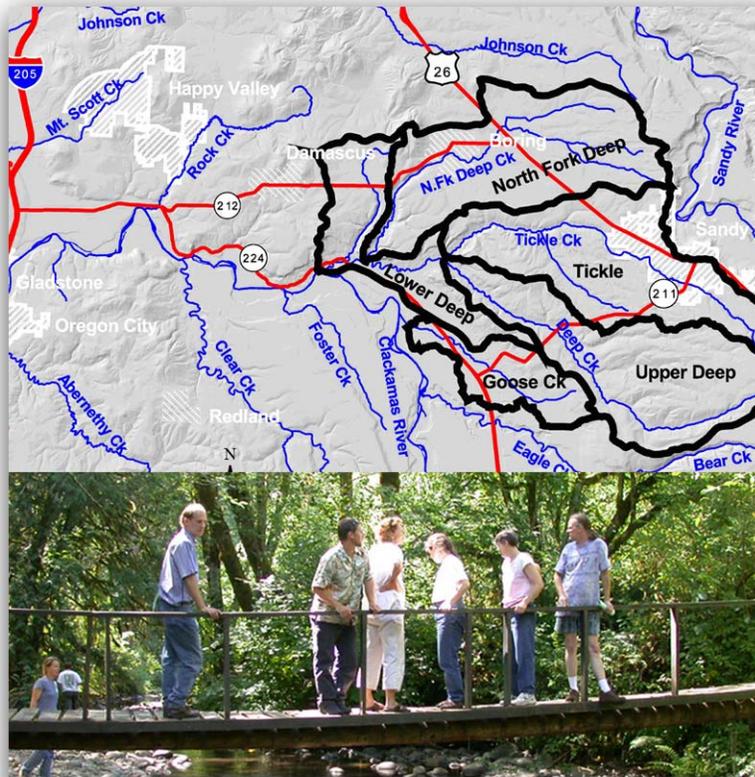


# DEEP AND GOOSE CREEK WATERSHED ASSESSMENT



Prepared For



May 2004

Prepared By



Watershed Professionals  
Network, LLC

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May 2004

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**Editors Note:** *The Watershed Assessment is a stand-alone document. The supporting maps and appendices are provided in electronic format on a CD Rom. Contact the Watershed Coordinator of the Clackamas River Basin Council for availability.*

# DEEP AND GOOSE CREEK WATERSHED ASSESSMENT

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## LIST OF MAPS AND APPENDICES

*The listed maps and appendices are provided in electronic format; they are not enclosed in this document.*

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*Map 2: Channel Habitat Type Map*

*Map 3: Geology Map*

*Map 4: Soils Map*

*Map 5: Riparian Vegetation Map*

*Map 6: Riparian Recruitment Map*

*Map 7: Riparian Shade Map*

*Map 8: Water Quality Map*

*Map 9: Fish Passage Barrier Map*

### Appendices

*Appendix 1: Fish passage assessment project: Eagle Creek results*

*Appendix 2: Fish Passage Assessment Project: Background and Methods*

*Appendix 3. Fish Passage Assessment Project: Field Forms*

*Appendix 4. Fish Passage Assessment Project: Prioritization Equation Results and Preliminary Design Recommendations*

*Appendix 5. Fish Passage Assessment Project: Crossing Descriptions*

*Appendix 6. Fish Passage Assessment Project: Phase 2 Methodology*

*Appendix 7. Potential contaminant source Excel spreadsheet for Deep/Goose watershed.*

*Appendix 8. ODFW Habitat Survey Reach Description & Summaries*

# WATERSHED SUMMARY

## ORGANIZATION OF THE SUMMARY

The watershed summary presents the findings of the Deep and Goose Creek Watershed Assessment in an abbreviated form. The watershed summary is organized in six sections, a recommendations synthesis, and a summary of each assessment component – *Hydrology*, *Riparian*, *Sediment Sources*, *Water Quality*, and *Fisheries*. For each component the critical question is answered by summarizing the *Existing Condition*, *Trends*, *Data Gaps*, and *Recommendations*.

## RECOMMENDATIONS SYNTHESIS

The CRBC can use this report and the maps to develop a specific action plan for the watershed tailored to their interests, abilities, and priorities. The following short list highlights protection and restoration opportunities for fisheries and water quality that is discussed in more detail in the remainder of the watershed summary.

- *Protection opportunity*. Landscape topography has provided protection from development in the watershed over time. The steeper canyon topography occurs along lower Deep Creek, Tickle Creek, and Upper Deep. These steep slopes are graphically illustrated by the grey geologic units (Troutdale Formation & Sandy River Mudstones) on the *Geology Map, Map 3*. Riparian areas along these reaches are conifers and mixed conifer/hardwoods that provide LWD recruitment potential even though current LWD loading is low. Protection of these steep areas will continue to afford protection from surface erosion and maintain high quality fish habitats. Pressure for developing these steep lands will mount as the more easily accessible land becomes scarcer.
- *North Fork Deep Subwatershed – Restoration opportunity*. The lower North Fork below Boring in the steeper section is generally in good condition. However, the riparian areas, streamside buffers, and shade are substantially reduced in many reaches above Boring where the North Fork breaks out into the flatter landscape. These alterations show up on the riparian vegetation (Map 5), riparian recruitment (Map 6) and riparian shade (Map 7) maps. The stream channels (e.g., Doane and Dolan Creeks) have also been substantially ditched (See red colors on Channel Habitat Type Map, Map X). Restoring stream channels meanders and riparian areas will improve fisheries habitat and buffer streams from pollutant inputs.
- *Ditched Reaches – Restoration opportunity*. Although the North Fork Deep subwatershed has the greatest amount of ditched channels (12.1 miles), these highly altered channels also occur in Goose Creek (2.6 miles), Lower Deep (5.7 miles), and Tickle Creek (1.1) miles. Altogether the ditched channels comprise 20 % of the streams mapped in the watershed representing a significant percentage of the stream network. Restoring stream channels is usually technically feasible, however, site-specific limitations and land owner objectives require site-specific design plans.

- *Water Quality in Tickle Creek.* Pollutant sources cause a spike in nitrates in lower Tickle Creek. A focused water quality survey is needed to identify the specific sources and solutions.
- *Fish Passage Restoration.* Restoring habitat connectivity is a high priority in anadromous fish streams. Fish passage barriers (39) have been identified and prioritized for correction.

## HYDROLOGY AND WATER USE (SECTION 2)

### *Question 2-1: What land uses are present in the watershed?*

**Existing Condition:** Current land uses within the watersheds was approximated using land cover information available from the US Geological Survey. Approximately 40% of the assessment area is currently forested, and an additional 40% is in agricultural uses. Low Intensity Residential areas make up an additional 7% of the watershed area. All other uses make up 2% or less of the total assessment area.

**Trends:** No quantitative information is available on changes in land use within the Deep and Goose Creek watersheds over time. However, trends most likely follow the general pattern seen in the Portland metropolitan region of full build out under current zoning regulations over the past 30 year period.

**Data Gaps:** Data used in this assessment was taken from imagery captured in the early 1990's. More recent data should be incorporated when available to capture recent changes.

**Recommendations:** Current information was sufficient for the purposes of this assessment, more recent data should be incorporated only if further assessment of land use impacts to watershed hydrology is desired.

### *Question 2-2: What is the flood history in the watershed?*

**Existing Condition:** No data on annual peak flows are available from any location within the Deep and Goose Creek watersheds. Consequently, data from three adjacent gages were analyzed to estimate peak flow history. Eight peak flow events having a ten-year or greater recurrence interval are estimated to have occurred from the early 1940's to present. The two largest peak flow events were the peak flow event of 12/21/1964 (the "'64 flood") and the event of 11/19/1996. Rain-on-snow is a less-important determinant of peak flows in these low-elevation watersheds than in the adjacent Cascade foothills.

**Trends:** Regionally, the period of the early-1960's to mid-1970's contained several relatively large flood events, which were followed by a period of relatively small events up to the mid-1990's. Consequently, events such as the 1996 flood appeared to many people as unusually large events, while in fact they are within the range of recent variability.

**Data Gaps:** No data are available to characterize daily streamflow or peak flows within the Deep and Goose Creek watersheds.

**Recommendations:** Establish continuous stream flow monitoring locations within the subwatersheds.

***Question 2-3: Is there a probability that land uses in the basin have a significant effect on peak and/or low flows?***

**Existing Condition:** No data or studies are available that address land use effects on peak and/or low stream flows within the Deep and Goose Creek watersheds. Two processes that may contribute to increased peak flow magnitudes were considered in this analysis:

1. **Wetland loss:** Wetlands have the ability to intercept and store storm runoff thereby reducing peak flows. Water stored in wetlands and released over time may be important to augment summertime low flows. A qualitative look at possible wetland loss suggests that present-day wetlands may occupy as little as 11% of the area that they occupied historically. Significant wetland loss may have occurred in the upper part of the North Fork Deep, Lower Deep, and Goose Creek subwatersheds.
2. **Increased impervious area:** Increases in the amount of impervious area may result in increased peak flow magnitudes by eliminating or reducing infiltration of precipitation, thereby shortening the travel time to stream channels. Increases in impervious area may also reduce summer low flows by reduction of groundwater recharge. An evaluation of possible peak flow increase due to impervious area indicates that all subwatersheds with the exception of Lower Deep Creek are currently at the threshold at which we would expect to begin seeing adverse impacts to hydrologic processes.

**Trends:** No evaluation was performed of the trends in wetland loss and increases in impervious area. However, the majority of the wetland loss was probably associated with early land clearing and conversion to farmland in the late 1800's – early 1900's. Current rates of wetland loss are probably low given current regulations on wetland protection. Conversely, the proportion of impervious area within the subwatersheds has probably increased at a steady rate since settlement of the area, as the area occupied by roads and structures increased with increasing population size.

**Data Gaps:** The NWI data used to describe current conditions is based on imagery from the mid to late 1980's, consequently it is representative of conditions approximately 15-20 years ago. In addition, the NWI most likely fails to identify many wetlands that currently exist within the watersheds, particularly in forested areas. The estimation of historic wetland area using mapped hydric soils is coarse in scale, and may not accurately represent true historic conditions. The estimation of effects due to impervious area is based on a relationship with road density. These results should not be considered conclusive; more comprehensive modeling would be needed to determine whether or not current levels of impervious area are significant.

**Recommendations:** The historical extent of wetlands within the watershed should be further investigated. In addition, a functional assessment of wetlands within the watershed should be conducted. More information on wetland condition and function is needed in order to identify and prioritize any wetland enhancement efforts. In addition, the BRAG may want to consider development of a model to assess the possible impacts to watershed hydrology associated with wetland loss and increase in impervious area. It is recommended that a modeling tool such as the Distributed Hydrology-Soil-Vegetation Model (DHSVM) developed by the University of Washington and Battelle Pacific Northwest Research Labs be used in any further hydrologic modeling.

***Question 2-4: For what beneficial use is water primarily used in the watershed?***

**Existing Condition:** Water is withdrawn from approximately 463 separate points of diversion within the Deep and Goose Creek watersheds. The majority of water withdrawn in the Deep Creek watershed is for irrigation (43%) and other agricultural purposes (35%), primarily nurseries. Instream rights account for an additional 16%. The remainder of the uses account for approximately 6% of the total. Within the Goose Creek watershed the majority of water withdrawn is for irrigation (12%) and other agricultural purposes (87%), primarily nurseries. Irrigated areas occur throughout the watersheds, however, the highest density occurs in the North Fork Deep Creek subwatershed,

**Trends:** The water right with the oldest priority date within the assessment areas is from 1924, and the most recent is from the year 2004. Few water rights (approximately 5% of the total withdrawal allowed today) existed prior to 1950. Water rights increased steadily from approximately 1950 to the present, with spikes occurring in the mid 1960's and mid 1980's.

**Data Gaps:** The OWRD database describes the quantity of water that is permitted to be withdrawn, however, information on actual water use is not available.

**Recommendations:** Encourage and support efforts of the OWRD to improve the Water Rights Information System to identify the current status of all water rights within the watershed, and the actual amount and timing of use.

***Question 2-5: Is water derived from a groundwater or surface-water source?***

**Existing Condition:** Based on OWRD records, The majority (52%) of the points of diversion are from surface waters, the remainder being from groundwater sources (34%) and reservoirs (14%). The majority of the volume of water withdrawn within the watersheds is evenly split between surface and groundwater.

**Trends:** Withdrawals from surface water sources have leveled out since the mid 1980's, while the rate of groundwater withdrawals has been increasing since approximately 1970.

**Data Gaps:** Same as for Question 2-4 above.

**Recommendations:** Same as for Question 2-4 above.

***Question 2-6: What type of storage has been constructed in the basin?***

**Existing Condition:** There are approximately 80 lakes and ponds located within the watersheds, many of which are constructed farm ponds. No large-scale reservoirs have been constructed within the watersheds.

**Trends:** Water rights for reservoir storage were essentially non-existent prior to 1950, increased steadily until the mid-1980, and then increased sharply up to the late 1990's. After that point water rights for reservoir storage have tapered off. It is not know if this pattern reflects construction of additional storage, or if it is only represents the acquisition of water rights for existing storage.

**Data Gaps:** Same as for Question 2-4 above.

**Recommendations:** Same as for Question 2-4 above.

***Question 2-7: Are there any withdrawals of water for use in another basin (interbasin transfers)? Is any water being imported for use in the basin?***

**Existing Condition:** No significant interbasin transfers were identified from OWRD records

**Trends:** Not applicable.

**Data Gaps:** None.

**Recommendations:** None.

***Question 2-8: Do water uses in the basin have an effect on peak and/or low flows?***

**Existing Condition:** The net effect of water withdrawals on monthly stream flows were estimated at the outlet of the Deep Creek watershed by comparing the sum of 1) consumptive uses (i.e., the portion of all water withdrawals that does not return to the stream), 2) water diverted for storage, and 3) instream water rights (if any) against the estimated monthly natural stream flows for average and dry years (represented by the 50% and 80% exceedance flow respectively). Results indicate that consumptive water use plus storage does not exceed the estimated volume of natural stream flow in any month, either in average (50% exceedance flows) or dry (80% exceedance flows) years. However, when the instream water right is added to the sum of consumptive uses and storage there is insufficient flow to meet all uses in the months of July – September in either average or dry years. Based on these estimates it appears unlikely that instream flow rates would be attained during these months in most years.

**Trends:** No quantitative trend analysis was performed, however, in as far as the total withdrawal amount for all water rights has been increasing over time (as described above), it is

likely that withdrawal effects on low flows have also been increasing over time as well. The estimates of natural stream flows available from the OWRD are based on average climatic conditions. The precipitation trend analysis (see Section 1.2.4) indicate that, regionally, we may have left a warm/dry precipitation cycle (which would result in lower than average summer stream flows) and entered a cool/wet cycle where summertime stream flows may be above average.

**Data Gaps:** OWRD data used to estimate net water withdrawals are only available for the mouth of the Deep Creek watershed. These same calculations should be made for the outlets of all remaining subwatersheds. As described under Question 2-2 above, no long-term streamflow data exists for the watersheds. The lack of streamflow data calls into question the OWRD estimates of “natural” stream flows. Furthermore, the lack of information on actual vs. permitted water use (as described above) decreases our confidence in the overall results.

### **Recommendations:**

1. Further investigate the magnitude of the effect of consumptive water uses on summertime stream flows. The lack of data characterizing stream flow conditions within the subwatersheds, and the lack of information on actual water use, result in uncertainty in the assessment of water use effects on summertime low flows. Further investigation into the magnitude of the effect will require: a) an evaluation of net water withdrawals at the outlets of all subwatersheds, b) establishment of continuous stream flow monitoring locations within the subwatersheds, and c) encouraging the efforts by the OWRD to identify current status, actual use, and timing of all water rights within the watershed as described in the beneficial use section above.

Despite the uncertainty in the magnitude of water use effects on low stream flows the BRAG may wish to identify and implement opportunities to improve summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions by water right holders. Actions should be focused in those subwatersheds where water withdrawals are greatest. Voluntary measures such as an increase in the efficiency of water distribution and application to irrigated areas will help improve summertime flow conditions. Further reductions in withdrawals through voluntary transfer of water rights (either temporarily or permanently) to organizations such as the Oregon Water Trust should also be considered.

## RIPARIAN/WETLAND HABITAT CONDITIONS (SECTION 3)

### *Question 3-1: What are the current conditions of riparian areas in the watershed?*

**Existing Condition:** Vegetation was mapped using aerial photo interpretation techniques within a 100' wide riparian corridor (on either side of the stream), along 108 miles of stream and pond perimeter within the Deep and Goose Creek watersheds. In addition, riparian shading was estimated from aerial photographs along all streams.

- **Current riparian vegetation:** The proportion of riparian area composed of tree-species ranged from approximately 80% of the total in the Upper Deep subwatershed to less than 40% in the North Fork Deep subwatershed. Forested riparian are primarily mixed conifer-hardwood species. The majority of forested riparian areas fall within the “medium” size class, with only a small proportion in either the “large” or “small” classes. The majority of forested riparian areas are classified as having “dense” canopy density. Shrub-dominated riparian areas were the least common type found in the assessment area, ranging from 2% of total riparian area in North Fork Deep to 13% in the Goose Creek subwatershed. Grass-like vegetation was a common type found in riparian areas within the assessment area ranging from approximately 9% of total riparian area in the Upper Deep Creek subwatershed to 30% in the North Fork Deep subwatershed. Areas dominated by non-riparian vegetation (primarily cultivated fields, pastures, lawns, and developed areas) ranged from 6% the Upper Deep Creek subwatershed to 28% in the North Fork Deep subwatershed.
- **Shade:** Lower than expected shade levels currently exist along streams in many headwater areas, particularly in the North Fork Deep Creek subwatershed. The degrees to which other factors affecting water temperature, such as riparian microclimate, are affected by a change in vegetation composition are not known.

**Trends:** Characterization of riparian vegetation and shade was based on a single year’s imagery (1998 for almost the entire watershed; 2002 for the very upstream ends of streams in the Upper Deep subwatershed), and as such no trends in conditions could be assessed. However, given the implementation of more stringent forest practice regulations, it is reasonable to assume that riparian tree size classes and shade have been increasing in the forested portions of the assessment area, at least over the past ten-year period.

**Data Gaps:** The photographs used to describe current riparian vegetation and shade levels were taken in 1998; consequently these results are representative of conditions four years ago.

**Recommendations:** Riparian conditions should be reassessed periodically (~ every five years) to assess changes due to management and enhancement activities.

*Question 3-2: How do the current conditions compare to those potentially present for this ecoregion?*

*Question 3-3: How can the current riparian areas be grouped within the watershed to increase our understanding of what areas need protection and what the appropriate restoration/enhancement opportunities might be?*

**Existing Condition:** Current riparian recruitment potential was organized by six riparian recruitment situations:

- Satisfactory: Riparian recruitment potential in these areas is currently satisfactory as compared with potential conditions for the ecoregion, and no enhancement is needed to achieve potential conditions. Only a very small proportion of the total length of stream is estimated to currently have satisfactory recruitment potential, ranging from 4% of the total length in the Upper Deep subwatershed, to 14% in the Lower Deep subwatershed.
- Approaching satisfactory: Riparian trees within these stands are smaller than the potential size for the ecoregion, however, the trees are of an adequate size to currently provide adequate LWM recruitment and shade. These stands are not as productive (in terms of riparian function) as they can be. However, if protected, these stands will attain potential conditions over time. Current riparian recruitment potential rated as approaching satisfactory ranges from 12% of the total length in North Fork Deep Creek to 35% in Upper Deep.
- Hardwood: Hardwood stands are generally approaching a size that is large enough to provide satisfactory recruitment potential, but are dominated by hardwoods where the potential vegetation is conifer or mixed stands. The hardwood category makes up a very small proportion of total stream length, ranging from 1% of the total length in North Fork Deep to 9% in the Upper Deep subwatershed.
- Narrow buffers: These stands have trees in the near-stream area that are of a size and species that are approaching satisfactory relative to potential conditions, however, these areas are very narrow. This category makes up only a very small proportion of total stream length, ranging from 1% of the total length in the Goose Creek subwatershed to 6% of the total length in the Upper Deep subwatershed. The primary sources of limitation to riparian forest development in these areas are agricultural practices and residential development, each of which have impacted approximately 1/3 of the length of riparian areas in the “narrow buffers” category. Other impacts are from past logging and infrastructure (primarily roads).
- Small-sparse: This grouping includes both stands of small- or regeneration-sized trees and sparse stands of medium- and large-sized trees. In both cases current recruitment potential is far removed from potential conditions, however (unlike the following grouping), these stands are forested. Percent of total riparian length within the “small-sparse” category ranges from 22% of total riparian length in the North Fork Deep subwatershed to 32% in the Upper Deep subwatershed.

- Absent: This grouping includes stands that are devoid of tree-type vegetation. This grouping makes up a significant proportion of the total riparian length in all subwatersheds, ranging from 14% in Upper Deep Creek to 55% in the North Fork Deep subwatershed. The primary sources of limitation to riparian forest development for the “absent” category are agricultural practices, although residential/commercial development is significant as well.

**Trends:** Same as for Question 3-1above.

**Data Gaps:** Same as for Question 3-1above.

**Recommendations:** The following protection/enhancement recommendations are grouped by the six riparian recruitment situations described above. Prioritization of protection/enhancement actions should favor 1) those streams that currently have (or have the potential for) fish usage, 2) those streams having channel characteristics that are most responsive to inputs of large woody material, and 3) are limited with respect to stream shading:

- Satisfactory: Protect current conditions. No enhancement necessary.
- Approaching satisfactory: Protect current conditions. No active enhancement actions are needed for the majority of these stands (i.e., just let them grow).
- Hardwood: Appropriate enhancement techniques may include conversion of some of these areas over time to conifer stands. However, many of these stands have some recruitment potential at present, and any conversion should be considered in light of other considerations (e.g., wildlife and aesthetic concerns). Among the hardwood-dominated stands, only areas that consist primarily of alder (which is short-lived and usually converts to salmonberry over time) should be considered for active restoration. The hardwood dominated stands should be the lowest priority for active enhancement activities.
- Narrow buffers: The inner (closest to the stream) portions of many of the stands will, if protected, provide more desirable conditions over time. The outer (farthest from the stream) portions of many of these stands would benefit from active enhancement techniques such as releasing the conifer component (if present) in hardwood-dominated portions of the stands, converting hardwood-dominated stands to conifer, under-planting sparse stands, or density management (commercial thinning) to accelerate structural development in conifer stands.
- Small-sparse: Active enhancement would greatly benefit many of these stands. Appropriate enhancement techniques may include releasing the conifer component in small mixed-species stands, converting the hardwood-dominated stands to conifer, under-planting sparse stands, or density management (commercial thinning) to accelerate structural development in conifer stands.
- Absent: In most cases these would be the highest priority areas for enhancement. Appropriate restoration/enhancement techniques would include riparian plantings.

***Question 3-4: Where are the wetlands in this watershed?***

**Existing Condition:** The National Wetland Inventory (NWI) was used to identify the locations of all wetlands within the watershed. A total 190 wetlands covering 330 acres were identified within the assessment area by the NWI. Wetland density (area occupied by wetlands/area of subbasin) ranged from 0.5% in the Upper Deep and Tickle Creek subwatersheds to 1.6% in the North Fork Deep subwatershed, and was 1.0% of the overall assessment area.

**Trends:** No evaluation was performed on the changes in wetland area and location over time. However, as described under Question 2-3 above, a comparison of current wetland area to area of hydric soils (an indicator of areas that may have contained wetlands historically) suggests that present-day wetlands may occupy as little as 11% of the area that they occupied historically within the entire assessment area, and that significant wetland loss may have occurred in the upper part of the North Fork Deep, Lower Deep, and Goose Creek subwatersheds. The majority of the wetland loss was probably associated with early land clearing and conversion to farmland in the late 1800's – early 1900's. Current rates of wetland loss are probably low given current regulations on wetland protection.

**Data Gaps:** The NWI data used to describe current conditions is based on imagery from the mid to late 1980's, consequently it is representative of conditions approximately 15-20 years ago. In addition, the NWI most likely fails to identify many wetlands that currently exist within the watersheds, particularly in forested areas. The estimation of historic wetland area using mapped hydric soils is coarse in scale, and may not accurately represent true historic conditions.

**Recommendations:** Same as described for Question 2-3 above.

***Question 3-5: What are the general characteristics of wetlands within the watershed?***

**Existing Condition:** Wetland characteristics are summarized by 1) wetland type, and 2) wetland modifications:

1. Palustrine aquatic bed wetlands (dominated by plants that grow principally on or below the surface of the water) are found only within the Goose Creek subwatershed where they make up only 1% of the total wetland area. Palustrine emergent wetlands (dominated by rooted herbaceous plants) are found within all subwatersheds, and range from 3% of the total wetland area in the Goose Ck subwatershed to 32% in the Lower Deep subwatershed. Palustrine forested wetlands (dominated by trees taller than 20 feet) are found in all subwatersheds, and make up the largest single grouping of wetlands; ranging from 12% of the total wetland area in the Tickle Creek subwatershed to 65% of the total wetland area in the Lower Deep Creek subwatershed. Palustrine open water wetlands (lakes and ponds) are found in all subwatersheds, and range from 3% of total wetland area in the Lower Deep Creek subwatershed to 39% in Upper Deep Creek. Palustrine scrub-shrub wetlands (dominated by shrubs and saplings less than 20 feet tall) are found in all subwatersheds with the exception of Lower Deep and make up from 3% (Upper Deep) to 42% (Goose Ck) of the total wetland area. Palustrine unconsolidated bottom wetlands (substrate is primarily mud or

exposed soils with less than 30% vegetative cover) are only found in the Tickle and Upper Deep Creek subwatersheds, where they make up 14% and 18% of the total wetland area respectively.

2. Wetland modifications: Excavated wetlands lie within a basin or channel excavated by humans. Wetland modified by excavation were found primarily within the North Fork Deep (15 occurrences), Tickle (13 occurrences), and Upper Deep (11 occurrences) subwatersheds; the remaining subwatersheds having only three occurrences each. Diked/Impounded wetlands are created or modified by a human-made barriers designed to obstruct the inflow of water, and were identified in all subwatersheds, but were most frequent within the Upper Deep, Tickle, and North Fork Deep subwatersheds. The water level in Partially drained/ditched wetlands has been artificially lowered, but soil moisture is still sufficient to support wetland vegetation. Only two occurrences of partially drained/ditched wetlands were noted, one each in the Lower Deep and North Fork Deep subwatersheds.

**Trends:** No information is available to quantitatively evaluate trends in wetland types and modifications, the assessment being based solely on NWI data acquired from 1980's imagery. However, current rates of wetland modification are probably low given current regulations on wetland protection.

**Data Gaps:** Same as described for Question 3-4 above.

**Recommendations:** Same as described for Question 2-3 above.

<b><i>Question 3-6: What opportunities exist to restore wetlands in the watershed?</i></b>
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**Existing Condition:** Current wetland information is insufficient to identify wetland enhancement opportunities.

**Trends:** The trend in opportunities to restore wetlands is improving: Interest in wetland protection is widespread as the importance of these areas to watershed function becomes better understood, and funding sources exist to pay for wetland protection and restoration efforts.

**Data Gaps:** Insufficient information exists to identify the amount and location of wetland loss, the wetland disturbances that limit wetland function, and the functions of specific wetlands that could be used to prioritize enhancement activities.

**Recommendations:** Same as described for Question 2-3 above.

## SEDIMENT SOURCES (SECTION 4)

### *Question 4-1: At present, what are the important sediment sources in the watershed?*

**Existing Condition:** Existing information is not sufficient to quantify current sediment sources in the watershed, but the following sediment sources are most likely to be important:

1. Surface erosion from agricultural lands. This includes erosion from bare ground left between nursery stock, Christmas trees, and berries, and bare ground left following ball and burlap harvesting of nursery stock in the winter. Eroded soil can be delivered to streams and wetlands if the areas of bare ground are close to a stream with insufficient buffers.
2. Surface erosion from gravel and dirt road and roadside ditches. Gravel and dirt roads provide another source of bare soil that is subject to erosion during rainfall events. Based on examination of the recent aerial photographs, there are many miles of un-mapped private roads used for agriculture and forest practices. Eroded sediment from roads and ditches can enter streams from roads at stream crossings or in locations where roads are close to streams. A total of 135 dirt/gravel road stream crossings and 44 paved road stream crossings were found in the watershed.
3. Surface erosion from bare soil during construction of homes and other structures. During construction of homes, businesses, and other structures, the ground is disturbed and often left uncovered for a period of 6 months to a year. Erosion from an individual construction site may be minor, but the cumulative effects of construction from many sites across the watershed could be larger.
4. Mass wasting (landsliding) from steep stream valley sides. This does not currently appear to be a large source of sediment since most stream valley sides are forested.

**Trends:** The trend in erosion and delivery of eroded sediments to streams is most likely improving: Interest in reducing loss of valuable soil resources and in protecting aquatic habitats from excess sediment is increasing. It is likely that surface erosion and mass wasting were larger sources of sediment in the past, during times when there was less awareness of the importance of cover crops on bare soil, and during times when stream valley sides were harvested.

**Data Gaps:** Insufficient information exists to quantify sediment sources. Quantification of surface erosion sources (agricultural lands, roads, construction areas) could be accomplished through use of models such as the USLE (Universal Soil Loss Equation), WEPP (Water Erosion Prediction Project) or SEDMODL2. Quantification of mass wasting sources could be done through an inventory from historical aerial photographs.

**Recommendations:** Continue education and financial incentives for landowners, county road engineers, and builders on the importance of maintaining ground cover and stream buffers on their land, roads, and road ditches.

***Question 4 2: In the future, what will be the important sources of sediment in the basin?***

**Existing Condition:** In the future, the existing sediment sources will likely continue to be surface erosion from areas of bare soil (agricultural areas, unsurfaced roads and road ditches, construction areas).

**Trends:** It is likely that erosion from agricultural lands should diminish in the future as landowners are educated about the importance of retaining soil resources and stream buffers.

**Data Gaps:** Same as for Question 4-1 above.

**Recommendations:** Same as for Question 4-1 above.

***Question 4 3: Where are severe erosion problems that are manageable, so as to be assigned a high priority for remediation techniques or projects?***

**Existing Condition:** Current sediment source data is insufficient to identify specific locations of severe erosion problems. Based on existing turbidity data (Section 5) it appears that the highest turbidity levels were measured in upper North Fork Deep Creek and Upper Deep Creek.

**Trends:** There is insufficient data to identify trends in specific erosion locations.

**Data Gaps:** Insufficient information exists to identify specific locations of severe sediment sources. Quantification of surface erosion sources (agricultural lands, roads, construction areas) could be accomplished through use of models such as the USLE (Universal Soil Loss Equation), WEPP (Water Erosion Prediction Project) or SEDMODL2 in combination with a field inventory of agricultural lands and roads in the watershed to provide site-specific information on ground cover, slope gradient, lengths and width of bare ground areas, and proximity to streams.

**Recommendations:** Continued education and incentives for landowners to reduce bare soil and maintain stream buffers should reduce soil loss and turbidity/fine sediment levels in streams. Identification of specific severe erosion areas would require a large effort and may not be warranted unless water quality monitoring indicates turbidity levels are extremely high.

## WATER QUALITY (SECTION 5)

**Question 5-1: What are the designated beneficial uses for streams in the watershed?**

<b>Beneficial Uses: Clackamas River Basin (OAR 340-41-442)</b>	
Public Domestic Water Supply*	Salmonid Fish Spawning
Private Domestic Water Supply*	Resident Fish & Aquatic Life
Industrial Water Supply	Wildlife & Hunting
Irrigation	Fishing
Livestock Watering	Boating
Anadromous Fish Passage	Water Contact Recreation
Salmonid Fish Rearing	Aesthetic Quality
	Hydro Power

With adequate pretreatment (filtration and disinfection) and natural quality that meets drinking water standards. (ODEQ 2001b).

**Question 5-2: What are the water quality criteria that apply to streams in the watershed?**

Water quality criteria that were used in this assessment are listed in the table below. A more comprehensive list is shown in the Water Quality Section of the report.

<b>Parameter (Beneficial Use)</b>	<b>Criteria Type/ Measurement</b>	<b>Criteria *</b>
<b>Nutrients</b> (Aesthetics)	Narrative Criteria  (phosphorus, nitrates)	No State numeric criteria.  Recommended criteria for Willamette Valley streams. (EPA 2001) Total Phosphorus 0.04 mg/L (40 µg/L) Nitrates 0.15 mg/L (150 µg/L)
<b>Temperature</b> (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria  (temperature)	Salmonid fish core areas: 60.8 ° F (16° C)  Salmon and Trout rearing and migration: 64 ° F (17.8° C)  Salmonid spawning: 55.4 ° F (13° C)
<b>Bacteria</b> (Water contact recreation)	Numeric Criteria  <i>Escherichia coli</i>	126 colonies/100 ml. (30 day log mean)  406/100 ml. (Single sample)

\* This description of criteria is abbreviated. Most criteria have associated conditions and exceptions that apply. The full text of the regulations should be used for a specific application (ODEQ 2004).

***Question 5-3: Are there stream reaches identified as water quality limited on the State's 303(d) list?***

The lower Clackamas River, from River Mill Dam to the mouth, is listed in the 1998 303(d) list for temperature, and Deep Creek is listed in the 2002 303(d) list for bacteria. Refer to the Water Quality Section of this report for details.

***Question 5-4: What do water quality studies, existing data sets, or other summary documents indicate about water quality conditions?***

**Existing Condition:** Deep Creek is impacted by pollutant sources to a greater degree than Clear Creek, a comparable watershed in the lower Clackamas River. The primary indicators are higher nutrient concentrations and increased temperature in comparison to Clear Creek.

**Nutrients, Bacteria and associated indicators:** The pollutant sources in Tickle Creek cause phosphorus to increase above guideline criteria for the ecoregion. This effect in Tickle Creek is carried downstream in Deep Creek, such that the Tickle Creek source is degrading water quality in Deep Creek as well. Specific conductance shows a similar pattern to nitrate concentrations in the watershed, indicating a source of pollution in lower Tickle Creek.

**Temperature:** The data shows a general correlation with the current riparian shade condition evaluation described in the riparian section of this report. Stream reaches mapped with shade in the 70 to 90 % category had lower temperatures and fewer exceedences of water quality criteria. This supports the general approach to lowering temperatures in streams, which is to work on riparian buffer protection in concert with tree planting programs. The riparian shade map can be used to identify those stream reaches that need particular work on reestablishing buffers and focus planting programs.

**Pesticides:** Minimal information specific to Deep Creek was available. This is a data gap that should be addressed due to the potential sources in the watershed.

**Trends:** There is no long-term data to evaluate the trend in water quality from a statistical approach. One can speculate that increased urbanization (and associated rural development) will continue to degrade water quality as is evident in Tickle Creek.

**Data Gaps:** See below, *Question 5-5: What are the key data/information gaps in water quality information?*

**Recommendations:**

**Coordination and Education:** There are numerous agencies that could assist the CRBC in protecting and enhancing watersheds; for example, Metro, OWEB, DEQ, ODFW, ODF, USDA NRCS, OSU Extension, and the Clackamas County SWCD. The Clackamas SWCD is a particularly suited to assist the CRBC in working with local landowners on the small acreages and hobby farms that occur in Deep Creek. The Clackamas County utilizes a “Micro Watershed” based approach to work with private landowners. Education activities can also be

closely coordinated with other agencies such as OSU – Extension and the Clackamas County SWCD.

**Restoration Activities:** Restoration refers to active management activities. Restoration activities for water quality should be prioritized in the denser population zones in the Lower Clear Creek subwatershed. Restoration activities may include:

- 1) Riparian planting programs (associated with education to maintain riparian zones) targeted at areas lacking shade identified in the riparian assessment.
- 2) Riparian fencing and livestock management to enhance vegetative coverage.
- 3) Livestock manure management.
- 4) Sediment and runoff control (e.g., sediment catchment basins) associated with nursery and farm operations.
- 5) Restoration of ditched channels to functioning stream channels with riparian buffers.

***Question 5-5: What are the key data/information gaps in water quality information?***

**Existing Condition and Data Gaps:** Water quality data collected by the Clackamas County SWCD (Clackamas County SWCD 2001) and Pacific Gas and Electric (PGE, 2002) provided useful information to characterize water quality conditions in Deep Creek. Suggested follow-up monitoring includes:

***Tickle Creek Nutrient Study***

A focused water quality study along Tickle Creek could better define the sources of nutrients that cause the increased nutrient concentrations. The study is outlined in the Water Quality Section of the report.

***Temperature***

Temperature monitoring over time at repeated locations would help provide information on effectiveness of the riparian area improvement actions.

***Monitoring Program Plan***

As with many watersheds, monitoring in Deep Creek lacks a comprehensive monitoring program plan, which would assure that data is collected with sufficient rigor to answer questions in a scientifically valid manner.

## FISHERIES (SECTION 6)

**Question 6-1: What salmonid species are documented in the watershed, are any of these currently ESA or candidate species?**

**Existing Condition:** A summary of salmonid species occurring in Deep and Goose Creeks is below.

Common name, population segment	Scientific name	ODFW status <sup>a</sup>	Federal status <sup>b</sup>	Federal agent
Chinook salmon, (L. Columbia R.)	Oncorhynchus tshawytscha	N	T	NMFS
Coho salmon, (L. Columbia R.)	Oncorhynchus kisutch	E	C	NMFS
Steelhead (L. Columbia R.)	Oncorhynchus mykiss	N	T	NMFS
Searun Cutthroat	Oncorhynchus clarki	S	P	USFWS
Bull trout	Salvelinus confluentus	N	T	USFWS
<i>a</i> E= endangered, T = threatened, P = proposed for listing, C = candidate species, S = species of special concern with conservation agreements, N = not listed, A = not applicable				
<i>b</i> E= endangered, T = threatened, P = proposed for listing, C = candidate species, S = species of special concern with conservation agreements				
Source: ( <a href="http://rainbow.dfw.state.or.us/nrimp/information/index.htm">http://rainbow.dfw.state.or.us/nrimp/information/index.htm</a> ).				

**Trends:** No quantitative information is available on changes in fish populations within the Deep and Goose Creek watersheds over time. However, trends most likely follow the regional pattern of declines.

**Recommendations:** Current information was sufficient for the purposes of this assessment.

**Question 6-2: What are the distribution, relative abundance and population status of salmonid species in the watershed?**

**Existing Condition:** No specific information was available on fish populations in Deep and Goose Creeks.

**Trends:** No quantitative information is available on changes in fish populations within the Deep and Goose Creek watersheds over time. However, trends most likely follow the regional pattern of declines.

**Recommendations:** Better information of distribution and habitat utilization of key salmonid fish species (especially sea run cutthroat) would better focus enhancement and planning efforts.

***Question 6-3: Which salmonid species are native to the watershed, and which have been introduced to the watershed?***

***Question 6-4: What are the species interactions?***

**Existing Condition:** There were very few records of stocking in the Deep/ Goose watershed, coho and rainbow trout are the only species recorded as having been stocked. With the limited history of stocking there are not any likely species interactions between native and non-native salmonids. There are no references to brook trout currently occurring in either Deep or Tickle Creeks. However, since smolt trapping data indicates Deep Creek is the biggest producer of bullfrog tadpoles and pumpkinseeds (B. Strobel USFS. Pers. comm. 2004)

**Trends:** There was not enough information on fish populations to evaluate trends.

**Recommendations:** Evaluate if non-native warm water species (ie. pumpkinseeds, bull frogs) are impacting salmonids.

***Question 6-5: What is the condition of fish habitat in the watershed (by sub-basin) where habitat data has been collected?***

**Existing Condition:** ODFW collected habitat data in 2003. Overall habitat conditions were fair to good where sampled. Pool frequencies and gravel availability was rated as good to fair for all reaches. The amount of fine sediments (silt, sand and organics) was fair to good with the uppermost reach of Deep Creek the only area with especially high fines. Wood volume was low at all sites except in reach 'Deep Creek 8'. Wood Volumes ranged from 1.5 to 10.5 m<sup>3</sup>/100m. In reach 'Deep Creek 8' the wood volume was 45.1 m<sup>3</sup>/100m. The pattern of low wood volumes is consistent with observations at other streams in Oregon and is usually due to historic stream cleaning practices, combined with limited riparian inputs due to historic harvest of large riparian trees.

Knotweed was observed in Lower Deep Creek.

**Trends:** Habitat data has only been collected once in this area which does not allow for evaluating trends.

**Recommendations:** Consider knotweed removal program. Determine what is unique in Deep Creek 8 where LWD levels are high. Determine sediment sources creating high fine sediment conditions in Deep Creek 11 and work to decrease sediment inputs.

***Question 6-6: Where are there potential barriers to fish migration?***

**Existing Condition:** Assessment of fish passage on 109 potential fish passage barriers in the Deep and Goose Creek watersheds was completed. Of the 109 barriers surveyed in Deep and

Goose Creek watersheds, 21 were found to completely block and 28 to partially block passage to salmonids and resident fish species. One of these is a natural barrier near the mouth of Noyer Creek and 9 were on non-fish bearing reaches. The remaining 39 were prioritized in order of the severity their blockage has on limiting fish movement. 18 of the 39 barriers partially or completely block *salmonid* passage. The locations of the instream barriers can be found on the fish passage maps in *Map 9: Fish Passage Barrier Map* and on the web-based Fish Passage Tool (<http://www.clackamasriver.org>).

**Recommendations:** Three of the top five crossings in Deep and Goose Creek are dams. Locating and gaining access to dams was more difficult than in-stream barriers on roads additional efforts to survey for additional dams should be made.

None of the top ten priority crossings are found in the Goose Creek watershed.

Despite being used for water quality testing from the waste water treatment plant, the highest priority barrier, DPD02, has the potential to be a good candidate for removal. The second highest priority barrier, DP026A, also has the potential for removal because it is no longer used. In addition, because the material blocking the inlet could be removed without affecting the culvert or bridge, active management to maintain the inlet opening is also a possible low-cost solution. The third and fourth highest priority crossings are owned by enthusiastic, cooperative landowners who are concerned about fish habitat and willing to participate in local projects.

## **1.0 INTRODUCTION**

The Clackamas River Basin Council (CRBC) contracted with Watershed Professionals Network to complete a streamlined watershed assessment for the Deep and Goose Creek watersheds. These watersheds are tributaries to the lower Clackamas River located below any major dams on the system, and therefore potentially important to restoration of anadromous fish species in the river. The assessment will emphasize the existing status of fish populations, the aquatic habitat, water quality and riparian condition. Recommendations are made to improve these resources through watershed council and stakeholder actions or fill critical data gaps in information.

A Fish Passage Barrier Assessment was completed in concert with this assessment and also includes the lower Eagle Creek watershed. The detailed report for the fish passage assessment is compiled in Appendices 1-6, however, the recommendations for improving fish passage in Deep and Goose Creek watersheds are in the Fisheries section of this report.

### **1.1 PURPOSE AND SCOPE**

The purpose of the assessment is to characterize current watershed conditions in the Deep and Goose Creek watersheds and to make recommendations to protect/enhance watershed natural resources, with particular reference to the aquatic environment. The assessment will aid the CRBC in identifying opportunities and setting priorities for watershed restoration actions.

#### **1.1.1 Approach**

The assessment generally followed the framework described in the *Oregon Watershed Enhancement Board's Watershed Assessment Manual* (WPN, 1999). The assessment focused on the following components: Hydrology; Riparian; Sediment Sources; Water Quality; and Fisheries. Generally the approach builds on existing information, and enhances this information with aerial photo interpretation and limited field checking. GIS was used as a critical assessment tool and method of displaying results.

In addition to the Fish Passage Barrier Assessment and WPN staff analysis, data on fisheries habitat condition was collected by the Oregon Department of Fish and Wildlife for this project during the 2003 field season. This information is incorporated into the Fisheries section.

#### **1.1.2 Organization of Document**

This document follows the overall organization of the assessment. An introduction provides a description of the natural resources and social and economic activities of the watershed. The report is organized by sections that address Hydrology; Riparian; Sediment Sources; Water Quality; and Fisheries. A summary of finding and recommendations is provided prior to the body of the report. Specific sections are listed below.

- ***Watershed Summary.*** The watershed summary is organized by critical question. Existing conditions, Trends, Data Gaps and Recommendations are addressed for each critical question. It should be understood, that “Trend” refers to professional opinion of general direction rather than a measured change in condition.

- ***Section 1: Introduction.***
- ***Section 2: Hydrology and Water Use.***
- ***Section 3: Riparian Conditions.***
- ***Section 4: Sediment Sources.***
- ***Section 5: Water Quality.***
- ***Section 6. Fisheries.***

Sections 2 through 6 are organized in the same manner. Each section is organized by the following subsections:

- ***Introduction***
- ***Critical Questions***
- ***Methods***
- ***Results***
- ***Information Gaps and Monitoring Needs***
- ***Conclusions and Recommendations.*** Recommendations refer to specific Watershed Council actions whenever possible.
- ***References***

Supporting ***Appendices*** and ***Maps*** are provided as separate hard copies and as electronic files on CD-ROM. The Clackamas Basin Watershed Coordinator can be contacted for copies.

