Oregon Department of Forestry: Compliance With Fish Passage and Peak Flow Requirements at Stream Crossings Pilot Study Results

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OREGON DEPARTMENT OF FORESTRY
FOREST PRACTICES MONITORING PROGRAM
TECHNICAL REPORT 6
March 2000

Acknowledgements

The assistance and cooperation of private landowners, representatives of the environmental community, Oregon State University (OSU), and Oregon Department of Forestry (ODF) field staff were instrumental in designing and implementing this project.

Kyle Abraham, Ted Perkins, Jim Ziobro, Jeff Peck, Conrad Tull, George Robison and Keith Mills, were all instrumental in the study design and implementation of this project. Kyle Abraham and Ted Perkins were also responsible for data collection. Cassandra Webber and Jan Pugh provided valuable project support. Ted Lorensen and David Morman prioritized this project for the monitoring program. This project would not have been possible without the participation of private landowners including Avery Interests, Boise Cascade Corporation, Cascade Timber Consulting, Ltd., Coastal Range Resources, L.L.C., Evenson Timberland Agency, Frank Lumber Company, Inc., The Timber Company, Giustina Land and Timber Company, Hull Oakes Lumber Company, John Hancock, M.L.I., Lone Rock Timber Company, Longview Fibre Company, Menasha Corporation, Oregon Department of Forestry, Roseburg Resources Company, Seneca Jones Timber Company, Silver Butte Timber Company, Simpson Timber Company, South Coast Lumber Company, Starker Forests, Inc., Stimson Lumber Company, Swanson-Superior Forest Products, Inc., Weyerhaeuser Company, Willamette Industries, and a number of other small, private landowners. The external and internal review committee also provided valuable input. The authors would also like to thank all the Forest Practices Foresters who made the site selection process possible, contacted landowners, and arranged logistics to support the field team.

TABLE OF CONTENTS

List of Figures

List of Tables

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This study has oversight by external and internal review committees. The committees' main functions are to review and approve the study design and reports. The committees met throughout the development of the project and will continue to meet annually.

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1998 Pilot Study Final Report:
Compliance With Juvenile Fish Passage and
Peak Flow Requirements at Stream Crossings

March 2000

INTRODUCTION

During the summer of 1998, the Oregon Department of Forestry (ODF) implemented a pilot study to test the field protocol for monitoring compliance with forest practices rules regarding stream crossings on fish-bearing streams (Type F). Oregon state statutes (ORS 498.351 and ORS 509.605) and current forest practices rules require that stream crossings on Type F streams must be installed to provide juvenile and adult fish passage. Crossings must also be designed with a capacity for a 50-year design peak flow. The main goals of the stream-crossing pilot project were:

- To refine study design and field methods and
- To provide preliminary results regarding compliance with juvenile fish passage and peak flow regulations.

The emphasis on fish passage, especially juvenile fish passage, has grown in importance over the last five years as the number of salmonids on the endangered species list has grown. ODF issued its first memorandum about constructing road crossings on Type F streams with an emphasis on juvenile fish passage in January 1995 (Mills and Stone, 1995). Since that time, the ODF fish passage guidelines have been expanded and improved three times (Robison, 1995; OWEB, 1997; OWEB, 1999). Other northwest state agencies began issuing guidelines during the same period (IDL, 1998; WDFW, 1999). Traditionally, a stream crossing design was considered successful when it maximized the speed and efficiency of water and debris passage with the smallest possible culvert. Changing from this to designing culverts that provide the low-velocity environment needed to allow upstream movement of juvenile fish is a dramatic paradigm shift. There is a steep learning curve for all involved with such a change, from engineers to the backhoe operators, and this is expected to surface in the monitoring results.

This pilot study was completed in 1998. The pilot study design and field protocol were then modified to improve sampling methods and repeatability. One hundred additional sites were then randomly selected and are being monitored with the modified protocol through 2000. Final study results from these 100 sites will be available in 2001.

Limitations of the Study

The results presented in this paper are based on the pilot study. Since the pilot study sample was not entirely random and was a small sample (57 crossings) the findings may not be representative and cannot be considered statistically reliable. Results from the larger random sample will confirm or reject pilot study findings with statistical validity. While the pilot study is not statistically reliable, the findings are reported to assist landowners, operators and ODF towards greater success in implementation of fish-friendly stream crossing strategies.

Furthermore, this report presents estimates of how many of the monitored sites are likely to pass both juvenile and adult fish. There are basically three methods one could use to assess fish passage at stream crossings: 1) direct observation of successful fish passage, 2) detailed velocity profiles and other measures of the stream crossings compared to fish swimming abilities, and 3) measures of surrogates indicative of velocity and other conditions (surrogates of #2) at the stream crossings. As the time, complexity and expense of the first two options was prohibitive, the third option for assessing fish passage was utilized. The limitation of this approach, however, is that data collected at the sites permit evaluation of only the most restrictive condition (juvenile fish passage likely year-round). Thus, sites deemed not likely to pass fish may actually be able to pass adult fish under most or all flow conditions and/or juvenile fish under other than low-flow conditions.

Other Monitoring Projects

This stream-crossing study is part of a larger BMP Compliance Monitoring Project (BMPCMP) designed to evaluate harvest units, high risk sites, roads, skid trails, wetlands, and riparian areas. Please refer to the BMPCMP pilot study report regarding these other compliance topics. (Dent and Robben, 1999). The ODF forest practices monitoring program is involved with other water quality, riparian and landslide studies which focus on the effectiveness of the rules in providing resource protection. Please refer to the forest practices monitoring strategy for more information on these studies (Dent, 1998a).

BACKGROUND INFORMATION

Juvenile Fish Passage Through Culverts

The goal to pass fish through culverts requires a change in thinking with regards to stream crossing installations. To begin with, the image that comes to mind when pondering fish passage is that of an adult salmon leaping through frothy white water as it makes its way upstream to native spawning grounds. Less thought of, but perhaps equally important, is the upstream movement of juvenile anadromous fish as well as resident fish. These younger and less athletic fish have been observed to make upstream migrations and are thought to do so for a number of reasons: to avoid predation, to seek appropriate habitat for given life stages (e.g. cooler temperatures, lower velocities), or to seek less populated areas with better opportunity for food and cover (Bustard and Narver, 1975; Cederholm and Scarlett, 1981; Everest, 1973; Fausch and Young, 1995; Gowan et al., 1994; Hartman and Brown,1987; Reiser and Bjornn, 1979; Shrivell, 1994). There is evidence that juvenile fish that are able to reach more favorable habitat conditions are larger in size and have better survival rates (Bustard and Narver, 1975; Skeesick, 1970).

Installation of road systems without regard to fish passage can jeopardize the biological integrity of a watershed by truncating the available habitat. Therefore, ODF requires that stream crossings are designed and installed to pass fish. Fish passage regulations for stream crossings are based on physical abilities of fish with the intent to accommodate the basic requirements for reproduction, habitat and refuge of the "weakest fish", usually juvenile fish. Fish swimming abilities vary by age and species as do timings of upstream migration. These issues can be considered when designing culverts for fish passage (OWEB, 1999).

Historically, culverts were installed to pass water as quickly as possible and minimize the likelihood that material would be retained in the culvert. However, to accommodate juvenile fish passage, culverts must be installed to minimize velocity through the pipe. Sometimes this involves retaining material in the culvert. Unlike their older counterparts, juvenile fish have greater limitations in terms of the ability to jump and then swim upstream against fast flowing water for any extended period of time (Bell, 1986). In addition to the physical limitations, fish appear to be reluctant to pass through culverts possibly due to the change in light and hydraulic conditions (Bates, 1995). Fish seem to conserve energy when navigating through culverts rather than utilizing their full athletic potential (Behlke et al., 1989). Therefore juvenile fish require very low gradient culverts (< 0.5%), resulting in low velocity water, that can be accessed without jumping into the culvert. Another strategy is to provide areas where the young fish can retreat from fast flowing water and rest before moving upstream again. Such an area is referred to as a "velocity refuge". Velocity refuges can be created within a culvert with structures such as baffles or with sediment retention to simulate a natural streambed. Such designs allow for slightly higher gradient culvert installations and therefore can be used in some of the higher gradient forest streams (4-12%). These strategies reduce culvert capacity for the 50-year flow and thus must be oversized to compensate for the loss. Juvenile fish passage can also be achieved with installations that maintain the native streambed (i.e. open bottom arches, bridges, or fords).

Designing culverts to pass juvenile fish is a relatively new approach to stream-crossing installations. While the Oregon Statute requiring fish passage was first adopted in 1955, it wasn't until the mid- to late 90's that the law was interpreted as pertaining to juvenile fish. The first detailed guidance on how to design stream crossings to pass juvenile fish was available from ODF in June 1995 (Robison, 1995). The Washington Department of Fish and Wildlife just published detailed guidelines in 1999 (WDFW, 1999). A memorandum of understanding (MOU) was signed in 1997 between Oregon Department of Transportation (ODOT), Oregon Department of Fish and Wildlife (ODF&W), Oregon Department of Agriculture (ODA), Division of State Lands (DSL), Federal Highway Administration (FHA), and the Oregon Department of Forestry (ODF) (ODOT, 1997). The MOU demonstrates agreement between these agencies to use the same criteria and guidelines when designing or consulting on projects that may affect fish passage.

Providing juvenile fish passage requires a change in thinking and it requires innovative engineering approaches that bridge the biological needs and the infrastructure needs. The design specifications are based on laboratory and biological research. While the science is fairly clear that juvenile fish do indeed move upstream, less clear is how successful the stream crossing solutions are at providing juvenile fish passage, and on how the fish-friendly crossings will endure over time. Nonetheless, forest landowners are motivated to install and upgrade existing installations to pass juvenile fish. Eighty-one percent of all fish passage improvement projects reported to the governor's office occurred on private industrial forest and state forestland in 1999 (Maleki and Riggors, 1999).

Peak Flow Design

Designing stream crossings to pass a given volume of water requires long-term gage records on stream flow. These records are then analyzed to determine the probability (or likelihood) that a given streamflow will occur each year. The probability is referred to as the return interval (e.g. 100-year flow). For example, a streamflow with a 50-year return interval has a 2% chance (1 in 50) of occurring *any* year while a 100-yr return flow has a 1% chance (1 in 100) of occurring any year. So while it is not likely, it is possible that a 100-year event may occur twice in one year or in two consecutive years. The actual volume of water (streamflow) that results from the 50-year flow varies from basin to basin and generally decreases with decreasing basin size. Return interval predictions are more accurate when the gage record covers a long period. Ideally the period of record is longer than the desired return interval prediction, in this case 50 years.

Most streams do not have any gage records from which to predict the 50-year return interval. Therefore the Department of Forestry has established a method that landowners can use to estimate the 50-year flow and design their crossings (e.g. culvert size, bridge span) accordingly. The model uses drainage area and precipitation intensity to predict streamflow. Streamflow is determined by locating the planned stream crossing on a streamflow intensity map. The maps display the 50-year peak flows in cubic feet per second, per mile squared (cfs/mi^2) overlain on a map of Oregon. To calculate the streamflow at a particular crossing, the landowner multiplies the basin area in square miles by the peak flow shown for that specific area. These maps are available in the ODF fish passage guidelines (OWEB, 1999) or can be downloaded from the ODF website (ODF, 1996). Small scale maps specific to western Oregon can also be purchased by placing an order with the Forest Practices Department in Salem. Landowners may use a different peak flow estimation model upon approval of the state forester.

Forest Practices Rules: Fish Passage and Peak Flows

The forest practices rules require that stream crossing installations pass a peak flow that at least corresponds to the 50-year return interval. The resulting installation must preclude ponding of water higher than the top of the culvert (OAR 629-625-0320 2a) and allow migration of adult and juvenile fish upstream and downstream during conditions when fish movement in the stream normally occurs (OAR 629-625-0320 2b). Culverts must also be maintained to pass juvenile and adult fish (629-625-600 8). If the stream crossing is on a wide flood plain, the crossing capacity can be reduced to avoid excessive fill. Under such a scenario, the installation must be at least as wide as the active channel, no soil fill is placed in the flood plain, and the downstream end of all fill must be armored with rock to protect the fill from eroding when a flood flow occurs. Guidance is available for design of overflow dips that can handle the excess floodwater at such crossings, and minimize erosion of the road prism and fill.

ODF Guidelines on Fish Passage

The landowner is responsible to comply with the fish passage rules described above for all stream crossings on Type F streams and the peak flow rules for all streams regardless of classification. However, the rule does not explicitly define how the landowner will install the crossings to provide for juvenile fish passage or the 50-year stream flow. In January 1995, the first ODF memorandum regarding construction of crossings on Type F stream was issued (Mills and Stone, 1995). This was followed by interim fish passage guidance dated June 16, 1995 (Robison, 1995). In cooperation with Oregon Department of Fish and Wildlife, a third guideline version was developed to aid the operator and/or landowner in choosing an appropriate strategy for the particular stream they are working in (OWEB, 1997). These guidelines describe eight different fish passage alternatives that can be applied and the precise specifications for those installations (e.g. resulting culvert gradient) as well as what type of channel the installation is appropriate for (e.g. channel gradient, valley fill) (Table 1). Methods are also described for determining the structure size needed to pass a 50-year design flow. Finally the guidelines provide a template for what a landowner should include in the written plan when notifying the department of stream crossing installations.

The stream crossing guidelines were updated again in 1999 after the completion of this pilot study (OWEB, 1999). The 1999 version consolidates alternatives 4 and 5 into one alternative. Also, alternatives 1 and 3 are combined into one alternative for a total of 6 alternatives rather than eight. Recommendations at the end of this report will pertain to the 1999 guideline version.

Table 1: Summary of ODF stream crossing installation options as described in the 1997 guidelines for passing juvenile and adult fish. Current guidelines have been revised as of June 1999 (OWEB, 1999).

Alternative	Design Option	Key Specifications That Allow Juvenile Fish Passage ∗	Appropriate Stream Characteristics
1 ∗∗	Non-stream simulation culvert	Culvert installed with $\leq$ 0.5% gradient to achieve low velocities.	Streams $\leq$ 0.5% gradient.
2 ♣	Culvert with outlet backwatering	Culvert placed at/below stream grade with downstream control structure(s) that back up water throughout the culvert.	Streams $\leq$ 5% with well defined channel. Can also mitigate existing problem culverts with outlet structures.
3 ∗∗	Partially buried culvert (non-stream simulation)	Sink culvert at inlet to lower resulting gradient to $\leq$ 0.5%. Difference between stream grade and resulting culvert grade is less than 2%. Depth of sinking $\leq$ 2 feet. Caution against creating an inlet drop.	Use on streams < 2.5% with deep valley fill. No bedrock at inlet, if inlet must be sunk to achieve resulting culvert gradient.
4 ∇	Culvert partially buried at inlet and outlet (stream simulation)	Resulting culvert grade = stream grade (but $\leq$ 4%). Culvert width = to channel width. May need to manually seed culvert with rock to initiate sediment deposition. Oversize to pass 50-year flow.	Streams $\leq$ 4%. Deep valley fill to sink culvert in. Mobile gravel and cobble substrate to build up in culvert. If fines dominate the natural streambed, this alternative may not work.
5 ∇	Culvert partially buried at both ends but deeper at inlet (stream simulation)	Resulting culvert grade is 1.5% < stream grade and $\leq$ 7%. Sink at least 1 foot. If resulting culvert grade > 4%, seed culvert. Oversize culvert to pass 50-year flow.	Streams $\leq$ 9%. Deep valley fill and mobile cobble and gravel streambed. If fines dominate the natural streambed, this alternative may not work.
6 ♣	Baffled Culvert	Culvert with flow obstructions inside the culvert to increase depth or roughness. Oversize culvert to pass 50-year flow.	Streams up to 12%. Valley fill not a factor.
7 °	Open Bottom Arch	Culvert placed on footings with a natural streambed below.	Only used in bedrock streams and shallow valley fill to insure stable footings
8 °	Bridge	Structure spans the channel and is placed on piers and/or abutments located in or near the stream.	Need to place footings on bedrock.

∗ = All designs require no jump at the outlet of crossing structures.

∗∗ = Design relies on low gradient ($\leq$ 0.5%), and resulting low velocity to pass fish.

♣ = Design creates low enough velocities to pass juvenile fish with structures either downstream or within the culvert.

∇ = Design relies on sediment retention to pass juvenile fish. Sediment retention must be adequate to simulate a natural streambed condition which provides velocity refuge for fish.

° = Design relies on maintaining natural streambed to pass fish.

STUDY DESIGN

Key Monitoring Questions

The key questions that this study is designed to answer include:

1. What percent of stream crossings are in compliance with the written plans?
2. What percent of stream crossings have a high likelihood to pass juvenile fish?
3. What percent of stream crossings have been installed in accordance with ODF guidelines?
4. What percent of stream crossings have been installed with adequate capacity for a 50-year flow?

These questions are further explored in the evaluation section of this paper.

Stream Crossing Site Selection

The study was designed to use a random sample of stream crossings that were installed in 1996 or 1997. A 1998 query of the Forest Activities Computerized Tracking System (FACTS) database identified 1505 road-construction sites that met the initial criterion of:

- new road reconstruction or re-construction
- construction took place in 1996 or 1997 and
- operation took place within 100 feet of waters of the state.

A random selection of 150 sites was performed from the 1505 crossings. Only 37 of the 150 sites were suitable for the study. The remainder of the sites identified in the query were not appropriate for one of the following reasons: on a Type N stream, the planned road construction never took place, the new road did not actually cross the stream, the stream crossing had been pulled, or there was a land use change withdrawing the crossing from Forest Practices jurisdiction. Due to time constraints a second random sample of the 1505 crossings was not performed. Instead, 20 more sites were volunteered by landowners and FPF's for a total sample of 57 stream crossings on fish-bearing streams. The stream-crossing site selection process was improved and initiated eight months in advance of the 2000 field season for the finalized version of this study. As a result, 100 stream-crossings have been randomly selected and are being monitored through 2000.

Field Methodology

The stream crossing field protocol was designed to assess if structures were installed in compliance with current technical guidelines regarding juvenile fish passage. At each crossing the following parameters were measured:

- Structure type and dimensions
- Culvert gradient
- Outlet: design, depth of countersinking, and outlet drop (if any)
- Outlet mitigation: design, dimensions and condition
- Inlet: design and depth of countersinking
- Overflow dip: design, dimensions and condition
- Footing condition for bridges and open bottom arches
- Sediment size and pattern in streambed simulation culverts
- Baffle dimensions and design

- Road fill depth and armoring
- Valley and channel characteristics
- Cross-sectional area under bridges
- GPS points and photos were taken of every culvert.

