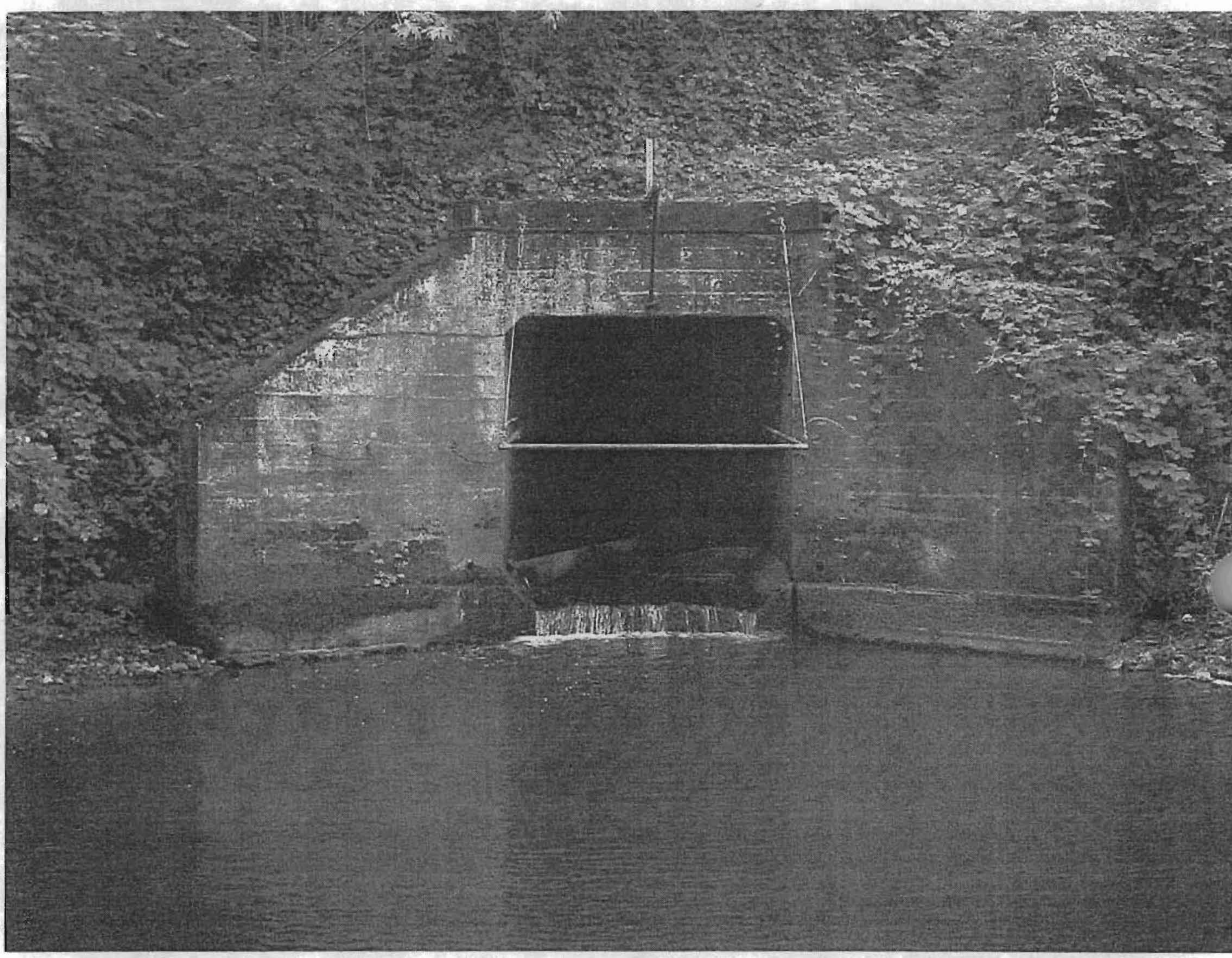
TRYON CREEK WATERSHED BASELINE ASSESSMENT AND MACROINVERTEBRATE STUDY

Prepared by the West Multnomah Soil and Water Conservation District

This final draft is presented to: the Oregon Watershed Assessment Board, which provided funding for the Baseline Assessment Report.

Project Manager: Elizabeth Callison
Editors: Elizabeth Callison, Jim Robison, and Brian Lightcap

Tryon Creek flows through a 400 ft. long concrete culvert under Highway 43 (State Street) in Lake Oswego, approximately 1000 ft. upstream from the creek's confluence with the Willamette River.



Tryon Creek Assessment Executive Summary and Observations

West Multnomah Soil & Water Conservation District (WMSWCD) Board members:
Brian Lightcap, Chair; Rick Sanders, Vice chair; George Sowder, Secretary; Kim Peterson, Treasurer; Elizabeth Callison; Nancy Park; and Dave Egger.

OVERVIEW

Tryon Creek is a typical urban stream that has been impacted by roads, development, storm water, sewer lines, non-native vegetation, and the chemicals used on private lands. It is also typical because continuing pressure for more housing and urban infrastructure worry many, in both the public and private sectors, that the water quality of the stream, its watershed vegetation, and its ability to sustain fish and other aquatics will continue to decline. It is, however, untypical compared to many other urban streams in the Portland area because much of this development is distant from the stream itself due to the stream's steep topography and also because over 650 acres are preserved and protected in Tryon Creek State Park.

The purpose of stream baseline assessments such as this is to assemble basic stream health information in one central location. This often does not happen because different state and local agencies gather information that oftentimes is not known to or shared by other agencies. As a result, actions to improve stream health often proceed without the desired comprehensive overview of the problems. Therefore, various and even conflicting opinions arise with regard to which studies are relevant, which water quality issues are most critical to address first, and, most importantly, what course of action should be pursued. This Baseline Report, made possible by Oregon Watershed Enhancement Board (OWEB) funding, is an attempt to bring the information contained in sundry documents together in order to develop more cohesive actions and ultimately to determine definitive goals to protect and enhance stream health. The West Multnomah Soil and Water Conservation District (WMSWCD) Board felt that the ultimate goal of not just stabilizing but improving this watershed was challenging because past projects have been conducted based on limited existing baseline information; for example, it is not known if the present stream health is at least stable. The City of Portland has collected most of the water quality data used by contributors in this report. The City will also be the primary entity evaluating and interpreting this data.

The genesis of this project, sponsored by WMSWCD, arose because of the concerns of one of its Directors. Elizabeth Callison, the Project Manager, felt that existing information should be assembled in one place and that further study should be conducted. Ms. Callison wrote a grant application , which was submitted to OWEB and subsequently approved. The effort to complete the grant took over three years and was led by Ms. Callison in a generous volunteer endeavor. In addition to working with contractors, she also trained volunteers to collect, quantify, and assess macroinvertebrate life in selected reaches of the creek. She also assembled and organized existing information and reports, working with scientists who contributed data on geology, hydrology, geomorphic conditions, and historic information on factors associated with the decline in stream health.

This Report contains the recommendations of many individuals as to directions that could be taken to prevent the decline of fish populations, usually seen as the ultimate measure of stream health. Please note that the recommendations and opinions expressed by individual contributors to this document are not necessarily endorsed by the WMSWCD; readers will have to evaluate the validity/usefulness of each report on their own. Nor does WMSWCD have a clear sense of priority on how best to proceed, for at this point this is a baseline study. The Cities of Portland and Lake Oswego are the lead agencies with respect to water quality in the watershed and are hopefully taking steps to improve and protect Tryon Creek to satisfy both the Endangered Species Act (ESA) and Clean Water Act (CWA). The various recommendations in this Report, some conservative and some extreme, represent sincere professional and personal efforts to describe existing conditions. As with any such efforts involving many disciplines, finding agreement on technical issues will take time, effort, and a sense of cooperation to reach common goals. WMSWCD hopes to be part of a consensus-building effort, one that will bring together the various agencies at the local, state, and federal level to establish mutually agreed-upon environmental goals and to develop projects and practices to ensure the achievement of those goals.

Readers may reach different conclusions as to the health of Tryon Creek and its tributaries; however, this stream is classified by the Oregon Department of Fish and Wildlife (ODFW) as an impaired urban stream because out of 100 points (pristine conditions), it scored less than 50. The WMSWCD Board hopes that it has produced a document that will be used to support local government direction, especially improving storm water management, and that it will be an instrument of change to focus concern where it is needed. The Board also hopes that this Baseline Assessment Report will enable local politicians and agency administrators to see why coordination of scientific efforts and a greater sharing of data can lead to more effective spending of funds to address environmental concerns. The Board will remain involved in the public dialogue on ways to improve the health of Tryon Creek and will continue its efforts to work with the Tryon Creek Watershed Council (TCWC) to influence actions that can be taken by various regulatory agencies, the Cities of Portland and Lake Oswego, and by individual landowners and developers.

OBSERVATIONS

WMSWCD knows that Tryon Creek is an impaired waterway due to poor water quality and fish passage obstructions. In the opinion of Project Manager Elizabeth Callison, water quality has been steadily declining; yet according to Portland Bureau of Environmental Services (BES), the water quality of Tryon Creek has improved in the last decade or so, but BES has not completed their scientific data upon which to base its conclusions. WMSWCD is working to determine which actions or projects will ultimately be most useful to preserve and improve water quality. There currently is an emphasis on storm water management solutions, as evidenced by the work and focus of the Portland Area Storm Water Advisory Committee (PASWAC). WMSWCD doesn't know with any degree of certainty whether there has been a decline in fish populations in the last 10 or even 20 years. There is only a small amount of information on fish resources, most of which has been produced by ODFW, first made available in November 2002. WMSWCD does have data to determine what a healthy creek of this size produces, and it is aware of an abundance of cutthroat trout in a comparable, but less-developed urban stream, Balch Creek. Balch's fish population seems to be stable and is about 30 percent higher than Tryon Creek's.

Although the intensity of roads and urban development for Balch Creek, flowing along NW Cornell Road, likely will never approach that of Tryon Creek, to many non-scientists, the numbers and size of cutthroat in either creek may seem remarkable. The WMSWCD Board was quite involved in the Balch Creek watershed 15 years ago to discourage a sewer pipeline (which would have allowed increased urban development) and the Board helped write a local erosion-control ordinance, adopted by the City of Portland. Tryon Creek health may never rival that of Balch Creek; a level of fish populations comparable to Balch Creek may be the best that Tryon Creek can achieve. Both creeks are described as impaired urban streams by ODFW's detailed criteria-rating system, but there are major differences in urban impacts on these creeks. So, do we know what to do to increase Tryon Creek fish populations another 30 percent and what can we infer from the macroinvertebrate population of either creek?

The Board of WMSWCD believes that government agencies, environmental organizations, and watershed landowners need to remain vigilant and open to ways of improving the health of Tryon Creek. The Board members know that headway toward solutions cannot be made by dwelling on the transgressions of the past. This Board is not an enforcement agency, but rather seeks watershed health through cooperation and partnership. The Board members believe they should learn from past problems, but unless they continue to nurture the ethic of finding ways to improve, the progress made in preserving and enhancing stream health will languish and our local society will become discouraged. This Board supports continuous, proactive community dialogue and actions focused on finding solutions and selecting enhancement projects with care and based on scientific knowledge. This Board will continue to support the Tryon Creek Watershed Council (TCWC) and its citizen and technical contributors to determine the need for additional study and to recommend actions on a priority basis.

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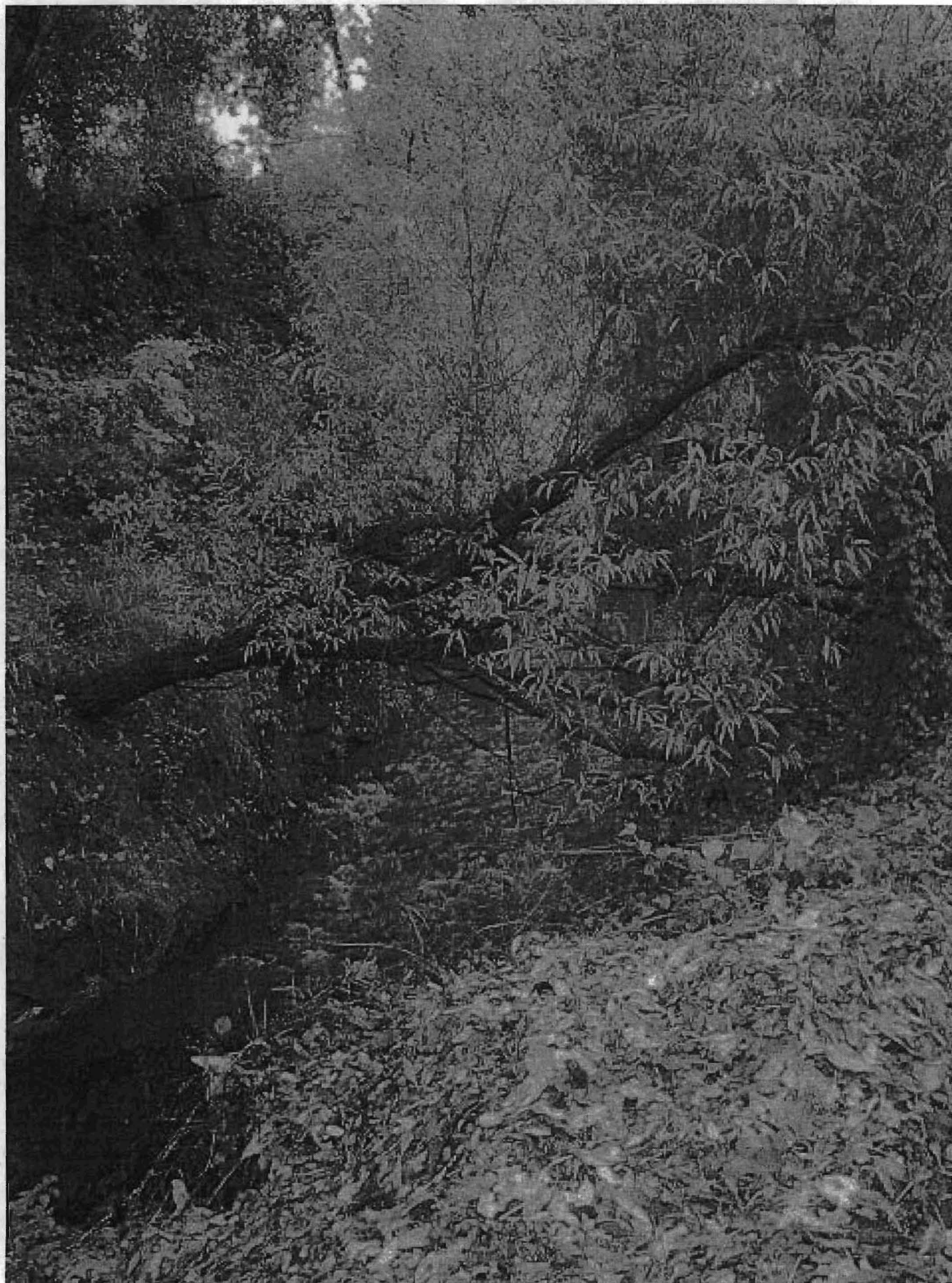
This Baseline Assessment Report is a collection of studies by a number of scientists as well as a summary of land use issues by Elizabeth Callison, the Project Manager. Complete versions of the individual scientists' reports included in this first edition of the publication, as well as the *Tryon Creek Atlas*, the BES *Upper Tryon Creek Corridor Assessment*, several Lewis and Clark College graduate student surveys, and other studies will be available in an electronic Appendix on the project website (westmultconserv.org) and in the StreamNet library.