## 1.2 STUDY AREA OVERVIEW

### 1.2.1 Study Area Location and Assessment Subwatersheds

The study area includes the Deep and Goose Creek watersheds, located in Clackamas County, Oregon (Figure 1-1; Map 1: Base Map). For the purposes of this assessment the watersheds have been subdivided into five subwatersheds. Subwatershed characteristics are given in Table 1-1. Elevations in the watershed range from approximately 140 feet at the confluence of Deep Creek and the Clackamas River, to over 1,600 feet at the eastern end of the assessment area. The city of Sandy is partially located within the assessment area, as is the unincorporated rural community of Boring. Cities and rural communities surrounding the assessment area include Estacada to the south, and Oregon City, Gladstone and Damascus to the west. Downtown Portland is approximately 20 miles northwest of the center of the assessment area. State Highways 211, 212, and 224, and U.S. Highway 26 pass through the watershed.

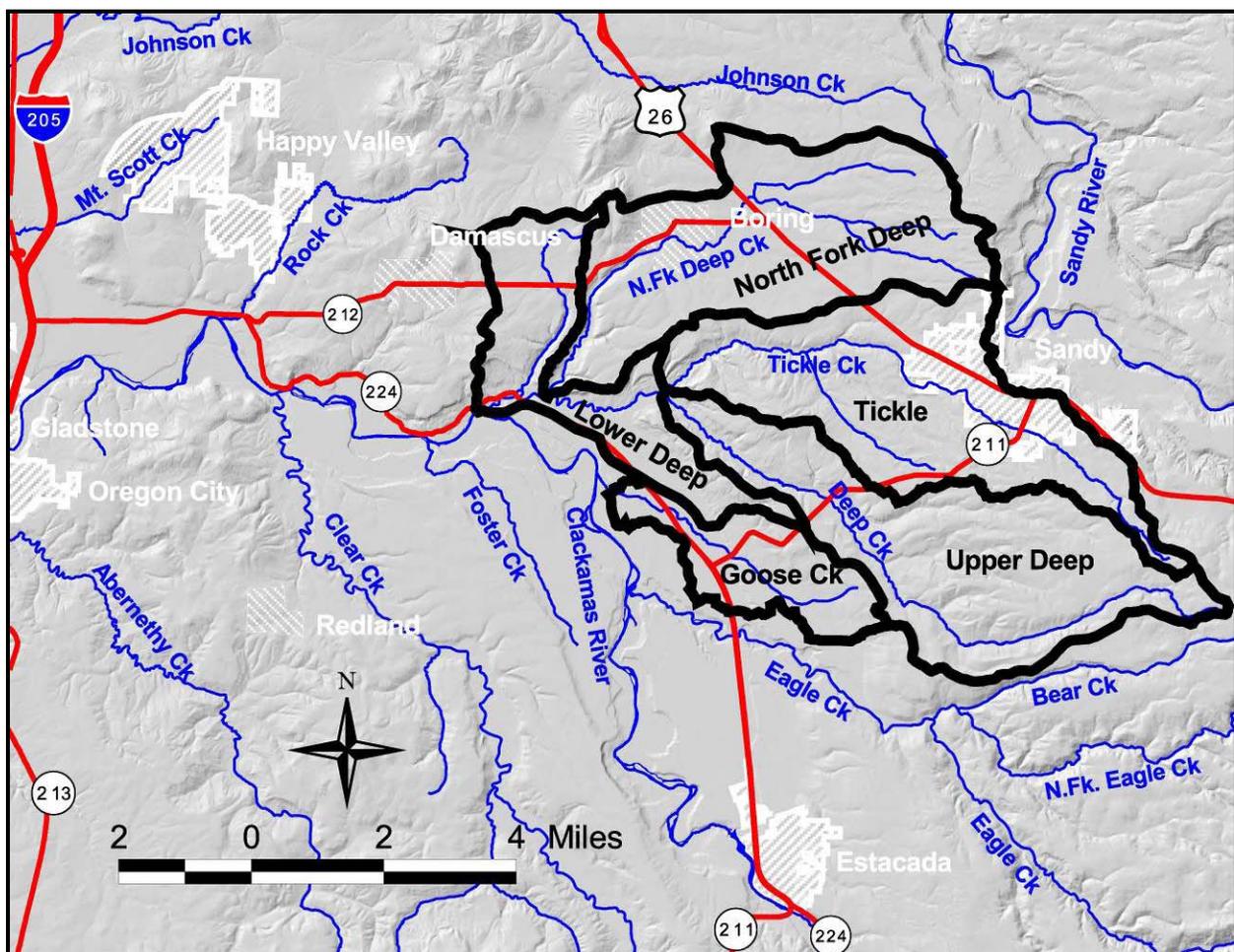


Figure 1-1. Location map of the Deep and Goose Creek watersheds. Data sources: BLM (2003), Clackamas County (2003, USGS (1999)).

**Table 1-1. Characteristics of subwatersheds within the Deep and Goose Creek watersheds.**

Subwatershed	Area (mi <sup>2</sup> )	Elevation (feet)			Slope (%)		
		Mean	Minimum	Maximum	Mean	Minimum	Maximum
Goose Ck	4.4	474	179	822	3	0	45
Lower Deep	7.1	483	138	994	6	0	64
North Fork Deep	14.2	613	188	1,010	3	0	57
Tickle	13.7	818	295	1,602	6	0	57
Upper Deep	13.9	963	295	1,642	7	0	53
Entire Deep/Goose	53.4	728	138	1,642	5	0	64

Note: Data sources: USGS (1999).

The topography of the Deep and Goose Creek watersheds is typical of areas within the Willamette Valley and adjacent foothills, with the areas of greatest relief occurring in the lower to mid-portions of the watersheds, where the largest streams have incised into the underlying geology, and the headwater areas having relatively flat or rolling topography (WPN, 2001). Mean subwatershed elevation and slope are relatively uniform throughout the assessment area (Table 1-1).

### 1.2.2 Water Features

Water features (i.e., streams and ponds) within the Deep/Goose assessment area (Figure 1-2; Map 1: Base Map) were summarized using data available for the Oregon Department of Forestry (ODF) Molalla District (ODF, 2003; Table 1-2). There are approximately 103 miles of stream within the assessment area, 58 miles of which is classified as fish-bearing<sup>1</sup>, and 39 of which is classified as non-fish bearing. An additional 5 miles of stream has unknown fish usage. Table 1-2 also provides a summary of the length of stream by ODF stream size. Almost all of the streams that are classified by ODF as “large” and “medium” sized are fish-bearing.

Ponds and lakes comprise a very small portion of the Deep/Goose assessment area (Figure 1-2; Table 1-2). There are a total of 77 ponds identified within the assessment area, ranging in size from approximately 1,000 square feet to five acres. Approximately 1/3 of the ponds are directly connected to a stream mapped by ODF.

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<sup>1</sup> This refers to fish use by resident fish; information on anadromous fish distribution, as well as more detail on resident fish, are provided in Section 6.0, Fisheries

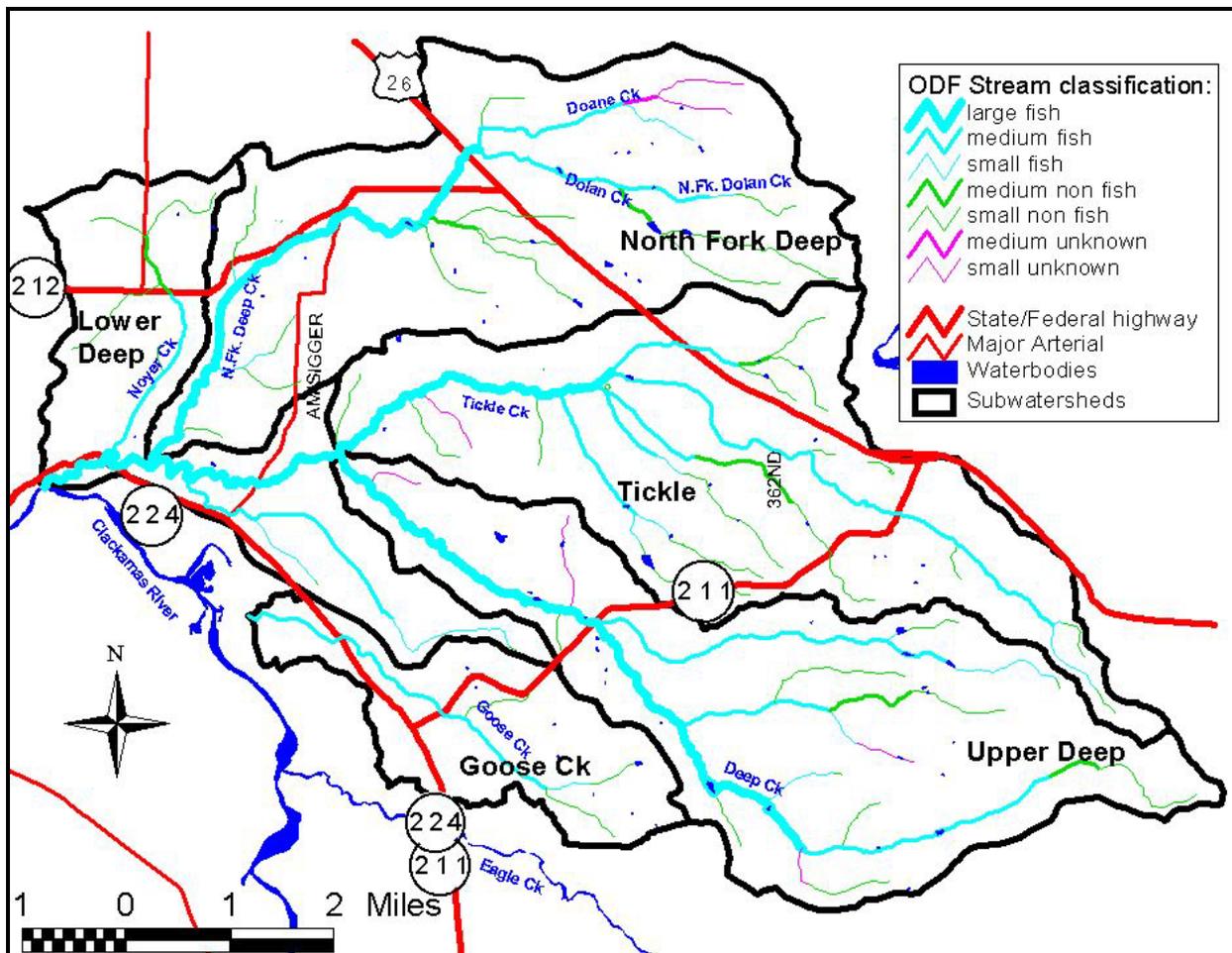


Figure 1-2. Water features within the Deep/Goose Creek assessment area. Data source: ODF (2003).

Table 1-2. Summary of water features within the Deep/Goose Creek assessment area.

Subwatershed	Streams (miles):								Lakes:	
	Fish-bearing			Non-fish		Unknown fish use		Grand Total	n	Acres
	Large	Med.	Small	Med.	Small	Med.	Small			
Goose Ck		3.7	0.4		2.2			6.3	8	2.0
Lower Deep	3.9	4.6	2.3	0.6	3.2			14.7	4	1.1
North Fork Deep	5.4	4.1	1.9	1.0	11.2	0.3	1.7	25.6	23	14.2
Tickle	3.2	10.3	2.0	1.4	11.4		0.8	29.1	18	10.5
Upper Deep	6.4	7.7	2.4	1.4	6.8		2.4	27.2	24	16.2
Entire Deep/Goose	19.0	30.4	9.1	4.5	34.8	0.3	4.9	102.8	77	44.1

Data source: ODF (2003).

### 1.2.3 Channel Habitat Types

Channels within the assessment area were classified into Channel Habitat Types (CHTs) to better understand; 1) the location of channel habitat types that provide key aquatic habitat conditions, 2) how land use impacts can alter the channel form and, 3) to identify how different types of channel will respond to restoration efforts. In addition, channel modifications were noted in order to provide insight on how human activities have directly changed channel morphology and aquatic habitat. The specific objectives of this CHT/modification evaluation were to understand:

1. The distribution of channel habitat types throughout the watershed;
2. The location of channel habitat types that are likely to provide specific aquatic habitat features, as well as those areas that may be the most sensitive to changes in watershed condition; and
3. An overview of the types and distribution of past and current channel modifications.

A modified version of the methodology from the Oregon Watershed Assessment Manual (WPN 1999) was used to identify CHTs, and channel modifications. Channel gradient was first calculated within a GIS for all channels within the assessment area using digital elevation model (DEM) data (USGS, 1999). Channel segments were then classified as to channel gradient classes (<1%, 1-2%, 2-4%, 4-8%, 8-16% and, >16%). Channel confinement classes (unconfined, moderately confined and confined), were assigned to the stream segments by inspection of topographic maps and stereo aerial photographs (SBG, 1998; SBG, 2002). Gross-scale channel modifications were also noted during the aerial photo interpretation. No field verification was conducted under this assessment.

The distribution of CHTs within the Deep/Goose assessment area are shown in Figure 1-3 and on Map2: Channel Habitat Types, and are summarized in Table 1-3 and in Figure 1-4. In the absence of human-caused disturbance, CHTs generally reflect the underlying geology and geomorphology of the assessment area. The lower gradient streams with moderate floodplain development are generally found along the larger streams in the lowermost portion of the system.. The steepest channels are found generally found not in the headwaters, but rather in small streams that come off the steep scarps found in the mid-portion of the watershed (i.e., CHT type MV; Figure 1-3). The greatest proportion of confined streams is found in the easternmost portion of the assessment area; in the rolling topography of the Cascade foothills (Figure 1-3). Streams disturbed by human activity, primarily agricultural ditching and draining, are found primarily in the North Fork Deep, Lower Deep, and Goose Creek subwatersheds (Figure 1-3). The following is a brief description of each CHT group identified in the assessment area.

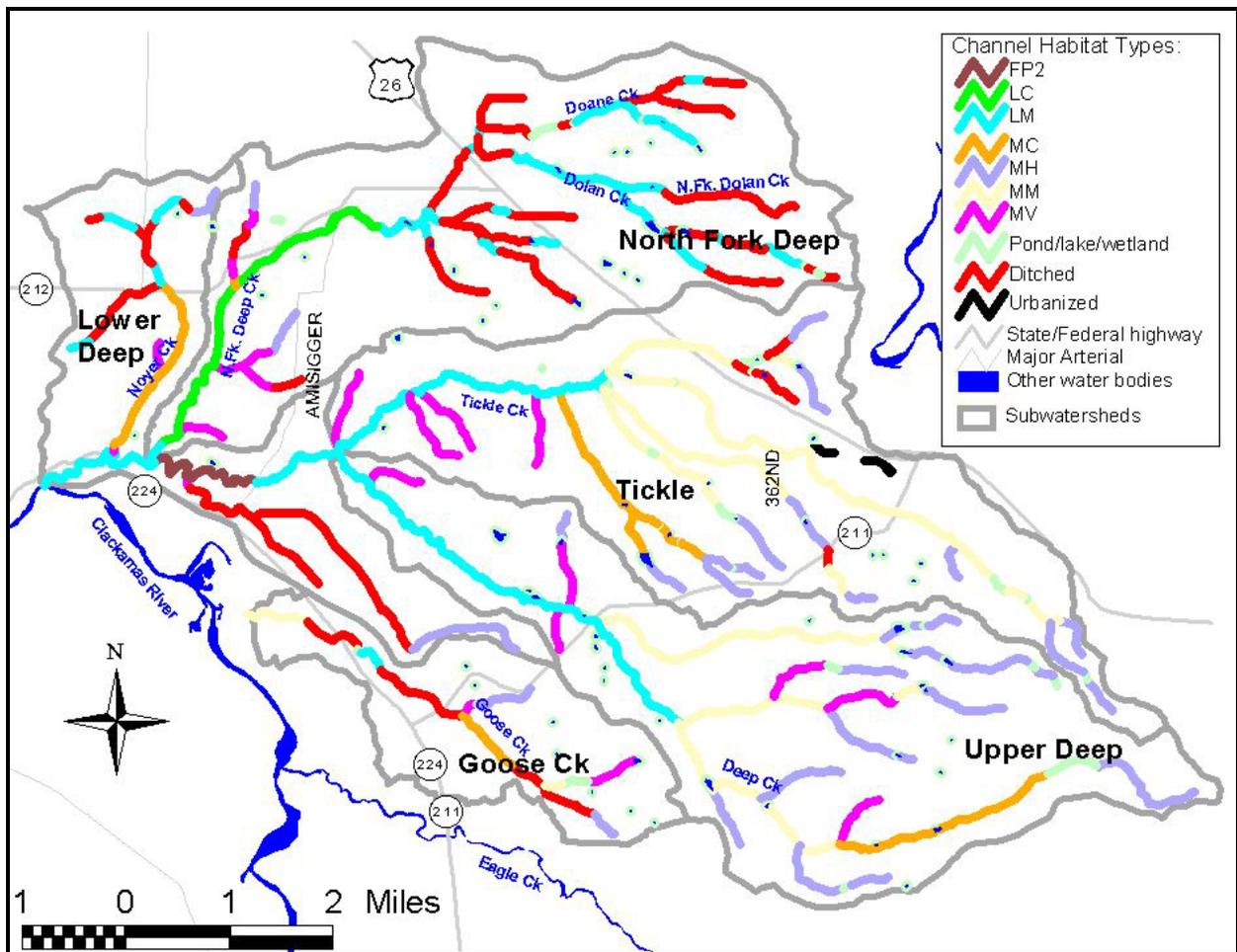
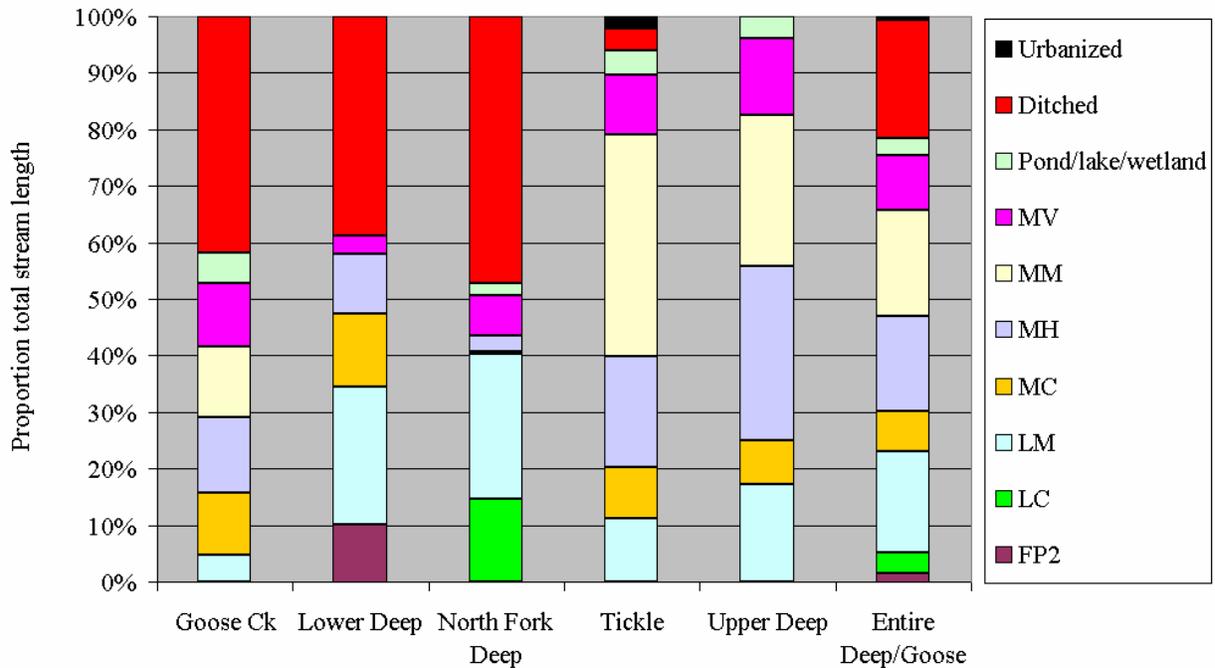


Figure 1-3. Channel Habitat Types (CHTs) in the Deep/Goose assessment area.

Table 1-3. Summary of miles of stream in each CHT by subwatershed.

CHT	Goose Ck	Lower Deep	N.Fk. Deep	Tickle	Upper Deep	Grand Total
FP2	-	1.5	-	-	-	1.5
LC	-	-	3.8	-	-	3.8
LM	0.3	3.6	6.5	3.3	4.7	18.4
MC	0.7	1.9	0.1	2.6	2.1	7.5
MH	0.8	1.6	0.7	5.7	8.3	17.1
MM	0.8	-	-	11.4	7.3	19.4
MV	0.7	0.5	1.8	3.1	3.7	9.8
Pond/lake/wetland	0.3	-	0.6	1.3	1.0	3.2
Ditched	2.6	5.7	12.1	1.1	-	21.5
Urbanized	-	-	-	0.7	-	0.7
<b>Grand Total</b>	<b>6.3</b>	<b>14.7</b>	<b>25.6</b>	<b>29.1</b>	<b>27.2</b>	<b>102.8</b>



**Figure 1-4. Distribution of CHTs by subwatershed within the Deep and Goose Creek assessment area.**

Low Gradient Floodplain (FP2) and Low Gradient Moderately Confined (LM) Channels: These low gradient channels are located on the lower portions of Deep and Tickle Creeks, and along the relatively undisturbed portions of headwater streams in the North Fork Deep Creek subwatershed (Figure 1-3). FP2 channels occur in broad valley bottoms with well-established floodplains, and channels would be expected to be sinuous, with extensive gravel bars, multiple channels, and terraces (WPN, 1999). LM channels are also low-gradient, commonly with narrow floodplains (two to four times the width of the active channel), but floodplains may be discontinuous due to confinement by low terraces or hill slopes. These channels tend to be slightly to moderately sinuous, often with side-channels. FP2 and LM channels would be expected to be the most responsive channels in the assessment area to changes in inputs of LWD, water and sediments.

Low Gradient Confined (LC) Channels: This CHT type occurs in the assessment area exclusively along the lower portions of the North Fork of Deep Creek (Figure 1-3). LC channels are contained by adjacent landforms which control lateral channel migration, often bound on one bank by hill slopes, with narrow floodplains in places (WPN, 1999).

Moderate Gradient Moderately Confined (MM) channels: This CHT type is most common in the upper portions of the Tickle and Upper Deep Creek subwatersheds (Figure 1-3). Channels within this CHT type are confined by adjacent hill slopes which limit channel migration and

floodplain development, however, a narrow (sometimes discontinuous) floodplain is usually present (WPN, 1999).

Moderate Gradient Confined (MC) channels: This CHT grouping is found in all subwatersheds with the exception of the North Fork Deep Creek (Figure 1-3). MC channels are, as their name suggests, more confined than MM channels, despite often being similar with respect to gradient.

Moderate Gradient Headwater (MH) channels: This CHT grouping occurs in the headwaters of most subwatersheds in the assessment area (Figure 1-3). These channels are similar to the LC channels, but occur exclusively in headwater regions. The low gradient and low streamflow volumes result in low stream power, consequently, they deliver relatively low volumes of sediment to downstream reaches (WPN, 1999).

Moderately Steep Narrow Valley (MV) channels: The MV channels are the highest gradient channels found within the assessment area, and are located primarily on the steep scarps found along the deeply incised valleys in the mid-portion of the watershed (Figure 1-3). MV channels are moderately steep and confined by adjacent hill slopes, and efficiently transport both coarse bedload and fine sediment (WPN, 1999).

Pond/Lake/Wetland channels: This grouping is not one of the standard CHT types given in the OWEB manual, however, it was created here to distinguish those channel lengths that are really ponds or wetland areas (with no defined channels), but are mapped by ODF as part of the channel system. These “channels” occur in a small proportion of the entire assessment area (Figure 1-3). As noted in the previous section, approximately 25 ponds are located on the stream network, and an additional 50 ponds are located off the stream channel but in the watershed. Many of these ponds are constructed farm ponds and the ones on the stream channel provide limited or no fish passage opportunities.

Ditched (D) channels: A number of the small tributaries in the assessment area have been straightened and ditched, presumably to improve drainage of agricultural lands. These stream segments are identified on the CHT map as ditches because the channel function in these segments is not the same as for an unmodified CHT. Approximately 40% of the total channel length in the Goose, Lower Deep, and North Fork Deep subwatersheds is classified within this category. These tributaries have the potential for significant habitat loss and water quality degradation due to straightening of the channel, proximity to road and farm property, and commonly a complete lack of shade or any cover.

Urbanized channels: This final CHT grouping was created to identify several streams that appear to have been obliterated or buried as a result of urbanization (i.e., these streams are no longer visible on aerial photos). This category refers to one stream, located in the headwaters of the Tickle Creek subwatershed (Figure 1-3).

The following observations can be drawn from the limited CHT assessment presented here. The extensive ditching of streams in portions of the assessment area should be evaluated for fisheries habitat and water quality implications, and these streams should be evaluated as to the degree of need and likelihood of success of channel restoration. The ponds located on the stream channels

have the potential to significantly impact water quality and impede passage of fish. In-channel ponds on fish bearing streams should be evaluated for potential impacts to water quality and fish passage.

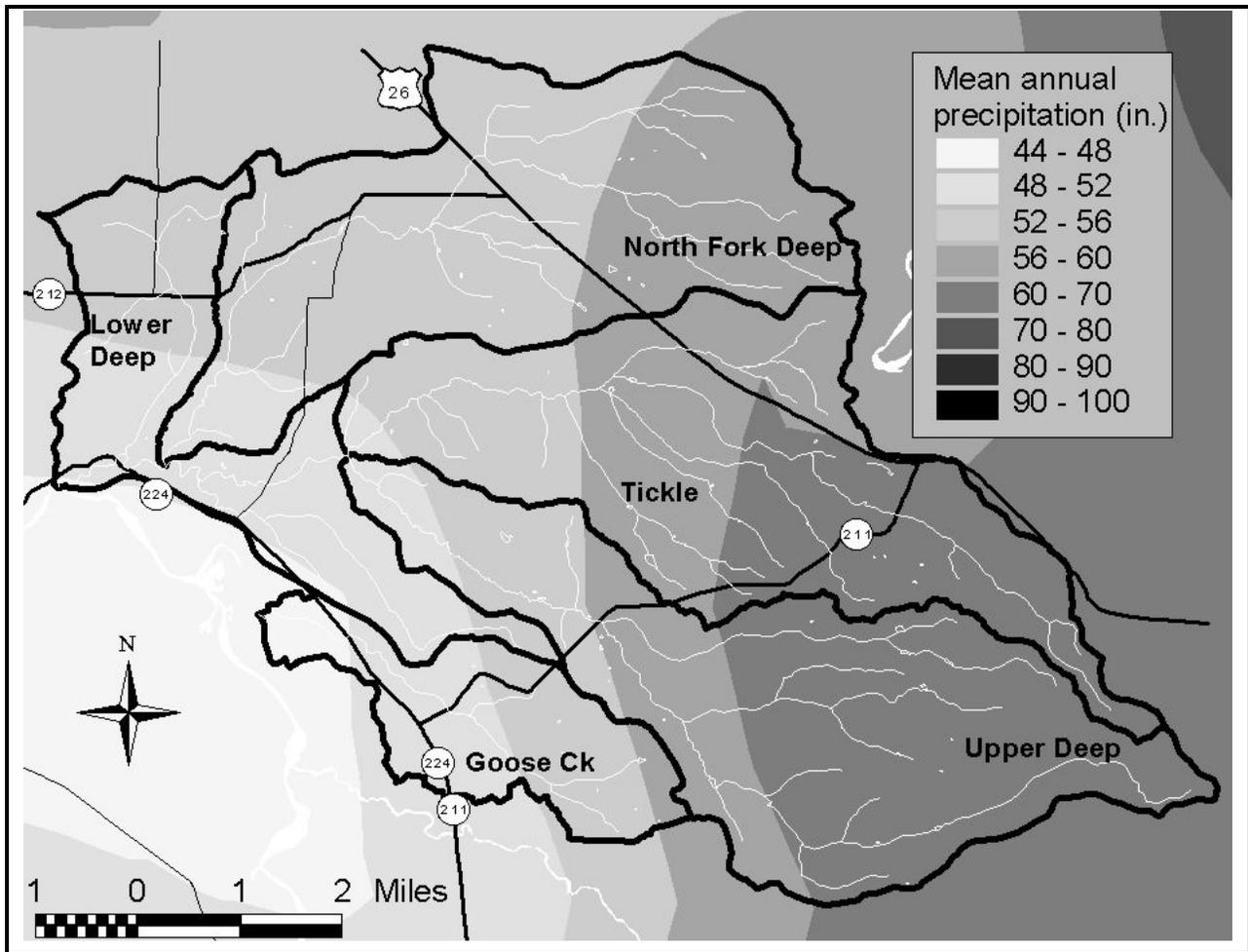
#### **1.2.4 Climate**

The Deep and Goose Creek watersheds are located at the interface of the Willamette Valley and Cascade Mountain foothills, and experience climatic conditions typical for those areas. Mean annual air temperature<sup>2</sup> is 52 °F. Mean minimum air temperature occurs in the months of December and January (46 °F), and mean maximum air temperature occurs in the months of July and August (79 °F). Snowfall is low, averaging less than three inches in the snowiest month (January), and only 5 inches on an annual basis.

Mean annual precipitation within the assessment area generally increases with increasing elevation (Figure 1-5). Mean annual precipitation ranges from approximately 47 inches near the mouths of Deep and Goose Creeks, to approximately 67 inches in the headwaters of the Upper Deep Creek subwatershed, and is 57 inches for the assessment area overall (Oregon Climate Service, 1998, 2004). Mean monthly precipitation is lowest in the month of July; averaging 1 inch in all subwatersheds (Oregon Climate Service, 1998). December has the highest values of mean monthly precipitation, and varies with elevation, ranging from 8 inches in the Goose Ck and Lower Deep subwatersheds to 9 inches in all remaining subwatersheds and for the entire assessment area overall.

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<sup>2</sup> Based on data available for the Estacada 2 SE climate station (352693), located approximately nine miles south of the center of the Deep/Goose assessment area, station elevation 410 feet, period of record for daily data 1948-present



**Figure 1-5. Mean annual precipitation in the Deep/Goose Creek watersheds. Data source: Oregon Climate Service (1998).**

The two primary patterns of climatic variability that occur in the Pacific Northwest are the El Niño/Southern Oscillation (ENSO) and the Pacific Decadal Oscillation (PDO). The two climate oscillations have similar spatial climate fingerprints, but very different temporal behavior; PDO events persist for 20-to-30 year periods, while ENSO events typically persist for 6 to 18 months (Mantua, 2001). Changes in Pacific Northeast marine ecosystems have been correlated with PDO phase changes. Warm/dry phases have been correlated with enhanced coastal ocean productivity in Alaska and decreased productivity off the west coast of the lower 48 states, while cold/wet phases have resulted in opposite patterns of ocean productivity (Mantua, 2001). Several studies (Mantua et al., 1997; Minobe, 1997; and Mote et al., 1999) suggest that five distinct PDO cycles have occurred since the late 1800's:

- 1890-1924 (cool/wet)
- 1925-1946 (warm/dry)
- 1947-1976 (cool/wet)
- 1977 –1995 (warm/dry)
- 1995–present (cool/wet)

The annual precipitation record from a climate station located in Estacada<sup>3</sup> was evaluated to understand whether local trends follow the documented PDO cycles. Data from this station was processed as follows:

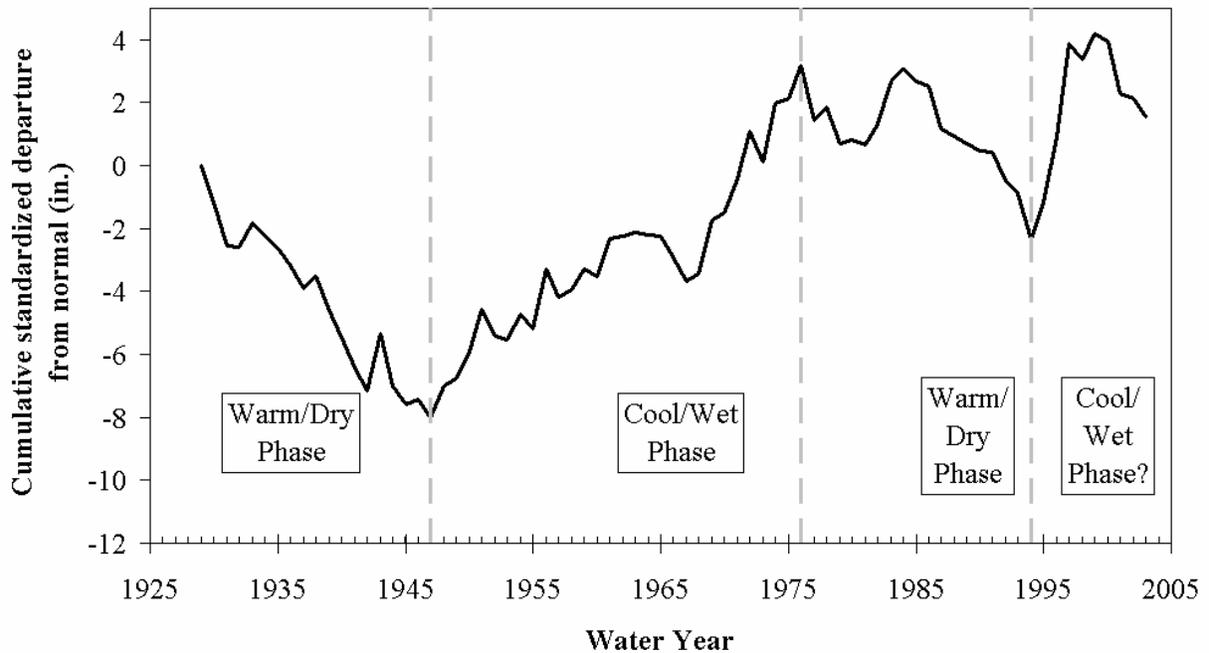
1. The mean and standard deviation was calculated for the annual precipitation at the Estacada 2 SE station over the period of record.
2. A standardized departure from normal was calculated for each year by subtracting the mean annual precipitation from the annual precipitation for a given year, and dividing by the standard deviation.
3. A cumulative standardized departure from normal was then calculated by adding the standardized departure from normal for a given year to the cumulative standardized departure from the previous year (the cumulative standardized departure from normal for the first year in a station record was set to zero).

This approach of using the cumulative standardized departure from normal provides a way to better-illustrate patterns of increasing or decreasing precipitation over time by reducing year-to-year variations in precipitation, thus compensating for the irregular nature of the data set. Values for the cumulative standardized departure from normal increase during wet periods and decrease during dry periods.

Results for the Estacada 2 SE station are given in Figure 1-6. Precipitation patterns from the Estacada 2 SE station generally follow the regional trends discussed above. The warm/dry phase that is regionally reported to have lasted until 1946 appears to have ended in 1947, and the following cool/wet phase appears to have lasted until 1976. A short-warm/dry phase appears to have occurred from approximately 1977 - 1994, and we currently appear to be in a cool/wet phase, however, data are not conclusive.

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<sup>3</sup> Total monthly precipitation records from the Estacada 2 SE climate station (Station #352693, located approximately nine miles south of the center of the Deep/Goose assessment area) were used for this analysis. Missing data for four months were estimated using data from the Oregon City climate station.



**Figure 1-6. Cumulative standardized departure from normal of annual precipitation for the Estacada 2 SE weather station. Local PDO cycles are shown as vertical dashed lines**

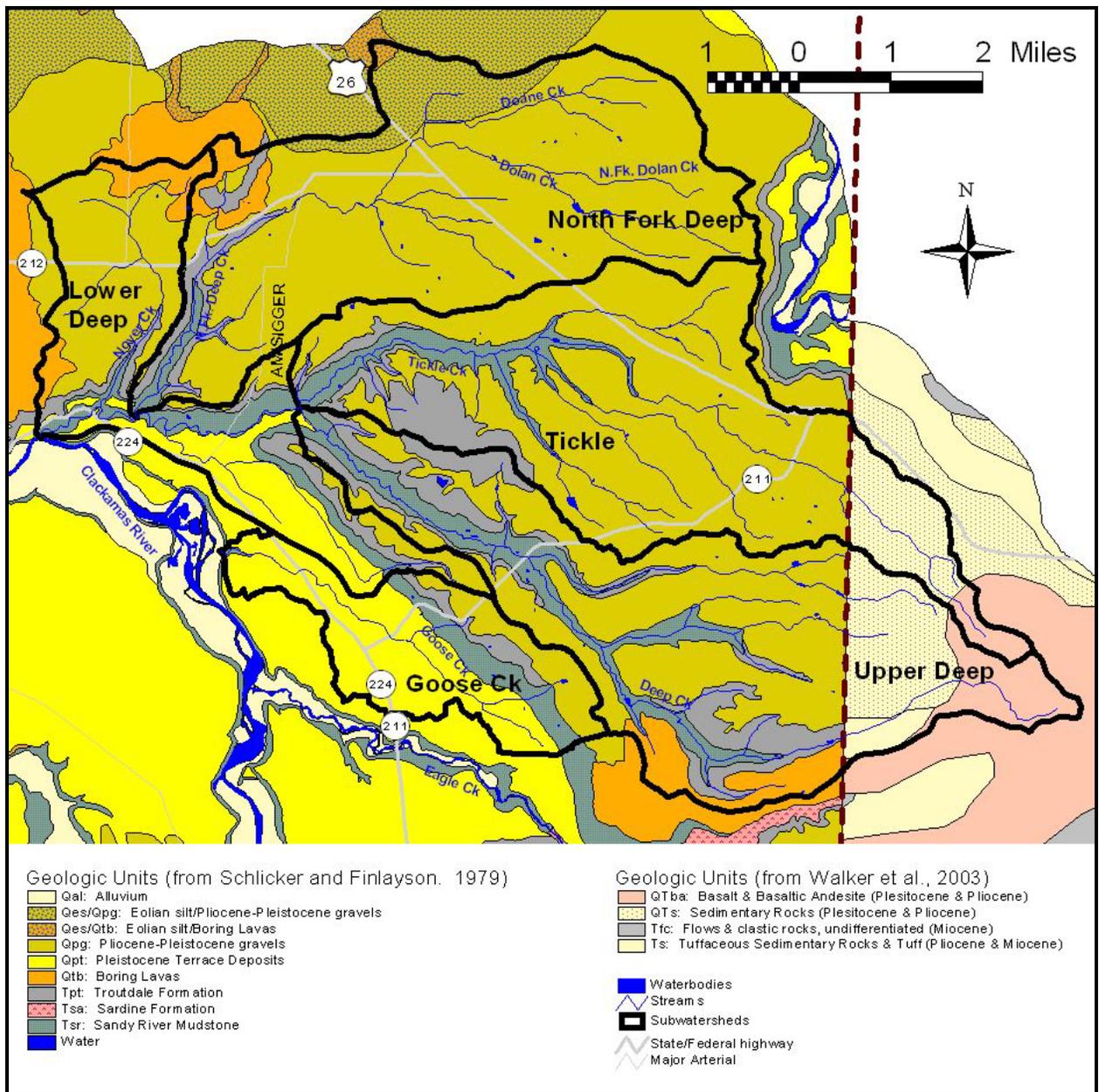
### 1.2.5 Geology: Rocks and Landforms

The geologic formations in the Deep and Goose creek watersheds are the result of the volcanic processes and subsequent stream and river erosion and deposition that shaped the area (Figure 1-7 and Map 3). Landforms closely follow the geologic units in the watershed. There are four major geology/landform units:

- **Volcanic (cinder) cones/Boring Lava** – there are 2 small volcanic cones along the northern boundary of the assessment area, just east and northwest of the town of Boring. These were formed around volcanic vents and are mapped as Boring Lava.
- **Plateaus and upper terraces/Plio-Pleistocene gravels and sedimentary rocks** – the relatively flat and gently sloping upland areas in the upstream portions of each of the sub-basins are plateaus and higher elevation terraces. These plateaus and terraces are composed of Plio-Pleistocene gravels and sedimentary rocks; weathered conglomerates, sandstones, and siltstones deposited by ancient rivers that flowed over the area.
- **Incised stream valleys/Troutdale formation and Sandy River Mudstone** – the steep areas along the main stream and tributary channels of Noyer Creek, North Fork Deep Creek, Tickle Creek, and Deep Creek are the result of incision by the streams through the upper terrace deposits into the underlying formations (Troutdale Formation and Sandy River Mudstone). These geologic units were deposited about 4 million years ago by

streams flowing off the growing Cascade Range. The Troutdale Formation is composed of mostly gravel and cobbles. The Sandy River Mudstone is finer-grained, well-cemented siltstone and fine sandstone. The steep valley sides are the primary locations where mass wasting can occur.

- **Lower alluvial terraces/Pleistocene Terrace Deposits** – the broad, flat terrace along the southern boundary of the watershed was cut by the ancient Clackamas River. This area is mapped as Pleistocene Terrace Deposits, composed of younger and relatively unweathered fluvial gravel, sand and silt deposits.

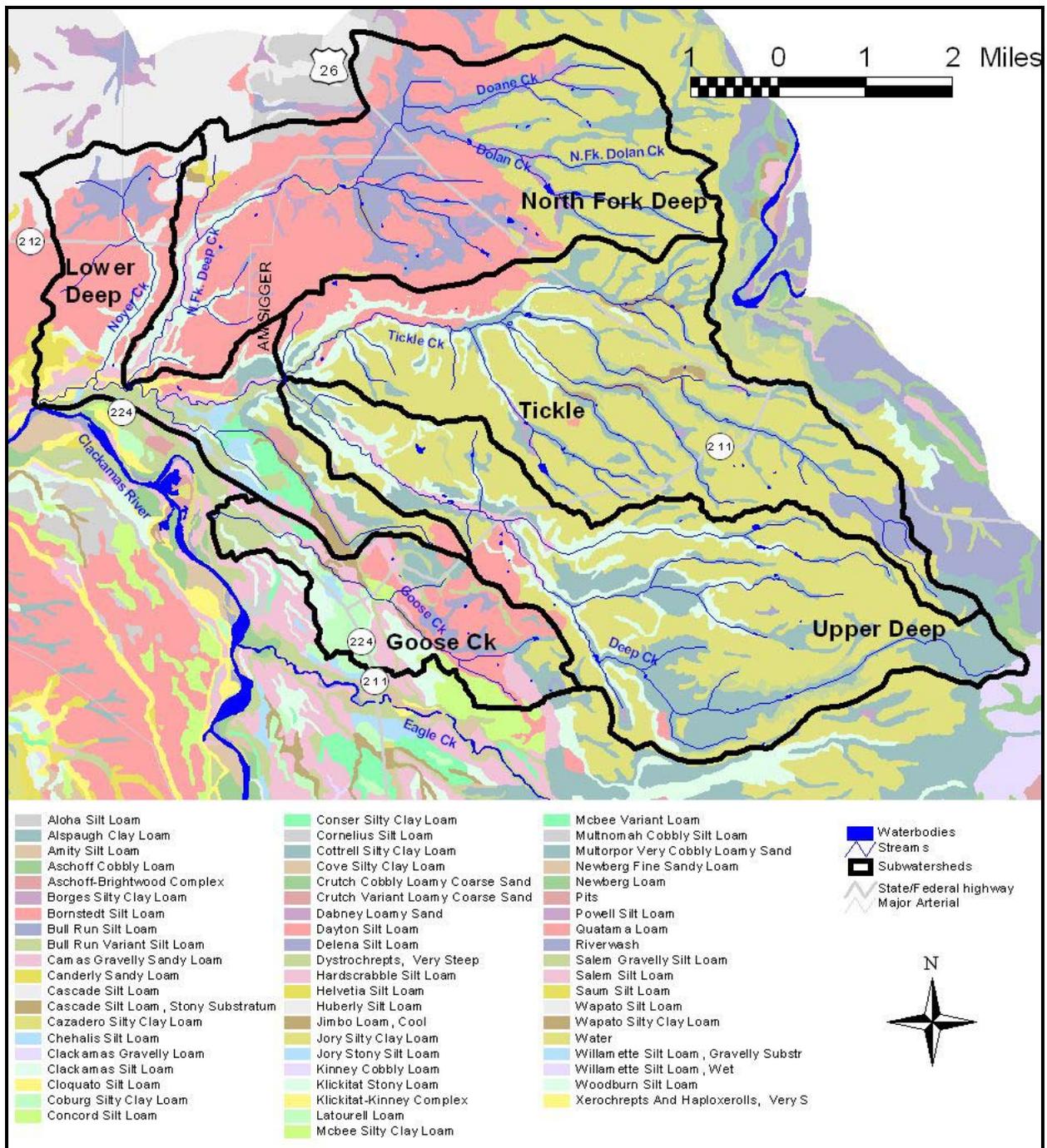


**Figure 1-7. Geology map of the Deep and Goose Creek watersheds. (Data sources: Schlicker and Finlayson (1979), Walker et al. (2003).)**

## 1.2.6 Soils

Soil is formed by the combination of weathering of parent material (geologic units) and organic processes, and is influenced by climate, topography, and the length of time the soil has to develop before major disturbance. The NRCS soil map layer (Figure 1-8 and Map 4) has over 50 soil units within the Deep and Goose Creek watersheds, however the main soil units are the Cazadero Silty Clay Loam and the Bornstedt Silt Loam.