The measurements were taken using a combination of an engineer's level, stadia rod, logger's tape, clinometer, and hip chain. Categorical data were collected on design specifications. A Trimble Geoexplorer global positioning station (GPS) was used at each crossing to establish location. For a more detailed understanding see Appendix A for the field protocol.

<u>Site and Study Descriptions</u>

All of the stream-crossing sites were on fish bearing streams and were located throughout western Oregon (Figure 1). Forty-eight percent of the stream-crossing sites were under industrial ownership, nine percent on non-industrial and none on other (State, city, county, non-profit). Ten percent of the sites were bridges, two percent were open arches, 34% were pipe arches, and 54% were round culverts. Seventeen percent were large streams, 42% were medium streams, and 40% were small streams. Stream gradient ranged from 0% to 12% and averaged 4%. Bankfull stream widths ranged from 2 to 34 feet and averaged 10 feet. Thirty-seven sites were randomly selected and 20 sites were volunteered (Figure 2).

There are four categories of compliance to be considered. They include compliance with written plans, likelihood to pass juvenile fish, proper implementation of guidelines, and capacity for the 50-year streamflow.

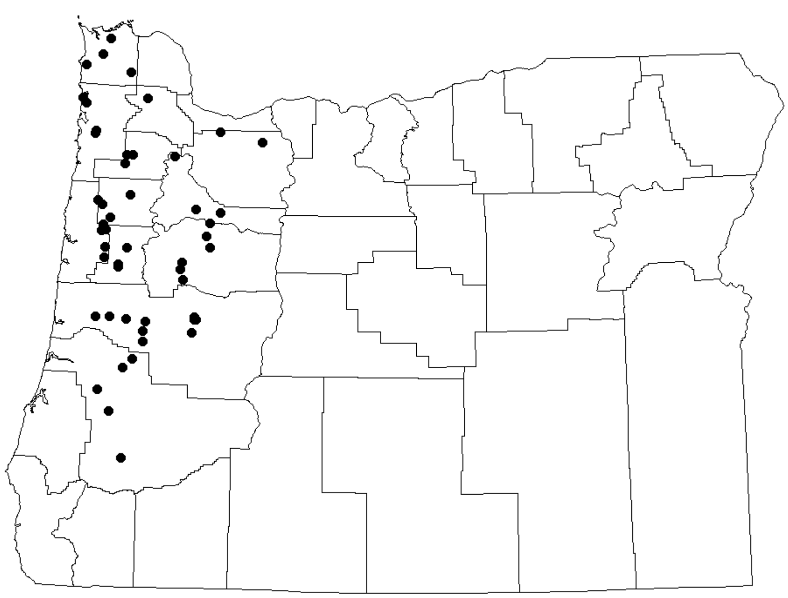

Figure 1: Location of monitoring sites.

EVALUATION OF STREAM CROSSINGS

Written Plan

What percent of stream crossings are in compliance with the written plans? To fully evaluate this key question, there are four elements to consider with regards to written plans and written plan compliance:

1. *Did the written plan have sufficient information to determine which alternative was being used?* The June 1995 and June 1997 ODF stream crossing guidelines describe eight alternatives a landowner can use to provide for juvenile fish passage at stream crossings. The written plans were evaluated to determine which alternative was being implemented so that the field data could be evaluated against the corresponding specifications.

2. *Did the written plan contain enough information for the chosen alternative?* The ODF fish passage guidance manual lists ten elements that should be included in written plans for stream crossing installations. Written plans were evaluated to determine if these elements were addressed. The required written plan elements vary depending on which alternative is selected and include:

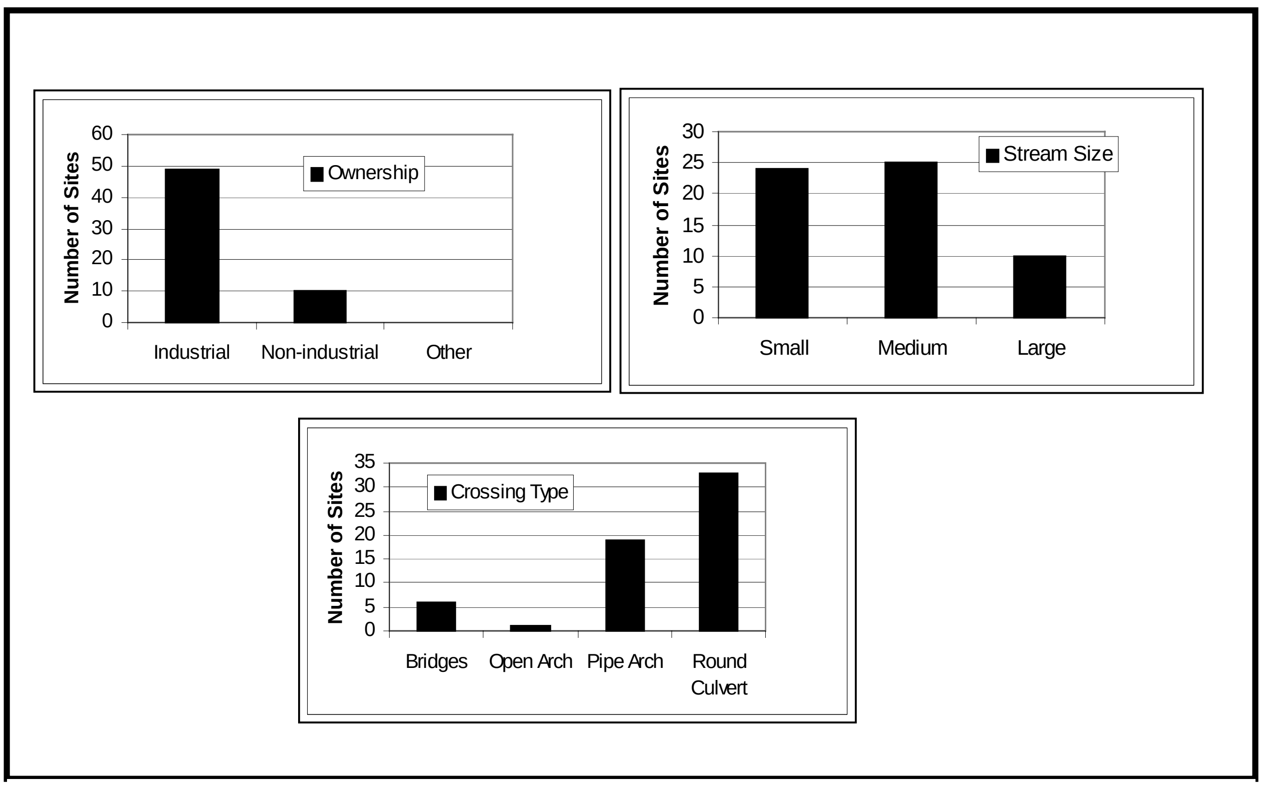

Figure 2: Stream crossing site characteristics.

- Location of crossing
- Size of watershed above the stream crossing and the 50-year peak flow calculation
- Diameter and lengths of culverts to be installed
- Existing stream gradient
- Resulting culvert gradient
- Streambed material
- Amount of valley fill material
- Outlet mitigation structure design
- Inlet design
- Freeboard designs for bridges and open bottomed structures

3. *Did the planned installation meet the guidelines?* This was evaluated by comparing the planned operation as described in the written plan with the criteria in the guidelines. This question investigates if potential installation problems began in the planning phase (see Appendices B and C for evaluation methods and data).

4. *Did the landowner/operator install the crossing as described in the written plan?* This is the purest compliance question since this is ultimately what a landowner must do. To answer this question field data were compared against the specifications in the written plan (see Appendices B and C for evaluation methods and data).

<u>Likelihood to Pass Juvenile Fish</u>
What percent of stream crossings have a high likelihood to pass juvenile fish? Rather than making direct observations of fish passage or taking detailed water velocity measurements, this study assumed that if a crossing met one of the following five criteria it would pass juvenile and adult fish:

1. Bridges and open-bottom arches,
2. Culverts installed at $\leq$ 0.5% gradient with no outlet drop[1],
3. Stream-simulation (sediment retention) culvert strategies with no outlet drop
4. Culverts with baffles or weirs (engineered designs) and no outlet drop, or
5. Culverts with backwatering from outlet mitigation structures.

ODF has issued three technical guidelines in 1995 and 1997 that apply to the structures sampled in this study (Mills and Stone 1995, Robison 1995, and OWEB 1997). Different guidelines applied to the ODF monitoring sites depending on when the written plan regarding installation was approved. Therefore, four of the study sites fell under the January 1995 guidelines, 44 under the June 1995, and nine under the June 1997 guidelines.

It is important to note the nature and timing of these guidelines. Since the guidelines are not the "rule" a landowner can be in compliance with the rule (e.g. culvert passes juvenile fish) but not follow the guidelines (e.g. embedded culvert in too steep of a channel). Such scenarios were considered in compliance.

[1] Where a site referenced the January 1995 (Mills and Stone) ODF fish passage guidelines an outlet drop of one foot or less was permitted.

Implementation of the Guidelines

What percent of stream crossings have been installed in accordance with ODF guidelines? In situations where it was clear which alternative was desired, the field and written plan data were compared against the guideline specifications for the particular alternative (see Appendices B and C for evaluation methods and data). Data were analyzed to determine if installations met the specific criterion regarding stream and valley characteristics, culvert gradient, outlet jumps, outlet mitigation, culvert dimensions, and sediment retention. Culverts installed according to the guidelines should have a high likelihood of both passing adult and juvenile fish and passing the 50-year flow.

50-Year Stream Flow Design

What percent of stream crossings have been installed with adequate capacity for a 50-year flow? A full discussion of this key question requires that three basic questions be addressed in relation to the design flow:

1) *Did the installed structure comply with the written plan?* A site was considered compliant with it's written plan if the installed stream crossing structure had an equal or greater capacity than was planned and passed the 50-year flow as shown in the plan. According to this criterion, however, it is possible to propose a structure too small to pass the 50-year flow and still be compliant with the written plan. Therefore the following question was also investigated.

2) *Was the 50-year flow correctly calculated?* ODF calculated the 50-year peak flow for each site. Watershed area upstream of the crossing was multiplied by the flow per square mile as derived from the ODF peak flow map. Watershed area upstream of the crossing was measured using a Geographic Information System (GIS). The actual crossing was located using a combination of the GPS point that was measured at the site, notification maps and topographic maps. This "ODF calculated" streamflow was compared against that in the written plan.

3) W*ill the stream crossing pass a 50-year flow?* Crossing design, culvert diameter, pipe-arch rise and span, inlet design, depth of embedded material and gradient were measured in the field. These data were used to calculate the volume of water that could be passed through the culvert (capacity). The 50-year design flow as calculated by ODF was compared to the capacity to determine if the crossing was in compliance with peak flow rules (OAR 629-625-0320 2a).

Capacity losses due to sediment retention and baffles were subtracted from the capacity calculations. Measurement and prediction errors were applied to the peak flow analyses.

> *Capacity Losses*. Use of sediment retention strategies and baffled culverts decreases the volume of water that can pass through a culvert. The depth of sediment and height of baffles were measured in the field. These measures were used to calculate the lost stream flow capacity. The losses due to sediment retention were not calculated for crossings installed under the 1995 guidelines. This was decided because those guidelines were not clear on how to deal with these losses.
>
> *Measurement and Prediction Errors*: The field measures were repeated on a subset of sites to determine measurement error. Based on these comparisons, the ability to estimate the 50-year capacity on an existing culvert was plus or minus 7% (p-value = .05).

An additional 10% error exists in the ability to predict the actual 50-year peak flow volume. These errors were applied to the capacity calculations.

RESULTS

The results are presented in the four categories as described above: Written Plans, Likelihood to Pass Juvenile Fish Passage, Implementation of Guidelines, and Peak Flow Capacity. In the following discussions, results will often be reported separately for "random" versus "volunteered" sites. See study design for more detail on this differentiation.

Stream crossings were evaluated by comparing data collected in the field by ODF personnel to written plan data and to the ODF fish passage guidelines. For more details about the evaluation process and results, see the evaluation section of this paper.

Written Plans

Did the written plan contain the necessary information to determine which of the eight installation alternatives was being used?

Forty-two out of 57 written plans (74%), contained the necessary information to determine which alternative was being used. It is important that written plans reflect this information for both administrative and monitoring purposes. When the alternative is not clearly stated then assumptions must be made to determine if the guidelines were properly implemented and if the installation goals were achieved.

Did the written plan contain the recommended information for the particular alternative?

The technical ODF guidelines provide a list of data that should be included in written plans to allow department personnel to judge the soundness of the installation proposal (see Evaluation of Stream Crossings section in this paper). Of the 42 sites with known alternatives, only 10 of the 23 random sites (43%) and two of the 19 volunteered sites (11%) contained the minimum amount of recommended detail. Figure 3 shows specifically what data were contained in the written plans.

Was the written plan properly implemented?

Seventy-eight percent of the random sites and 75 percent of the volunteered sites implemented the alternatives described in the written plans (Figure 4). The most common source of non-compliance with the volunteered written plans resulted from culverts installed at steeper gradients than planned (4 of 5 plans). The more common source of non-compliance with the random written plans were with a combination of culvert gradient and outlet drop. In many cases there was not enough data in the written plan to determine compliance with the recommended installation specifications.

Did the planned installation meet the guidelines?

Improper implementation of the guidelines sometimes began with poor planning. Where the alternative being used at the site was known, only 69% of the written plans actually planned for an installation that would have met the guidelines. The most common problem was that written plans proposed to install culverts steeper than recommended in the guidelines for the particular alternative.

Only one site's plan proposed to install an alternative inappropriate for the channel gradient according to the guidelines, though ODF measurements of channel gradients found nine sites fell

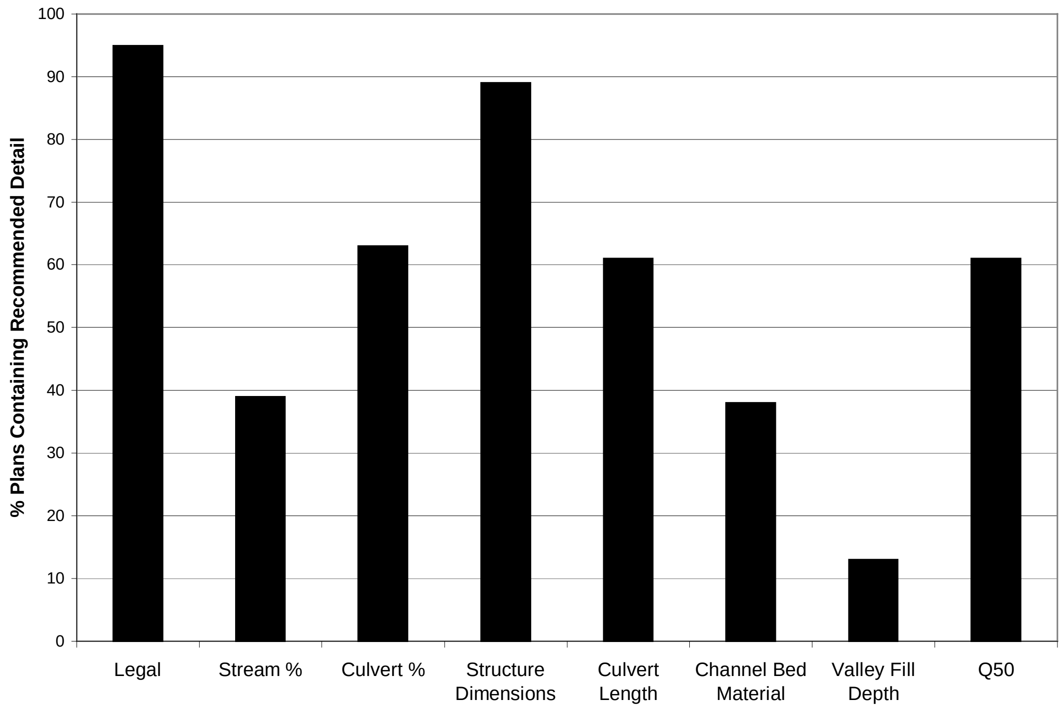

Figure 3: Percent of plans containing recommended written plan details. Q50 denotes 50-year flow calculations.

into this category in the field. One plan designed for a culvert gradient substantially different from that of the channel (Channel Gradient – Culvert Gradient > Guidelines), which can result in erosion at the outlet. Channel gradient can be a difficult parameter to measure in the field, and this shows in the lower correlation between ODF and written plan values (Figure 5).

On average, correlation between ODF and written plan channel gradients is high (0.02% difference), but differences between the values vary from 0 to 9%. To improve confidence in ODF measurement of channel gradient, the protocol was modified for the 1999 and 2000 field seasons to require clinometer measurements of gradient to be shot at a level rod.

Likelihood to Pass Juvenile Fish

What percent of stream crossings have a high likelihood to pass juvenile fish?

Results indicate that based on the assumptions described in the study design, a total of 38 out of 57 (67%) sites are considered likely to pass juvenile and adult fish. The random sites had less likelihood of passing juvenile fish than the volunteer sites. Fifty-nine percent of the random sites were likely to pass juvenile fish compared while 80% of the volunteered sites were likely to pass juvenile fish (Figure 5). However, six of the 22 random sites were bridges and one was an open arch culvert. The likelihood to pass juvenile fish drops to 50% when calculated without these sites. This is an indication of the difficulty in providing juvenile fish passage through culverts.

