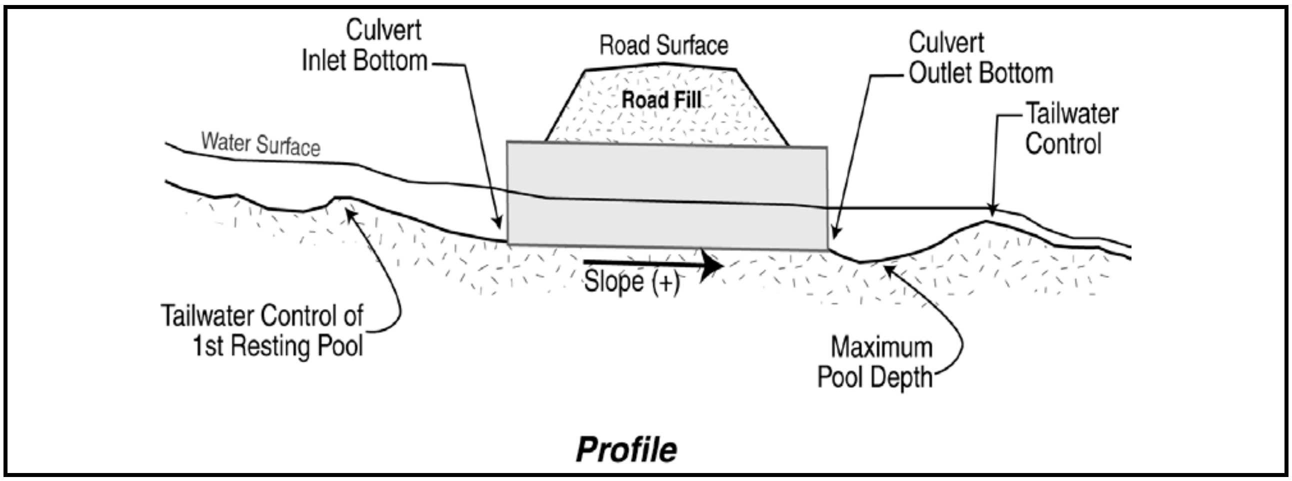


Figure 1. Diagram of required survey points though a culvert at a typical stream crossing.

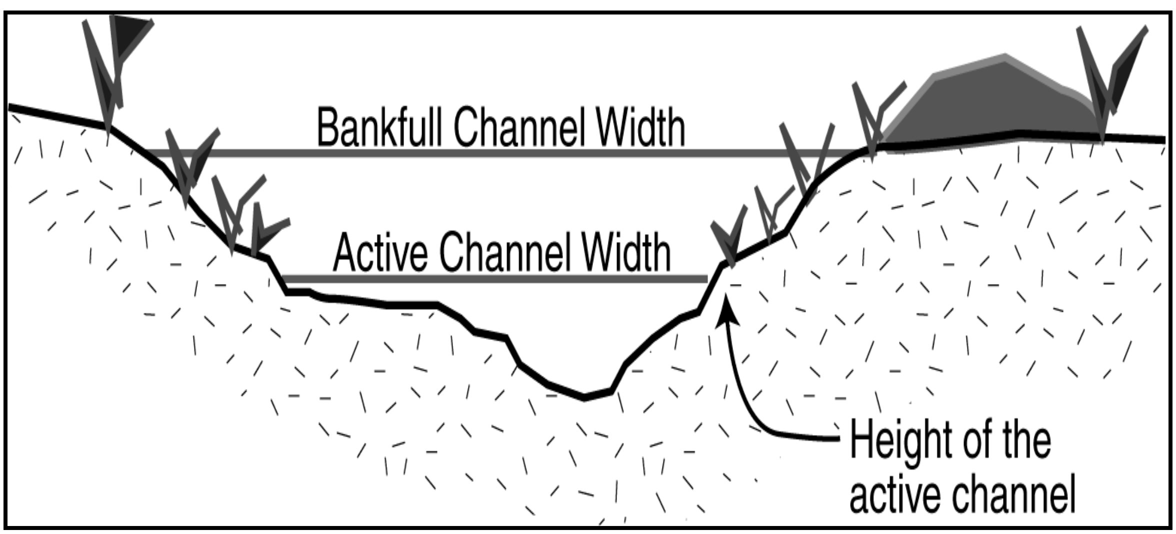


Figure 2. Active channel width versus bankfull channel width.

On a site-specific basis, the following additional survey points provided useful information for evaluating fish passage with FishXing:

- Apparent breaks-in-slope within the crossing. Older culverts often sag when road fills slump, creating steeper sections within a culvert. If only inlet and outlet elevations are measured, the overall slope will predict average velocities less than actual velocities within steeper sections. These breaks-in-slope may act as velocity barriers, which are masked if only the overall slope of the culvert is measured. The tripod and auto-level were set within the culvert or channel to measure breaks-in-slope.

- Steep drops in the stream channel profile immediately upstream of the culvert inlet. Measure the elevation at the tail of the first upstream holding water (where the tape was set) to estimate the channel slope leading into the culvert. In some cases, a fish may negotiate the culvert only to fail at passing through a velocity chute upstream of the inlet entrance. Inlet drops often create highly turbulent conditions during elevated flows.

All elevations were measured to the nearest 1/100' and entered with a corresponding station location (distance along center tape) to the nearest 1/10'.

Channel widths

Where feasible, at least five measurements of the active channel width above the culvert (visually beyond any influence the crossing may have on channel width) were taken. Active channel is defined as the portion of channel commonly wetted during and above winter base flows and is identified by a break in rooted vegetation or moss growth on rocks along stream margins. Some culvert design guidelines utilize active channel widths in determining the appropriate widths of new culvert installations (NMFS 2001; CDFG 2001; Robison et al 2000; Bates et al. 1999).

Although not required, in many cases a cross-section survey of at least the bankfull channel width at the outlet pool control was measured to increase the accuracy of passage analyses. For more detail, refer to the extensive "Help files" provided with FishXing (Love 2000).

Fill Estimate:

At each culvert, the volume of road fill placed above the stream channel is estimated from field measurements Fill volume estimates are incorporated into the ranking of sites for treatment and can assist in:

1. Calculating culvert flood capacity at HW/Fill =1 (water surface at top of fill prism).
2. Determining potential volume of sediment delivered to downstream habitat if the stream crossing fails.
3. Developing rough cost estimates for barrier removal by estimating equipment time required for fill removal and disposal site space needed.

Road fill volume is estimated using procedures outlined in Flannigan et al. (1998). The following measurements are taken to calculate the fill volume (Figure 3):

1. Upstream and downstream fill slope lengths (L_d and L_u).
2. Slope (%) of upstream and downstream fill slopes (S_d and S_u).
3. Width of road prism (W_r).
4. Top fill width (W_f).
5. Base fill width (W_c).

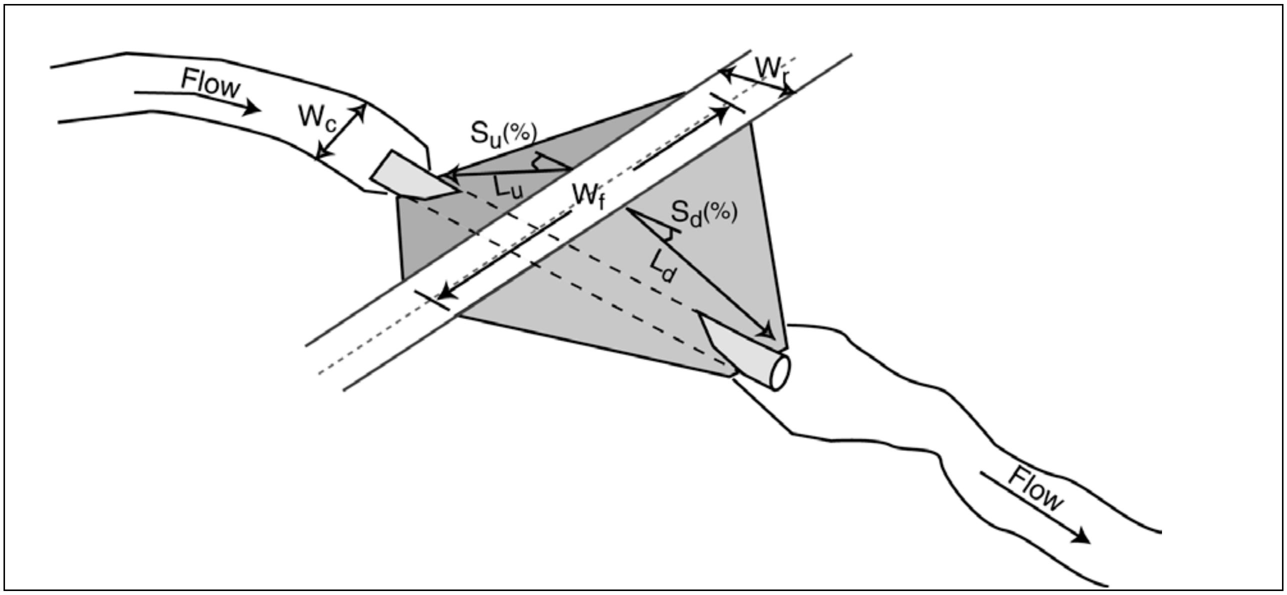


Figure 3. Road fill measurements.

Equations (1) through (4) were used calculate the fill volume.

(1) Upstream prism volume, V_u:

$$V_u = 0.25(W_f + W_c)(L_u \cos S_u)(L_u \sin S_u)$$

(2) Downstream prism volume, V_d:

$$V_d = 0.25(W_f + W_c)(L_d \cos S_d)(L_d \sin S_d)$$

(3) Volume below road surface, V_r:

$$V_r = 0.25(H_u + H_d)(W_f + W_c)\ W_r$$

where: $H_u = L_u \sin S_u$, and

$H_d = L_d \sin S_d$

(4) Total fill volume, V:

$$V = V_u + V_d + V_r$$

The fill measurements used as part of this inventory protocol were meant to generate rough volumes for comparison between sites while minimizing the amount of time required to collect the information. These volume estimates can contain significant error and should not be used for designing replacement structures.

Other Site-specific Measurements

For each site, the following culvert specifications were collected:
1. Length (to nearest 1/10 of foot);
2. Dimensions: diameter (circular), or height and width (box culverts), or span and rise (pipe arches);
3. Type: corrugated metal pipe (CSP), structural steel plate (SSP), concrete pipe, concrete box, bottomless pipe arch, squashed pipe-arch, or a composite of materials;
4. Overall condition of pipe (good, fair, poor, extremely poor);
5. Height and width of rustline (if present);
6. Position relative to flow and stream gradient;
7. Depth of jump pool below culvert;
8. Height of jump required to enter culvert;
9. Previous modifications (if any) to improve fish passage; and
10. Condition of previous modifications.

Qualitative notes describing stream habitat immediately upstream and downstream of each culvert were taken. Where feasible, variable lengths of the stream channel above and below crossings were walked to detect presence of salmonids and provide additional information regarding habitat conditions.

Data Entry and Passage Analyses

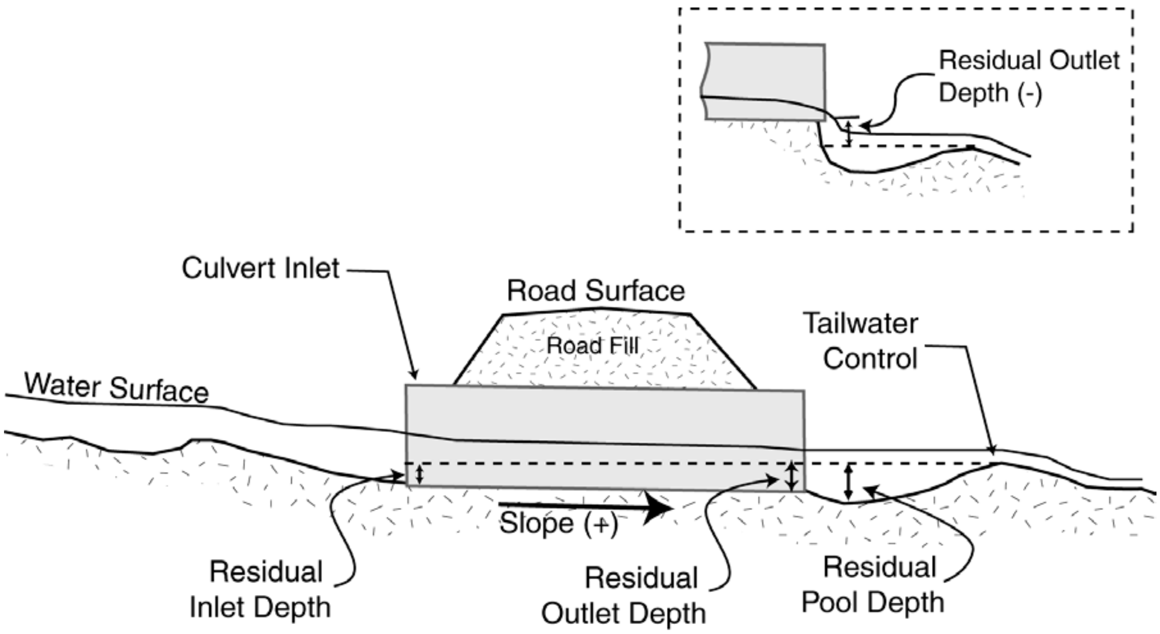
All survey and site visit data were recorded on waterproof data sheets. Then data for each culvert were entered into a spreadsheet (Excel 97). A macro was created to calculate thalweg elevations of longitudinal profiles and compute culvert slopes.

First-phase Passage Evaluation Filter: Green-Gray-Red

A filtering process was used to assist in identifying sites which either meet, or fail to meet, state and federal fish passage criteria for all fish species and lifestages (CDFG 2001; NMFS 2001). Using the field inventory data, calculate: average active channel width, culvert slope, residual inlet depth and drop at outlet (Figure 4). The first-phase passage evaluation filter was employed to reduce the number of crossings which require an in-depth passage evaluation with FishXing. The filter criteria were designed to quickly classify crossings into one of three categories:

- **GREEN**: Conditions assumed adequate for passage of all salmonids, including the weakest swimming lifestage.
- **GRAY**: Conditions may not be adequate for all salmonid species or lifestages presumed present. Additional analyses required to determine extent of barrier for each species and lifestage.
- **RED**: Conditions do not meet passage criteria at all flows for strongest swimming species presumed present. Assume "no passage" and move to analysis of habitat quantity and quality upstream of the barrier.