The Baseline Watershed Assessment Project was partially funded by the Oregon Watershed Enhancement Board and the West Multnomah Soil and Water Conservation District.

Thanks to the many volunteers and students during 2000-2002 !



Tryon Creek just upstream from its confluence with the Willamette. *Photo: T. Calabrese, 11/01.*

TABLE OF CONTENTS

PART 1

TRYON CREEK PFC ASSESSMENT

National Riparian Service Team
October 30 – November 1, 2001
Lake Oswego, Oregon

I. Introduction

The West Multnomah Soil and Water Conservation District (SWCD) requested that the National Riparian Service Team (NRST), a combined BLM and Forest Service cadre of watershed specialists, provide an assessment of the Tryon Creek watershed located in west Multnomah County. In response to this request, the NRST traveled to Lake Oswego, Oregon during the week of October 29-November 2, 2001. The team members participating in the technical assistance trip included Ron Wiley (Fisheries Biologist), Lorena Corzatt (Hydrologist), Steve Leonard (Ecologist/Grazing Management Specialist), and John Anderson (Fisheries Biologist/Large Wood Specialist). The purpose of the trip was to assess the physical processes affecting the baseline condition of the watershed and to identify the limiting factors concerning habitat for anadromous fish. The team made visual assessments of the watershed and selected reaches. Proper Functioning Condition (PFC) checklists were completed for seven stream reaches. Elizabeth Callison (SWCD Director at Large), Diane Bland (Volunteer), and Tom Calabrese and Craig Fanshier (SWCD Consultants) worked with the team to complete the Tryon Creek PFC assessment.

SWCD-Identified Issues:

- Lack of a comprehensive baseline watershed assessment;
- Identification of limiting factors affecting anadromous fish production;
- Effects of storm drain run-off on the function of the watershed and its streams;
- Effects on aquatic life of pollutants in storm-water run-off.

Issues to be addressed by the NRST included:

- Physical function of Tryon Creek and its tributaries;
- Effects of storm drain run-off flows on the physical characteristics of Tryon Creek;
- Identification of habitat limiting factors affecting anadromous fish production.

II. Methods

The Proper Functioning Condition assessment method described in the USBLM Technical Reference 15 (TR-15) [1] was used to complete the field assessment. Standard checklist field forms were completed by the multi-disciplinary team in the field (Appendix 1).

PFC Assessment

The PFC assessment concept was originally developed for the BLM by a team of fifty scientists specializing in hydrology, soils/geology, vegetation and biology. They developed the Riparian-Wetland Functional Checklist of seventeen hydrology, soils/geology and vegetation questions that must be applied to stream-riparian zones to determine their physical functionality. The assessment is used to identify any significant attributes that may be out of balance with the natural processes necessary for the system to function properly. The PFC teams commonly use Rosgen stream channel typing to determine whether the stream fits the expected landscape setting or is outside the natural range of variability (Rosgen 1996).

[1] Prichard, Don., J. Anderson, C. Correll, J. Fogg, K. Gebhardt, R. Krapf, S. Leonard, B. Mitchell, J. Staats. 1998. Riparian area management: a users guide to assessing proper functioning condition and the supporting science for lotic areas. TR 1737-15. Bureau of Land Management, BLM/RS/ST-98/001+1737, National Applied Resource Sciences Center, CO. 126 pp.

The PFC method has been tested in wildland environments managed by the USDI/USBLM, USDA/USFS and private agricultural lands in coordination with USDA/NRCS for over a decade. The methodology has been applied in Canada, Mexico and a number of other countries. It is currently being taught in a number of universities and is now making its way into metropolitan area use where it is successfully being used to collaboratively resolve issues associated with urban streams and wetlands.

PFC assessment requires that a team with journey-level skills in hydrology, soils/geology, vegetation and biology complete a field assessment using the Riparian-Wetland Functional Checklist. For assessment purposes, the team divides the stream into a series of finite segment (reaches) each having common attributes and processes. The results of the assessment are provided to land management agencies and citizen groups so they can have a mutual understanding of the physical processes that are governing the stream and watershed.

The PFC methodology recognizes four categories of stream functionality:

1) Proper functioning condition
   1. Dissipates stream energy associated with high waterflows, thereby reducing erosion and improving water quality;
   2. Filters sediment, captures bedload, and aids floodplain development;
   3. Improves flood-water retention and ground-water recharge;
   4. Develops root masses that stabilize streambanks against cutting action;
   5. Develops diverse ponding and channel characteristics to provide the habitat and the water depth, duration and temperature necessary for fish production, waterfowl breeding, and other uses;
   6. Supports greater biodiversity.

2) Functional-at-risk

   Riparian-wetland areas that are in functional condition but an existing soil, water, or vegetation attribute makes them susceptible to degradation.

3) Non-functional

   Riparian-wetland areas that clearly are not providing adequate vegetation, landform, or large woody material to dissipate stream energy associated with high flows and thus are not reducing erosion, improving water quality, etc.

4) Unknown

   Riparian-wetland areas that managers lack sufficient information about to make any form of determination.

Managers, landowners and concerned citizens have used PFC assessments for development of management strategies to achieve desired values that are realistic and achievable. PFC findings define the limits of the watershed's capacity to produce these values. An accurate portrayal of the physical processes and their present condition lets land users devise plans to manage the watershed for values important to the community.

III. Background

Tryon Creek and Western Oregon Watershed Processes

Aquatic habitats in western Oregon are products of the geology and soils, topography, vegetation, large woody material (LWM), climate, and hydrology of a watershed. Any alteration of these attributes can bring about changes in these habitats and their productivity. Additionally, a stream's channel and energy sources change from headwaters to mouth, and its biological community adapts accordingly. The lower reaches of the watershed are generally the fish producers while small headwater tributaries are a significant source of aquatic macroinvertebrates and nutrients.

The two basic types of streams in western Oregon are those that are wood dependent and those that are not. Tryon Creek is a wood dependent system. Tryon Creek and its tributaries developed in conjunction with a large conifer forest. The wood provided by huge tree boles trapped sediment and formed floodplains that in turn retained flood water and promoted the growth of riparian vegetation. Small streams such as Iron Mountain Creek need smaller trees, large streams need extremely large wood from mature conifer boles. LWM is the most important attribute in this stream type and the processes associated with it are the most important to the function of the watershed.

Tryon Creek watershed, as we see it today, is seriously compromised because the large wood has been lost. Early in the 19th century, beaver trappers significantly reduced the beaver populations of the northwest, compromising the integrity of beaver dams in the small streams. The impact of logging further disrupted channel functions. The continued removal of wood from stream channels to facilitate recreation and facility maintenance destabilizes the channel thus causing degradation. Under these conditions each high-water event flows unchecked downstream surging from side to side, eroding the streambanks and preventing the reestablishment of vegetation needed to help restabilize the channel. The loss of wood from these streams also affects the transport and storage of sediments. Large wood functions to temporarily store sediments within the channel. It also functions to slow and back up water, forcing flows out onto the floodplain area where sediments settle out. These deposits provide sites for vegetation to establish.

This wood, visible in the stream channel and on the surface of the floodplain area, is not the only wood that is important to stream function. As streams naturally meander across the valley bottom, the rate of movement is controlled by both live vegetation and surface downed wood and by buried wood. Studies have shown that a great deal of the volume of the meander belt is composed of buried wood. One study found buried wood made up 30% of the volume of a stream's meander belt. This wood is long-lived with life spans often measured in centuries, sometimes in thousands of years. Locally, wood 10,000 to 15,000 years old was found underlaying the Tualatin River (Oregonian, 2001). Studies throughout the world arrive at similar results (OSU 2000). Once this wood is removed, the stream is free to surge from side to side with little resistance.

In most of the Tryon Creek drainage, frequent flood-flows are not capable of reaching a relatively flat floodplain for energy dissipation, sediment deposition, and periodic flooding of riparian vegetation. The channel has down-cut and widened so the amount of water that formerly filled the channel and spilled onto the floodplain is now held within the deeper, wider channel. Very high, more infrequent flood-flows do reach the terraces. Reduction in resistance-forces (loss of large woody material and riparian vegetation, especially woody species) and increases in water velocity result in an increase of flow energy. The increased energy continually erodes the streambed and streambanks. This has been significant enough to produce rapid vertical adjustments to the channel network, disconnecting the channel from its frequent floodplain. The result is more water remaining in the channel and less water infiltrating into the floodplain aquifer during moderate flow events.

Wood has a number of other important functions. It serves as cover for fish at rest and as protection for them from high flows and predators. It may also provide ambush cover. Wood traps fine organic debris and helps retain nutrients in the stream. Wood is important in providing a substrate and food source for aquatic invertebrates that, in turn, provide food for fish. All functions are critical components in aquatic production and have a significant effect on fish community health.

Tryon Creek habitat is capable of sustaining a population of anadromous fish but it is far from optimum. Until large woody materials in the streams of Tryon Creek significantly increase, the anadromous fish populations will remain low. It appears that spawning and summer rearing habitat are adequate. The lack of winter habitat provided by wood complex may be a major limiting factor. The high flows of winter and spring force fish to seek cover complexes and, when they are absent, juvenile anadromous fish are usually lost from the system.

Long- term strategies are needed for tree and wood management. Once LWM is lost from a stream reach or watershed, it will take a very long time to recover. Based on the current average age and size of trees in the watershed as well as the species composition in riparian areas, it will require several centuries or more for full recovery to occur. However, landslides, wind-throw and ice storms will input significant amounts of material over the next several decades that can begin the recovery process. Due to a general skewing of riparian species composition in the riparian area towards deciduous trees, e.g., alder, much of this early wood will be relatively short-lived in the stream channel. The average size of the material will also be smaller. Therefore, it is important to recognize that this limitation in useful lifespan coupled with the smaller sizes of the material will slow stream recovery during the initial decades of recovery.

Management practices in the Tryon Creek watershed should develop a holistic approach to improving stream-riparian health. To accomplish this goal management should treat the stream-riparian ecosystem and the entire watershed as a whole. Efforts must be made to remove or manage the stressors to watershed processes. Current management activities must be carefully designed to ensure that effects from them do not exacerbate existing conditions. Management strategies should emphasize improvement of watershed-wide processes over unimportant and minor negative site-specific impacts to ensure that time and resources are not wasted.

Physical and Biological Properties of Tryon Creek

Tryon Creek watershed encompasses approximately 4,200 acres. The distance from the headwaters to the Willamette River is a little over seven miles. Most is within the City of Portland (75%), while some portions are within the City of Lake Oswego (15%) and unincorporated Multnomah and Clackamas counties. Approximately 650 acres are in parkland owned by the state or local and regional governments.

Tryon Creek provides habitat for winter steelhead, a species listed as threatened under the Endangered Species Act (ESA). It is on the DEQ 303 (d) list for elevated summer temperatures. Water pollution and accelerated storm run-off water have been an issue of concern. The stream is currently inhabited by winter steelhead and cutthroat trout. Coho salmon, Chinook salmon and Pacific lamprey inhabited the watershed but are now believed to be extripated.

Inventories of fish habitat, fish species, macro-invertebrates, water quality, water quantity and soils/geology have been conducted and will be used by the SWCD to develop a physical and biological baseline assessment. Recently collected data indicates that the macro-invertebrate populations are low and lack diversity. Based on the physical attributes of the stream and riparian areas observed by the NRST team biologists, there should be a robust macro-invertebrate population.

Tryon Creek drains a substantial urban area in its headwaters. This area contributes pollution from streets, storm drains, yard chemicals and roof protection chemicals that are all known to adversely affect aquatic organisms. Periodically, the sewer line is cleaned with root killing pesticides. Because of allowable seepage in the sewer line, these chemicals are also delivered to the riparian area. It is highly probable that these pollutants may be adversely affecting the macro-invertebrate and fish populations.