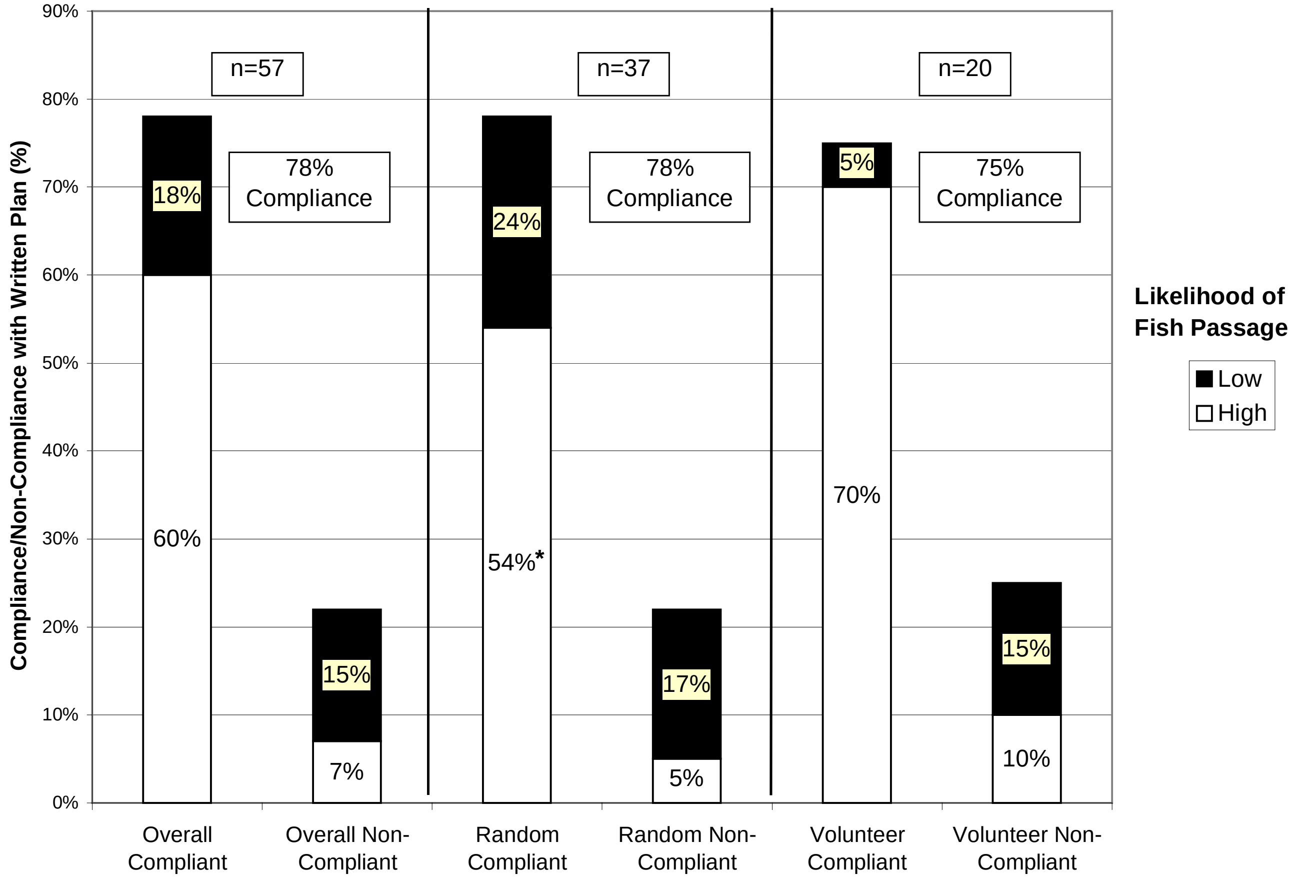

Figure 4. Compliance with alternatives described in the written plan and likelihood to pass juvenile fish. *Six of these sites were bridges and one an open arch culvert. The likelihood to pass fish drops to 50% when calculated without these seven sites.

Of the 38 sites that are likely to pass juvenile fish, ten crossings had culverts laid at a 0.5% or less with no measurable outlet drop. Another 14 achieved stream simulation or continuous rock within the pipe (both planned and unplanned) and no measurable outlet drop. Six relied on both sediment retention and gradients $\leq$ 0.5% to pass juvenile fish. Of the eight remaining sites that passed juvenile fish, one used baffles, one used an open arch culvert, and six were bridges.

Of the 19 sites considered unlikely to pass juvenile fish, the most common barrier was too steep a culvert with no sediment retention. Fifteen were culverts laid at gradients > 0.5% without retaining sediment, three had gradients > 0.5% and no sediment retention combined with measurable outlet drops (> 0.5 feet), and one was a baffled culvert with an outlet drop. Of these 19 sites, nine were evaluated as being non-compliant with their written plans. Had the written plans been successfully installed, overall fish passage rates would have increased to 75% (+5 sites). The other four sites either proposed a design with a low likelihood of passing fish or there was not enough information in the written plan to make a determination.

Figure 4 suggests an apparent contradiction, namely that ten of the 19 sites with a low likelihood of passing fish were considered compliant with their written plans. Seven of these sites were unsuccessful in achieving complete sediment retention as planned (Alternatives 4 and 5). These pipes may or may not completely fill in over time and may need to be manually seeded with cobble.

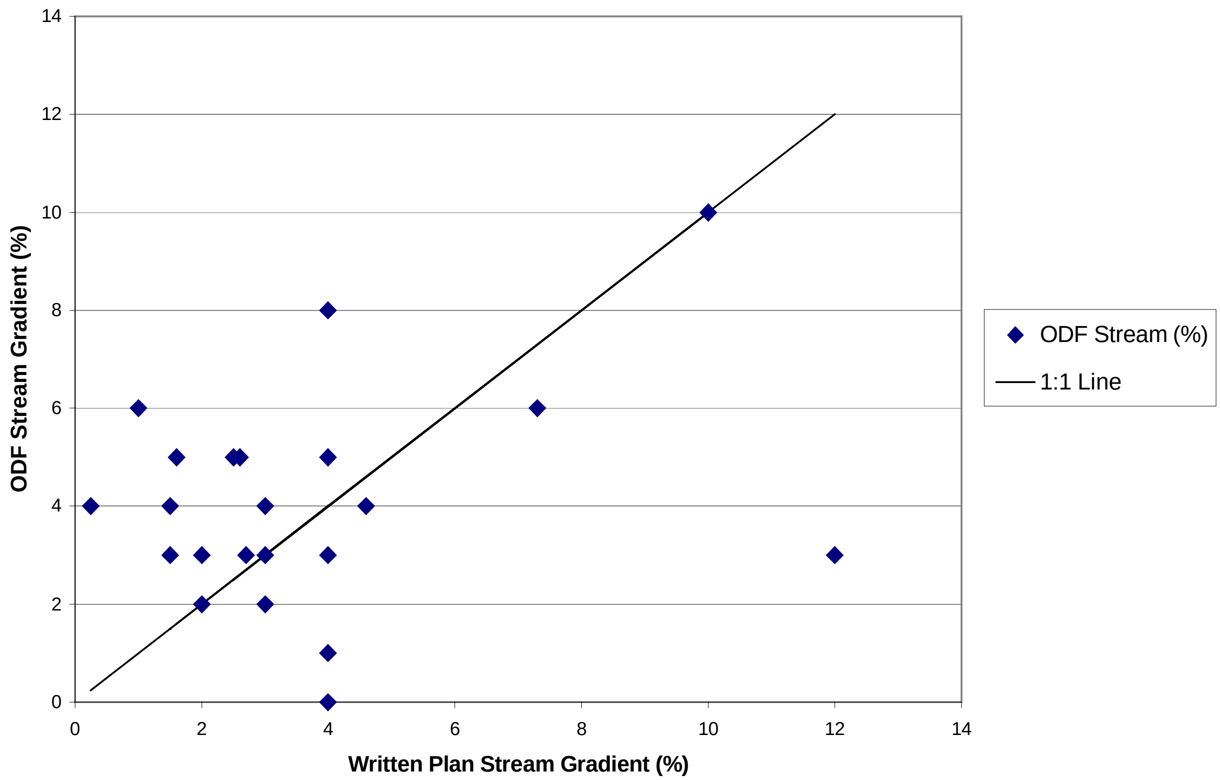

Figure 5: Channel gradient as recorded in the written plan versus that measured by ODF.

Implementation of Guidelines

What percent of stream crossings have been installed in accordance with ODF guidelines? To assess implementation of guidelines, field data collected at each site were compared against applicable guideline criteria. For example, if the written plan indicated alternative 1 was being used, field data on culvert gradient and outlet drop were measured against the 0.5% culvert gradient requirement and zero measurable outlet drop. However, the planned alternative could not be deciphered on 15 sites. These are referred to as "unknown alternatives" and are discussed later. Overall, 52% of the sites installed culverts in accordance with the guidelines (excluding unknown alternatives).

The most common reasons for sites not meeting the guidelines were for installing culverts at too steep a gradient for the chosen alternative (11 sites) and for selecting an alternative that was inappropriate for the channel gradient (9 sites) (see Figures 6 and 7)[2]. Additional issues included outlet drops, culvert length, and installing culverts at gradients substantially less than the channel gradient[3].

Did particular ODF guideline fish passage alternatives have greater success? The sample size collected for the pilot study does not permit definitive conclusions to indicate that one alternative is being installed more successfully than another. The small sample size is further

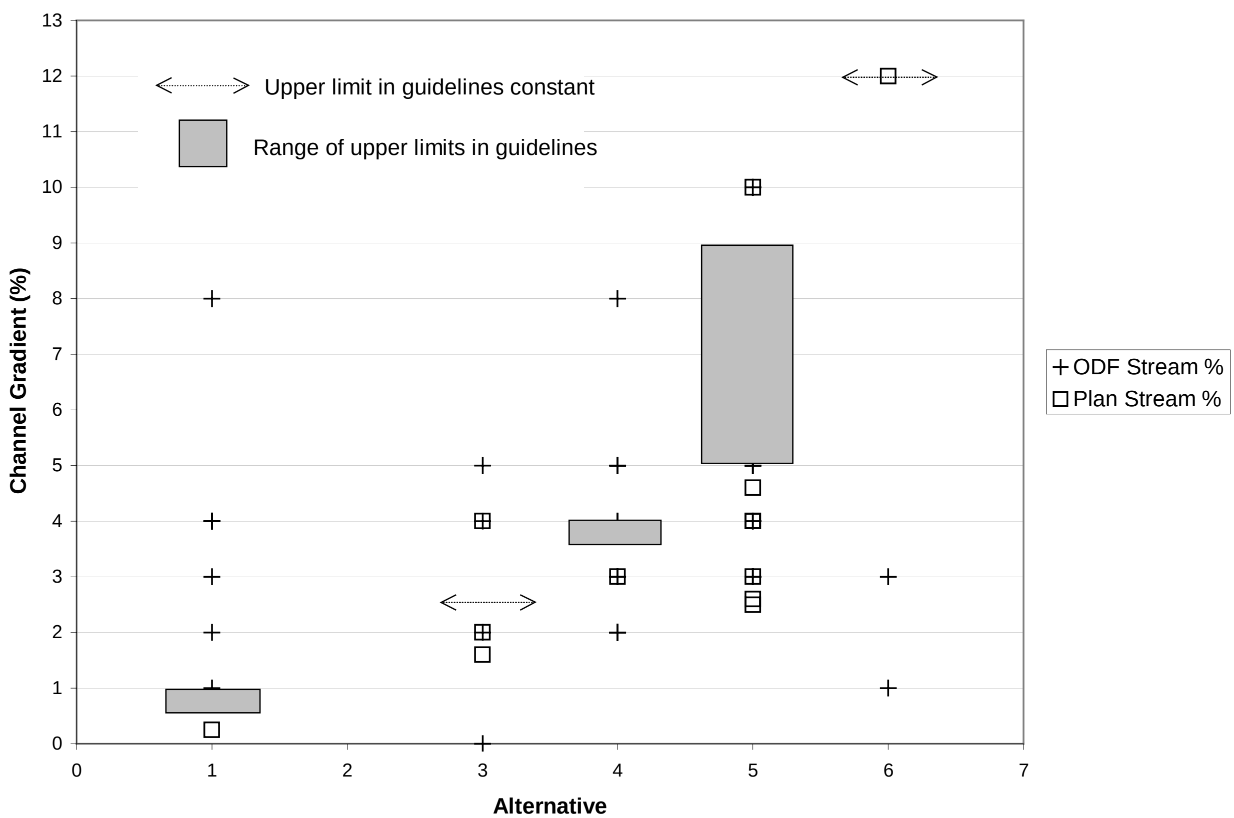

Figure 6: Channel gradient at stream crossings for six guideline alternatives. As the data reflects different guideline years, the upper limit of acceptable channel gradients may have changed over time (shaded boxes) or remained constant (dotted arrows). Channel gradients were not provided in all written plans, so the number of ODF channel gradients exceeds the number of written plan values.

exacerbated by the fact that 26% of the written plans did not have enough information to determine which strategy was trying to be achieved. Finally, the results are confounded by the large number

[2] Guideline criteria specify the range of channel gradients for which different alternatives are appropriate (e.g. Alternative 4 is appropriate for channel gradients 3.5%-4%, depending on guideline version).
[3] Certain alternatives are judged against a guideline criterion specifying the allowable difference between the channel and culvert gradient (Channel gradient – Culvert gradient > Guideline Criterion).

of sites that were volunteered for this study. The ability to test comparative success between strategies will be more robust with the 100 randomly selected sites currently being monitored.

The only alternatives with a large enough sample size to warrant further discussion were alternatives 4 (n=11), 5 (n=9) and installations with unknown alternatives (n=16). Alternative 4 requires burying the culvert equally at both ends to retain sediment. The sediment provides velocity refuge for juvenile and adult fish where they can rest as they make their way through the culvert. Alternative 4 is recommended for use in streams up to 3.5 - 4% gradient, depending on the guideline version referenced. For this alternative, 55% (6/11) of the culverts were installed in accordance with the guidelines. None of the sites, however, contained enough information in the written plans to allow for a complete evaluation and were comprised almost entirely of volunteered sites (8 out of 11).

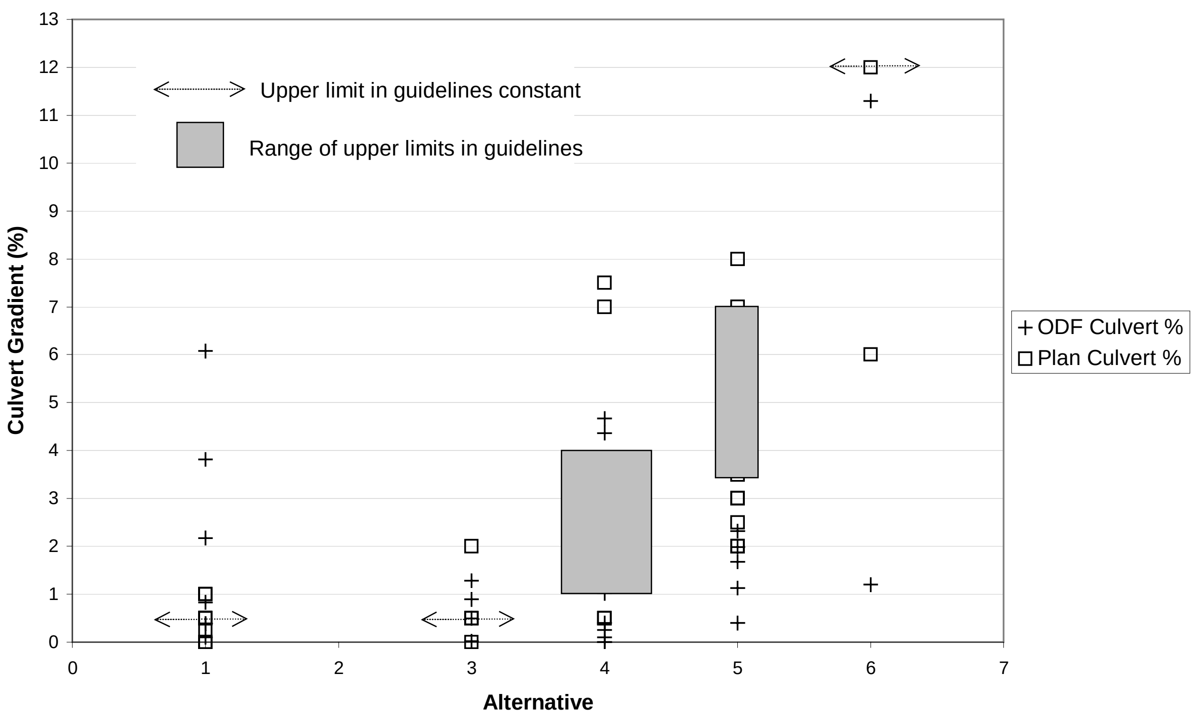

Figure 7: Culvert gradient at stream crossings for six guideline alternatives. As the data reflects different guideline years, the upper limit of acceptable culvert gradients may have changed over time (shaded boxes) or remained constant (dotted arrows). Culvert gradients were not provided in all written plans, so the number of ODF culvert gradients exceeds the number of written plan values.

Alternative 5 also relies on sediment retention strategies, but the inlet is buried to a greater depth allowing for use in streams as steep as 5 - 9%, depending on the guideline version referenced. Installation success with this alternative was similar to alternative 4 with 56% (5 of 9) of the culverts installed in accordance with the guidelines. Written plans contained more information. Three of the nine sites had all necessary data in the written plans, while the other six sites were lacking only two to three parameters, usually the type and depth of substrate at the site. Only two of the sites using this alternative were volunteered.

Since alternatives 4 and 5 relied on sediment retention strategies, it's important to consider success of sediment retention. Sediment retention pattern data were collected at 20 applicable sites. Fifty percent retained sediment for the full length of the pipe and another 35% were either barren only at the inlet or contained sparse rock (see Figure 7). The field protocol has been modified to enable an analysis of the influence of countersinking depth on sediment retention, an analysis that could not be done with the pilot study data.

The target alternative could not be deciphered from written plans for 15 sites. Fourteen of these sites were randomly selected. Agreement with the guidelines can only be evaluated with two criteria: outlet drops and capacity. Sixty-seven percent of the culverts were installed in accordance with these criterion. Insufficient capacity to pass the 50-year flow based on ODF calculations and measurable outlet drops caused the low rate of agreement between written plans and ODF guidelines for these 15 sites.