Follow the flowchart to determine a stream crossing's status as Green, Gray, or Red (Figure 5). Depending on geographic location within California, species of interest will vary. Within anadromous-bearing watersheds, CDFG has determined that culverts classified as "Green" must meet upstream passage criteria for both adult and over-wintering juvenile salmonids at all expected migration flows.



Residual Pool Depth = (Elev$_{\text{Tailwater Control}}$ – Elev$_{\text{Pool Bottom}}$)

Outlet Depth = (Elev$_{\text{Tailwater Control}}$ – Elev$_{\text{Culvert Outlet}}$) *(No outlet drop if Outlet Depth $\geq$ 0)*

Residual Inlet Depth = (Elev$_{\text{Tailwater Control}}$ – Elev$_{\text{Culvert Inlet}}$)

Figure 4. Measurements used in Green-Grey-Red filtering criteria.

Many stream crossings have unique characteristics which may hinder fish passage, yet they are not recognized in the filtering process. For culverts meeting the "Green" criteria, a review of the inventory data and field notes was necessary to ensure no unique passage problems exist before classifying the stream crossings as "100% passable".

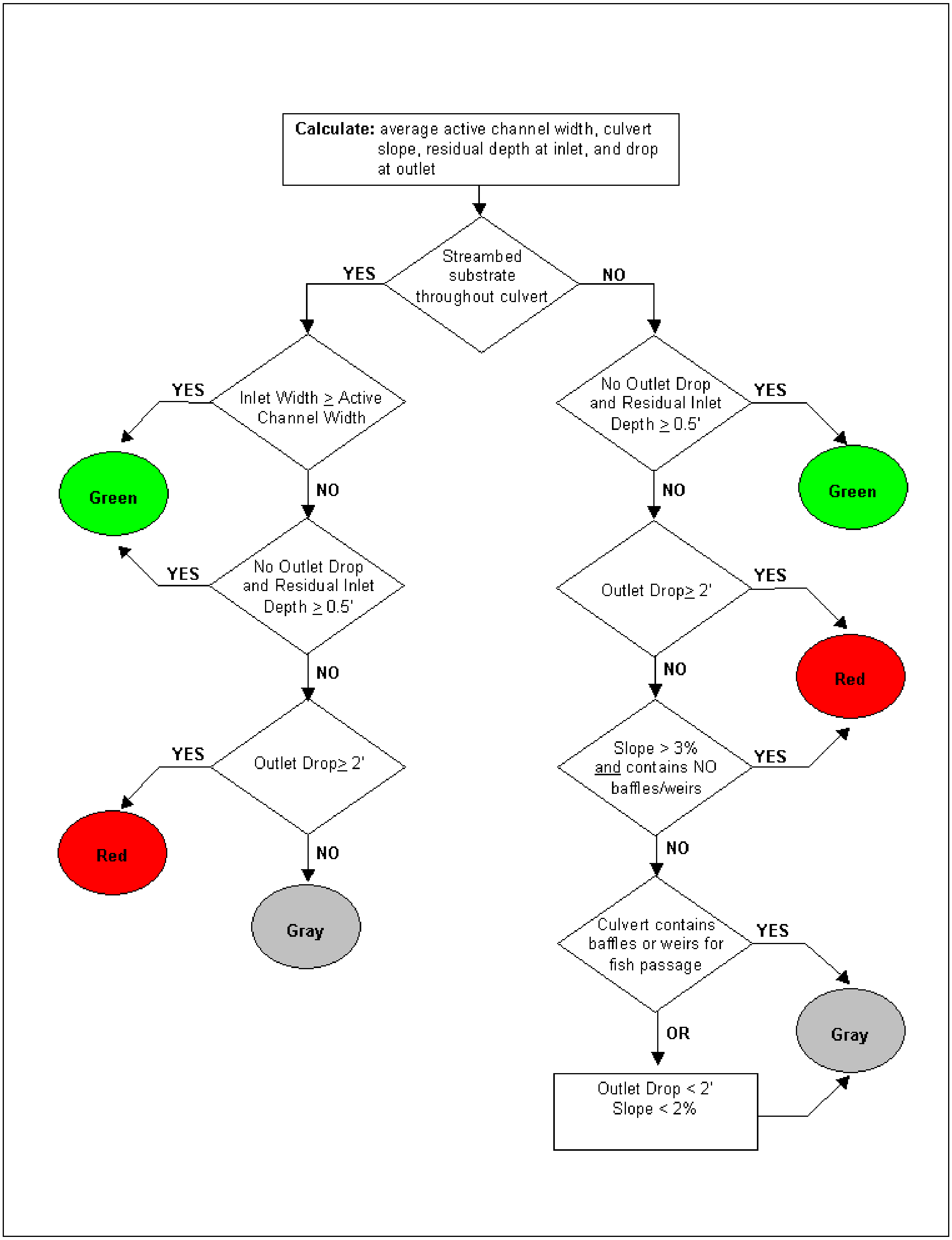


Figure 5. GREEN-GRAY-RED first-phase passage evaluation filter.

NOTE: FishXing Overview, Hydrology and Design Flow, Peak Flow Capacity, and Fish Passage Flows sections were written by Michael Love under a separate contract administered by CDFG (Taylor and Love, 2002).

FishXing Overview

FishXing is a computer software program developed by Six Rivers National Forest's Watershed Interactions Team - a group of scientists with diverse backgrounds in engineering, hydrology, geomorphology, geology and fisheries biology. Mike Furniss, a Forest Service hydrologist for Six Rivers, managed program development. A CD-ROM final version of FishXing was released in March, 2000. In-depth information regarding FishXing (or a copy) may be obtained at the Fish Crossing homepage on the internet (www.stream.fs.fed.us/fishxing/).

FishXing is an interactive software package that integrates a culvert design and assessment model for fish passage nested within a multimedia educational setting. Culvert hydraulics are well understood and model output closely resembles reality. FishXing successfully models (predicts) hydraulic conditions throughout the culvert over a wide range of flows for numerous culvert shapes and sizes. The model incorporates fisheries inputs including fish species, life stages, body lengths, and leaping and swimming abilities. FishXing uses the swimming abilities to determine whether the culvert installation (current or proposed) will accommodate fish passage at desired range of migration flows, and identify specific locations within the culvert that impede or prevent passage. Software outputs include water surface profiles and hydraulic variables such as water depths and average velocities displayed in both tabular and graphical formats.

FishXing used the survey elevation and culvert specifications to evaluate passage at sites defined as "Grey" by the first-phase evaluation filter for each species and lifestages of salmonids known to currently or historically reside in the Trinity County streams of interest. The swimming abilities and passage criteria used for each species and lifestage are listed Table 2. Although many individual fish will have swimming abilities surpassing those listed below, swim speeds were selected to ensure stream crossings accommodate passage of weaker individuals within each age class.

FishXing and other hydraulic models report the average cross-sectional water velocity, not accounting for spatial variations. Stream crossings with natural substrate or corrugations will have regions of reduced velocities that can be utilized by migrating fish. These areas are often too small for larger fish to use, but can enhance juvenile passage success. The software allows the use of reduction factors that decrease the calculated water velocities proportionally. As shown in Table 2, velocity reduction factors were used in the passage analysis of resident fish and juveniles with specific types of stream crossing structures.

Using the FishXing program, the range of flows that meet the depth, velocity, and leaping criteria for each lifestage were identified. The range of flows meeting the passage requirements were then compared to the lower and upper fish passage flows to determine "percent passable".

Table 2. Fish species and lifestages used in the fish passage along with associated swimming abilities and passage criteria. Passage flows are based on current adult salmonid criteria combined with observational data from northern California coastal streams.

Fish Species/Age Class	**Adult Steelhead, Chinook, and Coho**	**Juvenile steelhead and resident rainbow trout 2+ years old**	**Juvenile steelhead and resident rainbow trout 1+ years old**	**Juvenile steelhead, coho, and resident rainbow trout young-of-year**
Fish Length	500 mm	200 mm	130 mm	80 mm
Prolonged Mode				
Swim Speed	6.0 ft/s	2.8 ft/s	2.4 ft/s	2.0 ft/s
Time to Exhaustion	30 min	30 min	30 min	30 min
Burst Mode				
Swim Speed	10.0 ft/s	6.4 ft/s	4.5 ft/s	3.0 ft/s
Time to Exhaustion	5 s	5 s	5 s	5 s
Velocity Reduction Factors**	Inlet = 1.0 Barrel = 1.0 Outlet = 1.0	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8	Inlet = 0.8 Barrel = 0.6 Outlet = 0.8
Maximum Leaping Speed	12.0 ft/s	6.4 ft/s	4.5 ft/s	3.0 ft/s
Minimum Required Water Depth	0.8 ft	0.5 ft	0.3 ft	0.2 ft
Upper Passage Flow	2% flow (Nov-April)	10% flow (Nov-April)	10% flow (Nov-April)	10% flow (Nov-April)
Lower Passage Flow	95% flow (Nov-April)	95% flow (Nov-April)	95% flow (Nov-April)	95% flow (Nov-April)

** Velocity reduction factors only apply to culverts with corrugated walls, baffles, or natural substrate. All other culverts had reduction factors of 1.0 for all fish.

Hydrology and Design Flow

When examining stream crossings that require fish passage, three specific flows are considered: peak flow capacity of the stream crossing, the upper fish passage flow, and the lower fish passage flow. Because flow is not gauged on most small streams, it must be estimated using techniques that required hydrologic information about the stream crossing's contributing watershed, including:

- Drainage area;
- Mean annual precipitation;
- Mean annual potential evapotranspiration; and
- Average basin elevation.

Drainage area and basin elevations were calculated from a 1:24,000 USGS topographic map. For most projects, mean annual precipitation (MAP) and potential evapotranspiration (PET) are estimated from regional maps produced by Rantz (1968).

Peak Flow Capacity

Peak flows are typically defined in terms of a recurrence interval, but reported as a quantity; often as cubic feet per second (c.f.s.). Current guidelines recommend all stream crossings pass the flow associated with the 100-year flood without damage to the stream crossing (NMFS, 2001). Additionally, infrequently maintained culverted crossings should accommodate the 100-year flood without overtopping the culvert's inlet.

Determination of a crossing's flood capacity assisted in ranking sites for remediation. Undersized crossings have a higher risk of catastrophic failure, which often results in the immediate delivery of sediment from the road- fill into the downstream channel. Undersized crossings can also adversely effect sediment transport and downstream channel stability, creating conditions that hinder fish passage, degrade habitat, and may cause damage to other stream crossings and/or private property.

The first step was to estimate hydraulic capacity of each inventoried stream crossing. Capacity is generally a function of the shape and cross-sectional area of the inlet. Capacity was calculated for two different headwater elevations: water ponded to the top of the culvert inlet (HW/D = 1) and water ponded to the top of the road surface (HW/F=1). Nomograph equations developed by Piehl et. al (1988) were used to calculate capacity of circular culverts. Federal Highways nomographs presented in Norman et. al (1995) were used for pipe-arches and box culverts. Capacity of embedded culverts were determined using two hydraulic computer models, FishXing and HydroCulv.

The second step was to estimate peak flows at each crossing. This required estimating the 2-year, 5-year, 10-year, 25-year, 50-year, and 100-year peak flows. Regional flood estimation equations developed by Waananen and Crippen (1977) were used to estimate peak flows for the various recurrence intervals. The equations incorporate drainage area, MAP, and mean basin elevation as variable to predict peak flow in Northwestern California streams.

The third step was to compare the stream crossing capacity to peak flow estimates. Risk of failure was assessed by comparing a stream crossing's hydraulic capacity with the estimated peak flow for each recurrence interval. Each crossing was placed into one of six "sizing" categories:

1. equal to or greater than the 100-year flow,
2. between the 50-year and 100-year flows,
3. between the 25-year and 50-year flows,
4. between the 10-year and 25-year flows,
5. between the 10-year and 5-year flows.
6. less than the 5-year storm flow.

These six categories were utilized in the ranking matrix.

Fish Passage Flows

It is widely agreed that designing stream crossings to pass fish at all flows is impractical (CDFG 2002; NMFS 2000; Robison et al. 2000; SSHEAR 1998). Although anadromous salmonids typically migrate upstream during higher flows triggered by hydrologic events, it is presumed that migration is naturally delayed during larger flood events. Conversely, during low flow periods on many smaller streams, water depths within the channel can become impassable for both adult and juvenile salmonids. To identify the range of flows that stream crossings should accommodate for fish passage, lower and upper flow limits have been defined specifically for streams within California (CDFG 2002; NMFS 2000).

The NMFS guidelines designate the **lower fish passage flow (Q_{lp})** for adult, resident, and juvenile fish as the 95% exceedence flow (the flow equaled or exceeded 95% of the time) during the migration period. The **upper fish passage flow for adult salmonids ($Q_{hp\text{-}adult}$)** is defined as the 2% exceedence flow during the period of migration. Due to a lack of a well-defined upper passage flow for migrating juvenile and resident fish, the 10% exceedence flow ($Q_{hp\text{-}juvenile}$) for the migration period was chosen based on fish observations at stream crossings throughout northwestern California.

For Trinity County, upstream salmonid migration was assumed to occur between November and April. Between the lower and upper passage flows stream crossings should allow unimpeded passage of all adult salmonids.

To evaluate the extent to which a crossing is a barrier, passage was assessed between the lower and upper passage flows for each fish species and lifestage of concern. Identifying the 2% and 95% exceedence flows required obtaining average daily stream flow data from nearby gauged basins. Daily average flow data for small streams in Trinity County were available from the USGS and the US Forest Service Redwood Science Lab (RSL).