Coho salmon are currently absent from Tryon Creek. It is speculated that this may be a function of reduced Columbia River wild populations rather than a habitat deficiency in Tryon Creek. Very few tributaries of the Columbia or Willamette rivers have wild coho using them. If efforts to rebuild the Pacific Northwest coho population are successful, ODFW may be able to reintroduce them to Tryon Creek.

IV. Discussion

On Tuesday, October 30, 2001, Elizabeth Callison organized a meeting of stakeholders interested in the Tryon Creek watershed. Stakeholders presented information on the geology/soils and hydrology of the watershed. Ms. Callison provided maps, publications and an overview of the watershed. The NRST team led by Steve Leonard explained how PFC assessment is used to build a common vocabulary of riparian and stream processes to improve communication among interested stakeholders and volunteers. Prior to commencing field work, the PFC team reviewed 1:24,000 maps and established preliminary reach breaks for the streams to be assessed. The team used the MAPTECH computer program and GPS to mark PFC assessment locations and points of interest on USGS maps (Appendix 2). The GPS information and coordinates was described and recorded (Appendix 3).

Everyone who attended was invited to the field assessment. Late in the afternoon, the NRST team visited Arnold Creek, a typical headwater tributary.

On Wednesday, October 31, 2001, the team met with Elizabeth Callison and several volunteers and completed the PFC form for Arnold Creek before going to the field. Field examinations were made to the Spring Garden area, Foley/Balmer Green Space, Marshal Park and Tryon Creek reach 4.

On Thursday, November 1, 2001, the team and volunteers assessed Tryon Creek reaches 1-3 and Iron Mountain Creek reach 7.

Watershed Areas

The Tryon Creek watershed was divided into general types for team discussion purposes as 1) upper watershed urban area tributaries, 2) Tryon Creek major tributaries, 3) Tryon Creek alluvial valley and 4) the transport reach from Tryon Creek alluvial valley to the Willamette River.

Table 1. Reaches and Sites Visited by the NRST

Reach No.	Type	Waypoints	Stream Name
1	Transport	023	Tryon Creek mainstem (Willamette R.)
2	Transport	015 to 017	Tryon Creek mainstem (Canyon)
3	Alluvial Valley	017 to 014	Tryon Creek mainstem
4	Alluvial Valley	012 to 014	Tryon Creek mainstem
5	Alluvial Valley	008 to 090	Tryon Creek mainstem
6	Major Tributary	002 to 005	Arnold Creek
7	Major Tributary	014 to 022	Iron Mountain Creek
-	Alluvial Valley	009 to 011	Tryon Creek at Marshall Park
-	Alluvial Valley	006	Tryon Creek at Boones Ferry Culvert

Access to upper watershed tributaries was limited by private dwellings and dense Himalaya blackberry vines in many areas. While no formal PFC reaches were established in this area, the team spot-checked those locations that were accessible to determine the general character of the stream reaches. The lower alluvial valley and transport reaches were much more accessible and were more thoroughly examined by the team. See PFC determinations in table 2.

Upper Watershed Urban Area Tributaries
No PFC reaches established.
Spring Garden Creek upstream from Barbur Boulevard was determined to no longer function as a stream (visited Oct 31, 2001). The former stream has been turned into a drainage ditch, which in sections exhibits some stream-like characteristics. The extensive filling of the floodplain by home development and street construction has confined all flows to the channel. Numerous culverts at street and driveway crossings act to constrain and accelerate flow. Many storm drains were observed flowing from houses, streets and parking lots into Spring Garden Creek. It was felt that this situation was typical of the more highly developed areas in the upper watershed. These storm drains serve to accelerate water into the Tryon Creek basin downstream. They also carry pollutants.

The socio-political situation in the Spring Garden area does not provide managers with significant opportunities to change the stream's function. Many of the Tryon Creek headwater tributaries located in high density areas have been changed from their original stream functions to a new socio-politically-induced capacity as drainage structures. These ditches are modified from historic stream channels that generally can now only be classified as non-functional.

Tryon Creek Major Tributaries
PFC reaches 5, 6 and 7.
The tributaries of Tryon Creek have down-cut during the century of timber harvest and road building in the watershed. The geology and clay soil structure provides some channel stability. However, most of the channels lost their small floodplains when the large wood was removed. Arnold Creek, reach 6, is an example of a tributary in this condition. An unnamed tributary that flows into Marshal Park at waypoint 009 is also in this condition. Upper Tryon Creek in the Foley/Balmer Green Space, reach 5, still has a floodplain but lacks LWM needed to store sediment and narrow the channel. It also lacks a riparian community that can supply LWM. The area has been planted to red cedar and other species that will improve the health of the stream in the long-term. The Himalayan blackberries have been removed to aid riparian plant growth.

Iron Mountain Creek, reach 7, appears to have recovered from the affects of timber removal and is a good example of a stream that has reached the early stage of PFC. It has developed a small floodplain, has a source of LWM and has enough LWM in the channel to store sediment and slow run-off. Red cedar trees are relatively large and can supply a significant amount of large wood in the near future. It was noted that there is a significant amount of housing encroachment on the rim of this drainage.

The tributaries of Tryon Creek examined by the NRST are generally deficient in LWM needed to store sediment and retain water. The vegetation is generally less than 60 years old and too young to contribute significant amounts of LWM needed to rebuild the floodplains and channel structure. The density of conifer tree stems along many streams is too low and will prolong the period before LWM reaches optimum levels. In many locations Himalayan blackberry and trailing ivy prevent trees from becoming established along the stream banks.

Based on the extensive development in the upper watershed, it is probable that the upper watershed does contribute sediment or floodwater that may be outside the historic norm. However, there was no evidence that the upper watershed is adversely affecting functionality of the riparian area or stream channels at this time. Some tributary stream channels are down-cut but are presently able to process the current flow and sediment delivery from the urban area. Additional storm water run-off from urban development should be curtailed to ensure that the stream system is not pushed beyond its limit of resiliency.

Tryon Creek Alluvial Valley
PFC reaches 3, 4 and 5.
Tryon Creek, reaches 3 and 4, are located on two miles of Tryon Creek between High Bridge and the narrow canyon transport reach. This is a depositional reach that has deep soils and a wide historic floodplain. The channel sections examined by NRST show evidence of deep sediments and extensive accumulations of LWM.

The watershed and floodplain have been logged. It is believed that logging has occurred multiple times since the late 1800s. Based on tree stand age, the last logging appears to have occurred in mid-1900. Large woody material that had accumulated in the riparian zone and streams was eliminated during this period of disturbance. The stream is wood dependent for sediment and water storage. The loss of the accumulated wood resulted in channel erosion that converted the stream from one that could access its floodplain to one that cannot. The stream is now confined to a Rosgen F type channel (gulley).

The channel has been down-cut but the combination of clay soil type, buried LWM and riparian tree roots are currently preventing further down-cutting. The bedrock sill and narrow canyon reach at the downstream end of reach 3 appears to be acting as a control that limits further down-cutting.

One large beaver dam was found near the upper end of reach three. It was approximately five feet high and thirty feet long. It impounded water for several hundred yards upstream. The dam was not judged to be stable and was therefore not considered to be a significant long-term channel modifier. The dam does illustrate how beaver will influence the channel when large conifers accumulate to act as anchors for dams that will have long-term stability.

The character of this section of the watershed is well suited to coho salmon production. The stream is relatively low gradient with enough habitat to spawn and rear a significant population of steelhead, coho and cutthroat trout. Although there is a shortage of wood complexes useful for winter habitat, it is believed that the existing habitat would sustain a fisheries population. The ODFW aquatic inventory notes a significant shortage of wood for fish habitat in all reaches of Tryon Creek (ODFW 2000). There is a high probability that the habitat will continue to become more complex in the long-term, which will improve the population carrying capacity.

A recently published study of LWM indicated that a healthy amount of wood in a channel of this type in western Oregon and Washington should be approximately 99 m^3 of wood per 100 meters of stream (Fox 2001). The ODFW Tryon Creek inventory found a maximum of 3.2 m^3 per 100 meters.

Lower Transport Reach
PFC reaches 1 and 2.
Tryon Creek from its confluence to the upper end of a narrow rock-walled canyon transports sediment and does not store sediment. This area is a natural flume.
The stream's bottom and banks are primarily composed of bedrock. This constrained channel was divided into two reaches.

Reach 1 from the Willamette River to the State Street culvert has been extensively constricted by fill material placed on the north stream bank. The other bank is composed of bedrock. Reach 2 extends from the highway culvert upstream through a narrow canyon with steep bedrock walls.

The bedrock nature of these reaches precludes development of riparian vegetation that could significantly affect the channel. The smooth bed and walls of the channel concentrate stream energy so wood and sediment are sluiced out of the system.

Table 2. Tryon Creek Stream Reach PFC Determinations

Reach	Stream Name	PFC Determination	Trend
1	Tryon Creek mainstem (Willamette R.)	Nonfunctional	-
2	Tryon Creek mainstem (Canyon)	Proper Functioning Condition	-
3	Tryon Creek mainstem	Functional-at-risk	Upward
4	Tryon Creek mainstem	Functional-at-risk	Upward
5	Tryon Creek mainstem	Functional-at-risk	Upward
6	Arnold Creek	Nonfunctional	-
7	Iron Mountain Creek	Proper Functioning Condition	-
-	Tryon Creek at Marshal Park	No Determination*	-
-	Tryon Creek at Boones Ferry Culvert	No Determination*	-

* " No Determination:" These stream segments were spot-checked by the team but access was not adequate to complete a PFC checklist.

V. Conclusions

Physical watershed function
The NRST focused on the stream network of the Tryon Creek watershed. While stream condition provides insight into the broader overall watershed function it cannot be used as a surrogate. A comprehensive watershed assessment must be completed to provide a true picture of how well the Tryon Creek watershed is functioning. The results of the PFC assessment reported in this document should be a part of this larger assessment and in fact can be used to guide the design of such an assessment.

Viewed as a whole, the stream network of the Tryon Creek watershed is functioning-at-risk with an upward trend. It should be recognized that individual stream segments within the Tryon Creek watershed may range from those in proper functioning condition to those which are nonfunctional. The loss of LWM from the channel and floodplain has had the most adverse affect. Management strategies currently protect forest and streams from removal of LWM, and this influences the prediction of a continued upward trend.

Storm drain run-off

The headwater tributaries of Tryon Creek have been affected by the encroachment of housing, streets, and other city facilities. The urban area use Tryon Creek as a drainway for storm run-off. The addition of more structures, which increase the acceleration of water entering the system, may pass the upper limit of resilience for Tryon Creek. At that point, erosion of banks and loss of stream-riparian integrity would occur. Biotic attributes may be being affected. See water quality discussion below.

Anadromous fish habitat

Habitat in the watershed is adequate to sustain anadromous fish populations but at levels that would be considered lower than optimum. The loss of LWM needed to provide complex fish habitat is thought to be the major factor influencing fish production. Increases in amount of LWM will improve anadromous fish production but this will be a slow process taking decades and centuries. Managing the watershed to maintain and increase LWM will be beneficial to anadromous fish production in both the short and long-term.

Water quality

There is a need to investigate the water quality of Tryon Creek. Macro-invertebrate populations are commonly used as indicators of water quality. Initial inventories of macro-invertebrate populations indicated they were not diverse or abundant. Based on physical conditions of Tryon Creek watershed, it is the professional opinion of the NRST biologist that the streams should be supporting a robust macro-invertebrate population. The lower than expected macro-invertebrate populations would lead to a conclusion that water quality may be the cause.

VI. Recommendations

1. Develop a long-term watershed management plan to ensure that LWM entering the streams of Tryon Creek will be protected.

2. Develop management strategies that allow the removal of LWM only when it presents a serious and imminent threat to culverts or other essential facilities.

3. Develop a public awareness program that emphases the value of LWM in Tryon Creek.

4. Develop a program to remove Himalayan blackberry and trailing ivy from the riparian zone to aid colonization by native species.

5. Replant under-stocked stream corridors with native conifer species such as red cedar, hemlock, and Douglas-fir.

6. Research the history of the watershed and document the chronology and extent of activities that have impacted the forest, landscape and riparian -stream system. This can aid in understanding the current capability of the watershed and provide insight to relative timeframes necessary for recovery.

7. Develop an accurate map of forest types, stem density and age structure that can be used to model LWM input to the streams through time.

8. Age the LWM that is currently supporting the stream channel in reaches 3 and 4 to better understand the nature of Tryon Creek floodplain development.

9. Develop small ponds and/or marshlands throughout the watershed to capture and filter urban area run-off thus helping to reduce peak flows and absorb pollutants that come from streets, houses and yards.

10. Conduct a fish passage inventory using the latest measurement techniques and standards to ensure that all culverts in anadromous fish reaches are passable.

11. Support the reintroduction of coho salmon to the watershed.

12. Conduct a water quality study that can determine whether pollutants from the urban areas are adversely affecting macro-invertebrates and fish populations.

References

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Oregon State University. 2000. First International Conference on Wood in World Rivers. OSU, Corvallis, Oregon. October 23-27, 2000.

Oregonian, Newspaper. 2001. Daily edition October 31, 2001. Article on ancient wood discovered during excavation.

Vaidvoda, Alexis and T. Tappenbeck. 2000. Aquatic inventory project stream report, Tryon Creek. Oregon Department of Fish and Wildlife. Portland, OR.