Soils in the watershed are primarily fine-grained silty loams and silty clay loams. They have low permeability and are poorly drained. Erosion hazard ranges from slight on gentle slopes (less than 5 percent) to severe on steep slopes (over 15-30 percent). The soils are suitable for farming, crops, and timber production. Some soils can develop a hard pan (hard, impermeable layer) which inhibits drainage. Soil strength of some soils is low, affecting bearing strength for building.



**Figure 1-8. Soils within the Deep and Goose Creek watersheds. (Data Sources: NRCS (1985, 1998)).**

## 1.2.7 Hydrology

The Deep and Goose Creek watersheds are located in the Cascade foothills, where snowpack development is generally low. Monthly streamflows are highest in the winter months in direct response to higher rainfall values, and rain-on-snow peak flow events are generally rare. Few records are available to characterize streamflow within the Deep and Goose Creek watersheds. The locations of available stream flow data from within and around the watershed are shown in Figure 1-9 and summarized in Table 1-4.

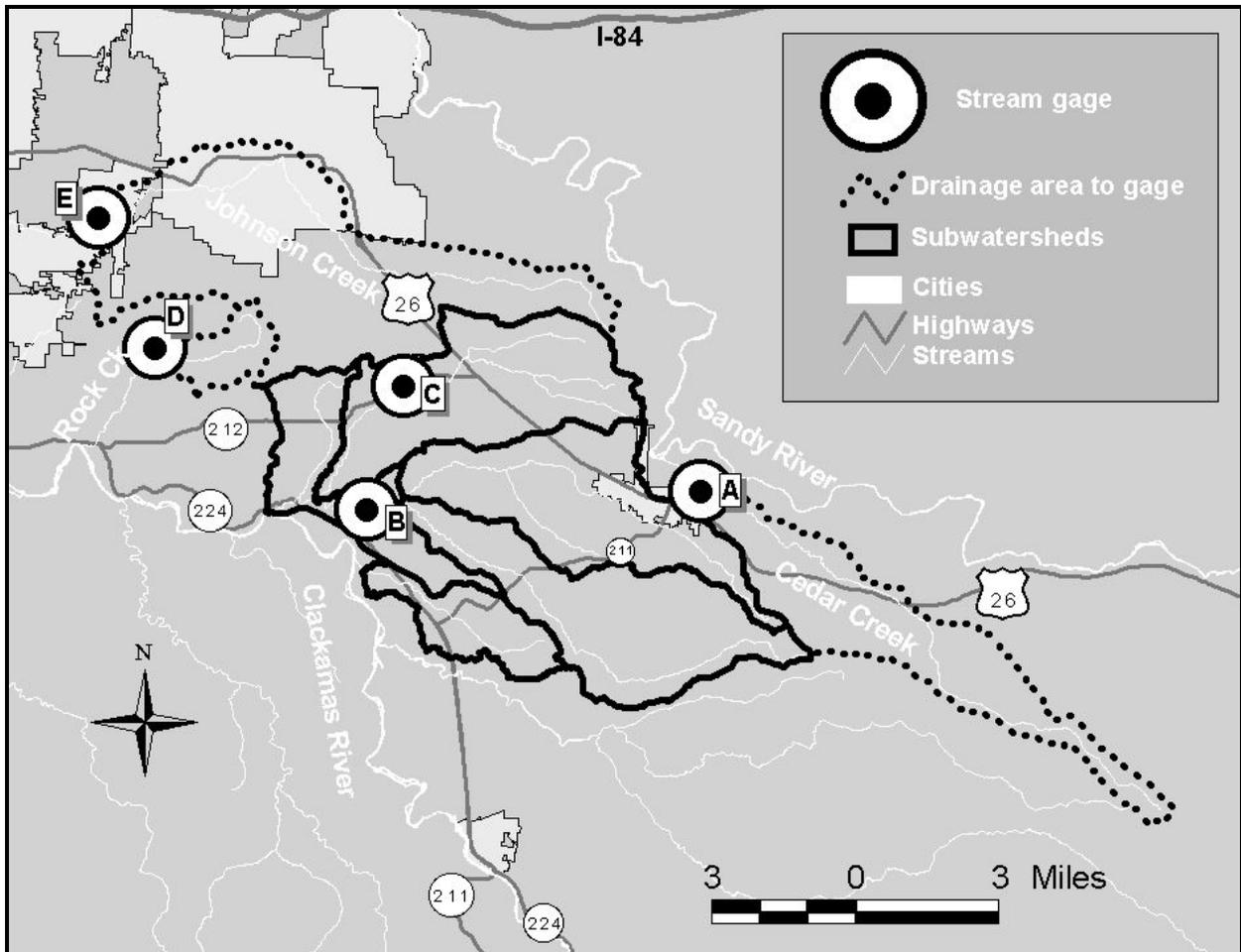


Figure 1-9. Stream gages within and around the Deep and Goose Creek watersheds.

**Table 1-4. Stream gages within and around the Deep and Goose Creek watersheds.**

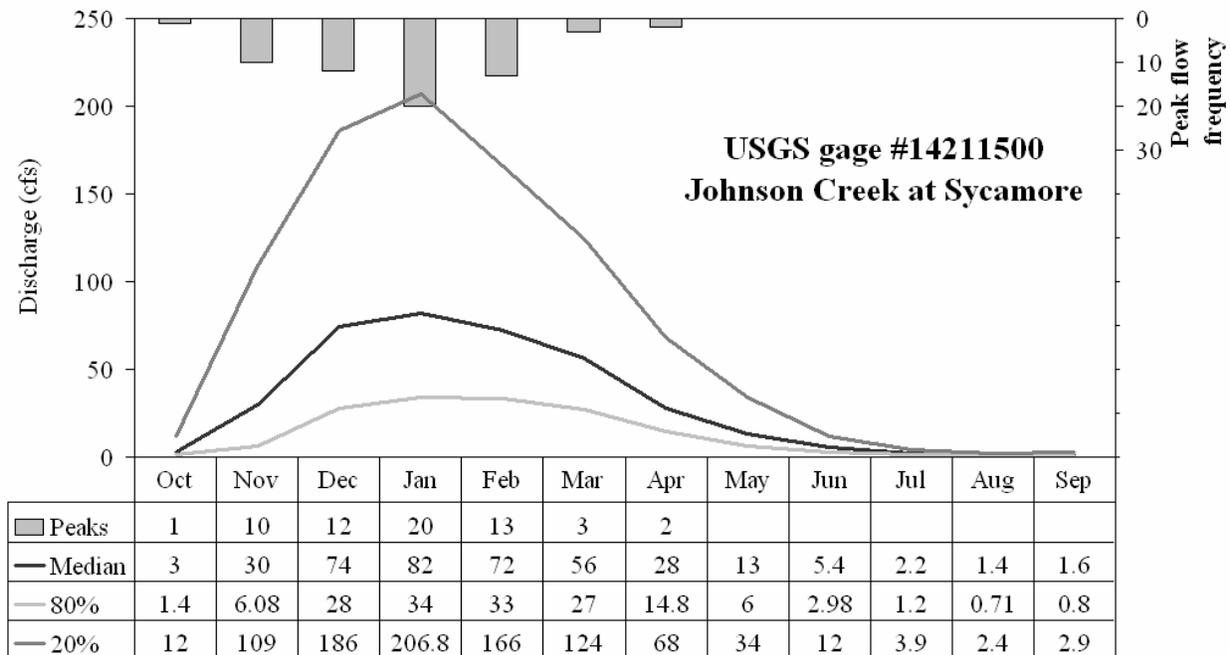
Map ID	Gage number: name	Drainage area (mi <sup>2</sup> )	Gage elev. (ft)	Period of record: Mean daily flow	POR: Peak flows (water years <sup>4</sup> )	Current status / responsible agency
A	14138400: Cedar Creek near Sandy	13.3	614	6/18/1970 - 9/30/1985	1971 - 1985	Inactive / OWRD
B	14210200: Deep Creek near Barton	28.3	250	1/22/1936 - 1/21/1937	n/a	Inactive / OWRD
C	14210255: N.Fk. Deep Creek near Boring	10.3	470	1/22/1936 - 12/18/1936	n/a	Inactive / OWRD
D	14210800: Rock Cr near Boring	2.3	300	n/a	1957 - 1966	Inactive / USGS
E	14211500: Johnson Creek at Sycamore	26.8	228	10/1/1940 - 9/30/2002	1941-2001	Active / USGS

Data sources: OWRD (2004), USGS (2004).

The continuous stream flow records from the two Oregon Water Resources Department (OWRD) gages within the Deep Creek watershed are of too short duration to be of much value in characterizing stream flow conditions. The longest-term gage in the vicinity, and the only gage still active, is the Johnson Creek gage, which drains the area located immediately north of the Deep Creek watershed (Figure 1-9). The watershed draining to the Johnson Creek gage is similar to the Deep Creek watershed with respect to drainage area and elevation (Table 1-4). Figure 1-10 shows the median, 80-percent, and 20-percent exceedance<sup>5</sup> flows at the Johnson Creek gage. Mean daily streamflow is highest during the winter months, with the highest values generally occurring in January. Annual peak flow events occur primarily in the months of December-February, and are most prevalent during January (Figure 1-10). Summertime stream flows are generally quite low, being at their lowest in the month of August.

<sup>4</sup> Water Year is defined as October 1 through September 30. The water year number comes from the calendar year for the January 1 to September 30 period. For example, Water Year 1990 would begin on October 1, 1989, and continue through September 30, 1990. This definition of water year is recognized by most water resource agencies

<sup>5</sup> The median, or 50% exceedance stream flow, is the stream flow that occurs at least 50% of the time in a given month. The 80% exceedance stream flow is exceeded 80% of the time, and can be thought of as the stream flow that occurs in a particularly dry month. Conversely, the 20% exceedance stream flow is exceeded only 20% of the time, and can be thought of as the stream flow that occurs in a particularly wet month.



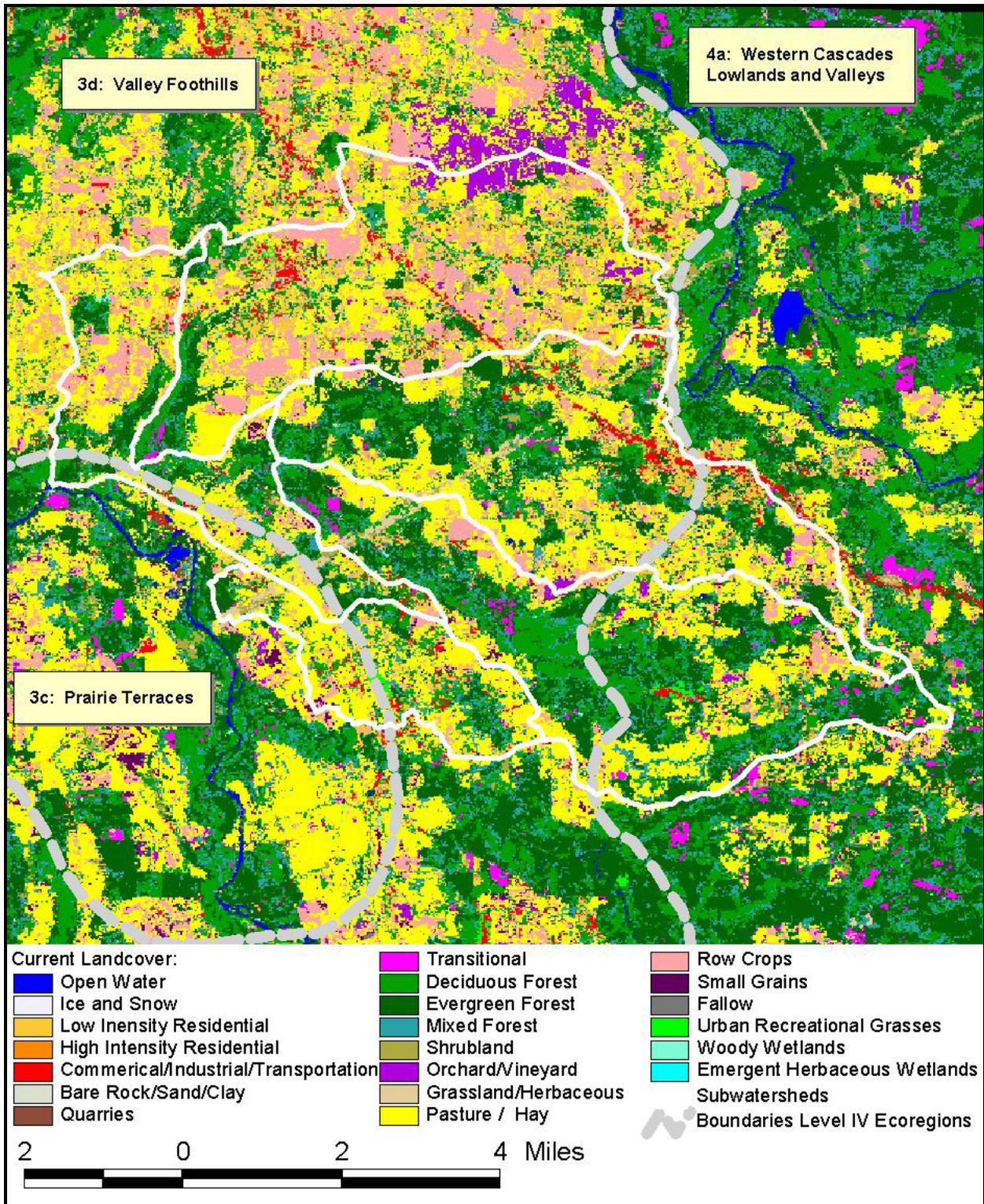
**Figure 1-10. Summary of streamflow conditions at the Johnson Creek stream gage.**

(Shown are median, 80% exceedance and 20% exceedance flows. Also shown is the frequency distribution for annual peak flows at the gage.)

## 1.2.8 Vegetation

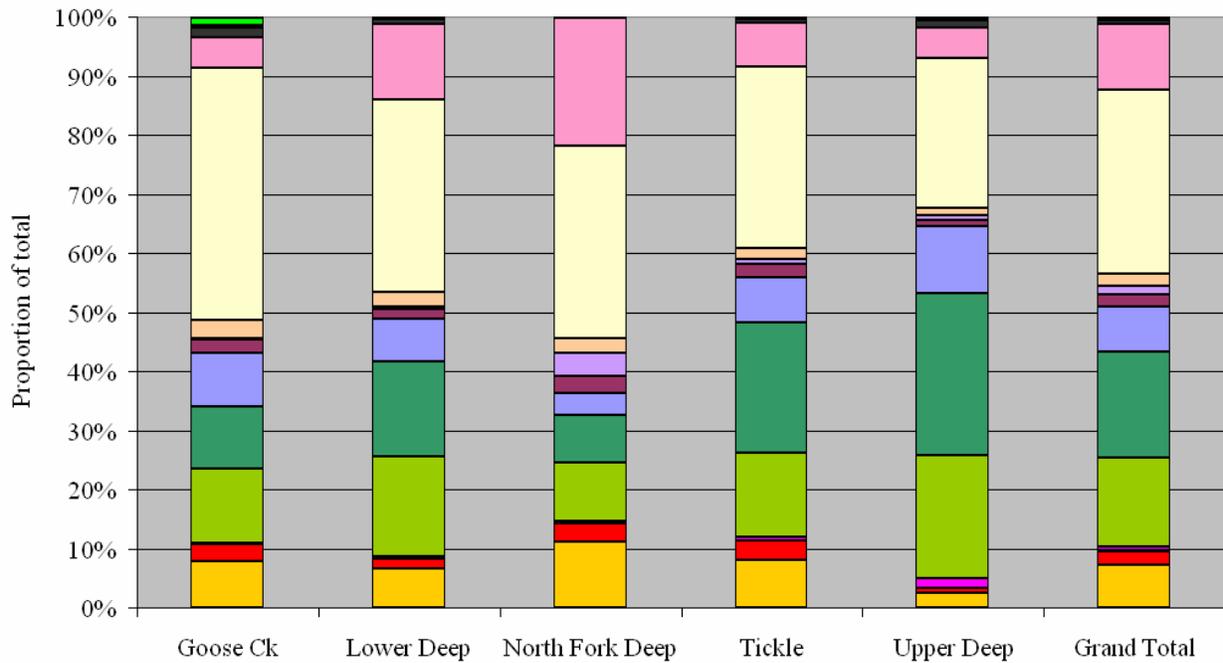
### 1.2.8.1 Current Vegetation

Current land cover/land use within the Deep/Goose Creek watershed was estimated using GIS coverages available from the USGS (1999b; Figure 1-11). The USGS data is part of the National Land Cover Dataset, and was compiled from Landsat satellite captured in the early 1990's. The data has a spatial resolution of 30 meters, and supplemented by other data where available. Current land cover / land use conditions are summarized in Figure 1-12 and Table 1-5. Forest covers approximately 40% of the assessment area (Evergreen Forest 18%, Deciduous Forest 15%, and Mixed Forest 8%), and a similar proportion of the assessment area is agricultural (Pasture/Hay 31% of total area, and Row Crops 11%). Low Intensity Residential areas make up an additional 7% of the watershed area. All other uses make up 2% or less of the total assessment area.



**Figure 1-11. Land cover within the Deep/Goose Creek watersheds.**

(Also shown are EPA Level IV Ecoregion boundaries. Data Sources: USGS (1999b), EPA (2003)).



**Figure 1-12. Summary of land cover within the Deep/Goose watersheds (USGS, 1999b).**

**Table 1-5. Summary of land cover within the Deep/Goose watersheds (USGS, 1999b).**

Landcover	Goose Ck	Lower Deep	North Fork Deep	Tickle	Upper Deep	Grand Total
Open Water	% 0	% 0	% 0	% 0	% 0	% 0
Low Intensity Residential	% 8	% 7	% 11	% 8	% 2	% 7
High Intensity Residential	-	-	-	% 0	-	% 0
Commercial/Industrial/Transportation	% 3	% 2	% 3	% 3	% 1	% 2
Bare Rock/Sand/Clay	-	% 0	% 0	% 0	% 0	% 0
Transitional	% 0	% 0	% 0	% 1	% 2	% 1
Deciduous Forest	% 13	% 17	% 10	% 14	% 21	% 15
Evergreen Forest	% 11	% 16	% 8	% 22	% 27	% 18
Mixed Forest	% 9	% 7	% 4	% 8	% 11	% 8
Shrubland	% 2	% 2	% 3	% 2	% 1	% 2
Orchards/Vineyards/Other	% 0	% 0	% 4	% 1	% 1	% 2
Grasslands/Herbaceous	% 3	% 2	% 3	% 2	% 1	% 2
Pasture/Hay	% 43	% 33	% 32	% 31	% 25	% 31
Row Crops	% 5	% 13	% 22	% 7	% 5	% 11
Small Grains	% 2	% 1	% 0	% 1	% 1	% 1
Fallow	% 0	% 0	-	% 0	% 0	% 0
Urban/Recreational Grasses	% 1	% 0	% 0	% 0	% 0	% 0
Woody Wetlands	% 0	% 0	% 0	% 0	% 0	% 0
<b>Grand Total</b>	<b>% 100</b>	<b>% 100</b>	<b>% 100</b>	<b>% 100</b>	<b>% 100</b>	<b>% 100</b>

### 1.2.8.2 Historic Vegetation

Information on historic vegetation in the assessment area can be inferred from US Environmental Protection Area (EPA) level IV ecoregion<sup>6</sup> mapping completed for the area. (EPA, 2003). Level IV ecoregion boundaries are also shown in Figure 1-11. Historic vegetation characteristics within EPA level IV ecoregions found within the Deep/Goose assessment area are summarized in Table 1-6 (WPN, 2001).

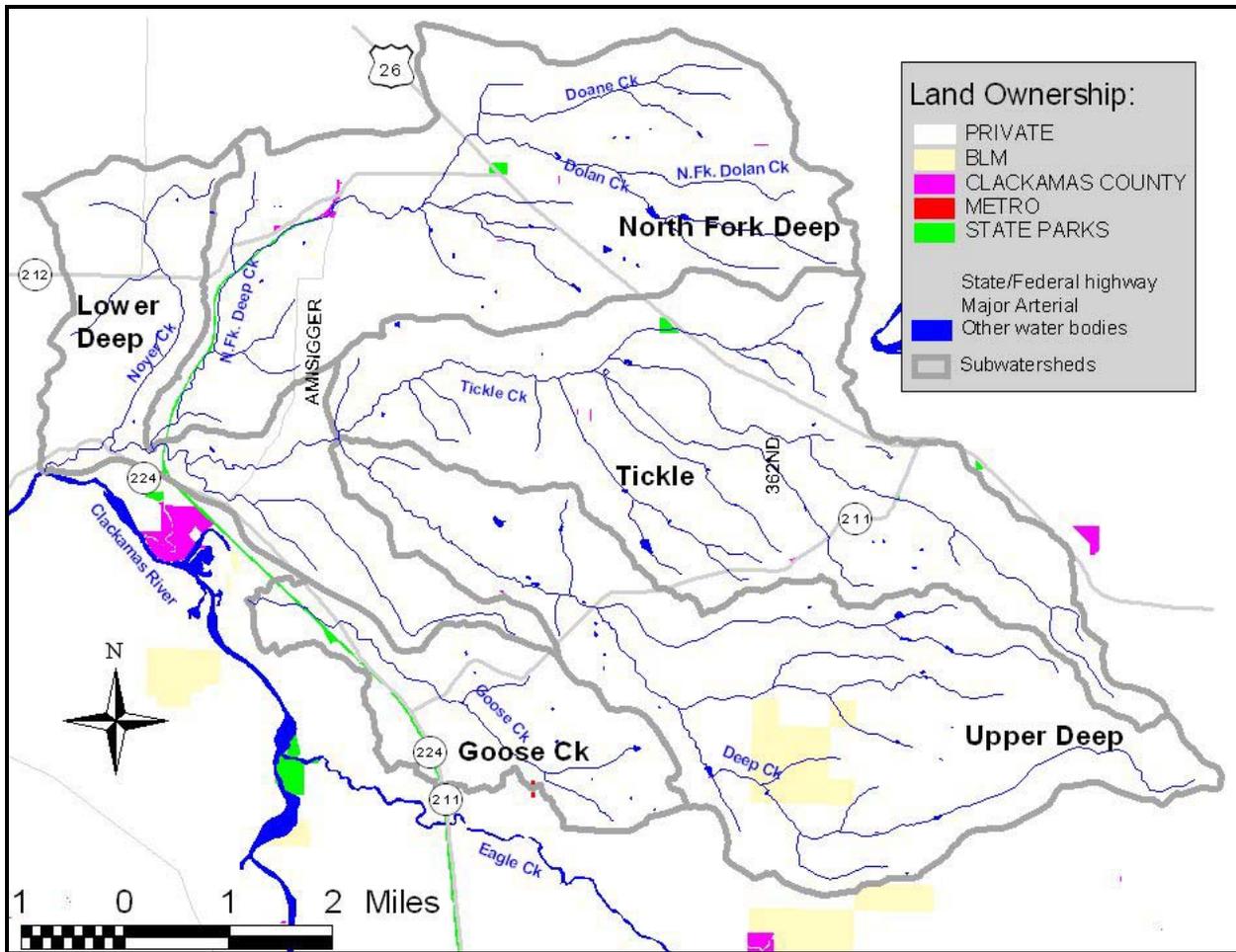
**Table 1-6. Historic vegetation characteristics within EPA level IV ecoregions found within the Deep/Goose assessment area (WPN, 2001).**

	Potential upland vegetation	Historic Crown Closure	Natural Disturbances
3c	Oregon white oak savanna, and prairies, with Oregon ash, Douglas-fir, grand fir and other wetland vegetation in wetter areas.	Areas other than floodplains were dominated by prairies and oak savannas with less than 30% crown closure. Fire suppression has replaced oak savannas with oak woodlands or Douglas fir forests with crown closures > 50%.	Periodic burning by Native Americans in the past maintained prairie vegetation and occasionally encroached on streamside vegetation. Frequent low-intensity fires may have been much more common within oak woodlands in the past. Fires are no longer a part of the ecosystem.
3d	Oregon white oak, madrone; some Douglas-fir and western red cedar.	Dense forests were historically found in this ecoregion, greater than 30% crown closure.	Periodic burning by native Americans in the past maintained prairie vegetation and occasionally encroached on streamside vegetation. Fires are no longer a part of the ecosystem.
4a	Douglas-fir, western hemlock, western red cedar, vine maple and western red alder forests.	Crown closure can be as low as 50% on drier sites. In general, historic crown closure is greater than 70%. Due to the absence of large wildfires, stand densities are greater than in the past.	Douglas-fir/western hemlock forests experience fire more frequently than neighboring silver fir/red fir forests, although the fire return interval is variable. While wildfires during late summer and fall once burned large areas within the lower western Cascade Mountains, streamside areas sometimes escaped the fires. Fire suppression has now eliminated most of these wildfires.

### 1.2.9 Land Ownership / Land Use

Information on land ownership was available from Clackamas County (2003). Land ownership within the assessment area is shown in Figure 1-13 and summarized in Table 1-7. Virtually the entire assessment area is in private ownership (Table 1-7).

<sup>6</sup> Ecoregions denote areas of general similarity in the type, quality, and quantity of environmental resources, and can serve as a spatial framework for the research, assessment, management, and monitoring of ecosystems and ecosystem components (Pater et al., 1998).



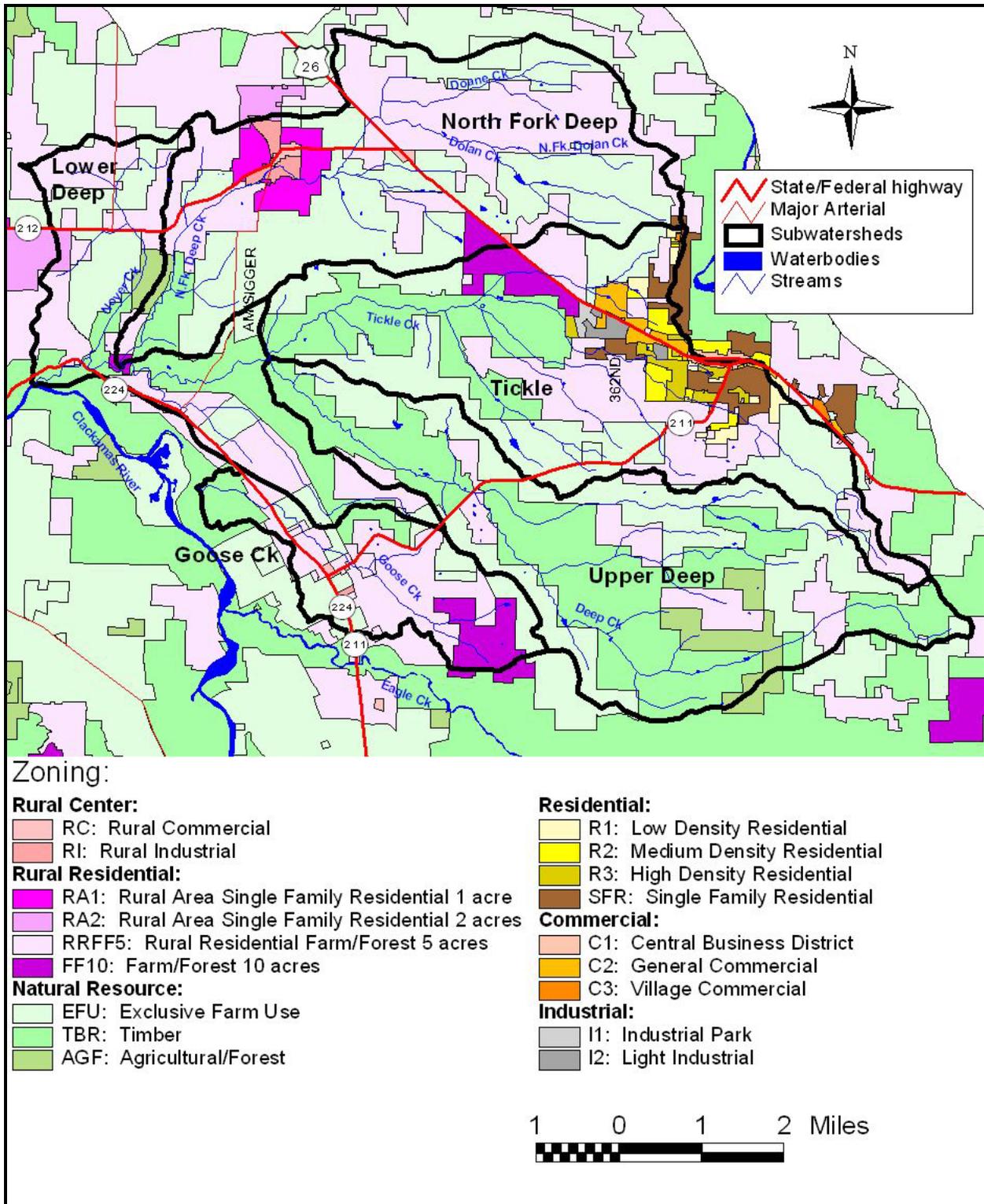
**Figure 1-13. Land ownership within the Deep and Goose Creek watersheds. Data source: Clackamas County (2003).**

**Table 1-7. Summary of land ownership (acres) within the Deep and Goose Creek watersheds.**

Name	Private	BLM	Clackamas County	METRO	State Parks
Goose Ck	2,808		0	1	37
Lower Deep	4,550				7
North Fork Deep	9,048		13		44
Tickle	8,758		3		12
Upper Deep	8,444	482	1		
Entire Area	33,607	482	18	1	100

Note: Values of “0” indicate less than 1 acre. Data source: Clackamas County (2003).

Information on current land zoning within the Deep and Goose Creek watersheds was available from Clackamas County (2003, 2004) and the City of Sandy (2004). Current zoning within the assessment area is shown in Figure 1-14 and summarized in Table 1-8. Lands designated as “Natural Resource” make up the largest proportion of watershed area in all subwatersheds with the exception of Goose Creek (Figure 1-14, Table 1-8). Lands zoned as “Exclusive Farm Use” (EFU) are zoned for primarily farm and forest activities, and have a minimum new parcel size of 80 acres (Clackamas County, 2004). EFU lands make up approximately 50% of the North Fork Deep subwatershed, and from 24% to 36% of the remaining subwatersheds. Lands zoned as “Timber” (TBR) include areas that are primarily used for forest production. Minimum new parcel size for TBR lands is also 80 acres. Proportion of subwatershed area zoned TBR ranges from 3% of the North Fork Deep subwatershed to 49% of the Upper Deep Creek subwatershed. The “Agricultural/Forest” (AGF) designation differs from the EFU lands in that these areas are characterized by a mixture of agricultural and timber uses (Clackamas County, 2004). The minimum new parcel size for AGF lands is also 80 acres. Lands zoned AGF are not found in the Goose Creek or Tickle subwatersheds, and make up 6% or less of the area in the remaining subwatersheds. The second largest zoning category found within the assessment area is Rural Residential lands (Figure 1-14, Table 1-8). Of these lands the “Rural Residential Farm/Forest - 5 acre lot size” (RRFF5) category are the most prevalent, making up from 13% to 48% of subwatershed area. The “Farm/Forest - 10 acre lot size” (FF10) zone also makes up a substantial portion (13%) of the Goose Creek watershed. All remaining zoning classes make up a relatively small proportion of subwatershed area.



**Figure 1-14. Current zoning within the Deep and Goose Creek watersheds. (Data sources: Clackamas County (2003, 2004), City of Sandy (2004))**

**Table 1-8. Summary of current zoning within the Deep and Goose Creek watersheds.**

	Zoning	Goose Ck	Lower Deep	North Fork Deep	Tickle	Upper Deep	Entire Area
Rural Center	RC	% 1	% 0	% 1	% 0	-	% 0
	RI	% 0	-	% 2	-	-	% 0
Rural Residential	RA1	-	-	% 5	-	-	% 1
	RA2	-	% 1	% 0	-	-	% 0
	RRFF5	% 48	% 41	% 38	% 25	% 13	% 29
	FF10	% 13	% 0	% 1	% 4	-	% 2
Natural Resource	EFU	% 24	% 29	% 50	% 34	% 33	% 36
	TBR	% 13	% 26	% 3	% 22	% 49	% 24
	AGF	-	% 3	% 1	-	% 6	% 2
Residential	R1	-	-	-	% 2	-	% 0
	R2	-	-	-	% 2	-	% 1
	R3	-	-	-	% 2	-	% 1
	SFR	-	-	% 0	% 4	-	% 1
Commercial	C1	-	-	-	% 0	-	% 0
	C2	-	-	-	% 2	-	% 1
	C3	-	-	-	% 0	-	% 0
Industrial	I1	-	-	-	% 0	-	% 0
	I2	-	-	-	% 1	-	% 0

Note: Shown is % of subwatershed area by zoning category. Values of “0” indicate less than 1%. Data sources: Clackamas County (2003, 2004), City of Sandy (2004).

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## **2.0 HYDROLOGY AND WATER USE**

### **2.1 INTRODUCTION**

This section of the report presents the results of the hydrology and water use assessment. The assessment uses existing information to summarize what is known about streamflow patterns, water use, and land use effects on streamflow in the Deep and Goose Creek watersheds. The results are followed by recommendations on future monitoring needs to fill data gaps and steps that can be taken to improve streamflow conditions.

### **2.2 CRITICAL QUESTIONS**

The Hydrology and Water Use assessment methodology outlined in the Oregon Watershed Assessment Manual (WPN, 1999) is designed around a series of critical questions that form the basis of the assessment. These critical questions are:

*Question 2-1: What land uses are present in the watershed?*

*Question 2-2: What is the flood history in the watershed?*

*Question 2-3: Is there a probability that land uses in the basin have a significant effect on peak and/or low flows?*

*Question 2-4: For what beneficial use is water primarily used in the watershed?*

*Question 2-5: Is water derived from a groundwater or surface-water source?*

*Question 2-6: What type of storage has been constructed in the basin?*

*Question 2-7: Are there any withdrawals of water for use in another basin (interbasin transfers)? Is any water being imported for use in the basin?*

*Question 2-8: Do water uses in the basin have an effect on peak and/or low flows?*

### **2.3 METHODS**

The purpose of the hydrology and water use section is to summarize existing information sources, identify data gaps that may require further study, and identify opportunities for improving stream flow conditions. In general, the methodology follows the outline presented in the Oregon Watershed Assessment Manual (WPN, 1999). Critical question 2-1, “What land uses are present in the watershed?” is addressed in Section 1.2.9 of this report above. The remainder of the assessment is divided among three primary tasks. Section 2.4.1 describes the flood history of the area (Section 1.2.7 above provides a summary of available streamflow information and estimated monthly stream flows). Data used in Section 2.4.1 was available primarily from

the U.S. Geological Survey (USGS). Section 2.4.2 characterizes water use among the subwatersheds. Water use information was obtained from the Oregon Water Resources Department (OWRD). Finally, Section 2.4.3 provides a discussion on the effects that current land use may have on streamflow in the watersheds. We are aware of no studies that have evaluated land use effects on either peak or low stream flows within the watersheds, consequently additional analysis on land use effects was performed as part of this assessment using methodologies outlined in the Oregon Watershed Assessment Manual (WPN, 1999).

## **2.4 RESULTS**

Results of the Hydrology / Water Use assessment are presented within Sections 2.4.1 - 2.4.3 below. Within each of the sections the applicable Critical Questions are identified and addressed.

### **2.4.1 Flood History**

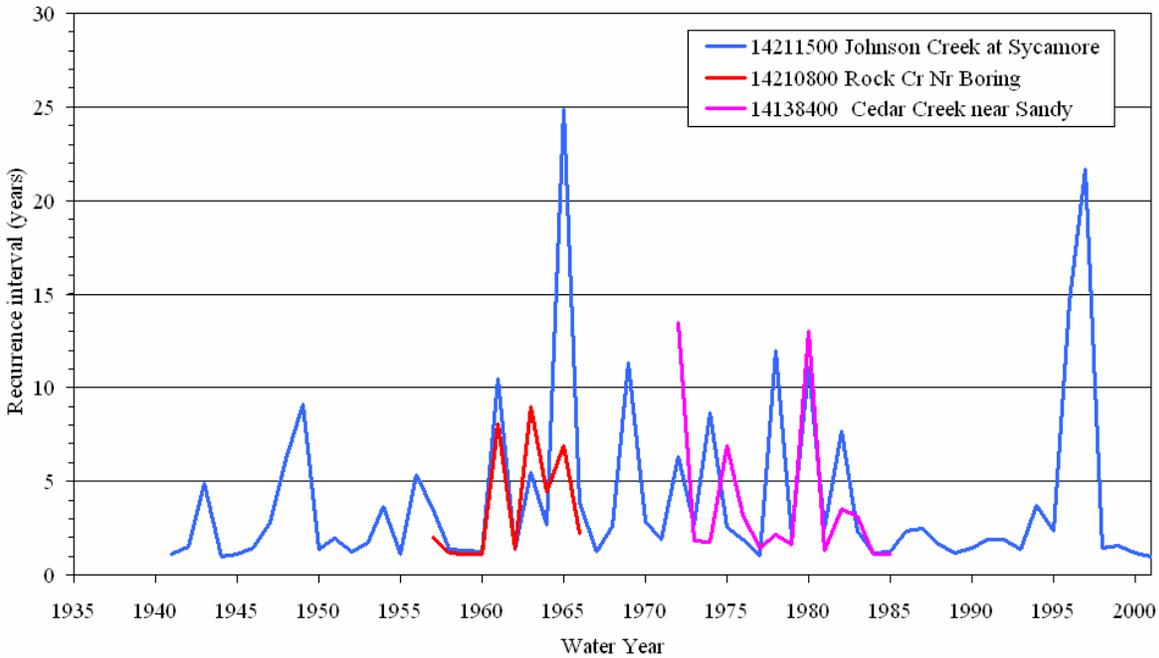
*Critical Question: What is the flood history in the watershed?*

The primary peak flow generating processes<sup>7</sup> active in Oregon are rainfall, snowmelt, and rain-on-snow (ROS). Rain-on-snow is the common term used to describe wintertime conditions when relatively warm wind and rain combine to produce rapid snowmelt. Appendix A of the Oregon Watershed Assessment Manual (WPN, 2001) identifies the dominant peak flow generating processes by EPA level IV ecoregion. Within the level IV ecoregions found within the vicinity of the Deep and Goose Creek watersheds the dominant peak flow generating processes are estimated as rainfall in all areas below 2,300 feet elevation, and as ROS in areas above 2,300 feet elevation. Regardless of the actual location of the ROS zone, it is important to recognize that ROS processes may occur within all elevation ranges; it is just that ROS has the greatest likelihood of significantly affecting peak flows within the ROS zone. The entire assessment area is located below 1,700 feet elevation (Table 1-1), consequently, peak flow events within the vicinity of the Deep and Goose Creek watersheds are primarily driven by wintertime rainfall events.

No data on annual peak flows are available from any location within the Deep and Goose Creek watersheds (Table 1-4). Consequently, gages having peak flow records from adjacent watersheds were used to estimate peak flow history within the Clear and Foster Creek watersheds. Peak flow records from three stream gages listed in Table 1-4 were used to construct the peak flow history. For purposes of comparison, the data are presented as a time series showing the recurrence interval of the annual flow event (Figure 2-1). This approach allows for a comparison of events from a wide variety of watershed sizes. Recurrence intervals were calculated for the period of record at each station using techniques described by the Interagency Advisory Committee on Water Data (1982). Peak flow magnitude was next plotted against probability (i.e., 1/recurrence interval) on log-probability paper. Recurrence interval was then interpolated for each event from the plotted values.

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<sup>7</sup> The hydrologic conditions responsible for generating peak stream flows in a watershed are referred to as the peak flow generating processes.



**Figure 2-1. Recurrence interval associated with annual peak flow events at three stream gages in the vicinity of the Deep and Goose Creek watersheds. (Data sources: USGS (2004a) and OWRD (2004a))**

Eight peak flow events having a ten-year or greater recurrence interval are estimated to have occurred at one or more locations over the period of record shown in Figure 2-1. The two largest peak flow events over the period of record were the peak flow event of 12/21/1964 (the “’64 flood”) and the event of 11/19/1996. The peak flow event of 2/7/1996, which was the largest regional rain-on-snow event of recent times, was only the third largest event on record at the gages in the vicinity of the assessment area, indicating that rain-on-snow is a less-important determinant of peak flows in these low-elevation areas (this is further illustrated by the fact that the 12/21/1964 event only had a recurrence interval of ~7 years at the Rock Creek gage; which drains an area of even lower elevation than the Johnson Creek gage).

## 2.4.2 Water Use

*Critical Question: For what beneficial use is water primarily used in the watershed?*

*Critical Question: Is water derived from a groundwater or surface-water source?*

*Critical Question: What type of storage has been constructed in the basin?*

*Critical Question: Are there any withdrawals of water for use in another basin (interbasin transfers) Is any water being imported for use in the basin?*

***Critical Question: Are there any illegal uses of water occurring in the basin?***

Data available from the Oregon Water Resources Department (OWRD, 2003, 2004b) were used to identify locations and characteristics of water use in the Deep and Goose Creek watersheds<sup>8</sup>. Only those water rights whose current status is given as “non-cancelled” were included in this assessment.

**2.4.2.1 Overview of Water Rights**

Water rights entitle a person or organization to use the public waters of the state in a beneficial way. Oregon’s water laws are based on the principle of prior appropriation (OWRD, 2002). The first entity to obtain a water right on a stream is the last to be shut off in times of low stream flows. In times when water is in short supply, the water right holder with the oldest date of priority can demand the water specified in their water right regardless of the needs of junior users. The oldest water right within the Deep and Goose Creek watersheds has a priority date of 10/27/1924, and the newest a priority date of 1/20/2004 (OWRD, 2004b).

Certain water uses do not require a water right (OWRD, 2002). Exempt uses of surface water include natural springs which do not flow off the property on which they originate, stock watering, fire control, forest management, and the collection of rainwater. Exempt groundwater uses include stock watering, less than one-half acre of lawn and garden watering, and domestic water uses of no more than 15,000 gallons per day.

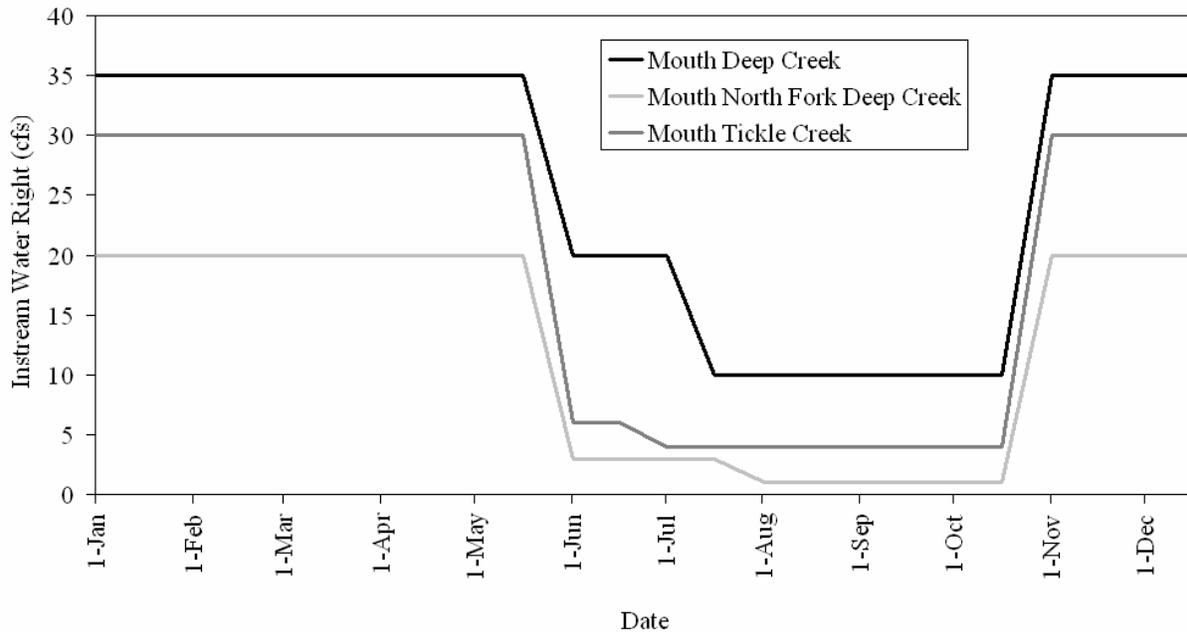
In Oregon, any entity wanting to use the waters of the state for a beneficial use has to go through an application/permit process administered by the OWRD. Under this process an entity applies for a permit to use a certain amount of water, and then establishes that the water is being used for a beneficial use. Once the beneficial use is established, and a final proof survey is done to confirm the right, a certificate is issued.