The following steps were followed to estimate upper and lower passage flows:

1. Obtained flow records from local stream gauges that met the following requirements:
   - At least 5-years of recorded daily average flows (do not need to be consecutive years);
   - A drainage area less than 50 square miles, and preferably less than 10 square miles; and,
   - Unregulated flows (no upstream impoundments or water diversions) during the migration season.

2. Discarded flows that fell outside of the migration period (November – April).

3. Estimated the average daily flow ($Q_{ave.}$) for both the gaged stream and the stream crossings using a regional runoff equation:

$$R = MAP - 0.40\,(PET) - 9.1$$ (from Rantz 1968)

and; Q_{ave} [cfs/cfs] = 0.0736 x (A) x (R)

Where;

R = Average annual runoff, in inches/year
MAP = Mean annual precipitation, in inches/year
PET = Potential evapotranspiration, in inches/year
A = drainage area, in square miles.

4. Divided the flows for each gauged stream by its estimated average daily discharge to normalize the data. Then created a flow duration table containing exceedence values and associated flows (Q/Q_{ave}).

5. Created a regional flow duration curve by averaging the exceedence flows (Q/Q_{ave}) of the gauged streams (Appendix C).

6. Determined the upper and lower passage flows for each stream crossing using the regional flow duration curve and the estimate of Q_{ave} for the stream crossing.

When analyzing fish passage with FishXing, these flows were used to determine the extent to which the crossing is a barrier. The stream crossing must meet water velocity and depth criteria between Q_{lp} and Q_{hp} to be considered 100% passable (NMFS 2000). For the ranking matrix, at each road crossing, the extent of the migration barrier was determined for each salmonid species and lifestage presumed present. Juvenile and resident trout passage was also determined between Q_{lp} and $Q_{hp;}$ however Q_{hp} was defined as the 10% exceedence flow instead of the 2% exceedence flow.

Habitat Information

Because this project addressed fish passage in 47 tributaries within the Trinity River watershed, plan development was based both on prior assessment and evaluation; and on conducting habitat assessment and evaluation as part of the project. Habitat conditions upstream and downstream of culvert locations relied on previously conducted habitat typing or fisheries surveys. Habitat information and fish distribution data were used from reports on file at CDFG and USFS offices in Weaverville and Hayfork. These surveys also provided information on past, present, and future land uses within watersheds that flow through culverts on the Trinity County road system.

Professional judgment from on-site inspection of culverts and stream habitat also aided habitat assessment and evaluation. In some cases, with landowner permission, longer reaches of stream were walked to better assess quality of habitat above and below county culverts. These surveys also aided in the examination of road crossings on private roads.

Length of potential salmonid habitat upstream of each county culvert was estimated off of digitized USGS 7.5 Minute Series topographic maps (Terrain Navigator, Version 3.01 by MapTech). The upper limit of anadromous habitat was considered when the channel exceeded an eight degree slope.

The presence of additional road crossings, above and below each county-maintained site, was also considered when evaluating potential habitat gains. In many cases, additional road crossings existed, either private-maintained, federal (USFS) or state (CALTRANS). These crossings were not evaluated in detail (with FishXing), but were examined for visual estimates of length, slope, and presence of perched outlets.

Initial Ranking of Stream Crossings for Treatment

The need for extensive habitat information collected in a consistent manner is also time consuming and expensive to generate. Detailed information was not available for many Trinity County watersheds and conducting surveys was beyond the scope (and budget) of this project. The ranking objective was to arrange the sites in an order from high to low priority using a suite of site-specific information. However, the "scores" generated were not intended to be absolute in deciding the exact order of scheduling treatments. Once the first-cut ranking was completed, professional judgment played an important part in deciding the order of treatment. As noted by Robison et al. (2000), numerous social and economic factors influenced the exact order of treated sites.

Because Trinity County intends on treating culvert sites identified as "high-priority" by submitting proposals to various fisheries restoration funding sources, additional opportunities for re-evaluating the biological merit of potential projects will occur through proposal review committees composed of biologists from CDFG and other agencies. The methods for ranking culvert locations is a developing process and will undoubtedly require refinement as additional information is obtained. This report also acknowledges (but makes no attempt to quantify or prioritize) that other potentially high-priority restoration projects exist throughout California, and these must all be considered when deciding where and how to best spend limited restoration funds.

However, recent research regarding watershed restoration considers the identification, prioritization, and treatment of migration barriers to restore ecological connectivity for salmonids a vital step towards recovering depressed populations (Roni et al. 2002).

Ranking Criteria

The criteria and scoring for ranking stream crossings were consistent with those developed for Part 10 of CDFG's *Salmonid Stream Habitat Restoration Manual* (Taylor and Love, 2002). The method assigns a score or value for the following criteria at each culvert location. The total score is the sum of five criteria: species diversity, extent of barrier, sizing, current condition, and habitat score.

1. **Species diversity:** number of salmonid species known to occur (or historically occurred) within the stream reach at the culvert location. **Score:** Because of ESA listing status as threatened coho salmon = **2** points; steelhead in Mad River and Eel River tributaries = **2** points; and non-listing status of chinook salmon and steelhead (in the Trinity River) = **1** point for each species. **Maximum score = 4 points.**

2. **Extent of barrier:** for each species and lifestage known to occur, over the range of estimated migration flows, assign one of the following values. **Score: 0** = 80-100% passable; **1** = 60-80% passable; **2** = 40-60% passable; **3** = 20-40% passable; **4** = less than 20% passable; **5** = 0% passable (RED by first-phase evaluation filter). For a total score, sum scores given for adult species and each year-class of juveniles. **Maximum score = 15 points.**

3. **Sizing (risk of failure):** for each culvert, assign one of the following values as related to flow capacity. **Score: 0 =** sized to NMFS standards of passing 100-year flow at less than inlet height. **1** = sized for at least a 50-year flow, low risk. **2** = sized for at least a 25-year flow, moderate risk. **3** = sized for less than a 25-year flow, moderate to high risk of failure. **4** = sized for less than a 10-year event, high risk of failure. **5** = sized for less than a five-year event, high risk of failure.

4. **Current condition:** for each culvert, assign one of the following values. **Score: 0** = good condition. **1** = fair, showing signs of wear. **3** = poor, floor rusting through, crushed by roadbase, etc. **5** = extremely poor, floor rotted-out, severely crushed, damaged inlets, collapsing wingwalls, slumping roadbase, etc.

5. **Habitat quantity:** above each crossing, length in feet to sustained 8% gradient. **Score:** Starting at a 500' minimum; 0.5 points for each 500' length class (**example**: **0** points for <500'; **1** point for 1,000'; **2** points for 2,000'; **3.5** points for 3,500'; and so on). **Maximum score = 10 points.**

6. **Habitat quality:** for each stream, assign a "multiplier" of quality (relative to other streams in inventory) after reviewing available habitat information.

- **Score: 1.0 = Excellent-** Relatively undeveloped, "pristine" watershed conditions. Habitat features include dense riparian zones with mix of mature native species, frequent pools, high-quality spawning areas, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. High likelihood of no future human development. Presence of migration barrier(s) is obviously the watershed's limiting factor.

- **0.75 = Good-** Habitat is fairly intact, but human activities have altered the watershed with likelihood of continued activities. Habitat still includes dense riparian zones of native species, frequent pools, spawning gravels, cool summer water temperatures, complex in-channel habitat, and/or channel floodplain relatively intact. Presence of migration barrier(s) is most likely one of the watershed's primary limiting factor.

- **0.5 = Fair-** Human activities have altered the watershed with likelihood of continued (or increased) activities, with apparent effects to watershed processes and features. Habitat impacts include riparian zone present but lack of mature conifers and/or presence of non-native species, infrequent pools, sedimentation evident in spawning areas (pool tails and riffle crests), summer water temperatures periodically exceed stressful levels for salmonids, sparse in-channel complex habitat, floodplain intact or slightly modified). Presence of migration barrier(s) may be one of the watershed's limiting factor (out of several factors).

- **0.25 = Poor-** Human activities have drastically altered the watershed with high likelihood of continued (or increased) activities, with apparent effects to watershed processes. Habitat impacts include riparian zones absent or severely degraded, little or no pool formations, excessive sedimentation evident in spawning areas (pool tails and riffle crests), stressful to lethal summer water temperatures common, lack of in-channel habitat, floodplain severely modified with levees, riprap, and/or residential or commercial development. Other limiting factors within watershed are most likely of a higher priority for restoration than remediation of migration barriers.

7. **Total habitat score:** Multiply #5 by #6 for habitat "score". A multiplier assigned for habitat quality, weighs the final score more on quality than sheer quantity of upstream habitat. **Maximum score = 10 points.**

For each culvert location, the five ranking criteria were entered into a spreadsheet and total scores computed. Then the list was sorted by "Total Score" in a descending order to determine an initial ranking. On closer review of the rank, some professional judgment was used to slightly adjust the rank of several sites. The list was then divided subjectively into groups defined as "high", "medium", or "low" priority.

The high-priority sites were generally characterized as complete migration barriers with significant amounts of upstream habitat for several species of anadromous salmonids. Medium-priority sites were characterized as limited in upstream habitat gains, limited species diversity, and/or were only barriers to juvenile migration. Low-priority sites were either limited in upstream habitat, habitat condition was poor, and/or the site allowed passage of adults and most juveniles.

Remediation of culvert sites identified as "high-priority" should be accomplished by submitting proposals to various fisheries restoration funding sources. The information provided in this report should be used to document the logical process employed to identify, evaluate, and rank these migration barriers.

Trinity County Public Works should consider ranking medium and low-priority sites a second time, focusing mainly on culvert condition, sizing, and amount of fill material within the road prism. A risk assessment may be conducted to determine the consequence of potential sediment delivery to the downstream channel if or when a crossing failed. Most medium and low-priority sites should not be considered candidates for treatment via limited restoration funding sources, unless an imminent site failure would deliver a significant amount of sediment to downstream salmonid habitat.

However, this information will provide Trinity County Public Works a list of sites in need of future replacement with county road maintenance funds. When these replacements are implemented, this report should provide guidance on treatments with properly-sized crossings conducive to adequate flow conveyance and unimpeded fish passage.

<u>Additional Considerations for Final Ranking</u>

On a site-specific basis, some or all of these factors were considered in rearranging the first-cut ranking to develop a final list for project scheduling:

1. Fish observations at crossings. Sites where fish were observed during migration periods were given higher priority in the final ranking. The species of salmonids observed, the number of fish, frequency of attempts, and the number of failed versus successful passage attempts were important variables considered. Sites with fish present are areas where immediate re-colonization of upstream habitat is likely to occur.

2. Stocks of fish presumed present. Streams likely to support the spawning and rearing of wild winter-run and/or summer-run steelhead were given a higher priority. This included tributaries to the New River, North Fork of the Trinity River, and Canyon Creek.

3. Amount of road fill. At stream crossings that were undersized and/or in poor condition, we examined the volume of fill material within the road prism potentially deliverable to the stream channel if the culvert were to fail. With the assistance of the Trinity County Planning Department, the status of these crossings as reported in the Five-County' road erosion assessment project was evaluated and utilized to confirm the potential for sediment delivery.

4. Presence, location, and barrier status of other stream crossings. In many cases, an individual stream was crossed by multiple roads under a variety of management or ownership. In these situations, close communication with other road managers was important. If multiple crossings are migration barriers a coordinated effort is required to identify and treat them in a logical manner – generally in an upstream direction starting with the lowermost crossing. In some cases the lowermost crossing was Trinity County-maintained and these sites were raised slightly in the final ranking. Conversely, Trinity County also maintains crossings above state or federal-maintained crossings that are currently impeding and/or blocking fish migration – these county sites were lowered in the final ranking.

5. Remediation project cost. With the assistance of the Trinity County Planning Department, the range of treatment options and associated costs were examined when determining the order in which to proceed and the type of treatment to implement at specific sites. In cases where Federally-listed fish species were present, costs were weighed against the consequences of failing to comply with the Endangered Species Act by not providing unimpeded passage.

6. Scheduling of other road maintenance and improvement projects. With the assistance of the Trinity County Planning Department, the upgrading of migration barriers during other scheduled maintenance and/or improvement activities was considered. When undersized or older crossings fail during storms, the County should be prepared to install properly-sized crossings that provide unimpeded passage for all species and life stages of fish.

RESULTS

Initial Site Visits

Initial site visits were conducted at a total of 107 stream crossings on roads in Trinity County (Table 3). However, only **51** of 107 crossings were surveyed and included in the fish passage evaluation and priority ranking. The reasons for excluding 56 sites in the evaluation varied and are listed in the right-hand column of Table 3. Most site visits and surveys were conducted during fall or spring low flows, which provided safer wading conditions in streams and through culverts.

The 51 surveyed sites were each given a unique ID number that was determined in an upstream direction starting at the Humboldt/Trinity county line and moving in generally a west to east direction (Table 4). A table of the 51 culvert sites inventoried and their location information is provided in Appendix A.

Site-specific characteristics, site photographs, maps, and habitat descriptions for the 51 sites evaluated for passage are provided in a "Catalog of Trinity County Culverts" (Appendix B). The following list is an overview of the culvert inventory:

1. A wide variety of culvert configurations and materials were discovered.

2. Some culverts were in poor condition (seven sites or 14%) and are due for replacement. Another 21 culverts (41%) were described as in "fair" condition, and starting to show signs of deterioration.

3. Most culverts were undersized when compared to recently released NMFS guidelines that recommend stream crossings pass the 100-year storm flow at less than 100% of inlet height. Only three sites (Gwin Gulch/Canyon Creek Road; Black Lassic Creek/Van Duzen Road; and Red Lassic/Van Duzen Road) were sized to pass more than a 100-year storm discharge. This is mostly likely because many county road crossings were constructed prior to the development of these conservative guidelines. Another four crossings were sized to pass between a 25-year and 50-year storm flow: PantherCreek/Ruth-Zenia Road (28-years); Quinby Creek/Denny Road (29-years); Unnamed trib to Mad River/Mad River Road (37-years); and Middle Weaver Creek/Oregon Street (47-years).

