Culvert Assessment and Prioritization Plan for Fish Passage in the Tillamook Bay Watershed, Tillamook County, Oregon – Version 1.1

Tillamook Estuaries Partnership
A National Estuary Project

Prepared by

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1.0. Introduction

1.1. Background

Improperly designed, constructed, or damaged culverts and other stream crossing structures can impede passage for migratory fishes and other aquatic wildlife; fragment and disconnect aquatic habitats; impair water quality; and compromise movement of stream bed materials, organic matter, and nutrients. Such structures have been implicated in dramatic reductions in accessible suitable habitats and associated with localized population declines, increased mortality and predation, decreased egg production, and other problems for many different fish species (Meehan 2005). The Tillamook Bay Watershed (the Watershed) consists of numerous stream systems and an extensive road network. As a result there are numerous road crossings within the Watershed, many of which use culverts to convey stream flows.

In the past, the Tillamook Estuaries Partnership (TEP) and partners have pursued opportunistic projects to upgrade culverts known to impede fish passage or impair habitat quality. Fish passage issues also have been addressed during crossing replacement projects where the primary goal was transportation safety or road corridor upkeep. However, until now, we have had insufficient information to develop a more systematic approach and prioritize passage barrier culverts for replacement throughout the Watershed.

In 2006, TEP and several partners completed a project in the Nestucca and Neskowin basins, Tillamook County, Oregon, during which existing and gathered data was used to identify barrier culverts and prioritize them for replacement (based primarily on their potential to impede fish passage and the quantity and quality of upstream habitats [Hoffman 2006]). The information generated during that project has facilitated cooperative efforts in strategically addressing fish passage issues in those watersheds. TEP and our partners regularly consult the final report for that project during work planning and project implementation efforts. Several barrier culvert replacement projects have been implemented in those watersheds as a result of the study. The study reported in this document utilized and built upon techniques and analyses developed during the Nestucca-Neskowin study.

A considerable amount of information on fish distribution and culverts and other potential barriers in the Watershed existed prior to this study. However, much of the information on culverts was outdated or insufficient to compare and contrast culverts and develop a strategic plan to replace fish passage barrier culverts. In addition, these existing data were insufficient to understand the general condition of culverts as needed by agencies responsible for transportation infrastructure.

With the above facts in mind, TEP undertook a project to identify, characterize and prioritize culverts for replacement throughout the Watershed. This document reports on the methods used to accomplish the study and it provides detailed information on culverts throughout the Watershed. Also included are the results of the process used to prioritize these culverts for replacement based primarily on their potential to impede fish passage and the quantity and quality of upstream habitats.

1.2. Study Area

This project investigated road-stream crossings throughout the Tillamook Bay Watershed, Tillamook County, Oregon (Figure 1). Five 5th Field Watersheds contribute freshwater to the bay: Kilchis River

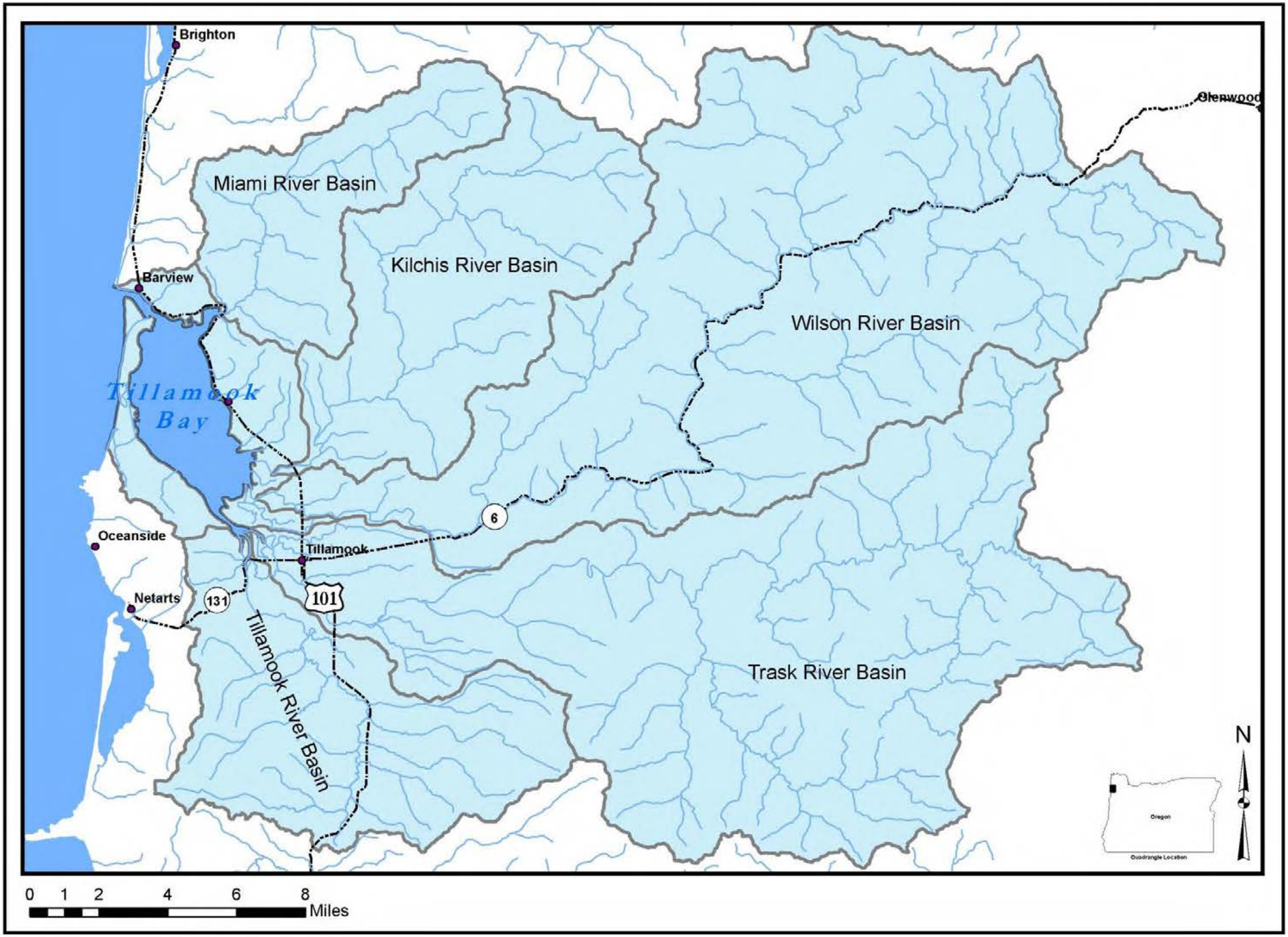

Figure 1. General overview map of Tillamook Bay Watershed.

Basin (Figure 2), Miami River Basin (Figure 3), Tillamook River Basin (Figure 4), Trask River Basin (Figure 5), and Wilson River Basin (Figure 6). In addition, there are several small tributaries that outlet directly into the Bay and are not included in these larger watersheds (Figure 7).

2.0. Methods

2.1. Preliminary Analyses

We used an ArcGIS (ESRI, Inc.) analysis to preliminarily identify road-stream crossings throughout the Watershed. Two data layers were critical to this automated analysis: a road layer and a stream layer that included stream gradient as one of its data fields. We used this analysis to identify potential crossings anywhere a mapped road intersected a mapped stream segment with a gradient of less than 15 percent slope. We used 15 percent as our cut off to minimize the potential that stream reaches occupied by anadromous fishes would be excluded from our analysis. Anadromous salmonids that regularly occur in the Watershed (Cutthroat trout [*Oncorhynchus clarki*], Steelhead trout [*O. mykiss*], Chum salmon [*O. keta*], Coho salmon [*O. kisutch*], and Chinook salmon [*O. tshawytscha*]) do not typically occupy stream reaches where gradients exceed 15 percent. This initial analysis did not attempt to differentiate between fish-bearing and non fish-bearing streams. We acknowledge that this analysis may not identify all crossings that may affect fish passage within the Watershed, but we believe that it was sufficient to identify a majority of crossings capable of affecting passage.

Using the above GIS analysis, we identified 1,529 potential crossings throughout the Watershed. These potential crossings occurred on roads administered by federal, state, and local governments and private roads owned by industrial and non-industrial land owners. Adjacent lands also were under varied ownership: federal-, state- and county-owned public lands, private industrial forest lands, and private agricultural, commercial and residential properties.

Before beginning field work, we used a Tillamook County taxlot data layer for an additional GIS analysis to identify owners of properties where the GIS-identified crossings occurred. We contacted all private property owners identified during this analysis by mail to request permission to access their property and investigate the crossings. We did not visit crossings that required crossing private lands where access was not provided. Most crossings on public roads were inspected. Access to the adjacent private property was not provided for some public road crossings. When this occurred, we were generally able to collect specific information about the crossing itself (e.g., crossing type, culvert dimensions, culvert gradient, etc.) but sometimes could not directly measure other variables if collecting that information required access outside of the public road right-of-way (e.g., bankfull width, upstream gradient, etc.). In these situations, we recorded visual estimates for such data (if possible). In some instances, the crossing inlet and outlet were outside of the road right-of-way and we were unable to collect most data on the crossing. We include two culverts in this report that meet this description.

2.2. Field Methods

2.2.1. Field Training

We hired six college student interns to complete the bulk of field work for this project. Interns completed an approximately two week orientation and training session before they began independent site visits.

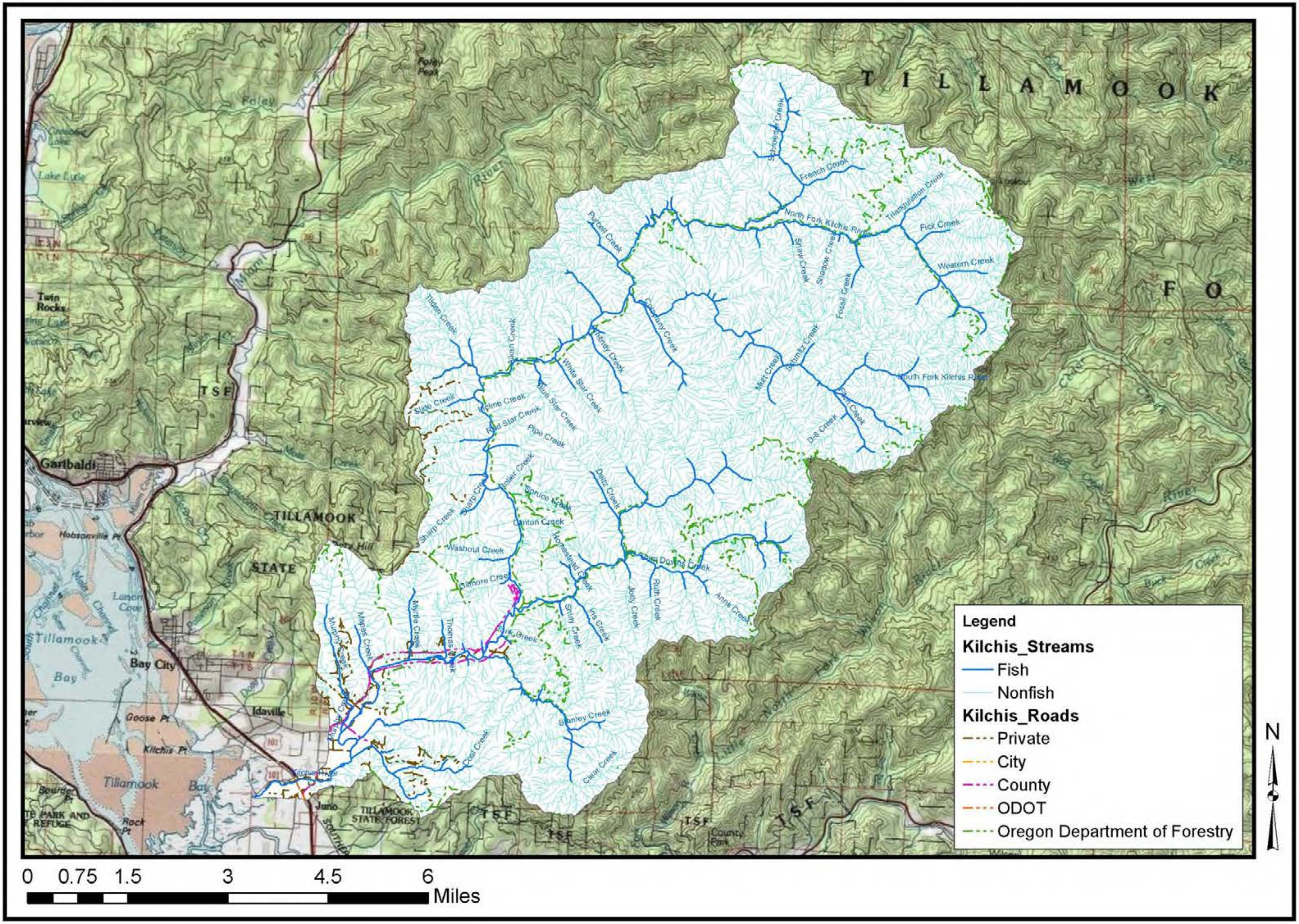

Figure 2. Map of Kilchis River Basin.