The OWRD also approves instream water rights for fish protection, minimizing the effects of pollution or maintaining recreational uses (OWRD, 2002). Instream water rights set flow levels to stay in a stream reach on a monthly basis, have a priority date, and are regulated the same as other water rights. Instream water rights do not guarantee that a certain quantity of water will be present in the stream; under Oregon law, an instream water right cannot affect a use of water with a senior priority date (OWRD, 2002).

Three locations within the Deep Creek watershed have designated instream water rights for “supporting aquatic life” (OWRD, 2004b). These locations are at the mouths of Deep, North Fork Deep, and Tickle Creeks. All three instream water rights have priority dates of 5/25/1966. Instream water rights at the three locations vary with date over the course of the year (Figure 2-2).

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<sup>8</sup> Of the two sources of data used in this portion of the assessment, the Water Rights Information System data is the most accurate and up to date (K. Boles, OWRD, pers. comm., 2/22/2002). The available GIS data was used primarily to show locations of diversions and water use and may not accurately reflect current conditions.



**Figure 2-2. Instream water rights by date at three locations within the Deep Creek watershed. (Data source: OWRD (2004b))**

#### **2.4.2.2 Locations of Water Withdrawals**

The OWRD identifies 463 points<sup>9</sup> of diversion for water rights within the Deep and Goose Creek watersheds (OWRD, 2004b). The approximate locations of these points of diversion are shown in Figure 2-3 (OWRD, 2003). Points of diversion for water rights are found within all subwatersheds (Figure 2-4). The majority (52%) of the points of diversion are from surface waters, the remainder being from groundwater sources (34%) and reservoirs (14%).

<sup>9</sup> The actual number of physical locations where water is diverted may be less than 463. Diversion points appear to be duplicated in the OWRD GIS coverage in some situations. For example, when more than one water right applies to a physical diversion the number of points may be duplicated

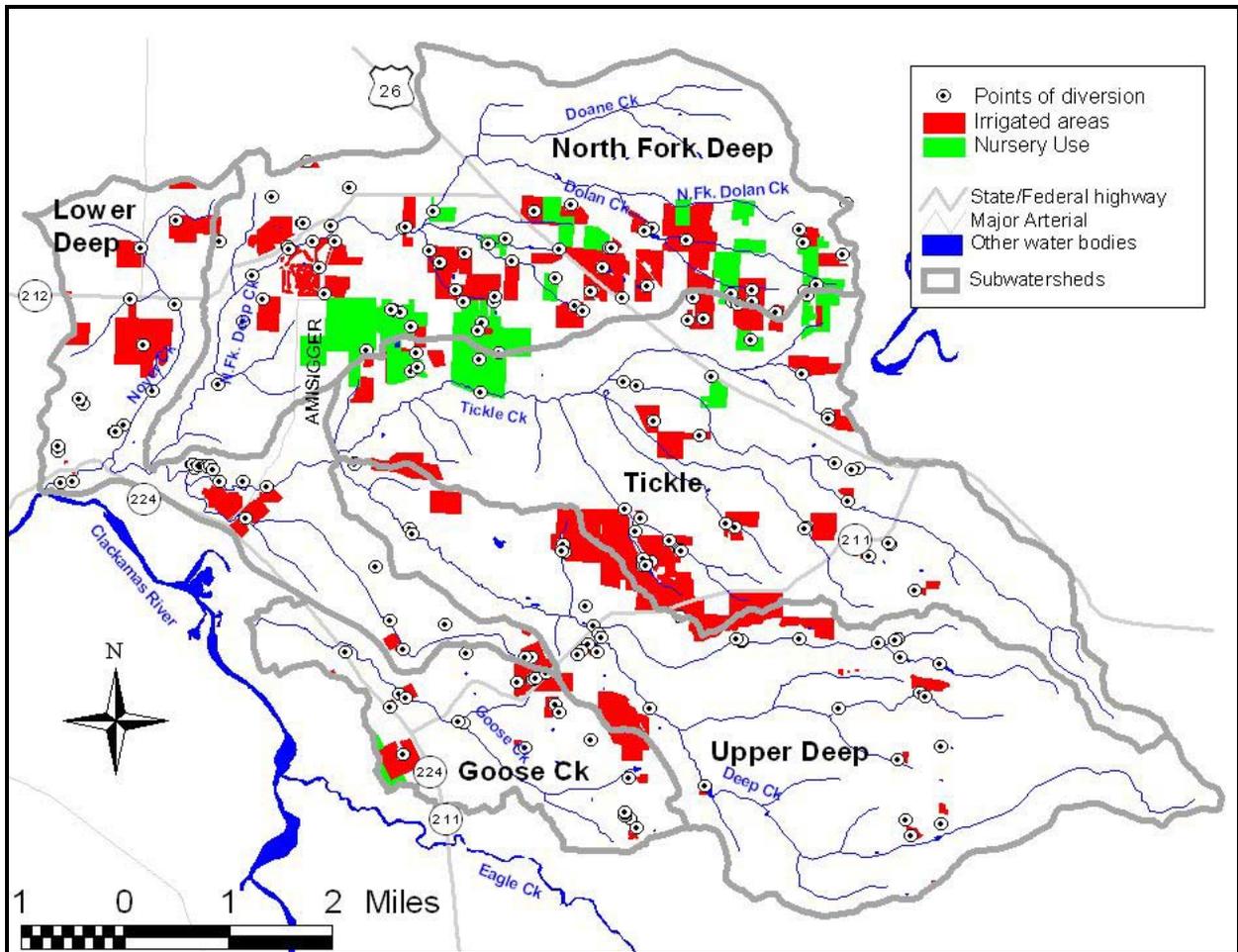


Figure 2-3. Points of diversion for water rights, and locations of irrigated areas within the Deep and Goose Creek watersheds. Data sources: Clackamas County (2003), OWRD (2003).

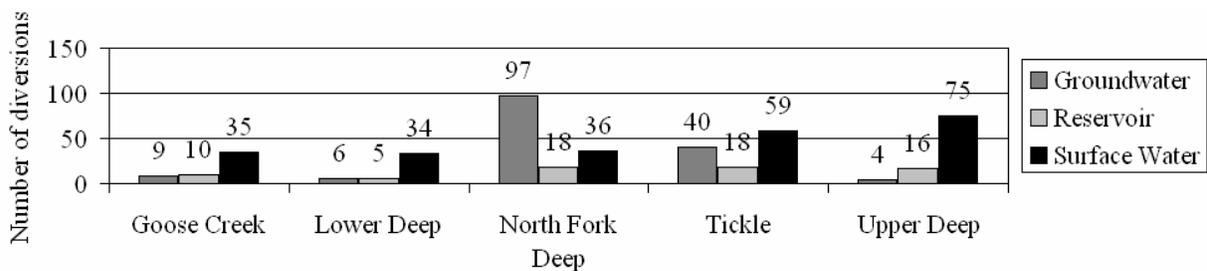
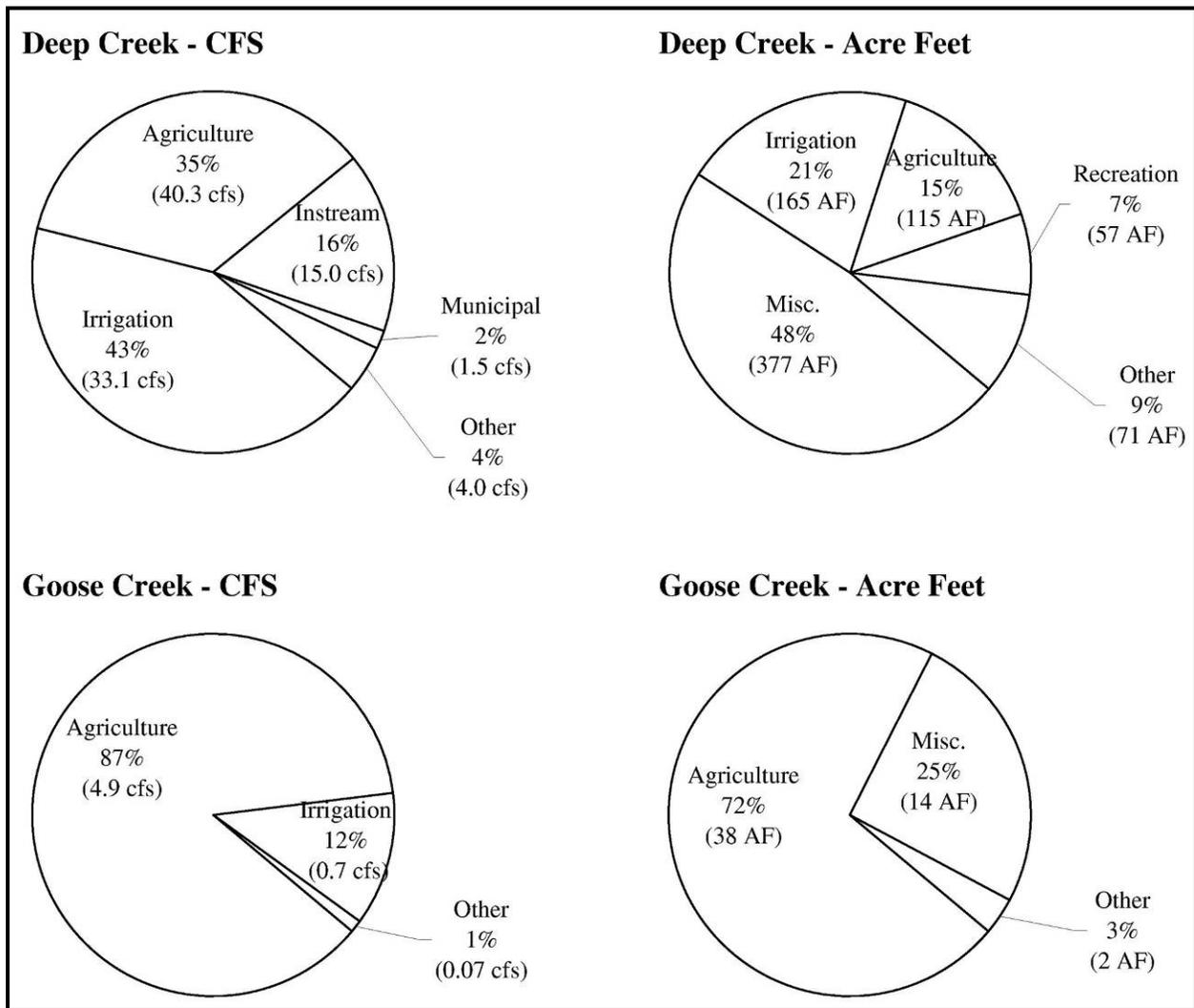


Figure 2-4. Distribution of water right points of diversion by subwatershed and water source within the Deep and Goose Creek watersheds. Data source: OWRD (2003).

### 2.4.2.3 Withdrawal Rates

Information on withdrawal rates associated with water rights within the Deep and Goose Creek watersheds is available through the OWRD (2004b). Rate of withdrawal given in the OWRD data is expressed as an instantaneous rate (i.e., cubic-feet per second), except for reservoir storage which is expressed as a total yearly volume (i.e., acre-feet). In addition, the withdrawal rate for many water rights changes by season (e.g., the allowable withdrawal rate may be lower in the summer months). Withdrawal rates for the Deep and Goose Creek watersheds are summarized in Figure 2-5. August 1<sup>st</sup> was chosen as the date for this summary, as this is typically the low flow period in the assessment area (Figure 1-10).



**Figure 2-5. Summary of the water rights within the Deep and Goose Creek watersheds on August 1st. Data source: OWRD (2004b).**

Irrigation and agriculture are the primary uses of water withdrawals within the watersheds (Figure 2-5). The highest density of irrigated lands occur in the North Fork Deep Creek subwatershed, however, irrigated areas occur throughout the watersheds (Figure 2-3). Nursery use makes up the majority of the withdrawals in the “Agriculture” category. Nursery lands are found primarily in the North Fork Deep and Tickle Creek subwatersheds (Figure 2-3). The “Miscellaneous category includes water stored for “aesthetics”, “fire protection” and general “storage”, and makes up a significant portion of the water storage in both watersheds..

### **2.4.3 Land Use Effects on Flow Regime**

#### **2.4.3.1 Water Withdrawals**

*Critical Question: Do water uses in the basin have an effect on peak and/or low flows?*

Two pieces of information are needed to estimate the net effects of water use on stream flows at any given location; 1) an estimate of the natural stream flow volume, and 2) an estimate of the consumptive portion of all upstream water withdrawals. Unfortunately, the gage records available for the Deep and Goose Creek watersheds are of insufficient duration to allow for a direct estimate of monthly stream flows at locations within the watersheds. The Oregon Water Resources Department has estimated natural monthly stream flows at the mouths of several water availability basins (WABs) within the vicinity of the watersheds (OWRD, 2004a). One of these locations corresponds with mouth of the Deep Creek watershed. The Natural Streamflow estimates available from the OWRD are the monthly 50% and 80% exceedance flows. The 50% exceedance stream flow is the stream flow that occurs at least 50% of the time in a given month. Conversely, the stream flow is also less than the 50% exceedance flow half the time. The 50% exceedance flow can be thought of as representing a “normal” stream flow for that month. The 80% exceedance stream flow is exceeded 80% of the time. The 80% flow is smaller than the 50% flow, and can be thought of as the stream flow that occurs in a dry month. These exceedance stream flow statistics are used by the OWRD to set the standard for over-appropriation: the 50% exceedance flow for storage and the 80% exceedance flow for other appropriations (OWRD, 2004a). These estimates of natural monthly stream flows were made by the OWRD using statistical models derived from multiple linear regressions.

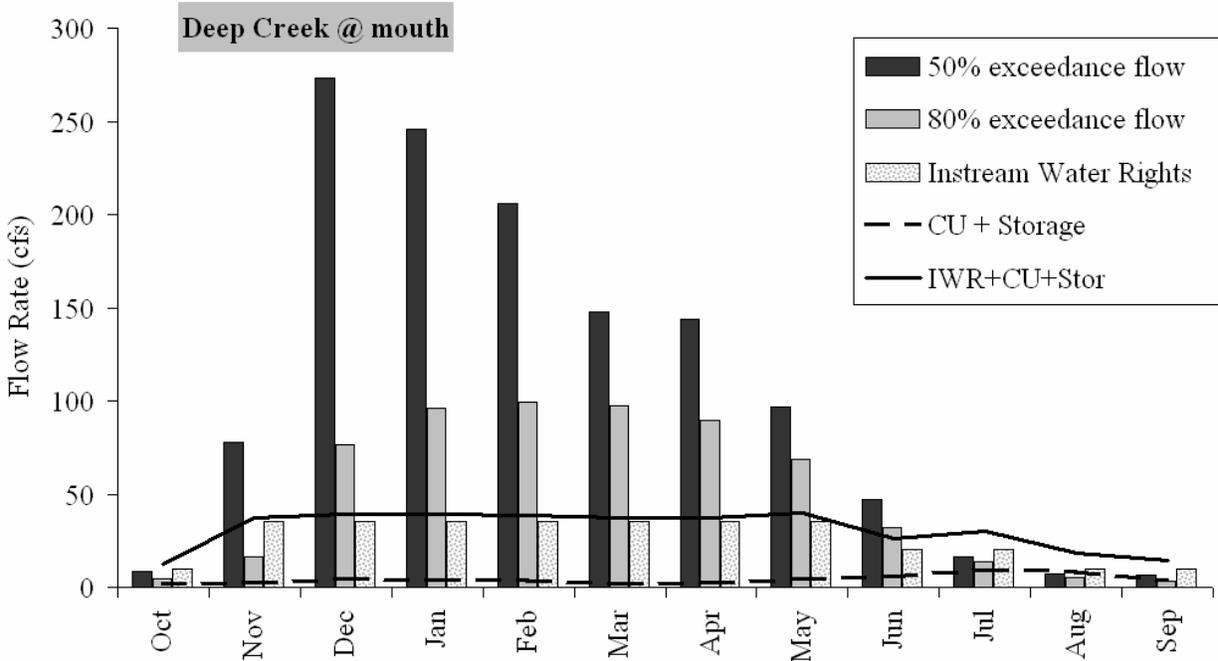
A consumptive use is defined as any water use that causes a net reduction in stream flow (OWRD, 2004a). These uses are usually associated with an evaporative or transpirative loss. The OWRD recognizes four major categories of consumptive use: irrigation, municipal, storage, and all others (e.g., domestic, livestock). The OWRD estimates the consumptive use for irrigation using estimates made by the USGS; including estimates from the 1987 Census of Agriculture, estimates from the OSU Cooperative Extension Office, 1989-90 Oregon Agriculture and Fisheries Statistics, and an OSU Study of Crop Water Requirements (OWRD, 2002c). Irrigation uses are not estimated to be 100 percent consumptive. Consumptive use from other categories of use is obtained by multiplying a consumptive use coefficient (e.g., for domestic use, the coefficient is 0.20) by the maximum diversion rate allowed for the water right. The OWRD assumes that all of the non-consumed part of a diversion is returned to the stream from which it was diverted. The exception is when diversions are from one watershed to another, in which case the use is considered to be 100 % (i.e., the consumptive use equals the diversion

rate). Consumptive use estimates available from the OWRD (2004a) for the mouth of Deep Creek were used in this assessment.

The net effect of water withdrawals on monthly stream flows were estimated at the mouth of the Deep Creek watershed in the following manner:

1. The estimated monthly natural stream flows for average and dry years (represented by the 50% and 80% exceedance flow respectively) were first plotted for each location.
2. The portion of all water withdrawals that does not return to the stream (i.e., the consumptive uses) was added to water diverted for storage for each month and plotted on the same graph.
3. Instream water rights for the watershed were also shown on the graph
4. Finally, the sum of instream water rights, consumptive uses, and storage was plotted on the graph.

The estimated net effect of water withdrawals on monthly stream flow is shown for the mouth of the Deep Creek watershed in Figure 2-6. These estimates indicate that consumptive water use plus storage does not exceed the estimated volume of natural stream flow in any month, either in average (50% exceedance flows) or dry (80% exceedance flows) years. However, when the instream water right is added to the sum of consumptive uses and storage there is insufficient flow to meet all uses in the months of July – September in either average or dry years. Based on these estimates it appears unlikely that instream flow rates would be attained during these months in most years.



**Figure 2-6. Estimated net effect of water withdrawals on monthly stream flows at the mouth of Deep Creek. (Shown are estimated natural stream flows for average and dry years (50% and 80% exceedance flows); the sum of consumptive uses (CU) and water storage; instream water rights; and the sum of instream water rights (IWR), consumptive uses (CU) and storage (STOR). Data source: OWRD (2004a))**

### 2.4.3.2 Other Land Uses

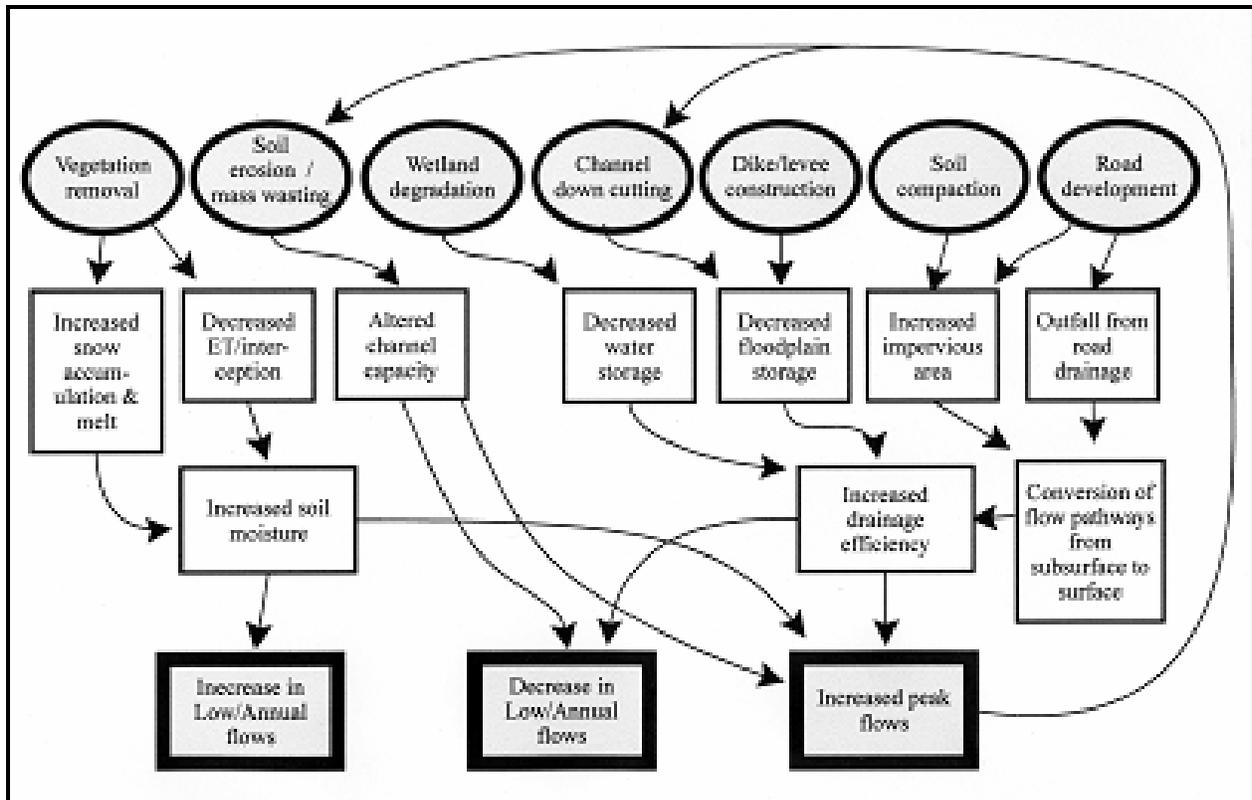
**Critical Question:** *Is there a probability that land uses in the basin have a significant effect on peak and/or low flows?*

We are aware of no data or studies that address the effects of other land uses on peak and/or low stream flows within the Deep and Goose Creek watersheds. The following narrative is broken into three parts. Section 2.4.3.2.1 provides background information on the primary ways that land use activities may affect stream flows. A qualitative look at possible streamflow impacts due to wetland loss is provided in Section 2.4.3.2.2. And an evaluation of possible peak flow increase due to impervious area is presented in Section 2.4.3.2.3.

#### 2.4.3.2.1 Background information on land use effects on stream flow

Figure 2-7 is a generalized diagram showing the primary interactions between land uses found in the Deep and Goose Creek watersheds and changes in peak, annual, and low stream flows. Note that Figure 2-7 does not include “top-level” land uses (e.g., Urbanization, Agriculture, Forest

Management, etc.). The reason for this is that there is considerable overlap between top-level land uses and the underlying hydrologic processes that they affect. For example, both urbanization and agricultural practices have the ability to affect vegetation removal, soil erosion/mass wasting, wetland degradation, channel down cutting, dike/levee construction, soil compaction, and road development. This analyst believes that, rather than discussing impacts by top-level land uses, it is more appropriate to discuss land use impacts in terms of the underlying processes.



**Figure 2-7. Generalized diagram of the primary interactions between land uses and changes in peak, annual, and low stream flows (adapted from Ziemer, 1998).**

Vegetation Removal: The primary mechanism by which vegetation removal may increase peak flow is through increased snow accumulation and melt during wintertime rain-on-snow events (WFPB, 1997; Figure 2-7). Rain-on-snow is the common term used to describe wintertime conditions when relatively warm wind and rain combine to produce rapid. Rain-on-snow flood events may occur in areas having significant wintertime snow packs, and are independent of land use. Removal of the forest canopy can augment rain-on-snow peak flows by increasing snow accumulation in openings and increasing the rate of snowmelt by increasing the effective wind speeds at the snowpack surface. The extent to which forest removal may augment rain-on-snow peak flows is a function of the amount of harvesting within the elevation range that defines the

rain-on-snow zone. At low elevations (below the rain-on-snow zone) winter temperatures are generally too warm to allow for significant snow accumulation, and at higher elevations wintertime precipitation generally falls as snow. As discussed in section 2.4.1 above, rain-on-snow does not appear to be an important process in peak flow generation within the Deep or Goose Creek watershed.

A secondary mechanism by which vegetation removal may increase peak and/or low flows is through changes in evapotranspiration (ET) and canopy interception (Dunne and Leopold, 1978; Figure 2-7). Vegetation can intercept a portion of the precipitation falling on a watershed, a further portion of which is evaporated back to the atmosphere during or after a storm event, thereby reducing the net precipitation reaching the soil. Evapotranspiration by vegetation removes moisture from the soil profile and returns it to the atmosphere. Increases in peak flows have been observed in some situations following harvest of trees, which are presumed to be the result of loss of canopy interception and evapotranspiration (Ziemer, 1998). Several studies have shown that water yield increases throughout the year, with the largest relative increases occurring during the summer and early fall months following logging. These studies have reported increases in summer flows ranging from 15 to 148 %.

Soil erosion and mass wasting: Soil erosion and mass wasting can increase quantities of sediments transported in stream systems. Deposition of both coarse and fine sediments in stream channels can result in a decrease in channel conveyance capacity, leading to an effective increase in frequency of flooding (Dunne and Leopold, 1978; Figure 2-7). In addition to the effects on peak flows, increases in aggradation of coarse sediments can increase the proportion of streamflow that travels subsurface, resulting in a reduction of effective summer low flows. Furthermore, as shown in Figure 2-7, increased peak flows can further exacerbate sedimentation problems through increased bank erosion and mass wasting.

Wetland degradation: Wetlands have the ability to intercept and store storm runoff, thereby reducing peak flows (Mitsch and Gosselink, 1986). This water is released over time and may be important to augment summertime low flows (Figure 2-7). A qualitative look at possible streamflow impacts due to wetland loss is provided in Section 2.4.3.2.2.

Channel down cutting and channelization: Channel down cutting and channelization have the same effect on the stream system; decreasing the amount of water that can be stored in channel banks and the floodplain (Figure 2-7). The difference between the two processes are that channel down cutting occurs without direct human assistance in response to changes in water volume and sediment loads, whereas channelization occurs through conscious human design through the construction of dikes and levees. Potential disadvantages to dikes and levees include loss of floodwater storage within the floodplain, which can result in higher downstream peak flows, reduced groundwater recharge, and subsequently lower summertime base flows. Areas of channelization occur throughout the assessment area (see section 1.2.3 above), however, with the exception of the North Fork Deep subwatershed, it is unlikely that present-levels of channelization have had significant impacts on stream flows. Further study would be required to evaluate possible impacts in the North Fork Deep subwatershed.

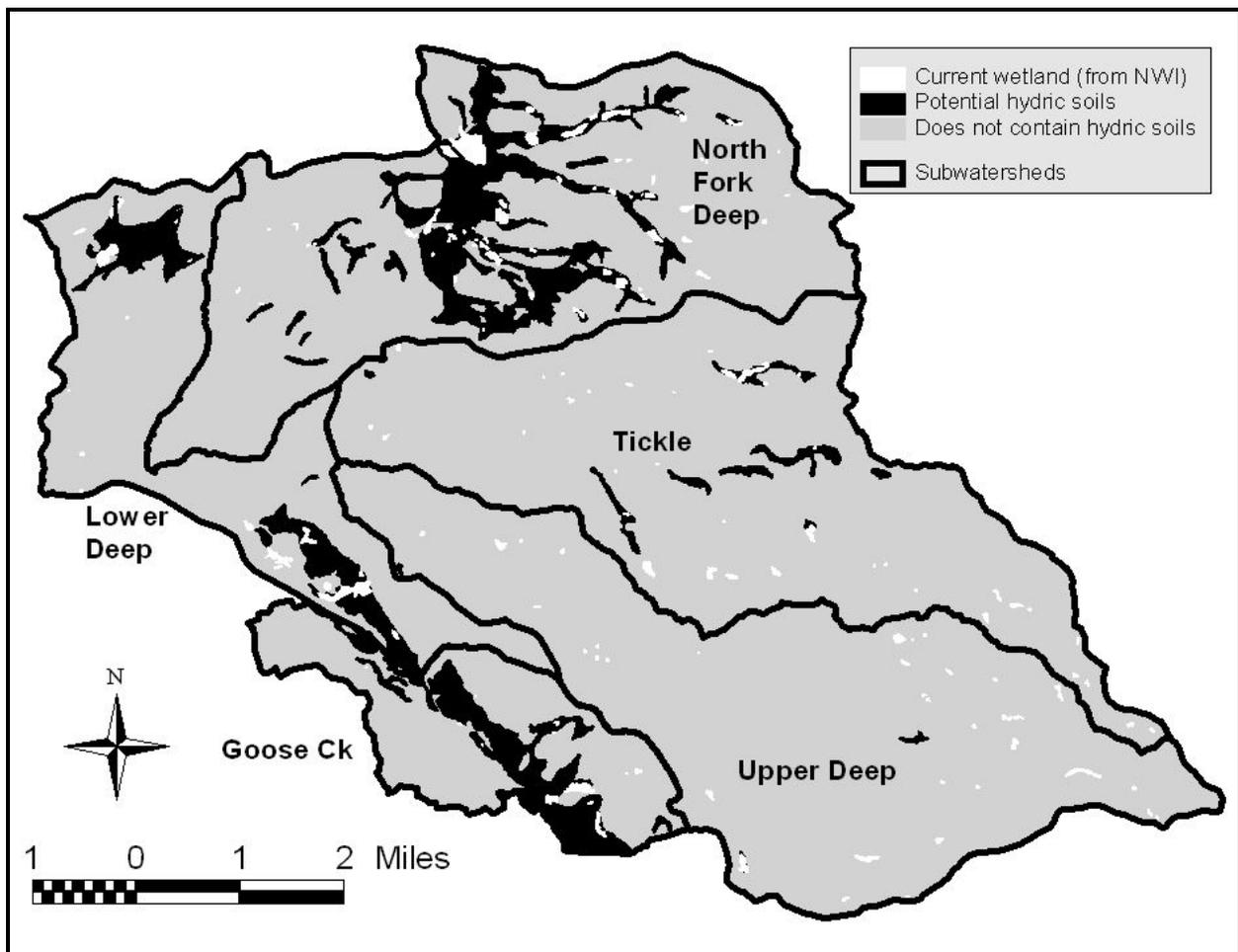
Soil compaction: Soil compaction can increase the amount of impervious area occurring in a watershed. Increases in the amount of impervious area, result in increased peak flow magnitudes by eliminating or reducing infiltration of precipitation, thereby shortening the travel time to stream channels (Dunne and Leopold, 1978; Figure 2-7). In addition to the effects on peak flows, increases in impervious area also reduce summer low flows by reduction of groundwater recharge (Dunne and Leopold, 1978). May and others (1997) suggest that impairment begins when percent total impervious area in a watershed reaches 10%. And an evaluation of possible peak flow increase due to impervious area is presented in Section 2.4.3.2.3.

Outfall from road drainage: In addition to increasing soil compaction, road networks have the potential to affect watershed hydrology by changing the pathways by which water moves through the watershed. Road networks affect flow routing by interception of subsurface flow at the road cutslope and through a reduction in road-surface infiltration rates resulting in overland flow (Figure 2-7). The net result may be that surface runoff is routed more quickly to the stream system if the road drainage network is well-connected with the stream channel network.

#### **2.4.3.2.2      *Wetland Loss***

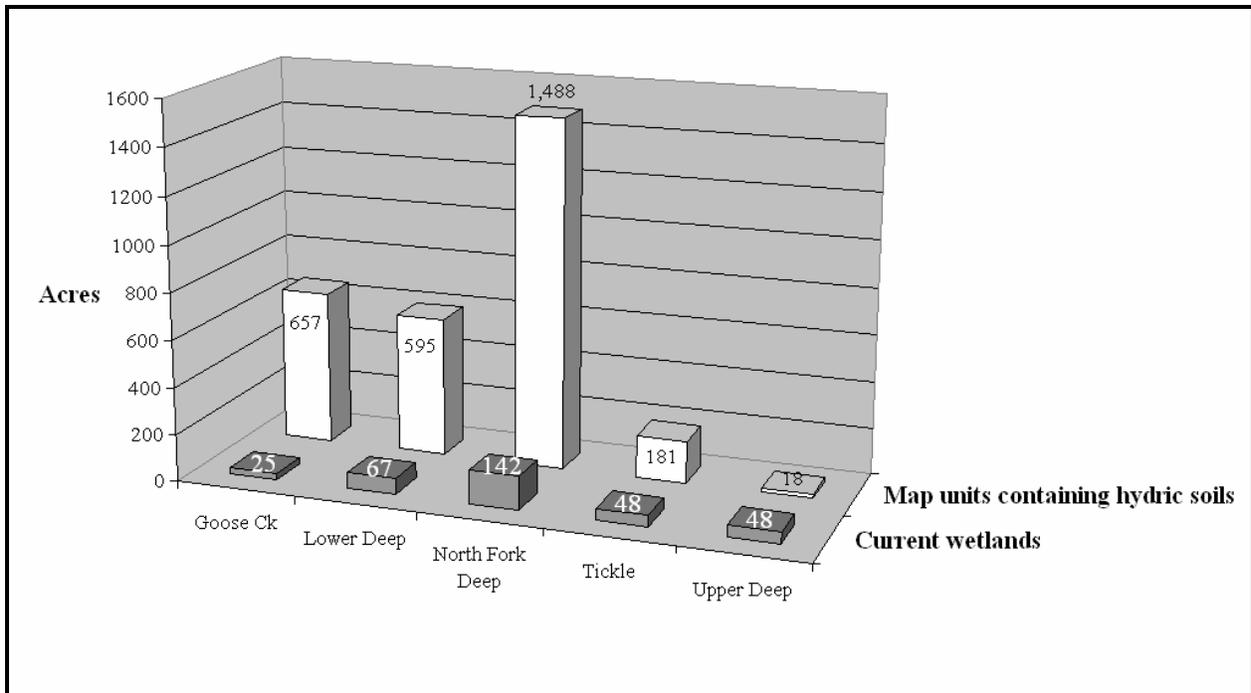
The purpose of this portion of the assessment is to identify those subwatersheds where wetland loss may be having an impact on current stream flows. However, no quantitative assessment was performed. One simple approach to estimating the area historically occupied by wetlands is by comparing present-day wetlands to the area within the watershed that is classified as having hydric soils. Hydric soils are soils that are, or have been, saturated, flooded, or ponded long enough during the growing season to develop anaerobic conditions in the upper part. If soils classified as hydric do not currently support wetlands they may be areas where wetlands formerly were located. The NRCS soil survey of the Clackamas area (NRCS, 1985; 1998) identifies hydric soils within several soil series. Not all of the area within these mapping units contains hydric soils, and not all of the hydric soils necessarily supported wetlands historically. However, this information provides us with an approximation of the extent that may have been occupied by wetlands historically.

Current wetland locations are available from the National Wetland Inventory (NWI) produced by the U.S. Fish and Wildlife Service (USFWS, 2004). The area currently occupied by wetlands, and the area of hydric soils within the Deep and Goose Creek watersheds, is shown in Figure 2-8.



**Figure 2-8. Current wetland locations, and soil mapping units that contain hydric soils within the Deep and Goose Creek watersheds. Data sources: NRCS (1998), (USFWS, 2004).**

Overall the Deep and Goose Creek watersheds have approximately 2,940 acres within soil mapping units that contain hydric soils and 330 acres currently occupied by wetlands (Figure 2-9). If all of these mapping units historically contained wetlands this would indicate that wetlands currently occupy only 11% of the area that they occupied historically. Significant wetland loss may have occurred in the upper part of the North Fork Deep, Lower Deep, and Goose Creek subwatersheds, where current wetland area makes up only 9%, 11%, and 4% respectively of the potential area of hydric soils (Figure 2-9). The Tickle Creek and Upper Deep Creek subwatersheds currently have a greater or approximately equal area in wetlands as in hydric soils.



**Figure 2-9. Comparison of area occupied by soil mapping units that contain hydric soils and area currently occupied by wetlands.**

### **2.4.3.2.3 Impervious area**

Increases in the amount of impervious area in a watershed, result in increased peak flow magnitudes by eliminating or reducing infiltration of precipitation, thereby shortening the travel time to stream channels (Dunne and Leopold, 1978). In addition to the effects on peak flows, increases in impervious area also reduce summer low flows by reduction of groundwater recharge (Dunne and Leopold, 1978). May and others (1997), in a summary of several previous studies, suggest that impairment begins when percent total impervious area (%TIA) in a watershed reaches 10%. May and others (1997) recommend that for Puget Sound lowland streams, the level of imperviousness should be limited to the <5%-10% TIA, unless extensive riparian buffers are in place.

May and others (1997) developed a relationship between % TIA and road density (expressed in miles of road/mi<sup>2</sup> watershed area). Watershed %TIA of 5% and 10% equates to a road density of 4.2 and 5.5 mile/ mi<sup>2</sup> respectively. Road density was calculated for each subwatershed in the Deep and Goose Creek watersheds using road data from Clackamas County (2003; Table 2-1). Note that several additional miles of private dirt and gravel roads were observed on the 1998 aerial photographs. While these un-mapped roads increase the total road density from that reported in Table 2-1, they likely do not affect the TIA to a large extent because they are somewhat pervious since they are not paved.

**Table 2-1. Road density by subwatershed. Data Source: Clackamas County (2003).**

Name	Road length (miles)	Subwatershed area (mi <sup>2</sup> )	Road density (miles/mi <sup>2</sup> )
Goose Ck	18.6	4.4	4.2
Lower Deep	22.9	13.9	1.6
North Fork Deep	58.4	13.7	4.3
Tickle	60.5	14.2	4.2
Upper Deep	31.2	7.1	4.4
Grand Total	191.6	53.4	3.6

Road densities among the subwatersheds range from 1.6 miles/mi<sup>2</sup> in the Lower Deep Creek subwatershed to 4.4 miles/mi<sup>2</sup> in the Upper Deep Creek subwatershed (Table 2-1). Based on the indices discussed above, the road densities in all subwatersheds with the exception of Lower Deep, are currently at the threshold values for TIA at which we would expect to begin seeing adverse impacts to hydrologic processes. Although these results should not be considered conclusive it may be wise to further examine, through more comprehensive modeling, whether or not increases in impervious area are significant.

## **2.5 INFORMATION GAPS AND MONITORING NEEDS**

The following are recommendations that address the most significant information gaps affecting the assessment presented above:

- Establish continuous stream flow monitoring locations within the subwatersheds

Efforts to characterize stream flow were hampered by the lack of continuous stream flow data from within the watersheds. Continuous stream flow data would improve understanding of peak flow history, allow for better estimation of natural stream flows, provide calibration data for any future modeling activity, and allow for better understanding of the effects of water use within the subwatersheds. Installing gages at or near the mouths of all five subwatersheds would adequately capture the major hydrologic patterns within the assessment area.

- Evaluate consumptive water use at the outlets of all subwatersheds to further evaluate effects of water uses on low flows

The assessment of the net effect of water withdrawals on monthly stream flows presented in section 2.4.3.1, was limited to an evaluation of conditions at the mouth of Deep Creek. A similar assessment should be performed at the outlets of all subwatersheds.

- Investigate historical extent of wetlands within the watershed.

A comparison of current wetland area to watershed area containing hydric soils indicates that wetlands may have historically occupied a much greater portion of the watershed than they

currently do. Further analysis is needed to define the historic extent of wetland area within the watershed.

- Perform functional assessment of wetlands within the watershed.

More information on wetland condition and function is needed in order to identify and prioritize any wetland enhancement efforts

- Model possible impacts to watershed hydrology associated with wetland loss and increase in impervious area.

It is recommended that a modeling tool such as the Distributed Hydrology-Soil-Vegetation Model (DHSVM) developed by the University of Washington and Battelle Pacific Northwest Research Labs be used in any further hydrologic modeling. Such a modeling effort should include an evaluation of all items included in Figure 2-7 (Generalized diagram of the primary interactions between land uses and changes in stream flows) of this report.

## **2.6 RECOMMENDATIONS AND POSSIBLE COUNCIL ACTIONS**

- Identify and implement opportunities to improve summertime stream flows

Despite the uncertainty in the magnitude of water use effects on low stream flows (see section 2.4.3.1), the BRAG may wish to identify and implement opportunities to improve summertime stream flows through increased water use efficiency, transfer of water rights to instream uses, and other voluntary actions by water right holders. Actions should be focused on those subwatersheds where consumptive use is probably greatest (e.g., those subwatersheds where irrigated acres are greatest; Figure 2-3). Voluntary measures such as an increase in the efficiency of water distribution and application to irrigated areas will help improve summertime flow conditions. Further reductions in withdrawals through voluntary transfer of water rights (either temporarily or permanently) to organizations such as the Oregon Water Trust should also be considered.

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## 3.0 RIPARIAN HABITAT CONDITIONS

### 3.1 INTRODUCTION

This section of the watershed analysis report presents the results of the riparian and wetlands assessment. The assessment uses existing information to summarize what is known about current riparian and wetlands conditions in the Deep and Goose Creek watersheds. The results are followed by recommendations on future monitoring needs to fill data gaps and steps that can be taken to improve riparian and wetland conditions.

### 3.2 CRITICAL QUESTIONS

The Riparian/Wetlands assessment methodology outlined in the Oregon Watershed Assessment Manual (WPN, 1999) is designed around a series of critical questions that form the basis of the assessment. These critical questions are:

*Question 3-1: What are the current conditions of riparian areas in the watershed?*

*Question 3-2: How do the current conditions compare to those potentially present for this ecoregion?*

*Question 3-3: How can the current riparian areas be grouped within the watershed to increase our understanding of what areas need protection and what the appropriate restoration/enhancement opportunities might be?*

*Question 3-4: Where are the wetlands in this watershed?*

*Question 3-5: What are the general characteristics of wetlands within the watershed?*

*Question 3-6: What opportunities exist to restore wetlands in the watershed?*

### 3.3 METHODS

#### 3.3.1 Riparian Assessment Methods

The purpose of this portion of the assessment was to evaluate current riparian vegetation<sup>10</sup> conditions for their ability to provide recruitment<sup>11</sup> of large woody material<sup>12</sup> (LWM) and stream shading. The assessment was conducted using the methodology outlined in the OWEB manual

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<sup>10</sup> Riparian vegetation refers to the vegetation found on stream banks and adjoining floodplain

<sup>11</sup> Recruitment, in the context of riparian function, refers to the natural addition over time of new large wood pieces to a stream channel from riparian forests. It is the physical movement of large wood from stream-side forest into the stream channel

<sup>12</sup> Large woody material, as it is used in this context, refers to pieces of wood (either tree trunks, stumps, or large branches) important in the formation of channel shape, and consequently, in creating and enhancing fish habitat.

(WPN, 1999). Current riparian conditions within the study area were evaluated using stereo aerial photographs<sup>13</sup>. Color stereo aerial photos at 1:10,200 scale, taken in 1998 (SBG, 1998) were available for the majority of the assessment area, while 1:22,680 scale color photos, taken in 2002, were used for the easternmost portion of the assessment area (SBG, 2002). The spatial distribution of historic vegetation was estimated using USEPA level IV ecoregion maps (EPA, 2003), and descriptions of potential riparian conditions were taken from WPN (2001). No field-verification was conducted for this assessment. All known streams in the subwatersheds were included in this assessment (ODF, 2003; Figure 1-2, Table 1-2), totaling approximately 103 miles in length. Of the total length of streams included, approximately 60% were identified by the Oregon Department of Forestry as having fish use.

### 3.3.1.1 Riparian condition units (RCUs)

The fundamental mapping unit, for which all information in this portion of the assessment was collected, is the Riparian Condition Unit or RCU. An RCU is a portion of the riparian area for which riparian vegetation type, size, and density remain approximately the same. When riparian characteristics change a new RCU is defined. Each RCU occurs on only one side of the stream (i.e., riparian areas on the opposite side of the stream are separate RCUs).

Riparian characteristics typically change with distance from the stream as soil moisture and stream-related disturbance changes. Often, the immediate streamside area will contain hardwoods or shrub species, while areas farther away from the stream will be dominated by upland vegetation. In recognition of these differences in vegetation, two data collection zones were defined moving laterally away from the edge of the stream. Riparian area #1 (RA1) was defined from the edge of the stream channel out to the approximate limit of the streams immediate influence. The lateral distance of RA1 varied from a 25 feet to 100 feet depending on the characteristics of the site. A second mapping unit, riparian area #2 (RA2), was defined from the outer edge of RA1 to a distance of 100 feet from the edge of the stream channel. The purpose of including this additional riparian area was to account for additional recruitment that may come from as far away as 100 feet from the stream edge<sup>14</sup>.

Information for each RCU was mapped directly in ArcView GIS, using USGS orthophotos as a backdrop to properly place the RCU location. RCUs were mapped within ArcView as polylines. The following information was collected for each RCU and is included in the attribute table of the GIS coverage:

- **RA1 Width:** Width (horizontal distance) of RA1 (for riparian area #1 as described above) measured perpendicular to the stream as estimated from aerial photographs.

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<sup>13</sup> Stereo aerial photographs refer to high-resolution aerial photographs that are taken from an airplane along a straight flight line. When sequential pairs are viewed with a device called a stereoscope the land features appear three-dimensionally

<sup>14</sup> Although recruitment has the potential to come from as far away from the stream as the site potential tree height, the majority of functional wood is recruited within 100 feet (horizontal distance) or less of the stream's edge (McDade et al. 1990).