Waypoint List and location description

002 –Arnold Creek, reach 6 storm drain grates at the end of street above the creek

003 – Arnold Creek, reach 6, PFC assessment site, eroded channel

004 – Arnold Creek, reach 6, PFC assessment site, large whole tree in channel

005 – Arnold Creek, reach 6, 35th Street over the creek

006 – Tryon Creek trash collector at the Boones Ferry road culvert

007 – Tryon Creek confluence with Spring Garden Creek

008 - Tryon Creek, reach 5, Foley/Balmer Green Space PFC assessment site

009 – Tryon Creek, Marshal Park confluence with unnamed tributary

010 – Tryon Creek, Marshal Park falls area

011 – Tryon Creek, Marshal Park USGS brass cap, T1S, R1E center Sec. 28

012 – Tryon Creek, upper end reach 4, below high bridge, sample pt. 8

014 – Tryon Creek, upper end reach 3 and lower end reach 4 at Iron Mountain Bridge

015 – Tryon Creek, lower end reach 2, upstream edge of culvert under highway

017 – Tryon Creek, upstream end of canyon, reach 2 and beginning of reach 3

019 – Iron Mountain Creek, reach 7, macroinvertebrate sample site

020 – Iron Mountain Creek, reach 7, confluence with tributary (culvert under trail)

021 – Iron Mountain Creek, reach 7, bridge with poor fish access culvert and tributary

022 – Iron Mountain Creek, reach 7, trailhead with sign board

023 – Tryon Creek, reach 1, below main highway culvert

Tryon Creek PFC Assessment
Photo Record
October 30 – November 1, 2001

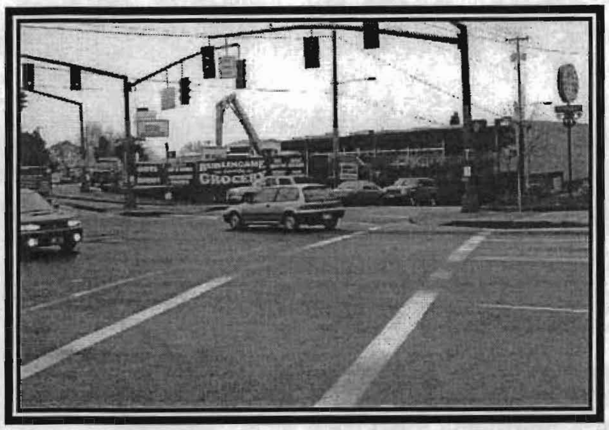


Figure 1. Upper watershed urban streets and business district

Figure 2. Streets, culverts and residential development constraining Spring Garden Creek.

Figure 3. Spring Garden Creek culvert at Taylors Ferry and 26th Street.

Figure 4. Residential yards encroaching on Tryon Creek riparian zone in the upper watershed.

Figure 5. Municipal sewer line crossing Tryon Creek, reach 4.

Figure 6. Himalaya blackberry vines choking out riparian vegetation on Tryon Creek, reach 4.

Figure 7. Non-native ivy vines on trees in Tryon Creek State Park.

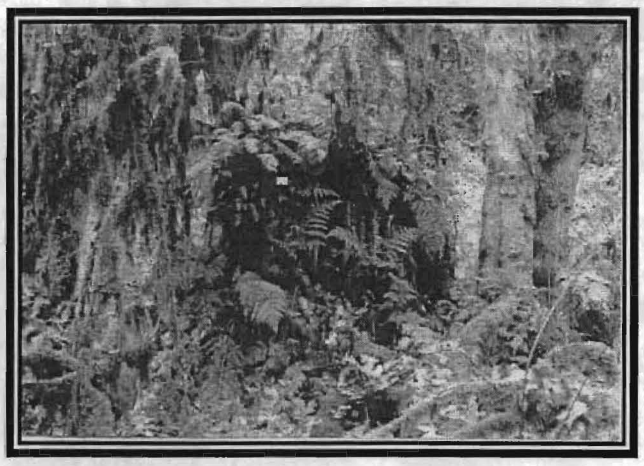


Figure 8. Large conifer tree stump (>4' diameter) on the bank of Tryon Creek, reach 4.

Figure 9. Large western red cedar stump at High Bridge on the bank of Tryon Creek.

Figure 10. Deciduous trees (red alder) along Tryon Creek, reach 3 and 4.

Figure 11. Western red cedar plantings along Tryon Creek, reach 4.

Figure 12. Small diameter woody material accumulating in Tryon Creek, reach 4.

Figure 13. Rosgen F type channel (gulley) with the old flood plain occupied by alders along Tryon Creek Reaches 3 and 4.

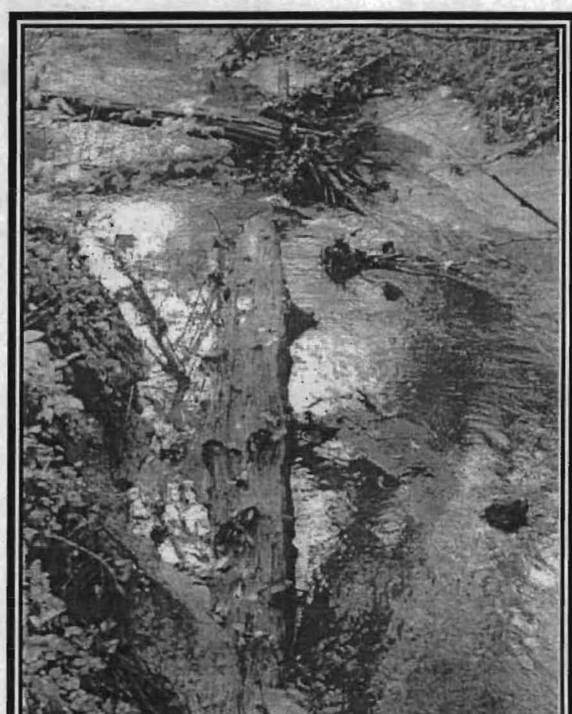
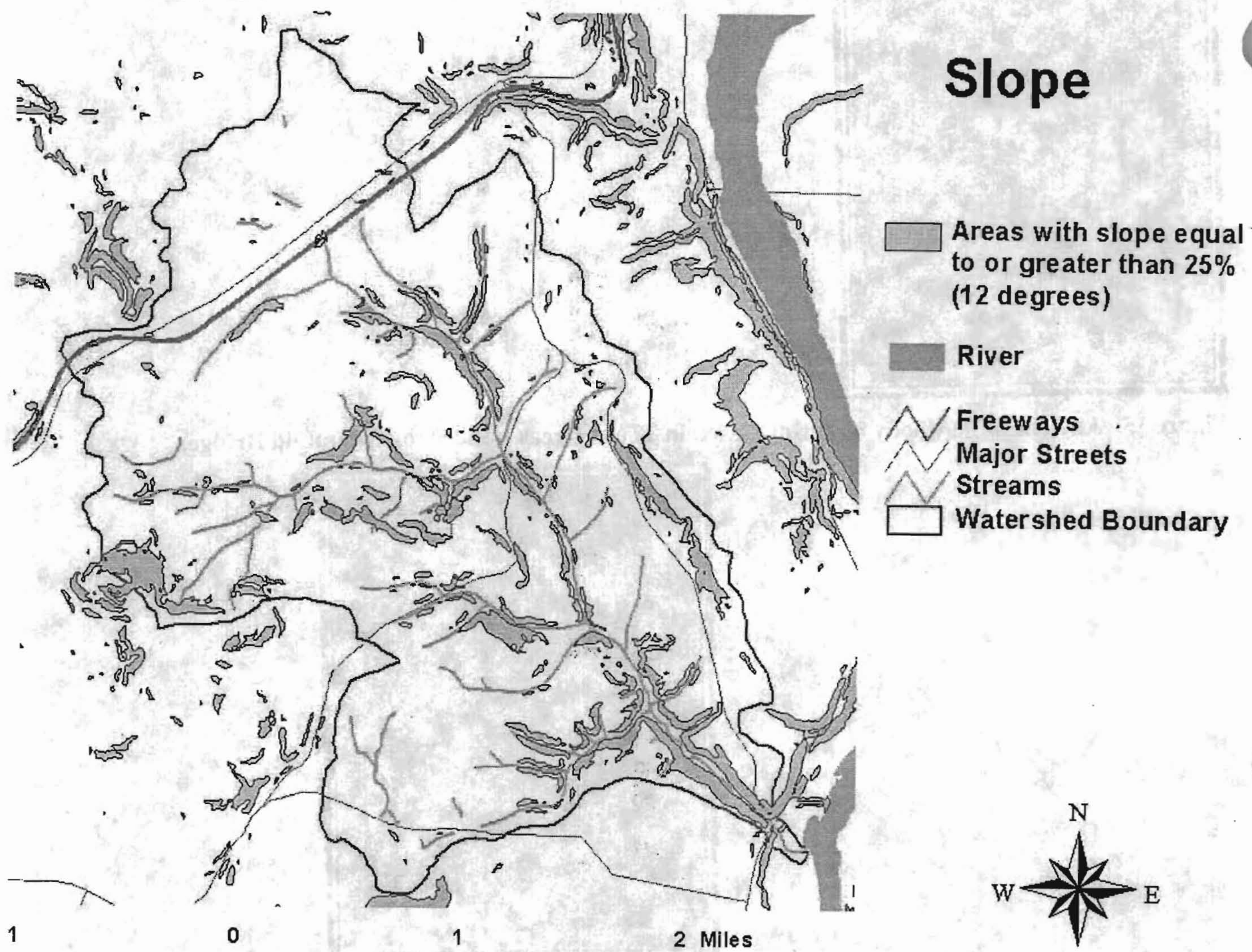


Figure 14. Ancient buried large wood Tryon Creek, Reach 4. Note the log is protruding from the clay bank that was probably deposited several thousand years ago.

Figure 15. Ancient large woody material buried in Tryon Creek under Iron Mountain Bridge.

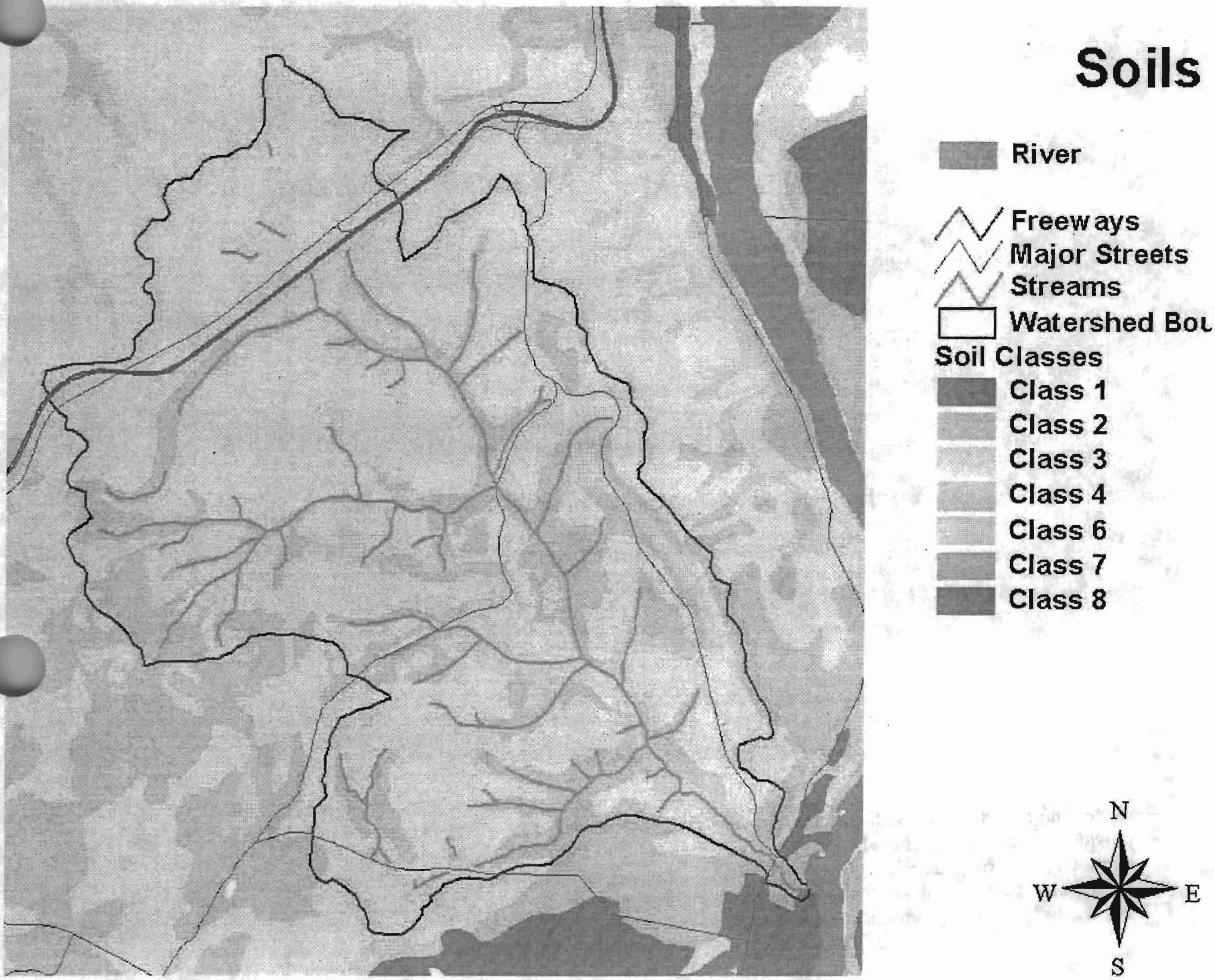
Figure 16. Iron Mountain Creek in proper functioning condition. Note wood in the channel and conifers (western red cedar) providing a source of large wood for the riparian zone.

Figure 17. Typical small tributary in Tryon Creek State Park. Note the dominance of hardwood trees in the riparian area. Note wood accumulating in the channel bottom.



Slope
Areas with slope equal to or greater than 25% (12 degrees)
River
Freeways
Major Streets
Streams
Watershed Boundary
1
0
1
2 Miles
N
W
E

Map: Tryon Watershed, Soil Classes. Metro RLIS map.
(Ref. Natural Resources Conservation Service.)