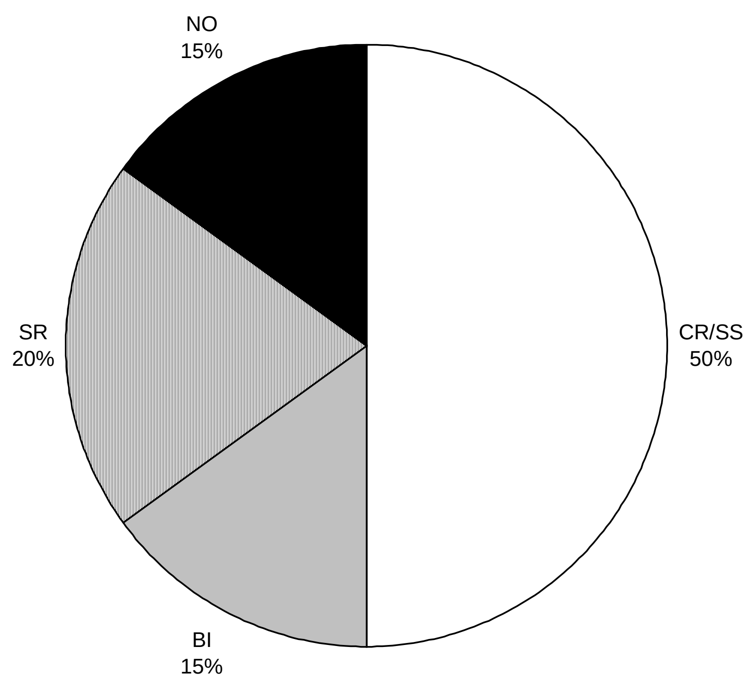

Figure 8: Percentage and pattern of sediment retention with stream-simulation strategies (Alternative 4 and 5). CR/SS: Continuous rock or stream simulation, BI: Barren at the inlet, SR: Sparse rock, NO: No sediment retention.

50-year Stream Flow Design

Did the installation capacity comply with the 50-year flow calculation in the written plan?
A site was considered compliant with it's written plan if the installed stream crossing structure had a capacity equal to or greater than the 50-year flow as shown in the plan. By this criterion,

compliance was 97%. However, only 35 (61%) of the sites actually had enough information in their written plans for this comparison to be made. Furthermore, it is possible to propose a structure too small to pass the 50-year flow and still be compliant with the written plan. This issue is addressed below.

Was the 50-year flow calculated correctly?

Ten of the 35 (29%) sites with 50-year flow calculations in the written plan estimated flood flows that were less than those calculated by ODF. These sites ranged from 2% to 16% lower flow values than ODF, but only three sites differed from the ODF values by greater than 5%.

On average, the difference between written plan and ODF flood flow values was greater where plan calculations had higher flow values. These remaining 15 sites exceeded ODF calculations by 1% to 67% and were 17% greater on average. The greatest differences between ODF and written plan values were due to watershed acreage discrepancies, though acreages were similar overall (average Plan acres/ODF acres = 0.99). Furthermore, the cubic feet per square mile (CSM) value chosen for the written plan tended to be more conservative (larger) than that chosen by ODF (average Plan CSM was 10% greater).

Where the written plan calculated a lower 50-year flow value than ODF, did this necessarily mean that road-crossing designers would have planned to install a structure smaller than what ODF would have chosen? Of these ten sites, three of the structure capacities proposed in the plan would not have passed the 50-year flow as calculated by ODF. The flood passage problem was compounded by the fact that these three sites had reduced culvert capacities due to sediment-retention and baffled designs, which was apparently unaccounted for in the written plans.

It was also possible to make this comparison (planned structure capacity vs. ODF 50-year flow) where a written plan provided structure dimensions but no flow calculations (for a combined total of 51 sites). All of the capacities proposed in these plans, however, would have passed the ODF flood flow. Therefore, 94% (48/51) of the sites had written plan structure capacities that would have passed the 50-year flow as determined by ODF.

Will the installed structure pass a 50-year peak flow?

Ninety-one percent (52 out of 57) of installed structures would have passed the ODF calculated 50-year flow. Of the five that did not, four sites did not provide written plan calculations of the 50-year flow and the fifth calculated a lower flow value than ODF. All five of these sites did, however, provide structure capacities in the written plan, and not planning for capacity losses due to sediment retention and baffled designs was a problem for two sites. Were sites without 50-year flow calculations more prone to not pass the ODF flood flow than sites where the data was readily available in the written plan? Eighteen percent (4/22) of the sites without data would not have passed the ODF flood flow as opposed to a 3% (1/35) non-passing rate, suggesting that more complete 50-year flow calculations in the written plan may result in more success at installing a flood-resistant structure.

SUMMARY AND DISCUSSION

Written Plans

The results indicate that 78% of the random sites were in compliance with their written plans. However, only 74% contained enough information in the written plans to determine installation objectives, and only 29% of these plans had sufficient details for a complete evaluation against the guidelines. These results suggest a need for increased emphasis on detailed written plans. The written plan is an important tool for department personnel to use when determining compliance, assessing the soundness of the operation proposal, and evaluating the effectiveness of proposed guideline alternatives. Lower rates of installation success with regards to the 50-year flow was observed when there was less detail in written plans. This is due in part to culvert capacity losses from sediment-retention and baffle/weir designs not being accounted for in the design flow calculations. Furthermore, 31% of the written plans with known alternatives proposed stream-crossing designs that did not meet the guidelines.

Juvenile Fish Passage and Implementation of the Guidelines

It is critical to note that to our knowledge no other agency has implemented a monitoring project that assesses structures with the level of scrutiny that matches that of this ODF monitoring project. ODF considered the installation strategy and its appropriateness for the stream channel (e.g. gradient and valley type) as a measure of successful implementation of the guidelines. The likelihood of fish passage was also based on a set of assumptions about the hydraulic conditions provided by the stream crossing alternative designs. Therefore, care must be taken in comparing ODF findings to other reports.

Fifty-two percent of the sites installed culverts in accordance with the guidelines (excluding unknown alternatives). The most common reasons for sites not meeting the guidelines were installing culverts at too steep a gradient for the chosen alternative and for selecting an alternative that was inappropriate for the channel gradient (see Figures 6 and 7). Additional issues included outlet drops, culvert length, and installing culverts at gradients substantially less than the channel gradient.

Based on the conditions assumed to provide fish passage, only 59% of the random sites have a high likelihood to pass juvenile fish, while 80% of the volunteered sites are highly likely to pass juvenile fish (see Evaluation of Stream Crossings, Likelihood to Pass Juvenile Fish). The overall average is approximately 67%. With such a small sample size caution should be used in trying to apply these numbers to the total population of new installations. Despite the small sample size, the study does highlight four important points:

- *Innovative solutions to juvenile fish passage involve a paradigm shift in stream crossing design*. Current guidelines are based on scientific findings regarding the biological needs of juvenile fish. The new stream crossing installations are an attempt to accommodate biological needs while still meeting the infrastructure needs. These approaches require sediment retention and/or slow moving water in culverts. Traditionally the goal was to move water through culverts as quickly as possible and keep the culvert clear of all material. Therefore, fish-friendly installations require a change in approach.

- *The contemporary nature of juvenile fish passage regulations*. The guidelines that recommended eight juvenile fish passage alternatives were first released five years ago and have been modified three times. The landowner, operators, and department personnel are still learning how to achieve the standards described therein. The guidelines require rigorous design plans and careful assessments of channel characteristics for successful implementation.

- *More detail is needed in written plans*. While the sample size is extremely low, these results also emphasize that written plans do not contain an adequate level of detail. More detail (chosen alternative, culvert grade, channel grade, valley fill depth, etc.) is needed for department personnel to judge the soundness of the plan and the likelihood that the installation will provide juvenile fish passage.

- *There is a continued need for stream crossing workshops*. Findings suggest a need for more training on the guidelines for landowners, operators and ODF personnel. Training should focus on guideline criteria, identification of strategies appropriate for various channel types, methods and tools for measuring stream crossing parameters, and improving documentation.

50-year Stream Flow Design

Compliance with the 50-year flow calculation provided in the written plan was high (97%), but only 61% (35 out of 57) of the written plans actually contained complete peak flow calculations. Of the 35 written plans with peak flow calculations, 91% (32 out of 35) were considered accurate when compared to ODF calculations. Differences between ODF and landowner calculations were mostly attributable to discrepancies in acreage estimations. Ninety-one percent (52 out of 57) of the installations were estimated to pass the ODF-calculated 50-year flow. Four out of the five with insufficient capacity did not provide peak flow calculations in the written plan.

RECOMMENDATIONS

Monitoring

Implement Final Version of the Stream Crossing Monitoring Protocol. ODF has initiated the implementation of this monitoring project on a larger random sample. Fifty sites were visited in 1999 and an additional 50 sites will be visited in 2000. The larger random sample will be used to confirm or reject the pilot study findings and delve into some of the issues that were not adequately addressed with this pilot study.

ODF should develop methods to monitor the effectiveness of the alternative designs to pass juvenile fish. Current guidelines apply scientific knowledge about biological needs to culvert design. The assumptions are that (1) current guidelines accommodate juvenile fish physical limitations and that (2) passage can be provided if the physical needs (e.g. stream velocity, jumping heights, water depths) of the juvenile fish are met. These assumptions need to be tested in the field.

ODF should develop methods to monitor maintenance issues associated with these fish-friendly stream crossings. The guidelines propose designs to pass juvenile and adult fish and the 50-year flow, but still in question are how long they will last and what kind of maintenance program is required to assure fish passage and capacity for the design flow over time. These kinds of issues need to be monitored to determine the durability, longevity and maintenance issues with fish-friendly culverts.

Policy

There is no indication at this point that the Forest Practices policies need to be changed. The FPA requires that juvenile fish passage is provided on all fish-bearing streams. The ODF guidance represents the cutting edge of what is understood about juvenile fish needs and the ability to provide stream-crossing conditions that meet those needs. However there are three recommendations which may improve the program delivery:

Increase the consistency and the amount of information that is exchanged between the department and the landowner in written plans for stream crossings. Written plans should provide greater detail on what is trying to be achieved by referencing a specific guideline alternative (e.g. alternative 7: open bottom arch) and listing the recommended elements (e.g. resulting culvert grade, stream gradient, valley fill) for that alternative. Where the planner is intentionally choosing a design or design characteristics that are outside of criteria outlined in the guidelines, this should also be specified. An example of an excellent written plan from the pilot study is shown in Appendix D.

Update the Forest Practices Rule and Statute Guidance Manual to Include a Synopsis of the Fish Passage Guidance. The ODF Guidance Manual is a document used by department personnel and available to the public, which provides greater detail on how rules should be implemented. As a means of addressing the written plan content concerns described above, Table 2 was developed to summarize the applicable criteria that should be included in written plans and which criteria apply to each alternative. This level of detail would increase the ability of the Forest Practices Forester, the ODF hydrologist and landowners to judge if the strategy is appropriate for the particular stream and to more accurately determine compliance.

Furthermore, under the 1999 Juvenile Fish Passage Guidelines, the six alternatives described are summarized in Table 3. Tables 2 and 3, or something similar to them, should be embedded in the official ODF guidance manual. This will provide more consistent access to the most recent information about necessary written plan data and juvenile fish passage strategies for department personnel.

ODF should continue to provide education and training opportunities for landowners, operators and department personnel. ODF provided three training sessions in northwest, southwest, and eastern Oregon in the spring of 1999 for landowners and Forest Practices Foresters. The training covered the goals and methods for passing juvenile fish through culverts. These training sessions were well attended and a valuable exchange of information took place between the department, landowners and other experts in the field of juvenile fish passage.

The department also co-sponsored a forest road stewardship workshop with Oregon State University in March of 2000. Part of the agenda addressed juvenile fish passage. A series of workshops sponsored by OFRI and For the Sake of Salmon is going to be offered in Summer 2000. These workshops will provide training on juvenile fish passage issues.

In addition to training on the concepts of stream crossing design, further emphasis needs to be placed on ensuring consistency and accuracy of the measurements necessary for the planning and evaluation of these crossings. Some examples of this would include discussion and demonstration of the ideal tools to measure culvert gradient (e.g. clinometers vs. levels), channel gradient, and culvert outlet drops. Maintaining a dialogue with Forest Practices Foresters, landowners, and land managers will help to ensure consistency in how stream crossing parameters are measured.

Table 2: Criteria that should be included in written plans for various guideline alternatives.

Required Criteria to Include in the Written Plans	Alternative
List one of the alternative numbers 1-6 from 1999 Guidelines that is being attempted OR clearly describe strategy for unique design	All alternatives.
Legal location (Township, range, section)	All alternatives
Channel gradient	All alternatives
Resulting culvert gradient	3, 4, 5 and 6
Active channel width	2 – 6
50-year flow calculation • Acreage or square miles AND • Cubic feet per square mile (CMS) as chosen from ODF Peak Flow Map AND • Design flow (CFS) OR • Complete calculation if using method other than ODF Peak Flow Map • Culvert capacity losses to sediment retention or baffled design (Alternatives 3 and 6) • Adjustment for wide floodplains/overflow dips (Include where applicable) • Calculation and diagram for bridge capacity (Alternative 1)	All alternatives
Difference between the channel and culvert gradient	3
Elevation change over length of crossing	5
Depth of inlet sinking	3 and 4
Depth of outlet sinking	3
Channel bed material	3 and 4
Valley fill depth	2, 3 and 4
Downstream weirs • Outlet weir spacings (relative to outlet and channel width) • Outlet weir heights (relative to inlet elevation and weir drop heights)	5 or where outlet weirs are used
Baffle/weir designs • Baffle/weir configuration • Depth of flow calculations • Energy dissipation calculations at design flows • Other calculations/diagrams pertinent to design	6

Table 3: Summary of stream crossing installation criteria for each alternative in the 1999 ODF Fish Passage Guidelines.

Alternative[1]	Channel Gradient (%)	Culvert Gradient (%)	Outlet Drop (ft)	Channel – Culvert Gradient (%)	Elevation Change (ft)	Culvert Diameter or Span = Active Channel Width	Inlet Depth	Outlet Depth (ft)	Channel Bed Material	Valley Fill Depth
1. Bridge	No limit	--	--	--	--	Y	--	--	--	--
2. Open arch culvert	No limit	No limit	--	--	--	Y	--	--	--	Shallow (near bedrock)
3a. Streambed Simulation (Round Culvert)	≤8% (difficult >4%)	≤8% (difficult >4%)	0 ft.	≤1.5% (up to 3% with care)	--	Y	At least 40%*diameter or 2 feet (use greater value)	At least 40%*diameter or 2 feet (use greater value)	≤Cobble (few boulders)	Deep (no bedrock)
3b. Streambed Simulation (Pipe Arch)	≤8% (difficult >4%)	≤8% (difficult >4%)	0 ft.	≤1.5% (up to 3% with care)	--	Y	At least 20%*rise or 18 inches (use greater value)	At least 20%*rise or 18 inches (use greater value)	≤Cobble (few boulders)	Deep (no bedrock)
4. Culvert placed at 0% gradient	≤2.5%	≤0.5% (Plan for 0%)	0 ft.	--	--	Y	If sinking inlet: 6 inches or greater	--	If sinking inlet: ≤Cobble (few boulders)	If sinking inlet: deep (no bedrock)
5. Culvert w/outlet backwatering[2]	≤4%	--	0 ft.	--	≤2 ft	Y	--	--	--	--
6. Weir/baffle culverts[3]	≤12%	≤12%	0 ft.	--	--	Y	--	--	--	--

[1]All alternatives must show complete calculations for the 50-year design flood flow. This includes the watershed area, cubic feet per square mile (CMS), and final flood flow calculation in cubic feet per second (CFS) if using the ODF method OR a complete calculation for an approved alternate peak flow estimation technique. If a bridge is being installed, a diagram and calculation of the capacity with three feet of freeboard is required.

[2] Also required: (A) Outlet weir spacing – first downstream weir 10-15 feet from outlet or two channel widths with subsequent weirs placed 1-2 channel widths apart (B) Outlet weir heights – first downstream weir set at eight inches greater elevation than the elevation of the culvert inlet and subsequent weirs with drops less than or equal to six inches.

[3] Expertise and/or experience in hydraulic engineering required for this design. Written plan should include diagram and description of baffle/weir configurations, depth of flow calculations, energy dissipation calculations at design flows, and other necessary information.

Shaded alternatives must account for culvert capacity losses due to sediment retention or baffle/weir designs in the 50-year flow calculation.

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APPENDIX A: DETAILED FIELD METHODS

APPENDIX A: DETAILED FIELD METHODS

Note: The complete protocol is available upon request. The methods described here represent what is currently being used by the ODF to monitor stream crossings.

SITE SELECTION

One hundred fish-bearing stream sites will be randomly selected from a population of 1580 notifications in 1998. The selection will be stratified by ODF districts and by landowner class. Each district sample will be stratified by the total number of notifications for each landowner type (industrial, non-industrial, or other) with road construction activities occurring within 100 feet of waters of the state. To ensure adequate representation across the state, we will randomly select 5% from each ODF district or a minimum of five sites per district. Some of the sites in this population will not meet the needs of the study for one of the following reasons: the stream is not a type F stream, the operation did not take place, and/or there is not a stream crossing. In these instances, a new site will be selected.

FIELD METHODS

The following methods were drawn from three documents:

- *Oregon Department of Forestry's Best Management Compliance Audit Project, Version 3.0* (Dent, 1998),
- ODF memorandum titled *Interim fish passage guidance at road crossings* (Robison, June 16, 1995), and
- *Oregon Road/Stream Crossing Restoration Guide: summer 1998 draft* (Oregon Plan for Salmon and Watersheds, 1998).

The following measurements and information will be taken at all fish-bearing stream crossings for each site. Refer to figure 3 for a schematic of features.

GENERAL INFORMATION

Notification Number:	From notification
Road number:	If there isn't one use NA.
Road name:	If the road does not have a name, then assign a name (perhaps after a nearby stream, or harvest unit).
Georegion:	Coast, South Coast, Interior, Blue Mountains, East Cascades, West Cascades, or Siskiyou
Legal:	Township, range, and section
Landowner:	Industrial, Non-industrial, or Other (State, county, non-profit, etc.)
Operation:	Construction or Reconstruction
Year (4 digits):	Completion date of roadwork.

Reason for reconstruction: Flood Repair, Reopen, Oregon Plan, Maintenance, Other

Photo documentation: #1 looking upstream with jump in photo, #2 inside the barrel looking upstream, and #3 looking downstream at inlet

Crossing Identification: notification number.

Structure Location: GPS reading or latitude and longitude from a map if a reading is not possible.

Stream classification: Taken from notification or written plan when available, checked with ODF fish presence maps.