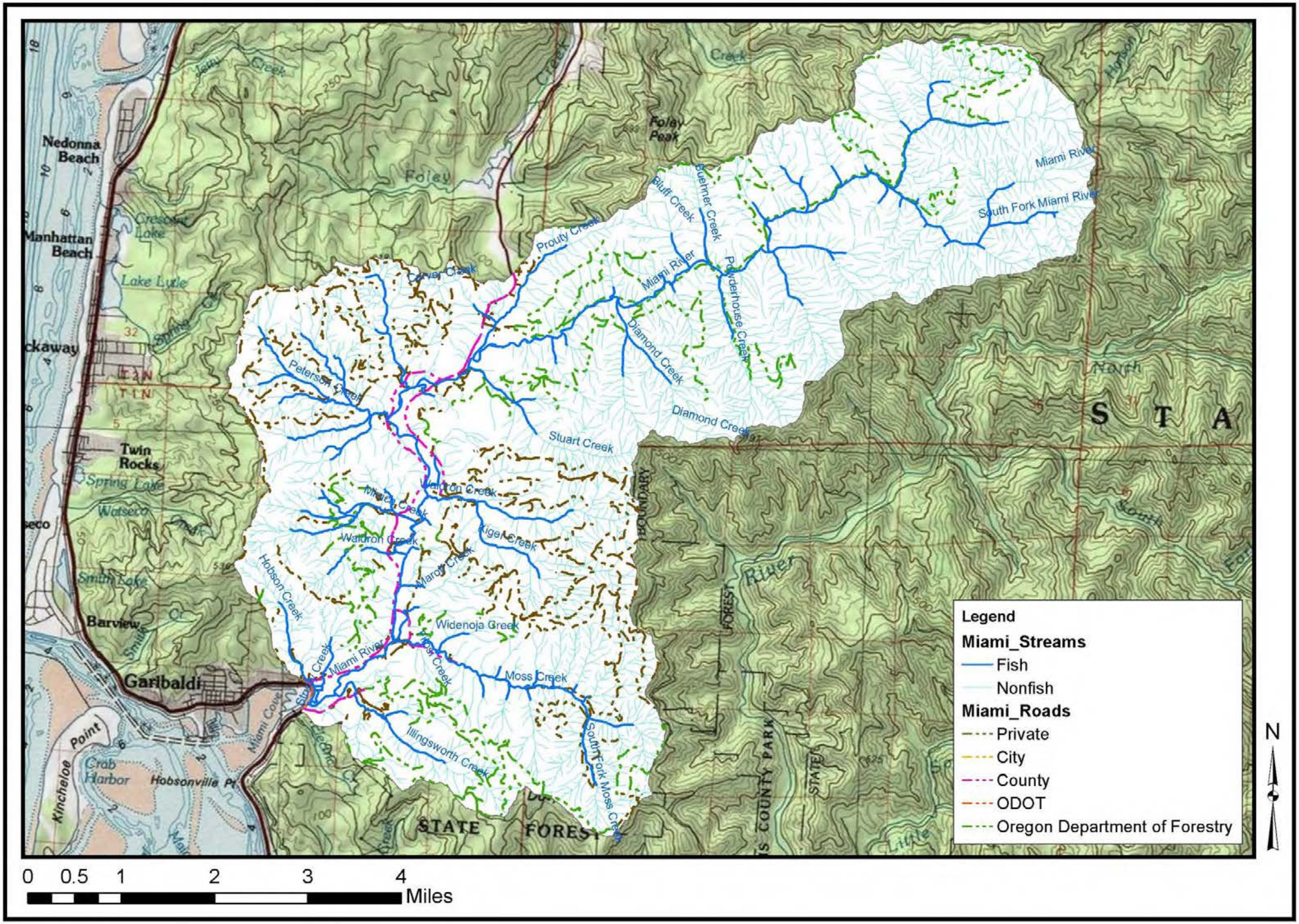

Figure 3. Map of Miami River Basin.

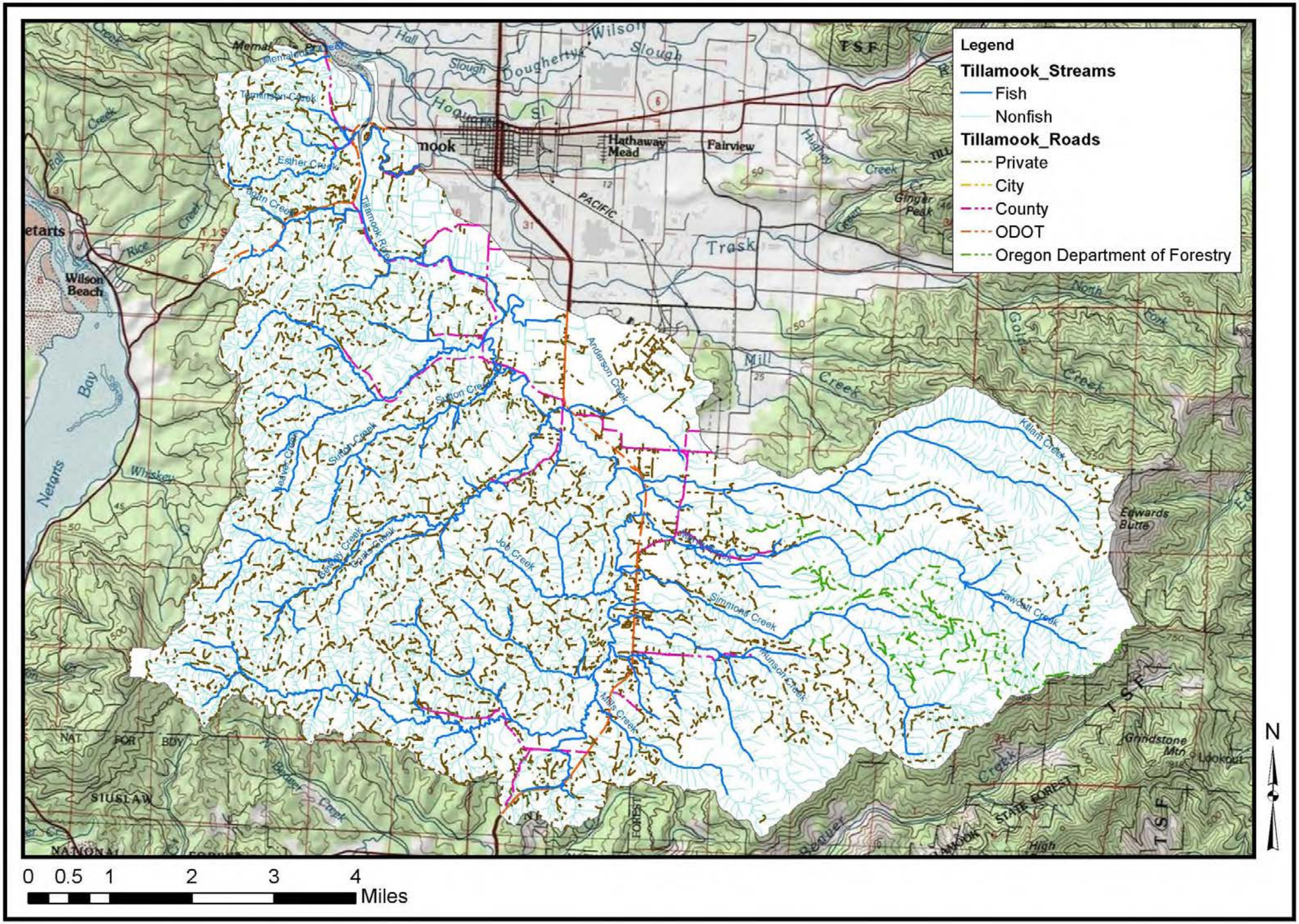

Figure 4. Map of Tillamook River Basin.

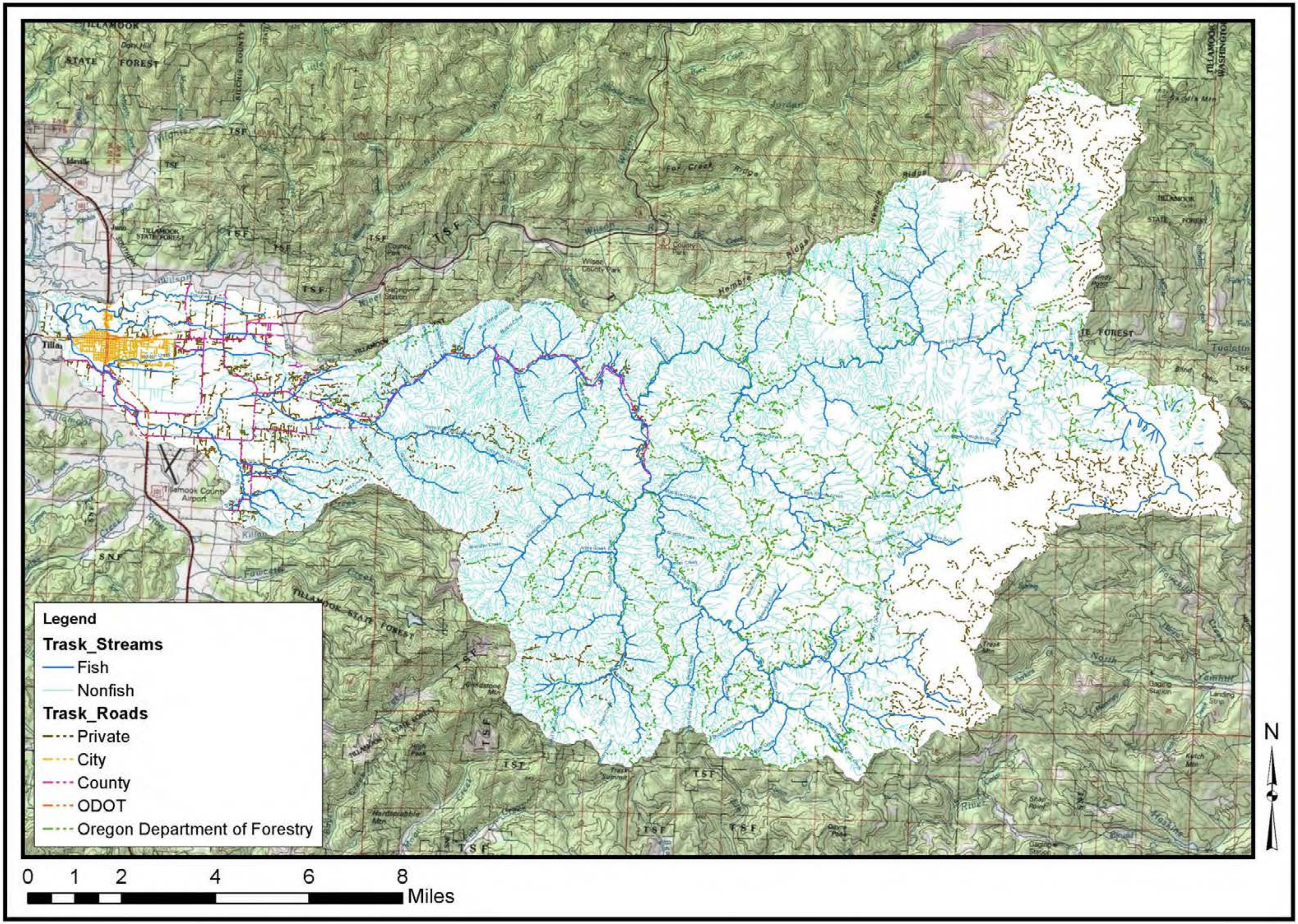

Figure 5. Map of Trask River Basin.

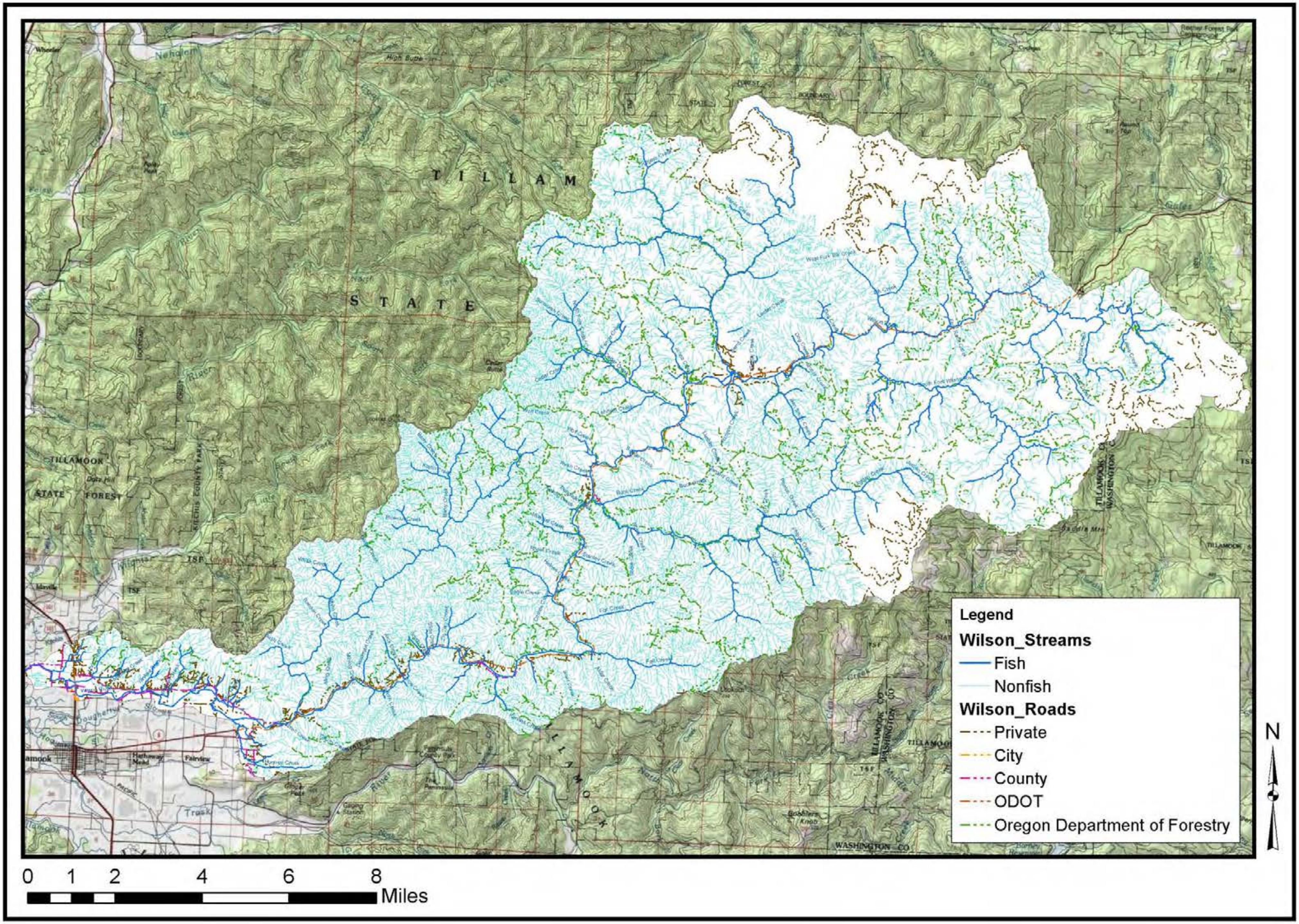

Figure 6. Map of Wilson River Basin.