PART 2

Prepared for:
West Multnomah Soil and Water Conservation District

Prepared by:
Natural Resources Management Group
Craig D. Fanshier, Senior Hydrologist,
and
Heather C. Clark, Geographic Information System Specialist

April 11, 2002

(Note: This report is a focused, preliminary hydrogeologic assessment of the Tryon Creek watershed. The intent was to provide an initial review of readily available hydrogeologic data for guiding additional detailed studies. This assessment will assist with preparing numerical groundwater models by supplying preliminary groundwater elevations for the bedrock aquifer(s) and conceptual hydrogeologic relations for the general hydrostratigraphic units. The complete report with maps and graphs is in an Appendix to this Baseline Report.)

Summary of Watershed Characteristics

Watershed characteristics were described in the Upper Tryon Creek Corridor Assessment[2] (BES, 1997). The Tryon Creek watershed is approximately 4,200 to 4,500 acres. Tryon Creek is approximately 7-miles long and flows to the southeast and discharges into the Willamette River near State Street in Lake Oswego. Tributaries to Tryon Creek include Arnold Creek, Falling Creek, Oak Creek, Park Creek, and Nettle Creek. Arnold Creek and Falling Creek are the two main tributaries to upper Tryon Creek watershed and can be considered sub areas (Figure 1).

Development in the area has focused around the perimeter of the watershed, which is generally the groundwater recharge area. Tryon Creek is the general discharge area and it is generally undeveloped and densely wooded. The stream corridors of the tributaries to Tryon Creek are generally undeveloped. The 640-acre Tryon Creek State Park is located within the undeveloped and densely wooded area along the axis of the creek in the lower portion of the watershed.

Impervious (paved and covered) surfaces are generally located within the development around the perimeter of the watershed. An estimate of the area of impervious surface in the entire watershed is not available. Metro's 2040 future land use plan predicts 28 percent. Mapped impervious area in the upper watershed ranges from 5 to 56 percent (BES, 1997).

General Topography
The watershed is bounded to the east by the Palatine Hills (extending north into the Burlingame neighborhood), to the north by the Tualatin Mountains (Portland's West Hills), and to the west by the Mt. Sylvania. The elevation in the watershed ranges from approximately 10 feet mean sea level (msl) at the outlet to the Willamette River to approximately 970 feet at Mt. Sylvania. Approximately 60 to 75 percent of the upland area in the watershed exceed a 30 percent slope. Some slopes exceed 50 percent. The upper area of the watershed (Multnomah Village and Capital Highway areas) is generally much flatter and is likely the primary recharge area for the bedrock aquifer(s).

Climate
The climate of the Tryon Creek watershed is slightly wetter and slightly cooler than most of the Portland area. The growing season in the watershed is approximately 200 days. Summers are moderately warm and winters are wet and mild. The watershed receives measurable precipitation on approximately 160 days, totaling nearly 45 inches per year. 70 percent of the moisture is received from November through March; 5 percent is received from June through August. Marine air often blankets the entire Willamette Valley, causing morning cloudiness that tends to evaporate in late afternoon. Winds are typically from the west, however, east winds can bring cold air in the winter and hot, dry air during the summer.

Surface Water
Tryon Creek has large seasonal fluctuations in water volume, primarily related to variations in precipitation and stormwater runoff. During winter months, Tryon Creek carries large amounts of stormwater runoff that cannot penetrate the watershed's thick clayey surface soils. Summer flows are much lower. A stream gage recording station was placed in Tryon Creek at Boones Ferry during the summer of 1995 by the City of Portland. This gage was washed out during the winter of 1996. Stream gage data was not available from the city of Portland. The USGS installed a new flow meter in lower Tryon Creek (Iron Mtn. Bridge) August 2, 2001. Discharge measurements of 0.63 cubic feet per second (cfs) and 1.0 cfs were recorded on August 17 and October 12, 2001 (respectively).

Wetlands
According to the 1989 National Wetlands Inventory, prepared by the U.S. Fish and Wildlife Service, the only significant wetlands are within the stream regime. The lower end of Tryon Creek is classified as R3OWZ (riverine system, upper perennial subsystem, open water class, non-tidal water regime, intermittently exposed/permanent). The upper reaches of Tryon Creek and its tributaries are classified as PFOIW and PFOIY (palustrine system, forested class, broadleaf deciduous subclass with "W" indicating non-tidal water regime temporary/intermittently flooded and "Y" indicating saturated semipermanent or seasonal flooding).

Soils and Impervious Areas
The soils are principally either Cascade silt loam (subdivided into 4 categories based on slopes) or Cascade-Urban land complex (subdivided into 3 categories based on slopes). Minor areas have Cornelius-Urban land complex (subdivided into 2 categories based on slopes) and Delena silt loam (Green, 1983)[3]. These soil types generally have slow percolation rates.

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[2] BES. 1997. Upper Tryon Creek Corridor Assessment. Prepared by City of Portland Bureau of Environmental Services. Et Al, August 1997.

[3] Green. George L. 1983. Soil Survey of Multnomah County, Oregon. By US Department of Agriculture, Soil Conservation Service and Forest Service.

Permeability rates are typically 0.6 to 2.0 inches per hour. However, on steep slopes permeability decreases to 0.06 to 0.2 inches per hour, likely due to reduced time the water remains on the soil before it runs off.

The first 7 to over 60 feet of material encountered in borings for water wells are reported as clay. An additional 20 to 40 feet weathered rock is reported on some boring logs below the clay encountered at the surface. Typically these units will have low recharge rates. These factors reduce the amount of precipitation that can recharge the aquifer(s). Annual recharge rates used for preparing a numerical model for the Parrett Mountain area (composed of Columbia River Basalt Group basalts [CRBG]) ranged from 11.4 to 16.7 inches per year. These rates may be similar to the Tryon Creek Watershed area.

Geology

Geologic units in the Tryon Creek watershed are shown on Figures 1 and 2. Descriptions from State of Oregon Department of Geology and Mineral Industries (DOGAMI) geologic map series GMS-59, *Geologic Map of the Lake Oswego Quadrangle, Clackamas, Multnomah, and Washington Counties, Oregon, 1989* are summarized below and presented on Table 1:

-*Qal — Alluvium (Quaternary). River and stream deposits of silt, sand, and gravel composed of mixed lithologies.*

-*Qff — fine-grained facies (Pleistocene). Coarse sand to silt deposited by catastrophic floods.* This unit is located along the southern boundary of the study area.

-*QTs — Undifferentiated sediments (Pliocene to Holocene). Commonly fine-grained, massive to finely bedded sediments that mantle bedrock units and are, in part, interfingered with the boring lavas. The unit has been divided into the (1) Portland Hills Silt (Quaternary loess often present about 400 feet msl) lacustrine deposits (slackwater facies of catastrophic flood deposits found generally below 400 feet msl, (2) lacustrine deposits, (3) Troutdale Formation, and (4) Helvetia Formation. The unit QTs is underlain by the Frenchmen Springs Member, Wanapum Basalt of the CRBG.*

-QTb — *Boring Lavas (Pliocene to Pleistocene). Light gray to gray, diktytaxitic, olivine (less commonly plagioclase) phyric basalt and basaltic andesite flows erupted from a series of local vents, usually as cones composed of interstratified cinders and lava.*

-*Columbia River Basalt Group (CRBG) (Middle Miocene). Miocene tholeittic flood-basalts flows that were erupted approximately 17 to 6 million years ago from long linear fissure system in northeastern Oregon, eastern Washington, and western Idaho. Members of the Frenchmen Springs Member of the Wanapum Basalt and Grande Ronde basalts are present with the study area*

Frenchman Springs Member Wanapum Basalt (middle Miocene)

- *Tfsh — Basalt of Sand Hollow (middle Miocene). Flows are typically blockly to columnar jointed, but occasionally display entablature and colonnade jointing styles.*
- *Tfg — Basalt of Ginkgo (middle Miocene). Flows are commonly blocky to columnar jointed, often displaying well-formed prismatic colonnades. Fresh exposures are dark gray to black.*

Grande Ronde Basalt (middle Miocene)

- *Tgsb — Sentinel Bluffs Unit (middle Miocene). Flows typically are blockly to columnar jointed, and rarely display entablature and colonnade jointing styles.*
- *Tgww — Winter Water unit (middle Miocene). The Winter Water unit consists of two flows that display a wide range of jointing patterns, from columnar to entablature/colonnade.*
- *Tgo — Ortley unit (middle Miocene). Ortley flows commonly display entablature/colonnade jointing style.*

Twh — Basalt of Waverly Heights and associated undifferentiated sediments (Eocene). Subaerial to subaqueous basaltic lava flows and associated sediments that unconformably underlie flows of the Columbia River Basalt Group. Unit Twh is believed to represent a portion of an oceanic island that was accreted to Western Oregon.

Depositional History, Discontinuities, and Unconformities

The Willamette-Puget Sound lowland was part of a broad continental shelf of the ocean extending from the Cascades westward. The older rocks in the lowland basin are volcanic rocks (basalt flows and volcaniclastic units) that erupted as part of an oceanic island archipelago that was accreted to the western margin of North America. Some portions of the unit are possibly submarine. The basin volcanic rocks subsided and a forearc basin formed on top. During interim periods without Columbia River Basalt Group (CRBG) lava flows, limonite was deposited in bogs in un-drained depressions on the basalt surface. Limonite was mined from Iron Mountain (at the southwest boundary of the Tryon Creek watershed). These iron deposits have been assigned to the Vantage interbed that formed on the Grande Ronde basalt prior to extrusion of the younger basalts. After the final extrusion of the basalt flow, the surface remained near sea level though out much of the late Miocene, while a deep weathered zone developed upon the upper part of the basalt. The weathering of these surfaces produced the characteristic reddish bauxite rich clays. The Boring lavas erupted after the deposition of the CRBG and before the Willamette Silts were deposited. This surface was covered by the Willamette Silts, part of the undifferentiated sediments (QTs) sequence. The QTs unit is interfingered with the Boring Lavas (QTb). The extent of the QTs under the QTb in the study area is not known.

The CRBG and the Basalts of Waverly Heights (Twh) units were deposited in fundamentally different environments. The Twh unit was deposited as part of an island-arc-sequence of volcanic rocks, which are typically erupted as a series of volcanic islands with proximal flows into a shallow sea. During interflow periods volcaniclastic material (ash) and typical basin sediments would be expected to be deposited on top of the last lava flow. Lava flows from these island volcanoes would typically not extend great distances as compared to the CRBG flows. Typically, the Twh basalts are not expected to have deep weathering profiles when they are deposited underwater. The CRBG were regionally extensive flat lying lava flows. Weathered surfaces can develop before the next lava flow is deposited.

Structure
Uplifting, tilting, and folding are attributed to the continued subduction of the Juan de Fuca plate. The major structural features in the area are the generally north-northwest trending (north 25 degrees west) Oatfield fault along the eastern portion of the Tryon Creek watershed (along Palatine Hill) and the Sylvania Fault near the western edge of the watershed. The Oatfield and Sylvania faults are normal faults sub-parallel to the Portland Hills fault. The faults may have some right lateral movement. The block of rock separated by the faults (the main part of the Tryon Creek watershed), based on apparent movements along the faults as shown on the DOGAMI's GMS-59 geologic map, indicate the block has been tilted to the northeast. The Tryon Creek watershed drainage pattern seems to correlate with the block rotation, with steeper, less developed and shorted minor tributaries along the east side of the watershed, along the Oatfield fault, and tributaries with longer reaches located along the west side. The western extent of the watershed and the general extent of the tributaries roughly coincides with the Sylvania fault.

The CRBG shown north (approximately Marquam Hill area and north) and south (approximately Lake Oswego and south) of the Tryon Creek area are shown on GMS-59 as having more faulting than shown in the Twh rocks mapped in the Tryon Creek watershed. Since the Twh rocks are older and were emplaced by continental drift and accretion, they should be expected to also have a higher degree of faulting than what is shown on the published geologic map. The fault system(s) in the Twh unit not be apparent due to thick soil cover and weathering profile.

Folding and faulting occurred during the late Miocene or very early in the Pliocene after extrusion of the CRBG, resulting in a network of less prominent faults and the formation of anticlines and synclines. Extrusion of the Boring lavas was guided by the fracture pattern in the older basalts. Geophysical evidence suggests that uncovered intrusions of Boring Lavas may be emplaced along fractures. The influence of the potential shallow intrusions to groundwater flow have not been evaluated. Some increased groundwater flow could occur in the Twh rock near the margins of the intrusions if the Twh was fractured during emplacement of the intrusions. During the late Pliocene and much of the Pleistocene uplift and erosion caused incision of the streams.

Well Log Review
When a new well is drilled, the driller completes a water well report or monitoring well report which contains information about the well's owner, location, use, depth, as well as geologic and water level data collected by the driller. Oregon Water Resources Department (OWRD) maintains well reports organized by township, range, and section description. The Tryon Creek watersheds covers all or portions of sections 20, 21, 27, 28, 29, 30, 31, 32, 33, and 34 in township 1 south, range 1 east, Willamette Meridian (Multnomah County) and sections 2, 3, and 4 in township 2 south, range 1 east, Willamette Meridian (Clackamas County). Well reports can be divided into well logs for water supply wells and the others are for geotechnical holes or monitoring wells. The two types of logs are discussed below:

-Well logs (reports) for water supply wells are typically deeper than 100 feet in order to reach a reliable groundwater source. Generally, the water supply wells are constructed to obtain groundwater from the basalt or other bedrock units interbedded within the basalts Well logs for geotechnical or monitoring wells are typically shallower than approximately 30 feet below ground surface (bgs).