- **RA1 Code:** Vegetation characteristics within RA1 were noted using a three-letter code that describes vegetation type (first letter), vegetation size (second letter), and vegetation density (third letter). The choices are given in Table 3-1. For example, “CSD” would mean a riparian stand that is predominantly conifer, small in size (i.e., 4-12 inch average stand diameter at breast height), and dense. Note that size and density only apply to forested stands.
- **RA2 Code:** Same as previous, but for RA2 (i.e., riparian area #2 as described above). Note that in cases where RA1 width = 100 feet there is no RA2 code (i.e., riparian conditions are similar across the entire width of the RCU).
- **Source of limitation to riparian forest development:** The primary sources of limitation (if any) to riparian forest development were estimated from aerial photographs. The sources identified within the Deep and Goose Creek watersheds included agricultural operations, development, infrastructure (e.g., powerlines, road right-of-way), logging, and site conditions (e.g., wetland conditions).
- **Notes:** Additional notes were taken describing, to the extent possible from aerial photographs, other notable features within the RCU, such as dominant vegetation type (e.g., “cultivated fields”), disturbances (e.g., “recently logged”), or sources of permanent discontinuities (e.g., “roads”).

**Table 3-1. Codes used to describe vegetation (from WPN, 1999).**

<b>Vegetation type code</b>	
C	Mostly conifer trees (>70% of area)
H	Mostly hardwood trees (>70% of area)
M	Mixed conifer/hardwoods
B	Brush species
G	Grass/meadow
N	No riparian vegetation
<b>Size class code</b>	
R	Regeneration (<4-inch average diameter at breast height (DBH))
S	Small (4- to 12-inch average DBH)
M	Medium (>12- to 24-inch average DBH)
L	Large (>24-inch average DBH)
N	Non-forest (applies to vegetation Types B, G, and N)
<b>Stand density code</b>	
D	Dense (<1/3 ground exposed)
S	Sparse (>1/3 ground exposed)
N	Non-forest (applies to vegetation Types B, G, and N)

### 3.3.1.2 Shade mapping

Current shade conditions were mapped separately from the RCUs. Riparian shading was estimated from the aerial photographs using the criteria given in Table 3-2. Streams were broken into segments having similar riparian shading using the indicators of riparian shading given in Table 3-2. Stream orientation (i.e., the compass direction that the stream runs) and topographic shading (i.e., the shade provided by hills and other landscape features) were not assessed due to the difficulty in evaluating their importance from aerial photographs.

**Table 3-2. Shade estimation criteria (from WFPB, 1997).**

Indicator	% Shade
Stream surface not visible	>90%
Stream surface slightly visible or visible in patches	70-90%
Stream surface visible but banks not visible	40-70%
Stream surface visible and banks visible at times	20-40%
Stream surface and banks visible	0-20%

### 3.3.1.3 Determination of current riparian large wood recruitment potential

The approach to assessing current riparian large wood recruitment potential involves 1) defining what historic recruitment potential was likely to have been, 2) characterizing current recruitment potential, and 3) comparing current to historic recruitment potential to evaluate if current potential is either “satisfactory” (i.e., defining areas that should be protected and where no enhancement is needed), or “unsatisfactory”. Further, we wish to identify the factors that are limiting current recruitment potential in the areas that are not “satisfactory”.

The Oregon Watershed Assessment Manual (WPN, 1999) uses EPA Level IV ecoregions to describe potential streamside recruitment conditions. The Deep and Goose Creek watersheds fall within three Level IV ecoregions (see Figure 1-11). Potential streamside vegetation descriptions for the three ecoregions found in the assessment area are given in Table 3-3. Potential conditions would vary within an ecoregion depending on the geomorphic conditions of a given reach, as well as varying over time in response to disturbance. For example, in the absence of fire suppression, only approximately 2/3 of the forested area in Western Oregon would be expected to be in an old-growth condition in any given year, due to fire re-setting the growth cycle. The potential conditions listed in Table 3-3 can perhaps be considered a “most probable condition” of the riparian vegetation, recognizing that there would be some variability over time.

**Table 3-3. Potential streamside vegetation within the Deep and Goose Creek watersheds (WPN, 2001).**

Level IV ecoregion	RA1 description	RA2 description	Other considerations
Prairie Terraces (3c)	<p><b>Type:</b> Hardwoods (black cottonwood, willows, Oregon ash, bigleaf maple, western hawthorn) &amp; shrubs (Douglas spirea, snowberry).</p> <p><b>Size:</b> Large</p> <p><b>Density:</b> Dense</p>	Same	Reed canarygrass and Himalayan blackberry (invasive species) often dominate in areas without trees. Oregon white oak, Douglas-fir, and grand fir grow on adjacent terraces that are well-drained.
Valley Foothills (3d)	<p><b>Type:</b> Mixed (Douglas-fir, western hemlock, red alder, bigleaf maple) and shrubs (willow, snowberry, Douglas spirea).</p> <p><b>Size:</b> Medium</p> <p><b>Density:</b> Dense</p>	<p><b>Type:</b> Mixed (Douglas-fir, grand fir, and bigleaf maple)</p> <p><b>Size:</b> Large</p> <p><b>Density:</b> Dense</p>	Few conifers where slopes are unstable or perpetually wet. Vegetation is often highly altered where there is significant beaver browsing and dam building.
Western Cascades Lowlands and Valleys (4a)	<p><b>Type (Constrained streams):</b> Hardwoods (red alder, cotton-wood, bigleaf maple) and shrubs (vinemaple, red osier dogwood, devil's club, stink currant and salmonberry).</p> <p><b>Type (Semi- &amp; Unconstrained streams):</b> Mixed (Western red cedar, red alder, cotton-wood, bigleaf maple) and shrubs such as vinemaple, red osier dogwood, devil's club, stinkcurrant and salmonberry.</p> <p><b>Size:</b> Medium</p> <p><b>Density:</b> Dense</p>	<p><b>Type:</b> Conifers (Douglas-fir, western hemlock, western redcedar, true firs at higher elevations). Some hardwoods may be present.</p> <p><b>Size:</b> Large</p> <p><b>Density:</b> Dense</p>	Under certain circumstances, there are a few potential plant communities which have no woody vegetation, and are characterized by herbaceous plants such as Oregon and great oxalis, Cooley's hedgenettle and ladyfern, skunk cabbage, and lenticular sedge. See Diaz and Mellen (1996) and Campbell and Franklin (1979) for more details about specific plant communities and where they occur.

The Oregon Watershed Assessment Manual (WPN, 1999) provides a methodology for placing similar RCUs into groupings that can help summarize the major riparian impacts in the watershed. These groupings, called riparian recruitment situations, also provide a way to categorize riparian areas in ways that will respond similarly to restoration treatments.

The first step in developing riparian recruitment situations for the Deep and Goose Creek watershed was to determine which RCUs currently have “satisfactory” riparian recruitment. Determination of current satisfactory recruit potential followed the approach given in the Manual (WPN, 1999); current conditions in both RA1 and RA2 were compared to potential conditions given in Table 3-3. Areas where current riparian vegetation is similar (with respect to type, size, and density) to potential conditions were rated as having “satisfactory” current recruitment potential. The remaining RCUs in the watershed currently have unsatisfactory riparian conditions as compared to the potential conditions shown in Table 3-3. These remaining RCUs were further divided into a set of riparian recruitment situations that are appropriate for the watershed.

Riparian recruitment situations were defined using the information that was collected in section 3.3.1.1 above. The riparian recruitment situations defined for the Deep and Goose Creek watersheds are as follows:

- **Satisfactory**: Current riparian recruitment potential is satisfactory as compared with potential conditions for the ecoregion. RCUs included in this grouping generally consist of dense stands of large-sized conifers within RA2.
- **Approaching satisfactory**: Trees within the RCUs that are included in this classification are smaller than the potential size for the ecoregion; generally falling in the Medium size class (Table 3-1). However, the trees are of an adequate size to currently provide adequate LWM recruitment and shade. These stands are not as productive (in terms of riparian function) as they can be. However, if protected, these stands will attain potential conditions over time. RCUs included in this grouping generally consist of dense stands of medium-sized conifers and mixed conifer/hardwood within RA2
- **Hardwood**: Trees within these stands are generally approaching a size that is large enough to provide satisfactory recruitment potential, but are dominated by hardwoods where the potential vegetation is conifer or mixed stands. RCUs included in this grouping generally consist of dense stands of medium-sized hardwood trees within RA1 and/or RA2.
- **Narrow buffers**: RCUs included in this classification generally have trees in the near-stream area that are of a size (generally medium-sized, with a few areas of large-sized trees) and species (conifer or mixed conifer/hardwood) approaching satisfactory relative to potential conditions. However, these areas are very narrow. Source of limitation may include agricultural operations, residential development, infrastructure (roads, power lines, etc.), and past logging. The outer (farthest from the stream) portions of these stands consist of a variety of vegetation types and sizes; regeneration- and small-sized conifers and mixed conifer/hardwoods. Tree and shrub vegetation is absent in many areas of agricultural and residential land use.
- **Small-sparse**: This grouping of RCUs includes both stands of small- or regeneration-sized trees, and sparse stands of medium- and large-sized trees. In both cases current recruitment potential is far removed from potential conditions, however (unlike the following grouping), these stands are forested.
- **Absent**: This grouping includes RCUs that are devoid of riparian tree vegetation. Vegetation within the RCUs included in this grouping consists primarily of riparian grass species, shrub species, and non-riparian vegetation (cropland, pasture, and some areas of non-native vegetation).

### 3.3.2 Wetlands Assessment Methods

The methods used in this assessment are described in the Oregon Watershed Assessment Manual (WPN, 1999), with exceptions noted below. The purpose of this assessment was to identify locations of wetlands within the Deep and Goose Creek watersheds and to summarize available data on current wetland conditions.

All information about wetland locations and current conditions used in this assessment was derived from digital National Wetland Inventory (NWI) data produced by the U.S. Fish and Wildlife Service (USFWS, 2004); no local wetland inventory information being available for the watershed. The dates of the source imagery used to produce the digital maps are not known, but were probably sometime in the 1980's. No additional aerial photo interpretation was performed for this assessment.

The Oregon Watershed Assessment Manual suggests assessing only the wetlands that are greater than 200 feet from the channel to avoid having to examine the very complex NWI mapping that can occur near stream channels. In this assessment all palustrine<sup>15</sup> wetland polygons were included regardless of distance from stream channels, however, wetlands that appear in the NWI as line features (i.e., riparian wetlands) were not included.

The Cowardin classification code (Cowardin et al., 1979) was available for each wetland included in the NWI. The System-Class-Subclass, Water Regime Modifiers, and Special Modifiers for wetlands found within the Deep and Goose Creek watersheds is shown in Table 3-4.

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<sup>15</sup> The Palustrine System includes all nontidal wetlands dominated by trees, shrubs, emergents, mosses or lichens

**Table 3-4. Classification for NWI wetlands found in the Deep and Goose Creek watersheds.**

<b><u>System-class-subclass</u></b>	
<b>PAB5</b>	Palustrine aquatic bed, unknown submergent vegetation
<b>PEM1</b>	Palustrine emergent persistent
PEM1/UB	Palustrine emergent persistent / unconsolidated bottom
<b>PFL</b>	Palustrine, flat
<b>PFO1</b>	Palustrine forested – broad leaved deciduous
PFO/EM1	Palustrine forested / palustrine emergent persistent
PFO1/UB	Palustrine forested, broad-leaved deciduous / unconsolidated bottom
<b>POW</b>	Palustrine open water
<b>PSS1</b>	Palustrine scrub-shrub – broad leaved deciduous
PSS/EM1	Palustrine scrub-shrub / emergent persistent
<b>PUB</b>	Palustrine unconsolidated bottom
<b><u>Water regime modifiers:</u></b>	
F = Semipermanently flooded	
K = Artificially flooded	
W = Intermittently flooded/temporary	
Y = Saturated/semi permanent/seasonal	
Z = Intermittently exposed / permanent	
<b><u>Special modifiers:</u></b>	
d =Partially drained/ditched	
h =Diked/Impounded	
x =Excavated	
Source: (Cowardin and others, 1979)	

### 3.4 RESULTS

#### 3.4.1 Current riparian vegetation conditions

*Critical Question: What are the current conditions of riparian areas in the watershed?*

The material presented in this section of the report summarizes current riparian vegetation conditions as estimated through aerial photo interpretation. Riparian vegetation was mapped for approximately 1,900 individual riparian condition units (RCUs) along a total length of approximately 108 miles of stream and pond perimeter within the Deep and Goose Creek watersheds. Current riparian vegetation types are shown in Figure 3-1 (refer to Map 5: Riparian Vegetation Map, for further detail). The distribution of riparian vegetation by type, size, and density classes within the entire Deep and Goose Creek watershed is summarized Figure 3-2, Figure 3-3, and Figure 3-4.

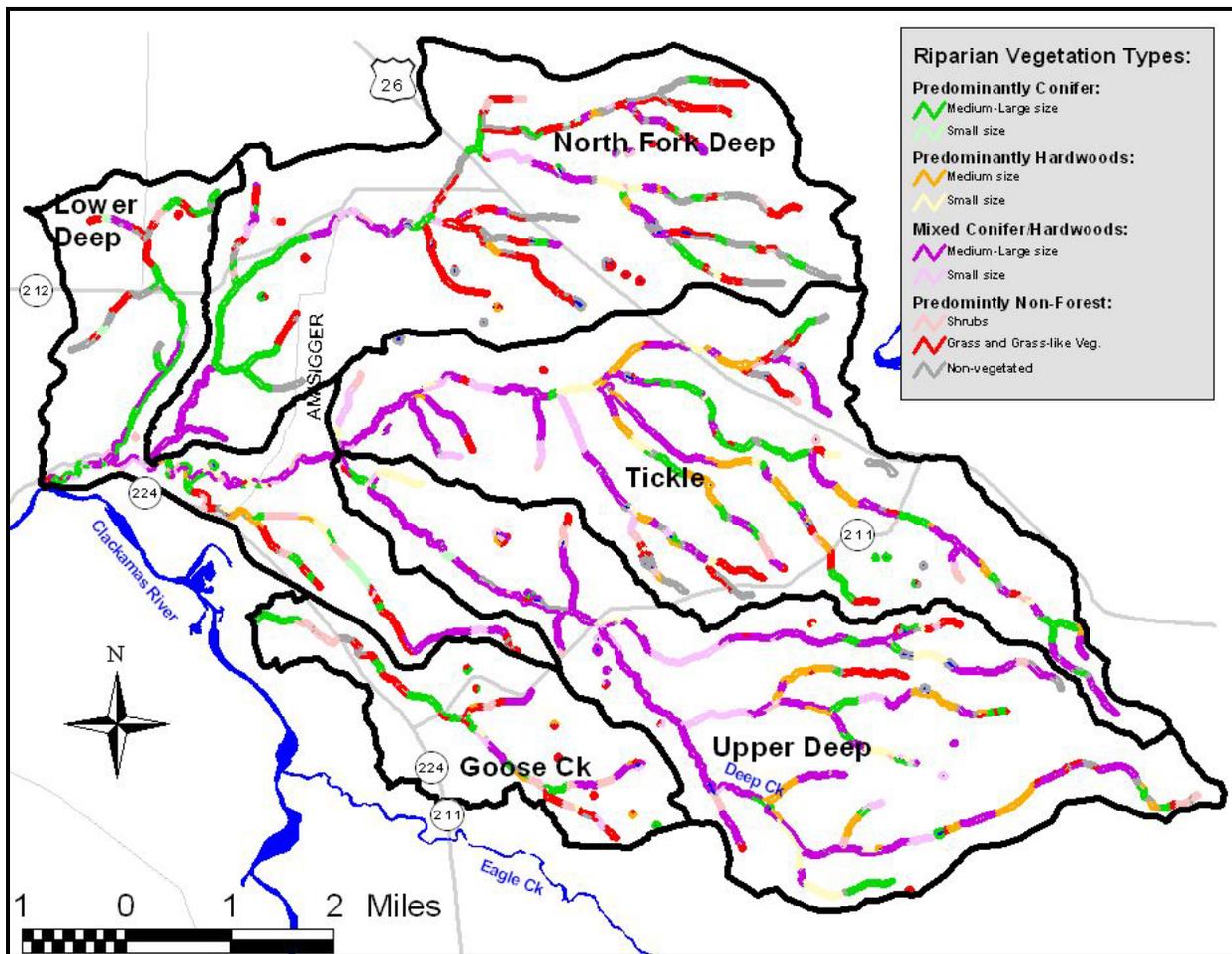
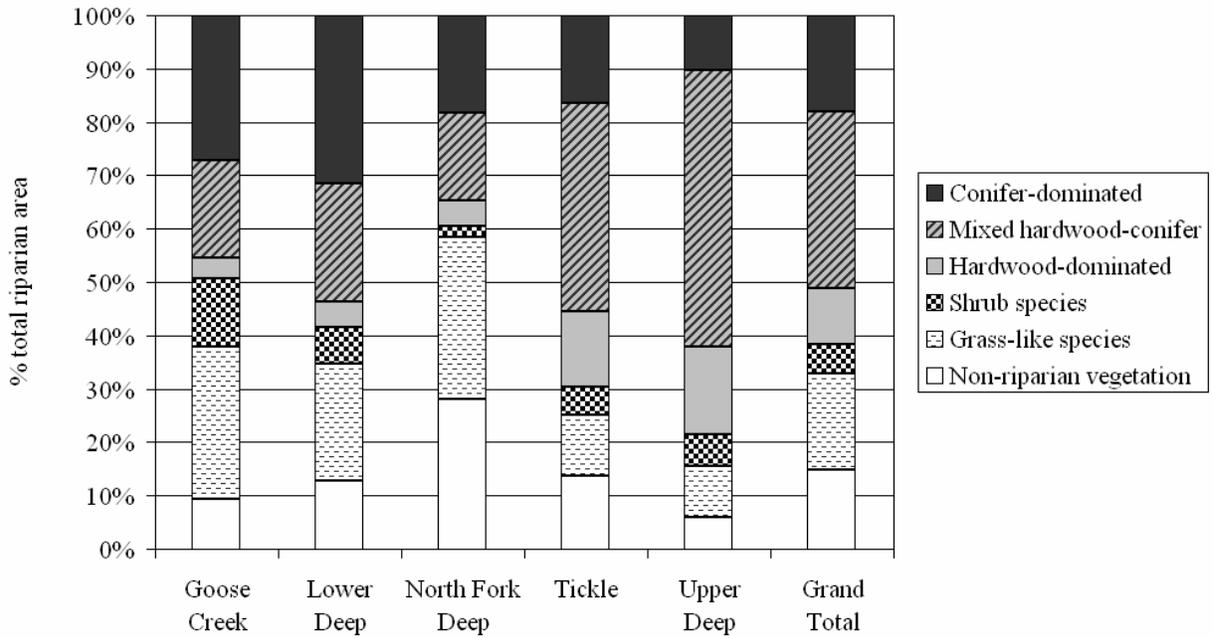
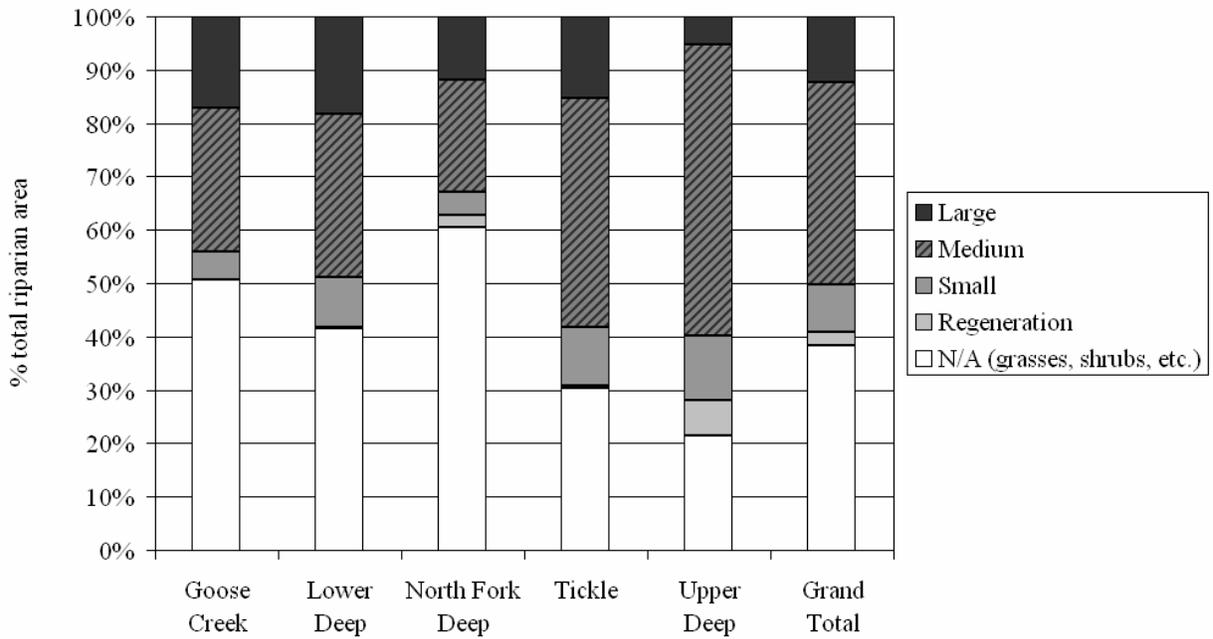


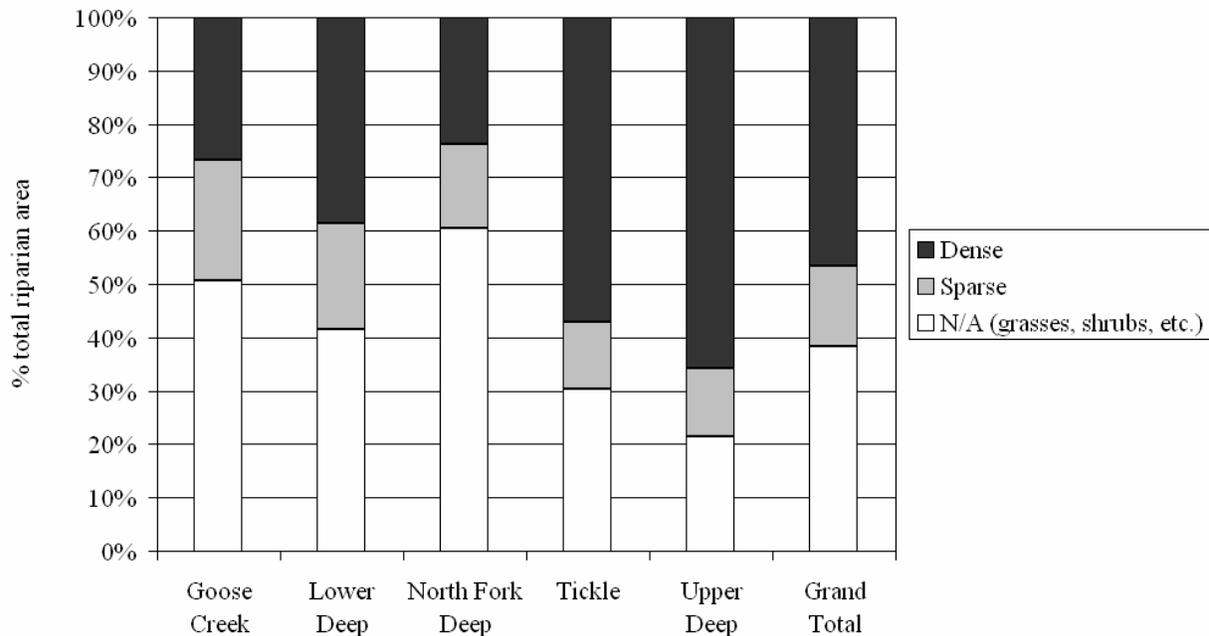
Figure 3-1. Current riparian vegetation within the Deep and Goose Creek watersheds.



**Figure 3-2. Distribution of riparian vegetation by primary types within subwatersheds. See Table 3-1 for a description of vegetation types.**



**Figure 3-3. Distribution of riparian vegetation by size class within subwatersheds. See Table 3-1 for a description of size classes.**



**Figure 3-4. Distribution of riparian vegetation by canopy density class within subwatersheds. See Table 3-1 for a description of density classes.**

Riparian vegetation conditions varied greatly among the subwatersheds. The proportion of riparian area<sup>16</sup> composed of tree-species ranged from approximately 80% of the total in the Upper Deep subwatershed to less than 40% in the North Fork Deep subwatershed (Figure 3-2). Of these forested riparian areas the majority tended to be mixed conifer-hardwood dominated, as opposed to either pure conifer or pure hardwood. Shrub-dominated riparian areas were the least common type found in the assessment area, ranging from 2% of total riparian area in North Fork Deep to 13% in the Goose Creek subwatershed. Grass-like vegetation was a common type found in riparian areas within the assessment area. Grass-like vegetation includes areas that are completely comprised of riparian and upland grasses (or grass-like plants), as well as areas that contain some scattered trees and shrubs, but the dominant vegetation are grasses. Grass-like vegetation ranged from approximately 9% of total riparian area in the Upper Deep Creek subwatershed to 30% in the North Fork Deep subwatershed. The classification “non-riparian vegetation” includes primarily cultivated fields, pastures, lawns, and developed areas that fall within the riparian assessment area. The proportion of total riparian area classified as non-riparian vegetation ranged from 6% the Upper Deep Creek subwatershed to 28% in the North Fork Deep subwatershed.

The distribution of riparian vegetation by size class within the subwatersheds is shown in Figure 3-3. The size class designation only applies to tree-vegetation. Consequently from 21% (in the

<sup>16</sup> Calculated as a width-weighted length by riparian type.

Upper Deep Creek subwatershed) to 60% (in the North Fork Deep subwatershed) of the total riparian area is listed as “N/A” in Figure 3-3. The proportion of total riparian area classified in the “regeneration-size” classification is low throughout the watershed, making up 7% of the total riparian area in the Upper Deep subwatershed, but being 3% or less elsewhere. The higher proportion of “regeneration-size” riparian stands in the Upper Deep subwatershed may reflect the more frequent occurrence of logging in that subwatershed than elsewhere. The majority of forested riparian areas fall within the “medium” size class, with only a small proportion in either the “large” or “small” classes.

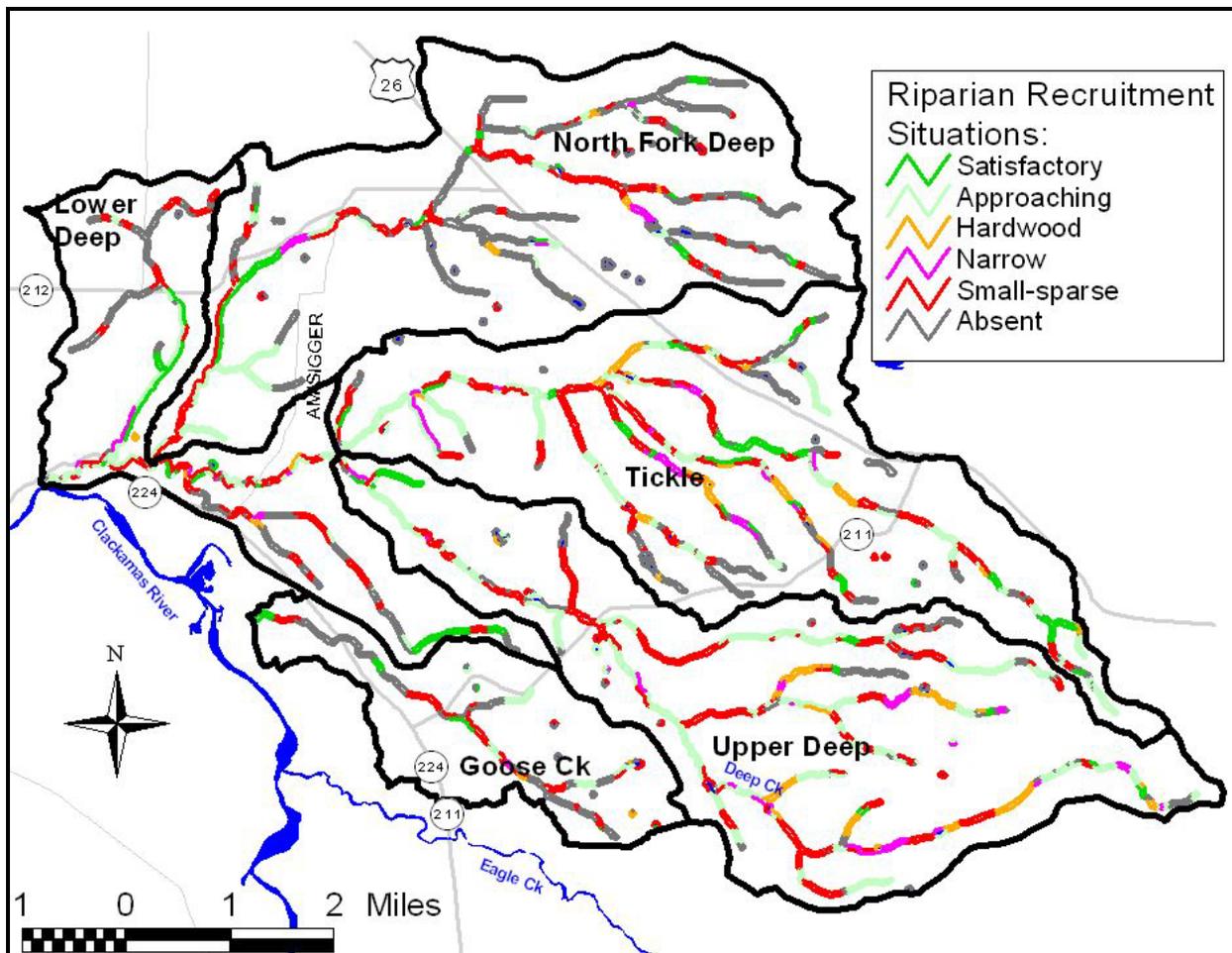
The distribution of riparian vegetation by canopy density classes within subwatersheds is shown in Figure 3-4. The canopy density designation only applies to tree-vegetation. Consequently from 21% (in the Upper Deep Creek subwatershed) to 60% (in the North Fork Deep subwatershed) of the total riparian area is listed as “N/A” in Figure 3-4. The majority of forested riparian areas are classified as having “dense” canopy density, which reflects the fast growth and productivity of forest stands in the region.

### **3.4.2 Riparian recruitment potential**

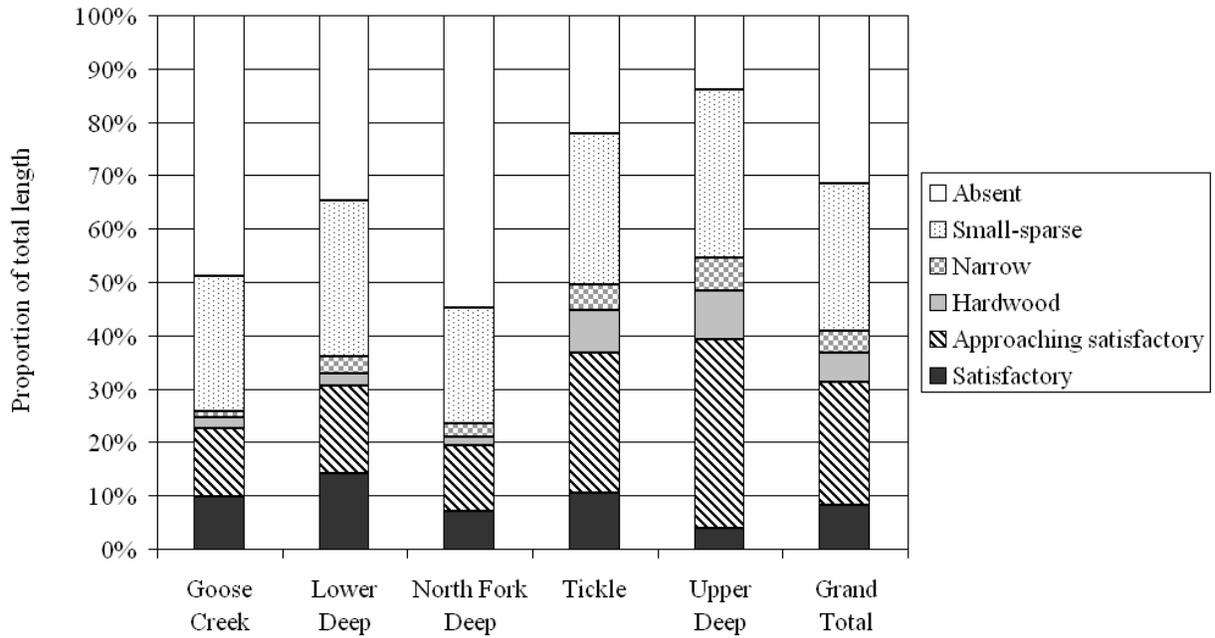
***Critical Question:***     *How do the current conditions compare to those potentially present for this ecoregion?*

***Critical Question:***     *How can the current riparian areas be grouped within the watershed to increase our understanding of what areas need protection and what the appropriate restoration/ enhancement opportunities might be?*

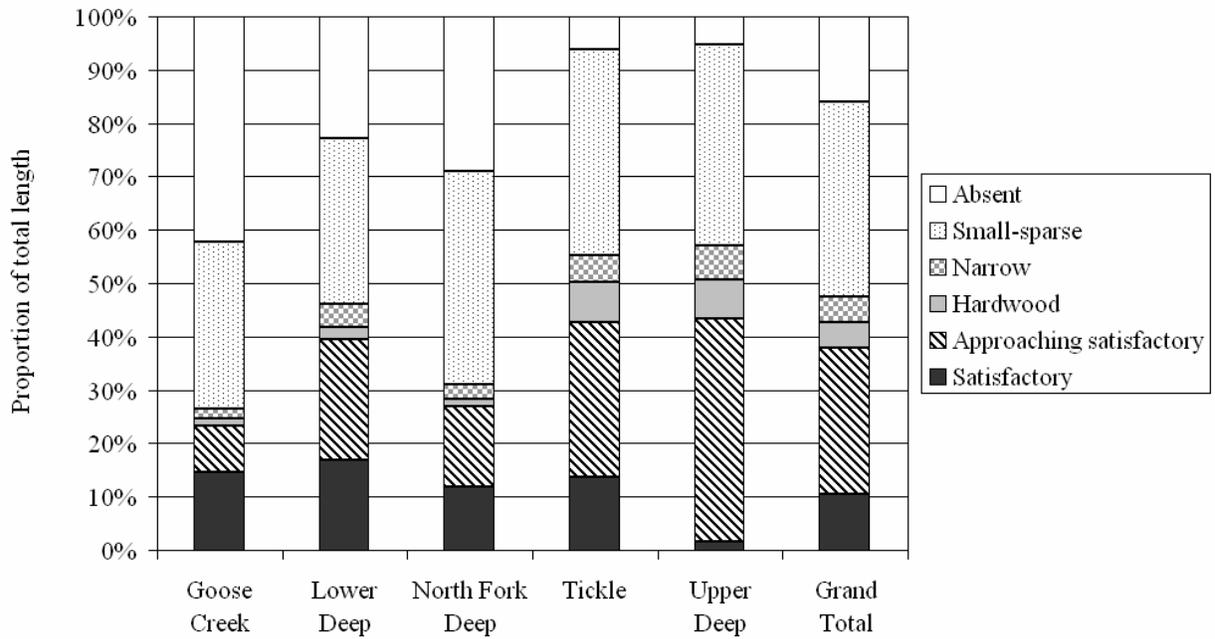
Current riparian recruitment potential was organized by the six riparian recruitment situations described in section 3.3.1.3 above. Riparian recruitment situations within the subwatersheds are shown in Figure 3-5 (See Map 6: Riparian Recruitment Map, for further detail). A summary of current riparian situations by subwatershed is given in Figure 3-6 for all streams, and a summary by fish-bearing streams only is given in Figure 3-7.



**Figure 3-5. Riparian recruitment situations in the Deep and Goose Creek watersheds. Refer to Map 8: Riparian Recruitment Map, for further detail**



**Figure 3-6. Summary of current riparian recruitment situations by subwatershed. Categories are percent of total riparian length for each subwatershed.**



**Figure 3-7. Summary of current riparian recruitment situations by subwatershed for fish-bearing streams only.**

Only a very small proportion of the total length of stream within the subwatersheds are estimated to currently have “satisfactory” riparian recruitment potential (Figure 3-6 and Figure 3-7). Riparian areas estimated to currently have “satisfactory” riparian recruitment potential range from 4% of the total length in the Upper Deep subwatershed, to 14% in the Lower Deep subwatershed (Figure 3-6). The pattern is similar when considering fish-bearing streams alone (Figure 3-7). As discussed in Section 3.3.1.3 above, disturbance from natural sources (e.g., fire and floods) would result in riparian conditions being in an earlier seral stage in approximately 1/3 of the total riparian area in any given year. In other words, at the watershed scale we might only expect to find approximately 2/3 of the total length of riparian areas rated as “satisfactory” in any given year. The small proportion of riparian length that is currently rated as “satisfactory” in the Deep and Goose Creek Watersheds indicates that current conditions within the watersheds are far below potential conditions, even when natural variability is accounted for.

Riparian areas that currently have recruitment potential ratings of “approaching satisfactory” and “hardwood” also provide (or will provide in the near future if allowed to grow) some level of LWM recruitment potential. If these two categories are combined with the “Satisfactory” category, then the proportion of riparian areas that currently offer some recruitment potential for LWM ranges from approximately one fifth of the total riparian length in the North Fork Deep subwatershed to approximately half the riparian length in the Upper Deep subwatershed (Figure 3-6). Again, the pattern is similar when considering the fish-bearing streams alone (Figure 3-7).

The “narrow buffers” category of current riparian recruitment potential makes up only a very small proportion of total stream length within all subwatersheds (Figure 3-6 and Figure 3-7). Ranging from 1% of the total length in the Goose Creek subwatershed to 6% of the total length in the Upper Deep subwatershed. The primary sources of limitation to riparian forest development in these areas are agricultural practices and residential development, each of which have impacted approximately 1/3 of the length of riparian areas in the “narrow buffers” category. Other impacts are from past logging and infrastructure (primarily roads).

A large proportion of riparian areas fall within the “small-sparse” category, ranging from 22% of total riparian length in the North Fork Deep subwatershed to 32% in the Upper Deep subwatershed (Figure 3-6). For fish-bearing streams the proportion is even greater, ranging from 31% of total riparian length (Goose Creek, Lower Deep) to 40% (North Fork Deep subwatershed; Figure 3-7). Overall the primary sources of limitation to riparian forest development for the “small-sparse” category are agricultural practices, logging, and residential/commercial development, however, the source of limitation varies in different parts of the assessment area. Agricultural practices cause the largest impacts in the Goose Creek and North Fork Deep subwatersheds, while logging is the primary source in the Upper Deep subwatershed. The high proportion of small-sparse stands in the Upper Deep subwatershed is primarily due to reforestation of past timber harvest areas that were harvested prior to the more stringent Oregon Forest Practices rules that are currently in effect.

The grouping of riparian areas shown as “absent”, in Figure 3-6 and Figure 3-7, includes those riparian areas that are devoid of tree-type vegetation. This grouping makes up a significant proportion of the total riparian length in all subwatersheds. Percent of total riparian length within the “absent” category ranges from 14% in Upper Deep Creek to 55% in the North Fork

Deep subwatershed. The pattern is similar when only fish-bearing streams are considered (Figure 3-7). Overall the primary sources of limitation to riparian forest development for the “absent” category are agricultural practices, although residential/commercial development is significant as well.

### **3.4.3 Riparian shade**

Current riparian shade levels within the Deep and Goose Creek watersheds are shown in Figure 3-8 and summarized in Figure 3-9 and on Map 7: Riparian Shade Map. It is difficult to assess if current shade levels are below potential levels, and if so, to what extent. The Oregon Watershed Assessment Manual (WPN, 1999) does not include a methodology for estimating potential shade levels. However, we would generally expect shade levels to be proportional to basin position, with the headwater areas generally more well shaded than areas near the mouth of the basin. The relatively low shade levels along the lower mainstem of Deep Creek are to be expected, given the size of the channel, despite the relatively dense riparian forest that is present. The headwater areas however, particularly in the North Fork Deep Creek subwatershed, appear to be abnormally low in terms of riparian shade. The degree to which riparian areas within the watershed are deficient in terms of recruitment potential (as discussed in section 3.4.2 above), are not necessarily reflected in riparian shade levels, because small trees, shrubs, and even dense non-woody vegetation can provide high levels of shade. The degrees to which other factors affecting water temperature, such as riparian microclimate is affected by a change in vegetation composition are not known.

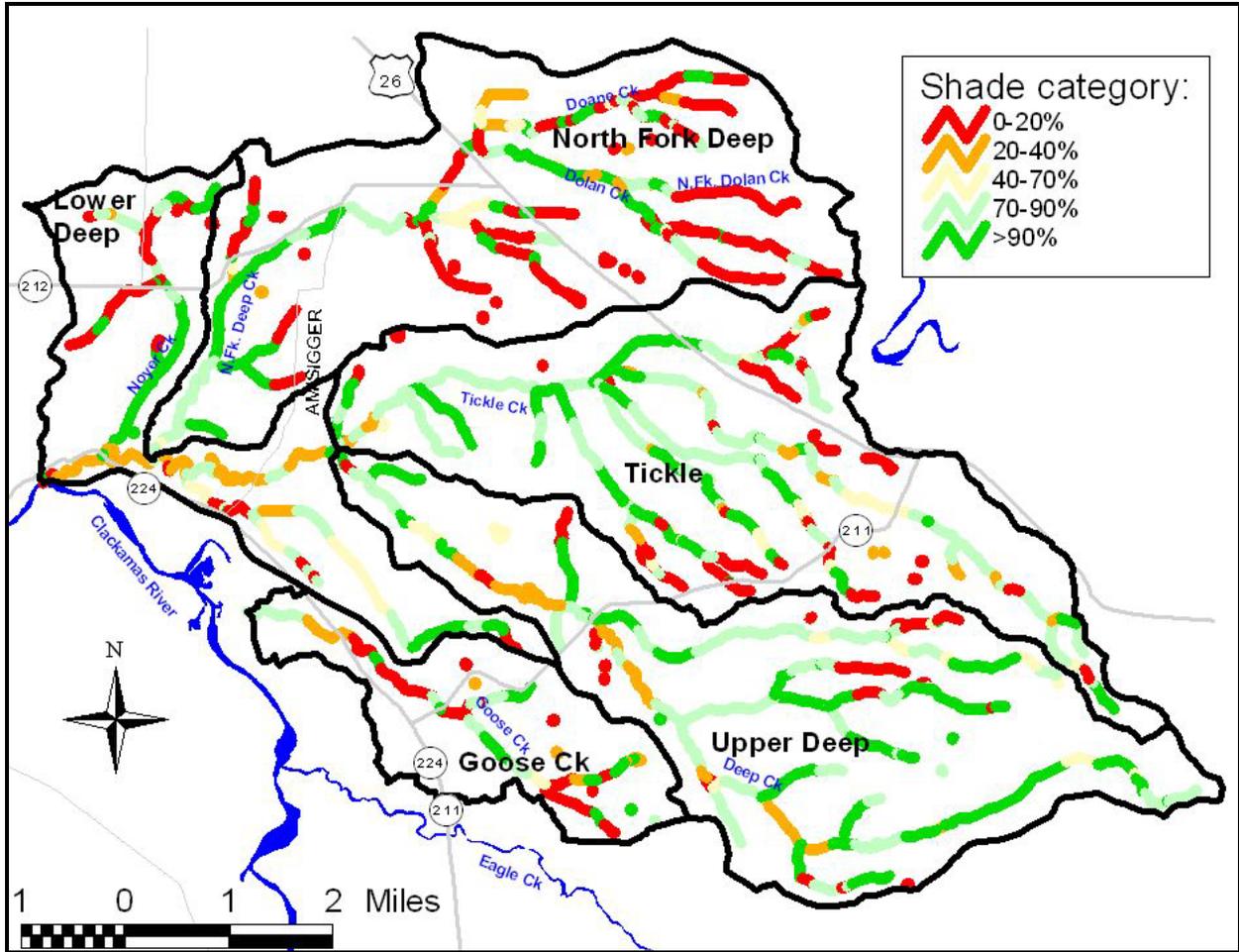
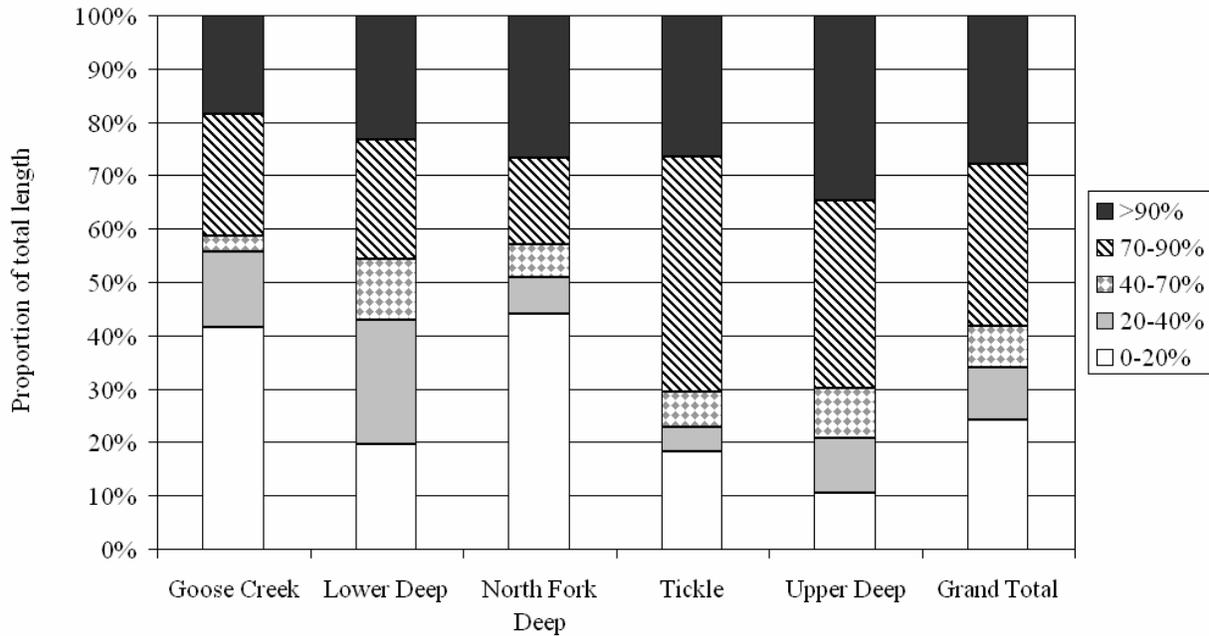


Figure 3-8. Current riparian shade levels in the Deep and Goose Creek watersheds.