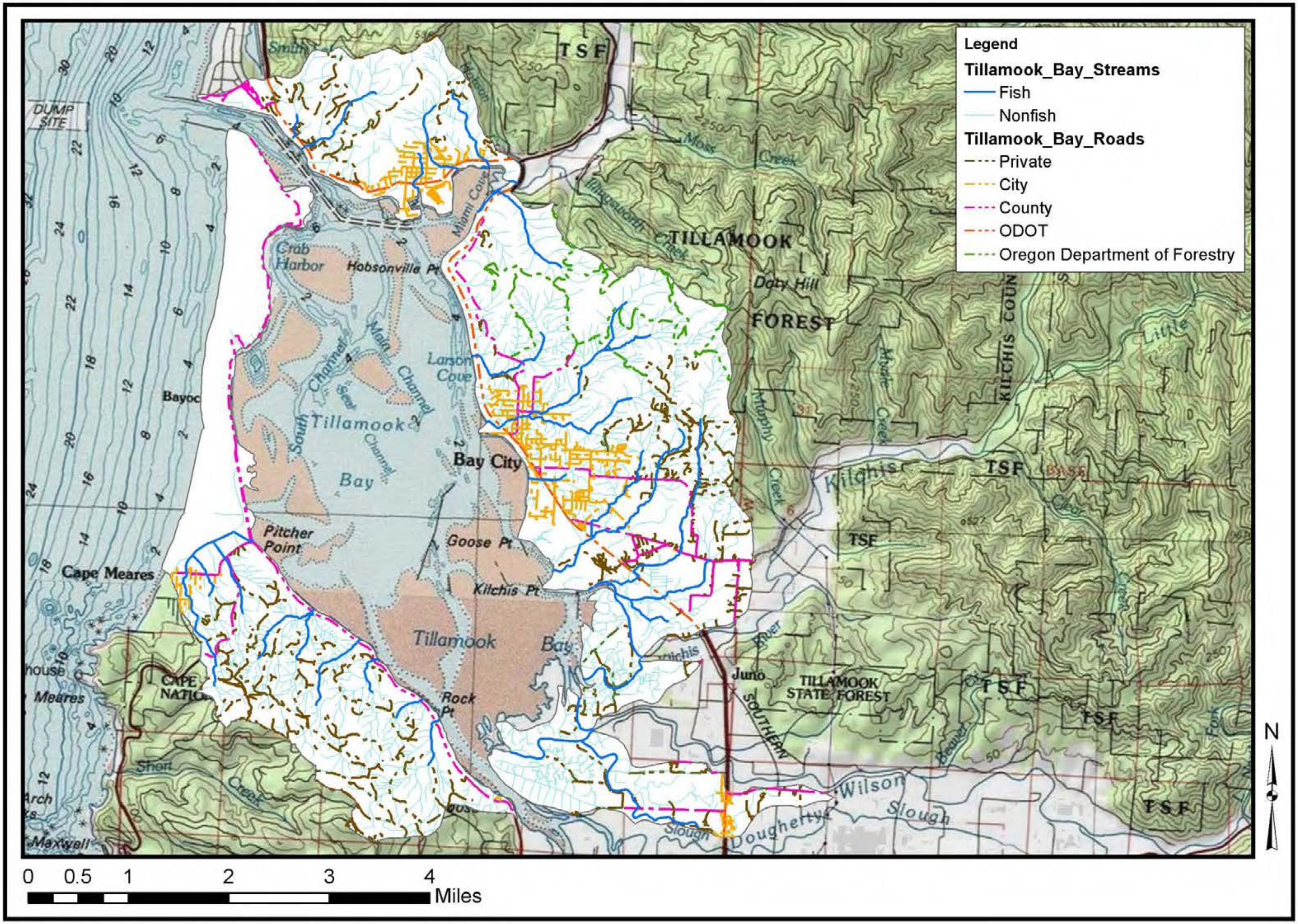

Figure 7. Map of Tillamook Bay Tributaries.

This consisted of two days of classroom training followed by field training. Classroom presentations covered a variety of topics including the Watershed, anadromous fish and their ecology, crossing structure classification and condition assessment, work safety, field methods, data management, etc. Interns spent the remainder of the training period working directly with the Project Manager conducting actual culvert surveys (see below). Together, we surveyed several GIS-identified crossings. This group field effort assured that each intern performed and became familiar with all aspects of the data collection and management process and were collecting data in a similar manner before they worked independently.

2.2.2. Preliminary Classification and Data Collection at Culverts

After the training, we established three, two-person field crews. Between late June and mid-September, 2011, these crews visited (or attempted to visit) each of the GIS-identified crossings that we had permission to access.[1]

At each crossing, we completed an initial screening process to establish whether the crossing was a "Fish Culvert" or "Not a Fish Culvert" (NFC). This process was the first step of our assessment and prioritization scheme and determined the appropriate data collection effort that the crew would need to complete for each crossing.

Crossings classified as "Fish Culverts" consisted of a culvert crossing structure on a known or potentially fish-bearing stream. The results section of this report primarily addresses these crossings. Crossings classified as NFC were crossings where (a) the crossing structure was something other than a culvert (e.g., a ford or a bridge)[2], and/or (b) the stream reach was identified as Nonfish and/or appeared to lack suitable habitats for fishes (based on field observations). Although field crews had access to Oregon Department of Forestry (ODF) stream information as presented in figures 2-7 (and discussed in greater detail later in this report), they also made field determinations. The crews assessed whether a stream appeared fish-bearing or non fish-bearing based on a review of in-stream habitats and the surrounding riparian and upland communities (coupled with review of mapped information). This could be a challenging decision and often involved repeat visits and/or post-fieldwork review of additional data sources (e.g., RBA and fish distribution data). It is important to note that these determinations were made outside of the normal period for ODF fish presence/absence surveys and did not follow ODF protocols (ODF 2009).

In a few cases, we made determinations that differed from the ODF designation. There was a single instance, where we made an NFC determination on a stream verified as supporting fish. This culvert (#280) occurs on a small tributary of Elliot Creek in the upper Wilson River Basin. Our crew felt that the stream above this crossing was too small to support fish. The Fish-Verified reach of this stream extends approximately 0.1 miles above culvert #280. Because the segment above the culvert was so short and only resident fish occupy this portion of the Wilson River Basin, we did not return to the crossing to resample. We made a few NFC determinations for crossings on modeled fish streams. This decision was typically made when the stream was very small with marginal instream habitats and highly disturbed riparian and upland communities. There also were instances where the stream appeared capable of supporting fishes (upstream and/or downstream of the culvert), but where topographic and geophysical conditions at or near the culvert seemed to preclude upstream passage regardless of whether a culvert was present (e.g., culvert

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[1] Between Fall 2011 and Summer 2012 we completed additional field work to clarify questions regarding previously surveyed pipes and to collect information on crossings not visited while field crews were employed.

[2] These structures were not necessarily on stream reaches that were "non-fish." In fact, bridges were often on larger streams known to support fish.

built on or near bedrock falls or in other extremely steep gradient conditions).[3] Conversely, we made a few Fish Culvert determinations for crossings on s tream reaches designated Nonfish (verified and modeled – see below). These were generally situations where the crossing was located on a stream that appeared capable of supporting fish (at least seasonally) and flowed through naturally vegetated upland and riparian communities. In addition, these crossings also were typically in close proximity to stream reaches known to support salmonids.

During site visits at each fish culvert, crews collected a variety of data to characterize both the culvert and its adjacent stream reach and provide for subsequent analyses (Appendix 1-Crossing Assessment Form). We collected much of this data along a longitudinal profile that extended from above the culvert downstream to below the culvert and included all pertinent points needed to fully characterize the culvert and adjacent stream reach (Figure 8).[4] We used an optical surveyor's level, levelling rod and fiberglass tape measure to collect elevational data along the longitudinal profile. Units for all our levelling rods and fiberglass tapes were decimal feet (i.e., feet, tenths, and hundredths).

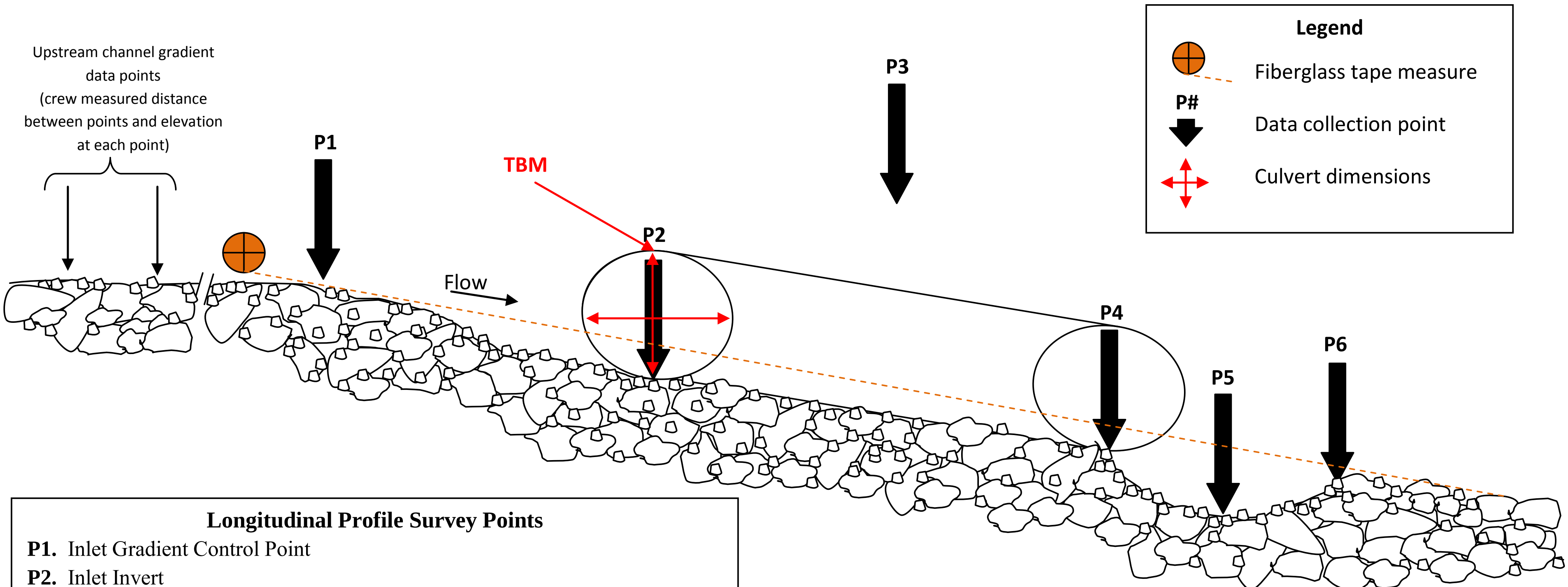
We initially established a Temporary Bench Mark (TBM), selected a location for the surveyor's level, and stretched the fiberglass tape measure from upstream to downstream along the stream centerline. The TBM was typically established on the top of the culvert on the inlet side and was given an arbitrary elevation of 100.00 ft (Figure 8). All other elevations were recorded relative to this 100.00 ft TBM. Crews attempted to set up the surveyor's level in a location with a line-of-sight view of all data points depicted on Figure 8. In a few instances, this was not possible and the crew moved the level partway through data collection and followed standard surveying procedures to re-establish Height-of-Instrument (relative to TBM) before continuing collection of elevational data. Elevational data was used for several different calculations needed to characterize fish culverts (see Figure 8 and Section 2.3). In several cases site topography or other obstacles made it impossible to collect longitudinal profile data using surveying equipment. In such instances, crews measured gradients directly using an Abney level and measured perch height directly using the tape measure or levelling rod (if an outlet perch was present).

Crews also collected other data needed to fully characterize each fish culvert in addition to the aforementioned longitudinal profile data (Appendix 1-Crossing Assessment Form). These included:

- several stream attributes (e.g., bankfull width [generally based on an average of three upstream measurements] and substrate conditions),
- culvert location (UTM coordinates, Public Land Survey System coordinates [i.e., Township and Range coordinates], and mile post),
- culvert type (shape and material),
- culvert dimensions (horizontal and vertical measurements),

[3] Resident cutthroat trout populations regularly occur upstream of both natural and anthropogenic barriers. However, in these situations, a resident fish passing downstream of these points would likely be incapable of returning upstream whether the culvert was there or not.

[4] Data collection points along the longitudinal profile and methodologies used to measure and analyze these data generally follow Clarkin et al. (2005).



Longitudinal Profile Survey Points

P1. Inlet Gradient Control Point
P2. Inlet Invert
P3. Road Surface (fill over culvert barrel not depicted)
P4. Outlet Invert
P5. Outlet Pool Bottom
P6. Tailwater Control Point

All elevations were relative to a Temporary Benchmark (TB) with an assumed elevation of 100.00 ft. This point was generally located on top of the culvert on the inlet side.

Calculations Based on Longitudinal Profile Data

Inlet Gradient (% slope) = ((P1 elev. – P2 elev.) / (P1 dist. – P2 dist.))*100
Culvert Length (to nearest 0.1 ft) = P2 dist. – P4 dist.
Culvert Gradient (% slope) = ((P2 elev. – P4 elev.) / Culvert Length) * 100
Culvert Perch (to nearest 0.1 ft) = P4 elev. – P6 elev.
Upstream Channel Gradient (% slope) = ((Upper elev. – Lower elev.) / dist.) * 100

Figure 8. Illustration depicting typical points where longitudinal profile data was collected at road-stream crossings in the Tillamook Bay Watershed, Tillamook County, Oregon. At each of the points indicated, crews recorded both distance along the fiberglass tape and the elevation of the point relative to the Temporary Benchmark (TBM = 100.00 ft) elevation. Drawing also depicts culvert dimensions recorded during field work. Below the drawing are descriptions of longitudinal profile points and the calculations made with these data used to further characterize each culvert.

- culvert condition (problems that could cause the culvert to plug or fail and affect resources [Clarkin et al. 2005] and condition categories developed and used by transportation agencies to assess the condition and performance of culverts [Hunt et al. 2010]), and
- inlet rust line height[5],

In addition, crews took a ser ies of photographs to better illustrate culvert conditions (inlet, outlet, upstream from inlet, downstream from outlet, and sometimes special condition photos [e.g., excessive corrosion or other damages]). They also drew a site sketch that depicted the culvert relative to the road corridor; locations of the surveyor's level, longitudinal profile data points, photo points; and other pertinent details regarding the crossing (e.g., aprons, wingwalls, riprap, boulders, large wood, etc.).

Crews did not collect the same level of information at crossings initially identified as NFC. For these crossings the crew simply recorded the coordinates of the crossing and noted the type of crossing present (e.g., bridge, culvert, etc.). In a few instances where an NFC culvert was in very poor condition, the crews also noted the condition of the culvert and took photographs.

2.3. Post-Field Work Analyses

Following field work, we performed additional analyses to assess the potential for culverts to impede fish passage and determine the amount of potentially suitable habitat upstream of each culvert. We also convened a group of local fisheries biologists and others familiar with the Watershed to classify the quality of habitats upstream of each culvert. We incorporated all of this information into a Prioritization Model, which forms the basis for our recommended replacement strategy. We discuss the above analyses and models in detail below. The scoring strategy for each variable in the Prioritization Model is discussed in Section 2.3.6.

2.3.1 Longitudinal Profile Data Analyses

We used longitudinal profile data to calculate several pieces of pertinent information: culvert length, inlet gradient, culvert gradient, upstream channel gradient, and culvert perch height. The formulas for these calculations are shown on Figure 8. We used average bankfull width and the horizontal dimension of the culvert to calculate a Bankfull Width:Culvert Width Ratio. The results of the above calculations for each of the assessed culverts were used in analyses discussed below and are incorporated into tables later in this report.

2.3.2. Barrier Determination Model

We used the results of the above calculations and additional information collected in the field in a model that assesses the potential for a culvert to impede fish passage. The result of the barrier determination model is one of the parameters considered in our Prioritization Model (see below).

We selected the BLM Coarse Screen Filter, Version 2.2 as our barrier determination model. (Table 1). This model is based on juvenile salmonid passage potential and was used for a previous TEP culvert

[5] Rust lines typically form at the level of persistent high flows on steel culverts (similar staining can occur on concrete pipes). Rust line height is a good indicator of culvert capacity relative to stream flow. Rustline height exceeding 1/3 to 1/2 of the culvert diameter is a good indication that the pipe is undersized for the stream channel and its flows.