S Small
M Medium
L Large

Structure Information

Crossing Shape (code):

RC Round Culvert
PA Pipe Arch
OA Open-Arch
BR Bridge
FD Ford
OT Other

Structure size: Diameter (in) and length (ft) for round culvert,
Length, rise and span (ft) for arches,
Span (ft) for bridge or ford.

Resulting culvert gradient (%): measured with a transit level. Crew will record the elevation at each end of the culvert and divide by culvert length. Where the culvert inlet is beveled, care must be taken to ensure that the culvert length measured corresponds to the length over which the transit level measurements were observed.

Culvert condition: will be described as good, mechanical damage, rusted, bottom out, collapsed or other (specify).

Footing condition: for bridges and open-bottom arches will be described as

ST Stable
ER Eroding
FL Failing

OVERFLOW DIP MEASURES

Overflow dip: may be used on roads built on wide flood plains (use NA if not present). Using a transit level the crew will measure the elevation of the structure, the lowest elevation of the dip, and the elevation of the lowest point controlling the capacity of the overflow dip. The width of the overflow dip is measured from the height of the lowest point controlling the overflow dip capacity to the opposite side of the dip.

Overflow dip ***road surface*** *armor (code):* Using the codes in table 1, classify the size of material used to armor the road surface of the dip (may be more than one, but no more than three).

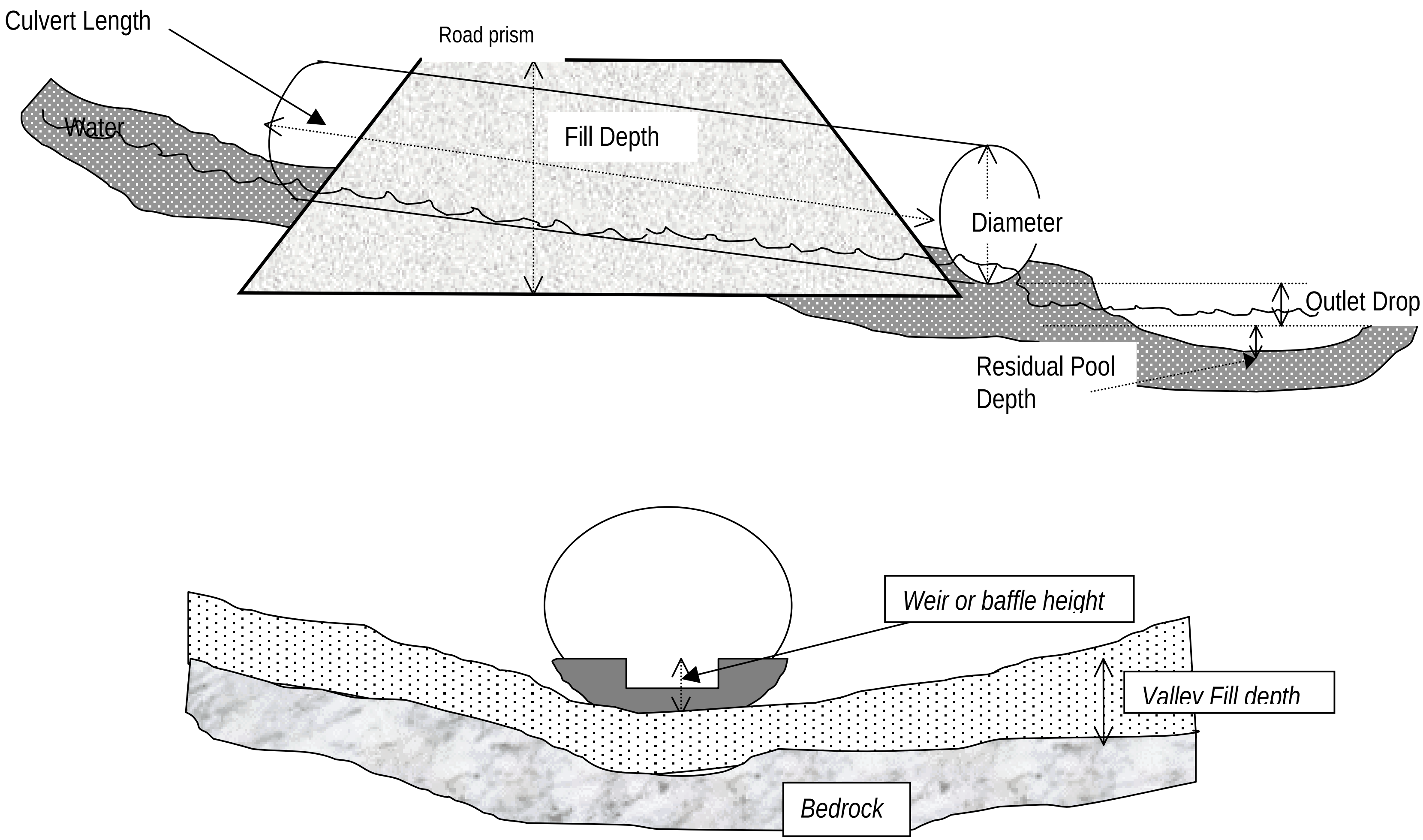


Figure 1. Culvert schematic and measurements for monitoring fish passage and 50-year flow design.

Overflow dip ***road fill*** *armor size:* Using the codes in table 1, classify the size of material used to armor the road fill associated with the dip (may be more than one but no more than three codes). This is recorded separately for the downstream and upstream sides of the crossing.

Table 1. Codes used for size classification of material used in road fill armor, road surface armor, stream crossing structures, and channel substrate.

Code	*Material*	*Size description*
BD	Bedrock	Bigger than a car/continuous layer
BL	Boulders	Basketball to car-sized
CB	Cobble	Tennis ball to basketball
GR	*Gravel*	Ladybug to tennis ball
FN	Fines	Silt/clay muck to visible particle; gritty
NO	---	None
NA	---	Not applicable

Overflow dip road surface condition:

ST	Stable
ER	Eroding
FL	Failing

Overflow dip road fill condition:

ST	Stable
ER	Eroding
FL	Failing

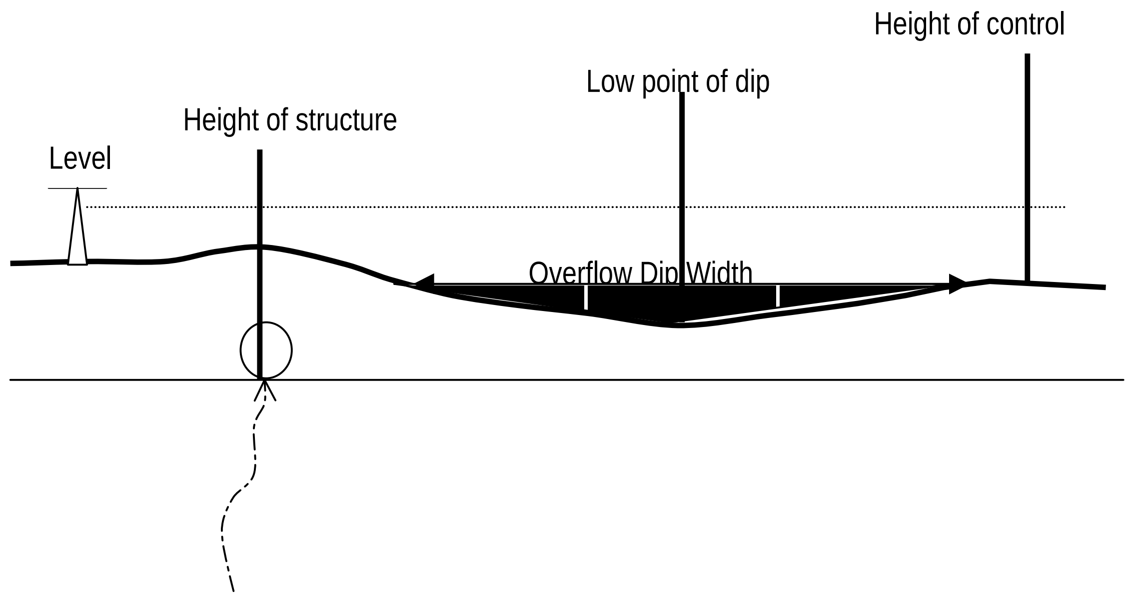
Dip width: The width of the overflow dip is measured from the height of the lowest point controlling the overflow dip capacity to the opposite side of the dip.

Distance from dip to structure: Measured from the center of the crossing structure to the lowest point in the dip.

Dip low point: Lowest point in the overflow dip relative to the crossing structure as measured with the level.

Dip control point: Lowest point of the two upper boundaries of the overflow dip controlling the capacity of the overflow dip.

Overflow Elevation (ft): The difference between the height of the culvert bottom and the height of the bottom of the overflow dip.



OUTLET MEASURES

Outlet drop (ft): the difference between the heights of the downstream control point (controlling the residual[4] water surface) and the culvert outlet as measured with a level. If residual water surface is above the bottom of the culvert, these measurements will have a negative value.

Residual pool depth (ft): max depth of residual pool below the outlet drop.

Outlet mitigation structure type[5]

GW	Gabion weirs
RW	Rock weirs
WD	Woody debris
WR	Wood and rock
NO	None
OT	Other, explain

Intent: According to the landowner/crossing designer, was the intent of the outlet structure to mitigate an outlet drop (OD), to backwater the culvert (BA), to retain sediment within the culvert (SR), or other (OT, explain).

Backwatering (ft): Length of backwatering within the pipe due to outlet mitigation.

Outlet mitigation drop (ft): measured from the residual water surface of the structure to the residual water surface below the structure. If more than one structure (multiple weirs) there will be a measure between each structure.

Distance between outlet mitigation and crossing (ft): Measured from the outlet to the mitigation

[4] Residual pool is defined as the remaining pool that exists when riffles are de-watered
[5] Mitigation structures are installed downstream of culverts to back water into the culverts or to retain sediment.

structure, if there are multiple structures crew will document distance between them.

Condition of outlet structures:	ST	Stable
	BE	Bank erosion around structure
	UC	Actively undercutting structure
	SD	Sediment deposition behind structures has filled to elevation of outlet

Stream condition of structure: Wetted: water flows over the residual nick point
De-watered: Structure has no water flowing over the residual nick point

BAFFLE MEASURES

Baffle design:	WB	Weir baffles
	OF	Offset weir
	PW	*Porior design notch weir*
	NW	Notch Weir
	MW	Multiple weirs
	SR	Sediment Rack
	OW	1 Outlet Weir only
	OT	Other
	NO	None

Distance between baffles (ft)*:* average for multiple weirs**.**

Distance between last baffle and outlet (ft): Measured from the base of the last baffle to the outer edge of the culvert.

Height of Baffle: measured at the highest point of the baffle.

Depth of Baffle Notch (ft): measured from top of baffle to base of notch.

ROAD FILL MEASURES

Road fill depth (ft): in vertical feet from the outside edge of the road surface to the original channel measured on the downstream side of the crossing with a transit level.

Road Fill Armor (code): Using the codes in table 1 classify the size of material used for armoring the road fill on the upstream and downstream side of the crossing.

Channel and Valley Measures
Stream channel gradient (%): Measured with a clinometer upstream from the influence of the crossing inlet.

Channel Substrate: Upstream of the influence of the culvert inlet, characterize the size of the channel substrate using the codes described in table 1.

Bankfull flow width (ft): measured at the average annual high water mark upstream from the influence of the culvert inlet.

Stream/valley fill (code): This refers to the layers of unconsolidated gravel, sand cobble, and other sediment that lie over the top of the bedrock. It is measured from the parent material or bedrock to the top of the deposit.

NF	No fill: (mostly bedrock channel, possibly point bar deposits and terrace-like sediment deposits < 5 feet high, may be valley- wall constrained)
SF	Shallow fill: (limited bedrock plus cobble/gravel/sand channel with narrow floodplain and terraces 5-10 feet high)
DF	Deep Fill: (no bedrock showing in channel, broad, well-developed floodplain)

Valley type (code):	NV	Less than 3 x channel width or < 100 feet (on a side)
	WV	Wide valley: greater than 3 x channel width or >100 feet (on a side)

INLET MEASURES

Inlet opening (%): as compared to design opening area

Inlet design (code):	NM	Not mitered.
	MI	Mitered
	OT	Other

Inlet Drop (Yes/No): Note if there is an inlet drop.

NATURAL-BED OR COUNTERSUNK DESIGNS

Sediment pattern (code): For natural-bed or countersunk structure designs give a qualitative description of how material is arranged in the structure. Use NA for structures that are not designed to collect sediment (baffled culvert, bridge).

SS	Simulated streambed (channel type forms such as bars and sinuosity, material contiguous)
CR	Contiguous rock fill (rock contiguous throughout the structure)
SR	Sparse rock fill (rock in culvert but not contiguous)
NM	No material in culvert
MO	Material in outlet, but barren at inlet.
NA	Not applicable

Bed material in structure (code): For natural-bed or countersunk structure designs document the size of material (listed in table 1) for the length of the crossing. There may be more than one but no more than three. Use NA for structures that are not designed to collect sediment (baffled culvert, bridge) and NO if there is no material in the culvert.

Direction of Counter-sinking:	IN	Inlet
	OT	Outlet
	BO	Both

NO neither

Depth of countersinking (ft): Quantitative measurement at location of countersinking. This measure is the difference between a level height taken at a point within 5-10 feet of the culvert inlet representing the streambed elevation and a height taken at the bottom of the culvert. Negative values indicate that the culvert is countersunk.

Countersunk (yes/no): A qualitative assessment as to whether or not the pipe was countersunk.

FORD MEASURES

Outlet jump (ft): Measured from outlet to residual water surface.

Residual Flow Depth (ft): Measured at the deepest point in the ford to the residual water surface.

Residual Pool Depth (ft): Measured at the deepest part of the pool downstream of the crossing when present to the residual water surface.

Material Type: *Rock, Other (explain)*

Material Size used for the ford upstream, at the crossing and downstream of the crossing (code): characterize the size of material in each location as described in Table 1. There can be more than one but no more than three.

<u>Minimizing Sediment</u>

Filtering: distance between crossing and last cross drain structure (waterbar, grade shift, pipe) upslope from the crossing.

Armor at road drainage site (code): Using the codes listed in table 1, characterize the size of material used to armor the ditch outlet at the site of the crossing.

Road surface condition: Describe the section of road draining into the stream crossing as:

GD Good
RU Rutted
GU Gullied
FL Failing

FIFTY-YEAR RECURRENCE FLOW

<u>For all crossings:</u>

Area upstream of the crossing (square miles): will be measured from a 7.5 minute topographic map.

<u>Baffled/embedded culverts</u>:

Height of baffle or embedded material (ft): measured at inlet or where cross-section represents the average constriction.

Bridges (Figure 2):

Bridge Type:	LS	Log stringer
	RR	Railroad Car
	MI	Metal I-beam
	CC	Concrete

Bridge Span (ft): Measured from one side of the stream to the other.

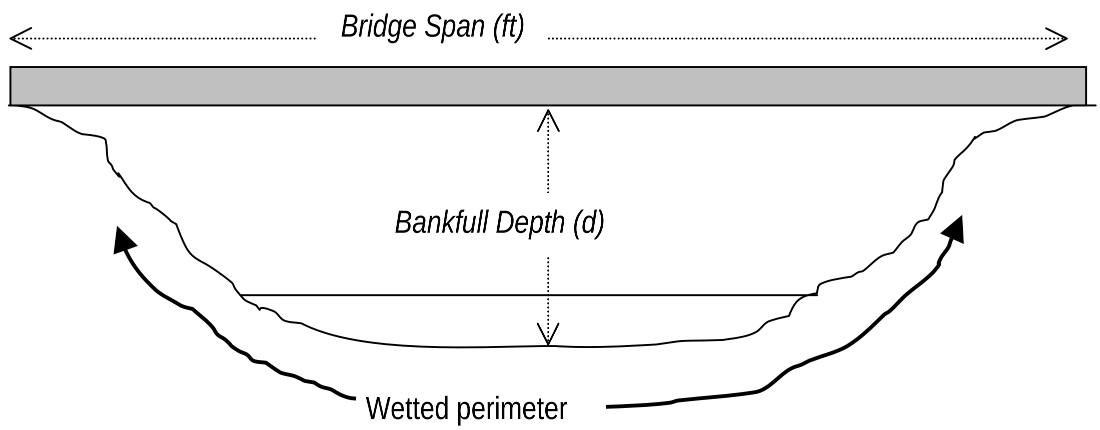


Figure 2. Schematic of measurements needed for calculating flow capacity of bridge design.

Bankfull depth – d (ft): measured from channel bed to the bottom of the bridge (this measure will be used to calculate wetted perimeter and cross-sectional area) every 0.5 feet on streams with a wetted width less than 10 feet and every foot on streams 10 feet and greater. Ability of the bridge to pass 50-year stream flow event will be calculated assuming three feet of freeboard.

Increment: Record the increment used to measure depth.

Distance from left bank (ft): Record distance from left bank, taking a measure every 0.5 feet on streams less than 10 feet and every foot on streams 10 feet and greater (this measure will be used to calculate wetted perimeter and cross-sectional area).

WRITTEN PLANS

A copy of the written plan will be made for each site. Two documents have recently described guidelines for what should be included in a written plan. The first was an ODF Memorandum circulated within the department and to landowners and operators. The subject was: *Interim fish passage guidance at road crossings*, (E. George Robison, June 16, 1995). The information in the ODF memorandum was duplicated in a section (pages 12-14) of the document titled: O*regon* *road/stream crossing restoration guide: summer 1998 draft* (Oregon Plan for Salmon and Watersheds, 1998). The following checklist was developed for assessing written plans, based on the June 16, 1995 ODF memorandum and the stream crossing restoration guide.

CROSSINGS
Location: Legal description
Structure: Round culvert, pipe arch, open bottom, bridge, ford, Overflow dip, other
Structure size: Diameter, length, rise, and span
Existing stream gradient
Resulting culvert gradient
Bed material in stream channel
Valley fill information
Outlet mitigation
Inlet condition

PEAK-FLOW RELATED DATA
Cross-sectional data: Detailed stream channel cross-section data (bridges and open-bottom arches): wetted perimeter, cross-sectional area

Watershed size: Size of watershed above stream crossing for 50-year peak flow calculation

QUALITY ASSURANCE/QUALITY CONTROL

There is a detailed section on this topic in the *Oregon Department of Forestry's BMP Compliance Audit Project* (Dent 1998). The Oregon Department of Forestry's Hydrologist and Monitoring Coordinator will train the fish-passage crews. On a subset of sites, two crews will measure the same sites to test repeatability of the methods.