**Figure 3-9. Summary of current riparian shade levels by subwatershed.**

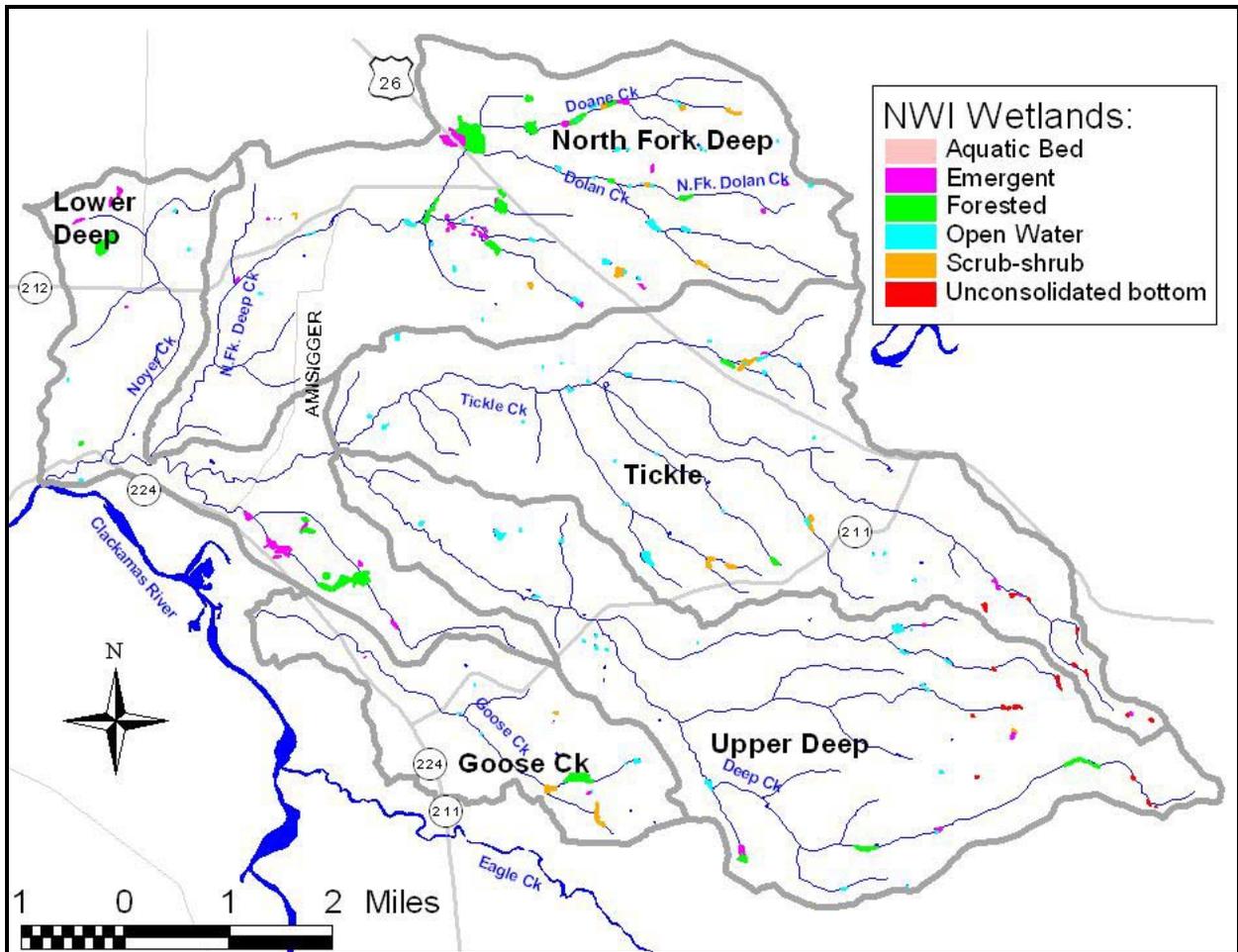
### 3.4.4 Wetlands

**Critical Question:** *Where are the wetlands in this watershed?*

**Critical Question:** *What are the general characteristics of wetlands within the watershed?*

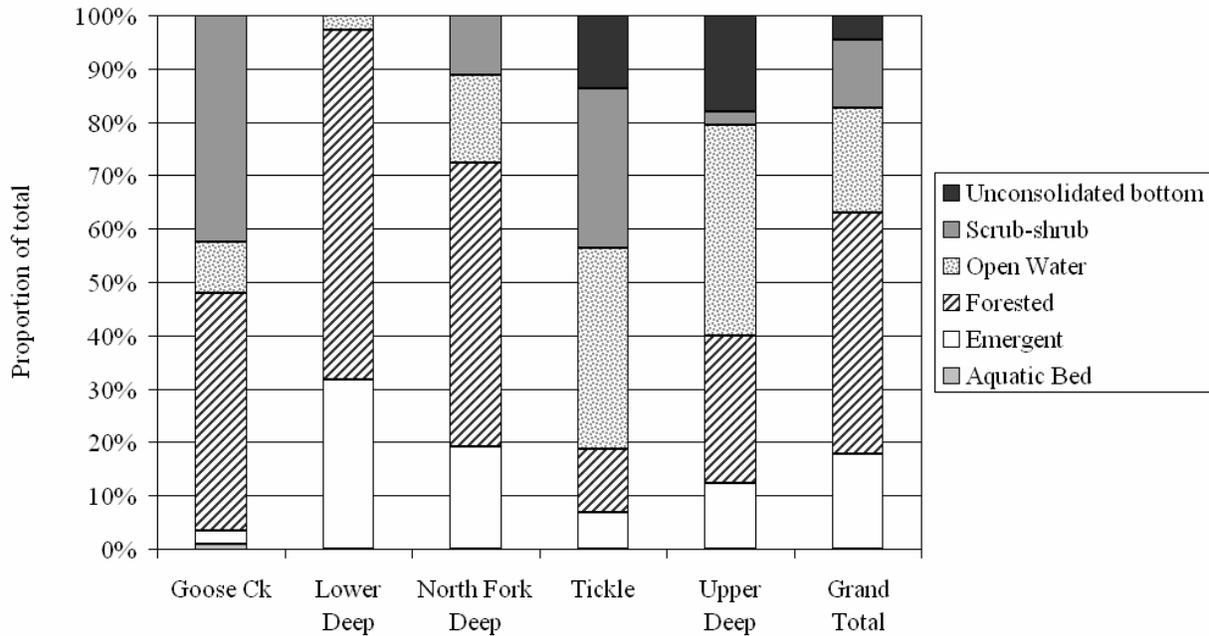
**Critical Question:** *What opportunities exist to restore wetlands in the watershed?*

The National Wetlands Inventory (NWI) identified a total of 190 wetlands covering 330 acres in the Deep and Goose Creek watersheds (USFWS, 2004). Wetland locations within the watersheds are shown in Figure 3-10 and summarized in Figure 3-11. Wetland density (area occupied by wetlands/area of subwatershed) ranged from 0.5% in the Upper Deep and Tickle Creek subwatersheds to 1.6% in the North Fork Deep subwatershed, and was 1.0% of the overall assessment area.



**Figure 3-10. Wetlands within the Deep and Goose Creek watersheds.**

(Data source: USFWS (2004))



**Figure 3-11. Distribution of wetland area by subwatershed.**

Palustrine aquatic bed wetlands are dominated by plants that grow principally on or below the surface of the water for most of the growing season in most years. Palustrine aquatic bed wetlands are found only within the Goose Creek subwatershed where it makes up only 1% of the total wetland area.

Palustrine emergent wetlands are wetlands dominated by rooted herbaceous plants, such as cattails and grass. Palustrine emergent wetlands are found within all subwatersheds, and range from 3% of the total wetland area in the Goose Ck subwatershed to 32% in the Lower Deep subwatershed.

Palustrine forested wetlands are defined as wetlands dominated by trees taller than 20 feet. Palustrine forested wetlands are found in all subwatersheds, and make up the largest single grouping of wetlands. Palustrine forested wetlands range from 12% of the total wetland area in the Tickle Creek subwatershed to 65% of the total wetland area in the Lower Deep Creek subwatershed.

Palustrine open water wetlands (lakes and ponds) are found in all subwatersheds. Palustrine open water wetlands make up from 3% (Lower Deep Creek subwatershed) to 39% (Upper Deep Creek subwatershed) of total wetland area within the subwatersheds.

Palustrine scrub-shrub wetlands are defined as wetlands that are dominated by shrubs and saplings less than 20 feet tall. Palustrine scrub-shrub wetlands are found in all subwatersheds

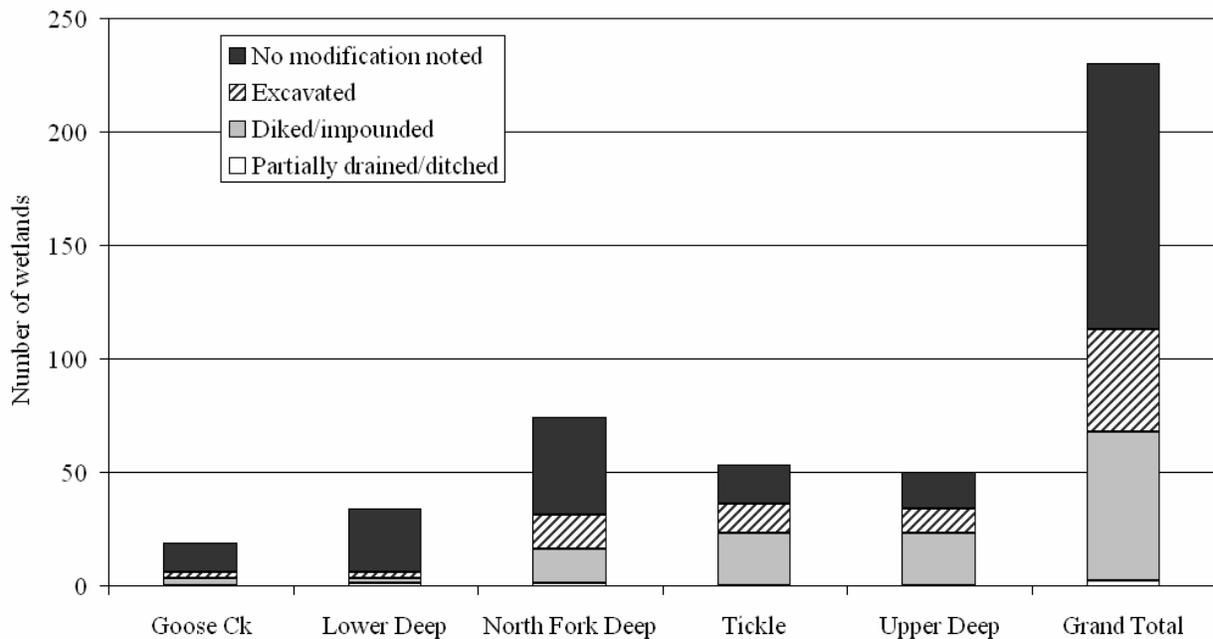
with the exception of Lower Deep. In the subwatersheds where scrub-shrub wetlands are found they make up from 3% (Upper Deep) to 42% (Goose Ck) of the total wetland area.

Palustrine unconsolidated bottom wetlands are those wetlands whose substrate is primarily mud or exposed soils, and have less than 30% vegetative cover. Palustrine unconsolidated bottom wetlands are only found in the Tickle and Upper Deep Creek subwatersheds, where they make up 14% and 18% of the total wetland area respectively.

Many wetlands have been created, modified or destroyed through the intentional or unintentional actions of humans. The NWI attempted to identify these modifications where possible. Three of these “special modifiers” (Table 3-4) were noted for wetlands within the Deep and Goose Creek watersheds:

- Excavated wetlands: Wetlands that lie within a basin or channel excavated by humans.
- Diked/Impounded wetlands: Diked wetlands are created or modified by a human-made barrier or dike designed to obstruct the inflow of water. Impounded wetlands are created or modified by a barrier or dam which purposefully or unintentionally obstructs the outflow of water.
- Partially drained/ditched: The water level in these wetlands has been artificially lowered, but soil moisture is still sufficient to support wetland vegetation.

Excavated wetlands were found primarily within the North Fork Deep (15 occurrences), Tickle (13 occurrences), and Upper Deep (11 occurrences) subwatersheds; the remaining subwatersheds having only three occurrences each (Figure 3-12). Wetland modifications due to dikes and impoundments were identified in all subwatersheds, but were most frequent within the Upper Deep, Tickle, and North Fork Deep subwatersheds. Only two occurrences of partially drained/ditched wetlands were noted, one each in the Lower Deep and North Fork Deep subwatersheds. Further discussion of possible wetland loss not captured by the NWI is included in section 2.4.3.2.2 of this report.



**Figure 3-12. Frequency of wetland modifications. Data source: USFWS (2004).**

### 3.5 INFORMATION GAPS AND MONITORING NEEDS

The information generated for this report was sufficient to characterize current riparian conditions within the Deep and Goose Creek watershed; consequently, few information gaps are identified here pertaining to riparian conditions. The following are recommendations that address the most significant information gaps affecting the assessment presented above:

- Quantify current large woody material (LWM) loadings within streams.

Prioritization of riparian enhancement activities should take into consideration current levels of LWM loadings within streams so as to identify those reaches where enhancement or recruitment potential is most critical. ODFW collected habitat data in Deep and Tickle Creeks in 2003 these survey found low levels of in-channel LWM in almost all reaches sampled. The conditions in other portions of the watershed are unknown but also likely low. While quantifying LWM loadings, ground-truthing of riparian vegetation types and shade levels should be conducted.

- Investigate historical extent of wetlands within the watershed.

The current wetland density within the watershed is very low (approximately 1% of the watershed area is in wetlands). A comparison of current wetland area to watershed area

containing hydric soils (Section 2.4.3.2.2) indicates that wetlands may have historically occupied a much larger area within the watershed than they currently do. Further analysis is needed to define the historic extent of wetland area within the watershed.

- Perform functional assessment of wetlands within the watershed.

More information on wetland condition and function is needed in order to identify and prioritize wetland enhancement efforts. It is recommended that a comprehensive wetland inventory and functional assessment be conducted for the watershed. Examples of wetland inventories, and assistance in developing an inventory for the watershed, can be obtained from the Oregon Division of State Lands.

### 3.6 RECOMMENDATIONS AND POSSIBLE COUNCIL ACTIONS

- Protect and enhance riparian areas watershed-wide

The following protection/enhancement recommendations are grouped by the six riparian recruitment situations described in section 3.3.1.3 above. Prioritization of protection/enhancement actions should favor those streams 1) that currently have (or have the potential for, 1) fish usage, 2) having channel characteristics that are most responsive to inputs of large woody material, and 3) that are limited with respect to stream shading:

**Satisfactory**: Current riparian recruitment potential is satisfactory as compared with potential conditions for the ecoregion. No enhancement needed to achieve the potential conditions for the portion of the watershed where these RCUs occur. RCUs included in this grouping generally consist of dense stands of medium- to large-sized conifers within at least a portion of the riparian zone. Protect these areas.

**Approaching satisfactory**: Trees within the RCUs that are included in this classification are smaller than the potential size for the ecoregion; however, the trees are of an adequate size to currently provide adequate LWM recruitment and shade. These stands are not as productive (in terms of riparian function) as they can be. However, if protected, these stands will attain potential conditions over time. RCUs included in this grouping generally consist of dense stands of medium-sized conifers and mixed conifer/hardwood within at least a portion of the riparian zone. No active enhancement actions are recommended for the majority of these stands. Protect these areas.

**Hardwood**: Trees within these stands are generally approaching a size that is large enough to provide satisfactory recruitment potential, but are dominated by hardwoods where the potential vegetation is conifer or mixed stands. RCUs included in this grouping generally consist of dense stands of medium-sized hardwood trees. Appropriate enhancement techniques may include conversion of some of these areas over time to conifer stands. However, many of these stands have some recruitment potential at present, and any conversion should be considered in light of other considerations (e.g., wildlife and aesthetic concerns). Among the hardwood-dominated stands, only areas that consist primarily of alder (which is short-lived and usually

converts to salmonberry over time) should be considered for active restoration. Given that the following categories (i.e., Narrow Buffers, Small-Sparse, and Absent) represent conditions where significantly less riparian recruitment potential currently exists, the hardwood dominated stands should be the lowest priority for active enhancement activities.

**Narrow buffers:** RCUs included in this classification generally have trees in the near-stream area that are of a size (generally medium-sized , with a few areas of large-sized trees) and species (conifer or mixed conifer/hardwood) approaching satisfactory relative to potential conditions. However, these areas are very narrow. The source of limitation includes agricultural operations, residential/commercial development, infrastructure (roads, power lines, etc.), and past logging. The outer (farthest from the stream) portions of these stands consist of a variety of vegetation types and sizes. Within areas of forestry land use the stands generally consist of regeneration-sized (<4 inch average DBH) and small-sized (4-12 inch average DBH) conifers and mixed conifer/hardwoods. Tree and shrub vegetation is absent in many areas of agricultural and residential land use. Some areas would benefit from active enhancement techniques such as releasing the conifer component (if present) in hardwood-dominated portions of the stands, converting hardwood-dominated stands to conifer, under-planting sparse stands, or density management (commercial thinning) to accelerate structural development in conifer stands.

**Small-sparse:** This grouping of RCUs includes both stands of small- or regeneration-sized trees, and sparse stands of medium- and large-sized trees. In both cases current recruitment potential is far removed from potential conditions, however (unlike the following grouping), these stands are forested. Active enhancement would greatly benefit many of these stands. Appropriate enhancement techniques may include releasing the conifer component in small mixed-species stands, converting the hardwood-dominated stands to conifer, under-planting sparse stands, or density management (commercial thinning) to accelerate structural development in conifer stands.

**Absent:** This grouping includes RCUs that are devoid of riparian tree vegetation. Vegetation within the RCUs included in this grouping consists primarily of riparian grass species, brush species, and non-riparian vegetation (cropland, pasture, and some areas of non-native vegetation). In most cases these would be the highest priority areas for enhancement. Appropriate restoration/enhancement techniques would include riparian plantings.

Due to the generally poor recruitment potential at this time, active enhancement through density management (i.e., commercial thinning) is recommended for many of the RCUs summarized above. Density management can accelerate not only LWM potential, but provide landscape diversity and wildlife connectivity. See the Clear and Foster Creek watershed analysis (WPN, 2002) for a discussion on implementing density management / thinning practices.

### **3.7 REFERENCES**

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## 4.0 SEDIMENT SOURCES

### 4.1 INTRODUCTION

The erosion, transport, and deposition of sediment are processes that occur naturally in every watershed. In areas with relatively high precipitation, such as the western Pacific Northwest, physical and chemical weathering processes break down rocks into smaller fragments and dissolved constituents and streams transport them through the watershed. As the sediments move through the watershed, they are deposited for short or long periods of time within the stream channels or on floodplains, and eventually are transported out of the watershed.

Human activities can change the amount of sediment supplied to and moved through streams by removing protective vegetation, re-grading slopes, or changing the amount and timing of streamflows. Increased sediment production can result in aggradation in streams, high turbidity levels, or changes to aquatic habitat. Reduced streamflows as a result of water withdrawals, or increased peak flows from impervious areas such as parking lots, can also alter aquatic habitat by changing the transport of sediment.

The primary types of erosion processes that occur in the Pacific Northwest are mass wasting (such as landslides and debris flows) and surface erosion. As a result of the flat topography in much of the Deep and Goose creek watersheds, mass wasting processes are limited to the steep valley sides along the incised major streams. Surface erosion can occur wherever the ground is bare, such as construction sites, tilled fields, or around crops. Wind erosion can also occur during periods of dry, windy weather on areas with exposed soil.

### 4.2 CRITICAL QUESTIONS

The purpose of this module is to assess the locations and significance of sediment sources in the Deep Creek and Goose Creek basins, including both natural processes (and the physical conditions that control them) and those produced or affected by land use. The assessment of sediment sources is usually divided into separate evaluations of mass wasting (i.e., landslides and debris flows) and of surface erosion (from roads, agricultural, and other lands). Since an important part of this module is the determination of relative significance, it is desirable to integrate the mass-wasting and surface-erosion elements sufficiently to rank the various sources and processes together.

The critical questions are:

***Question 4-1: At present, what are the important sediment sources in the watershed?***

***Question 4-2: In the future, what will be the important sources of sediment in the basin?***

***Question 4-3: Where are severe erosion problems that are manageable, so as to be assigned a high priority for remediation techniques or projects?***

## **4.3 METHODS**

### **4.3.1 General Approach**

Potential sediment sources in the Deep and Goose creek watersheds were assessed based on a review of existing data, maps, GIS layers, and aerial photographs, with a one-day field visit. This limited scope provided enough information to identify the major potential sediment sources in the watershed and the relative risks of erosion from different activities in the watershed, but did not allow for quantification of sediment inputs, transport, or depositional processes.

### **4.3.2 Background Information**

Geologic mapping compiled by Schickler and Finlayson (1979), Walker and MacLeod (1991) and Walker et al. (2003) were the most recent products available for the Deep and Goose Creek area. Soil information from the Natural Resource Conservation Service (NRCS 1985 and 1998; formerly the Soil Conservation Service) was used to provide a map and information on soil properties and erosion hazards. Information on slope gradient and topography was generated from a 10-meter DEM (digital elevation model; USGS 1999a). Land cover data generated by the United States Geological Survey (USGS 1999b) was used to identify areas with different vegetation/land use types.

The Clackamas County GIS coverage of roads and streets was used to identify mapped highways, arterials, and local roadways (Clackamas County 2003). Based on field verification by the stream crossing field crew and perusal of the 1998 aerial photographs, this road coverage did not include all of the roadways on private lands used for agriculture, forest management, and local access purposes.

### **4.3.3 Surface Erosion**

Surface erosion was assessed based on existing topography, soil, land cover, stream, and road layers in the GIS. The highest probability of delivering soil to streams occurs where land use that results in bare soil conditions is on erodible soils and close to streams. The GIS layers were overlain to determine the acres of different land cover/land use types in close proximity to streams with different soil types and slope gradients. Recent aerial photographs (SBG 1998 and 2002) were also examined to identify relative amount of bare ground associated with different land use types. Helpful conversations with the Clackamas County Soil and Water Conservation District employees also provided information about land use and conservations practices in the area (R. Gruen and C. Klock, personal communication).

Unpaved roads and road ditches can also be a source of eroded sediment. The road and stream GIS layers were overlain to determine number and location of road crossings where roads and ditches could deliver sediment to streams. The field inventory of road crossings (see fish passage section) was also used to identify locations of private roads not in the GIS road layer. These locations were inspected on the aerial photographs to determine if the roads appeared to be paved or not.

#### **4.3.4 Mass Wasting**

Mass wasting was assessed based on an existing mapping of landslides, debris flows, and slumps produced by Schlicker and Finlayson (1979). In addition, the aerial photos were reviewed to look for evidence of more recent mass wasting.

### **4.4 RESULTS**

#### **4.4.1 Geology: Rocks, Soils, Landforms**

The geologic history of the lower Clackamas region, spanning about 15 million years has been characterized by the interaction of the volcanic and stream erosion and depositional processes along the border between the Cascade Range and the Portland Basin (part of the Willamette structural trough). The materials include volcanic and sedimentary rocks: basalt and andesite flows; relatively soft conglomerate, sandstone, mudstone, and siltstone; and unconsolidated river terrace deposits. Mapped geologic units are shown on Map 3. A brief description of the major geologic units is included in the following sections; more information is available in Schlicker and Finlayson (1979) and Walker and MacLeod (1991).

##### **4.4.1.1 Troudale Formation, Sandy River Mudstone**

As the Cascade Range rose (starting about 4 million years ago), the ancestral Columbia River and streams flowing off the growing mountains deposited sediments in the trough to the west. These fluvial conglomerates, sandstones, and siltstones form on of the thickest layers of materials in the Portland Basin. In the study area, they form the canyon walls in the incised stream valleys of Deep and Tickle creeks.

The fine-grained lower unit, the Sandy River Mudstone (or mudstone and siltstone member of the Troutdale Formation), is mostly well-cemented, thin-bedded siltstone and fine sandstone. The Troutdale Formation (or conglomerate member of the Troutdale) consists primarily of gravel and sand, also well cemented, typically exposed above the mudstone units. These names indicate river deposits formed in the channel (conglomerates and gravels) or overbank floodplains (fine sands, silts, organic matter) of the ancient rivers. The units likely interfinger with each other in many areas.

##### **4.4.1.2 Boring Lava**

Volcanic activity extended across the Portland Basin in the late Pliocene and Pleistocene (about 3.2-0.5 million years ago). Dozens of volcanic vents in the area erupted intermittently, forming cinder cones, shield volcanoes, and some extensive lava plateaus. The Boring Lava, named for the Boring Hills, includes basalt, agglomerate, and tuff-breccias. The Clackamas River and its tributaries later eroded into the formerly nearly-continuous surface of the Boring Lavas and cones that probably once stretched from Oregon City to the Cascade foothills.

The Boring Lava include dense rocks, more porous lavas, breccias, and mudflow deposits. In places where they were not covered by later deposits, these rocks can be deeply weathered, in many cases leaving only scattered boulders in clay saprolite. One of the former cinder cone/vents can be seen in the cone-like hill along the very northern boundary of the Deep Creek watershed.

#### **4.4.1.3 Pliocene-Pleistocene Gravels**

During the time that the intermittent volcanic activity that produced the Boring Lava was occurring, streams continued to flow over the area, eroding and depositing sediment in much the same manner as in the present time. These streams deposited the gravels, conglomerates, and finer-grained sedimentary units that cover most of the flat upland surfaces in the watersheds. These sediments likely interfinger with the Boring Lava in many locations since they were laid down contemporaneously.

#### **4.4.1.4 Pleistocene Terrace Deposits**

A large river, probably the ancestral Clackamas, eroded into the volcanic and sedimentary rocks, and left broad terraces on both sides of the present-day Clackamas River. These Pleistocene terrace deposits consist of gravel, sand, and finer-grained sediments and are not as deeply weathered as the older Plio-Pleistocene gravels that remain on the higher surfaces in the watershed.

#### **4.4.1.5 Landforms**

The topographic map shows four primary landform types in the Deep and Goose Creek Watershed. These landforms result from the volcanic processes that shaped the areas and subsequent stream and river erosion and roughly follow the geologic map units (Map 3).

- Volcanic (cinder) cones – there are 2 small volcanic cones along the northern boundary of the assessment area, just east and northwest of the town of Boring. These were formed around volcanic vents and are mapped as Boring Lava.
- Plateaus and upper terraces – the relatively flat and gently sloping upland areas in the upstream portions of each of the sub-basins are plateaus and higher elevation terraces (mapped as Plio-Pleistocene gravels and sedimentary rocks).
- Incised stream valleys – the steep areas along the main stream and tributary channels of Noyer Creek, North Fork Deep Creek, Tickle Creek, and Deep Creek are the result of incision by the streams through the upper terrace deposits into the underlying formations (Troutdale formation and Sandy River Mudstone). These are the primary locations where mass wasting can occur.
- Lower alluvial terraces – the broad, flat terrace along the southern boundary of the watershed was cut by the Clackamas River. This area is mapped as Pleistocene Terrace Deposits on Map 3.

#### 4.4.1.6 Soils

Soil is formed by the combination of weathering of parent material (geologic units) and organic processes, and is influenced by climate, topography, and the length of time the soil has to develop before major disturbance. The NRCS soil map layer (Map 4) has over 50 soil units within the Deep and Goose Creek watersheds, however there are 6 main soil units. The properties of the primary soil units are shown in Table 4-1.

**Table 4-1. Erosion Properties of Primary Soil Units (source NRCS 1985).**

Soil Unit Name	Percent of Watershed Area	Soil Texture	Permeability	Hazard of water erosion <sup>1</sup>	Kf erodibility factor <sup>2</sup>
Cazadero Silty Clay Loam	37%	Silty clay loam	Moderately slow	Slight to moderate	0.28
Bornstedt Silt Loam	17%	Silt loam to silty clay loam	Slow	Slight to severe	0.32-0.37
Cottrell Silty Clay Loam	10%	Silty clay loam	Moderately slow	Slight to moderate	0.24-0.43
Klickitat Stony Loam	8%	Stony loam to very gravelly clay loam	Moderate	Severe	0.24-0.28
Delena Silt Loam	5%	Silt loam to silty clay loam	Moderate to Slow	Slight	0.2-0.43
Alspaugh Clay Loam	4%	Clay loam	Moderately slow	Low-moderate	0.28-0.32

<sup>1</sup> The hazard of water erosion depends upon slope gradient; erosion hazard is higher on steeper slopes.

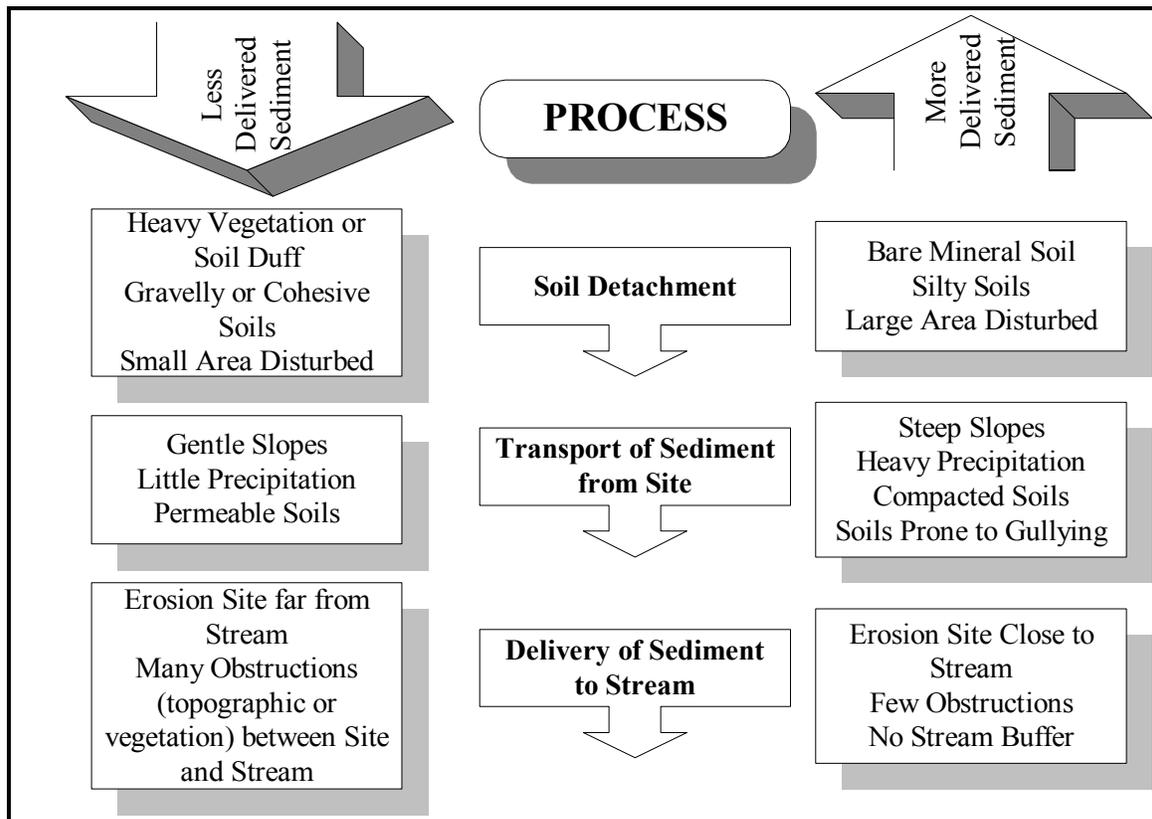
<sup>2</sup> The Kf factor is a measure of the erodibility of the soil when disturbed. Higher Kf factors indicate more erodible soil.

Soils in the watershed are primarily fine-grained silty loams and silty clay loams. They have low permeability and are poorly drained. Erosion hazard ranges from slight on gentle slopes (less than 5 percent) to severe on steep slopes (over 15-30 percent). The soils are suitable for farming, crops, and timber production. Some soils can develop a hard pan (hard, impermeable layer) which inhibits drainage. Soil strength of some soils is low, affecting bearing strength for building.

#### 4.4.2 Surface Erosion

Surface erosion is the detachment of individual soil particles by water, wind, or dry ravel. Erosion of surface soil horizons can reduce the productivity of a site. Surface erosion produces fine-grained sediment (sand, silt, clay) that can increase turbidity and harm fish and other aquatic organisms if it enters streams. Surface erosion can be understood as three processes: soil detachment, transport of soil from the site, and delivery of sediment to a stream. The relative probability that each of these erosion, transport, and delivery processes will occur in a specific

location is dependent upon factors such as soil erodibility, ground cover, rate of precipitation, slope gradient, distance from a stream, and presence or absence of stream buffers. (Figure 4-1).



**Figure 4-1. Factors Affecting Surface Erosion, Transport, and Delivery to Streams.**

In the Deep and Goose creek watersheds, surface erosion on undisturbed areas is low because the humid climate allows thick vegetation to grow, protecting the soil from erosion. However, disturbance of the soil can remove the protective vegetative cover and result in erosion. If erosion occurs in close proximity to a stream or wetland with no buffers, eroded soil can be delivered to the waterbody. The primary land use activities in the watershed that result in disturbed soil are agriculture/forestry, roads, and construction sites. Table 4-2 shows the number of acres of each landcover type in close proximity to streams in the sub-basins.

**Table 4-2. Acres of Land by Cover Type within 200 feet of Streams (source USGS 1999b).**

<b>USGS Landcover</b>	<b>Goose Ck</b>	<b>Lower Deep</b>	<b>North Fork Deep</b>	<b>Tickle</b>	<b>Upper Deep</b>	<b>Grand Total</b>
Forest	131	398	421	920	1,063	2,933
Commercial/Industrial/Transportation	4	13	37	19	5	78
Urban/Residential	19	22	108	52	17	218
Grassland/Shrubland	15	23	78	56	33	205
Pasture	125	196	371	280	197	1,168
Row Crops	11	48	204	60	31	354
Orchards/Vineyards	1	4	27	5	3	39
Total	306	704	1,246	1,391	1,348	4,996

#### **4.4.2.1 Agricultural and Forest Land**

Most of the flat, rural areas in the Deep and Goose Creek watersheds are used for agriculture (USGS 1999b; Figure 1-11). The primary uses are for growing nursery stock, Christmas trees, berries, pastures, and row crops. Much of the steep stream valley sidewall areas is forested. The amount of ground disturbance in the watershed varies by agricultural and forestry use as well as conservation measures used by individual landowners.

Traditional practices for nursery stock, berries, row crops and Christmas trees result in bare soil conditions between cultivated plants (R. Gruen and C. Klock, personal communication). Approximately 8 percent of the area in close proximity to streams (within 200 feet) in the Deep and Goose Creek basin is characterized by row crops, orchards, or vineyards (Table 4-2; USGS 1999b), with higher percentages in North Fork Deep Creek (18%) and lower percentages in the other sub-basins. Nursery stock that is harvested as ball and burlap plants are generally harvested in the late winter, and can result in bare soil through the rest of the rainy season. Some landowners in the watershed practice conservation measures to limit bare soil and delivery to streams. These measures include planting cover crops (permanent or annual) between row crops to reduce erosion and soil loss, use of sediment basins to capture eroded soil, and stream buffers to help filter out any soil transported toward streams.

Ground cover in pasturelands can vary widely depending on how heavily these lands are used. Approximately 23 percent of the area close to streams is used for pasture or hay (Table 4-2; USGS 1999b). Goose Creek has the highest percentage of pastureland close to streams (42%), and Upper Deep has the lowest percentage (15%). Management practices that result in higher ground cover in pastures include light stocking densities and rotational grazing. Vegetative buffers and fencing to keep stock away from streambanks also reduce sediment input to streams.

The majority (58 %) of steep stream valley sides and valley bottoms in the watershed are forested (Table 4-2; USGS 1999b). Inspection of the 1998 aerial photographs indicates that mature forest cover is present in most of these areas. Some areas are being managed for timber

production and show signs of recent harvest. Timber harvest can result in short-term increases in surface erosion if the ground cover is disturbed by burning or other site preparation techniques. However, areas revegetate quickly and surface erosion is short-lived. Stream buffers and leaving ground cover during harvest can reduce surface erosion on managed lands.

#### 4.4.2.2 Roads

Erosion from unpaved roads and from road ditches along all types of roads can be a source of fine-grained sediment. This sediment can be delivered to streams if the roads/ditches drain directly to streams, or to areas within 200 feet of streams (Megahan and Ketcheson 1996). Dirt or gravel roads can be a large sediment source if they are heavily used during wet weather conditions. Road ditches can also be a source of sediment if they are re-graded just prior to or during the rainy winter season.

In the Deep and Goose Creek watersheds, there are 44 locations where paved roads cross streams, and 135 locations where unpaved roads cross streams (Table 4-3). Site-specific data on the erosion characteristics of these roads and stream crossings was not available, but each location is a potential source of sediment delivery to a stream.

**Table 4-3. Number of Road Stream Crossings (source: Clackamas County GIS 2003, field checked by Jenny Walsh).**

Road Type	Goose Ck	Lower Deep	North Fork Deep	Tickle	Upper Deep	Grand Total
Paved road	2	7	16	13	6	44
Unpaved road	16	12	34	37	36	135

There are also many miles of roads in close proximity to streams (within 200 feet). Nearly 7 miles of paved road and at least 12 miles of unpaved roads are close to streams (Table 4-4). The length of actual unpaved road near streams is likely higher than those listed in Table 4-4 because the field inventory of road crossings done for the fish passage analysis found over 60 stream crossings that were associated with roads that were not on the GIS road layer. These were primarily on unpaved roads on private lands, used for access to agricultural or forested areas.

**Table 4-4. Miles of Road within 200 feet of Streams (source Clackamas County GIS 2003).**

Road Type	Goose Ck	Lower Deep	North Fork Deep	Tickle	Upper Deep	Grand Total
Paved Road	0.2	1.3	2.5	2.1	0.8	6.9
Unpaved Road	1.3	1.0	2.3	4.0	3.1	11.6

Road management practices that can limit the amount of sediment that reaches streams include surfacing the portion of roads that drain to streams with gravel or asphalt, restricting the use of

unpaved roads during wet weather, limiting the number of stream crossings, and limiting grading of road ditches to the dry summer season.

#### **4.4.2.3 Construction Areas**

During construction of houses, commercial buildings, parking lots, and other structures, the surrounding land is generally disturbed and graded, resulting in bare soil. While the area disturbed for each structure is small and only disturbed for approximately 6 months until construction is completed, the cumulative effects of these sites over the entire watershed and through time could be larger. This is especially true in areas around towns and populations centers that will be subjected to increased construction as more homes are built. Proper erosion control techniques and ordinances could reduce this potential sediment source. Use of silt fences, temporary cover, and stream buffers all reduce erosion and/or delivery of sediment to streams.

#### **4.4.3 Landslide-Prone Areas**

Landslides do not appear to be a major source of sediment in the Deep and Goose Creek watershed. The majority of the watershed is flat or gently sloping and not susceptible to mass movements. The areas prone to landslides are the steep valley walls along major streams (Figure 1-7; Schickler and Finlayson 1979). While these areas are close to streams, resulting in likely delivery of sediment, inspection of the recent aerial photographs only showed a few new, small slides in these areas. These areas are also generally forested, reducing the likelihood of mass wasting. If these areas are clearcut, landslide potential increases for approximately 20 years until trees regrow sufficiently to increase root strength.

#### **4.4.4 Sediment Source Summary**

Based on existing information, surface erosion from areas of bare soil is most likely the dominant sediment source in the Deep and Goose Creek watersheds. Land use practices that result in soil disturbance and potential soil loss include agriculture (nursery stock, Christmas trees, row crops, berries, pasture); timber production; unpaved roads and road ditches; and construction. Disturbed areas in close proximity to streams pose the greatest risk of delivery of eroded sediment to streams. Conservation practices can greatly reduce soil loss and delivery of eroded sediment to streams. These include use of cover crops on agricultural lands, limiting stream crossings on unpaved roads, limiting disturbance of roadside ditches, temporary cover and use of silt fences on construction sites, and retention of streamside buffers.

Mass wasting (landslides) are likely a relatively minor sediment source in the Deep and Goose Creek watersheds due to the gently sloping topography. The only areas prone to landslides are the steep valley walls along major streams and tributaries; these areas are currently forested, reducing the potential for mass wasting.

#### **4.5 INFORMATION GAPS AND MONITORING NEEDS**

Insufficient information exists to quantify sediment sources. Quantification of surface erosion sources (agricultural lands, roads, construction areas) could be accomplished through use of models such as the USLE (Universal Soil Loss Equation), WEPP (Water Erosion Prediction Project) or SEDMODL2. If quantification of specific areas is needed, it would require field verification of parameters such as site-specific ground cover density, slope gradient, length and width of disturbed areas, and distance to streams. Quantification of mass wasting sources could be done through an inventory using historical aerial photographs.

#### **4.6 CONCLUSIONS AND RECOMMENDATIONS**

Surface erosion from disturbed areas is likely the largest sediment source in the Deep and Goose Creek watersheds. Land uses that can result in soil disturbance include agriculture (nursery stock, Christmas trees, berries, row crops, and pasture); timber harvest, unpaved roads and road ditches; and construction sites. Conservation practices that can reduce soil loss and delivery of sediment to streams vary widely by landowner and include use of cover crops, rotational grazing, reducing road/stream crossings, limiting clearing or road ditches, use of silt fences around construction sites, and retention of stream buffers.

Continue education and financial incentives for landowners, county road engineers, and builders regarding the importance of maintaining ground cover and stream buffers on their land, roads, and road ditches will continue to help limit soil loss and delivery of sediment to streams in the watershed.

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## **5.0 WATER QUALITY**

### **5.1 INTRODUCTION**

This section of the watershed analysis report presents the results of the water quality assessment. The water quality assessment uses existing information to summarize what is known about water quality patterns in the Deep and Goose Creek Watersheds. The results are followed by recommendations regarding steps that can be taken to improve water quality conditions.

Water quality – the biological, chemical, and physical properties of water – is an important indicator of the health of the watershed. Biological characteristics of water quality include bacterial indicators, the composition and abundance of algae, and the status of populations of aquatic insects and other organisms (macroinvertebrates). Chemical and physical characteristics include factors such as nutrients, sedimentation, temperature, dissolved oxygen, and introduced chemical contaminants.

### **5.2 CRITICAL QUESTIONS**

In order to guide the assessment, a number of critical questions were developed during the project scoping.

*Question 5-1: What are the designated beneficial uses for streams in the watershed?*

*Question 5-2: What are the water quality criteria that apply to streams in the watershed?*

*Question 5-3: Are there stream reaches identified as water quality limited on the State’s 303(d) list?*

*Question 5-4: What do water quality studies, existing data sets, or other summary documents indicate about water quality conditions?*

*Question 5-5: What are the key data/information gaps in water quality information?*

### **5.3 METHODS**

The purpose of the water quality section is to evaluate existing information sources, identify data gaps, and identify opportunities for water quality improvement. The Oregon Department of Environmental Quality (DEQ) provided information on beneficial uses, water quality criteria, and the list of “water quality limited” stream segments. Where appropriate, water quality characteristics are described in terms of the existing State of Oregon water quality standards.