-Monitoring well are generally constructed to obtain shallowest groundwater, which is generally more likely to have been impacted by surface facilities (leaking underground storage tanks, dry wells, etc).

NRMG obtained well logs for the water supply wells and selected monitoring wells and geotechnical holes in the Tryon Creek watershed using the OWRD internet site. Monitoring well and geotechnical hole well logs were selected on the basis of the depth, groundwater level data, and lithologic data they provided. NRMG located selected wells (water wells, monitoring wells, and geotechnical holes) within the Tryon Creek Watershed (Appendix A) on Figure 1.

Portland Metro's Regional Land Information System (RLIS) map data (May 1999 edition) was used to prepare an electronic base map of the Tryon Creek watershed. Well locations were plotted on the electronic basemap using ArcView (version 3.2) software. NRMG compared its data layer to one created by the Portland Bureau of Environmental Services (BES). All wells were ultimately plotted in ArcView and manually transferred to a final paper base map (Figure 1) prepared using a portion of GMS-59.

Method Used to Locate Well Logs on the Basemap
Well logs generally provide several types of location data for wells. The first is the well owner's address, which is sometimes, but more often not, the actual location of the well. Well logs might also include the address, tax lot, development tract, or township, range, and section description of the actual well location. NRMG used location data listed on well logs to plot wells electronically in ArcView. Wells with a numeric street address were plotted at that address. Rand McNally Streetfinder (1999) software was used to approximate the address location on a street. The approximate address of the well was then visually located and plotted in ArcView. Wells with only a quarter-quarter section location description were plotted in the approximate center of the indicated quarter-quarter section. Wells with only a section location description were plotted in the approximate center of the indicated section. All of the wells are represented as points in the data layer. NRMG did not use the tax lot numbers, donation land claim numbers, or development tract location descriptions provided on some well logs to plot well locations. NRMG did not field check the plotted well locations, nor were any well locations determined by a global positioning system (GPS).

Data Comparison
NRMG compared its data layer of well points to a geographic information system (GIS) data layer created by the BES. The BES GIS-data layer was provided by West Multnomah Soil and Water Conservation District. The layer contains points representing well locations in and around the Tryon Creek watershed.

The BES data appears to have been plotted according to OWRD well log location descriptions. Most of the well points are very close to those plotted by NRMG, typically differing by only a few blocks along a street (a few of the well points in the two distinct layers coincide exactly). BES's well locations appear to have been plotted according to the same method used by NRMG. A few of the wells, however, are incorrectly plotted according to the well owner's address instead of the actual street address or location description of the well. The BES data layer covers only Multnomah County, whereas NRMG's data layer covers Multnomah and Clackamas Counties, both of which are included in the Tryon Creek watershed. Therefore, NRMG compared only those well locations plotted in Multnomah County to those in the BES data layer.

Final Data Layer
NRMG's final data layer is composed of wells located as accurately as possible by well log address, section, and quarter-quarter section location descriptions. In instances where NRMG's and BES's coinciding wells were plotted in nearly, but not the exact same location, NRMG edited points in its data layer to coincide with BES well location points. The decision to defer to BES's data points was made on a point-by-point basis. If the location of BES's point appeared to have been plotted according to a more specific location description (such as a tax lot) than that used by NRMG to plot the same point, then the BES point was awarded higher confidence.

Groundwater
NRMG used hydrogeologic information supplied on the well logs, geologic maps, and NRMG's experience in conducting hydrogeologic assessment to evaluate the occurrence and movement of groundwater.

Evaluation of Hydraulic Properties
Hydraulic properties of the aquifer can be estimated using drawdown information supplied on some well reports. Transmissivity can be estimated from specific capacity *(United States Department of Interior, Bureau of Reclamation, Groundwater Manual, 1977)*. This method provides a reconnaissance level of analysis of the aquifer's hydraulic properties. Specific capacity is the amount of water produced in a minute divided by the feet of drawdown in a well. Transmissivities estimated using this method tend to be higher than actual, but the method is adequate for evaluating water resources. Well discharge, feet of drawdown, specific capacity, and estimated transmissivity for water supply wells in or near the watershed are summarized in Table 2 and organized by hydrostratigraphic unit.

Occurrence and Movement

Groundwater levels reported on boring logs for the bedrock aquifer system were used to prepare a groundwater elevation contour map. Groundwater elevations were estimated by subtracting the depth to static water reported on the water well logs from an estimated land surface elevation based on the location of the well on the USGS 7.5-minute quadrangle. Groundwater elevation contours are shown on Figure 3. The groundwater contour map was generated using Surfer (version 7). These elevations are approximate and were prepared from a sparse data set. There maybe inaccuracies in ground surface elevations and actual static groundwater depths. Also, groundwater is often encountered at different depths than where it finally equilibrates at, which can indicate confined conditions or slow recharge rates. For the purposes of this study only the final static water level was used to generate groundwater elevation contours. However, this interpretation can provide a basis for beginning to understand the general occurrence of groundwater and the general direction of flow.

The data set is also limited due to the lack of repeated measurements in the same well which is used to evaluate seasonal fluctuations and response to rainfall events. For the purposes of this study, seasonal variations could not be taken into account. Seasonal information would be useful in evaluating groundwater surface water interactions.

The occurrence of groundwater can be divided into the following four general hydrostratigraphic units:

- Shallow water within the overlying fine grained units (silts, QTs, weathered basalt overburden, and Qff)
- Boring Lavas (QTb)
- Columbia River Basalt Group (CRBG)
- Basalt and undifferentiated sediments of the Waverly Heights (Twh)

This assessment used the lithology descriptions on the well reports in conjunction with the geologic map prepared by the state. Lithologic description provided on the boring logs varied widely in detail. Many of the water well logs have a limited amount of detail in the description. However, this provides a good start for assessing the general hydrogeologic nature of the basic hydrostratigraphic units within the watershed. The general occurrence and movement of water in the four hydrostratigraphic units is discussed below.

Shallow Water Within the Overlying Fine Grained Units

The overlying fine grained units includes the clays that formed from the weathering of basalts and the extensive area of QTs sediments. For the purposes of this study, silts and clays were not distinguished from the loess deposits that blanket the watershed above approximately 300 feet msl, undifferentiated sediments, or the Troutdale and Sandy River Mudstone Formations. These units may be able to be differentiated into different hydrostratigraphic units with more detailed study.

Shallow groundwater is typically encountered in many of the geotechnical and monitoring well borings from less than 10 feet to approximately 33 feet below ground surface (bgs). This unit appears to be recharged primarily from precipitation. Groundwater levels within this unit are anticipated to have a large seasonal variability. The degree or amount of interaction with surface water tributaries is not known and requires additional study. The direction of groundwater flow in the shallow units is most likely controlled by local topography and was not evaluated.

Boring logs in the Sylvania pass area (where interstate highway I-5 crosses Capital Highway) indicate that the unit QTs is underlain by CRBG. The degree of interconnection within underlying bedrock units is not clear based on the limited amount of groundwater information in the basalts overlain by QTs. Well log 59213[4] indicates that groundwater was encountered at 126 feet bgs in the area that is overlain by silts and clays than have a static water level of 10 to 20 feet bgs. This may indicate that recharge to the underlying bedrock unit is by gravity drainage. The shallower depth to groundwater in the basalt in this area does not appear to be as deep as other areas in the basin.

Based on groundwater contour map (Figure 3), the groundwater recharge area for the basalt aquifers of the Tryon Creek watershed is near Sylvania pass and extends east into the Multnomah area. This may suggest that the flat areas with QTs may provide a higher degree of recharge to the underlying basalt aquifer than areas with steeper slopes. Which may suggest that in steeper areas, within the watershed, do not provide as great of recharge through the silts and clays due to the increased runoff potential. The groundwater divide between Fanno Creek to the north and Tryon Creek watershed can not be evaluated with out additional groundwater elevation data. The groundwater divide may not coincide with the surface drainage boundary.

The unit tends to have very low yields of groundwater to wells. Hydraulic properties of the fine grained material could not be evaluated because the information was not available. However, using typically hydraulic conductivity values for silts and

[4] (this well log is for abandonment and does not contain lithology information. For the purposed of this study it is assumed to have been constructed in underlying basalt).

clays of approximately $1x10^{-3}$ to $1x10^{-6}$ centimeters per second published in text books, transmissivity values would tend to be on the order of 1 to 100 square feet per day (ft^2/day) (assuming a saturated thickness of 40 feet).

Boring Lavas
The stratification of cinder zones and lavas may tend to provide preferential flow paths within the Boring lavas. Groundwater elevation contours shown on Figure 3 tend to indicate that the Boring lavas drain fairly well. Groundwater in the southwest portion of the Boring lavas may flow out of the Tryon Creek watershed toward the southwest into the lower reach of Fanno Creek watershed rather than into Tryon Creek watershed.

QTs unit may also act as a barrier to the vertical movement of groundwater from the Boring lavas to the underlying basalts in the area where QTs is interfingered with or underlie QTbs. QTs does not appear to extend south under the boring lavas south of Mt Sylvania. The distance QTs does extend is unclear based on limited boring logs in the area. Other limits to vertical flow may be caused by interbedded weathered horizons of Boring lavas. This tends to cause groundwater to flow horizontally rather than to recharge the deeper bedrock aquifer system. The relation of vertical flow limits with OTs and weathered horizons is not well understood.

Water supply wells constructed in area of QTb have higher estimated transmissivity values, relative to the other wells considered to be constructed in the CRBG or basalts of the Waverly Heights unit. Mult 2818, Mult 2819, and Mult 2820 have estimated transmissivity values of 2,380, 2,273, and 1,264 ft^2/day (respectively). These high values may indicate that QTb can provide substantially more water than the CRBG. Water supply well Mult 2818 (drilled to a depth of 425 feet bgs) may intercept water from both the QTbs and the underlying basalts. It is important to note that wells drilled on the edge of the surficial expression of the mapped QTb are most likely to receive groundwater primarily from the underlying basalts. Therefore, the transmissivity for well Mult 2824 is grouped with transmissivity for the CRBG basalts.

Well Mult 2819 also has relatively high transmissivity but this may be due to low volumes removed during the pump test or water leaking from higher layers down the outside of the casing. Approximately 143 feet of red, brown and yellow shale (fine grained sediments were encountered, because of the proximity to other wells that has identified strata at a similar elevation as the sediments exposed in this boring as Troutdale Formation equivalent this unit may also be Troutdale Formation.

Water supply well Mult 2822 encountered 47 feet of boring lava (from 50 to 97 feet bgs). The overlying material is assumed to be clay from weathered basalt. This boring also has a rather shallow static water level of 23 feet bgs. This well is on the southwest side of Mt Sylvania and may have a shallow depth to water because it is being recharged from preferential groundwater flow from the northeast through the stratified QTbs.

The western side of Mt Sylvania may be partially underlain by Troutdale Formation equivalent rocks. Generally light colored fine grained-sedimentary rocks (shale) or lithologies interpreted to be sedimentary (clay and sandy clay) units where encountered in borings for Mult 2817, Mult 2818, and Mult 2819.

Groundwater levels for the bedrock aquifer system in the Mt Sylvania area does not coincide with the basalt groundwater high shown on Figure 3. This further indicates that groundwater in the Boring lavas may be flowing toward the southwest and recharge is limited through the thick surface clay, steeper upper slopes of Mt Sylvania, and the stratified nature of the QTbs.

Basalt of the Waverly Heights Unit
Groundwater in the CRBG and basalt of Waverly Heights unit appears to provide base flow to the middle and lower portions of Tryon Creek, based on the groundwater contour elevations shown on Figure 3. However, sufficient data in the upper watershed was not available to evaluate the contribution of groundwater to the upper drainage.

Several wells drilled in the Waverly Heights unit contains significant sequences of sedimentary rocks or lithologies (clay) that could be interpreted as sedimentary rather than weathering of basalt. Well Mult 2827 is the only boring along the west side of Tryon Creek near the park that encountered sedimentary units. Well Mult 2827 encountered a thick sequence of clays, clayey shales, and shaly sandstone. This is the only deep boring in the area. This area represents a potential place to further evaluate more permeable areas for artificial recharge.

Along the southern crest of Palatine Hill, groundwater can be encountered at shallow depths in the wells constructed in clay, gravels, and basalt. Water supply wells Mult 2832 and Mult 2835 encountered sedimentary rocks along the crest of Palatine hill. These wells are near the Oatfield fault and have shallow groundwater levels. Boulders, gravels, and clays were logged by the driller in water supply well Mult 2832 and the static water level was 7 feet bgs. Well Mult 58080 had a static water level of 19 feet bgs and is assumed to be installed in the overlying clays (because it was hand dug to approximately 30 feet bgs. However, it is unknown whether this well was constructed in basalt or overlying silts and clays. The shallow depth to water along Palatine Hill may be due to focused recharge along the fault or the fault acting as a boundary to groundwater migration from the recharge area along the crest of Palatine hill toward Tryon Creek. There may also be a higher degree of connection between shallow and deeper groundwater in this area. However, it may also indicate that the Oatfield fault is limiting groundwater migration to the west and could be acting as a groundwater divide causing groundwater to flow east toward the Willamette River. Permeable zones could be off-set by faulting.

Wells Mult 2834 and Mult 3281indicate that the basalts of the Waverly Heights unit can yield significant quantities of water to wells, indicating high permeability in some zones and areas. Others logs show lower transmissivities, indicating that the unit as a whole is variable. During drilling well Mult 2834, the water level in the boring dropped when the borehole was advanced into a deeper water bearing zone. This may indicate that the unit, at least in this area, is not confined, which is different than the typically semi-confined occurrence of groundwater in the CRBG. Significant variation in the occurrence of groundwater in the Waverly Heights unit, could be expected. The structural controls on the occurrence and movement of groundwater flow need to be evaluated.