   Thirty-seven of the 51 culverts (or 73%) were extremely undersized, overtopping on less than a ten-year storm flow (Table 4). Twenty-six culverts (51% of all sites) overtopped on a storm flow of less than five years; these sites should be of concern from a road's maintenance and safety point of view.

Table 3. List of 107 stream-crossing locations visited in Trinity County.

BASIN NAME	STREAM NAME	ROAD NAME	SURVEY STATUS
TRINITY TRIBUTARIES			
	Trinity House Gulch	Browns Road	**SURVEYED**
	Dutton Creek	Steiner Flat Road	Bridge
	Tom Lang Gulch	Old Highway 231	Not fish-bearing
	Deadwood Creek	Deadwood Road	**SURVEYED**
	Phillips Gulch	Trinity Dam Boulevard	Not fish-bearing
	Vitzthum Gulch	Steel Bridge Road	Not fish-bearing
	Jesse Gulch	Reading Creek Road	Not fish-bearing
	Camp Gulch	Reading Creek Road	Not fish-bearing
	Panwauket Gulch	Reading Creek Road	Not fish-bearing
	Barleyfield Creek	Reading Creek Road	**SURVEYED**
	Mule Gulch	Indian Creek Road	Ford
	Middleton Gulch	Deerlick Springs Road	**SURVEYED**
	Spring Gulch	Deerlick Springs Road	**SURVEYED**
	Dark Gulch	Lewiston Road	Not fish-bearing
	Hoadley Gulch	Turnpike Road	Bridge
	Un-named Tributary in Lewiston	Goose Ranch Road	**SURVEYED**
	Little Browns Creek	Roundy Road	**SURVEYED**
	East Branch	East Weaver Creek Road	**SURVEYED**
	Sharber Creek	Fountain Ranch Road	**SURVEYED**
	Un-named Tributary	South Fork Road	**SURVEYED**
	Bell Creek	Denny Road	**SURVEYED**
	Panther Creek	Denny Road	**SURVEYED**
	Rancheria Creek	Denny Road	Not fish-bearing
	Quinby Creek	Denny Road	**SURVEYED**
	Fall Creek	Denny Road	Not fish-bearing
	Un-named Tributary	Underwood Mountian Road	**SURVEYED**
	Barney Gulch	East Fork Road	**SURVEYED**
	Fisher Gulch	Canyon Creek Road	Not fish-bearing
	Rarick Gulch	Canyon Creek Road	**SURVEYED**
	Gwin Gulch	Canyon Creek Road	**SURVEYED**
	Conrad Gulch	Canyon Creek Road	**SURVEYED**
	Maple Creek	Dutch Creek Road	**SURVEYED**
	Dutch Creek	Dutch Creek Road	Ford
	Conner Creek	Red Hill Road	**SURVEYED**
	Conner Creek	Connor Creek Road	**SURVEYED**
	Conner Creek	Red Hill Road	Not fish-bearing
	McKinney Gulch	Red Hill Road	**SURVEYED**
	Mill Creek	Dutch Creek Road	Not fish-bearing
	Deep Gulch	Dutch Creek Road	Not fish-bearing
	Soldier Creek	Dutch Creek Road	**SURVEYED**
	Soldier Creek	Evans Bar Road	**SURVEYED**
	Bell Gulch	Dutch Creek Road	Not fish-bearing
	Bell Gulch	Evans Bar Road	Not fish-bearing
	Sheridan Creek	Sky Ranch Road	Not fish-bearing
	Oregon Gulch	Sky Ranch Road	**SURVEYED**
	Sidney Gulch	Memorial Drive	**SURVEYED**

Table 3 (continued). List of 107 stream-crossing locations visited in Trinity County.

BASIN NAME	STREAM NAME	ROAD NAME	SURVEY STATUS
TRINITY TRIBUTARIES			
	Garden Gulch	Easter Avenue	**SURVEYED**
	Middle Weaver Creek	Oregon Street	**SURVEYED**
	Ten Cent Gulch	Center Street	Not fish-bearing
	Lance Gulch	Browns Ranch Road	Not fish-bearing
	West Weaver Creek	Oregon to West Weaverville	Bridge – Conspan arch
	Hawkins Creek	Hawkins Bar Road	**SURVEYED**
	Hawkins Creek	Flame Tree Road	**SURVEYED**
South Fork Trinity River	Grapevine Creek	Lower South Fork Road	Not fish-bearing
	Monroe Creek	Lower south Fork Road	Not fish-bearing
	Slide Creek	Lower south Fork Road	**SURVEYED**
	Mill Creek	Lower south Fork Road	**SURVEYED**
	Grassy Flat Creek	Hyampom Road	**SURVEYED**
	Big Canyon	Hyampom Road	Could Not Survey
	Dinner Gulch	Hyampom Road	Not fish-bearing
	Jud Creek	Hyampom Road	**SURVEYED**
	James Creek	Hyampom Road	Not fish-bearing
	Salt Creek	Dips Road	Fords
	Cedar Gulch	Hyampom Road	Not fish-bearing
	Bean Gulch	Hyampom Road	Not fish-bearing
	Kingsbury Gulch	Riverview Road	**SURVEYED**
	Kingsbury Gulch	Morgan Hill Road	**SURVEYED**
	Morgan Gulch	Morgan Hill Road	Not fish-bearing
	Coonrod Gulch	Morgan Hill Road	Not fish-bearing
	McCovey Gulch	Morgan Hill Road	Not fish-bearing
	Thompson Gulch	Laurel Drive	Not fish-bearing
	Thompson Gulch	Brady Road	Not fish-bearing
	Carter Gulch	Brady Road	Not fish-bearing
	Carter Gulch	Laurel Drive	Not fish-bearing
	Donaldson Creek	Big Creek Road	**SURVEYED**
	Little Barker Creek	Barker Creek Road	**SURVEYED**
	Duncan Creek	Summit Creek Road	**SURVEYED**
	Shock Creek	Summit Creek Road	Ford
	Summit Creek	Summit Creek Road	Ford
	Summit Creek	Summit Creek Road	Ford
	Summit Creek	Summit Creek Road	**SURVEYED**
	Carrier Gulch	Wildwood Road	**SURVEYED**
	Bridge Gulch	Wildwood Road	Need Access
	Curley Gulch	Wildwood Road	Not fish-bearing
	Gant Gulch	East Fork Hayfork Road	Not fish-bearing
	Sims Creek	Sims Creek Road	Not fish-bearing
	Hall City Creek	Wildwood Road	**SURVEYED**
MAD RIVER	Maynard Creek	Mad River Road	Not fish-bearing
	Rock Creek	Mad River Road	Not fish-bearing
	Olsen Creek	Mad River Road	**SURVEYED**
	Cherry Glade Creek	Mad River Road	**SURVEYED**

Table 3 (continued). List of 107 stream-crossing locations visited in Trinity County.

BASIN NAME	STREAM NAME	ROAD NAME	SURVEY STATUS
MAD RIVER			
	Un-named Tributary	Mad River Road	**SURVEYED**
	Dunbar Creek	Mad River Road	Bridge
	Black Lassic Creek	Van Duzen Road	**SURVEYED**
	Red Lassic Creek	Van Duzen Road	**SURVEYED**
EEL RIVER	Bar Creek	Ruth Zenia Road	Unable to Survey
	Panther Creek	Ruth Zenia Road	**SURVEYED**
	Salt Creek	Ruth Zenia Road	Not fish-bearing
	Burgess Creek	Zenia Lake Mountain Road	Not fish-bearing
	Burgess Creek	Burgess Ranch Road	**SURVEYED**
	Yew Wood Creek	Justice Road	Not fish-bearing
	Yew Wood Creek	Zenia Lake Mountain Road	Not fish-bearing
	Bluff Creek	Bluff Creek Road	Map Incorrect-Does not cross road
	Bluff Creek	Bluff Creek Road	Map Incorrect-Does not cross road
	Wilson Creek	Zenia Lake Mountain Road	**SURVEYED**
	Mud Creek	Alder Point Bluff Road	**SURVEYED**
	Beuford Creek	Alder Point Bluff Road	No, steep drop below road

Table 4. Site ID numbers for 51 Trinity County culverts in the Trinity River Basin.

SITE ID #	STREAM NAME	ROAD NAME
#1	Unnamed tributary to So. Fork Trinity River	South Fork Road
#2	Slide Creek	Lower South Fork Road
#3	Mill Creek	Lower South Fork Road
#4	Grassy Flat Creek	Hyampom Road
#5	Jud Creek	Hyampom Road
#6	Kingsbury Gulch#1	Riverview Road
#7	Kingsbury Gulch#2	Morgan Hill Road
#8	Donaldson Creek	Big Creek Road
#9	Little Barker Creek	Barker Creek Road
#10	Duncan Creek	Summit Creek Road
#11	Summit Creek	Summit Creek Road
#12	Carrier Gulch	Wildwood Road
#13	Hall City Creek	Wildwood Road
#14	Sharber Creek	Fountain Ranch Rd
#15	Hawkins Creek#1	Hawkins Bar Road
#16	Hawkins Creek#2	Flame Tree Road
#17	Bell Creek	Denny Road
#18	Panther Creek – tributary to Trinity River	Denny Road
#19	Quinby Creek	Denny Road
#20	Unnamed tributary to Trinity River	Underwood Mountain Road
#21	Barney Gulch	East Fork Road
#22	Conner Creek#1	Conner Creek Rd.
#23	Conner Creek#2	Red Hill Rd.
#24	Conrad Gulch	Canyon Creek Rd
#25	Rarick Gulch	Canyon Creek Rd
#26	Gwin Gulch	Canyon Creek Rd
#27	McKinney Gulch	Red Hill Rd.
#28	Oregon Gulch	Sky Ranch Rd
#29	Soldier Creek #1	Evans Bar Rd
#30	Soldier Creek #2	Dutch Creek Rd
#31	Maple Creek	Dutch Creek Rd
#32	Middleton Gulch	Deerlick Springs Road
#33	Spring Gulch	Deerlick Springs Road
#34	Barleyfield Creek	Reading Creek Road
#35	Little Browns Creek	Roundy Rd
#36	Middle Weaver Creek	Oregon Street
#37	Sidney Gulch	Memorial Drive
#38	Garden Gulch	Easter Ave
#39	East Branch Creek	East Weaver Creek Rd
#40	Trinity House Gulch	Browns Mountain Rd

Table 4 (continued). Site ID numbers for 51 Trinity County culverts in the Trinity River Basin.

SITE ID #	STREAM NAME	ROAD NAME
#41	Unnamed tributary of Trinity River in Lewiston	Goose Ranch Rd
#42	Deadwood Creek	Hatchery Rd
#43	Olsen Creek	Mad River Road
#44	Cherry Glade Creek	Mad River Road
#45	Unnamed tributary of Mad River	Mad River Road
#46	Black Lassic Creek	Van Duzen Road
#47	Red Lassic Creek	Van Duzen Road
#48	Mud Creek	Alder Point Bluff Road
#49	Burgess Creek	Burgess Ranch Road
#50	Wilson Creek	Zenia Lake Mountain Road
#51	Panther Creek – tributary to North Fork Eel River	Ruth Zenia Road

Table 5. Hydraulic capacity of 51 Trinity County stream crossings. Capacity is expressed as both a discharge (cfs) and a return-interval (years) for flows overtopping culvert inlet (HW/D=1) and overtopping road prism (HW/F=1).

Site ID #	Stream Name	Road Name	Capacity at HW/D=1 (cfs)	Capacity at HW/F=1 (cfs)	Return Interval to Overtop Culvert (years)	Return Interval to Overtop Road Prism (years)
#1	Unnamed Tributary to South Fork Trinity	South Fork Road	**45**	**78**	**2**	**2**
#2	Slide Creek	Lower South Fork Road	**199**	**268**	**7**	**12**
#3	Mill Creek	Lower South Fork Road	**362**	**568**	**12**	**33**
#4	Grassy Flat Creek	Hyampom Road	**212**	**594**	**5**	**42**
#5	Jud Creek	Hyampom Road	**134**	**303**	**3**	**7**
#6	Kingsbury Gulch#1	Riverview Road	**190**	**306**	**3**	**3**
#7	Kingsbury Gulch#2	Morgan Hill Road	**160**	**160**	**3**	**3**
#8	Donaldson Creek	Big Creek Road	**134**	**323**	**6**	**20**
#9	Little Barker Creek	Barker Creek Road	**134**	**345**	**5**	**18**
#10	Duncan Creek	Summit Creek Road	**269**	**520**	**4**	**8**
#11	Summit Creek	Summit Creek Road	**64**	**95**	**7**	**12**
#12	Carrier Gulch	Wildwood Road	**371**	**641**	**24**	**154**
#13	Hall City Creek	Wildwood Road	**140**	**240**	**4**	**5**
#14	Sharber Creek	Fountain Ranch Rd	**176**	**213**	**2**	**2**
#15	Hawkins Creek#1	Hawkins Bar Road	**223**	**605**	**3**	**10**
#16	Hawkins Creek#2	Flame Tree Road	**176**	**447**	**2**	**6**
#17	Bell Creek	Denny Road	**314**	**678**	**4**	**9**
#18	Panther Creek – Trinity R.	Denny Road	**800**	**1,900**	**11**	**118**
#19	Quinby Creek	Denny Road	**2,214**	**6,147**	**29**	**>250**
#20	Unnamed trib. to Trinity R.	Underwood Mountain Road	**64**	**149**	**2**	**3**

Table 5 (continued). Hydraulic capacity of 51 Trinity County road crossings. Capacity is expressed as both a discharge (cfs) and a return-interval (years) for flows overtopping culvert inlet (HW/D=1) and overtopping road prism (HW/F=1).