Data will be collected on standardized field data sheets. A file will be kept for each site containing a copy of the written plan, map showing the site location, any relevant paperwork, and field data sheets. Field data will be entered into a computer database on an ongoing basis.

REPORTS

A preliminary report will be prepared and presented to the Oregon Board of Forestry in 1999 along with the overall BMP Compliance Audit Findings. The project will be continued in 1999 and possibly 2000, with a final report by 2001.

REFERENCES

Dent, Liz. 1998. *Oregon Department of Forestry's Best Management Practices Compliance Audit Project, version 3.0*. Oregon Department of Forestry, 2600 State Street, Salem, Oregon, 97310. 69 pp.

Oregon Plan for Salmon and Watersheds. *Oregon Road/Stream Crossing Restoration Guide: Summer 1998 Draft*. 1998. Governor's Watershed Enhancement Board. 255 Capital St. N.E., Salem, OR, 97310-0203. 52 pp.

Robison, E. George. 1995. *Interim fish passage guidance at road crossings.* June 16 1995. Oregon Department of Forestry, 2600 State Street, Salem, Oregon, 97310. 14 pp.

APPENDIX B: STREAM CROSSING EVALUATION METHODS

APPENDIX B: STREAM CROSSING EVALUATION METHODS

Provides the basis for comparisons between the ODF field data, written plan data, and the guidelines. Actual Access database formulas are shown followed by written explanations.

Field vs. Guidelines

Culvert %

1) GradeDifference(FvsG): [Culvert Grade (%)]-[Guideline Culvert Gradient (%)]

2) CulvGradeDiffCall(FvsG): IIf([Guideline Culvert Gradient (%)] Is Null,"NA",IIf([GradeDifference(FvsG)]<=[ODFCulvGradeError] Or [GradeDifference(FvsG)]<0 Or [Culvert Grade (%)]<=[Guideline Culvert Gradient (%)],"Accept","Reject"))

   Where a guideline culvert gradient exists, accept if the difference between the ODF culvert gradient and the guideline gradient is less than the measurement error, if the difference is negative, or if the culvert gradient is less than the guideline gradient (else reject).

Channel %

3) StreamGradeDiff(FvsG): [Channel Gradient (%)]-[GuideStreamGrade]

4) StreamGradeDiffCall(FvsG): IIf([Alternative]="7" Or [Alternative]="8" Or [Alternative]="9","NA",IIf([Channel Gradient (%)]>[GuideStreamGrade] And [StreamGradeDiff(FvsG)]>[TlbFieldError]![FieldStreamError],"Reject","Accept"))

   Where a stream gradient is applicable, reject if the ODF channel gradient is greater than the guidelines and the difference between the ODF channel gradient and the guidelines is greater than the measurement error (else accept).

Culvert Length (ft)

5) LengthDiffCall(FvsG): IIf([Guideline Culvert Length (ft)] Is Null,"NA",IIf([Length (ft)]<[Guideline Culvert Length (ft)],"Accept","Reject"))

Outlet Drop (ft)

6) OutDropCall(FvsG): IIf([Alternative]="7" Or [Alternative]="8" Or [Alternative]="9","NA",IIf([Outlet Drop (ft)]-[Guideline Outlet Drop (ft)]<=[T Guidelines]![ODFOutDropError],"Accept","Reject"))

   Where applicable, accept if the difference between the ODF measured outlet drop and the guidelines is less than the measurement error (else reject).

Culvert Elevation Drop (ft)

7) CulvertDropCall(FvsG): IIf([Alternative]<>"3","NA",IIf(([Culvert Grade (%)]*[Length (ft)])/100-([ODFCulvGradeError]*[Length (ft)])/100<=[T Guidelines]![GuideCulvertDrop],"Accept","Reject"))

   Where applicable, accept if the culvert elevation drop minus the error term is less than or equal to the guidelines (else reject).

Channel – Culvert %

8) ChanCulvDiff: [Channel Gradient (%)]-[Culvert Grade (%)]

9) ChanCulvDiffCall: IIf([Alternative]<>"3" And [Alternative]<>"5","NA",IIf(Abs([ChanCulvDiff])>[T Guidelines]![GuideChanCulvDiff] And Abs([ChanCulvDiff])-[ODFChanCulvDiffError]>[T Guidelines]![GuideChanCulvDiff],"Reject","Accept"))

   Where applicable, reject if the absolute difference between the channel and culvert gradient exceeds the guidance and exceeds the guidelines after accounting for measurement error (else accept).

Channel Bed Material

10) SubTypeCall(FvsG): IIf([Alternative]<>"3" And [Alternative]<>"4" And [Alternative]<>"5","NA",IIf([T Channel/Valley]![Sed Size 1]="BD","Reject","Accept"))

   Where applicable, reject if the ODF determined channel bed material is bedrock (else accept).

Valley Fill Depth

11) SubDepthCall(FvsG): IIf([Alternative]<>"3" And [Alternative]<>"4" And [Alternative]<>"5","NA",IIf([T Channel/Valley]![Stream/Valley Fill]="SF","Reject","Accept"))

   Where applicable, reject if the valley fill is shallow.

50-year Flow

12) CapacityCall(FvsG): IIf([Alternative]="9","NA",IIf([T Guidelines]![Guideline Year]<>"Jan 1995" And [ODFCapYesLoss]*1.07<[ODF CFS]-([ODF CFS]*0.1),"Reject",IIf([T Guidelines]![Guideline Year]="Jan 1995" And [T Structure Information]![ODFCapNoLoss]*1.07<[ODF CFS]-[ODF CFS]*0.1,"Reject","Accept")))

   If it applies to the alternative used, and the guidelines used were not January 1995, then a structure is rejected if the structure capacity measured in the field (including losses to sediment/baffles) with a 7% measurement error is less than the ODF determined 50-year flow with a 10% error. If the guidelines used were January 1995, then the same logic applies except structure capacity losses due to sediment retention were not accounted for.

Overall

13) Overall(FvsG): IIf([CulvGradeDiffCall(FvsG)]="Reject" Or [StreamGradeDiffCall(FvsG)]="Reject" Or [LengthDiffCall(FvsG)]="Reject" Or [OutDropCall(FvsG)]="Reject" Or [CulvertDropCall(FvsG)]="Reject" Or [ChanCulvDiffCall]="Reject" Or [SubTypeCall(FvsG)]="Reject" Or [SubDepthCall(FvsG)]="Reject" Or [CapacityCall(FvsG)]="Reject","Reject","Accept")

    If any of the applicable criteria were rejected, site is rejected overall (else accept).

Field vs. Written Plan

Note: Where the alternative is known (and the criteria applies), a site receives a "reject" if it does not meet both the written plan AND the guidelines.

Culvert %

1) GradeDifference(FvsP): [Culvert Grade (%)]-[Plan Culvert Gradient (%)]

2) CulvGradeDiffCall(FvsP): IIf([Alternative]="7" Or [Alternative]="8" Or [Alternative]="9","NA",IIf([Plan Culvert Gradient (%)] Is Null,"ND",IIf([GradeDifference(FvsP)]<=[ODFCulvGradeError]+[T Guidelines]![LOwnerCulvGradeError] Or [GradeDifference(FvsP)]<0 Or [Culvert Grade (%)]<=[Plan Culvert Gradient (%)] Or [Culvert Grade (%)]<=[T Guidelines]![Guideline Culvert Gradient (%)],"Accept","Reject")))

    Where culvert gradient applies to the alternative used, if the culvert gradient is greater than that in the written plan and exceeds the guidelines (after accounting for ODF and landowner measurement error), reject the design. Note: sites where the alternative used is unknown are compared ONLY against the written plan.

Channel %

3) StreamGradeDiff(FvsP): [Channel Gradient (%)]-[T Written Plan]![Plan Stream Gradient (%)]

    ODF Measured Channel Gradient – Channel Gradient in the Written Plan

4) StreamGradeDiffCall(FvsP): IIf([Alternative]="7" Or [Alternative]="8" Or [Alternative]="9","NA",IIf([Plan Stream Gradient (%)] Is Null,"ND",IIf([Channel Gradient (%)]>[T Written Plan]![Plan Stream Gradient (%)] And [StreamGradeDiff(FvsP)]>[ODFStreamGradeError]+[T Guidelines]![LOwnerStreamGradeError] And [Channel Gradient (%)]>[T Guidelines]![GuideStreamGrade],"Reject","Accept")))

    Where stream gradient applies to the alternative used, if the channel gradient measured by

ODF is greater than that in the written plan and exceeds the guidelines (after accounting for ODF and landowner measurement error), reject the design.

Culvert Length (ft)

5) LengthDiffCall(FvsP): IIf([Guideline Culvert Length (ft)] Is Null,"NA",IIf([Plan Culvert Length (ft)] Is Null And [Guideline Culvert Length (ft)] Is Not Null,"ND",IIf([Length (ft)]>[Guideline Culvert Length (ft)] And [Length (ft)]>[Plan Culvert Length (ft)],"Reject","Accept")))

   Where it applies to the alternative used, if the ODF measured culvert length is greater than that in the written plan and exceeds the guidelines, reject the design.

Outlet Drop (ft)

6) OutDropCall(FvsP): IIf([Guideline Outlet Drop (ft)] Is Null,"NA",IIf([Outlet Drop (ft)]>[Guideline Outlet Drop (ft)]+[T Guidelines]![ODFOutDropError] And [Plan Outlet Drop (ft)] Is Not Null And [Outlet Drop (ft)]>[Plan Outlet Drop (ft)],"Reject",IIf([Outlet Drop (ft)]>[Guideline Outlet Drop (ft)]+[T Guidelines]![ODFOutDropError] And [Plan Outlet Drop (ft)] Is Null,"Reject","Accept")))

   Where it applies to the alternative used, if the culvert outlet drop is greater than that in the written plan and exceeds guidelines (after accounting for ODF measurement error), reject the design. Furthermore, if the outlet drop exceeds that in the guidelines and no information is provided in the written plan, reject the design.

Culvert Elevation Drop (ft)

7) CulvertDropCall(FvsP): IIf([Alternative]<>"3","NA",IIf([Plan Culvert Drop (ft)] Is Null,"ND",IIf([Culvert Drop (ft)]>[Plan Culvert Drop (ft)] And [Culvert Drop (ft)]>[T Guidelines]![GuideCulvertDrop] And [Culvert Drop (ft)]-[Plan Culvert Drop (ft)]>([T Guidelines]![ODFCulvGradeError]*[Length (ft)])/100,"Reject","Accept")))

   *(Culvert drop equals the difference between the culvert elevation at the inlet and at the outlet. Culvert drop error was determined as: (ODF Culvert Gradient Error * Culvert Length)/100) Written plan culvert drop was utilized if provided, otherwise it was calculated from the culvert gradient and length in the written plan.)

   Where it applies to the alternative used, if the culvert drop is greater than that in the written plan and exceeds the guidelines (after accounting for ODF measurement error), reject the plan.

Channel – Culvert %

8) ChanCulvDiff: [Channel Gradient (%)]-[Culvert Grade (%)]

   ODF Measured Channel Gradient – ODF Measured Culvert Gradient

9) ChanCulvDiffCall: IIf([T Guidelines]![GuideChanCulvDiff] Is Null,"NA",IIf([Plan Chan-Culv Grade] Is Null And [T Guidelines]![GuideChanCulvDiff] Is Not Null,"ND",IIf([ChanCulvDiff]>[Plan Chan-Culv Grade] And [ChanCulvDiff]>[T Guidelines]![GuideChanCulvDiff]+[ODFChanCulvDiffError]+[LOwnerChanCulvDiffError],"Reject","Accept")))

*(Channel – Culvert Measurement Error = Stream Gradient Measurement Error + Culvert Gradient Measurement Error)

Where it applies to the alternative used, if the Channel Gradient – Culvert Gradient value was greater from field measurements than that in the written plan and exceeds the guidelines (after accounting for ODF and landowner measurement error), reject the design.

Channel Bed Material

10) SubTypeCall(FvsP): IIf([Alternative]<>"3" And [Alternative]<>"4" And [Alternative]<>"5","NA",IIf([Plan Bed Material] Is Not Null,"Accept","ND"))

Where applicable to the alternative used, if the type of channel substrate was included in the written plan, accept the design.

Valley Fill Depth

11) SubDepthCall(FvsP): IIf([Alternative]<>"3" And [Alternative]<>"4" And [Alternative]<>"5","NA",IIf([Plan Valley Fill] Is Not Null,"Accept","ND"))

Where applicable to the alternative used, if the depth of valley fill was included in the written plan, accept the design.

50-year Flow

12) CapacityDiff: [Plan Capacity (Actual) (cfs)]-[ODFCapYesLoss]

*(Losses = depth of sediment retained in structure or baffles, weirs, etc.)

Plan Capacity Including Losses – ODF Measured Capacity Including Losses

13) CapacityCall(FvsP): IIf([Alternative]="9","NA",IIf([Plan Capacity (Actual) (cfs)] Is Null Or [Plan CFS] Is Null,"ND",IIf([T Guidelines]![Guideline Year]<>"Jan 1995" And [CapacityDiff]>0 And [ODFCapYesLoss]*1.07<[PlanCFSFinal]-[PlanCFSFinal]*0.1,"Reject",IIf([T Guidelines]![Guideline Year]="Jan 1995" And [Plan Capacity (Chart) (cfs)]-[T Structure Information]![ODFCapNoLoss]>0 And [T Structure Information]![ODFCapNoLoss]*1.07<[PlanCFSFinal]-[PlanCFSFinal]*0.1,"Reject","Accept"))))

Reject if the capacity of the installed structure is smaller than planned (either due to a smaller structure or the amount of sediment retained in the structure – capacity allowed a 7% error) AND does not pass the written-plan determined 50-year flow with a 10% error. Because January 1995 guidelines do not describe accounting for capacity losses, the structure is not judged including losses to sediment retention/baffles.

Overall

14) Overall(FvsP): IIf([Alternative]<>"U" And [CulvGradeDiffCall(FvsP)]="Reject" Or [StreamGradeDiffCall(FvsP)]="Reject" Or [LengthDiffCall(FvsP)]="Reject" Or [OutDropCall(FvsP)]="Reject" Or [CulvertDropCall(FvsP)]="Reject" Or [ChanCulvDiffCall]="Reject" Or [SubTypeCall(FvsP)]="Reject" Or [SubDepthCall(FvsP)]="Reject" Or [CapacityCall(FvsP)]="Reject","Reject",IIf([Alternative]="U" And [OutDropCall(FvsP)]="Reject" Or [CapacityCall(FvsP)]="Reject" Or [CulvGradeDiffCall(FvsP)]="Reject" Or [StreamGradeDiffCall(FvsP)]="Reject","Reject","Accept"))

    If any criteria for a site are rejected, then the site receives "Reject" overall. Note: sites with unknown alternatives are judged only against the written plan for culvert and channel gradient and against both the written plan and the guidelines for outlet drop and the 50-year flow.

Written Plan vs. Guidelines

Culvert %

1) GradeDifference(PvsG): [Plan Culvert Gradient (%)]-[Guideline Culvert Gradient (%)]

2) CulvGradeDiffCall(PvsG): IIf([Alternative]="9","NA",IIf([Guideline Culvert Gradient (%)] Is Null,"NA",IIf([Plan Culvert Gradient (%)] Is Null,"ND",IIf([GradeDifference(PvsG)]<=[ODFCulvGradeError]+[T Guidelines]![LOwnerCulvGradeError] Or [GradeDifference(PvsG)]<0 Or [Plan Culvert Gradient (%)]<=[Guideline Culvert Gradient (%)],"Accept","Reject"))))

    Where applicable and where the data is provided, accept if the difference between the plan culvert gradient and the guidelines is less than the measurement error or if the difference is less than zero or if the plan gradient is less than the guidelines (else reject).

Channel %

3) StreamGradeDiff(PvsG): [T Written Plan]![Plan Stream Gradient (%)]-[GuideStreamGrade]

4) StreamGradeDiffCall(PvsG): IIf([Alternative]="7" Or [Alternative]="8" Or [Alternative]="9" Or [GuideStreamGrade] Is Null,"NA",IIf([Plan Stream Gradient (%)] Is Null And [GuideStreamGrade] Is Not Null,"ND",IIf([T Written Plan]![Plan Stream Gradient (%)]>[GuideStreamGrade] And [StreamGradeDiff(PvsG)]>[ODFStreamGradeError]+[T Guidelines]![LOwnerStreamGradeError],"Reject","Accept")))

Where applicable and the data is provided, reject if the plan channel gradient exceeds the guidance and the difference between the plan and guidance gradients is greater than the measurement error (else accept).

Culvert Length (ft)

5) LengthDiffCall(PvsG): IIf([Guideline Culvert Length (ft)] Is Null,"NA",IIf([Plan Culvert Length (ft)] Is Null And [Guideline Culvert Length (ft)] Is Not Null,"ND",IIf([Plan Culvert Length (ft)]>[Guideline Culvert Length (ft)],"Reject","Accept")))

   Where applicable and the data is provided, reject if the plan culvert length exceeds the guideline culvert length (else accept).

Outlet Drop (ft)

6) OutDropCall(PvsG): IIf([Alternative]="7" Or [Alternative]="8","NA",IIf([Plan Outlet Drop (ft)]>[Guideline Outlet Drop (ft)],"Reject","Accept"))

7) OutDropCall(PvsG): IIf([Alternative]="7" Or [Alternative]="8" Or [Alternative]="9","NA",IIf([Plan Outlet Drop (ft)]>[Guideline Outlet Drop (ft)],"Reject","Accept"))

   Where applicable and the data is available, reject if the plan outlet drop exceeds the guidelines (else accept).

Channel – Culvert %

8) ChanCulvDiffCall(PvsG): IIf([Alternative]<>"3" And [Alternative]<>"5","NA",IIf([Alternative]="3" And [Plan Chan-Culv Grade] Is Null Or [Alternative]="5" And [Plan Chan-Culv Grade] Is Null,"ND",IIf(Abs([Plan Chan-Culv Grade])>[T Guidelines]![GuideChanCulvDiff],"Reject","Accept")))

Where applicable and the data is available, reject if the difference between channel and culvert in the plan exceeds the guidelines (else accept).