Table 1. U.S. Bureau of Land Management Coarse screen filter for juvenile salmonid passage assessment, Version 2.2.

	Structure	Green	Gray	Red
1	Bottomless pipe arch or countersunk pipe arch, Substrate 100% coverage through pipe and invert depth greater than 20% of culvert rise.	Culvert installed at channel grade (+/- 1%), culvert span to bankfull width ratio greater than 0.9, no blockage.	Culvert installed at channel grade (+/- 1%), culvert span to bankfull width ratio greater than 0.5, less than or equal to 10% blockage.	Culvert not installed at channel grade (+/- 1%), culvert span to bankfull width ratio less than 0.5, greater than 10% blockage.
2	Pipe arches (1x3 corrugation and larger). Substrate less than 100% coverage through pipe or invert depth less than 20% of culvert rise.	Culvert gradient less than 0.5%, no perch, no blockage, culvert span to bankfull width ratio greater than 0.75.	Culvert gradient between 0.5 to 2.0%, less than 4" perch, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5.	Culvert gradient greater than 2.0%, greater than 4" perch, greater than 10% blockage, culvert span to bankfull width ratio less than 0.5.
3	Circular CMP or ABS, 48 inch span and smaller, spiral or annular (CMP) corrugations, regardless of substrate coverage.	Culvert gradient less than 0.5%, no perch, no blockage, culvert span to bankfull width ratio greater than 0.75	Culvert gradient 0.5 to 1.0%, perch less than 4 inches, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5.	Culvert gradient greater than 1.0%, perch greater than 4 inches, blockage greater than 10%, span to bankfull width ratio less than 0.5.
4	Circular CMPs with annular corrugations larger than 1x3 and 1x3 spiral corrugations (>48" span), substrate less than 100% coverage through pipe or invert depth less than 20% culvert rise.	Culvert gradient less than 0.5%, no perch, no blockage, culvert span to bankfull width ratio greater than 0.75.	Culvert gradient between 0.5 to 2.0%, less than 4" perch, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5.	Culvert gradient greater than 2.0%, greater than 4" perch, greater than 10% blockage, culvert span to bankfull width ratio less than 0.5.
5	Circular CMPs with 1x3 or smaller annular corrugations (all spans) and 1x3 spiral corrugations (>48" span), 100% substrate coverage through pipe and invert depth greater than 20% of culvert rise.	Culvert gradient less than 1%, no perch, no blockage, culvert span to bankfull width ratio greater than 0.75	Culvert gradient 1.0 to 3.0%, perch less than 4 inches, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5.	Culvert gradient greater than 3.0%, perch greater than 4 inches, blockage greater than 10%, culvert span to bankfull width ratio less than 0.5.
6	Circular CMPs with 2x6 annular corrugations (all spans), 100% substrate coverage through pipe and invert depth greater than 20% of culvert rise.	Culvert gradient less than 2.0%, no perch, no blockage, culvert span to bankfull width ratio greater than 0.75	Culvert gradient 2.0 to 4.0%, less than 4" perch, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5.	Culvert gradient greater than 4.0%, greater than 4 inch perch, greater than 10% blockage, culvert span to bankfull width ratio less than 0.5.
7	Special items; log stringer or modular bridge,	No encroachment on bankfull width.	Encroachment on bankfull width (either streambank).	Structural collapse.
8	Baffled structure installations (all culvert sizes and configurations).	No perch, no blockage. Culvert span to bankfull width ratio greater than 0.75. 100% substrate in pipe but baffles protruding.	Outlet with less than 6 inch perch, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5. Less than 100% substrate.	Perch greater than 6 inches, greater than 10% blockage, culvert span to bankfull width ratio less than 0.5. Less than 100% substrate.
9	Weir installations (all culvert sizes and configurations).	No perch, no blockage. Culvert span to bankfull width ratio greater than 0.75. Weirs provide 6 inch minimum pool depth and no jumps exceed 4 inches.	Outlet with less than 6 inch perch, less than or equal to 10% blockage, culvert span to bankfull width ratio greater than 0.5. Weirs with pool depths less than 6 inches. Jumps over weirs greater than 4 inches.	Perch greater than 6 inches, greater than 10% blockage, culvert span to bankfull width ratio less than 0.5. Weirs without pools, no resting areas. Weir Jumps> 4 inches
10	Concrete Box Culverts	Culvert backwatered or mostly backwatered w/100% substrate. Culvert span to bankfull width ratio greater than 0.75. No blockage.	Culvert gradient up to 2%. Outlet with less than 4 inch perch. 100% substrate in pipe. Culvert span to bankfull ratio greater than 0.5.	Perch greater than 4 inches. Culvert span to bankfull ratio less than 0.5. Laminar flow. Less than 100% substrate in pipe.
11	Circular concrete and smooth wall ABS culverts.	100% substrate in pipe. Slope less than .5%. No Perch	Less than 100% substrate in pipe. Slope .5-1%. Perch less than 4 inches	No substrate. Slope greater than 1% Perch greater than 4 inches.

assessment for the Nestucca and Neskowin watersheds (Hoffman 2006).[6] During preparation of that report, the author and her technical advisory committee evaluated this and two other commonly used barrier determination models. They selected this model because it is very conservative in determining whether a culvert is a barrier and it differentiates culverts based on the degree to which juvenile fish passage is impeded.

Based on the type of culvert and a suite of characteristics, the model places culverts into one of three passage categories: Green = Not a Barrier (juveniles are able to move past the culvert under all conditions), Gray = Partial Barrier (under some conditions the culvert may preclude juvenile passage), and Red = Complete Barrier (the culvert may block juvenile passage under all conditions). Within the prioritization model, culverts classified as Green received 1 point, Gray culverts received 2 points, and Red culverts received 3 points.

As also stressed by Hoffman (2006), no barrier model is flawless and the determinations made by employing a model are not absolute (juveniles may occasionally get past a culvert classified as a complete barrier and under some conditions a green culvert may preclude juvenile passage). However, we have confidence in the results of the model. We believe that it provides a good approximation of real-world conditions and is sufficiently rigorous to allow comparisons among culverts.

2.3.3. Upstream Habitat Length

We used GIS to estimate the linear amount of potentially suitable habitat upstream of each culvert. This is one of the variables in the Culvert Prioritization Model and is termed Upstream Habitat Length (see below). For the prioritization model, upstream habitat lengths were divided into four classes (each encompassing a range of upstream habitat lengths): 0.0 – 0.5 miles, 0.6 – 1.0 miles, 1.1 – 1.5 miles, and > 1.6 miles. Each culvert was placed in one of these four classes based on the total linear amount of suitable habitat upstream of the culvert and scored accordingly (0.0 – 0.5 miles = 1 point, 0.6 – 1.0 miles = 2 points, 1.1 – 1.5 miles = 3 points, > 1.6 miles = 4 points).

We based our decisions for this parameter on a composite of fields in the attribute table of the ODF Stream Layer mentioned previously. These fields are: Fishpres (Fish Presence = Fish, Nonfish, or Unknown), Verfish (Fish Presence Verified? = Verified or Assumed) and Modfish (Fish Presence Modeled = Fish, Nonfish, or Not Modeled[7]). For presentation purposes, we considered six potential categories that result from this composite: Fish-Verified, Fish-Assumed, Fish-Modeled, Nonfish-Verified, Nonfish-Assumed, and Nonfish-Modeled. Figures 2-7 depict these different stream designations. Although we differentiated reaches based on these designations on maps provided in this report, we did not differentiate between the -Verified, -Assumed and -Modeled classifications for our analyses.

The vast majority of crossings we identified as fish culverts, were located on Fish-Verified, Fish-Assumed or Fish-Modeled stream reaches. For these crossings, we consider the amount of potentially

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[6] Adult salmonids are much more capable swimmers than juveniles and can move past obstacles that would preclude juvenile passage. Using juvenile passage potential results in a more conservative assessment and minimizes the potential for problem culverts to be overlooked. Our model considered a drop of ≥ 4 inches to be a juvenile barrier.

[7] Only reaches designated Unknown in the Fishpres field are modeled.

suitable habitat to be the combined length of all reaches designated Fish-Verified, Fish-Assumed and Fish-Modeled upstream of the given culvert.

We used an alternative approach for the few crossings we classified as fish culverts, but which occurred on streams classified as Nonfish-Verified, Nonfish-Assumed and Nonfish-Modeled. For these culverts, the length of upstream habitat was subjective and based on review of stream gradients, intrinsic potential model outputs and other variables. We reviewed this suite of information and used professional opinion to define the upstream limit (generally where stream gradient became excessively steep and intrinsic potential fell to very low values).

We assumed no upstream barriers (anthropogenic or natural) for the upstream habitat length analysis. In other words, we assumed that the entire length of Fish-Verified, Fish-Assumed and Fish-Modeled reaches upstream of the subject culvert were accessible to juvenile salmonids. We acknowledge that this assumption is an oversimplified view of the watershed. There are known and possibly unknown barrier culverts above many of the culverts analyzed for this report (known culverts are included in this prioritization process). Other anthropogenic barriers also may occur. In addition, permanent and temporary natural barriers occur throughout the Watershed. Some of these barriers are known, while others may be unknown. The degree to which many natural obstacles (and unknown anthropogenic features) may impede fish passage also is largely unknown. Some may mark the end of fish distribution altogether, some may only preclude passage under certain conditions, while others may preclude anadromous passage, but may not mark the end of resident fish use.

We also acknowledge that our method places an enormous amount of faith in the data and model outputs used by ODF and Oregon Department of Fish and Wildlife (ODFW) to classify streams throughout the Watershed. The stream classifications are used for regulatory and management decisions, however, so we assume that they are suitably robust for the purpose of our analysis (ODF 2009).

There are a vast number of variables to consider and a great amount of uncertainty is inherent in obtaining results for the Upstream Habitat Length parameter. We believe the method we chose is an objective and data-driven approach to identifying and comparing upstream habitats for the culverts we analyzed and are confident in the results of this analysis.

2.3.4. Upstream Habitat Quality

We ranked the quality of habitats upstream of each subject culvert. This also is one of the variables in the Culvert Prioritization Model and is termed Upstream Habitat Quality (see below). Within the prioritization model there are three potential responses for this variable: Poor (1 point), Fair (2 points) and Good (3 points).

To populate this variable for each culvert, we convened a one-day meeting of local fisheries biologists and other technical specialists familiar with streams in the study area and GIS data sets with attributes that imply habitat quality. During this meeting, participants reviewed data for each individual fish culvert evaluated in this study and formulated a consensus opinion on the quality of habitats upstream of each culvert. If a participant had first-hand knowledge regarding a stream (typically information on water quality, in-stream and adjacent habitats, fish survey results, etc.) they provided that information to the group. The group also reviewed a variety of GIS data including mapped fish distributions (ODFW data layers for coho and winter steelhead distributions), juvenile snorkel survey results (Rapid Bio Assessment

[RBA] data – Bio-Surveys, LLC. 2005, 2006 and 2007), output from intrinsic potential models (Burnett et al. 2003 and 2007)[8], and stream gradients. The group considered this suite of information in its entirety in formulating its consensus opinion for each assessed culvert.

We rated upstream habitat quality as Poor when the following attributes were predominant upstream of the subject culvert: very small streams with limited flows, steep stream gradients (generally > 8 percent gradient), compromised adjacent upland and riparian habitats (adjacent land primarily supporting agricultural, commercial or residential development or subject to recent and ongoing timber harvests, etc.), low intrinsic potential scores (scores generally < 0.300 for both coho and steelhead), and RBA data indicating low numbers of juvenile salmonids upstream of the subject culvert or in nearby reaches if no RBA data exists for reaches upstream of the subject culvert (juvenile coho, cutthroat and steelhead densities generally less that 0.3 fish per square meter of pool surface).

We rated upstream habitat quality as Fair when the following attributes were predominant upstream of the subject culvert: moderate gradients (generally 4-8 percent gradient), forested upland habitats and intact riparian habitats, moderate intrinsic potential scores (intrinsic potential scores generally between 0.300 and 0.600 for coho or steelhead), and RBA data indicating moderate numbers of juvenile salmonids upstream of the subject culvert or in nearby reaches if no RBA data exists for reaches upstream of the subject culvert (juvenile coho, cutthroat or steelhead densities generally ranging from 0.3-1.0 fish per square meter of pool surface).

We rated upstream habitat quality as Good when the following attributes were predominant upstream of the subject culvert: low to moderate gradients (generally < 6 percent gradient), forested upland habitats and intact riparian habitats, moderate to high intrinsic potential scores (intrinsic potential scores generally above 0.500 for coho or steelhead), and RBA data indicating moderate to high numbers of juvenile salmonids upstream of the subject culvert or in nearby reaches if no RBA data exists for reaches upstream of the subject culvert (juvenile coho, cutthroat or steelhead densities generally > 0.8 fish per square meter of pool surface).

In the tables that provide data on each individual culvert we analyzed for this report (see below), we also included a + or – modifier for some culverts. We included this modifier when the evaluation team felt that habitat conditions were somewhat better or somewhat worse than the Poor or Fair classification would otherwise suggest. In a situation where multiple culverts may have the same overall prioritization score and similar habitat quality scores, this qualifier may be used as a “tie breaker” to facilitate strategic planning of culvert replacements.

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[8] These models are based on physical landscape characteristics that have been positively correlated with productive habitats for coho and steelhead (valley width, channel gradient and mean annual flow). Intrinsic potential scores range from 0.0 to 1.0 (low to high). The models are not a perfect measure of habitat quality because they do not account for actual present conditions that affect habitat quality (e.g. condition of adjacent riparian and upland habitats, water quality and other in-stream conditions, etc.). However, they are one of the few tools that objectively evaluate the habitat potential of individual stream reaches across large geographic areas.

2.3.5. Fish Species Present

We included the type of fish likely to be affected by a given culvert as one of the parameters in our prioritization model. There were three potential responses for this variable: No Fish (1 point), Resident Fish (2 points) and Anadromous Fish (3 points).

By definition, all culverts identified as fish culverts are likely to affect fishes, so we did not apply the "No Fish" category to any culverts evaluated for this report. For the few culverts that we identified as Fish Culverts, but which occurred on Nonfish designated stream reaches (see explanation above), we used the fish classification for the adjacent downstream reaches for that variable in our model. For example, if the adjacent downstream reaches supported anadromous fish, we populated the Fish Presence variable of the model with the value for anadromous fishes (we feel it is reasonable to assume that if a barrier culvert did not exist that the fish using the adjacent downstream reaches would have access to reaches above the subject culvert).

Most culverts in our assessment occurred on streams that are known or potentially occupied by anadromous fishes. As a result, most culverts we analyzed received a full score (3 points) for fish presence. There are a few notable exceptions.