Site ID #	Stream Name	Road Name	Capacity at HW/D=1 (cfs)	Capacity at HW/F=1 (cfs)	Return Interval to Overtop Culvert (years)	Return Interval to Overtop Road Prism (years)
#21	Barney Gulch	East Fork Road	**134**	**361**	**3**	**9**
#22	Conner Creek#1	Conner Creek Rd.	**579**	**643**	**14**	**18**
#23	Conner Creek#2	Red Hill Rd.	**664**	**895**	**19**	**43**
#24	Conrad Gulch	Canyon Creek Rd	**212**	**347**	**8**	**19**
#25	Rarick Gulch	Canyon Creek Rd	**176**	**474**	**5**	**16**
#26	Gwin Gulch	Canyon Creek Rd	**1,203**	**2,801**	**211**	**>250**
#27	McKinney Gulch	Red Hill Rd.	**55**	**106**	**3**	**7**
#28	Oregon Gulch	Sky Ranch Rd	**293**	**293**	**3**	**3**
#29	Soldier Creek #1	Evans Bar Rd	**436**	**618**	**5**	**7**
#30	Soldier Creek #2	Dutch Creek Rd	**436**	**565**	**5**	**6**
#31	Maple Creek	Dutch Creek Rd	**92**	**226**	**4**	**18**
#32	Middleton Gulch	Deerlick Springs Road	**154**	**346**	**3**	**5**
#33	Spring Gulch	Deerlick Springs Road	**75**	**157**	**4**	**9**
#34	Barleyfield Creek	Reading Creek Road	**64**	**160**	**3**	**5**
#35	Little Browns Creek	Roundy Rd	**192**	**393**	**6**	**17**
#36	Middle Weaver Creek	Oregon Street	**1,300**	**1,400**	**47**	**60**
#37	Sidney Gulch	Memorial Drive	**290**	**433**	**8**	**18**
#38	Garden Gulch	Easter Ave	**176**	**318**	**4**	**10**
#39	East Branch Creek	East Weaver Creek Rd	**478**	**607**	**10**	**10**
#40	Trinity House Gulch	Browns Mountain Rd	**230**	**265**	**6**	**7**

Table 5 (continued). Hydraulic capacity of 51 Trinity County road crossings. Capacity is expressed as both a discharge (cfs) and a return-interval (years) for flows overtopping culvert inlet (HW/D=1) and overtopping road prism (HW/F=1).

Site ID #	Stream Name	Road Name	Capacity at HW/D=1 (cfs)	Capacity at HW/F=1 (cfs)	Return Interval to Overtop Culvert (years)	Return Interval to Overtop Road Prism (years)
#41	Unnamed Tributary of Trinity R. in Lewiston	Goose Ranch Rd	**176**	**178**	**4**	**4**
#42	Deadwood Creek	Hatchery Rd	**450**	**1,026**	**3**	**6**
#43	Olsen Creek	Mad River Road	**208**	**378**	**6**	**13**
#44	Cherry Glade Creek	Mad River Road	**142**	**216**	**6**	**10**
#45	Unnamed Tributary of Mad River	Mad River Road	**150**	**308**	**37**	**>250**
#46	Black Lassic Creek	Van Duzen Road	**1,220**	**2,812**	**243**	**>250**
#47	Red Lassic Creek	Van Duzen Road	**999**	**2,764**	**205**	**>250**
#48	Mud Creek	Alder Point Bluff Road	**1,600**	**3,600**	**16**	**198**
#49	Burgess Creek	Burgess Ranch Road	**362**	**511**	**11**	**23**
#50	Wilson Creek	Zenia Lake Mountain Road	**380**	**1,200**	**6**	**71**
#51	Panther Creek – Eel River	Ruth Zenia Road	**633**	**1,529**	**28**	**837**

Passage Analyses

The **GREEN-GRAY-RED** first-phase evaluation filter reduced the number of sites requiring in-depth analyses with FishXing. Forty-one of 51 sites (80%) were defined as **RED**, or failing to meet CDFG's fish passage criteria for adult and juvenile salmonids throughout the entire range of migration flows (CDFG 2001). It is important to note that a crossing which failed to meet the criteria may still actually provide partial or temporal passage during certain flow conditions because CDFG's criteria were set at conservative values to account for weaker swimming individuals for any given species. However, all **RED** sites were given a "total barrier" score in the ranking matrix.

Only a single stream crossing was defined as **GREEN** with the first-phase evaluation filter, Mill Creek/Lower South Fork Road. This culvert was defined as **GREEN** for only the hydraulic option, meaning there were adequate residual depths within the culvert, no outlet drop, and a mild slope. The culvert failed to meet the **GREEN** criteria for the natural channel option = fully embedded with natural stream substrate and not constricting channel width through the crossing. However, this culvert was undersized (100% of inlet height on a 12-year storm flow).

FishXing proved an extremely useful tool in estimating the extent of passage at the nine **GRAY** sites and identifying the probable causes of blockages. However, like most models which attempt to predict complex physical and biological processes with mathematics, there were limitations and assumptions that must be acknowledged.

Over the past five winters, repeated visits to numerous culverts within the Five-County region during migration flows revealed some confounding results generated by FishXing:

1. Adult salmonids having great difficulties entering culverts which FishXing suggested were easily within the species' leaping and swimming capabilities.

2. Adult salmonids successfully migrating through water depths defined as "too shallow" by current fish passage criteria.

3. The behavior and abilities of fish are too varied and complex to be summed up with an equation or number taken from a published article. Even a single fishes' leaping and swimming abilities at a culvert may change as numerous attempts are made. Five seasons of extensive winter-time observations at culverts in the Five-Counties region have documented individual fish become fatigued over repetitive attempts, and conversely documented other fish gaining access to culverts after numerous failed attempts (Taylor 2000 and 2001; Love pers. comm.).

Due to these factors, passage evaluation results generated by FishXing were used conservatively in the ranking matrix by lumping "percent passable" into large (20%) categories. Adult steelhead and coho salmon were lumped as the "adult" run, resident coastal rainbow trout and two-year old (2+) steelhead were grouped as the "resident trout" run, and one-year old (1+) and young-of-the-year (y-o-y) steelhead and coho salmon were grouped as the "juvenile" run.

Passage results generated by FishXing are displayed as "percent passable" for the range of migration flows calculated for each stream crossing location within the five sub-watershed categories or areas (Figures 6-10). For each site, by species and lifestage, FishXing evaluation results are provided in Appendix C. The "Comments" column in Appendix C lists assumptions made concerning specific sites while running FishXing.

Most culverts were some form of barrier to juvenile salmonids, more so for young-of-year (y-o-y's) and one-year old (1+) juveniles than two-year old fish (2+). For y-o-y and 1+ fish, 50 of 51 (or 98%) of the culverts were total barriers. For 2+ juveniles, 46 of 51 sites (90%) were total barriers. Only Mill Creek/Lower South Fork Road allowed for unimpeded juvenile upstream migration over the entire range of estimated migration flows.

For both age classes of juveniles, their extremely small size renders them most vulnerable to perched culverts or those with velocities during migration flows exceeding two to four feet per second. Passage evaluation scores are provided in the Culvert Ranking Matrix (Appendix D).

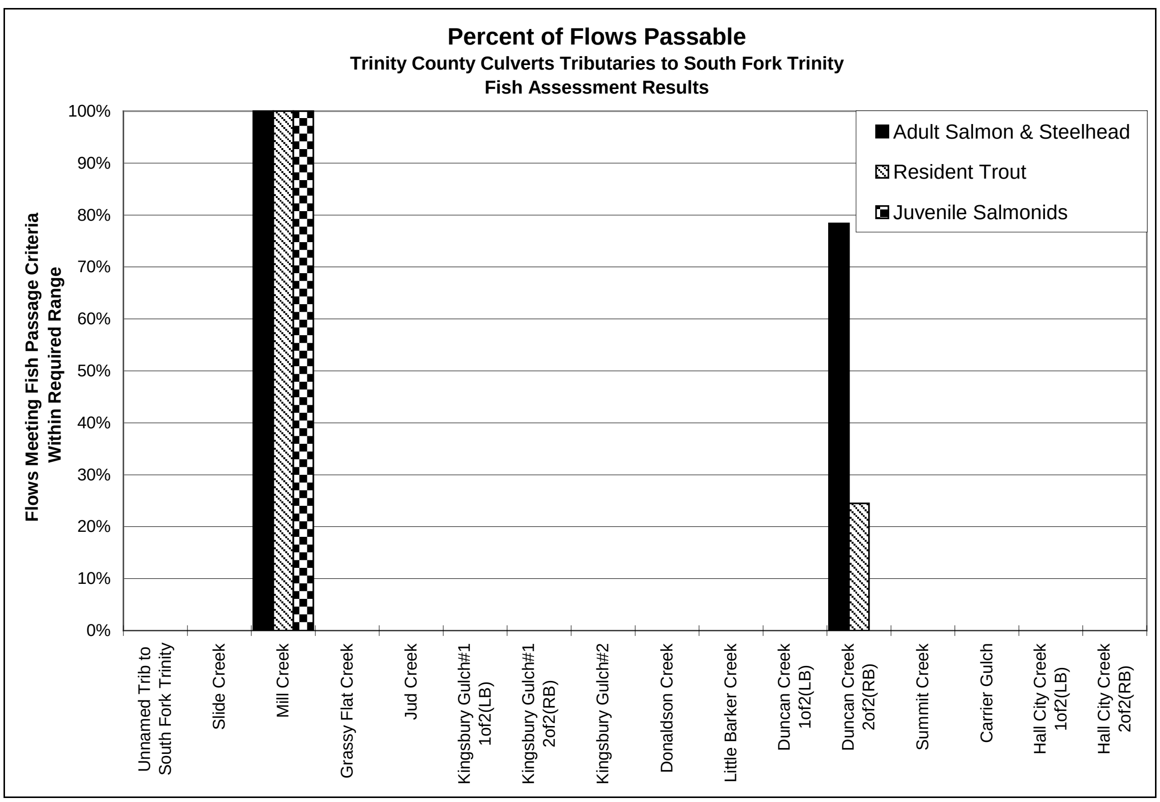


Figure 6. Percent passable as estimated by the Green-Gray-Red evaluation filter and FishXing for 13 Trinity County stream crossings within the South Fork Trinity River sub-watershed, by life stages.

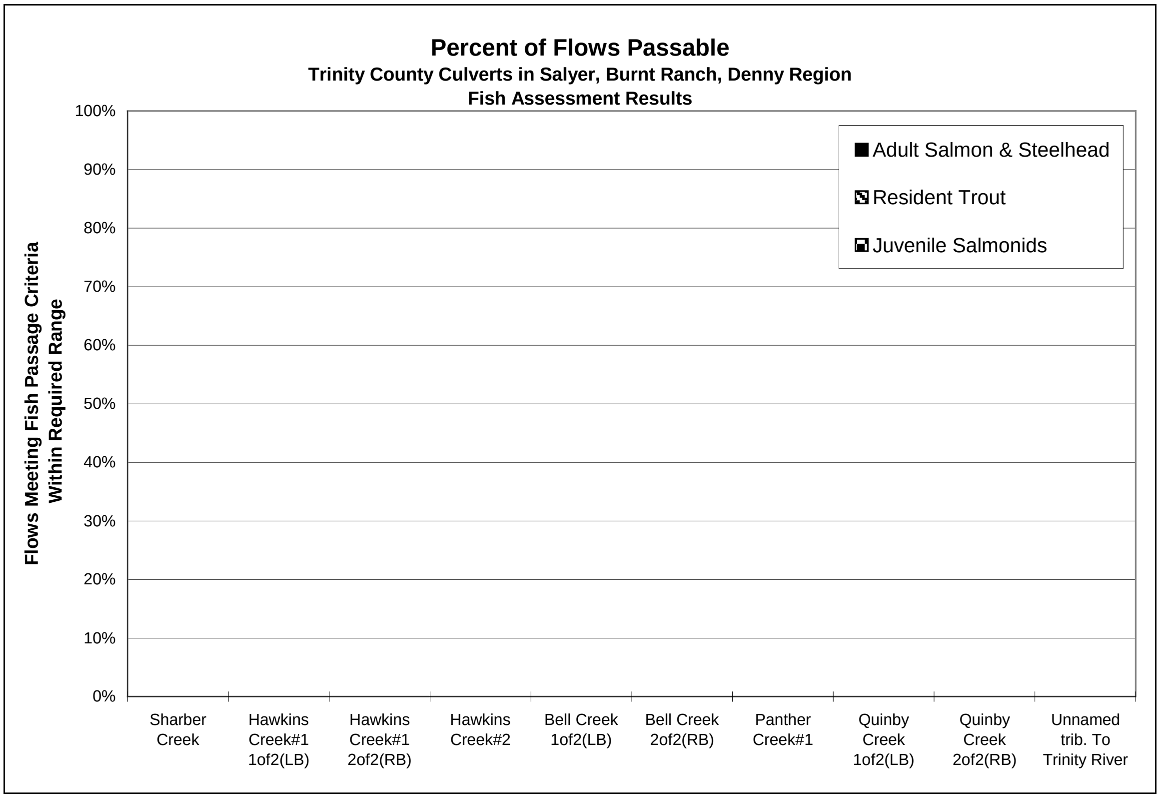


Figure 7. Percent passable as estimated by the Green-Gray-Red evaluation filter and FishXing for seven Trinity County stream crossings within Trinity River tributaries in the Denny area, by life stages.