Existing water quality information was obtained from cooperators of the CRBC and from agency websites. Relevant sources of water quality information are listed in Table 5-1. Reports that are more general to the Clackamas River were described in the Deep Creek Report (WPN, 2002) and are not repeated here. This report focuses on sources of water quality data in the Deep Creek watershed and its applicability to project objectives.

Sources of water quality degradation are assessed in other sections of this report: 1) sediment and related pollutants are evaluated in the Sediment Chapter (4.0), 2) Riparian shade conditions that influence temperature are assessed in the Riparian Habitat Condition Chapter (Section 3.4.3 ), and potential contaminant sources based on the Source Water Assessment are discussed in Section 5.4).

**Table 5-1: Water Quality Data and Information for Deep Creek.**

<b>Applicable Water Quality Reports &amp; Data Sets in Deep Creek</b>	
Clackamas County SWCD, 2001	<p><b>Report Title:</b> Tributaries of the Clackamas River Watershed.</p> <p><b>Topic: Nutrients, turbidity, bacteria</b> Six monitoring sites in Deep Creek, sampled monthly in 2001.</p> <p><i>A primary source of data for the watershed assessment.</i></p>
Student Academy, 2004	<p><b>Report Title:</b> Not a report, on-line database.</p> <p><b>Topic: Chemistry and Temperature Data</b> Eight chemistry stations in Deep Creek sampled quarterly or less. Three temperature stations in Deep Creek watershed.</p> <p><i>Three temperature stations used in this report.</i></p>
Carpenter, K. 2003	<p><b>Report Title:</b> Water quality and algal conditions in the Clackamas River Basin.</p> <p><b>Topic: Nutrients and Algae</b> Clackamas River scale study; includes one station in Deep Creek. Provides river basin scale framework to interpret nutrient effects.</p>
Shibahara, T. 1999	<p><b>Report Title:</b> Excel spreadsheet data base.</p> <p><b>Topic: Temperature</b> <i>Temperature data in Deep Creek watershed for 1997, 1998, 1999.</i></p>

## RESULTS

### 5.3.1 Designated Beneficial Uses

The protected beneficial uses are designated at the river basin level in the State of Oregon water quality rules as indicated in Table 5-2. Beneficial uses in Deep Creek encompass human needs of water such as drinking water supply and irrigation, as well as the needs of fish, wildlife, and

aesthetics. Fisheries and drinking water supply are the most sensitive uses to pollution so assessing these uses also provides a sufficient assessment for other uses as well.

**Table 5-2: Beneficial uses of water protected in the Clackamas River Basin.**

<b>Beneficial Uses: Clackamas River Basin (OAR 340-41-442)</b>	
Public Domestic Water Supply*	Salmonid Fish Spawning
Private Domestic Water Supply*	Resident Fish & Aquatic Life
Industrial Water Supply	Wildlife & Hunting
Irrigation	Fishing
Livestock Watering	Boating
Anadromous Fish Passage	Water Contact Recreation
Salmonid Fish Rearing	Aesthetic Quality
	Hydro Power
*With adequate pretreatment (filtration and disinfection) and natural quality that meets drinking water standards. (ODEQ 2001b).	

### 5.3.2 Water quality criteria.

***Key Question: What are the water quality criteria that apply to streams in the watershed?***

*Water quality criteria* are defined to protect the beneficial uses of water, and are comprised of numeric criteria and narrative standards. Criteria applicable to issues identified in Deep Creek are listed in Table 5-3. This includes numeric criteria from the state regulations for dissolved oxygen, pH, total dissolved solids, water temperature, bacteria, and toxic substances. Evaluation criteria are numeric values based on the literature; these are listed to provide guidance in interpreting the narrative standards.

**Table 5-3: Abbreviated summary of applicable water quality criteria.**

<b>Parameter (Beneficial Use)</b>	<b>Criteria Type/ Measurement</b>	<b>Criteria *</b>
<b>Dissolved Oxygen</b> (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria  Dissolved oxygen (mg/L)	Salmonid Spawning: Greater than 11.0 mg/L  Cold Water Aquatic Life: Greater than 8.0 mg/L.  (Several conditions apply, refer to State standards for details.)
<b>pH and TDS</b> (Resident fish and aquatic life, water contact recreation)	Numeric Criteria (pH) (Total Dissolved Solids)	pH: 6.5 – 8.5  TDS: 100 mg/L
<b>Nutrients</b> (Aesthetics)	Narrative Criteria  (phosphorus, nitrates)	No State numeric criteria.  Recommended criteria for Willamette Valley streams. (EPA 2001) Total Phosphorus 0.04 mg/L (40 µg/L) Nitrates 0.15 mg/L (150 µg/L)
<b>Temperature</b> (Resident fish and aquatic life, salmonid spawning and rearing)	Numeric Criteria  (temperature)	Salmonid fish core areas: 60.8 ° F (16° C)  Salmon and Trout rearing and migration: 64 ° F (17.8° C)  Salmonid spawning: 55.4 ° F (13° C)
<b>Turbidity</b> (Resident fish and aquatic life, water supply, aesthetics)	Narrative Criteria  (turbidity (NTU))	Not greater than 10% increase over natural stream turbidity (ODEQ 2001b).  Screening criteria for aquatic life– 50 NTU (WPN 1999)  Screening criteria for slow sand filter (National Drinking Water Clearinghouse 2000)
<b>Bacteria</b> (Water contact recreation)	Numeric Criteria  <i>Escherichia coli</i>	126 colonies/100 ml. (30 day log mean)  406/100 ml. (Single sample)
<b>Toxics</b> (Resident fish and aquatic life)	Numeric Criteria	Numeric criteria are identified for 120 organic and inorganic toxic substances in Table 20 in the Oregon Water Quality Standards (ODEQ 2001b).
<b>Biological Criteria</b> (Resident fish and aquatic life)	Narrative Criteria  (measured using macroinvertebrates)	Waters of the State shall be of sufficient quality to support aquatic species without detrimental changes in the resident biological communities.
<b>Sedimentation</b> (Resident fish and aquatic life, salmonid spawning and rearing)	Narrative Criteria	Formation of bottom deposits deleterious to fish or other aquatic life or injurious to public health, recreation, or industry are not allowed.
* This description of criteria is abbreviated. Most criteria have associated conditions and exceptions that apply. The full text of the regulations should be used for a specific application (ODEQ 2004).		

### 5.3.3 Stream reaches on the State's 303(d) list

**Key Question:** *Are there stream reaches in the watershed identified as water quality limited on the State's 303(d) list?*

The federal Clean Water Act requires states to maintain a list of “*water quality limited streams*” that do not meet water quality standards.

The lower Clackamas River, from River Mill Dam to the mouth, is listed in the 1998 303(d) list for temperature, and Deep Creek is listed in the 2002 303(d) list for bacteria. The recommendations from this assessment will be developed to improve water quality and address the 303(d) listing.

**Table 5-4: 303(d) listed waters applicable to Deep Creek watershed (ODEQ 2004b).**

<b>Stream Segment (Description)</b>	<b>Parameter/ Criteria</b>	<b>Supporting Data or Information</b>
<b>Clackamas River</b> Mouth to River Mill Dam (2002 303(d) List.	<b>Temperature</b> Rearing 64° F (17.8 C) Season: Summer	DEQ Data (Site 402913; RM 1.2): 76% (39 of 51) Summer values exceeded temperature standard (64) with exceedances each year and a maximum of 75.2 in WY 1986 - 1995; 7 day average of daily maximum of 70.4 exceeded standard (64) in 1995.
<b>Deep Creek, RM</b> 1.9 to 14.1 (2002 303(d) List.	<b>E Coli</b> 126 organisms per 100ml, no single sample > 406	Clackamas county data. Site 502 RM 6.7: 3/8 samples > 406.

### 5.3.4 Water Quality Conditions

#### 5.3.4.1 Background

Information was available on a number of water quality parameters. This report will focus on those parameters most relevant to fisheries and domestic water supplies. The information will be evaluated in the following order: nutrients, bacteria, turbidity and water temperature. Nutrient concentrations and water temperature are fundamental measures of ecological health, and directly relate to support of fish and aquatic communities. Turbidity, an indirect measure of suspended sediment, and bacteria are evaluated in relation to protection of domestic water supplies. There is minimal information regarding contaminants or biological indicators in Deep Creek, so we will not address this topic. The reader is directed to a detailed study being completed by the USGS at the Clackamas River Basin scale which is to be published in 2004.

### 5.3.4.2 Flow and Climatic Patterns

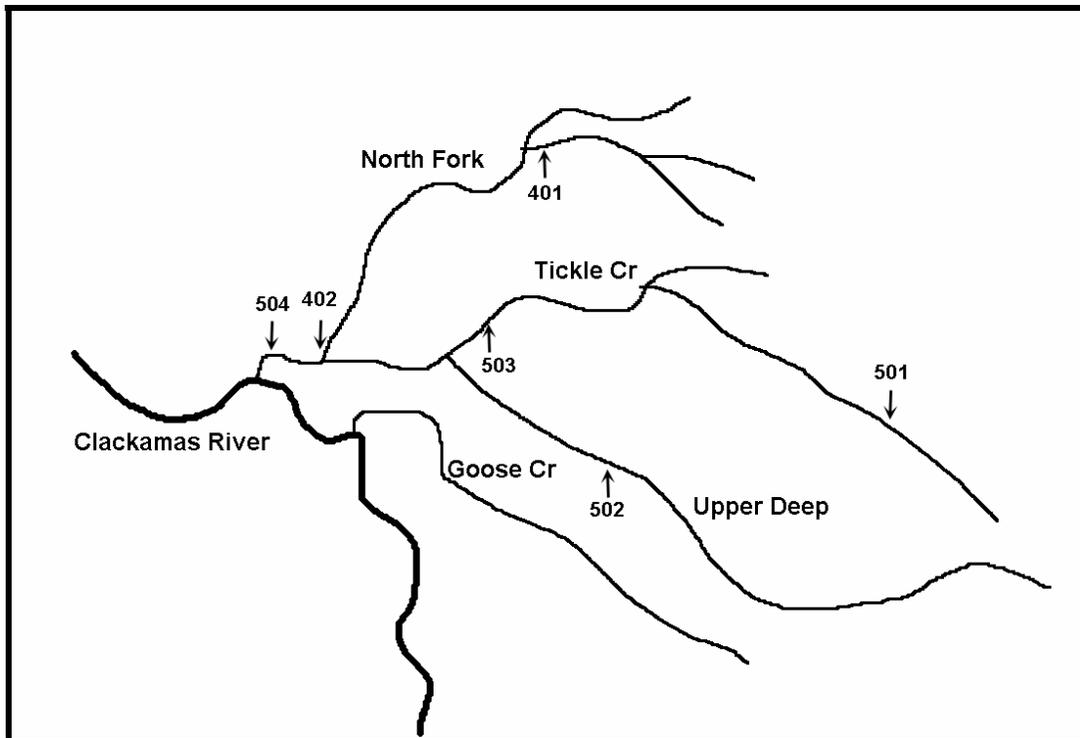
Variation in water quality is controlled primarily by streamflow, which in turn depends on climatic factors that influence annual and decadal flow patterns. Variability in flows is the first place to look for explanation of seasonal or annual changes in water quality. High streamflow during the winter months (see Figure 1-10, section 1.2.7), particularly during the first high flows of the season, will result in higher inputs of sediments and correspondingly higher turbidity values. Conversely, low summertime stream flows offer less opportunity to dilute pollutants, therefore suspended sediments associated with, for example, sewerage treatment effluents will be more concentrated in the water column. Long term trends in precipitation (see Figure 1-6, section 1.2.4) will result in periods of relatively higher inputs of sediments (during cool/wet climatic periods) or more concentrated summertime pollutant loads (during warm/dry periods).

### 5.3.4.3 Water Quality Data Evaluated

The primary source of water chemistry data is the Clackamas County SWCD study (Clackamas County SWCD, 2001). The monitoring stations are shown in the table below. An abbreviated station name is provided for use in the figures. The station numbers were used by the SWCD and are referenced here to maintain continuity with their data base.

Station #	Name in Database	Abbreviated Name
Site #401	Hwy 26 @ N. Fork Deep Cr.	NF Hwy 26
Site #402	Camp Kuratli @ N. Fork Deep Cr.	NF Camp Kuratli
Site #501	Langensand Rd. @ Tickle Cr.	Upper Tickle
Site #503	Tickle Creek Rd. @ Tickle Cr.	Lower Tickle
Site #502	Hwy. 211 @ Deep Cr.	Deep @ Hwy 211
Site #504	Camp Kuratli @ Deep Cr.	Deep @ Kuratli

See Figure 5-1 for a diagram that shows the relative location of these stations. Refer to *Map 8: Water Quality Map* for an accurate location of the stations on the stream layer.



**Figure 5-1: Water quality monitoring stations on Deep Creek.**

#### **5.3.4.4 Nutrients**

##### **Comparison to Criteria**

Nitrogen and phosphorus are the primary cause of eutrophication. Symptoms of eutrophication include excessive growth of algae, low dissolved oxygen, turbid water, changes in macroinvertebrate communities, and in extreme cases, fish kills. In addition, the increase in algae and turbidity may increase the need to chlorinate water for domestic supplies. This, in turn, may lead to higher levels of disinfection by-products that have been shown to increase the risk of cancer (EPA, 2001).

The natural level of nutrients varies across landscapes in relation to factors including geology, climate, soil, plant communities, and erosion processes so target desired levels need to be developed at local scales. EPA has developed recommended criteria at the ecoregion scale based on reference site monitoring (EPA, 2001). The Deep Creek watershed occurs within the Willamette Valley ecoregion; the recommended criteria for streams in this ecoregion is 0.04 mg/L (40 µg/L) for total phosphorus, and 0.15 mg/L (150 µg/L) for nitrates (usually reported by water quality laboratories as the combination of NO<sub>2</sub> + NO<sub>3</sub>).

Because of the high variability of water quality at a site, box-and-whisker plots are used to display the water chemistry data. These plots are useful because they show the central tendency and variability of the data. The box in a box-and-whisker plot encompasses the middle fifty percent of the data (the 25<sup>th</sup> to 75<sup>th</sup> percentile), the whiskers show the 10<sup>th</sup> and 90<sup>th</sup> percentiles, and the dots show the outliers (the 5<sup>th</sup> and 95<sup>th</sup> percentile). Water quality may exceed criteria for a short period of time in any stream (pristine or developed), but when most of the data (the box) are above the criteria line then it indicates that human sources of pollution are likely and should be further evaluated or controlled.

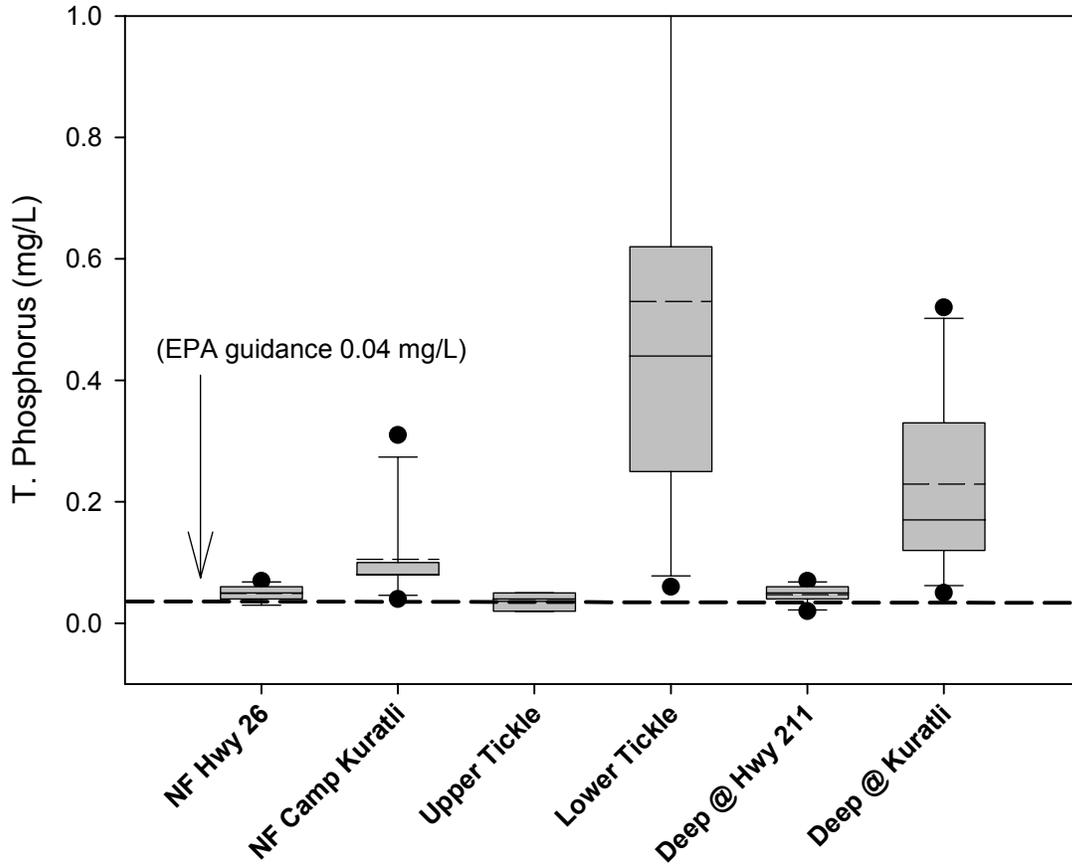
Total phosphorus and nitrate concentrations show a similar pattern (Figure 5-2 and Figure 5-3). Total phosphorus peaks at the Lower Tickle Creek site and this effect is retained in Deep Creek below the mixing zone with North Fork Deep Creek (Note the higher concentration at the Camp Kuratli site at Deep Creek).

The dashed line in Figure 5-2 indicates the EPA recommended criteria for total phosphorus (0.04 mg/L). The pollutant source in Tickle Creek causes phosphorus to increase well above the criteria. This effect in Tickle Creek is echoed downstream in Deep Creek at the Camp Kuratli monitoring station. Phosphorus concentrations for rest of the monitoring stations generally occur in the range expected for this ecoregion and also for that observed in Clear Creek. (The median total phosphorus concentration in Clear Creek at the mouth for this same time period (same data source) was 0.05 mg/L.)

Nitrates generally exceed the EPA recommended criteria of 0.15 mg/L throughout the watershed (Figure 5-3). The same pattern of increase, as observed for phosphorus, occurs for nitrates in Tickle Creek. A peak concentration of nitrates is observed at Lower Tickle Creek, with this effect carried downstream as evident by the increase observed at the Deep Cr. @ Kuratli station.

The concentration of nitrates in Deep Creek is much higher than observed in Clear Creek for the same data set. If one factors out the effect of Tickle Creek on nitrate concentrations, nitrate concentrations are still three-to-four times higher in Deep Creek than in Clear Creek. (For example, the median concentration for Clear Creek at the mouth is 0.12 mg/L; compared to NF Deep @ Hwy 26 (0.41 mg/L), Upper Tickle (0.39 mg/L), and Deep Cr. @ Hwy 211 (0.28 mg/L).

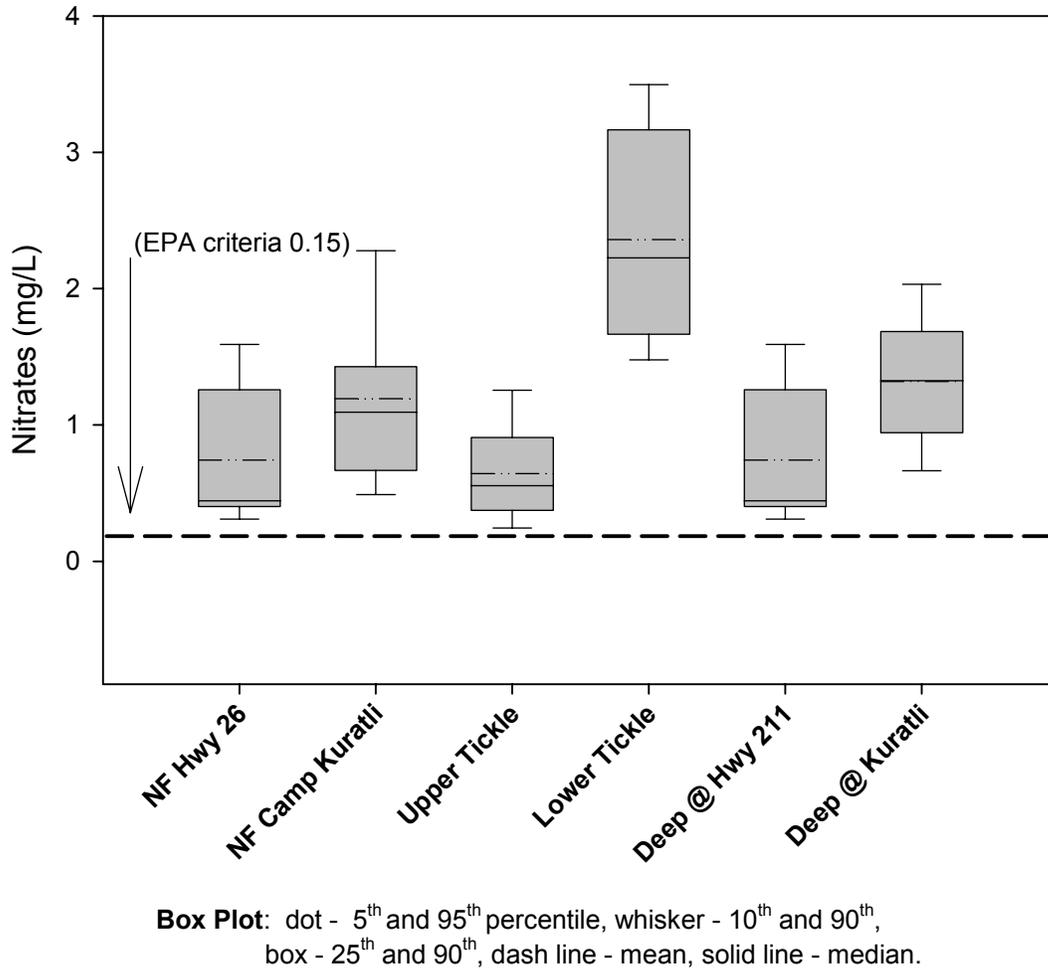
Deep Creek Watershed, Jan. to Oct. 2001  
T. Phosphorus (mg/L)



**Box Plot:** dot - 5<sup>th</sup> and 95<sup>th</sup> percentile, whisker - 10<sup>th</sup> and 90<sup>th</sup>,  
box - 25<sup>th</sup> and 90<sup>th</sup>, dash line - mean, solid line - median.

**Figure 5-2: Total Phosphorus in Deep Creek, 2001.**

Deep Creek Watershed, Jan. to Oct. 2001  
Nitrates (mg/L)

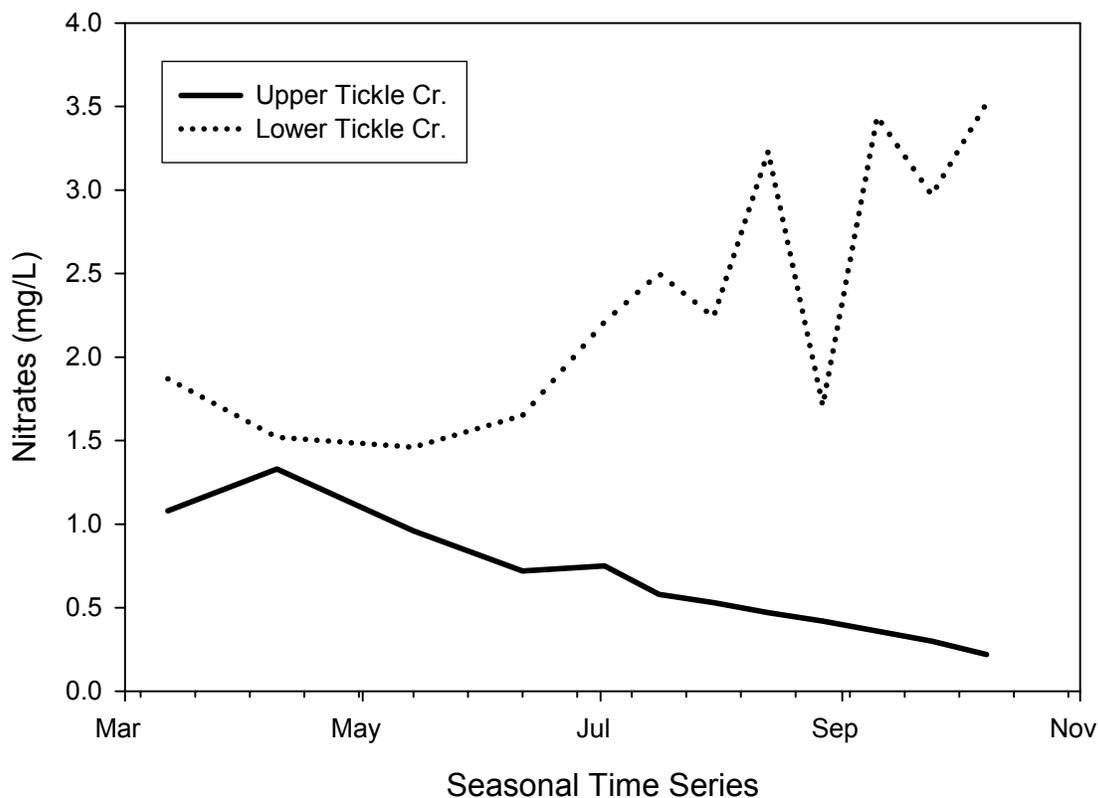


**Figure 5-3: Nitrates measured in Deep Creek, 2000 and 2001.**

**Seasonal Patterns**

Nitrate and phosphorus concentrations are plotted over time ( Figure 5-4 and Figure 5-5) for Tickle Creek to assist in evaluating possible sources. Nitrates rise in Lower Tickle Creek throughout the summer, apparently in direct response to lower dilution as flows decrease during this period. This pattern indicates a constant source or combination of sources, such as septic systems. The Sandy STP wastewater is diverted to irrigation at a nursery from May 1 to October 31 during this period so the STP is not a candidate source.

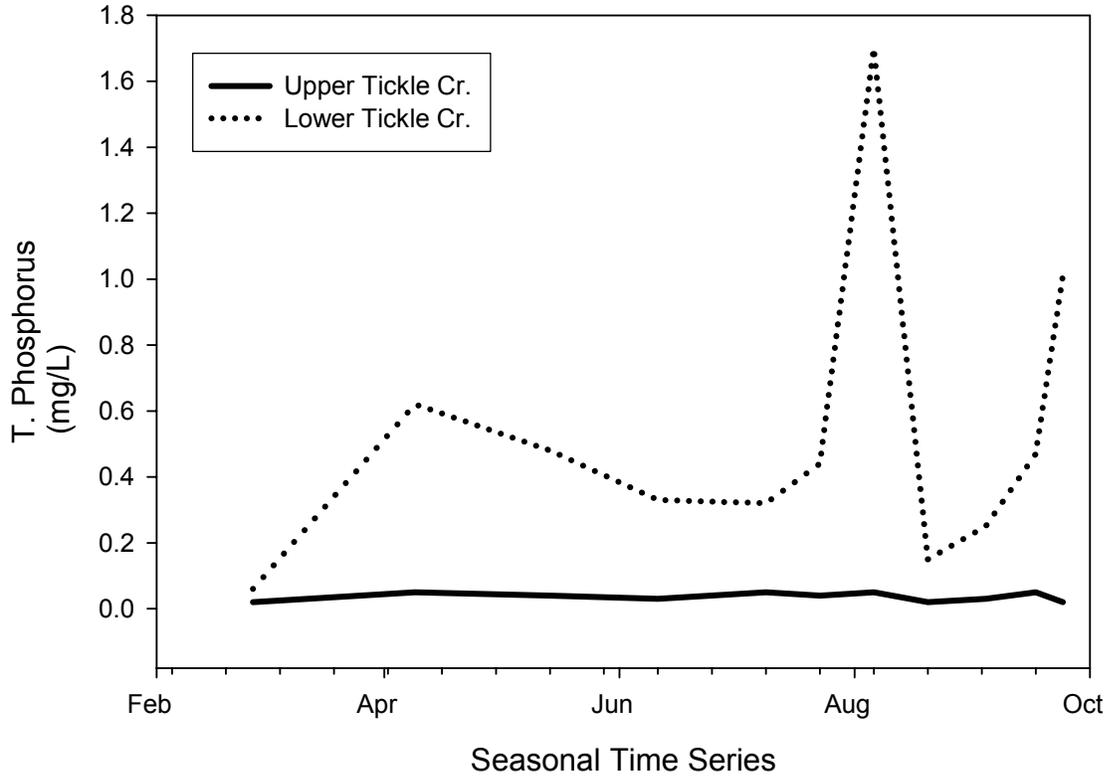
### Tickle Creek, Mar. to Oct. 2001. Seasonal Nitrate Concentration



**Figure 5-4: Nitrate concentrations in Tickle Creek, spring to fall in 2001.**

The phosphorus time series shows some fairly discrete spikes occurring, for example, in August and October (Figure 5-5). Total phosphorus is associated with particulate material, so potential sources are sediment from farm fields, roads, storm events (cumulative erosion sources) or particulates from animal wastes. Nursery operations which are prevalent in the watershed may generate episodic sediment events when crops are harvested or fields are prepared for planting, and are therefore a plausible source.

Tickle Creek, Mar. to Oct. 2001.  
Seasonal T. Phosphorus Concentration



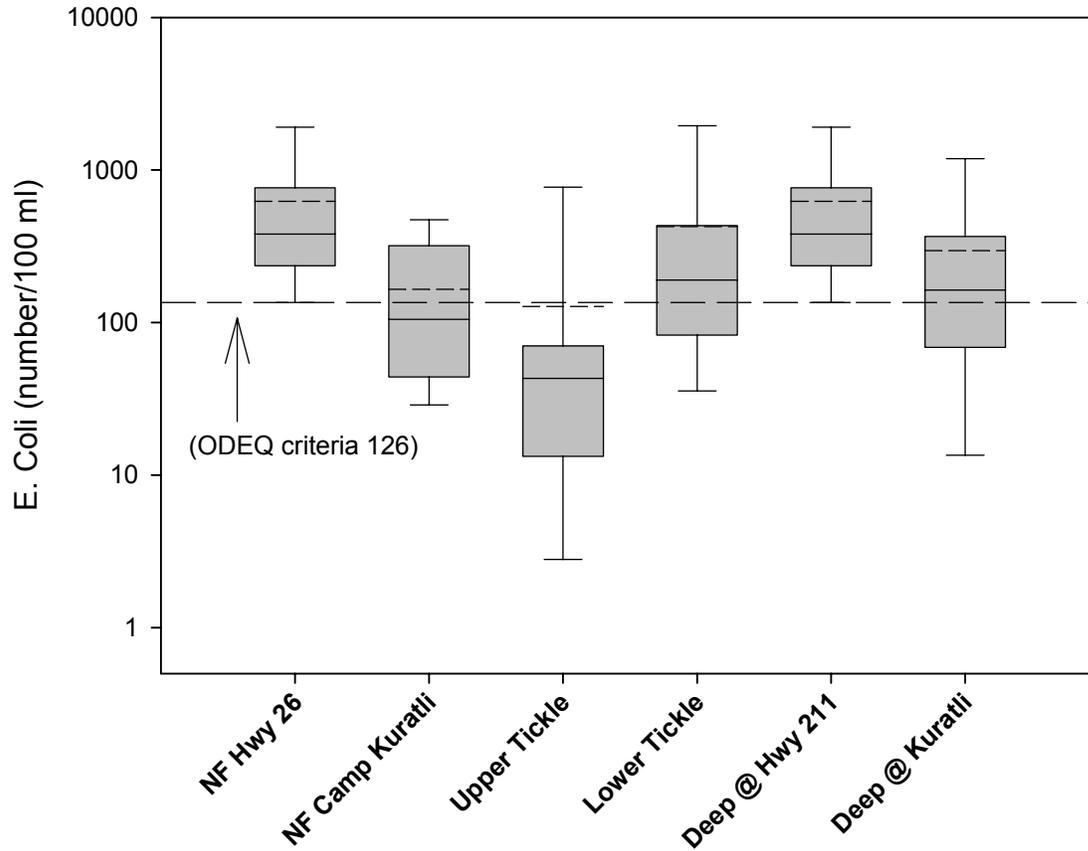
**Figure 5-5. Total Phosphorus concentrations in Tickle Creek, spring to fall in 2001.**

#### **5.3.4.5 Bacteria and Specific Conductance**

*E. coli* (*Escherichia coli*) is a type of fecal coliform bacteria commonly found in the intestines of warm blooded animals and humans. The presence of *E. coli* in water is an indication of recent sewage or animal waste contamination, and a possible indication that other pathogens may also be present. The Oregon water quality criteria of 126 colonies/100 ml is the criteria used to list Deep Creek on the 303(d) list.

Specific conductance is a measure of the ability of water to conduct an electrical current, which increases with the amount of dissolved salts, and therefore provides an indirect measure of total dissolved solids (TDS). TDS is presented along with bacteria because increases in TDS serve as an indication of contamination from sewage, although increases in TDS can also be attributed to other sources such as road salt and fertilizer.

Clear Creek Watershed, Jan. to Oct. 2001  
E. Coli Bacteria (Number/100 ml)



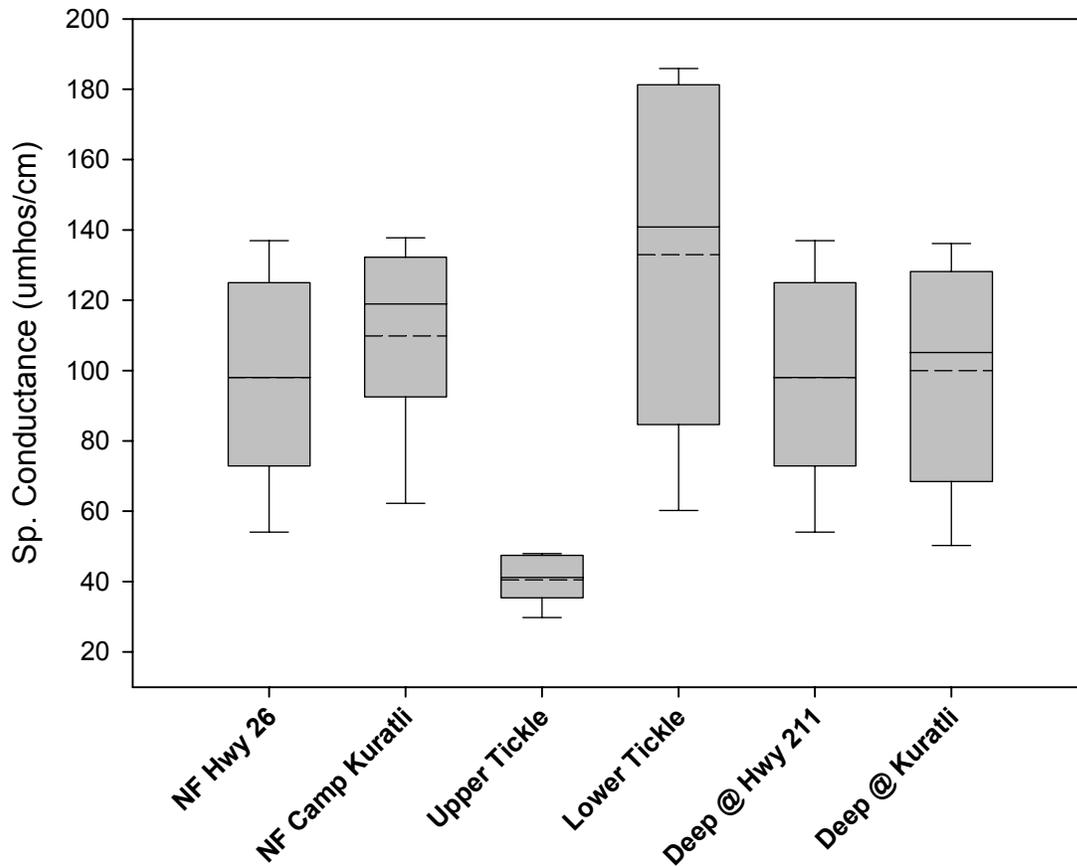
**Box Plot:** dot - 5<sup>th</sup> and 95<sup>th</sup> percentile, whisker - 10<sup>th</sup> and 90<sup>th</sup>,  
box - 25<sup>th</sup> and 90<sup>th</sup>, dash line - mean, solid line - median.

**Figure 5-6. Indicator bacteria in Deep Creek, 2001.**

E. coli exceed criteria at most of the stations except for Upper Tickle Creek (Figure 5-6). Many sources may cumulatively contribute to the bacterial load in these streams – livestock waste from cattle and horses, pet waste, failing septic systems, and storm water runoff. Upper Tickle Creek shows minimal contamination, consistent with the pattern for nutrients.

Specific conductance (Figure 5-7) shows a similar pattern to the E. coli bacteria, except for a much more pronounced difference between Upper and Lower Tickle Creek. The similarity in pattern for three parameters - specific conductance, nitrates, and E. coli bacteria – provides an indication that septic systems in the Sandy area are a potential pollutant source.

DeepCreek Watershed, Jan. to Oct. 2001  
Sp. Conductance



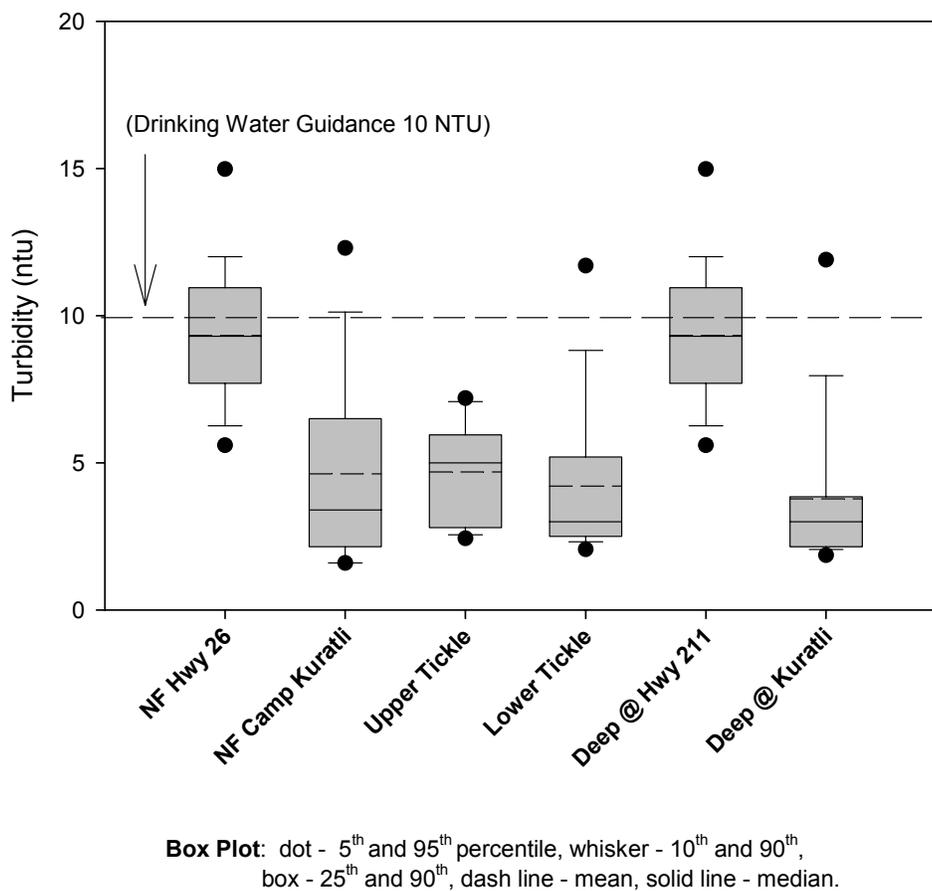
**Box Plot:** dot - 5<sup>th</sup> and 95<sup>th</sup> percentile, whisker - 10<sup>th</sup> and 90<sup>th</sup>, box - 25<sup>th</sup> and 90<sup>th</sup>, dash line - mean, solid line - median.

**Figure 5-7. Specific conductance in Deep Creek, 2001**

### 5.3.4.6 Turbidity

Turbidity is a measure of water clarity, and is measured in units called Nephelometric Turbidity Units (NTU). The lower the turbidity value, the clearer is the water. Suspended sediment and organic matter are the primary causes of turbidity in streams. There is no numeric standard for turbidity, but a level above 50 NTU is thought to affect salmon and trout by reducing their sight-feeding ability (Lloyd et al., 1987). Suspended solids directly impact water treatment facilities by clogging the fine sand in slow sand filters. Source water having turbidity less than 10 NTU is recommended for these systems (National Drinking Water Clearinghouse 2000).

Deep Creek Watershed, Jan. to Oct. 2001  
Turbidity (ntu)



**Figure 5-8. Turbidity (NTU) measured in Deep Creek, 2001.**

Turbidity exhibits a different pattern (Figure 5-8) than for the nutrients, bacteria, and conductivity. The stations, NF Deep @ Hwy 26 and Deep Cr. @ HWY 211, show pronounced increases in turbidity in comparison to the other stations. As a direct indicator of suspended sediment, this pattern indicates a higher sediment load or spike in these two watersheds. Although many sources are feasible, the most likely source of sediments are nursery or other cropland activities in these watersheds.

### 5.3.4.7 Temperature

#### Data Sources and Criteria

Two sources of water temperature data were available for this report. Data for 1997, 1998, and 1999 were provided by PGE (Shibahara 1999). Data for 2002 and 2003 were provided by the Student Academy Program (Torrey Lindbo 2004).

Temperature is compared to the DEQ temperature criteria for salmonid rearing by calculating the *7-day moving average of the maximum daily temperatures*, the number of days this value exceeds the criteria, and the percent of days measured that exceed criteria. Oregon water temperature criteria were recently revised to address fish core areas, rearing and migration, and salmonid spawning (ODEQ 2004b).

- Salmon and Trout rearing and migration: 64 ° F (17.8° C)
- Salmonid fish core areas: 60.8 ° F (16° C)
- Salmonid spawning: 55.4 ° F (13° C)

Data are compared to the rearing and migration criteria (17.8° C), and to the salmonid fish core areas criteria of (16° C) since the data sets cover the summer period.

#### Temperature Summary

Temperature has been measured at number of different sites in Deep Creek. Data are listed by year and by station in Table 5-5. The Map Key refers to the symbols for the water quality stations map ([Map 8: Water Quality](#)).

The table shows the data source, the beginning and ending date for the data, and the interval between measurements. Since these specific monitoring details differ, the results cannot be compared over time to evaluate trends. However, the data are useful to indicate general stream conditions.

Tickle Creek consistently exhibits a lower temperature regime than the rest of the watershed as indicated by qualitatively comparing the number of days that exceed criteria in Table 5-5. The station, Deep Creek@ Hwy 211, also consistently has a lower temperature regime than further downstream at Deep Creek at or near the mouth.

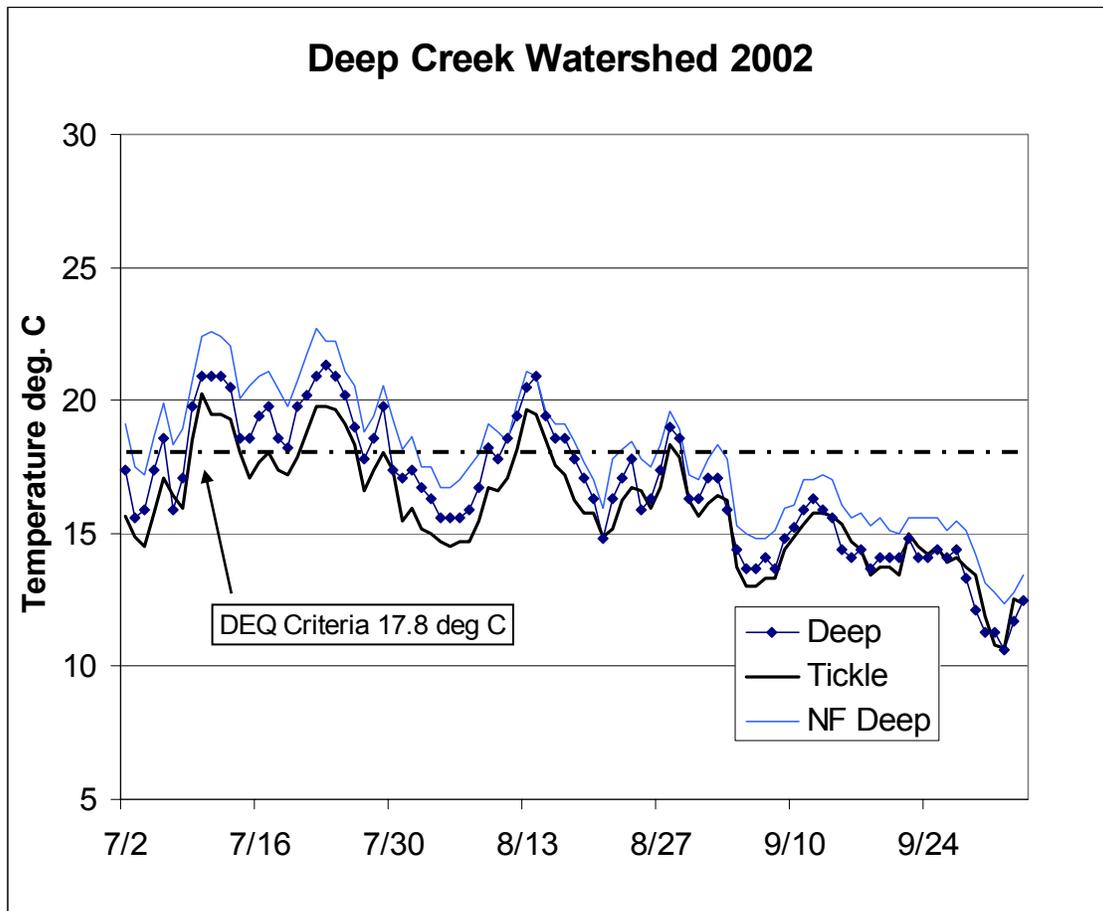
Decreasing the temperature criteria from (17.8° C) to (16° C) increases the number of criteria exceedences at many locations, indicating that a greater effort at riparian enhancement will be required to meet this more stringent criteria.