Within the Watershed, there are a few large natural barriers (e.g., University Falls on Elliot Creek in the upper Wilson River Watershed) and anthropogenic barriers (e.g., the dam that forms Barney Reservoir on the Middle Fork North Fork Trask River) that prevent upstream migration of anadromous fishes. A few culverts assessed for this report are located on designated fish streams above these known anadromous barriers. These streams support resident cutthroat trout populations and the culverts on these reaches received scores for resident fish (2 points) within the prioritization model.

2.3.6. Prioritization Model

Results from the above analyses were incorporated into a Prioritization Model which yields a composite score for each culvert (Table 2). We used the model developed and used by Hoffman (2006) for this analysis.

Hoffman's model essentially compares culverts against one another by giving each a composite score based upon the severity of the barrier, the quantity and quality of upstream habitats, and the types of fish affected (resident or anadromous). The results of this model form the basis of our prioritization plan and are incorporated into tables later in this report.

2.4. Prioritization Action Plan

The final step in this culvert assessment project was to develop a plan to facilitate and guide replacement of fish passage barrier culverts in the Watershed based primarily on the outcomes of the above analyses. Our goal was to collect up-to-date information on as many potential barrier culverts as possible, make objective comparisons among these culverts, and facilitate development and implementation of projects to replace barrier culverts in a fashion that maximizes benefits to fishes.

Table 2. Culvert Prioritization Model used to compare and prioritize culverts in the Tillamook Bay Watershed for replacement.

Parameter	Points	Criteria	Criteria Based on
Barrier Severity	1	Not a Barrier (Green)	Juvenile Barrier Determination Model (BLM Coarse Screen Filter Version 2.2).
	2	Partial Barrier (Gray)	
	3	Complete Barrier (Red)	
Upstream Habitat Length	1	0.0 – 0.5 miles	Fish presence fields in Oregon Department of Forestry GIS stream layer.
	2	0.6 – 1.0 miles	
	3	1.1 – 1.5 miles	
	4	>1.6 miles	
Upstream Habitat Quality	1	Poor	Professional judgment of advisory committee. Supported by review of several GIS data layers and firsthand knowledge.
	2	Fair	
	3	Good	
Fish Species Present	1	No Fish	Review of GIS fish distribution data.
	2	Resident	
	3	Anadromous	

As noted above, the Tillamook Bay Watershed is quite large and is composed of five river basins and numerous tributaries that outlet directly to the bay. Larger basins (e.g., Trask and Wilson basins) have greater numbers of larger (longer) streams than the smaller basins (e.g., Miami and Kilchis basins). Thus, more culverts in the larger basins are likely to receive the maximum score for the Upstream Habitat Length parameter of the prioritization model than in smaller basins. As a result, comparing culverts across all basins would disproportionally bias our results towards the larger basins. To make our prioritization scheme more user-friendly, facilitate its use by partners that may work more in one portion of the Watershed than others, and remove the aforementioned potential source of bias we based our prioritization recommendations and present our findings below using a basin-by-basin format (rather than lumping culverts across all basins).

We ranked culverts with higher prioritization model scores as higher priority for replacement than those with lower scores. However, many culverts scored equally and the spread between the lowest and highest ranking culverts in some basins was only a few points. When end users use this document for planning replacement projects, we suggest that they use differences in ecological factors discussed above (e.g., + or – "tie breaker" modifier for habitat quality, actual Upstream Habitat Length values, etc.) and overall culvert condition scores to further inform their decision making processes.

Our goal was to prioritize culverts based on objective and measurable variables and facilitate an efficient and effective replacement strategy to improve conditions for fish populations in the Watershed. We recognize that some potential replacements may be easier to implement than others based on potential willingness of landowners to participate, potential to obtain funding, and other factors. However, it is beyond the scope of this project to consider such factors associated with replacement projects and, thus, they were not incorporated into our ranking process.

3.0. Results

We identified 1,526 potential crossings through the initial GIS-based identification effort discussed above.[9] We did not receive permission to access 362 of the GIS-identified crossing locations that occurred on private lands or required travel on private roadways. In addition, we determined that 311 of the GIS-identified crossings do not exist (DNE). We identified a crossing as DNE for one of two reasons: (1) the road on which the crossing was expected to occur did not exist (typically these roads had been decommissioned by the land owner), or (2) the GIS-identified crossing was what our field crews referred to as a "Phantom Crossing." We believe phantom crossings were identified in GIS due to errors in the spatial data sets used for the analysis or errors associated with the geospatial analysis used to identify intersections of road and stream polylines. Phantom crossings occurred primarily where road and stream polylines ran parallel, and in very close proximity, to one another. In these situations, a slight alignment error in one or both polylines (as compared to "real world" conditions) could cause GIS to identify an intersection between road and stream polylines where none actually existed. Conversely, GIS could identify an intersection in error if the distance between the road and stream polylines was less than the tolerance level setting used for the ArcGIS intersect analysis (e.g., if the tolerance level for the ArcGIS intersect analysis is set at one meter and the polylines are less than one meter apart, the application would identify a crossing). In either of these circumstances, GIS could identify a crossing where none occurred.

We visited 853 of the 1,526 GIS-identified crossings during field work for this report. In addition, we collected information on 20 crossings not identified by GIS, but which appeared notable to field crews when observed in the field. Therefore, we surveyed a total of 873 crossings for this report. We identified 658 NFC crossings (465 culverts, 190 bridges, two fords, and one hatchery diversion structure) and 215 Fish Culverts: 21 (10 percent) were not barriers to juvenile fish passage (Green), 36 (17 percent) were partial barriers to juvenile fish passage (Gray) and 156 (73 percent) were complete barriers to juvenile fish passage (Red). We lacked sufficient information for two culverts to determine a barrier rating (2 unknown – 1 percent).

The sections that follow summarize our results and provide detailed information on the 215 fish culverts we surveyed (including maps and photos) and replacement prioritization recommendations for each basin in the Tillamook Bay Watershed.

3.1. Prioritization Analysis

As noted above, a majority of culverts included in this report were rated as complete barriers to fish passage. In addition, most culverts in this report also were on streams that should be accessible to anadromous fishes (if not for these anthropogenic barriers). As a result, the variables that most affected our prioritization rankings were habitat quantity and habitat quality.

[9] GIS-identified crossings numbers 453 and 454 turned out to be a single long crossing that passed under several roads and city lots before terminating at Tillamook Bay. The number of culverts reported from this point forward treats these as a single crossing.

In general, culverts ranked as High Priority affected a considerable amount of potentially suitable habitat and/or affected relatively high quality habitats. Medium Priority culverts typically impeded passage to lesser amounts of potentially suitable habitat or somewhat lower quality habitats than those ranked as High Priority. Culverts ranked as Low Priority generally affected only small amounts of habitat and often these habitats were of relatively low quality. When using this report as a guide to identify and plan potential culvert replacement projects, culverts with higher priority ratings should take precedence over lower ranked culverts whenever possible.

We feel it is important to stress that although we rank many culverts as Low Priority for replacement in the following sections, this does not imply that these culverts are unimportant and should not be targeted for replacement. On the contrary, figures 2-7 graphically demonstrate that most streams in the Watershed are not fish-bearing. As a result, all anthropogenic barriers on fish-bearing streams are important with respect to the conservation and long-term viability of native fish populations in the Watershed. However, under most circumstances, culverts receiving Low Priority scores should be targeted for replacement to improve fish passage only after higher ranked culverts have been replaced.

We also include information below on several culverts that at the time of our surveys did not appear to be barriers to fish passage (Barrier Severity Rating = Not a Barrier). Based on their overall prioritization model scores, several of these culverts ranked as High or Medium Priority (despite scoring very low in one of the model parameters). These culverts occurred on streams with large amounts of upstream habitat and/or high-quality habitats and occupied by multiple anadromous species. Although these culverts didn't appear to impede upstream passage at the time of our survey, this may not always be the case. Culverts wear out and stream conditions change, so we recommend regular monitoring visits to verify that these pipes continue to allow access to the streams systems on which they occur.

As noted earlier, we implemented our prioritization process basin-by-basin to facilitate its use by end users and minimize potential bias. The following paragraphs summarize our findings for each basin.

Kilchis River Basin - We surveyed 24 fish culverts in the Kilchis River Basin (Table 3). These crossings affected a total of approximately 12.4 miles of upstream habitats (Table 9). There were 10 High Priority culverts in this basin. We rated four culverts in the Kilchis Basin as Medium Priority. Six culverts in this basin received scores that placed them in the Low Priority range. In addition, four culverts in this basin received scores that would have placed them in the Low Priority range, but these did not appear to be barriers to fish passage at the time of our survey.

Miami River Basin - We surveyed 21 fish culverts in the Miami River Basin (Table 4). These crossings affected a total of approximately 13.8 miles of upstream habitats (Table 9). There were seven High Priority culverts in this basin. We rated six culverts in the Miami Basin as Medium Priority. Six culverts in this basin received scores that placed them in the Low Priority range. In addition, two culverts in this basin received scores that would have placed them in the Low Priority range, but these did not appear barriers to fish passage at the time of our survey.

Tillamook Bay Tributaries - We surveyed 35 fish culverts on streams that outlet directly into Tillamook Bay or Cape Meares Lake (Table 5). These crossings affected a total of approximately 13.8 miles of upstream habitats (Table 9). There were 13 High Priority culverts on these streams. Notably, 10 of these 13 crossings occur on two streams in the Bay City area: Patterson Creek and Doty Creek. We rated 13 culverts on Tillamook Bay tributaries as Medium Priority. Nine culverts in this basin received scores that placed them in the Low Priority range.

Tillamook River Basin - We surveyed 15 fish culverts in the Tillamook River Basin (Table 6). These crossings affected a total of approximately 35.6 miles of upstream habitats (Table 9). There were five High Priority culverts in this basin. We rated three culverts in the Tillamook Basin as Medium Priority. Two culverts in this basin received Low Priority ratings. Additionally, we surveyed two culverts in this basin that did not appear to be barriers to fish passage at the time of our survey, but received scores that would have placed them in the High Priority range (due primarily to the quality and quantity of upstream habitats). There were three similar culverts that received scores that would have placed them in the Medium Priority range.

Trask River Basin - We surveyed 64 fish culverts in the Trask River Basin (Table 7). These crossings affected a total of approximately 35.8 miles of upstream habitats (Table 9). There were 17 High Priority culverts in this basin. We rated 11 culverts in the Trask Basin as Medium Priority. Thirty (30) culverts in this basin received Low Priority ratings. Additionally, we surveyed one culvert in this basin that did not appear to be a barrier to fish passage at the time of our survey, but received a score that would have placed it in the High Priority range (due primarily to the quality and quantity of upstream habitats). There were three similar culverts that received scores that would have placed them in the Medium Priority range and two that scored in the Low Priority range.

Wilson River Basin - We surveyed 56 fish culverts in the Wilson River Basin (Table 8). These crossings affected a total of approximately 30.9 miles of upstream habitats (Table 9). There were 12 High Priority culverts in this basin. We rated 10 culverts in the Wilson Basin as Medium Priority. Twenty-eight (28) culverts in this basin received Low Priority ratings. Additionally, we surveyed one culvert in this basin that did not appear to be a barrier to fish passage at the time of our survey, but received a score that would have placed it in the Medium Priority range (due primarily to the quality and quantity of upstream habitats). There are three similar culverts that received scores that would have placed them in the Low Priority range. Finally, two culverts in this basin were on public roads, but we were unable to collect any data on them because we did not have access to the adjacent private property. As a result, we were unable to calculate a prioritization score for these culverts.

Table 9 summarizes priority rankings and total miles of affected upstream habitat for each basin. It also includes the sum total of upstream habitat in the Tillamook Bay Watershed affected by the 215 fish culverts reported on in this document.

Table 3. Prioritization table for Kilchis Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
649	Kilchis	Murphy Creek	Curl Road	434654	5039811	Circular	40	48	Fair	-0.4	none	Gray	2.0	11	H
640	Kilchis	Murphy Creek	Kilchis River Road	434871	5040218	Circular	40	66	Fair	1.6	none	Gray	1.7	11	H
663	Kilchis	Unnamed trib, Kilchis River	Curl Road	435082	5039482	Circular	38	48	Fair	1.4	none	Gray	1.8	11	H
262	Kilchis	Whitney Creek	Kilchis Forest Road	440298	5049327	Circular	100	84	Poor	7.0	4.5	Red	1.1	11	H
603	Kilchis	Mapes Creek	Kilchis River Road	435239	5041132	Circular	50	54	Poor	2.5	none	Red	0.7	10	H
591	Kilchis	Myrtle Creek	Kilchis River Road	436198	5041562	Circular	41	66	Poor	3.3	3.7	Red	1.0	10	H
629	Kilchis	Vaughn Creek	Doughty Road	433319	5040431	Circular	35	29	Poor	1.9	0.1	Red	0.9	10	H
620	Kilchis	Vaughn Creek	Private Drive	433396	5040789	Circular	30	48	Fair	1.9	0.7	Red	0.7	10	H
608	Kilchis	Vaughn Creek	Pike Road	433409	5040853	Circular	34	48	Fair	5.9	0.8	Red	0.6	10	H
621	Kilchis	Vaughn Creek	Private Drive	433393	5040779	Pipe Arch	23	74	Fair	1.7	0.4	Red	0.7	10	H
327	Kilchis	Blue Star Creek	Kilchis Forest Road	438990	5048635	Circular	100	60	Fair	4.0	2.5	Red	0.5	9	M
472	Kilchis	Un. trib, Little S.F. Kilchis R.	Unnamed	441782	5045388	Pipe Arch	60	156	Fair	7.1	7.1	Red	0.6	9	M
674	Kilchis	Unnamed trib, Coal Creek	Private Drive	435604	5039169	Circular	40	30	Poor	5.5	4.5	Red	0.2	9	M
181	Kilchis	unnamed trib, N. Fk. Kilchis R.	Kilchis River Road	448643	5050834	Circular	50.5	66	Good	0.1	0.1	Red	0.5	9	M
292	Kilchis	Aiken Creek	Tilden Bluffs Road	438574	5048715	Circular	54	66	Poor	1.9	6.2	Red	0.1	8	L
673	Kilchis	Hathaway Slough	Alderbrook Loop Road	433617	5039600	Circular	38	24	Poor	1.0	0.1	Red	0.3	8	L
573	Kilchis	Tank Creek	Kilchis Forest Road	438509	5041958	Circular	69	30	Fair	5.6	3.1	Red	0.1	8	L
589	Kilchis	Thomas Creek	Kilchis River Road	437077	5041645	Circular	43	48	Poor	1.8	3.4	Red	0.5	8	L
120	Kilchis	Unnamed trib, Schroeder Ck	Miami Divide Road	444731	5052521	Circular	46	48	Fair	6.8	9.8	Red	0.3	8	L
329	Kilchis	White Star Creek	Kilchis Forest Road	439526	5048697	Circular	65	66	Poor	3.2	6.7	Red	0.5	8	L
658	Kilchis	Vaughn Creek	Alderbrook Loop Road	433158	5039725	Box	35	100	Fair	0.5	0.2	Green	1.4	8	N/A
514	Kilchis	Unnamed trib, Sam Downs Ck	Sans Down Road	444479	5044396	Pipe Arch	95	144	Good	6.7	none	Green	0.4	7	N/A
505	Kilchis	Unnamed trib, Sam Downs Ck	Sam Downs Road	444916	5044416	Pipe Arch	82	144	Fair	4.9	none	Green	0.4	7	N/A
510	Kilchis	Sam Downs Creek	Sam Down Road	445122	5044237	Pipe Arch	52	96	Good	6.7	none	Green	0.1	6	N/A