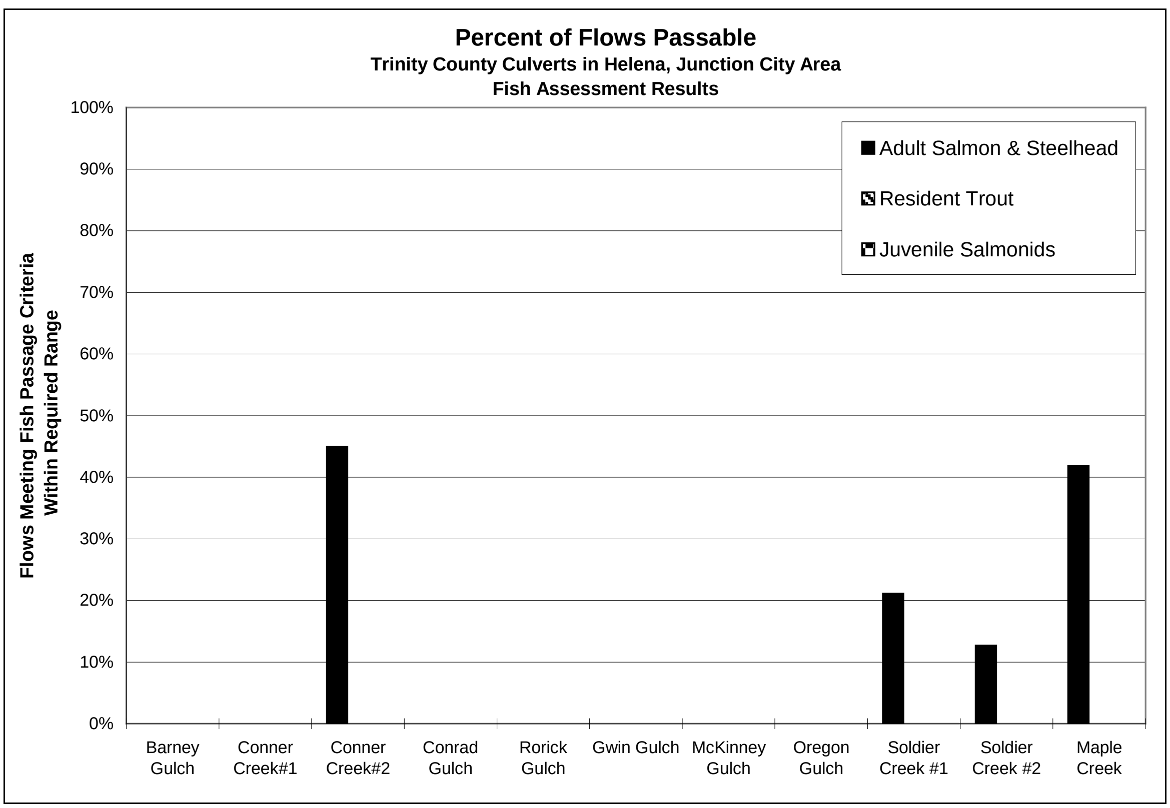


Figure 8. Percent passable as estimated by FishXing for 11 Trinity County stream crossings within Trinity River tributaries in the Junction City area, by life stages.

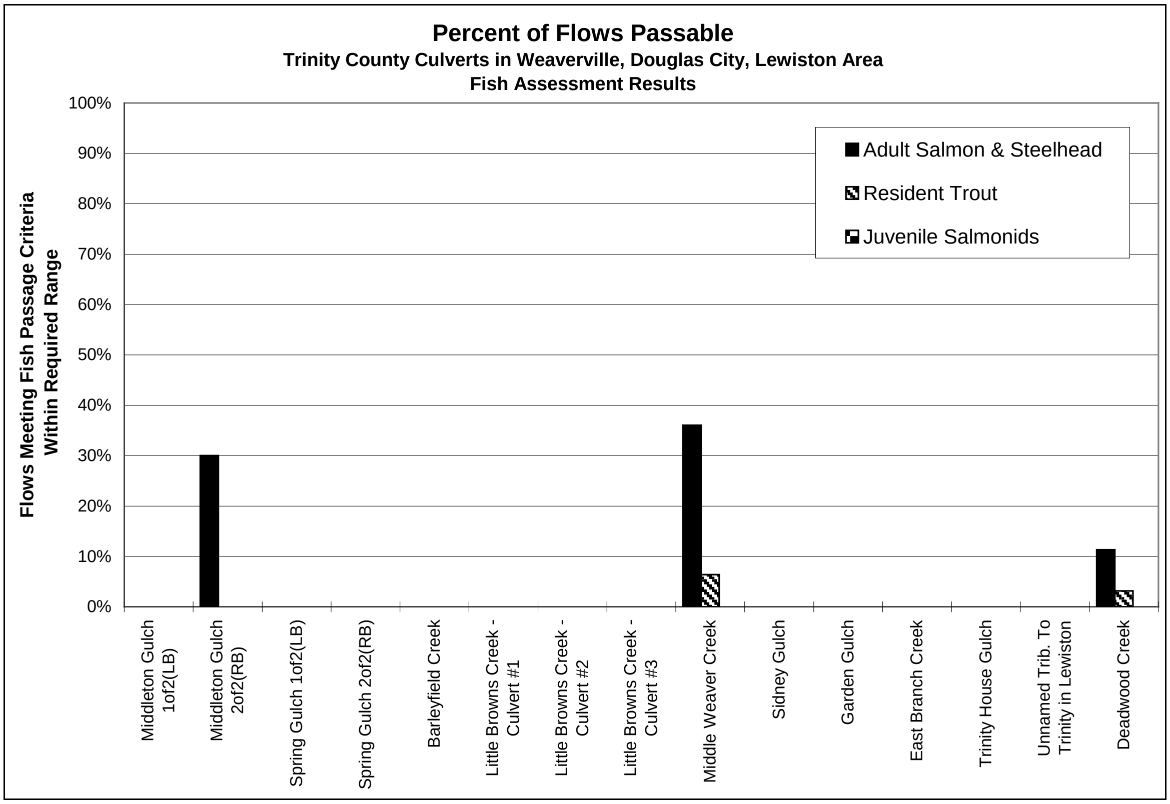


Figure 9. Percent passable as estimated by FishXing for 11 Trinity County stream crossings within Trinity River tributaries in the Weaverville area, by life stages.

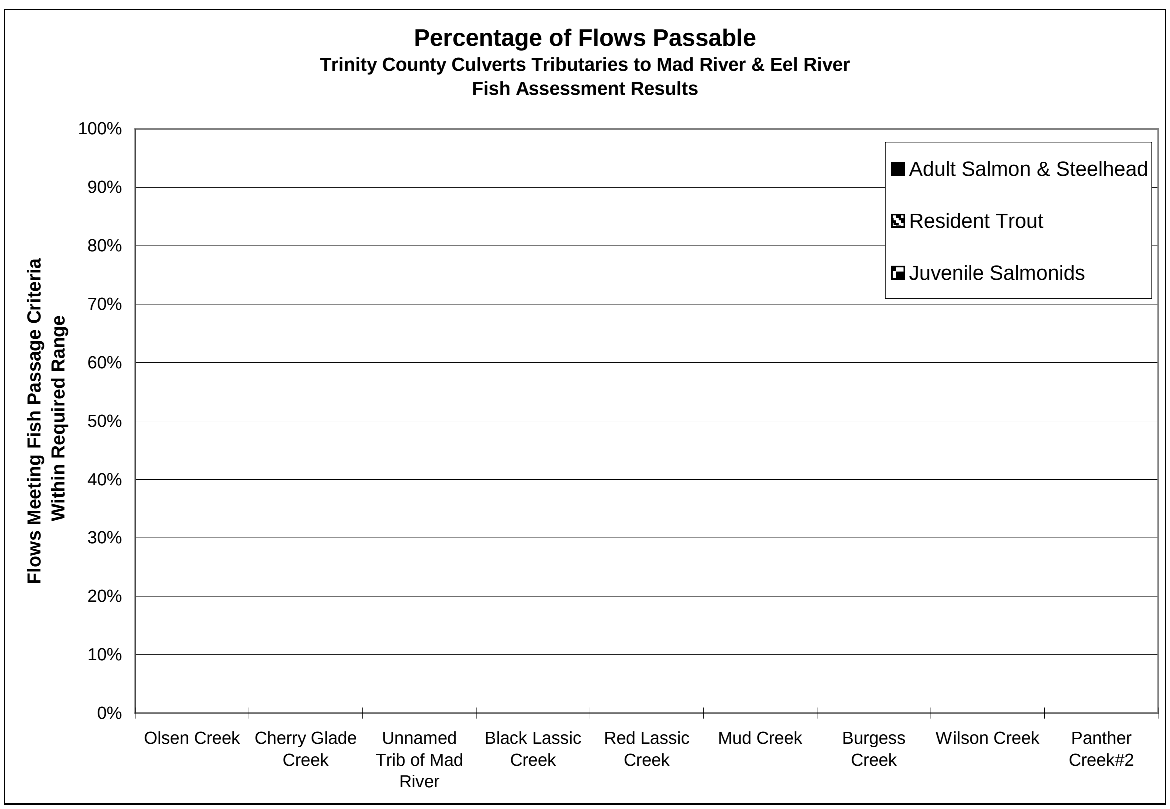


Figure 10. Percent passable as estimated by FishXing for nine Trinity County stream crossings within the Mad River and Eel River watersheds, by life stages.

Ranking Matrix

The 51 Trinity County culvert locations were sorted by "Total Scores", the sum of the five ranking criteria (Appendix D). The final list of the Trinity County culverts reflects changes made due to professional judgment(Table 6). Two sites were added to the ranking that were not surveyed: West Weaver Creek/Oregon Street (culvert was replaced prior to start of inventory) and Little East Fork Creek/Canyon Creek Road (replacement project was funded and designed prior to start of inventory).

Table 6. Ranking for 51 culvert locations on the Trinity County road system.

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#1	West Weaver Creek	Oregon Street	**Tied for 1st**	Top-priority site due to: severity of barrier = "RED" for all species; life stages and quantity and quality of upstream habitat (over two miles) ; and sizing and condition of current crossing. Both coho salmon and steelhead are known to currently utilize West Weaver Creek for spawning and rearing. **NOTE:** West Weaver Creek at Oregon Road was treated in the summer of 2000 with a ConSpan® open-bottomed arch culvert.
#2	Little Browns Creek	Roundy Road	**Tied for 1st**	High-priority due to: severity of barrier = "RED" for all species and life stages; condition and sizing of current culvert; and quantity and quality of upstream habitat. Both coho salmon and steelhead are known to currently utilize Little Brown's Creek for spawning and rearing. Adult fish have been observed up to this crossing, but none above it. A full replacement is recommended because the current crossing (comprised of three culverts) is undersized. The replacement project must address the potential for head-cutting of the upstream channel. Grade control weirs are recommended to minimize head-cutting – however, some upstream channel scour may be beneficial due to its aggraded condition.
#3	Deadwood Creek	Hatchery Road	**2nd**	High-priority due to: severity of barrier = "GREY" for adult salmonids and "RED" for juvenile life stages; quantity of upstream habitat; and potential species diversity. Deadwood Creek's proximity to Lewiston Dam and Hatchery create a situation where it is highly likely that coho salmon, chinook salmon, and steelhead all utilize the creek for spawning and rearing. The current culvert is partially back-watered, yet has a steep drop at the inlet that creates a velocity barrier. A full replacement is recommended as the best long-term solution because the current culvert is extremely undersized and overtops on less than a five-year storm flow. However, the large amount of road fill (≈ 2,900 cubic yards) may make a full replacement cost-prohibitive.
#4	Oregon Gulch	Sky Ranch Road	**Tied for 3rd**	High-priority due to: severity of barrier = "RED" for all species and life stages and potential habitat gain of nearly six miles. Both adult coho salmon and steelhead have been observed in the lower reach of Oregon Gulch. During the winter of 2001-2002, adult steelhead were observed leaping unsuccessfully at the Oregon Gulch/Sky Ranch Road outlet (Everett, pers. comm.). The current concrete box culvert is undersized and is in fair condition – starting to show signs of wear. The crossing is located at Oregon Gulch's confluence with the Trinity River, effectively blocking migration to all available upstream habitat.

Table 6 (continued).

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#5	Garden Gulch	Easter Avenue	**Tied for 3rd**	High-priority due to: severity of barrier = "RED" for all species and life stages; good habitat quality and significant length of upstream habitat gain (approximately 1.7 miles). Coho salmon were observed in the lower Garden Gulch channel (below Highway 299) attempting to spawn in December of 2001 (Lancaster, pers comm). Downstream of Easter Avenue, there is a migration barrier at the Highway 299 culvert. The Highway 299 culvert is undersized and may have contributed to the flooding of downtown Weaverville during the January, 1997 storm. The County should coordinate a replacement project at Easter Avenue with a downstream CalTrans project. Habitat conditions improve significantly in upper Garden Gulch from the channelized lower section in downtown Weaverville.
#6	Sidney Gulch	Memorial Drive	**Tied for 4th**	High-priority due to: severity of barrier = "RED" for all species and life stages; good habitat quality and significant length of upstream habitat gain (approximately 4.5 miles). This site was raised in the final ranking because coho salmon were observed migrating and spawning in Sidney Gulch in December of 2001 (Everest, pers. comm.). The fish took from 2.5 to 5.5 hours to migrate through the concrete, trapezoidal flood channel of lower Sidney Gulch before reaching the Memorial Drive culvert (Everett, pers. comm.). The current culvert is undersized and overtops on less than a ten-year storm flow.
#7	East Branch Creek	East Weaver Creek Road	**Tied for 4th**	High-priority due to: severity of barrier = "RED" for all species and life stages; good habitat quality and significant length of upstream habitat gain (approximately three miles). This site was raised in the final ranking because coho salmon were observed throughout the Weaver Creek watershed in December of 2001. Current culvert is undersized and overtops on less than a ten-year storm flow.
#8	Kingsbury Gulch #1	Riverview Road	**Tied for 3rd**	High-priority due to: severity of the barrier = "RED" for all species and life stages and significant length of upstream habitat gain (approximately 7.9 miles). The two culverts that comprise this crossing are extremely undersized and in poor condition. The exact scheduling of this project may be postponed due to total cost of re-establishing passage to the upstream habitat. There are two more crossings immediately upstream that have passage and/or flooding issues to address. The next crossing is under the Hayfork Airport runway and then the culvert on Morgan Hill Road. Treating these three migration barriers is vital in re-establishing ecological connectivity between Kingsbury Gulch and Hayfork Creek. Re-establishing access to over seven miles of spawning and rearing habitat is a high-priority.
#9	Conner Creek #1	Conner Creek Road	**5th**	High-priority due to severity of the barrier = "RED" to all species and life stages with nearly two miles of good quality upstream habitat. Initial efforts to modify the existing box culvert appear ineffective. Offset baffles were installed in half of the culvert – yet when the site was surveyed the baffles were clogged with debris, with all the flow sheeting across the un-baffled section of the culvert. Conner Creek #2 is located 1,100' upstream and is a partial adult barrier and most likely a total barrier for all age classes of juveniles. Both sites should be treated concurrently or in consecutive years.