Channel Bed Material

9) SubTypeCall(PvsG): IIf([Alternative]<>"3" And [Alternative]<>"4" And [Alternative]<>"5" Or [T Written Plan]![Guideline Year]="Jan 1995","NA",IIf([Plan Bed Material] Is Null And [GuideSubType] Is Not Null,"ND",IIf([Plan Bed Material] Is Not Null And [Plan Bed Material]<>"BD","Accept","Reject")))

   Where applicable, accept if the written plan provided a channel bed material and it was not bedrock (else reject).

Valley Fill Depth

10) SubDepthCall(PvsG): IIf([Alternative]<>"3" And [Alternative]<>"4" And [Alternative]<>"5" Or [T Written Plan]![Guideline Year]="Jan 1995","NA",IIf([Plan Valley Fill] Is Null,"ND","Accept"))

    Where applicable, accept if the written plan provided information about the valley fill depth (else no data).

50-year Flow

11) CapacityCall(PvsG): IIf([Alternative]="9","NA",IIf([Plan Capacity (Actual) (cfs)] Is Null Or [Plan CFS] Is Null,"ND",IIf([T Guidelines]![Guideline Year]<>"Jan 1995" And [Plan Capacity (Actual) (cfs)]<[ODF CFS]-[ODF CFS]*0.1,"Reject",IIf([T Guidelines]![Guideline Year]="Jan 1995" And [T Written Plan]![PlanCapNoLoss]<[ODF CFS]-[ODF CFS]*0.1,"Reject","Accept"))))

    If it applies to the alternative, and the data is available in the written plan, then a written plan is rejected if the ODF determined 50-year flow (with a 10% error) exceeds the capacity of the structure in the plan. Capacity losses to sediment/baffles are not accounted for if the January 1995 guidelines were used.

Overall

12) Overall(PvsG): IIf([CulvGradeDiffCall(PvsG)]="Reject" Or [StreamGradeDiffCall(PvsG)]="Reject" Or [LengthDiffCall(PvsG)]="Reject" Or [OutDropCall(PvsG)]="Reject" Or [CulvertDropCall(PvsG)]="Reject" Or [ChanCulvDiffCall(PvsG)]="Reject" Or [SubTypeCall(PvsG)]="Reject" Or [SubDepthCall(PvsG)]="Reject" Or [CapacityCall(PvsG)]="Reject","Reject","Accept")

    Where any of the applicable criteria are rejected, reject overall (else accept).

APPENDIX C: DATA, GUIDELINE CRITERIA, EVALUATION AND FISH PASSAGE RESULTS

APPENDIX C: DATA, GUIDELINE CRITERIA, EVALUATION, AND FISH PASSAGE RESULTS

Glossary:
Guideline Year: Date of guideline in use when written plan was submitted.

Alternative: Fish passage strategy used from guidelines

1: Culvert placed with little or no gradient
2. Culvert placed with little or no gradient with a backwatering structure at the outlet.
3. Culvert placed with little or no gradient by sinking the inlet.
4. Culvert with inlet and outlet sunk equally to retain sediment.
5. Culvert with inlet sunk more than outlet to retain sediment.
6. Culvert with baffles or weirs.
7. Bottomless-arch culvert.
8. Bridge.

Culvert Elevation Drop: The change in elevation from the inlet to culvert outlet in feet.

Channel substrate: FG – fine gravel, FN – fines, SC – small cobble, LC – large cobble, SD – sand, CG – coarse gravel, BL – boulder, BD – bedrock, ND – no data, NA – not applicable.

Valley Fill Depth: Are the sediments in the valley and stream bottom deep (DF) or near bedrock/shallow (SF).

Capacity (with losses): The structure flow capacity reduced by sediment retention or baffle/weir design.

Capacity (no losses): The structure flow capacity without sediment retention or baffles/weirs.

ODF Field Data

SiteNo	Guideline Year	Alternative	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	Capacity (with losses) (cfs)	Capacity (no losses) (cfs)	50-year Flow (cfs)
1	Jan 1995	4	1.2	2	36	0	0.44	0.8	FG , FN , NA	DF	64	64	70
2	Jan 1995	4	0.4	5	40.2	0.2	0.18	4.6	FG , SC , SD	DF	129	129	157
3	Jan 1995	4	0.25	3	40.5	0	0.1	2.75	SC , FG , NA	DF	46	46	36
4	Jan 1995	4	0	2	40.1	0	0	2	SC , FG , CG	DF	113	113	121
5	June 1995	1	2.17	4	48	0	1.04	1.83	SD , FG , SD	DF	113	113	88
6	June 1995	1	6.08	8	72	0	4.38	1.92	CG , NA , NA	DF	64	64	26
7	June 1995	3	0.5	4	60	0	0.32	3.5	CG , FG , NA	DF	253	262	316
8	June 1995	8		3					SC , NA , NA	DF	626	626	403
9	June 1995	1	3.81	4	32	1	1.22	0.19	LC , CG , SD	DF	31	31	32
10	June 1995	5	1.98	4	50.5	0	1	2.02	LC , SC , NA	DF	110	113	65
11	June 1995	3	1.28	5	48.3	0.05	0.62	3.72	SC , NA , NA	DF	178	178	136
12	June 1995	5	2.32	8	57	0	1.32	5.68	LC , NA , NA	DF	645	645	454
13	June 1995	5	1.68	3	57	0	0.96	1.32	CG , SC , NA	DF	640	645	454
14	June 1995	5	6.81	10	80.8	0	5.5	3.19	BL , LC , NA	DF	254	262	77
15	June 1995	U	1.15	2	48	0	0.55	0.85	CG , FG , NA	DF	246	262	195
16	June 1995	8		1					SD , BD , FG	SF	1913	1913	1229

ODF Field Data

SiteNo	Guideline Year	Alternative	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	Capacity (with losses) (cfs)	Capacity (no losses) (cfs)	50-year Flow (cfs)
17	June 1995	8		1					SC , CG , SD	DF	2089	2089	1845
18	June 1995	4	1.02	3	64.5	0	0.66	1.98	BL , LC , SC	DF	567	572	548
19	June 1995	6	1.2	1	41	0	-0.49	-0.2	FN , NA , NA	DF	60	87	92
20	June 1995	U	0.02	2	61	0.5	0.01	1.98	FN , NA , NA	DF	79	79	21
21	June 1995	5	3.98	4	48.5	0	1.93	0.02	LC , BL , SC	DF	510	571	243
22	June 1995	1	0.83	1	30	0	0.25	0.17	CG , FG , NA	DF	64	64	55
23	June 1995	U	0.93	4	44	0	0.41	3.07	FG , SD , CG	DF	103	113	94
24	June 1995	U	1.38	3	40.5	0.4	0.56	1.62	FG , NA , NA	DF	178	178	184
25	June 1995	U	4.6	5	80	0	4.1	0.4	SC , CG , NA	SF	491	491	278
26	June 1995	4	0.1	8	40	0	0.04	7.9	CG , SC , FG	DF	94	113	109
27	June 1995	4	0	4	50.6	0	0	4	CG , FG , NA	DF	161	177	112
28	June 1995	1	-0.11	4	36.6	0	-0.04	4.11	ND, ND , ND	DF	220	220	208
29	June 1995	8		1					LC , NA , NA	DF	3300	3300	754
30	June 1995	8		12					BL , NA , NA	DF	3521	3521	261
31	June 1995	U	0.9	3	30	0	0.28	2.1	CG , SC , NA	DF	31	31	24
32	June 1995	5	1.13	5	30.1	0	0.34	3.87	SC , FG , NA	DF	176	209	112
33	June 1995	5	0.4	5	48	0	0.19	4.6	FG , CG , SC	DF	239	239	98

ODF Field Data													
SiteNo	Guideline Year	Alternative	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	Capacity (with losses) (cfs)	Capacity (no losses) (cfs)	50-year Flow (cfs)
35	June 1995	6	11.3	3	45	1.3	6.12	-8.3	FN , SD , NA	DF	83	113	96
36	June 1995	7		5	40				LC , SC , CG	DF	141	141	80
37	June 1995	8		3					ND, ND , ND	DF	3314	3314	560
38	June 1995	U	0.5	4	32.95	0	-0.14	3.5	SC , CG , NA	DF	144	187	39
39	June 1995	9	0.5	6	20	0	0.18	5.5	SC , LC , BL	DF	5	5	331
40	June 1995	U	0.58	8	34.2	0	0.2	7.42	FN , NA , NA	DF	5	5	11
41	June 1995	U	4.2	3	46.5	1.3	1.94	-1.2	FN , NA , NA	DF	64	64	56
42	June 1997	U	3.16	6	67	0	2.12	2.84	FN , NA , NA	DF	235	235	137
43	June 1997	U	0.8	1	40	0.1	0.32	0.2	SD , FG , NA	DF	124	124	500
44	June 1995	U	-0.16	3	50.1	0.5	-0.08	3.16	LC , SC , NA	DF	408	408	223
45	June 1997	4	4.67	5	48.8	0	2.28	0.33	SC , NA , NA	DF	193	193	30
46	June 1997	4	4.36	4	46.3	0	2.02	-0.36	FG , FN , NA	DF	107	107	44
47	June 1997	5	6.19	3	51.4	0	3.18	-3.19	FN , NA , NA	DF	80	80	42
48	June 1995	U	1.97	2	30.5	1.9	0.6	0.03	SD , FG , NA	SF	113	113	87
50	June 1995	U	3.52	1.5	45.5	1.6	1.6	-2.02	CG , NA , NA	DF	279	279	225
51	June 1995	U	0.54	5	40.5	0	0.22	4.46	SC , NA , NA	DF	212	224	166
52	June 1995	3	0.02	2	43	0	0.01	1.98	CG , FG , NA	DF	160	195	181

ODF Field Data													
SiteNo	Guideline Year	Alternative	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	Capacity (with losses) (cfs)	Capacity (no losses) (cfs)	50-year Flow (cfs)
58	June 1995	1	0.1	4	56	0	-0.06	3.9	FG , SD , CG	DF	183	183	129
59	June 1995	1	0.39	3	28	0	0.11	2.61	FG , SD , NA	DF	224	224	180
82	June 1997	4	2.2	2	40	0	0.88	-0.2	FN , NA , NA	DF	63	78	62
83	June 1997	3	0.89	0	36	0	0.32	-0.89	FN , FG , NA	DF	87	87	87
84	June 1997	1	0.39	2	28.5	0	0.11	1.61	CG , FG , SD	DF	104	104	85
89	June 1995	4	1.19	2	40.5	0	0.48	0.81	FN , SD , NA	DF	170	178	38
100	June 1997	5	6.42	6	83.8	0	5.38	-0.42	BL , LC , CG	DF	531	625	318

Written Plan Data

SiteNo	Guideline Year	Alternative	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	Capacity (with losses) (cfs)	Capacity (no losses) (cfs)	50-year Flow (cfs)
1	Jan 1995	4			36						53	64	
2	Jan 1995	4			40						94	113	
3	Jan 1995	4			40						41	46	
4	Jan 1995	4			40						101	113	
5	June 1995	1	0			0.25					113	113	94
6	June 1995	1	0		72	0.25					31	31	26
7	June 1995	3	0.5		60		0.3				367	367	
8	June 1995	8		2.7							450	450	404
9	June 1995	1	1		32						31	31	
10	June 1995	5	2	3.0	50			1			79	113	
11	June 1995	3	0.5	1.6	48		0.24	1.1			178	178	
12	June 1995	5	3	4.0				1	Yes	Yes	562	645	506
13	June 1995	5	3	4.0				1	Yes	Yes	562	645	506
14	June 1995	5	8	10.0	80			2	Yes	Yes	185	262	94
15	June 1995	U	0		34						262	262	
16	June 1995	8		4.0							3000	3000	1170
17	June 1995	8											
18	June 1995	4									701	841	630
19	June 1995	6	6		40						60	87	80.5
20	June 1995	U			48						64	64	
21	June 1995	5	3.5	4.6	48			1.1			342	470	292
22	June 1995	1	1								64	64	66
23	June 1995	U	1.5	1.5							113	113	105
24	June 1995	U	1.5	1.5							178	178	192
25	June 1995	U	0								367	367	
26	June 1995	4	0.5		40						155	178	114
27	June 1995	4	0.5								134	170	133
28	June 1995	1	0.25	0.3	48	0			Yes		262	262	226
29	June 1995	8							Yes				710
30	June 1995	8											
31	June 1995	U		3.0	30						31	31	26

Written Plan Data													
SiteNo	Guideline Year	Alternative	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	Capacity (with losses) (cfs)	Capacity (no losses) (cfs)	50-year Flow (cfs)
32	June 1995	5	2.5	2.5			0.8	0			124	170	114
33	June 1995	5	2	2.6	48			0.6			161	227	112
35	June 1995	6	12	12.0	44						83	113	93
36	June 1995	7		4.0	40				Yes		150	154	89
37	June 1995	8		2.0							2000	2000	563
38	June 1995	U											
39	June 1995	9										87	
40	June 1995	U			28						11	11	
41	June 1995	U	2		34						64	64	
42	June 1997	U	1.5	1.0	68				Yes		240	240	190
43	June 1997	U	2								159	159	
44	June 1995	U	1		50						427	427	211
45	June 1997	4	7.5		54						79	96	
46	June 1997	4	7		50						111	130	
47	June 1997	5	6		50						184	184	
48	June 1995	U			24						113	113	83
50	June 1995	U											
51	June 1995	U			40						262	262	159
52	June 1995	3	2	2.0	42		0.84	1	Yes		233	233	177
58	June 1995	1	0.5		56						184	184	183
59	June 1995	1	0.5		28						219	219	214
82	June 1997	4	2.8	3.0	40		1.12	0.5			54	69	52
83	June 1997	3	0	4.0	36		0	4			113	113	81
84	June 1997	1	0.5								104	104	84
89	June 1995	4									136	178	65
100	June 1997	5	7	7.3	84			0.3	Yes		418	650	312

Guideline Criteria and Error Terms A

Guideline Year	Alternative	Max Culvert %	+/- ODF Culvert Error %	+/- LO Culvert Error %	Culvert Length (ft)	Outlet Drop (ft)	Outlet Drop Error (ft)	Channel %	ODF Channel % Error	LO Channel % Error	Culvert Elevation Drop (ft)	Culvert Elevation Drop Error (ft)
Jan 1995	4	1	0.12	0.5	50	1	0.5		2	2		
June 1995	1	0.5	0.12	0.12	50	0	0.5	1	2	2		
June 1995	2	5	0.12	0.5		0	0.5	5	2	2		
June 1995	3	0.5	0.12	0.12		0	0.5	2.5	2	2	2	(ODF Culv % Error*Culv Length)/100
June 1995	4	3.5	0.12	0.5		0	0.5	3.5	2	2		
June 1995	5	3.5	0.12	0.5		0	0.5	5	2	2		
June 1995	6	12	0.12			0	0.5	12	2	2		
June 1995	7								2	2		
June 1995	8								2	2		

Guideline Criteria and Error Terms A

Guideline Year	Alternative	Max Culvert %	+/- ODF Culvert Error %	+/- LO Culvert Error %	Culvert Length (ft)	Outlet Drop (ft)	Outlet Drop Error (ft)	Channel %	ODF Channel % Error	LO Channel % Error	Culvert Elevation Drop (ft)	Culvert Elevation Drop Error (ft)
June 1995	U					0	0.5					
June 1995	9											
June 1997	1	0.5	0.12	0.12	60	0	0.5	0.5	2	2		
June 1997	2	4	0.12	0.5		0	0.5	5	2	2		
June 1997	3	0.5	0.12	0.12		0	0.5	2.5	2	2	2	(ODF Culv % Error*Culv Length)/100
June 1997	4	4	0.12	0.5		0	0.5	4	2	2		
June 1997	5	7	0.12	0.5		0	0.5	9	2	2		
June 1997	6	12	0.12			0	0.5	12	2	2		
June 1997	7								2	2		
June 1997	8								2	2		

Guideline Criteria and Error Terms A

Guideline Year	Alternative	Max Culvert %	+/- ODF Culvert Error %	+/- LO Culvert Error %	Culvert Length (ft)	Outlet Drop (ft)	Outlet Drop Error (ft)	Channel %	ODF Channel % Error	LO Channel % Error	Culvert Elevation Drop (ft)	Culvert Elevation Drop Error (ft)
June 1997	U					0	0.5					
June 1997	9											

Guideline Criteria and Error Terms B

Guideline Year	Alternative	Channel - Culvert %	ODF Channel - Culvert Error %	LO Channel - Culvert Error %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)	50-year Flow Error (cfs)
Jan 1995	4						Capacity > Q50	Capacity 7%, Q50 10%
June 1995	1						Capacity > Q50	Capacity 7%, Q50 10%
June 1995	2						Capacity > Q50	Capacity 7%, Q50 10%
June 1995	3	2	(ODF Culv % Error) + (ODF Channel % Error)	(LO Culv % Error) + (LO Channel % Error)	<=Cobble	Deep	Capacity > Q50	Capacity 7%, Q50 10%

Guideline Criteria and Error Terms B								
			ODF	LO				50-year
		Channel -	Channel -	Channel -			50-year	Flow
		Culvert	Culvert	Culvert	Channel	Valley Fill	Flow	Error
Guideline Year	Alternative	%	Error %	Error %	Substrate	Depth	(cfs)	(cfs)
June 1995	4				<=Cobble	Deep	Capacity > Q50	Capacity 7%, Q50 10%
June 1995	5	2	(ODF Culv % Error) + (ODF Channel % Error)	(LO Culv % Error) + (LO Channel % Error)	<=Cobble	Deep	Capacity > Q50	Capacity 7%, Q50 10%
June 1995	6						Capacity > Q50	Capacity 7%, Q50 10%
June 1995	7					Shallow	Capacity > Q50	Capacity 7%, Q50 10%
June 1995	8						Capacity > Q50	
June 1995	U						Capacity > Q50	Capacity 7%, Q50 10%
June 1995	9						Capacity > Q50	Capacity 7%, Q50 10%
June 1997	1						Capacity > Q50	Capacity 7%, Q50 10%
June 1997	2						Capacity > Q50	Capacity 7%, Q50 10%
June 1997	3	2	(ODF Culv % Error) + (ODF Channel % Error)	(LO Culv % Error) + (LO Channel % Error)	<=Cobble	Deep	Capacity > Q50	Capacity 7%, Q50 10%