Table 4. Prioritization table for Miami Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
462	Miami	Illingsworth Creek	Ekroth Road	431174	5045718	Pipe Arch	37	72	Fair	0.1	none	Gray	1.3	12	H
189	Miami	Peterson Creek	Miami Foley Road	431586	5050520	Circular	46	96	Poor	1.0	0.2	Gray	6.2	12	H
138	Miami	Prouty Creek	Miami Forest River Rd	433364	5052149	Pipe Arch	45	110	Fair	3.8	0.2	Red	1.1	12	H
448	Miami	Hobson Creek	Hobson Creek Road	430234	5046127	Circular	27	42	Poor	2.7	0.3	Red	0.8	10	H
432	Miami	Hobson Creek	Hobson Creek Road	430115	5046264	Circular	24	40	Poor	1.3	3.6	Red	0.7	10	H
352	Miami	Waldron Creek	Miami Foley Road	431665	5048197	Circular	52	36	Fair	2.5	none	Red	0.7	10	H
320	Miami	Minich Creek	Minich Creek Road	431133	5048601	Circular	68	18	Poor	7.0	6.8	Red	0.6	10	H
450	Miami	Hobson Creek	Miami Foley Road	430417	5045916	Pipe Arch	140	78	Unk	4.2	none	Gray	1.0	9	M
449	Miami	Hobson Creek	Private Drive	430308	5045955	Circular	26	36	Poor	-1.0	none	Gray	0.9	9	M
444	Miami	Struby Creek	Miami Foley Road	430542	5045965	Circular	43	24	Poor	4.6	none	Red	0.5	9	M
273	Miami	Unnamed trib, Minich Creek	Minich Creek Road	430996	5048047	Circular	61	24	Fair	7.0	1.8	Red	0.2	9	M
278	Miami	Unnamed trib, Minich Creek	Minich Creek Road	430917	5048132	Pipe Arch	75	60	Poor	4.0	3.0	Red	0.3	9	M
126	Miami	Carver Creek	Miami Foley Road	433224	5052341	Circular	91	36	Poor	3.1	2.2	Red	0.2	9	M
230	Miami	Unnamed trib, Miami River	Private Drive	432506	5049559	Circular	20	36	Poor	0.1	none	Gray	0.6	8	L
225	Miami	Unnamed trib, Miami River	New Miami River Rd	432423	5049870	Circular	93	48	Poor	4.7	0.9	Red	0.2	8	L
115	Miami	Unnamed trib, Miami River	Miami Forest River Rd	436328	5052920	Circular	30	36	Fair	4.4	1.6	Red	0.1	8	L
84	Miami	Unnamed trib, Miami River	Miami River Forest Rd	439281	5054779	Pipe Arch	55	120	Fair	3.6	10.3	Red	0.2	8	L
5101	Miami	Unnamed trib, Miami River	Miami River Forest Rd	439759	5054992	Circular	42	60	Fair	1.8	7.2	Red	0.1	8	L
87	Miami	Unnamed trib, Miami River	Miami River Forest Rd	440590	5054528	Pipe Arch	61	104	Good	3.3	0.4	Red	0.1	8	L
279	Miami	Unnamed trib, Minich Creek	Minich Creek Road	431186	5048972	Pipe Arch	60	97	Fair	2.0	none	Green	0.6	8	N/A
93	Miami	Unnamed trib, Miami River	Miami River Forest Rd	438027	5054143	Pipe Arch	55	120	Good	4.5	none	Green	0.2	6	N/A

Table 5. Prioritization table for Tillamook Bay tributaries.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
647	Till. Bay	Doty Creek	Highway 101	431728	5039890	Pipe Arch	75	66	Fair	0.7	0.5	Red	1.7	12	H
578	Till. Bay	Patterson Creek	5th Street	430568	5041806	Box	71	96	Fair	0.5	1.8	Red	3.6	12	H
575	Till. Bay	Patterson Creek	Unnamed	430727	5041881	Circular	36	60	Critical	3.4	0.8	Red	2.3	12	H
5555	Till. Bay	Patterson Creek	8th Street	430799	5041890	Circular	41	56	Critical	-0.2	none	Red	2.3	12	H
572	Till. Bay	Patterson Creek	9th Street	430901	5041865	Pipe Arch	42	48	Fair	unk	unk	Red	2.2	12	H
636	Till. Bay	Doty Creek	Vaughn Road	432285	5040153	Circular	37	36	Fair	0.3	0.1	Red	1.2	11	H
581	Till. Bay	Patterson Creek	Highway 101	430242	5041650	Box	105	96	Fair	0.2	none	Gray	3.8	11	H
579	Till. Bay	Patterson Creek	4th Street	430484	5041795	Circular	97	72	Fair	1.6	none	Gray	3.7	11	H
637	Till. Bay	Doty Creek	Alderbrook Loop Road	432147	5040015	Circular	41	36	Fair	0.1	0.1	Gray	1.4	10	H
622	Till. Bay	Doty Creek	Private Drive	432654	5040550	Circular	19	45	Poor	8.0	0.6	Red	0.8	10	H
689	Till. Bay	Flower Pot Creek	Bayocean Road	427301	5038583	Circular	56	48	Fair	0.7	unk	Gray	1.4	10	H
441	Till. Bay	Smith Creek	Highway 101	426950	5046015	Box	81	48	Poor	1.0	7.7	Red	1.0	10	H
440	Till. Bay	Smith Creek	Harbor View Drive	427105	5046081	Circular	52	56	Critical	11.9	1.9	Red	0.9	10	H
686	Cape Meares Lk.	Coleman Creek	Pacific Avenue	425312	5038726	Circular	39	36	Fair	3.1	2.1	Red	0.7	9	M
613	Till. Bay	Doty Creek	Doughty Road	432729	5040868	Circular	36	46	Fair	-1.1	none	Gray	0.7	9	M
605	Till. Bay	Doty Creek	Private Drive	432768	5041048	Circular	31	48	Fair	3.4	none	Red	0.5	9	M
599	Till. Bay	Doty Creek	Timberline Drive	432833	5041204	Circular	40	48	Good	1.2	0.9	Red	0.4	9	M
593	Till. Bay	Doty Creek	Private Drive	432915	5041390	Circular	44	24	Fair	6.3	4.2	Red	0.3	9	M
476	Till. Bay	Electric Creek	Highway 101	430186	5045387	Circular	~160	48	Critical	variable	none	Red	1.0	9	M
559	Till. Bay	Larson Creek	Old Bay City Road	430546	5042675	Circular	55	36	Poor	1.8	1.5	Red	0.4	9	M
542	Till. Bay	Patterson Creek	Unnamed	431891	5042999	Circular	43	36	Poor	5.0	1.6	Red	0.5	9	M
5304	Till. Bay	School Creek	Parking Lot	429112	5045771	Circular	~125	36	Poor	1.0	none	Red	0.7	9	M
453/454	Till. Bay	School Creek	Several in Garibaldi	429205	5045779	Circular	~700	36	Unk	2.0	none	Red	0.9	9	M
413	Till. Bay	Smith Creek	Barview Forest Rd	427659	5046723	Circular	45	36	Poor	3.0	7.5	Red	0.3	9	M
702	Till. Bay	Unnamed trib, McCoy Cove	Bayocean Road	428043	5038123	Circular	48	48	Fair	0.2	unk	Gray	0.9	9	M
543	Till. Bay	Unnamed trib, Patterson Creek	Unnamed	431979	5042920	Circular	41	42	Poor	4.2	3.1	Red	0.4	9	M
675	Cape Meares Lk.	Coleman Creek	5th Street	425267	5039131	Circular	50	42	Fair	6.1	unk	Gray	1.0	8	L
778	Till. Bay	Dick Creek	Bayocean Road	429330	5036881	Pipe Arch	44	72	Poor	2.1	unk	Gray	0.5	8	L
528	Till. Bay	Patterson Creek	Patterson Creek Road	432101	5043624	Circular	74	36	Poor	2.0	2.2	Red	0.1	8	L
452	Till. Bay	School Creek	Driftwood Avenue	429064	5045799	Pipe Arch	82	96	Fair	3.0	none	Gray	0.8	8	L
757	Till. Bay	Unnamed trib, Bock Point	Bayocean Road	429068	5037210	Circular	59	36	Fair	0.0	unk	Gray	0.3	8	L
725	Till. Bay	Unnamed trib, Boulder Point	Bayocean Road	428308	5037848	Circular	52	72	Poor	2.8	unk	Gray	0.4	8	L
5302	Till. Bay	Whitney Creek	Highway 101	429847	5045882	Circular	55	36	Poor	1.0	none	Red	0.5	8	L
5301	Till. Bay	Whitney Creek	Arizona Way	429817	5045895	Pipe Arch	61	42	Fair	1.0	none	Gray	0.4	8	L
5303	Till. Bay	Whitney Creek	Martin Smith Lane	429760	5045944	Circular	55	36	Critical	3.5	0.7	Red	0.4	8	L

Table 6. Prioritization table for Tillamook Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
1234	Tillamook	Killam Creek	Highway 101	437142	5022712	Box	109	96	Fair	0.4	4.4	Red	8.4	13	H
1381	Tillamook	Munson Creek	Highway 101	437008	5024593	Box	69	144	Fair	0.1	1.0	Red	4.3	13	H
908	Tillamook	Esther Creek	Highway 131	431197	5033781	Circular	155	66	Poor	1.0	none	Gray	3.9	12	H
931	Tillamook	Esther Creek	Tomlinson Road	430928	5033563	Circular	25	60	Poor	1.2	0.1	Gray	2.9	12	H
1438	Tillamook	Unnamed trib, Tillamook River	Private Drive	434395	5022847	Circular	17	60	Critical	1.6	none	Gray	2.4	12	H
1330	Tillamook	Simmons Creek	Highway 101	437043	5025427	Open Arch	113	240	Fair	0.4	0.2	Green	6.5	11	N/A
1457	Tillamook	Mills Creek	Highway 101	436581	5022611	Box	134	120	Fair	0.2	none	Green	2.3	11	N/A
893	Tillamook	Tomlinson Creek	Private Drive	430943	5033987	Circular	19	60	Critical	-1.2	0.4	Red	0.5	10	M
932	Tillamook	Unnamed trib, Esther Creek	Private Drive	430845	5033558	Circular	34	30	Fair	-0.4	none	Gray	0.8	10	M
6666	Tillamook	Unnamed trib, Tillamook River	Highway 101	435587	5028596	Circular	109	56	Fair	3.5	none	Gray	1.6	10	M
1102	Tillamook	Unnaned trib, Beaver Creek	Private Drive	431060	5029663	Circular	40	90	Poor	-1.2	none	Green	1.5	10	N/A
1404	Tillamook	Unnamed trib, Munson Creek	Munson Creek Road	438611	5023756	Open Arch	61	156	Fair	4.2	0.2	Green	1.4	10	N/A
1401	Tillamook	Pleasant Valley Creek	Highway 101	437013	5023817	Box	80	96	Fair	0.5	0.3	Green	1.1	10	N/A
848	Tillamook	Memaloose Creek	Bayocean Road	430623	5035363	Pipe Arch	48	66	Poor	1.2	0.3	Red	0.5	9	L
985	Tillamook	Unnamed trib, Fagan Creek	Highway 131	429888	5032065	Circular	104	48	Fair	3.9	0.3	Red	0.3	9	L