Table 6 (continued).

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#10	Kingsbury Gulch #2	Morgan Hill Road	**Tied for 6th**	High-priority due to: severity of the barrier = "RED" for all species and life stages and significant length of upstream habitat gain (approximately seven miles). The arch culvert set on a concrete floor that comprises this crossing has been modified to improve fish passage with baffles and an outlet weir. Unfortunately, the offset baffles were installed incorrectly (and probably increase velocities) and the boulder weir has been partially washed-out by high flows. The exact scheduling of this project may be postponed due to total cost of re-establishing passage to the upstream habitat. There are two more crossings immediately downstream that have passage and/or flooding issues to address. The next crossing downstream is under the Hayfork Airport runway and then the culvert on Riverview Road. Treating these three migration barriers is vital in re-establishing ecological connectivity between Kingsbury Gulch and Hayfork Creek. Re-establishing access to over seven miles of spawning and rearing habitat is a high-priority.
#11	Soldier Creek #1	Evans Bar Road	**Tied for 8th**	High-priority due to: severity of the barrier = meets CDFG passage criteria on 22% of migration flows for adult steelhead and is "RED" for all life stages; and significant length of upstream habitat gain (≈ 2.1 miles). . Current culvert is extremely undersized and overtops on less than a five-year storm flow. Two additional stream crossings are located upstream that are migration barriers: Soldier Creek #2 (≈ 2,300') and a USFS crossing (≈5,000'). A passage problem for migrating salmonids may exist at the confluence of Soldier Creek and the Trinity River due to effects of past mining practices (Lancaster, pers. comm.). The County should investigate this situation further and contact the appropriate agencies to treat this area prior to implementing stream crossing replacement projects on Evans Bar Road and Dutch Creek Road.
#12	Soldier Creek #2	Dutch Creek Road	**7th**	High-priority due to severity of the barrier = "RED" for all species and life stages; and significant length of upstream habitat gain (≈ 1.7 miles). Current culvert is extremely undersized and overtops on less than a five-year storm flow. Soldier Creek #2 is located between two additional stream crossings that are migration barriers: Soldier Creek #2 is located ≈ 2,300' downstream and a USFS crossing is located ≈5,000' upstream. A passage problem for migrating salmonids may exist at the confluence of Soldier Creek and the Trinity River due to effects of past mining practices (Lancaster, pers. comm.). The County should investigate this situation further and contact the appropriate agencies to treat this area prior to implementing stream crossing replacement projects on Evans Bar Road and Dutch Creek Road.
#13	Conner Creek #2	Red Hill Road	**25th**	High-priority due to: allows for partial passage of adults (meets CDFG passage criteria on 45% of migration flows), but is probably a total barrier to all life stages of juveniles. There is approximately 1.6 miles of potential upstream habitat. Was raised in priority because the crossing scored fairly low due to its good condition and moderate sizing. Also, when Connor Creek #1 is treated (1,100' downstream), then this site is the next upstream migration barrier.

Table 6 (continued).

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#14	Barney Gulch	East Fork Road	Tied for 6th	Moderate-priority due to: although the crossing is "RED" for adult and juvenile steelhead and there is a substantial length of potential upstream habitat – the upstream is fairly steep and no information exists regarding habitat quality or fish distribution. The current crossing is extremely undersized and overtops on less than a five-year storm flow. Below the crossing's outlet there is a very steep drop over rip rap and boulders – treatment of this site will have to address re-grading the channel and working with this material.
#15	Quinby Creek	Denny Road	Tied for 8th	Moderate-priority due to: although the crossing is "RED" for adult and juvenile steelhead and there is a substantial length of potential upstream habitat (nearly four miles) – the upstream is fairly steep and very little information exists regarding habitat quality or fish distribution. Quinby Creek may be utilized by summer-run steelhead. The natural channel below Denny Road is moderately steep ≈ 8%. The current crossing is comprised of two large (12.5' diameter) culverts and is sized for approximately a 30-year storm flow. Modifying the existing culverts to improve passage should be considered due the high cost of implementing a full replacement because the stream crossing contains nearly 6,000 cubic yards of fill material.
#16	Hall City Creek	Wildwood Road	Tied for 8th	Moderate-priority due to: : although the crossing is "RED" for adult and juvenile steelhead and there is a substantial length of potential upstream habitat (nearly four miles) – very little information exists regarding habitat quality or fish distribution in Hall City Creek. No fish were observed during site survey, even though channel had ample flow of cool water. Several un-screened diversions were present inside both culverts. This site ranked high because both culverts are extremely undersized (over top on less than a five-year storm flow) and are in poor condition.
#17	Little East Fork Creek	Canyon Creek Road	9th	Moderate-priority due to: although "RED" for both adult and juvenile steelhead, there is a limited amount of available upstream habitat (3,100'). The site was raised in priority because this crossing sustained major damage during the January 1997 flood and is in need of repair. Site is extremely undersized and the crossing overtops on nearly an annual basis. The road receives moderately-heavy usage because of popular trailheads into the Canyon Creek – Trinity Alps area. **NOTE:** a bridge is scheduled for construction in the summer of 2002.
#18	Sharber Creek	Fountain Ranch Road	Tied for 8th	Moderate-priority due to: although the crossing is "RED" for adult and juvenile salmonids and there is a substantial length of potential upstream habitat (≈ 1.1 miles) – very little information exists regarding habitat quality or fish distribution. The main feature creating a migration barrier at this crossing is the splash boards a local has placed at the culvert inlet to divert stream flow (see photo in Appendix B). It is not known if the landowner removes these boards during the winter migration period. The appropriate agencies should work with the landowner to develop a fish-friendly (and legal) water diversion. **NOTE:** after completing field inventories and passage evaluations, this crossing was determined to be privately-maintained.

Table 6 (continued)

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#19	Un-named Tributary of Trinity River near Lewiston	Goose Ranch Road	**Tied for 15th**	Low-priority due to: although the crossing is "RED" for adult and juvenile steelhead and there is a substantial length of potential upstream habitat (nearly three miles) – no information exists regarding habitat quality or fish distribution in this un-named tributary. Current crossing is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#20	Rarick Gulch	Canyon Creek Road	**17th**	Moderate-priority due to: current crossing is "RED" for adults and juveniles – but there is a limited amount of upstream habitat (≈ 2,800'). The site was raised in the final ranking because Trinity County considers treating all county-maintained migration barriers to Canyon Creek tributaries as a priority. If treated concurrently with county crossings on Conrad and Gwin Gulches, access to nearly 2.1 miles of potential habitat will be re-established. When needed, replace with a properly-sized crossing.
#21	Conrad Gulch	Canyon Creek Road	**20th**	Moderate-priority due to: current crossing is "RED" for adults and juveniles – but there is a limited amount of upstream habitat (≈ 5,700'). The site was raised in the final ranking because Trinity County considers treating all county-maintained migration barriers to Canyon Creek tributaries as a priority. If treated concurrently with county crossings on Rarick and Gwin Gulches, access to nearly 2.1 miles of potential habitat will be re-established. When needed, replace with a properly-sized crossing.
#22	Donaldson Creek	Big Creek Road	**16th**	Low-priority due to: although the crossing is "RED" for adult and juvenile steelhead and there is a substantial length of potential upstream habitat (≈ 1.3 miles) – no current information exists regarding habitat quality or fish distribution in Donaldson Creek. No fish were observed during site survey, however habitat conditions adjacent to crossing appeared good. Current crossing is undersized and overtops on less than a ten-year storm flow. When needed, replace with a properly-sized crossing.
#23	Little Barker Creek	Barker Creek Road	**Tied for 15th**	Low-priority due to: although "RED" for adult and juvenile steelhead there is no current information exists documenting salmonid presence. Site was raised slightly in final ranking due to the potential length of upstream habitat (≈ 1.9 miles). Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#24	Hawkins Creek #1	Hawkins Bar Road	**14th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with potentially over a mile of upstream habitat, little is known about habitat quality or fish distribution. Natural channel below Hawkins Bar Road is steep with several four to six foot drops over boulders and bedrock. Site was also dropped in final ranking because of the high cost of treating both county-maintained sites on Hawkins Creek. Additionally, a concrete diversion dam with no fish passage is located immediately upstream of Flame Tree Road crossing. When needed, replace with a properly-sized crossing.

Table 6 (continued)

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#25	Hawkins Creek #2	Flame Tree Road	**10th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with potentially over a mile of upstream habitat, little is known about habitat quality or fish distribution. Natural channel below Hawkins Bar Road crossing is steep with several four to six foot drops over boulders and bedrock. Site was also dropped in final ranking because of the high cost of treating both county-maintained sites on Hawkins Creek. Additionally, a concrete diversion dam with no fish passage is located immediately upstream of Flame Tree Road crossing. The current crossing is in poor condition. When needed, replace with a properly-sized crossing.
#26	Grassy Flat Creek	Hyampom Road	**11th**	Low-priority due to: although "RED" for adult and juvenile steelhead there is a limited amount of upstream habitat, plus no current information exists documenting salmonid presence. Crossing has a substantial drop in elevation which would make a full replacement an expensive project When needed, replace with a properly-sized crossing.
#27	Summit Creek	Summit Creek Road	**29th**	Low-priority due to: although "RED" for adult and juvenile steelhead there is a limited amount of upstream habitat, plus no current information exists documenting salmonid presence. Site should be periodically inspected for condition. Culvert is undersized, when needed, replace with a properly-sized crossing.
#28	Wilson Creek	Zenia Mountain Road	**12th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with potentially over a mile of upstream habitat, little is known about habitat quality or fish distribution in Wilson Creek. A replacement project at this site would be expensive due to the removal of the current crossing's headwall, concrete apron, and steel plating within culvert (see photo in Appendix B). Site should be periodically inspected for condition. Culvert is undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#29	Middle Weaver Creek	Oregon Street	**18th**	Low-priority due to: although there is nearly ten miles of habitat in tributaries above Oregon Street that is used by coho salmon and steelhead – the current crossing allows for adult and juvenile passage on most migration flows. Site should be periodically inspected for condition. Culvert is moderately-sized and conveys ≈ a 47-yeat storm flow before overtopping. When needed, replace with a properly-sized open-bottom arch or a bridge.
#30	Jud Creek	Hyampom Road	**Tied for 27th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with potentially over a mile of upstream habitat, little is known about habitat quality or fish distribution in Jud Creek. Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing. Another stream crossing is located approximately 2,500' upstream of Hyampom road – appears to be USFS-maintained.

Table 6 (continued)

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#31	Carrier Gulch	Wildwood Road	**22nd**	Low-priority due to: although "RED" for adult and juvenile steelhead and with potentially over two miles of upstream habitat, little is known about habitat quality or fish distribution in Jud Creek. Two age classes of juvenile steelhead were observed in a pool ≈ 75' upstream of Wildwood Road. Because there is over two miles of relatively low-gradient habitat above Wildwood Road, a stream survey is recommended to better assess the potential fisheries habitat. Site should be periodically inspected for condition. Culvert is moderately-sized and overtops on ≈ a 25-year storm flow. When needed, replace with a properly-sized crossing.
#32	Gwin Gulch	Canyon Creek Road	**42nd**	Moderate-priority due to: current crossing is "RED" for adults and juveniles – but there is a limited amount of upstream habitat (≈ 2,600'). The site was raised in the final ranking because Trinity County considers treating all county-maintained migration barriers to Canyon Creek tributaries as a priority. If treated concurrently with county crossings on Conrad and Rarick Gulches, access to nearly 2.1 miles of potential habitat will be re-established.
#33	Middleton Gulch	Deerlick Springs Road	**23rd**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a limited length of potential upstream habitat (≈ 1,800'). No information was available to assess fisheries or habitat value. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#34	Bell Creek	Denny Road	**24th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (≈ 1,300'). Denny Road crosses Bell Creek in the upper reach of anadromy. Site was dropped in ranking because of limited available habitat, plus there appears to be an earthen dam located ≈ 3,500' downstream of Denny Road (see USGS map in Appendix B). Site should be periodically inspected for condition. Culvert is undersized, when needed, replace with a properly-sized crossing.
#35	Mud Creek	Alder Point Bluff Road	**13th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). Dropped in ranking because of limited available habitat, plus natural channel appears quite steep on either side of Alder Point-Bluff Road. Site should be periodically inspected for condition. Culvert is undersized, when needed, replace with a properly-sized crossing.
#36	Un-named tributary to South Fork Trinity River	South Fork Road	**Tied for 26th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year flow. When needed, replace with a properly-sized crossing.
#37	Barleyfield Creek	Reading Creek Road	**30th**	Low-priority due to: : although "RED" for adult and juvenile steelhead and with a limited length of potential upstream habitat (≈ 2,500'). No information was available to assess fisheries or habitat value. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.

Table 6 (continued)

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#38	Un-named tributary to Trinity River	Underwood Mountain Road	**28th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#39	Cherry Glade Creek	Mad River Road	**19th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a limited length of potential upstream habitat (≈ 3,500'). No information was available to assess fisheries or habitat value. Culvert is undersized and overtops on less than a 10-year storm flow. USGS map indicates a stream crossing ≈1,000' upstream of Mad River Road. When needed, replace with a properly-sized crossing.
#40	Olsen Creek	Mad River Road	**21st**	Low-priority due to: : although "RED" for adult and juvenile steelhead and with a limited length of potential upstream habitat (≈ 2,400'). No information was available to assess fisheries or habitat value. Culvert is undersized and overtops on less than a 10-year storm flow. USGS map indicates a stream crossing ≈ 800' upstream of Mad River Road. When needed, replace with a properly-sized crossing.
#41	Burgess Creek	Burgess Ranch Road	**26th**	Low-priority due to although "RED" for adult and juvenile steelhead and with a limited length of potential upstream habitat (≈ 1,100'). The downstream channel is quite steep, with several reaches of eight to 10% slopes. No information was available to assess fisheries or habitat value. Culvert is undersized and overtops on less than a 10-year storm flow. When needed, replace with a properly-sized crossing.
#42	Slide Creek	Lower South Fork Road	**32nd**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#43	McKinney Gulch	Red Hill Road	**33rd**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#44	Spring Gulch	Deerlick Springs Road	**35th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<500'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.