**Table 5-5. Summary of temperature monitoring in the Deep Creek watershed.**

Temperature Stations	Map Key	Data Source	Begin Date	End Date	Interval (hours)	Total Days	Days over (17.8 °C)	Days over criteria (%)	Days over (16 °C)
<b>1997</b>									
Tickle Cr @ Tickle Cr Road	01	PGE	7/2/1997	10/6/97	1.3	91	2	2 %	57
Goose Cr @ Hiway 224	02	PGE	7/2/1997	10/3/97	2.6	94	79	84 %	84
Deep Cr @ Hiway 211	03	PGE	7/1/1997	9/28/97	1.3	90	25	28 %	67
Deep Cr @ Hiway 224	04	PGE	10/6/1997	7/2/97	1.3	90	55	61 %	72
<b>1998</b>									
Tickle Cr @ Tickle Cr Road	01	PGE	6/19/1998	10/7/98	2.4	111	29	26 %	58
NF Deep Cr @ Hiway 211	03	PGE	6/19/1998	9/17/98	2.2	91	63	69 %	85
Deep Cr. @ above NF Deep Cr	05	PGE	6/20/1998	9/17/98	2.2	90	62	69 %	77
Deep Cr @ Mouth	06	PGE	6/19/1998	9/17/98	2.2	90	63	70 %	85
<b>1999</b>									
Deep Cr @ Hiway 211	03	PGE	6/23/1999	9/5/99	1	74	40	54 %	54
Deep Cr @ Mouth	06	PGE	7/2/1997	10/3/97	2.4	94	82	87 %	88
<b>2000</b>									
Deep Cr @ Mouth	06	PGE	5/4/2000	9/22/00	1	106	55	52 %	81
<b>2002</b>									
Tickle Cr @ 362 <sup>nd</sup> Ave	07	SWRP	7/02/2002	10/4/2002	0.5	95	21	22 %	44
NF Deep Cr @ Springwater Rd.	08	SWRP	7/02/2002	10/4/2002	0.5	95	50	53 %	69
Deep Cr @ Hiway 211	03	SWRP	7/02/2002	10/4/2002	2.0	95	31	33 %	55
<b>2003</b>									
Deep Cr @ Hiway 211	03	SWRP	7/12/03	10/2/03	1.0	83	40	48 %	59

## Daily Temperature Pattern

The data collected by the Student Academy for 2002 is shown in Figure 5-9. The monitoring sites exhibit the same daily variation indicating the primary influence of air temperature on water temperature. The spread between individual data points, however, illustrate the effect of the local and upstream site conditions on water temperature. Upper Tickle Creek, with a good riparian shade canopy, has the lowest temperatures with the greatest divergence occurring at N.F. Deep Creek. This station is located at the edge of the Boring community; the data indicating a less intact riparian corridor.



**Figure 5-9. Seasonal pattern of maximum temperatures in Deep Creek tributaries, 2002. (Deep = Deep Cr @ Hiway 211, Tickle = Tickle Cr @ 362nd Ave, NF Deep = NF Deep Cr @ Springwater Rd.)**

## 5.4 SOURCE WATER ASSESSMENT

The 1996 federal Safe Drinking Water Act (SWDA) Amendments mandated that states conduct source water assessments for public water supplies. Source water assessments are completed by the Oregon Department of Environmental Quality and Oregon Health Division in coordination with local water providers and communities. The source water assessments delineate the groundwater and surface water source areas, which supply public water systems, and inventory the potential sources of contamination within these areas.

The Source Water Assessment for the Clackamas River Basin was completed jointly by DEQ, CRBC, the South Fork Water Board, North Clackamas County Water Commission, Clackamas River Water, and the City of Estacada. The database generated by the survey identifies all potential contaminant sources that occur within a designated source area, and ranks these potential sources as contaminants as low, moderate, or high.

The assessment is intended to identify “*potential*” contaminant sources (PCS). This does not mean that a potential source is a threat to surface or groundwater. The PCS may have a high level of treatment or are applying the most effective best management practices; these qualifications are not listed in the database. Nor is there any implication of cause-and-effect relationships to water quality. What the database does allow is the ability to associate the location of the PCS with the stream system and provide a means to sort by potential risk to surface water.

The information from the PCS database was plotted by subwatershed within the Deep and Goose Creek watersheds. (See *Map 8: Source Water Assessment*.) The PCS location is identified in the map using a unique reference number in the corresponding database. The database provides descriptive information on each PCS, and provides an associated qualitative risk ranking. The risk to surface water is rated as high, moderate and low.

The database has been sorted in a manner to focus on the potentially higher risk contaminant sources. Table 5-6 lists all sites in the database sorted by seven categories. This table lists 2,760 PCS in the watershed, with the number of sites approximately proportional to the subwatershed area. To better focus the potential use of the database, the data were further stratified by sites within 500-ft of a stream (Table B), and further by sites listed as High Risk to surface water (Table C). This reduces the potential list of sites within the watershed from the 2,760 to 766 sites to 418 sites.

The primary value of this information is the ability to sort sites by use of the spreadsheet and the map to focus on contaminant sources to develop a specific project in a subwatershed. The CRBC can use the map and database effectively to develop projects on a micro-watershed basis or to target a specific sources – such as potential toxics or bacteria sources. It would only require sorting the spreadsheet differently to focus on a specific area.

**Table 5-6. Summary of pollutant contaminant sources in the Deep Creek watershed.**

<b>Table A – All Sites within the Deep and Goose Creek watersheds.</b>						
<b>Group</b>	<b>Goose</b>	<b>Lower Deep</b>	<b>North Fork Deep</b>	<b>Tickle</b>	<b>Upper Deep</b>	<b>Grand Total</b>
Agriculture	110	17	219	292	445	1083
Commercial	12	31	409	48	141	641
Dumpsite			20	19	2	41
Misc	43	3	114	75	124	359
Residential	23	1	117	37	88	266
Septic	41		33	94	141	309
Storage Tanks	1	14	43	1	2	61
<b>Grand Total</b>	<b>230</b>	<b>66</b>	<b>955</b>	<b>566</b>	<b>943</b>	<b>2760</b>

<b>Table B – Sites within 500-ft of streams.</b>						
<b>Group</b>	<b>Goose</b>	<b>Lower Deep</b>	<b>North Fork Deep</b>	<b>Tickle</b>	<b>Upper Deep</b>	<b>Grand Total</b>
Agriculture	56	7	69	106	146	384
Commercial	1	30	20	24	8	83
Dumpsite			3	6		9
Misc	36	2	39	36	37	150
Residential	8	1	14	5	18	46
Septic	16		1	24	35	76
Storage Tanks	1	14	3			18
<b>Grand Total</b>	<b>118</b>	<b>54</b>	<b>149</b>	<b>201</b>	<b>244</b>	<b>766</b>

<b>Table C – Sites within 500-ft Rated as High Risk Sites</b>						
<b>Group</b>	<b>Goose</b>	<b>Lower Deep</b>	<b>North Fork Deep</b>	<b>Tickle</b>	<b>Upper Deep</b>	<b>Grand Total</b>
Agriculture	38		54	52	87	231
Commercial	1	23	14	20		58
Dumpsite			3	6		9
Misc	22	2	30	21	26	101
Residential	7	1	8	1	2	19
<b>Grand Total</b>	<b>68</b>	<b>26</b>	<b>109</b>	<b>100</b>	<b>115</b>	<b>418</b>

## 5.5 WATER QUALITY SUMMARY, INFORMATION GAPS, AND MONITORING NEEDS

### *Nutrients and associated indicators*

It is useful to contrast results from the Deep Creek watershed to a similar watershed within the Clackamas River basin. The Clear Creek watershed, located on the west side of the lower Clackamas River, provides a watershed in a comparable physical setting. The primary difference between the two watersheds is the degree of agricultural and urban development, with Deep Creek being more intensively developed for urban, suburban, and agriculture uses. The “reference” watershed is more useful than direct comparison to EPA guidelines because EPA guidelines were developed at much larger ecoregion spatial scales.

Total phosphorus and nitrate concentrations show a similar pattern in the Deep Creek watershed. Total phosphorus peaks at the Lower Tickle Creek site and this effect is retained in Deep Creek below the mixing zone with North Fork Deep Creek, as indicated by the higher concentration at the Camp Kuratli site on Deep Creek. The pollutant sources in Tickle Creek cause phosphorus to increase well above the criteria. This effect in Tickle Creek is carried downstream in Deep Creek at the Camp Kuratli monitoring station. Specific conductance shows a similar pattern to nitrate concentrations in the watershed, indicating a source of pollution in lower Tickle Creek.

Phosphorus concentrations for the rest of the monitoring stations are similar to that observed in Clear Creek and as expected for this ecoregion using EPA’s guidelines. The median total phosphorus concentration in Clear Creek at the mouth for this same time period (and same data source) was 0.05 mg/L, which is similar to EPA’s ecoregion guideline of 0.04 mg/L. The concentration of nitrates in Deep Creek, however, is much higher than observed in Clear Creek for the same data set. If one factors out the effect of Tickle Creek on nitrate concentrations, nitrate concentrations are still three-to-four times higher in Deep Creek than in Clear Creek.

The seasonal pattern in nitrate concentration, increasing throughout the low flow period, indicates a constant source that is less diluted during the low flow period. Known point sources do not discharge to the stream during this period, so a likely source is septic systems that cumulatively contribute to a build up of nitrates during the time when surface flow does not provide dilution.

Identifying the nutrient source based on existing data is highly speculative since we are only comparing two stations, one above Sandy and the other close to the mouth of Tickle Creek. A focused water quality study along Tickle Creek could better define the location of the source, and the likely sources along the creek. Nitrates and phosphorus could be sampled at closely spaced monitoring sites along the creek during the summer months. After each sampling run, the data would be evaluated in relation to potential sources, and then the sampling locations adjusted again to focus on identified hot spots. The study could be done by students during the summer with the help of a water quality professional on study design, quality control, and interpretation.

## ***Turbidity***

Turbidity exhibits a different pattern than for nutrients, bacteria, and conductivity. The stations, in upper North Fork and Upper Deep Creek, show pronounced increases in turbidity in comparison to the other stations. As a direct indicator of suspended sediment, this pattern indicates a higher sediment load in these two watersheds. Although many sources are feasible, the most likely sources of sedimentation are nursery or other cropland activities in these watersheds.

## ***Water Temperature***

The major factors that affect temperature patterns in streams are riparian vegetation and shade, channel morphology and hydrology (IMST, 2000). Riparian vegetation directly affects stream temperature by intercepting solar radiation and reducing stream heating. Limited canopy cover can also increase the difference between the daily maximum and minimum water temperatures, contributing to higher temperatures during the day due to increased solar radiation and lower temperatures at night because the insulating canopy cover has been decreased (IMST, 2000).

The water temperature data evaluated was collected over various years so these data are not directly comparable, however, the data shows a good general correlation with the current riparian shade condition evaluation (See *Map 7: Riparian Shade Map*). Stream reaches mapped with shade in the 70 to 90 % category had lower temperatures and fewer exceedences of water quality criteria. This supports the general approach to lowering temperatures in streams, which is to work on riparian buffer protection in concert with tree planting programs. The riparian shade map can be used to identify those stream reaches that need particular work on reestablishing buffers and focus planting programs.

The newly adopted ODEQ water quality standards for temperature provide additional challenges to land owners and land managers. Good temperature information will assist the CRBC and land owners over time in meeting this challenge. A temperature monitoring program should be established to collect data at the same locations for a long time period (decades), so the data is comparable and able to show the effects of efforts to improve temperature conditions. The monitoring program could be developed for the entire lower Clackamas River basin to complement monitoring that should be taking place on federal ownership in the upper part of the basin.

## **5.6 RECOMMENDATIONS AND POSSIBLE COUNCIL ACTIONS**

### ***Coordination and Education:***

There are numerous agencies that are interested in assisting the CRBC in protecting and enhancing watersheds; for example, Metro, OWEB, DEQ, ODFW, ODF, USDA NRCS, OSU Extension, and the Clackamas County SWCD. The Clackamas SWCD is a particularly suited to assist the CRBC in working with local landowners on the small acreages and hobby farms that occur in Deep Creek. Education activities can also be closely coordinated with other agencies such as OSU – Extension and the Clackamas County SWCD.

### ***Restoration Activities:***

Restoration activities may include:

- 1) Riparian planting programs (associated with education to maintain riparian zones) targeted at areas lacking shade identified in the riparian assessment.
- 2) Riparian fencing and livestock management to enhance vegetative coverage.
- 3) Livestock manure management.
- 4) Sediment and runoff control associated with nursery and farm operations.

### ***Information/assessment:***

- 1) ***Tickle Creek Nutrient Study:*** A focused water quality study along Tickle Creek could better define the sources of nutrients that cause the increased nutrient concentrations. See Section 5.5 for the rationale and general outline of a study.
- 2) ***Temperature:*** Temperature monitoring over time at repeated locations would help provide information on effectiveness of the riparian area improvement actions. See Section 5.5 for further information.
- 3) ***Coordinated Monitoring and Trend Data:*** As with many watersheds, monitoring in Deep Creek lacks a comprehensive Monitoring Program Plan. A comprehensive monitoring program plan would assure that data is collected with sufficient rigor to answer questions in a scientifically valid manner. Currently a number of entities collect data, but the value of that data is compromised by the lack of an objective based monitoring plan that outlines minimum sample frequency, standard protocols, and quality assurance/quality control procedures.

Trend data at a small number of selected stations will provide the most useful information over time to determine if water quality is getting better or worse in Deep Creek. Trend analysis requires a high sample frequency (number of samples/time period) over a long period of time to be effective. Monitoring programs also require continuous flow data at an associated gaging station to be effective in interpreting the data.

A detailed Monitoring Program Plan should be developed prior to collection of any further data sets. The monitoring plan should be developed with professional assistance from an experienced water quality specialist. Refer to the OWEB Watershed Assessment Manual, Chapter 10, (WPN 1999) and Water Quality Monitoring Guide Book (Oregon Plan for Salmon and Watersheds 1999) for further guidance.

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## 6.0 FISHERIES

### 6.1 INTRODUCTION

Understanding and documenting the habitat conditions and the habitat needs of the watershed's fish species help identify which fish populations in the watershed are potentially declining and where watershed enhancements may have the most direct benefits. This report summarizes available information on the fish populations, stock status, and habitat conditions in the Deep and Goose Creek watersheds. The report focuses on salmon and trout because these species have been the focus of most studies of fish populations and habitat conditions. There was limited information available specific to Deep and Goose Creeks thus this report summarizes information in reports on the larger Clackamas subbbasin developed by a variety of sources including Oregon Department of Fish and Wildlife, and METRO.

### 6.2 CRITICAL QUESTIONS

The goals of this document are to compile and evaluate available information on fish populations, in-stream habitat and migration barriers and actions that can be taken to enhance or restore those habitats. The information will be used to evaluate impacts to important areas of current fish use and prioritize potential voluntary action opportunities.

The critical questions are:

*Question 6-1: What salmonid species are documented in the watershed, are any of these currently ESA or candidate species?*

*Question 6-2: What are the distribution, relative abundance and population status of salmonid species in the watershed?*

*Question 6-3: Which salmonid species are native to the watershed, and which have been introduced to the watershed?*

*Question 6-4: What are the species interactions?*

*Question 6-5: What is the condition of fish habitat in the watershed (by sub-basin) where habitat data has been collected?*

*Question 6-6: Where are there potential barriers to fish migration?*

### 6.3 METHODS

This report is based on existing information which was compiled and summarized in order to develop the best available answer for the listed critical questions and to identify key information gaps. At the start of the project a literature search was conducted and initial contacts made with agency representatives. Table 6-1 summarizes the existing reports and pertinent results that were used.

The upper extents of resident fish use were obtained from Oregon Department of Forestry (ODF). The GIS data from the ODFW/ Streamnet site on distribution of anadromous species in the watershed was downloaded from this page: <http://rainbow.dfw.state.or.us/nrimp/information/fishdistdata.htm>. This information was evaluated and combined to create one map showing the distributions of anadromous and resident fish in the watershed.

Natural fish passage barriers were identified though consulting the ODFW passage barrier database and the Clackamas Watershed Atlas (Metro, 1997). An assessment of fish passage at stream crossings in Deep, Goose, and Eagle Creeks was completed in 2003 (See Fish Passage Appendices). As part of this project over 150 potential stream-road crossings were identified using GIS mapping tools. These crossings were evaluated based on their location and fish Passage. Full results are mapped and available at <http://www.clackamasriver.org>.

Fish stocking data was obtained from the ODFW/ Streamnet WEB site (<http://www.osu.orst.edu/dept/nrimp/>). ODFW biologists were contacted about other fish enhancement programs that have occurred in Goose, Deep and Tickle Creeks.

There was limited fisheries data and no existing habitat data available for the Creeks. ODFW collected habitat data in 2003 in Deep Creek the data is summarized in this report.

**Table 6-1. Summary of applicable Fisheries Reports.**

Applicable Fisheries Reports & Data Sets in Clear and Foster Creeks	
Murtagh et al., 1992	<p><b>Report Title:</b> Clackamas SubBasin Fish Management Plan,  <b>Topic:</b> Describes habitat and the background status, management considerations, policies, and objectives for Winter Steelhead, Summer Steelhead, Spring Chinook salmon, Fall Chinook salmon, Coho salmon, warmwater fish, trout, and whitefish in the Clackamas River subbasin.</p> <p><i>A primary source of data for the assessment.</i></p>
Cramer, S.P. et al. 1995	<p><b>Report Title:</b> Status of Willamette River Spring Chinook Salmon in Regards to the Federal Endangered Species Act - <b>Part 1</b>,  <b>Topic:</b> Part 1 of two reports designed to assist the NMFS in determining whether spring Chinook should be listed as threatened and endangered. Reports assemble and synthesize the best available information on spring Chinook salmon status in the Willamette River Basin.</p> <p><i>No specific mention of Deep or Tickle Creeks.</i></p>
Cramer, S.P. et al. 1996	<p><b>Report Title:</b> Status of Willamette River Spring Chinook Salmon in Regards to the Federal Endangered Species Act - <b>Part 2</b>,  <b>Topic:</b> Assembles and synthesizes the best available information on Spring Chinook population structure, trends, and risks to persistence of spring Chinook salmon in the Willamette River Basin. This report specifically determines the extent and causes of trends in abundance and assesses the risks that threaten persistence.</p> <p><i>No specific mention of Deep or Tickle Creeks.</i></p>
Foster, C.A. 1998	<p><b>Report Title:</b> 1997 Willamette River Spring Chinook Salmon Run  <b>Topic:</b> Describes characteristics of the spring Chinook salmon run in the Willamette River, the effects of recreational fishing on the run, and fish production and its contribution to fisheries.</p>

	<i>No specific mention of Deep or Tickle Creeks.</i>
Cramer, S.P., Cramer, D.P. 1994	<b>Report Title:</b> Status and Population Dynamics of Coho Salmon in the Clackamas River <b>Topic:</b> Report assembles the known information concerning the native coho population in the Clackamas River. This population is considered the last remaining viable wild coho population in the Columbia Basin.
	<i>No specific mention of Deep or Tickle Creeks.</i>
S.P. Cramer and Associates, 1997	<b>Report Title:</b> Synthesis and Analysis of the Lower Columbia River Steelhead Initiative, S.P. Cramer and Associates. <b>Topic:</b> Describes conservation measures and analyzes their effects on wild steelhead population of the Lower Columbia River ESU. Reviews steelhead demographics, defines the problem, offers a design for a solution, and then analyzes that proposed solution.
	<i>No specific mention of Deep or Tickle Creeks.</i>

## 6.4 RESULTS

### 6.4.1 Fish Species, Distribution & Relative Abundance

- *What salmonid species are documented in the watershed, are any of these currently ESA or candidate species?*
- *What is the distribution, relative abundance and population status of salmonid species in the watershed?*

Anadromous fish occurring in the Clackamas basin include: spring and fall chinook, coho salmon, winter steelhead, summer steelhead (non-native), migratory cutthroat trout and lamprey (ODFW). Deep, Goose and Tickle Creeks are utilized by spring chinook, fall chinook, winter steelhead and coho salmon. Deep Creek also has a significant run of sea-run cutthroat trout (B. Strobel USFS pers comm. 2003). Very little is known about the status and life history of searun cutthroat trout in the Clackamas Basin. No references or specific information was found in the course of this analysis.

Resident fish potentially occurring in Deep and Goose Creeks include, cutthroat trout, rainbow trout and mountain whitefish. The last confirmed sighting of a bull trout in the Clackamas River was in the early 1970's, bull trout are thought to have been eliminated from the basin (Cramer xx).

In addition to salmonids USFS smolt trapping has captured pacific lamprey. Trapping data also indicates Deep Creek is the biggest producer of bullfrog tadpoles and pumpkinseeds (B. Strobel USFS. Pers. comm..2004).

The distribution of anadromous and resident fish in Deep and Goose Creeks is illustrated in Map 1. The ESA status of key species is summarized in Table 6-2. The length of stream used by anadromous fish in Deep and Goose creeks is summarized in Table 6-3.

**Table 6-2. Summary of ESA listing status of fish occurring in the Deep and Goose Creek watersheds.**

Common name, population segment	Scientific name	ODFW status <sup>a</sup>	Federal status <sup>b</sup>	Federal agent
Chinook salmon, (L. Columbia R.)	Oncorhynchus tshawytscha	N	T	NMFS
Coho salmon, (L. Columbia R.)	Oncorhynchus kisutch	E	C	NMFS
Steelhead (L. Columbia R.)	Oncorhynchus mykiss	N	T	NMFS
Searun Cutthroat	Oncorhynchus clarki	S	P	USFWS
Bull trout	Salvelinus confluentus	N	T	USFWS
<i>a</i> E= endangered, T = threatened, P = proposed for listing, C = candidate species, S = species of special concern with conservation agreements, N = not listed, A = not applicable				
<i>b</i> E= endangered, T = threatened, P = proposed for listing, C = candidate species, S = species of special concern with conservation agreements				
Source: ( <a href="http://rainbow.dfw.state.or.us/nrimp/information/index.htm">http://rainbow.dfw.state.or.us/nrimp/information/index.htm</a> ).				

**Table 6-3. Length of stream (miles) used by anadromous fish, by subwatershed.**

Subwatershed	Coho	Fall Chinook	Spring Chinook	Winter Steelhead
Goose Ck	2.1			2.1
Lower Deep	6.0	2.0	1.4	5.6
North Fork Deep	7.6			10.0
Tickle	7.0			7.1
Upper Deep	7.4			7.4
Grand Total	30.0	2.0	1.4	32.3
Source: ODFW fish use coverage.				

### **Fall and Spring Chinook**

Chinook are federally listed as Threatened. Both fall and spring chinook utilize only the lower portion of Deep Creek Creek (*Map 1: Base Map*) for spawning and rearing (Note: The base map provides the fish distribution.) The current fall run probably originates from ‘tule’ stock released in Clackamas in 1952 to 1981, or may be remnants of the historic native stock (Murtagh et al. 1992, Cramer xx). Hatchery produced fall chinook have not been released in the Clackamas basin since 1981 (Murtagh et al., 1992, Cramer xx). There is limited information on the historic and current distribution and abundance of fall chinook, this is partially because of the difficulty in distinguishing them from spring chinook (run timing overlaps and at spawning they look similar (Cramer xx). However the average annual returns of fall chinook to the Clackamas basin from 1981 to 1991 is estimated to be 840 fish, which may include some spring chinook (Cramer xx). The Clackamas fall chinook has not been popular with anglers due to their dark color, early spawning time and poor flesh quality (Murtagh et al., 1992).

Historically the Clackamas River was considered one of the largest producers of spring chinook (Murtagh et al. 1992). The current run is a combination of hatchery and naturally produced fish.

The timing of fall and spring chinook in the lower Clackamas streams is summarized in Table 6-4. Fall chinook only spawn in the lower reaches of Deep Creek and have not been documented using Goose Creek. Spawning occurs in late August and September with the peak in mid-September (Murtagh et al., 1992). Smolts outmigrate at age zero+ starting in April and peaking in June.

### **Winter Steelhead**

Winter Steelhead stocks in the Clackamas basin are federally ESA listed as Threatened. The winter steelhead population consists of fish from Eagle Creek Hatchery stock, Big Creek Hatchery stock and native wild population. Winter steelhead use a wider variety of habitat types than spring chinook and coho and will use all accessible stream reaches (Cramer xx). There have been recent increases in hatchery returns and declines in wild steelhead returns have raised concerns hatchery fish may be mixing with wild fish (Cramer xx).

The timing of wild winter steelhead in the Clackamas River is summarized in Table 4. Winter steelhead will use all accessible stream reaches (Cramer xx). Migration occurs from November through June and spawning occurs from late April through June (Cramer xx, Murtagh, 1992). Juvenile steelhead rear for 1 year and out migrate the spring following emergence (Murtagh, 1992).

Fish from the Eagle Creek Hatchery and Big Creek stock have been released in the Clackamas to improve angling opportunities in December and January. Returns of these fish are earlier (January – April) the wild steelhead returns (Murtagh, 1992).

### **Coho Salmon**

The wild coho salmon stocks in the Clackamas basin are candidate species for federal ESA listing and are state-listed as Endangered. There are both wild and hatchery stocks of coho salmon occurring in the Clackamas basin. The hatchery stock (called early run) is produced at Eagle Creek National Fish Hatchery and stocked in the basin, there is also a self sustaining population which is thought to have originated from fish from Eagle Creek hatchery but which reproduces naturally throughout the basin (Cramer xx). The early run fish were introduced to provide a recreational fishery and to provide coho for harvest in downstream and ocean fisheries (Murtagh et al., 1992). The wild population (late run) is considered the last remaining wild coho stock with a substantial run in the entire Columbia River Basin (Murtagh et al., 1992).

The late wild run generally spawn above the North Fork Reservoir, on the mainstem Clackamas (Cramer xx), the self-sustaining early run fish spawn primarily in the Clackamas River above the Collawash (Cramer xx). No information was available about Goose Creek populations. Based on smolt trapping, Burke Strobel of the USFS felt Deep Creek vies with Clear Creek for the title of being the number one producer of coho smolts in the lower Clackamas Basin. The Big Bottom reach of the Upper Clackamas is the largest producer overall (B. Strobel, personal communication 2004). The smolt trapping information also shows coho coming out of Deep Creek are the biggest coho smolts in the basin on average for the watersheds that have been sampled.

Table 6-4 summarizes the timing of anadromous fish life history stages in the lower Clackamas River (based on Murtagh 1992, Cramer xx).

**Table 6-4: Summary of the timing of anadromous fish life history stages in the lower Clackamas River.**

	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
<b>Winter Steelhead</b>												
Adult Immigration												
Adult Holding												
Spawning												
Egg/Alevin Inc												
Emergence												
Rearing												
Juvenile Emigration												
<b>Fall Chinook - Black Spring Chinook - Grey</b>												
Adult Immigration												
Adult Holding												
Spawning												
Emergence												
Juvenile Emigration												
<b>Coho</b>												
Adult Immigration												
Adult Holding												
Spawning												
Egg/ Alevin Incubation												
Emergence												
Rearing												
Juvenile Emigration												

### 6.4.2 Fish Stocking

- Which salmonid species are native to the watershed, and which have been introduced to the watershed?
- What are the species interactions?

The fish species stocked in Clear and Foster Creeks are summarized in Table 6-5 (Hatchery release data downloaded from: [www.osu.orst.edu/dept/nrimp/information/index.htm](http://www.osu.orst.edu/dept/nrimp/information/index.htm)). Data available on the WEB site only listed released until 1991. There were very few records of stocking in the Deep/ Goose watershed, coho and rainbow trout are the only species recorded as having been stocked.

With the limited history of stocking there are not any likely species interactions between native and non-native salmonids. There are no references to brook trout currently occurring in either Deep or Tickle Creeks. However, since smolt trapping data indicates Deep Creek is the biggest

producer of bullfrog tadpoles and pumpkinseeds (B. Strobel USFS. Pers. comm. 2004) it may be worth considering if these warm water species are impacting salmonids.

**Table 6-5: Summary of fish stocking in Deep/ Goose Creek Watershed.**

Species	Tickle Creek	NF Deep	Deep Creek
Coho salmon	1981,83,84,	1981	1948,49,52-63,68,81,83,85
Rainbow trout			1948, 49, 1952-63

### 6.4.3 Aquatic Habitat Conditions

- *What is the condition of fish habitat in the watershed (by sub-basin) where habitat data has been collected?*

ODFW collected habitat data in Deep and Tickle Creeks June to September 2003. This is the only data available for the basin. There is no information on Goose Creek.

The Deep Creek habitat survey covered 17,924 meters (11.14 miles) upstream of the confluence with the Clackamas River. Eleven reaches were designated based on channel morphology, gradient, land ownership and tributary junctions. Scour pools and riffles were the dominant instream habitat types, gravel and cobble were the dominant substrate types.

The Tickle Creek habitat survey covered 12,462 meters (7.74 miles). Five reaches were designated based on channel morphology, gradient, land ownership, and tributary junctions. Riffles and scour pools were the dominant instream habitat types, while cobble and gravel were the dominant substrate types.

**Table 6-6: Summary of key habitat parameters measured during the 2003 ODFW habitat survey in Deep and Tickle Creeks, with the ODFW habitat benchmark rating.**

	<b>Reach Length (m)</b>	<b>Pool Frequency (channel widths) (Benchmark Rating)<sup>a</sup></b>	<b>Gravel (% area) (Benchmark Rating)<sup>b</sup></b>	<b>Fine Sediment (% area) (Benchmark Rating)<sup>c</sup></b>	<b>Large Woody Debris (m<sup>3</sup>/100m) (Benchmark Rating)<sup>d</sup></b>
<b>Deep Creek 1</b>	1460	4 (good)	28 (fair)	12 (fair)	2.0 (poor)
<b>Deep Creek 2</b>	1022	2.6 (good)	39 (good)	13 (fair)	4.2 (poor)
<b>Deep Creek 3</b>	3637	2.6 (good)	42 (good)	20 (fair)	5.5 (poor)
<b>Deep Creek 4</b>	293	-	-	-	-
<b>Deep Creek 5</b>	480	3.1 (good)	40 (good)	17 (fair)	1.9 (poor)
<b>Deep Creek 6</b>	3622	3.2 (good)	38 (good)	11 (fair)	10.5 (poor)
<b>Deep Creek 7</b>	3480	3.9 (good)	27 (fair)	13 (fair)	7.4 (poor)
<b>Deep Creek 8</b>	458	2.5 (good)	26 (fair)	14 (fair)	45.1 (good)
<b>Deep Creek 9</b>	280	-	-	-	-
<b>Deep Creek 10</b>	938	7.3 (good)	33 (fair)	9 (good)	9.0 (poor)
<b>Deep Creek 11</b>	3098	3.6 (good)	26 (fair)	40 (poor)	5.9 (poor)
<b>Tickle 1</b>	6202	3.9 (good)	31 (fair)	10 (good)	2.1 (poor)
<b>Tickle 2</b>	361	-	-	-	-
<b>Tickle 3</b>	1149	3.4 (good)	33 (fair)	16 (fair)	3.4 (poor)
<b>Tickle 4</b>	261	-	-	-	-
<b>Tickle 5</b>	4816	4.5 (good)	39 (good)	18 (fair)	1.5 (poor)

**The ODFW Habitat Benchmark Ratings are based on the following criteria:**

**a- POOL FREQUENCY (Channel Widths);** poor = >20 , good= <8

**b- GRAVEL (% AREA);** poor=<15%, good=>35%

**c- SILT-SAND-ORGANICS (% AREA);** poor=>25%, good=<10%

**d- LWD VOLUME / 100 m STREAM LENGTH;** poor=<20. good=>30

Overall habitat conditions were fair to good where sampled. Pool frequencies and gravel availability was rated as good to fair for all reaches. The amount of fine sediments (silt, sand and organics) was fair to good with the uppermost reach of Deep Creek the only area with especially high fines. Wood volume was low at all sites except in reach ‘Deep Creek 8’. Wood Volumes ranged from 1.5 to 10.5 m<sup>3</sup>/100m, In reach ‘Deep Creek 8’ the wood volume was 45.1 m<sup>3</sup>/100m.

The pattern of low wood volumes is consistent with observations at other streams in Oregon and is usually due to historic stream cleaning practices, combined with limited riparian inputs due to historic harvest of large riparian trees.

Knotweed was observed in Lower Deep Creek. Japanese knotweed is an herbaceous perennial that grows very quickly on thick single stems, which appear reddish brown, and includes simple branches when large. It is native to Japan, also North China, Taiwan, and Korea. It is spread by cuttings or pieces of rhizomes, often inadvertently as discards from gardens or carried along rivers or stream beds, where it can colonize extremely quickly after floods. Knotweed grows extremely quickly: within 6 days, a viable plant exists from a small rhizome, especially when the rhizome is in water, which is why river/stream banks tend to get overwhelmed. It grows over 6 feet in first couple months of spring, shading out all other species around it. Even when the visible parts of the plant are cut away, the rhizomes sustain it, making it extraordinarily persistent. Knotweed can withstand almost all types of soil, light, and drought conditions and rhizomes will survive to grow plant even if buried 3 feet deep, or under asphalt.

Knotweed reduces riparian biodiversity because forces out native plants through shade and thick ground cover, damages wildlife habitat, is expensive to treat, and aesthetically displeasing. It is extremely difficult and time consuming to eradicate once it is established. Hybridization has already occurred on a wide scale, and the potential exists for much greater interbreeding/evolution, making it even more difficult to control. It has been declared a noxious weed in several states. Because the leaves and stems fall thickly and take a long time to decompose, no other plants (except the new Japanese knotweed shoots) can grow in an affected area.

#### **6.4.4 Potential Barriers to Fish Migration**

Natural barriers to fish migration such as waterfalls, steep cascades, or bedrock chutes are uncommon in the Deep and Goose Creek watersheds. Watershed geology and topography do not favor these features. Though other forms of natural barriers such as seasonal flow restrictions and decreasing channel size do impede salmonid and resident fish migration, barriers introduced by roads, water impoundment, or landowner aesthetics are much more common blockages to upstream and downstream movement.

Fish passage barriers are not restricted to particular landownerships. Public, including federal, state, county, and municipal, and private ownerships all construct barriers to fish passage. In the Deep and Goose Creek watersheds, 55% of the surveyed barriers were on private ownerships. County ownership made up 35% of the barriers and 10% were on state-owned roads. These percentages are characteristic of ownership representation in other Clackamas River watersheds such as Eagle, Clear and Foster Creeks, with the exception that federal ownership might replace state ownership (Robison and Walsh 2003). Regardless, it is essential to the success of a fish passage assessment effort to survey passage barriers on all landownership types.

#### **6.4.4.1 Barrier Determination and Summary**

293 total potential barriers were examined in the Deep, Goose, and Eagle Creek watersheds in the Lower Clackamas River Basin. Of these, 163 potential instream barriers were surveyed in late summer and fall of 2003. We did not survey 130 possible barriers because they were situated on non-fish bearing and/or headwater reaches. Assessment of fish passage on 109 barriers in the Deep and Goose Creek watersheds is presented here. Assessment of fish passage on 54 barriers in the Eagle Creek watershed is reported in Appendix 1. Of the 109 barriers surveyed in Deep and Goose Creek watersheds, 21 were found to completely block and 28 to partially block passage to salmonids and resident fish species. One of these is a natural barrier near the mouth of Noyer Creek and 9 were on non-fish bearing reaches. The remaining 39 were prioritized in order of the severity their blockage has on limiting fish movement. 18 of the 39 barriers partially or completely block *salmonid* passage. Based on the prioritization methods presented in Appendix 2, barriers to salmonid species will have a higher priority than barriers that affect only resident fish species. The locations of the instream barriers can be found on the fish passage maps in *Map 9: Fish Passage Barrier Map* and on the web-based Fish Passage Tool (<http://www.clackamasriver.org>).

The methods used to identify and survey instream potential barriers in the field, to determine if a potential barrier blocked or partially blocked fish passage, and to prioritize the blockage severity are available in Appendix 2. Prioritization results and Phase One design recommendations are in Appendices 4 and 5. Appendix 3 is a copy of the field forms.

#### **6.4.4.2 High Priority Barriers**

Prioritization, which accounts for a barrier's distance from the Clackamas River, the length and quality of potential habitat upstream, the general types of fish that use the stream reach (salmonids, resident, exotic), and the habitat quality of the reach, identified the most significant barriers to salmonid movement in Deep and Goose Creeks.

None of the five top priority barriers in the Deep and Goose Creek watersheds is a complete blockage to fish passage. All are partial barriers that block passage to at least juvenile and weak swimming salmonids at some point during the year. Of the top 10, only two are complete barriers. The ten barriers identified as the highest priority are:

*Crossing DPD01* – This is a cement weir maintained by a Clackamas County wastewater treatment facility outside of Boring on the North Fork Deep Creek. The County uses the weir to test water quality for permitting purposes. The 27 foot wide weir spans the creek just downstream of the bridge on Ritchey Road. The weir is a partial barrier to juvenile fish because of the jump height and the width of the cement barrier. In addition, the weir's footing on each bank is eroding.

*Crossing DP026A* – This crossing is an unused bridge/culvert on the North Fork Deep Creek, not far upstream from the wastewater facility's weir. It is on privately-owned, industrial property. The bridge portion of the crossing is a log-spanner with approximately 15 feet of fill and

vegetation growing on top. A 6-foot diameter metal culvert sits underneath the log spanners. The pipe has become a partial barrier because a beaver dam and other debris have blocked its inlet resulting in a 2.5-foot jump that fish have to clear to exit the pipe.

*Crossing DPD02* – This barrier is a dam on private property on the North Fork Deep Creek upstream of DPD01 and DP026A. It is a partial barrier to fish passage from June to October when the landowner has the spillboards in place. The landowner manages the spillboards by removing them in early October and installing them after mid-June. When the spillboards are out this crossing does not represent a barrier to fish passage.

*Crossing DPD05* – This is a 30-foot high dam with a fish ladder running up its face and four weirs downstream that raise the channel on Deep Creek. It is on private property. The weirs are partial barriers because each rises one to two feet above the water level and is 2-feet wide at the top. The fish ladder jump pools are 5-feet long, which can be short depending on the fish species and size. The fish ladder's jump heights are also tall at 1.2 feet. The landowner is interested in working with the council and the Oregon Department of Fish and Wildlife to improve the barrier as much as possible.

*Crossing DP037* – This crossing is a box culvert on the North Fork Deep Creek that runs underneath Highway 26. It is a partial barrier to passage because of a high outlet drop, borderline box slope, and long length. In addition, because of a cement wall through its center, it could be a velocity barrier at high flows.

*Crossing DP069* – This is a crossing on Tickle Creek near the Sandy wastewater treatment facility on private property, though the wastewater treatment facility likely has an easement to use or full ownership of the road. The crossing has three culverts. All three are partial to complete barriers to fish passage. The two culverts that receive the most flow have slopes at or over 4%. The third culvert is less steep at 2%, but is also above the water level from summer through late fall. It and the middle culvert are rusted through their bottoms.

*Crossing DP074* – This crossing on Tickle Creek is a combination dam and pipe culvert on private property. The crossing is a partial barrier because the culvert has a steep slope combined with a hydraulically challenging inlet created by the dam.

*Crossing DP083* – This crossing is a double culvert crossing immediately upstream of DPD05 on Deep Creek. Though the road is marked on the GIS road layer as a Clackamas County easement, local residents and the County have treated it as a private road. It is a barrier for juvenile and/or weaker swimming fish because of the pipe slope and flow constriction.

*Crossing DP079* – This crossing is a box culvert underneath SE Orient Road on a tributary of Tickle Creek. It is a complete barrier to fish passage because of its steep gradient, length, and potential high velocities caused by constricted flow.

*Crossing DP116* – This crossing is a cement box culvert on Tickle Creek that has been identified by the ODFW as a barrier. It runs under State Highway 211. The fish passage survey found this

crossing to be a complete barrier. It has a high outlet jump, steep slope, long length, and narrow width which could cause velocity issues.

Prioritization ranking information for the other 29 crossings in the Deep and Goose Creek watersheds are available in Appendices 4 and 5 and/or on the Fish Passage Tool ([www.clackamasriver.org](http://www.clackamasriver.org)).

#### **6.4.4.3 Action Planning**

The crossings that the survey identified, based on habitat features, as the highest priority barriers are a fair representation of the general character of fish passage in Deep and Goose Creeks. In general, fish passage is not the most important limiting factor in these basins. Other factors, such as water quality, may have a greater influence on the habitat quality and quantity available to anadromous salmonids. In addition, the identified high-priority barriers have the potential to respond to fairly simple and cost-effective solutions to facilitate full passage. Many barriers also have willing, cooperative landowners.

It is notable that three of the top five crossings in Deep and Goose Creek are dams. A strong effort was made during the survey to survey instream dams. These structures are important barriers to fish passage. Even though locating and gaining access to dams is more difficult than in-stream barriers on roads, every effort to survey dams should be made during a fish passage assessment.

None of the top ten priority crossings are found in the Goose Creek watershed. The highest priority crossing on Goose Creek is ranked as #14. It is a pipe arch that is a partial barrier on private land to the west of Highway 224. Goose Creek is a small watershed with shorter distances of available habitat upstream of each crossing. It is also uncertain whether anadromous species can enter Goose Creek during low flow periods. Cobble deposits reworked at its confluence with the Clackamas River during the 1996 flood may create a seasonal barrier to the entire creek system.

Despite being used for water quality testing from the waste water treatment plant, the highest priority barrier, DPD02, has the potential to be a good candidate for removal. The landowner is willing to discuss removal, the test results from the facility have been consistently clean according to the facility manager (personal communication, 9/16/03, D. Benfield), and the weir's condition is beginning to degrade. The second highest priority barrier, DP026A, also has the potential for removal because it is no longer used. In addition, because the material blocking the inlet could be removed without affecting the culvert or bridge, active management to maintain the inlet opening is also a possible low-cost solution. The third and fourth highest priority crossings are owned by enthusiastic, cooperative landowners who are concerned about fish habitat and willing to participate in local projects.

Conversely, DP079, the highest ranked complete barrier to fish passage in the Deep Creek watershed, has a partial barrier crossing not far downstream and not much available fish habitat above it. As a result, despite its full barrier status, it would be a lower priority crossing to

replace. In general, however, many of the fish passage barriers have at least one potential resolution that will facilitate cooperative, cost-effective action planning.

## **6.5 INFORMATION GAPS AND MONITORING**

- There is no information on searun cutthroat population or use in the watershed. Since this species is not well understood population sampling may be considered.
- The presence of non-native warmwater aquatic species (bull frog tadpoles, pumpkinseeds) has been noted. These species have the potential to impact salmonid survival and productivity. It would be useful to have a better understanding of their distribution and habitat utilization.
- No habitat sampling has ever been completed in the Goose, and North Fork Deep Creek subwatersheds. These are areas most likely to be impacted by land use activities habitat conditions should be evaluated.
- The reach Deep Creek 8 (in Upper Deep Creek) sampled by ODFW had high levels of large wood. This condition is unique and efforts should be made to understand why this area has high wood numbers and identify means to maintain current conditions.
- The uppermost reach in Deep Creek sampled by ODFW had high fine sediments. Determining the fine sediment sources in this area would likely reduce fines sediments throughout Deep Creek.
- Large woody debris supply is limited throughout the watershed. Continue riparian planting for long term supply of large wood. Investigate opportunities to introduce large wood to the channel. Educate landowners about benefits of large wood and impacts of landscaping to the edge of the creek.
- There are numerous ponds mapped and visible on aerial photos. Several of the high priority passage barriers are dams. Pond operations of in-channel ponds potentially blocking anadromous fish passage should be investigated.
- The CHT evaluation identified sections of stream that have been ditched. Ditching of portions of Goose Creek and tributaries in North Fork Deep and Tickle Creeks is a common channel-modification and should be evaluated for fish habitat implications.

## **6.6 RECOMMENDATIONS AND POSSIBLE COUNCIL ACTIONS**

The presence of knotweed in small portions of lower Deep Creek should be a concern and removal efforts should be considered.

## **6.7 REFERENCES**

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