Table 7. Prioritization table for Trask Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
1127	Trask	Mill Creek	Private Drive	440016	5029440	Circular	22	42	Poor	1.5	0.7	Red	1.8	13	H
1106	Trask	Mill Creek	Brickyard Road	439145	5029501	Circular	56	32	Poor	1.1	unk	Red	2.4	12	H
1107	Trask	Mill Creek	Private Drive	439439	5029531	Circular	26	48	Poor	0.1	1.2	Red	2.2	12	H
1105	Trask	Mill Creek	Private Drive	439636	5029535	Circular	27	29	Poor	1.0	0.4	Red	2.1	12	H
987	Trask	Green Creek	Trask River Road	440497	5032236	Circular	50	53	Poor	5.6	1.0	Red	1.7	12	H
1128	Trask	Mill Creek	Private Drive	439929	5029449	Circular	27	37	Poor	2.4	0.8	Red	1.9	12	H
902	Trask	Samson Creek	Trask River Road	449229	5033876	Circular	46	84	Poor	5.5	1.1	Red	1.5	12	H
1094	Trask	Unnamed trib, Mill Creek	Brickyard Road	438771	5029891	Circular	67	48	Poor	0.9	0.1	Red	3.5	12	H
1120	Trask	Edwards Creek	Edwards Creek Road	450857	5029214	Pipe Arch	45	96	Fair	0.1	3.8	Red	0.8	11	H
942	Trask	Holden Creek	Lumber mill road	434837	5033295	Circular	199	78	Poor	unk	unk	Red	3.2	11	H
945	Trask	Holden Creek	Lumber mill road	435013	5033315	Circular	41	60	Critical	1.5	0.6	Red	3.1	11	H
948	Trask	Holden Creek	Murray Way	435550	5033273	Circular	20	48	Poor	5.8	none	Red	2.7	11	H
1342	Trask	Pothole Creek	Murphy Camp Road	459224	5024799	Circular	53	60	Fair	6.6	1.3	Red	0.4	11	H
1134	Trask	Unnamed trib, Mill Creek	Magnolia Drive	438891	5028837	Pipe Arch	37	144	Fair	0.3	0.3	Gray	3.8	11	H
1137	Trask	Unnamed trib, Mill Creek	Brickyard Road	439127	5028736	Circular	43	36	Poor	0.9	0.4	Red	1.9	11	H
1136	Trask	Unnamed trib, Mill Creek	Private Drive	439203	5028756	Circular	22	36	Fair	2.3	0.2	Red	1.8	11	H
1402	Trask	Unnamed trib, S. F. Trask River	South Fork Trask Road	452161	5023649	Circular	45	48	Poor	6.2	none	Red	0.7	11	H
1476	Trask	Headquarters Camp Creek	East Fork Road	457836	5022036	Open Arch	50	114	Fair	0.0	none	Green	1.6	11	N/A
1448	Trask	Bales Creek	East Fork Bypass	454053	5022706	Pipe Arch	47	150	Fair	1.2	0.3	Gray	1.0	10	M
952	Trask	Holden Creek	Miller Road	434445	5033277	Circular	95	66	Poor	unk	none	Gray	3.4	10	M
946	Trask	Holden Creek	Evergreen Road	435218	5033198	Box	39	96	Fair	2.4	0.3	Gray	2.9	10	M
947	Trask	Holden Creek	Marolf Loop Road	436344	5033372	Box	28	78	Fair	0.3	none	Gray	2.2	10	M
930	Trask	Holden Creek	McCormick Loop Rd.	437353	5033678	Circular	46	60	Poor	1.7	0.1	Red	1.5	10	M
1099	Trask	Unnamed trib, Bark Shanty Ck	Bark Shanty Road	458843	5029888	Circular	40	66	Fair	9.2	1.4	Red	0.6	10	M
1455	Trask	Unnamed trib, E.F. S.F. Trask R.	Headquarters Grade	462635	5022586	Circular	45	54	Fair	1.4	0.9	Red	0.5	10	M
955	Trask	Unnamed trib, Holden Creek	Private Drive	434496	5032993	Circular	30	36	Critical	-1.6	none	Red	1.1	10	M
918	Trask	Unnamed trib, Trask River	Trask River Road	446257	5033862	Circular	50	66	Poor	6.0	5.0	Red	0.7	10	M
915	Trask	Unnamed trib, Trask River	Trask River Road	450088	5033724	Pipe Arch	59	91	Fair	0.2	2.9	Red	0.8	10	M
864	Trask	Unnammed trib, N.F. Trask R.	N.F. Trask R. Road	463625	5034818	Circular	60	90	Fair	8.4	2.4	Red	0.6	10	M
1058	Trask	Unnamed trib, July Creek	Cruiser Creek Road	462266	5030364	Pipe Arch	78	126	Fair	3.0	none	Green	1.3	10	N/A
1095	Trask	Unnamed trib, Mill Creek	Private Drive	439674	5029747	Pipe Arch	44	126	Fair	0.1	none	Green	2.9	10	N/A
1447	Trask	East Fork South Fork Trask R.	Headquarters Grade	462642	5022621	Pipe Arch	40	138	Poor	-0.7	none	Green	0.8	10	N/A
1021	Trask	Harenkrat Creek	Chance Road	442541	5031175	Circular	35	36	Poor	22.0	2.5	Red	0.1	9	L
1516	Trask	Headquarters Camp Creek	East Fork Road	459354	5021000	Circular	33	48	Fair	2.2	1.2	Red	0.7	9	L
929	Trask	Holden Creek	Trask River Road	438068	5033726	Circular	34	36	Fair	2.9	none	Red	1.0	9	L
1059	Trask	July Creek	July Creek Road	461780	5030780	Circular	72	50	Fair	6.4	4.3	Red	0.7	9	L
1113	Trask	M.F. North Fork Trask R.	Flora Mainline	468438	5029260	Circular	105	64	Poor	7.0	1.5	Red	1.0	9	L
1483	Trask	Rock Creek	Headquarters Grade	461513	5021915	Circular	32	30	Poor	5.7	none	Red	1.0	9	L
1453	Trask	Unnamed trib, Bales Creek	East Fork Bypass	454482	5022650	Pipe Arch	79	120	Fair	1.9	none	Gray	0.1	9	L
1431	Trask	Unnamed trib, Boundary Creek	East Fork Trask	457106	5023017	Circular	41	36	Fair	3.9	2.3	Red	0.3	9	L
1472	Trask	Unnamed trib, Headquarters Camp Ck	East Fork Road	457721	5022175	Circular	50	54	Fair	2.3	2.3	Red	0.3	9	L

Table 7. Prioritization table for Trask Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
965	Trask	Unnamed trib, M.F. N.F. Trask R.	Unnamed	468598	5032837	Circular	60	36	Fair	5.0	6.0	Red	0.7	9	L
1378	Trask	Unnamed trib, S. F. Trask River	South Fork Trask Road	452218	5024301	Circular	61	56	Fair	5.9	1.6	Red	0.2	9	L
1027	Trask	Unnamed trib, Trask River	Long Prairie Road	439161	5031219	Circular	59	54	Poor	0.3	0.5	Red	0.6	9	L
999	Trask	Unnamed trib, Trask River	Trask River Road	441421	5032051	Circular	80	24	Poor	6.2	1.5	Red	0.3	9	L
907	Trask	Unnamed trib, Trask River	Trask River Road	448996	5033853	Circular	70	60	Poor	7.0	0.6	Red	0.6	9	L
889	Trask	Burton Creek	Trask River Road	447331	5034084	Circular	57	90	Critical	5.5	unk	Red	0.1	8	L
1520	Trask	Headquarters Camp Creek	Headquarters Grade	459744	5020580	Circular	90	98	Fair	3.7	2.0	Red	0.4	8	L
1487	Trask	Rock Creek	Unnamed private road	462517	5021876	Circular	55	30	Fair	5.0	1.3	Red	0.5	8	L
1499	Trask	South Fork Rock Creek	Headquarters Grade	460004	5021270	Circular	67	36	Poor	1.4	6.6	Red	0.1	8	L
1109	Trask	Unnamed trib, Cruiser Creek	Cruiser Creek Road	461704	5029778	Circular	44	48	Fair	4.6	none	Red	0.3	8	L
1146	Trask	Unnamed trib, Mill Creek	Brickyard Road	438824	5028627	Circular	46	36	Poor	1.2	none	Red	0.4	8	L
1156	Trask	Unnamed trib, Mill Creek	Brickyard Road	438728	5028449	Circular	43	30	Poor	0.7	0.3	Red	0.2	8	L
5001	Trask	Unnamed trib, S. F. Trask River	South Fork Trask Road	452240	5024299	Circular	61	55	Poor	9.9	2.7	Red	0.2	8	L
1039	Trask	Unnamed trib, Trask River	Chance Road	439686	5031041	Circular	40	54	Fair	2.5	0.6	Red	0.2	8	L
925	Trask	Unnamed trib, Trask River	Trask River Road	447854	5033645	Circular	70	36	Fair	7.5	2.6	Red	0.3	8	L
903	Trask	Unnamed trib, Trask River	Trask River Road	449111	5033866	Circular	56	36	Fair	4.9	1.9	Red	0.4	8	L
944	Trask	Unnamed trib, Trask River	Private Drive	450089	5033396	Circular	30	36	Good	4.0	3.0	Red	0.1	8	L
927	Trask	Unnamed trib, Trask River	Trask River Road	451247	5033597	Circular	44	36	Poor	9.2	0.6	Red	0.3	8	L
1010	Trask	Unnamed trib, Trask River	Trask River Road	452667	5031535	Circular	64	48	Critical	3.0	4.5	Red	0.1	8	L
962	Trask	Unnammed trib, N.F. Trask R.	Reiner Road	468476	5033151	Circular	57	30	Critical	6.4	9.5	Red	0.2	8	L
1112	Trask	Unnamed trib, M.F. N.F. Trask R.	Unnamed	468510	5029400	Circular	100	42	Poor	12.0	3.0	Red	0.1	7	L
1060	Trask	July Creek	Cruiser Creek Road	462101	5030429	Pipe Arch	51	120	Fair	7.3	none	Green	0.4	7	N/A
1068	Trask	Whirlwind Creek	Cruiser Creek Road	461662	5030154	Pipe Arch	43	120	Fair	3.1	none	Green	0.3	7	N/A

Table 8. Prioritization table for Wilson Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
249	Wilson	Deyoe Creek	Unnamed	471310	5049236	Pipe Arch	50	76	Poor	0.6	0.6	Red	1.7	13	H
667	Wilson	Fox Creek	Highway 6	452405	5039358	Box	94	120	Poor	5.2	4.0	Red	2.0	13	H
697	Wilson	Zig Zag Creek	Highway 6	447732	5038310	Box	150	126	Poor	8.0	13.0	Red	1.6	13	H
199	Wilson	Dog Creek	Highway 6	461602	5050380	Box	116	96	Fair	3.7	unk	Red	1.1	12	H
231	Wilson	Elliot Creek	Univ. Falls Road	469275	5049565	Circular	80	76	Poor	1.0	1.5	Red	3.3	12	H
910	Wilson	Hughey Creek	Marvin Lane	440715	5033783	Pipe Arch	45	96	Fair	6.7	none	Red	1.8	12	H
792	Wilson	Juno Creek	Boquest Road	433660	5036608	Circular	unk	48	Fair	6.0	unk	Red	2.3	11.5	H
814	Wilson	Beaver Creek	Sollie Smith Road	437528	5036405	Circular	104	48	Fair	2.6	none	Gray	1.6	11	H
202	Wilson	Lewis Creek	Scoggins Creek Road	472642	5050895	Pipe Arch	54	94	Good	1.8	none	Gray	0.8	11	H
333	Wilson	Runyon Creek	Highway 6	457794	5048327	Circular	42	51	Poor	1.0	8.0	Red	0.9	11	H
305	Wilson	Scotty Creek	Highway 6	458912	5048759	Circular	100	42	Poor	5.0	1.1	Red	0.5	11	H
178	Wilson	Unnamed trib, Devils Lake Fork	Powerhouse Rd	473094	5050767	Circular	29	36	Poor	2.3	1.3	Red	0.6	11	H
266	Wilson	Elliot Creek	Unnamed	470343	5049056	Pipe Arch	66	120	Poor	2.7	1.1	Red	1.0	10	M
775	Wilson	Hatchery Creek	Highway 6	444613	5036903	Box	75	60	Fair	5.0	unk	Red	0.8	10	M
901	Wilson	Hughey Creek	Hughey Lane	440230	5034296	Circular	70	72	Fair	3.5	none	Gray	2.3	10	M
760	Wilson	Jack Creek	Highway 6	446088	5037216	Box	97	60	Poor	7.0	unk	Red	1.0	10	M
405	Wilson	Luebke Creek	Highway 6	456036	5046768	Circular	51	54	Poor	10.8	1.1	Red	0.7	10	M
713	Wilson	Smith Creek	Highway 6	446846	5037955	Box	143	120	Poor	8.0	1.5	Red	0.6	10	M
584	Wilson	Stanley Creek	Highway 6	452383	5041793	Box	115	60	Poor	12.0	4.0	Red	0.8	10	M
176	Wilson	Unnamed trib, Devils Lake Fork	#7 Clyde's Trail	473526	5050908	Circular	34	48	Critical	8.3	none	Red	0.3	10	M
222	Wilson	Unnamed trib, Devils Lake Fork	Scoggins Creek Road	474112	5049754	Pipe Arch	50	108	Poor	-0.2	2.0	Red	0.5	10	M
5306	Wilson	Yankee Branch	Latimer Road	436467	5036370	Circular	87	36	Fair	-1.0	none	Gray	1.1	10	M
781	Wilson	Unnamed trib, Juno Creek	Latimer Road	434655	5036763	Circular	84	108	Fair	2.3	0.1	Green	1.6	10	N/A
877	Wilson	Donaldson Creek	Fairview Road	440491	5034773	Circular	69	36	Poor	4.4	2.1	Red	0.3	9	L
696	Wilson	Fern Creek	Highway 6	447331	5038383	Box	100	48	Poor	9.3	3.5	Red	0.5	9	L
447	Wilson	Hoskins Creek	Highway 6	455519	5045832	Circular	66	72	Fair	3.6	2.2	Red	0.1	9	L
755	Wilson	Juno Creek	Juno Hill Road	434841	5037351	Circular	50	42	Poor	3.2	0.1	Red	0.5	9	L
268	Wilson	Moore Creek	East Ben Smith Road	460473	5049046	Pipe Arch	43	78	Poor	3.5	2.6	Red	0.2	9	L
693	Wilson	Smith Creek	Smith Creek Road	446299	5038612	Circular	27	72	Fair	9.3	2.7	Red	0.3	9	L
150	Wilson	Unnamed trib, Devils Lake Fork	Powderhouse Loop Rd	472570	5051758	Pipe Arch	68	78	Good	4.7	2.4	Red	0.2	9	L
304	Wilson	Unnamed trib, Jones Creek	Jones Creek Road	456150	5048626	Pipe Arch	45	100	Fair	1.8	1.0	Red	0.4	9	L
780	Wilson	Unnamed trib, Juno Creek	Juno Hill Road	434906	5036782	Circular	29	30	Critical	6.1	0.8	Red	0.9	9	L
300	Wilson	Unnamed trib, S.F. Wilson R.	Prison Camp Road	463422	5048729	Pipe Arch	43	94	Good	4.5	2.2	Red	0.2	9	L
240	Wilson	Unnamed trib, Wilson River	Highway 6	460589	5049407	Circular	80	24	Poor	9.0	1.0	Red	0.6	9	L
227	Wilson	Unnamed trib, Wilson River	Highway 6	460951	5049662	Circular	61	36	Fair	4.3	1.8	Red	0.2	9	L
265	Wilson	Elliott Creek	Unnamed	470043	5049124	Pipe Arch	41	102	Good	2.6	0.2	Green	1.2	9	N/A
881	Wilson	Donaldson Creek	Private Drive	440956	5034462	Circular	34	18	Fair	4.4	5.7	Red	0.1	8	L
735	Wilson	Unnamed trib, Beaver Creek	Beaver Creek Road	437842	5037849	Circular	86	42	Poor	11.0	4.0	Red	0.1	8	L
388	Wilson	Unnamed trib, Ben Smith Creek	Ben Smith Creek Road	459298	5047224	Pipe Arch	63	96	Good	6.3	none	Gray	0.3	8	L
246	Wilson	Unnamed trib, Devils Lake Fork	Unnamed	473811	5049357	Circular	34	18	Poor	4.2	2.6	Red	0.1	8	L
356	Wilson	Unnamed trib, S.F. Wilson R.	C-Line Road	465646	5048242	Pipe Arch	67	126	Fair	9.2	4.3	Red	0.3	8	L

Table 8. Prioritization table for Wilson Basin.