Guideline Criteria and Error Terms B

			ODF	LO				50-year
		Channel -	Channel -	Channel -			50-year	Flow
		Culvert	Culvert	Culvert	Channel	Valley Fill	Flow	Error
Guideline Year	Alternative	%	Error %	Error %	Substrate	Depth	(cfs)	(cfs)
June 1997	4				<=Cobble	Deep	Capacity > Q50	Capacity 7%, Q50 10%
June 1997	5	3	(ODF Culv % Error) + (ODF Channel % Error)	(LO Culv % Error) + (LO Channel % Error)	<=Cobble	Deep	Capacity > Q50	Capacity 7%, Q50 10%
June 1997	6						Capacity > Q50	Capacity 7%, Q50 10%
June 1997	7					Shallow	Capacity > Q50	Capacity 7%, Q50 10%
June 1997	8						Capacity > Q50	
June 1997	U						Capacity > Q50	Capacity 7%, Q50 10%
June 1997	9						Capacity > Q50	Capacity 7%, Q50 10%

ODF Field Data vs. Written Plan Evaluation Results

NA = Not Applicable, ND = No Data,

SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
1	4	VOL	Accept	ND	ND	Accept	Accept	NA	NA	ND	ND	ND
2	4	VOL	Accept	ND	ND	Accept	Accept	NA	NA	ND	ND	ND
3	4	VOL	Accept	ND	ND	Accept	Accept	NA	NA	ND	ND	ND
4	4	VOL	Accept	ND	ND	Accept	Accept	NA	NA	ND	ND	ND
5	1	VOL	Reject	Reject	ND	ND	Accept	NA	NA	NA	NA	Accept
6	1	VOL	Reject	Reject	ND	Accept	Accept	NA	NA	NA	NA	Accept
7	3	RAN	Accept	Accept	ND	NA	Accept	Accept	ND	NA	NA	ND
8	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
9	1	RAN	Reject	Reject	ND	Accept	Reject	NA	NA	NA	NA	ND
10	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	ND
11	3	RAN	Reject	Reject	Accept	NA	Accept	Accept	Accept	NA	NA	ND
12	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
13	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
14	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
15	U	RAN	Reject	Reject	ND	NA	Accept	NA	NA	NA	NA	ND
16	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
17	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	ND
18	4	VOL	Accept	ND	ND	NA	Accept	NA	NA	ND	ND	Accept
19	6	VOL	Accept	Accept	ND	NA	Accept	NA	NA	NA	NA	Accept
20	U	RAN	Accept	ND	ND	NA	Accept	NA	NA	NA	NA	ND
21	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	Accept
22	1	RAN	Accept	Accept	ND	ND	Accept	NA	NA	NA	NA	Accept
23	U	RAN	Accept	Accept	Accept	NA	Accept	NA	NA	NA	NA	Accept
24	U	RAN	Accept	Accept	Accept	NA	Accept	NA	NA	NA	NA	Accept
25	U	VOL	Reject	Reject	ND	NA	Accept	NA	NA	NA	NA	ND
26	4	VOL	Reject	Accept	ND	NA	Accept	NA	NA	ND	ND	Reject
27	4	VOL	Accept	Accept	ND	NA	Accept	NA	NA	ND	ND	Accept
28	1	VOL	Accept	Accept	Accept	Accept	Accept	NA	NA	NA	NA	Accept
29	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	ND
30	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	ND

ODF Field Data vs. Written Plan Evaluation Results												
	NA = Not Applicable, ND = No Data,											
SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
31	U	RAN	Accept	ND	Accept	NA	Accept	NA	NA	NA	NA	Accept
32	5	VOL	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	Accept
33	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	Accept
35	6	RAN	Reject	Accept	Accept	NA	Reject	NA	NA	NA	NA	Accept
36	7	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
37	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
38	U	RAN	Accept	ND	ND	NA	Accept	NA	NA	NA	NA	ND
39	9	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	U	RAN	Accept	ND	ND	NA	Accept	NA	NA	NA	NA	ND
41	U	RAN	Reject	Reject	ND	NA	Reject	NA	NA	NA	NA	ND
42	U	RAN	Reject	Reject	Accept	NA	Accept	NA	NA	NA	NA	Accept
43	U	RAN	Accept	Accept	ND	NA	Accept	NA	NA	NA	NA	ND
44	U	RAN	Accept	Accept	ND	NA	Accept	NA	NA	NA	NA	Accept
45	4	RAN	Accept	Accept	ND	NA	Accept	NA	NA	ND	ND	ND
46	4	RAN	Accept	Accept	ND	NA	Accept	NA	NA	ND	ND	ND
47	5	RAN	Accept	Accept	ND	NA	Accept	NA	ND	ND	ND	ND
48	U	RAN	Reject	ND	ND	NA	Reject	NA	NA	NA	NA	Accept
50	U	RAN	Reject	ND	ND	NA	Reject	NA	NA	NA	NA	ND
51	U	RAN	Accept	ND	ND	NA	Accept	NA	NA	NA	NA	Accept
52	3	RAN	Accept	Accept	Accept	NA	Accept	Accept	Accept	NA	NA	Accept
58	1	VOL	Accept	Accept	ND	Accept	Accept	NA	NA	NA	NA	Accept
59	1	VOL	Accept	Accept	ND	Accept	Accept	NA	NA	NA	NA	Accept
82	4	VOL	Accept	Accept	Accept	NA	Accept	NA	NA	ND	ND	Accept
83	3	VOL	Reject	Reject	Accept	NA	Accept	Accept	Accept	NA	NA	Accept
84	1	VOL	Accept	Accept	ND	ND	Accept	NA	NA	NA	NA	Accept
89	4	VOL	Accept	ND	ND	NA	Accept	NA	NA	ND	ND	Accept
100	5	VOL	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	ND	Accept

Written Plan vs. Guidelines Evaluation Results												
	NA = Not Applicable, ND = No Data,											
SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
1	4	VOL	Accept	ND	NA	Accept	Accept	NA	NA	NA	NA	ND
2	4	VOL	Accept	ND	NA	Accept	Accept	NA	NA	NA	NA	ND
3	4	VOL	Accept	ND	NA	Accept	Accept	NA	NA	NA	NA	ND
4	4	VOL	Accept	ND	NA	Accept	Accept	NA	NA	NA	NA	ND
5	1	VOL	Reject	Accept	ND	ND	Reject	NA	NA	NA	NA	Accept
6	1	VOL	Reject	Accept	ND	Reject	Reject	NA	NA	NA	NA	Accept
7	3	RAN	Accept	Accept	ND	NA	Accept	Accept	ND	ND	ND	ND
8	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
9	1	RAN	Reject	Reject	ND	Accept	Accept	NA	NA	NA	NA	ND
10	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	ND
11	3	RAN	Accept	Accept	Accept	NA	Accept	Accept	Accept	ND	ND	ND
12	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
13	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
14	5	RAN	Reject	Reject	Reject	NA	Accept	NA	Accept	Accept	Accept	Accept
15	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
16	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
17	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	ND
18	4	VOL	Accept	ND	ND	NA	Accept	NA	NA	ND	ND	Accept
19	6	VOL	Reject	Accept	ND	NA	Accept	NA	NA	NA	NA	Reject
20	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
21	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	Accept
22	1	RAN	Reject	Reject	ND	ND	Accept	NA	NA	NA	NA	Accept
23	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
24	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
25	U	VOL	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
26	4	VOL	Accept	Accept	ND	NA	Accept	NA	NA	ND	ND	Accept

Written Plan vs. Guidelines Evaluation Results													
	NA = Not Applicable, ND = No Data,												
SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
27	4	VOL	Accept	Accept	ND	NA	Accept	NA	NA	ND	ND	Accept
28	1	VOL	Accept	Accept	Accept	Accept	Accept	NA	NA	NA	NA	Accept
29	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	ND
30	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	ND
31	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
32	5	VOL	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	Accept
33	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	ND	ND	Accept
35	6	RAN	Reject	Accept	Accept	NA	Accept	NA	NA	NA	NA	Reject
36	7	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
37	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
38	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
39	9	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
41	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
42	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
43	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
44	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
45	4	RAN	Reject	Reject	ND	NA	Accept	NA	NA	ND	ND	ND
46	4	RAN	Reject	Reject	ND	NA	Accept	NA	NA	ND	ND	ND
47	5	RAN	Accept	Accept	ND	NA	Accept	NA	ND	ND	ND	ND
48	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
50	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	ND
51	U	RAN	Accept	NA	NA	NA	Accept	NA	NA	NA	NA	Accept
52	3	RAN	Reject	Reject	Accept	NA	Accept	Accept	Accept	Accept	ND	Accept
58	1	VOL	Reject	Accept	ND	Reject	Accept	NA	NA	NA	NA	Accept
59	1	VOL	Accept	Accept	ND	Accept	Accept	NA	NA	NA	NA	Accept
82	4	VOL	Reject	Accept	Accept	NA	Accept	NA	NA	ND	ND	Reject

Written Plan vs. Guidelines Evaluation Results												
	NA = Not Applicable, ND = No Data,											
SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
83	3	VOL	Reject	Accept	Accept	NA	Accept	Accept	Reject	ND	ND	Accept
84	1	VOL	Accept	Accept	ND	ND	Accept	NA	NA	NA	NA	Accept
89	4	VOL	Accept	ND	ND	NA	Accept	NA	NA	ND	ND	Accept
100	5	VOL	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	ND	Accept

ODF Field Data vs. Guidelines Evaluation Results

NA = Not Applicable, ND = No Data,

SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
1	4	VOL	Reject	Reject	Accept	Accept	Accept	NA	NA	Accept	Accept	Accept
2	4	VOL	Reject	Accept	Accept	Accept	Accept	NA	NA	Accept	Accept	Reject
3	4	VOL	Accept	Accept	Accept	Accept	Accept	NA	NA	Accept	Accept	Accept
4	4	VOL	Accept	Accept	Accept	Accept	Accept	NA	NA	Accept	Accept	Accept
5	1	VOL	Reject	Reject	Reject	Accept	Accept	NA	NA	NA	NA	Accept
6	1	VOL	Reject	Reject	Reject	Reject	Accept	NA	NA	NA	NA	Accept
7	3	RAN	Reject	Accept	Accept	NA	Accept	Accept	Accept	Accept	Accept	Reject
8	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
9	1	RAN	Reject	Reject	Reject	Accept	Reject	NA	NA	NA	NA	Accept
10	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
11	3	RAN	Reject	Reject	Reject	NA	Accept	Accept	Accept	Accept	Accept	Accept
12	5	RAN	Reject	Accept	Reject	NA	Accept	NA	Reject	Accept	Accept	Accept
13	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
14	5	RAN	Reject	Reject	Reject	NA	Accept	NA	Accept	Accept	Accept	Accept
15	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
16	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
17	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
18	4	VOL	Accept	Accept	Accept	NA	Accept	NA	NA	Accept	Accept	Accept
19	6	VOL	Reject	Accept	Accept	NA	Accept	NA	NA	NA	NA	Reject
20	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
21	5	RAN	Reject	Reject	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
22	1	RAN	Reject	Reject	Accept	Accept	Accept	NA	NA	NA	NA	Accept
23	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
24	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
25	U	VOL	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
26	4	VOL	Reject	Accept	Reject	NA	Accept	NA	NA	Accept	Accept	Accept
27	4	VOL	Accept	Accept	Accept	NA	Accept	NA	NA	Accept	Accept	Accept

ODF Field Data vs. Guidelines Evaluation Results

NA = Not Applicable, ND = No Data,

SiteNo	Alternative	Selection	Overall	Culvert %	Channel %	Culvert Length (ft)	Outlet Drop (ft)	Culvert Elevation Drop (ft)	Channel - Culvert %	Channel Substrate	Valley Fill Depth	50-year Flow (cfs)
28	1	VOL	Reject	Accept	Reject	Accept	Accept	NA	NA	NA	NA	Accept
29	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
30	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
31	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
32	5	VOL	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
33	5	RAN	Reject	Accept	Accept	NA	Accept	NA	Reject	Accept	Accept	Accept
35	6	RAN	Reject	Accept	Accept	NA	Reject	NA	NA	NA	NA	Accept
36	7	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
37	8	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	Accept
38	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
39	9	RAN	Accept	NA	NA	NA	NA	NA	NA	NA	NA	NA
40	U	RAN	Reject	NA	Accept	NA	Accept	NA	NA	NA	NA	Reject
41	U	RAN	Reject	NA	Accept	NA	Reject	NA	NA	NA	NA	Accept
42	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
43	U	RAN	Reject	NA	Accept	NA	Accept	NA	NA	NA	NA	Reject
44	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
45	4	RAN	Reject	Reject	Accept	NA	Accept	NA	NA	Accept	Accept	Accept
46	4	RAN	Reject	Reject	Accept	NA	Accept	NA	NA	Accept	Accept	Accept
47	5	RAN	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept
48	U	RAN	Reject	NA	Accept	NA	Reject	NA	NA	NA	NA	Accept
50	U	RAN	Reject	NA	Accept	NA	Reject	NA	NA	NA	NA	Accept
51	U	RAN	Accept	NA	Accept	NA	Accept	NA	NA	NA	NA	Accept
52	3	RAN	Accept	Accept	Accept	NA	Accept	Accept	Accept	Accept	Accept	Accept
58	1	VOL	Reject	Accept	Reject	Reject	Accept	NA	NA	NA	NA	Accept
59	1	VOL	Accept	Accept	Accept	Accept	Accept	NA	NA	NA	NA	Accept
82	4	VOL	Accept	Accept	Accept	NA	Accept	NA	NA	Accept	Accept	Accept
83	3	VOL	Reject	Reject	Accept	NA	Accept	Accept	Accept	Accept	Accept	Accept
84	1	VOL	Accept	Accept	Accept	Accept	Accept	NA	NA	NA	NA	Accept
89	4	VOL	Accept	Accept	Accept	NA	Accept	NA	NA	Accept	Accept	Accept
100	5	VOL	Accept	Accept	Accept	NA	Accept	NA	Accept	Accept	Accept	Accept

Likelihood of Fish Passage in the Field and According to the Written Plan

			Fish	Fish
			Passage	Passage
SiteNo	Alternative	Selection	Field	Plan
1	4	VOL	Low	High
2	4	VOL	High	High
3	4	VOL	High	High
4	4	VOL	High	High
5	1	VOL	Low	High
6	1	VOL	Low	High
7	3	RAN	High	High
8	8	RAN	High	High
9	1	RAN	Low	Low
10	5	RAN	High	High
11	3	RAN	Low	High
12	5	RAN	Low	High
13	5	RAN	Low	High
14	5	RAN	Low	High
15	U	RAN	High	High
16	8	RAN	High	High
17	8	RAN	High	High
18	4	VOL	High	High
19	6	VOL	High	High
20	U	RAN	High	ND
21	5	RAN	High	High
22	1	RAN	Low	Low
23	U	RAN	High	Low
24	U	RAN	Low	Low
25	U	VOL	High	High
26	4	VOL	High	High
27	4	VOL	High	High

Likelihood of Fish Passage in the Field and According to the Written Plan

28	1	VOL	High	High
29	8	RAN	High	High
30	8	RAN	High	High
31	U	RAN	High	ND
32	5	VOL	High	High
33	5	RAN	High	High
35	6	RAN	Low	High
36	7	RAN	High	High
37	8	RAN	High	High
38	U	RAN	High	ND
39	9	RAN	High	Low
40	U	RAN	High	ND
41	U	RAN	Low	Low
42	U	RAN	High	Low
43	U	RAN	Low	Low
44	U	RAN	High	Low
45	4	RAN	Low	High
46	4	RAN	Low	High
47	5	RAN	Low	High
48	U	RAN	Low	ND
50	U	RAN	Low	ND
51	U	RAN	High	ND
52	3	RAN	High	Low
58	1	VOL	High	High
59	1	VOL	High	High
82	4	VOL	High	High
83	3	VOL	Low	High
84	1	VOL	High	High
89	4	VOL	High	High
100	5	VOL	High	High

APPENDIX D: EXAMPLE OF WRITTEN PLAN

APPENDIX D: EXAMPLE WRITTEN PLAN

Date: July 29**,** 1996

Revision to July 22, 1996 Plan
Project Name: X Creek (Notification #)
Legal: T xx R xx S xx
Protected Waters: X Creek

Stream Characteristics:

1) X Creek is a Large Type 'F' stream with a medium gradient. The bed is comprised mainly of small to large cobbles.

2) The bed material appears deep enough to countersink these culverts.

Installation Plan:

1) No work will take place during wet conditions.
2) The existing wood culvert will be removed and disposed of in an approved disposal site.
3) The road width will be reduced to 20 feet to limit fill volume.
4) The road grade will increase to limit fill height and fill volume.
5) Excess material removed from the fill will be placed in disposal site as shown on the map.
6) Backfill material will be replaced in one foot lifts and machine compacted across the entire width of the fill.
7) The lower road and the wood culvert between the two roads will be removed to restore the original stream bed. Structures will be placed in the stream channel as needed to facilitate fish passage. This will be determined during the project as we see what develops.
8) All work will be done between August 1 and September 30.
9) An equipment access road will be left to the inlet of the culvert for maintenance purposes.
10) All exposed soil will be seeded immediately after construction.

Pipe Geometry:

1) The stream gradient is - 10% along this reach of stream.
2) The pipe will be placed on a 8% gradient.

3) The outlet will be buried 1 foot. The inlet will be buried ~2 feet to achieve a maximum 8% slope.
4) A lip or similar catch will be installed at the outlet end to insure the pipe backfills. Rocks will be hand placed in the pipe to speed the backfill.

Pipe Size:

6) 84-inch by 80-foot culverts will be placed in the crossings.

A) Watershed area = 200 acres.

B) 50-year event: New State method: 94 cfs.

C) Culvert size: New State method: 60-inch pipe.

D) Cross-sectional area: For a 60-inch diameter pipe, the cross-section = 19.63 square feet. By using a 72-inch pipe buried 2 feet at the inlet end, 20.02 square feet of cross-sectional area remains. Because of the size of the fill and the uncertainty of the backfill we will install an 84" diameter pipe at this location.