Columbia River Basalt Group

Groundwater within the CRBG typically flows along interflow zones and along vertical cooling and faulting fractures. Zones of faulting could increase vertical flow. Deeper basalts taped by deeper water supply wells typically behave as a semi-confined aquifer. In other areas (Parrett Mountain) where CRBG aquifer system has been studied, the system generally behaves as two systems. The shallow bedrock unit is typically less than 100 to 150 feet bgs. The deeper system is typically greater than 150 to 200 feet bgs.

Deepening of wells usually results in deeper groundwater levels, which typically represents either a localized lowering of potentiometric surfaces or a general downward hydraulic gradient.

Well Mult 2824, is a deep well (1,100 feet bgs) that provides good lithologic description. Approximately 5 interbeds (approximately 5 to 13 feet thick) along with mixed zones of soft and hard rock up to 70 feet thick were encountered. The water bearing properties of these beds were not reported. Because of the depth of the well, it can be assumed that at the edge of the QTb, sufficient quantities of groundwater were not obtained from the QTb, and the borehole had to be advanced into the deeper CRBG basalt units.

Well Mult 2823, near Mult 2824 encountered clay to a depth of 265 feet bgs and did not encounter groundwater. While Mult 2824 encountered water at 270 feet bgs. It is likely that the clay belongs to the QTs unit that is interfingered with the Qtb and the underlying CRBG in this area.

Well Mult 4295 has potentially encountered groundwater in a fracture zone or interflow zone of the basalts at approximately 190 feet bgs that had a static water level of 135 feet bgs, indicating the unit is possibly confined. The well is possibly constructed to obtain water from the CRBG not the shallower QTb.

Well Mult 2817 encountered clay up to 80 feet thick. During drilling circulation was lost between 105 to 148 feet, which indicates a highly permeable zone. Claystone, sandy clay, and clay were encountered from 270 feet to 393 feet bgs. These may be part of the Troutdale Formation as indicated in well log for Mult 2819. It is unknown if these are weathered basalts or interbedded sedimentary units.

Transmissivity of the CRBG ranges from 173 to 638 (averaging 429) ft^2/day. Clay overburden and thick sequences of interbedded sediments, paleosols, and weathered zones will tend to reduce vertical transmissivity.

Structural Controls on the Occurrence and Movement of Groundwater

The CRBG was most likely deposited near horizontal or on gently sloping surfaces (typically less than 5-degrees). Tilting of the block of rock that comprises most of the Tryon Creek watershed could provide gravity drainage of groundwater along the west side of the block to migrate along flow boundaries toward Tryon Creek.

Preliminary ideas indicate that groundwater in the CRBG is typically confined, while it may not be so in the Waverly Heights units. This may be related to the more disturbed nature caused by difference in the method of emplacement of the Waverly Heights unit compared too the relative horizontal and intact CRBG. However, more work is require to verify this hypotheses.

Water rights
Water rights maps for the watershed where obtained using OWRD's internet water rights information system (WRIS) for the same sections as identified above for the water well logs. Water rights maps show the approximate locations of the points-of-diversion (PODs) and places-of-use (POUs) associated with water rights. Each map is accompanied by a report containing data on all of the PODs and POUs shown on the map. NRMG identified 14 groundwater and surface water right PODs within or near the Tryon Creek watershed. The points of diversion for the water rights within the watershed (or groundwater rights adjacent to the watershed) are shown on Figure 4. The total quantity of water

these rights allow for diversion are 0.64 cubic feet per second (cfs) or 289 gallons per minute (gpm).NRMG did not evaluate whether the water rights are active or the amount of water actually used.

Artificial Aquifer Recharge
One potential method for retaining stormwater runoff is to collect stormwater runoff and to either pump (inject) or let it infiltrate by gravity means into the basalt aquifer. The primary concern of implementing artificial recharge is water quality concerns of allowing potentially impacted water into an un-impacted regional groundwater aquifer system. Artificial recharge to the basalt aquifer would require that the overlying fine grain sediments to be by-passed by either digging deep infiltration ponds or drilling recharge wells. The best location for artificial recharge sites that will provide base flow during the summer to the upper portions of the Tryon Creek watershed is in the recharge area. Artificial recharge into the interbedded sedimentary units in the Twh group will require further study.

Recommendations for Further Study

Data Collection Needs

- -Collect surface water runoff data. Install staff gages, collect stream velocity data, and prepare runoff curves. Develop stream profiles and cross sections.

- -Map the upstream extent of perennial flow in main channels and major tributaries during typical seasonal periods (normal winter, spring, summer, and fall).

- -Map and estimate discharge amounts of large outfalls.

- -Conduct a review of environmental databases for sites within the watershed.

- -Monitor groundwater levels in the shallow and deep systems on a minimum of seasonal basis. Establish a monitoring network using existing wells where available. Install automatic data loggers in selected wells near rainfall stations and staff gages.

- -Collect rainfall data through out the basin.

- -Conduct pump tests to calculate hydraulic parameters (hydraulic conductivity, transmissivity, and storativity) and to evaluate potential boundary conditions. Contact owners of deep wells and evaluate if additional testing could be conducting using existing wells.

- -Cation-anion analysis may be helpful in distinguishing water quality facies between bedrock aquifers and their degree of hydraulic connection.

- -Conduct surficial geologic mapping in the area to locate more permeable sedimentary beds.

- -Evaluation of in stream water uses.

Suggestion for Preparing Numerical Model

- -Prepare numerical groundwater model for the watershed. A model will be useful for evaluating land use options, infrastructure developments and modifications, and recharge options. The study area for a model needs to extend past the watershed boundaries to the north, west, and southwest to account for potential major recharge and discharge areas.

Policy Evaluations

-Evaluate artificial recharge as an option for the Cities of Portland and Lake Oswego.

-Evaluate other off-channel storage options.

-Prepare concepts for land use approval such as limiting impervious surface area, considering stormwater detention ideas, and protecting green spaces.

-Evaluate the potential for a down-spout disconnect program in the recharge areas.

-Evaluate using and obtaining surface water rights for conversion into in stream water rights.

Attachments:

Tables 1 through 3
Figures 1 through 4
Limitations
Appendix A: Water Well Logs

(Ed. note: for complete NRMG Report, visit the StreamNet Library or see electronic appendix, this publication.)

PART 3

Macroinvertebrate Report

Collection Date: August 31, 2001

Prepared for:
West Multnomah Soil and Water Conservation District

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INTRODUCTION

Biological monitoring provides an effective, easy-to-understand method for determining if a stream has been impacted by a pollution source. Biological monitoring in the Tryon Creek watershed has historically focused on the fish assemblages and distributions throughout this urban watershed (CPESA 2001). Although these fish surveys are valuable as biological indicators within the watershed, they can be expensive, time consuming, and difficult to perform. However, a more direct, faster measure to evaluate the biological condition of a stream can be performed by assessing the benthic macroinvertebrate community. Benthic macroinvertebrates are aquatic invertebrates large enough to see with the naked eye that live in the bottom parts of our waters. They are useful indicators of biological conditions (Barbour et al. 1999) because they:

- live in the water for all or most of their life
- stay in areas suitable for their survival
- are easy to collect
- differ in their tolerance to amount and types of pollution
- are easy to identify in the laboratory
- often live for more than one year
- have limited mobility
- are integrators of environmental condition

To benefit in the assessment and characterization of the Tryon Creek watershed, an assessment of the benthic macroinvertebrate communities was performed in August 2001. The Tryon Creek watershed is decidedly urban and very little information exists regarding the health of benthic macroinvertebrate communities within the watershed. This study was performed to start to accumulate baseline information on the biological conditions in the Tryon Creek watershed. The objectives of the benthic macroinvertebrate assessment were:

- To characterize and compare macroinvertebrate communities in a number of locations throughout the watershed, and relate changes in macroinvertebrate community structure to land use type and intensity.
- To provide a baseline set of data against which future improvement or degradation in the biological condition of the watershed can be evaluated.
- To train volunteers from Salmon Corps, Oregon Zoo, Tryon Creek Watershed Council, Lewis and Clark College, etc. in benthic macroinvertebrate sampling protocols.

METHODS

The Tryon Creek macroinvertebrate assessment follows the Level III assessment protocol listed by the Oregon Plan for Salmon and Watersheds (OWEB 1999). This is similar to the Rapid Bioassessment Protocol (RBP) which has been extensively tested in streams throughout the United States (Plafkin et al. 1989) (Barbour et al. 1999). ODEQ's Level III assessment provides the most sensitive measure of stream condition using benthic macroinvertebrate communities as the primary indicator.

Macroinvertebrates were collected in four tributaries to Tryon Creek and within four reaches in Tyron Creek mainstem designated by the Oregon Department of Fish and Wildlife (ODFW) Aquatic Inventory Project. A total of 15 sample locations were selected for the macroinvertebrate assessment. Five of these sites are located in tributaries to Tryon Creek and ten sites were located in Tryon Creek mainstem. The sites in the mainstem Tryon Creek are: two are located in Reach 1; two are located in Reach 2; two are located in Reach 3; and four are located in Reach 4 (Figure 1). The sites located in the tributaries are: Nettle Creek, Upper Park Creek, Lower Park Creek, Cedar Trail Creek, and Arnold Creek. A general description of each mainstem reach and tributary sampled follows with the sample name inside the parenthesis:

__Tryon Creek Mainstem__

- Reach 1: (Sample Sites R1-1, R1-2) Starts at the confluence of Tryon Creek with the Willamette River and ends at the west side of the State Route 43 creek crossing (culvert) (392 meters).

- Reach 2: (Sample Sites R2-3, R2-4) Begins at the west side of State Route 43 creek crossing and ends at the confluence of Nettle Creek with Tryon Creek in the Tryon Creek State Park (1,309 meters).

- Reach 3: (Sample Sites R3-5, R3-6) Begins at the confluence of Nettle Creek with Tryon Creek and ends at the confluence of Arnold Creek with Tyron Creek, just upstream from SW Boones Ferry Road culvert crossing (2,621 meters).

- Reach 4: (Sample Sites R4-7, R4-8, R4-9, R4-10) Begins at the confluence of Arnold Creek with Tryon Creek and ends at the confluence of Falling Creek with Tryon Creek just upstream with SW Lancaster (2,157 meters).

Tyron Creek Tributaries

- Nettle Creek: (Nettle Creek) This macroinvertebrate sampling site is located in Nettle Creek between Iron Mountain trail Stone Bridge and the confluence with Tyron Creek. This site is located in the Tryon Creek State Park and has a fairly established riparian area with a developed floodplain. Creek substrate is 75% embedded with fine sediments and gravel. The headwaters of Nettle Creek are very developed with high levels of impervious surfaces (Figure 3). The park trail and creek access account for some of the failing banks and elevated levels of fine sediments entering the creek.

- Cedar Trail Creek: (Cedar Trail Creek) This macroinvertebrate sampling site was located in an unnamed creek that crosses the State Park Cedar Trail (now called Cedar Trail Creek) approximately 250-feet upstream from the confluence with Tryon Creek. This site is located in the Tryon Creek State Park and has a good riparian area with some development in the headwaters. The stream substrate is 100% embedded with fine sediments and sparse gravel.

- Park Creek: (Upper and Lower Park Creek) Two macroinvertebrate sampling sites were located in Park Creek, the upper site and the lower site.

  The lower site was located approximately 250-feet upstream from the confluence with Tryon Creek. This site is located within the Tryon Creek State Park and has good riparian area with little development in the headwaters. The substrate in the Lower site was 50% embedded with fine sediment and gravel.

  The upper site is located in Park Creek adjacent to SW Boones Ferry road at the power substation. Park Creek is considered to be the best functioning creek in the Tryon Creek watershed. There is little development in the headwaters with large riparian areas dominated by mature conifers. The substrate is 10% embedded with fines and dominated by cobble and gravel. The banks and floodplain are connected to the channel and functioning.

- Arnold Creek: (Arnold Creek) This macroinvertebrate sampling site was located in Arnold Creek approximately 250-feet upstream from the confluence with Tryon Creek. This tributary is very developed along the riparian area and confined by urbanization. The riparian areas are marginal and the substrate is 60% embedded with fine sediment and gravel.

At each site, two sampling locations were randomly selected within each of two riffles using a random number table (ODEQ 1999). Benthic macroinvertebrates were collected with a 500 micrometer mesh D-frame kick net. At each location a 0.18 square meter (2 ft^2) area of the substrate was disturbed directly upstream of the kick net to a depth of 5-15 cm so that the current carries the macroinvertebrates and debris into the net. Larger substrate and debris was carefully scraped with a hard bristle brush in front of the net to dislodge any clinging macroinvertebrates. The four samples collected at each sample site were combined into a single composite sample, labeled, preserved in 70% isopropyl alcohol.

Each composited sample was delivered within one day to Aquatic Biology Associates, Inc. (ABA, Inc.) in Corvallis, Oregon for sorting, identification and analysis. Aquatic Biology Associates, Inc. is an independent laboratory specializing in freshwater benthic invertebrate taxonomy and analyses in the Pacific Northwest. Sub-samples of approximately 300 macroinvertebrates were randomly sorted from each composite sample using a grid overlay and sorting tray. Unsorted fractions were examined for large or rare macroinvertebrates that had not been included in the sorted fraction. Residue from which macroinvertebrates had been sorted was preserved for future examination for quality assurance purposes.

ABA, Inc. calculated 10 biometrics for each site (Appendix A, Table 1) following Karr's (1999) Benthic Index of Biological Integrity (BIBI) for montane streams with high biological integrity. A BIBI is a synthesis of diverse biological information which numerically depicts associations between human influence and biological attributes (Karr and Chu, 1999). It is composed of several biological metrics that are sensitive to changes in biological integrity caused by human activities (e.g., new development, leaking septic systems, lack of vegetation, etc.).