Table 6 (continued)

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#45	Panther Creek – tributary to North Fork Eel River	Ruth Zenia Road	**31st**	Low-priority due to: although "RED" for adult and juvenile steelhead and with limited length of upstream habitat (≈ 2600'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is moderately sized and overtops on approximately a 30-year storm flow. When needed, replace with a properly-sized crossing.
#46	Red Lassic Creek	Van Duzen Road	**34th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with limited length of upstream habitat (≈ 2300'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is properly sized and in good condition. When needed, replace with a properly-sized crossing.
#47	Trinity House Gulch	Browns Mountain Road	**36th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is undersized and overtops on less than a 10-year storm flow. When needed, replace with a properly-sized crossing.
#48	Panther Creek – tributary to Trinity River	Denny Road	**38th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (≈ 500'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is undersized and overtops on approximately a 10-year storm flow. When needed, replace with a properly-sized crossing.
#49	Maple Creek	Dutch Creek Road	**39th**	Low-priority due to: "GRAY" for adults and "RED" juvenile steelhead and with a limited length of marginal upstream habitat (≈ 2600'). Maple Creek was last surveyed to assess fisheries or habitat conditions in 1974 – and was rated as "poor" for steelhead spawning and rearing. Numerous debris jams were present in lower one mile, as well as extensive damage from past mining activities. Site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#50	Un-named Tributary to Mad River	Mad River Road	**37th**	Low-priority due to: although "RED" for adult and juvenile steelhead and with a very limited length of upstream habitat (<1,000'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is moderately sized and overtops on approximately a 37-year storm flow. When needed, replace with a properly-sized crossing.

Table 6 (continued)

Final Rank	Stream Name	Road Name	Initial Rank	Comments to Final Ranking
#51	Duncan Creek	Summit Creek Road	**40th**	Low-priority due to: current crossing allows for adult and juvenile passage on a fairly wide range of migration flows. There is an extensive reach of habitat upstream of the Summit Creek Road culverts (≈ 4.8 miles). On the USGS map there appears to be at five additional stream crossings on roads maintained by either private landowners or the USFS. The county site should be periodically inspected for condition. Culvert is extremely undersized and overtops on less than a five-year storm flow. When needed, replace with a properly-sized crossing.
#52	Black Lassic Creek	Van Duzen Road	**41st**	Low-priority due to: although "RED" for adult and juvenile steelhead and with limited length of upstream habitat (<1,000'). No information was available to assess fisheries or habitat value. Site should be periodically inspected for condition. Culvert is properly sized and in good condition. When needed, replace with a properly-sized crossing.
#53	Mill Creek	Lower South Fork Road	**43rd**	Low-priority due to: current crossing is "GREEN", thus meets CDFG's passage criteria for adult and juvenile passage on entire range of migration flows. Site should be periodically inspected for condition. Culvert is undersized and overtops on approximately a 12-year storm flow. When needed, replace with a properly-sized crossing.

Site-Specific Treatments and Scheduling

High-Priority Sites

During the past few years, several sources of restorations funds have been available for treating priority culverts – SB271, California Coastal Salmon Recovery Program (CCSRP), and Proposition 13 (Clean Water Bond). As of June, 2002 Trinity County has:

- Replaced the culvert at West Weaver Creek/Oregon Street with a ConSpan® open-bottom arch (fall of 2000).
- Secured funding to replace the culvert at Little East Fork Creek/Canyon Creek Road (scheduled for construction – fall of 2002).
- Scheduled to replace two lower priority sites with bridges – Olsen Creek/Mad River Road and Mud Creek/Alder Point Bluff Road. These sites are being treated in conjunction with other Trinity County DOT road improvement projects (scheduled for construction – fall of 2002).
- Secured funding to replace the box culvert at Oregon Gulch/Sky Ranch Road with a bridge (scheduled for construction – fall of 2003).
- Submitted proposals to treat Little Browns Creek/Roundy Road, Deadwood Creek/Hatchery Road, and East Branch Creek/East Weaver Creek Road.

Discussions with Trinity County Planning Department and USFS fisheries biologist (in Weaverville) have tentatively developed a multi-year plan for scheduling the funding, permitting, and implementation of the remaining six high-priority sites and three of the moderate priority sites. This tentative multi-year plan has the following sites scheduled for proposal submission, permit development and project implementation in the following sequence (note year of implementation assumes that un-secured funding will be available).

Year 2003:

- Submit proposals for: Conner Creek #1/Conner Creek Road, Soldier Creek #1/Evans Bar Road, and Soldier Creek #2/Dutch Creek Road.
- Develop permits for: Little Browns Creek, Deadwood Creek, and East Branch Creek.
- Implement treatments at: Oregon Gulch/Sky Ranch Road.

Year 2004:

- Submit proposals for: Garden Gulch/Easter Avenue, Quinby Creek/Denny Road and Conner Creek #2/Red Hill Road.
- Develop permits for: Conner Creeks #1, Soldier Creek #1, and Soldier Creek #2.
- Implement treatments at: Little Browns Creek and East Branch Creek.

Year 2005:

- Submit proposals for: Sidney Gulch/Memorial Drive and Barney Gulch/East Fork Road.
- Develop permits for: Garden Gulch, Quinby Creek, and Conner Creek #2.
- Implement treatments at: Conner Creek #1 and Solider Creeks #1 and #2.

Year 2006:

- Submit proposals for: Kingsbury Gulch #1/Riverview Road and Kingsbury Gulch #2/Morgan Hill Road.
- Develop permits for: Sidney Gulch and Barney Gulch.
- Implement treatments at: Garden Gulch, Quinby Creek, and Conner Creek #2.

Year 2007:

- Submit Proposals for: Rarick Gulch/Canyon Creek Road, Conrad Gulch/Canyon Creek Road, and Gwin Gulch/Canyon Creek Road.
- Develop permits for: Kingsbury Gulch #1 and #2.
- Implement treatments at: Sidney Gulch and Barney Gulch.

Year 2008:

- Develop permits for: Rarick Gulch, Conrad Gulch, and Gwin Gulch.
- Implement treatments at: Kingsbury Gulch #1 and #2.

Year 2009:

- Implement treatments at: Rarick, Conrad and Gwin Gulches along Canyon Creek Road.

All culvert replacements should follow recently developed state criteria and federal guidelines for facilitating adult and juvenile fish passage (CDFG 2001; NMFS 2001). However, site-specific characteristics of the crossing's location should always be carefully reviewed prior to selecting the type of crossing to install. These characteristics include local geology, slope of natural channel, channel confinement, and extent of channel incision likely from removal of a perched culvert.

For additional information, Bates et al. (1999) is recommended as an excellent reference to use when considering fish-friendly culvert installation options and Robinson et al. (2000) provides a comprehensive review of the advantages and disadvantages of the various treatment alternatives as related to site-specific conditions.

CDFG Allowable Design Options

Active Channel Design Option is a simplified design method that is intended to size a crossing sufficiently large and embedded deep enough into the channel to allow the natural movement of bed load and formation of a stable bed inside the culvert. Determination of the high and low fish passage design flows, water velocity, and water depth is not required for this option since the stream hydraulic characteristics within the culvert are intended to mimic the stream conditions upstream and downstream of the crossing.

The Active Channel Design Option is suitable for the following conditions:

- New and replacement culvert installations
- Simple installations with channel slopes of less than 3%.
- Short culvert lengths (less than 100 feet).
- Passage is required for all fish species and lifestages.

Culvert Setting and Dimensions

- **Culvert Width –** the minimum culvert width shall be equal to, or greater than, 1.5 times the active channel width.

- **Culvert Slope –** the culvert shall be placed level (0% slope).

- **Embedment –** the bottom of the culvert shall be buried into the streambed not less than 20% of the culvert height at the outlet and not more than 40% of the culvert height at the inlet. Embedment does not apply to bottomless culverts.

Stream Simulation Design Option

The Stream Simulation Design Option is a design process that is intended to mimic the natural stream processes within a culvert. Fish passage, sediment transport, flood and debris conveyance within the crossing are intended to function as they would in a natural channel. Determination of the high and low fish passage flows, water velocity, and water depth is not required for this option since the stream hydraulic characteristics within the culvert are designed to mimic the stream conditions upstream and downstream of the culvert.

Stream simulation crossings are sized as wide, or wider than, the bankfull channel and the bed inside the culvert is sloped at a gradient similar to that of the adjacent stream reach. These crossings are filled with a streambed mixture that is resistant to erosion and is unlikely to change grade, unless specifically designed to do so. Stream simulation crossings require a greater level of information on hydrology and topography and a higher level of engineering expertise than the Active Channel Design Option.

The Stream Simulation Design Option is suitable for the following conditions:

- New and replacement culvert installations.
- Complex installations with channel slopes less than 6%.
- Moderate to long culvert length (greater than 100 feet).
- Passage required for all fish species and lifestages.
- Ecological connectivity is required.

Culvert Setting and Dimensions

- **Culvert Width –** the minimum culvert width shall be equal to, or greater than, the bankfull channel width. The minimum culvert width shall not be less than six feet.

- **Culvert Slope -** the culvert slope shall approximate the slope of the stream through the reach in which it is being placed. The maximum slope shall not exceed 6%.

- **Embedment –** the bottom of the culvert shall be buried into the streambed, not less than 30% and not more than 50% of the culvert height. Embedment does not apply to bottomless culverts.

Substrate Configuration and Stability

- Culverts with slopes greater than 3% shall have the bed inside the culvert arranged into a series of step-pools with the drop at each step not exceeding 0.5 feet for juvenile salmonids.

- Smooth walled culverts with slopes greater than 3% may require bed retention sills within the culvert to maintain the bed stability under elevated flows.

- The gradation of the native streambed material or engineered fill within the culvert shall address stability at high flows and shall be well graded to minimize interstitial flow through it.

Hydraulic Design Option

The Hydraulic Design Option is a design process that matches the hydraulic performance of a culvert with the swimming abilities of a target species and age class of fish. The method targets specific species of fish and therefore does not account for ecosystem requirements of non-target species. There can be significant errors associated with estimation of hydrology and fish swimming speeds that are mitigated by making conservative assumptions in the design process. Determination of the high and low fish passage design flows, water velocity, and water depth are required for this option.

The Hydraulic Design Option requires hydrologic data analysis, open channel flow hydraulic calculations and information on the swimming ability and behavior of the target group of fish. This design option can be applied to the design of new and replacement culverts, and can be used to evaluate the effectiveness of retrofits for existing culverts.

The Hydraulic Design option is suitable for the following conditions:

- New, replacement, and retrofit culvert installations.
- Low to moderate channel slopes (less than 3%).
- Situation where either Active Channel Design or Stream Simulation Options are not physically feasible.
- Swimming ability and behavior of target fish species is known.
- Ecological connectivity is not required.
- Evaluation of proposed improvements to existing culverts.

For more information regarding the Hydraulic Design option, or to obtain the most recent copy of the CDFG *Culvert Criteria for Fish Passage*, contact the North Coast Regional Office at 601 Locust Street, Redding, CA 96001 (916)-5-2300.

NMFS Order of Preferred Alternatives

1. *No crossing* - relocate or decommission the road.

2. *Bridge* - spanning the stream to allow for long-term dynamic channel stability.

3. *Streambed simulation strategies* – bottomless arch, embedded culvert design, or ford.

4. *Non-embedded culvert* – this often referred to as a hydraulic design, associated with more traditional culvert design approaches limited to low slopes for fish passage.

5. *Baffled culvert, or structure designed with a fish way* – for steeper slopes.

For more information, or to obtain a copy of the NMFS *Guidelines for Salmonid Passage at Stream Crossings* go to the Southwest Region website at: http://swr.nmfs.noaa.gov

Moderate-Priority Sites

The exact scheduling for treating of the remaining “moderate-priority” sites is unknown at the time because:

1. Trinity County has a large task of completing the scheduling, contracting, permitting, and implementation required to treat the first 17 locations proposed in the tentative long-term scheduling. The County should focus on completing these higher priority projects with properly designed and constructed treatments before addressing the next tier of sites.

2. Trinity County is a participant in the Five-Counties Salmon Group, which plans to acquire treatment funds for passage problems in all five counties (Trinity, Mendocino, Del Norte, and Humboldt). Thus, the remaining “moderate-priority” tier of Trinity County culverts should be ranked and evaluated with respect to priority culverts located in the other four counties.

3. When addressing the “moderate-priority” tier of culverts, the current biological condition and/or importance (such as quantity) of the streams starts to diminish. Thus, these sites may not rank well compared to other types of projects proposed to state and federal funding sources. However, other sources of funding, such as urban stream programs should be considered. Sites in poor condition and/or undersized should be eventually treated with county maintenance and repair funds.

Low-Priority Sites

The remaining sites, ranked #15-26, are of “low-priority”. These sites either allow fish passage, or have minimal biological benefit if treated. However, these sites should be examined for “consequence-of-risk” as to current condition, sizing, and fill amount. All future replacements with county maintenance funds should include properly sized crossings that permit unimpeded passage of adult and juvenile salmonids.

The four most common activities impacting these Trinity County streams are timber harvesting, agriculture, unfenced grazing, and residential development. Most of these low-priority creeks generally exhibited some or all of the following characteristics:

1. Lack of pools and habitat complexity;
2. Denuded or non-existent riparian zones;
3. Extensive straightening, berming, and diking of channel;
4. High volumes of fine sediment; and
5. Warm summer water temperatures.

Limited fisheries restoration dollars should probably not be spent on improving fish passage in these streams, unless significant improvements occur to impacts of other land management activities. However, the County should carefully examine this list and determine which locations may be treated with existing maintenance funds.

For example, Trinity County DOT may have a general plan for improvements to specific traffic corridors or routes. Also, when low-priority culverts fail during winter storms, planners should examine the sizing of the failed structure and budget for properly-sized replacements. When applying for FEMA funds, Trinity County DOT and Water Agency should utilize this report to explain why the replacement should be a larger and higher-quality crossing (for both fisheries and future-flood benefits).

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