Crossing ID	Watershed	Stream Name	Road Name	Easting	Northing	Barrel Shape	Length (feet)	Width (inches)	Overall Condition	Culvert Slope (%)	Perch Height (feet)	Barrier Rating	Upstream Habitat (miles)	Prioritization Model Score	Priority
261	Wilson	Unnamed trib, S.F. Wilson R.	Stage Road	466347	5048623	Circular	67	57	Good	6.0	none	Red	0.1	8	L
803	Wilson	Unnamed trib, Wilson River	Sollie Smith Road	439248	5036338	Circular	60	36	Fair	14.0	0.2	Red	0.5	8	L
788	Wilson	Unnamed trib, Wilson River	Sollie Smith Road	439249	5036600	Circular	63	24	Poor	7.0	0.8	Red	0.3	8	L
722	Wilson	Unnamed trib, Wilson River	Highway 6	446487	5037891	Circular	50	24	Fair	4.8	none	Red	0.2	8	L
723	Wilson	Unnamed trib, Wilson River	Highway 6	450762	5037876	Box	39	60	Poor	3.5	0.2	Red	0.5	8	L
604	Wilson	Unnamed trib, Wilson River	Highway 6	451998	5041075	Circular	99	60	Good	7.3	0.1	Red	0.1	8	L
798	Wilson	Kansas Creek	Kansas Creek Road	449687	5036465	Pipe Arch	71	66	Fair	3.1	1.6	Red	0.4	7	L
822	Wilson	Kansas Creek	Kansas Creek Road	449858	5036361	Pipe Arch	56	55	Fair	9.9	1.4	Red	0.3	7	L
823	Wilson	Kansas Creek	Kansas Creek Road	449997	5036035	Circular	79	90	Poor	4.2	4.1	Red	0.1	7	L
762	Wilson	Unnamed trib, Kansas Creek	Kansas Creek Road	449522	5037009	Circular	39	30	Good	6.5	0.7	Red	0.1	7	L
799	Wilson	Unnamed trib, Kansas Creek	Kansas Creek Road	449598	5036566	Pipe Arch	69	156	Fair	1.6	0.4	Red	0.4	7	L
299	Wilson	Unnamed trib, Elliot Creek	Beaver Dam Road	469924	5048854	Pipe Arch	56	126	Fair	0.5	0.1	Green	0.5	7	N/A
465	Wilson	Unnamed trib, Little N.F. Wilson	Kilchis Lookout Road	450253	5045470	Pipe Arch	74	162	Good	2.4	none	Green	0.5	7	N/A
900	Wilson	Hughey Creek	Fairview Road	440177	5034672	Circular	unk	unk	unk	unk	unk	unk	2.6	?	?
898	Wilson	Hughey Creek	Highway 6	440083	5034989	Box	unk	unk	unk	unk	unk	unk	2.8	?	?

Table 9. Summary of replacement prioritization scores and miles of affected upstream habitats for fish culverts in the Tillamook Bay Watershed.

Basin	No. Culverts in Priority Rating Class					Total Miles of Affected Upstream Habitat[1]
	High	Medium	Low	Unknown	Not Barriers	
Kilchis River Basin	10	4	6		4	12.4
Miami River Basin	7	6	6		2	13.8
Tillamook Bay Tributaries	13	13	9			13.8
Tillamook River Basin	5	3	2		5	35.6
Trask River Basin	17	11	30		6	35.8
Wilson River Basin	12	10	28	2	4	30.9
Totals	**64**	**47**	**81**	**2**	**21**	**142.3**

[1] These values reflect the actual amount of potentially suitable habitat affected by fish culverts surveyed for this study. On stream systems affected by multiple culverts, it includes only the total length of habitat upstream of the lower-most culvert in the system. For example, the Patterson Creek sub-basin (a Tillamook Bay tributary) includes nine fish culverts. The lower-most culvert in the system is located near the mouth of the creek and all other culverts in this system are along reaches included in the upstream habitat length reported for the lower-most culvert. The total value reported for the Tillamook Bay Tributaries in this table includes the 3.8 miles of potentially suitable habitat upstream of the lowest culvert. The habitat length values reported in the tables in Appendix 2 for the other eight culverts in this system are not included in the total reported in this table because they are already captured by including the lower culvert.

3.2. Road Ownership Patterns

Several governmental entities and private parties own/administer the roads on which the culverts identified in this report occur. Ownership patterns vary somewhat by basin (Table 10).

Table 10. Summary of road ownership for fish culverts in the Tillamook Bay Watershed.

Road Owner	Basin					
	Kilchis	Miami[1]	Till. Bay[2]	Tillamook	Trask	Wilson
City	0	0	10	0	4	0
County	9	6	10	3	21	10
ODOT	0	1	5	5	0	18
ODF	11	9	4	3	25	26
Private	4	4	8	4	14	2

[1] Miami Basin culvert 138 is on a road segment with disputed ownership. It is not included in this table, because it is unclear who is responsible for this section of road.

[2] Culvert 453/454 in the Tillamook Bay Tributaries Basin includes city, private, and ODOT ownership. This mixed ownership is reflected in the table.

A majority of fish culverts included in this report (64 percent) are on Tillamook County and ODF roads. These entities own culverts in all six analysis units (i.e., all five river basins and the Tillamook Bay tributaries) and, when combined, have majority ownership of fish culverts in the Kilchis (83 percent), Miami (72 percent), Trask (72 percent) and Wilson (64 percent) basins.

Culverts on private roads also occur in all six analysis units. Ownership of these culverts includes agricultural, industrial forest and residential landowners. The Trask Basin has the greatest number of private culverts surveyed for this report (14 culverts). These are located primarily in the lower portion of the basin and many are within the Mill Creek and Holden Creek sub-basins. Private road culverts account for over a quarter of the fish culverts we surveyed in the Tillamook Basin (27 percent). Land ownership within this basin is predominantly private and industrial forest and agricultural landowners account for a majority of the private holdings within the basin. It is important to note that we did not have permission to access a majority of the crossings on private roads within the Tillamook Basin. Many of these crossings were on lands owned by Stimson Lumber Company. This company has an active and ongoing culvert assessment and replacement program that is regulated by ODF under provisions set forth in the Oregon Forest Practices Act (OAR 629-625).

Oregon Department of Transportation (ODOT) culverts occur in four of the six analysis units. A high percentage of crossings we surveyed in the Tillamook (33 percent) and Wilson (32 percent) basins occur on ODOT roads. The greatest number of ODOT culverts is in the Wilson Basin (18 culverts). These primarily occur on Highway 6. Many of these Highway 6 culverts are fairly large box culverts that will likely be replaced with bridges or much larger box culverts, so costs for these replacement projects will be high. Many of these Highway 6 culverts also include trash racks that have dramatically and adversely affected the streams on which they occur (see culvert 697 as an example). This fact also will complicate replacement efforts for these crossings.

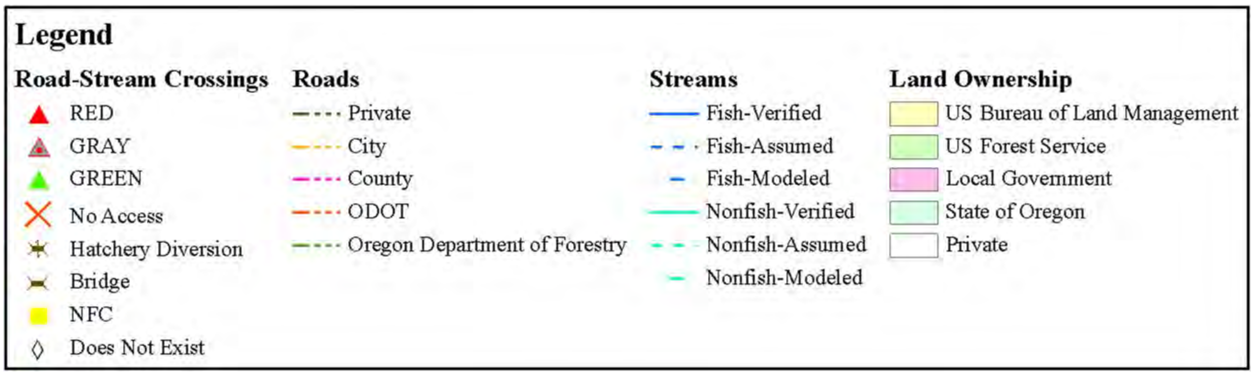
Several culverts in this report also occur on roads owned by one of several city governments. City-owned culverts occur in two of the six analysis units (Tillamook Bay Tributaries – City of Bay City and City of Garibaldi; Trask Basin – City of Tillamook). One third of the city-owned barrier culverts on streams that are direct tributaries to Tillamook Bay occur on a single stream, Patterson Creek. Salmonids continue to spawn on a portion of this stream despite the fact that eight barrier culverts occur along its length. Half of the barrier culverts on this stream (4 culverts), are on roads owned by the City of Bay City. The remaining barrier culverts on this stream are owned by ODOT, ODF, and Tillamook County.

3.3. Clustering

Earlier we noted that we prioritized culverts in this report basin-by-basin, in part to facilitate use of the document. In Appendix 2 below, we provide detailed information for each surveyed fish culvert (tabular information, photographs and maps). We present this information basin-by-basin (alphabetically). In addition, we have further refined our presentation based on geography and proximity. Specifically, the tables and maps for each basin begin with the lowermost culverts in the basin and end with culverts in the upper basin. The tables are further grouped by proximity – culverts in close proximity to one another (e.g., near one another along the same stream or road) are grouped and identified by headings. Each of these culvert groups or "clusters" are depicted on a single map and the map titles correspond to the headings that accompany the tables. We incorporated these refinements not only to make the document easier to use, but to facilitate project development, planning and implementation.

The information provided in Appendix 2 includes a matrix and a map for each culvert. The tables include detailed location information, characteristics of both the culvert and the stream channel, and the data used for the prioritization analysis. Each matrix also includes one or more photographs of the culvert and/or adjacent stream channel. Some also include additional notable information to further describe the culvert or adjacent stream conditions or clarify peculiarities in the tabular information. Appendix 2 also includes a table summarizing clusters for each basin.

The legend below is applicable for all maps in Appendix 2. Each map depicts crossings (symbology based on prioritization rating or other characteristics), roads (symbology based on ownership), streams (symbology based on ODF fish presence information), and land ownership (symbology based on ownership).



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Appendix 1

Tillamook Bay Culvert Prioritization Field Data Sheet

Date:___________

Crossing Assessment Form

Crossing ID:______

SITE INFORMATION — NFC:_____

Watershed:___________________________________ **Stream:**___________________________________

Road :___________________________________ **Ownership:**___________________________________

Mile Post:___________________________________

7.5-minute Quad:______________________________ **UTM: Zone:** 10 **East**________________ **North**_______________ NAD 83

Legal Description: T. _____, R. _____, Sec. _____, ____ ¼ of____¼ **Surveyors:**______________________________

CULVERT STRUCTURE

Multiple Structures at Site: yes no

Barrel Shape	Corrugations	Culvert Condition	Longitudinal Profile	Dist. (ft)	BS (+)	HI	FS (-)	Elev. (ft)
☐Box	☐2 2/3x1/2 in.	**(Check all that apply)**	Temp. Bench Mark	N/A				100.00
☐Circular	☐3x1 in.	☐Bent inlet	Inlet Gradient Control Pt (P1)					
☐Open Bottom Arch	☐5x1 in.	☐Debris plugging inlet	Inlet Invert (P2)					
☐Pipe-Arch	☐SSP 6x2 in.	☐Bottom worn thru	Road Surface (P3)					
	☐Smooth	☐Water under culvert	Outlet Invert (P4)					
Dimensions		☐Fill eroding	Outlet Pool Bottom (P5)					
______(ft) Horizontal	**Culvert Material**	☐Other:	Water Surface at P5 (add water depth to P5 elev.) →					
		☐None	Tailwater Control Point (P6)					
______(ft) Vertical	☐CMP	☐Steel ☐spiral						
		☐Alum ☐annular						
	☐SSP (Steel)	**Overall Condition**	**Culvert Length (P2 Dist – P4 Dist)**					
Inlet Blockage	☐Plastic	☐Good	**Culvert Slope***					%
☐Not Blocked	☐Concrete	☐Fair	** Calculate:(P2 – P4 elev / Culvert Length) x100 /*					
☐<10% Blockage	☐Wood	☐Poor	**Inlet Rustline Height**					ft
☐>10%Blockage	☐Other	☐Critical	**Road Surface:**					
		(lowest of all rating assignments for feature-see back)	**Road Fill Index:** *P3 - Elev. top of inlet (often TBM)*					

Inlet Type (circle): projecting mitered wingwall 10-30^{o} wingwall 30-70^{o} headwall apron trashrack Other

Comments (include outlet type and any other notable conditions)**:**

Substrate Particle Sizes (rank 1-3 in order of contribution to substrate)

	Bedrock	Boulder	Cobble	Gravel	Sand	Silt/Clay	Organics	Aquatic macrophytes
In Culvert								
Stream Channel								

Natural Substrate in Culvert (i.e., rock, wood, etc.) ☐ None ☐ Continuous ☐ Discontinuous (approx. %__________)

CHANNEL DESCRIPTION

Inlet Gradient: Calculate ((P1-P2 elev) / (P1-P2 dist)) * 100		((_____ - _____) / (_____ - _____))*100 =	%
Channel Gradient: Beyond culvert influence	Upstream	((Upper Elev________ - Lower Elev________) / Dist________)*100 =	%
	Downstream	((Upper Elev________ - Lower Elev________) / Dist________)*100 =	%
Bankfull Width: Beyond culvert influence (min. of 3 measurements)	Upstream widths	1)________, 2)________, 3)________, 4)________, 5)_________	AVG. =
	Downstream widths	1)________, 2)________, 3)________, 4)________, 5)_________	AVG. =
Inlet Width to Bankfull Width: _________ft (Inlet Width) / _________ft (Avg upstream BFW) →			_____________

PHOTOGRAPHS (Take whiteboard photo as first/last photos – record number of photos for each photo-point and order taken–– depict points on site drawing)

Inlet Photo Numbers:_______________________________ **Outlet Photo Numbers:**_______________________________

Upstream Photo Numbers: ___________________________ **Downstream Photo Numbers:** ___________________________

Other Photo Numbers:____

DRAWINGS Overall view from **Upstream** of culvert to **Downstream** of culvert

Include: P1-P6, Temporary Bench Mark (TBM), Instrument Location ( ), North arrow, Stream flow direction, wingwalls/headwall, apron, debris piles, photo points ( ), etc.

ADDITIONAL COMMENTS

Condition Assessment (Circle one for each appropriate category based on pipe material - *categories in FHWA Culvert Assessment Guide)*

CMP

Corrosion (above Invert):	Good	Fair	Poor	Critical
Cross-section Deformation:	Good	Fair	Poor	Critical
Invert Deterioration:	Good	Fair	Poor	Critical
Joints and seams:	Good	Fair	Poor	Critical

Plastic Pipe

Wall Condition:	Good	Fair	Poor	Critical
Cross-section Deformation:	Good	Fair	Poor	Critical
Invert Deterioration:	Good	Fair	Poor	Critical
Joints:	Good	Fair	Poor	Critical

Concrete

Cracking/Spalling:	Good	Fair	Poor	Critical
Cross-section Deformation:	Good	Fair	Poor	Critical
Invert Deterioration:	Good	Fair	Poor	Critical
Joints:	Good	Fair	Poor	Critical

Appurtenances

Headwall/Wingwall:	Good	Fair	Poor	Critical
Apron:	Good	Fair	Poor	Critical
Pipe End:	Good	Fair	Poor	Critical
Scour Protection:	Good	Fair	Poor	Critical

HABITAT INFORMATION

	Upstream	**Downstream**
Number of Culverts (list)		
Number of Known Barriers (list)		
Distance to Known Barriers		
Length of Upstream Habitat		

FISH PASSAGE EVALUATION

COARSE SCREEN FILTER EVALUATION: **GREEN** **GREY** **RED**

Appendix 2

Culvert tables and cluster maps for each basin in the Tillamook Bay Watershed