Five metrics of the ten total are related to taxa richness and composition; two metrics describe the relative tolerance or intolerance to organic pollution and sedimentation; two metrics describe the feeding ecology, and one metric quantified population dominance by the three most abundant taxa (Table 1). Tolerance values of each taxon to organic pollution and to sedimentation were determined using standardized values assigned by Karr (1999), which are used by the Oregon Department of Environmental Quality and in the Oregon Plan for Salmon and Watersheds.

Each metric was assigned a score of 1, 3, or 5 with 1 representing a "poor" condition and 5 representing relatively undisturbed ("good") conditions (Table 1). Scoring boundaries were selected based on their prior use in montane streams in Oregon and Washington. Individual metric scores were then summed for each site to derive a multi-metric composite score called a BIBI (Karr 1999). A high score indicates a healthy stream condition, while lower scores indicate degradation of stream conditions macroinvertebrates had been sorted was preserved for future examination for quality assurance purposes.

Two additional measures were used to relate land use to stream health: Brillouin's Diversity Index was calculated to evaluate biodiversity and level of dominance of taxa present in a community and their relative abundance's. Diversity Index is high if a community has many taxa and their abundances are evenly distributed; Diversity Index is low if the taxa are few and their abundances are unevenly distributed (Reif, 1999). Brillouin's Diversity normally ranges between 0-5 with higher values indicating little or no disturbance. Brillouin's Diversity Index measures the effect of community stress, but not pollution directly.

The Hilsenhoff Biotic Index (HBI) was calculated to summarize the overall pollution tolerances of the taxa collected (Hilsenhoff 1988). This index has been used to detect nutrient enrichment and its effects such as: low dissolved oxygen and shifts in pH. It was originally developed to detect organic pollution. Individual taxa were assigned an index value from 0 to 10. Taxa with HBI values of 0-2 are considered intolerant clean water taxa, and taxa with HBI values of 9-10 are considered pollution tolerant taxa. Samples with HBI values of 0-2 are considered clean, 2-4 slightly enriched, 4-7 enriched, and 7-10 polluted.

RESULTS

BIBI scores for all of the macroinvertebrate sampling sites ranged from 14 to 38, indicating that the macroinvertebrate community condition ranged widely among sites (Table 2 a, 2 b

Mainstem Sites

The majority of the mainstem sites were composed of one or more of three taxa: tolerant *Baetis tricaudatus* (mayfly), the tolerant genus Simulium (black fly) and the tolerant class Oligochaeta (segmented worm). Such dominance by few taxa is indicative of a stressed community. *B. tricaudatus* was dominant in four of ten sites and subdominant in 3 of ten sites. Oligochaeta was dominant in four of ten mainstem sites and subdominant in one of ten sites sampled.

Tributary Sites

The tributary sites were found to hold a variety of taxa, indicating a higher diversity with less impairment than the mainstem sites. Micropsectra and Hydropsyche dominated the tributary sites. These taxa are indicative of a less-stressed community.

The site referred to as the "control" or best condition site in the watershed, Upper Park Creek, was the only site which scored greater than 30, which indicates only slight impairment. The other tributary sites received scores of moderate-to-severe impairment but all the tributary sites outscored the mainstem sampling sites (Table 2 b).

Table 1. Biometrics and scoring criteria used to determine ecological condition of Tryon Creek watershed, August 2001. (OWEB 1999, Karr 1999, ABA, Inc. 2001).

Metric	Response to Degradation	Scouring Boundaries		
		1	3	5
Taxa richness and composition		Poor	Fair	Good
Total Number of Taxa	Decrease	0-19	20-40	>40
Number of Ephemeroptera taxa	Decrease	0-4	5-8	>8
Number of Plecoptera taxa	Decrease	0-3	4-7	>7
Number of Trichopera taxa	Decrease	0-4	5-9	>9
Number of long-lived taxa	Decrease	0-2	3-4	>4
Tolerance				
Number of intolerant taxa	Decrease	0-2	3	>3
% of individuals in tolerant taxa	Increase	>49	20-49	0-19
Feeding Ecology				
% of predator individuals	Decrease	0-2	3	>3
Number of clinger taxa	Decrease	0-10	11-20	>20
Population Attributes				
% dominance (3 taxa)	Increase	>74	50-74	0-50

Score Range (maximum 50)	Stream Condition
>39	No Impairment: passes Level III assessment. Indicates good diversity of invertebrates and stream conditions with little or no disturbance.
25-39	Moderate Impairment: clear evidence of disturbance exists
<25	Severe Impairment: conditions indicate high level of disturbance.

Table 2a. BIBI assessment scores of sites sampled in Tryon Creek mainstem, Multnomah County, Oregon, August 31, 2001.

Metric	Site R1-1	Site R1-2	Site R2-3	Site R2-4	Site R3-5	Site R3-6	Site R4-7	Site R4-8	Site R4-9	Site R4-10
Total Number of Taxa	3	3	3	3	3	3	3	3	3	1
Number of Ephemeroptera taxa	1	1	1	1	1	1	1	1	1	1
Number of Plecoptera taxa	1	1	1	1	1	1	1	1	1	1
Number of Trichopera taxa	1	1	1	1	1	1	1	1	1	1
Number of long-lived taxa	1	1	5	3	1	1	3	1	1	1
Number of intolerant taxa	1	1	1	1	1	1	1	1	1	1
% Tolerant taxa	1	1	1	3	1	3	1	3	1	1
% Predator	1	1	1	1	1	1	1	1	1	3
Number of clinger taxa	3	1	3	3	1	1	3	1	1	1
% Dominance (3 taxa)	3	3	3	3	3	3	1	5	5	1
Total Score	16	14	20	20	14	16	16	18	16	12
BIBI Composite	poor	poor	poor	poor	poor	poor	poor	poor	poor	poor

Table 2b. BIBI assessment scores of sites sampled in tributaries to Tryon Creek, Multnomah County, Oregon August 31, 2001.

Metric	Site Iron Mt (Nettle)	Site Bunk (Cedar)	Site Lower Park Ck.	Site Upper Park Ck.	Site Arnold Ck.
Total Number of Taxa	3	3	3	5	3
Number of Ephemeroptera taxa	1	1	1	1	1
Number of Plecoptera taxa	1	3	3	3	1
Number of Trichopera taxa	1	1	3	3	1
Number of long-lived taxa	5	5	3	5	3
Number of intolerant taxa	1	1	1	5	1
% Tolerant taxa	3	3	3	3	3
% Predator	1	3	3	5	1
Number of clinger taxa	3	3	3	3	3
% Dominance (3 taxa)	5	5	5	5	5
Total Score	24	28	28	38	22
BIBI composite	poor	fair	fair	fair	poor

Table 3. Subdominant taxons (three) scored by the Benthic Macroinvertebrate Index of Biologic Integrity (Karr 1999) for four tributaries and Tryon Creek, Mult. Co., Oregon, August 31, 2001.

Sample Site	Dominant 1	Dominant 2	Dominant 3
R1-1	**B. tricaudatus**	Simulium	Oligochaeta
R1-2	**Simulium**	**B. tricaudatus**	Gammarus
R2-3	**Oligochaeta**	Hydropsyche	Simulium
R2-4	**B. tricaudatus**	Hydropsyche	Simulium
R3-5	**Oligochaeta**	**B. tricaudatus**	Brillia
R3-6	**B. tricaudatus**	Oligochaeta	Hydropsyche
R4-7	**Oligochaeta**	B. tricaudatus	Hydropsyche
R4-8	Simulium	Brillia	Oligochaeta
R4-9	**B. tricaudatus**	Microspectra	Gammarus
R4-10	Oligochaeta	Theinemannimyia	Microspectra
Nettle Creek	Microspectra	Acari	Hydropsyche
Cedar Trail Creek	Juga	Cinygma	Dixa
Lower Park Creek	Zaitzevia	Hydropsyche	Microspectra
Upper Park Creek	Pisidium	Cinygma	Dixa
Arnold Creek	Microspectra	Oligochaeta	Hydropsyche

Table 4. Brillouin's diversity index and Hilsenhoff biotic index scored by the Benthic Macroinvertebrate Index of Biological Integrity (Karr 1999) for Tryon Creek and four tributaries, Portland, Oregon, August 31, 2001.

Sample Sites	Brillouin Diversity Index scoring range 1-5 (stressed to diverse)	Hilsenhoff Biotic Index scoring range 1-10 (sensitive to tolerant)
R1-1	2.27	6.14
R1-2	2.07	6.34
R2-3	2.21	6.21
R2-4	2.42	5.66
R3-5	2.40	6.36
R3-6	2.37	6.04
R4-7	2.15	6.07
R4-8	2.82	6.29
R4-9	2.51	6.23
R4-10	1.41	7.29
Nettle Creek	2.66	5.58
Cedar Trail Creek	2.70	4.33
Lower Park Creek	2.67	4.21
Upper Park Creek	2.40	4.40
Arnold Creek	2.59	5.85

Brillouin's scores ranged between 1.41 and 2.82, which indicates moderate levels of stress.
Hilsenhoff's scores ranged between 4.21 and 7.29, which indicates enriched water quality due to organic waste.

DISCUSSION AND CONCLUSION

Nearly half of the world's population currently resides in urban areas and urbanization is still increasing at an alarming rate (UN 1997). Urbanization has become one of the major environmental stressors on ecosystems (Pan et al. 2001). The present degraded condition of Tryon Creek is symptomatic of many urban streams that have excessive amounts of impervious surfaces in their watersheds (King County 1990 a, b; Booth 1991).

Typically, only a fraction of the total precipitation falling on a basin actually reaches the stream channel. The remainder: 1) never reaches the ground and is evaporated off the surfaces of vegetation, rooftops, paved areas, and other impervious surfaces; 2) enters the ground but is transpired by plants or evaporated from the soil; or 3) percolates deeply to the regional groundwater system, with any subsequent entry to subsurface channels significantly delayed. Of the fraction that reaches the channel, its time of arrival is controlled by whether it flows primarily through the subsurface or over the surface, how quickly it is collected into open channels, and whether it is detained in reservoirs (Booth 1991).

Studies performed on runoff in King County show that hydrologic changes imposed by urban development profoundly affect the disturbance frequency in developing basins. Using a continuous hydrologic computer model (HSPF), Booth (1991) determined the occurrence between 5-year flood events in a sample basin under completely forested conditions and fully urbanized conditions (40 percent impervious surface), using the same 40-year precipitation record for both simulations.

The simulation for the forested watershed resulted in seven floods at or above 5-year discharge, with as much as 14 years between floods. In contrast, the same precipitation record in the simulated urbanized watershed had only one year without a 5-year flood event. Since Booth's initial modeling work, additional studies have been conducted that indicate as little as 10 percent impervious surface in some watersheds may result in development of unstable stream channels and impact overall biotic integrity (Pan et al. 2001).

Our results indicate that stream conditions based on macroinvertebrate diversity and abundance metrics are in poor condition in the Tryon Creek watershed. Some of the tributary sample sites are in better condition than the mainstem sites. Several metrics indicate degradation in the macroinvertebrate communities throughout the watershed from past and current land uses, i.e. urbanization (sediment and pollution tolerant metrics).

A trend in decreasing BIBI scores within developed areas indicate that the metrics were able to relate the macroinvertebrate community health to land use intensity in the watershed. These results indicate that sedimentation and water quality would be suspected as the primary causes of any macroinvertebrate degradation in Tryon Creek watershed.

Our study shows that macroinvertebrate assemblages in Tryon Creek are characterized by low overall taxa richness and taxa richness of the three sensitive aquatic insect orders (Ephemerotpera, Plecoptera, and Tricoptera –EPT). The overall macroinvertebrate composition in Tryon Creek is characterized by sediment and pollution-tolerant taxa. Percent Hydrospychidae to Tricoptera and % Baetidae to Ephemeroptera were higher in Tryon Creek than those in the tributary sites. Both metrics are expected to increase with disturbance (Barbour et al. 1999). Also, the percent of scrapers in the tributary sites was higher than in the mainstem locations.

Although the data gathered for this assessment provides insight into the condition of the Tryon Creek watershed, their usefulness is restricted by the limited scope of the sampling survey. Linking macroinvertebrate community attributes to specific human-induced disturbances is beyond the scope of this survey. To make definitive conclusions about anthropogenic impacts on biological conditions in the Tryon Creek watershed, the scale of macroinvertebrate monitoring would need to be expanded, both spatially and temporally, and more quantitative evaluations of water chemistry and physical habitat would be needed.

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WQ Parameters
Tryon Creek Watershed, Oregon

Original Number	Sample Location Reach Designation Number	Date	Time	pH	Conductivity us/cm	Temperature (degrees C.)	Turbidity (ntu)	Dissolved Oxygen (mg/L.)	Method	Comments
1	R1-1	11/30/01	12:40	7.42	70	8	76	7	Colormetric	Heavy rain
2	R1-2	11/30/01	12:50	7.45	70	8	82	7	Colormetric	Heavy rain
3	R2-3	11/30/01	12:28	7.51	70	8	105	7	Colormetric	Heavy rain
4	R2-4	11/30/01	9:10	7.09	50	8	165	6	Colormetric	Heavy rain
4	R2-4	12/10/01	11:30	7.54	130	7	9.4	8.84	WTW Meter	Light rain
8	R3-5	11/30/01	10:54	7.37	70	8	58.5	5.5	Colormetric	Heavy rain
10	R3-6	11/30/01	11:30	7.4	80	8.5	70	5.5	Colormetric	Heavy rain
10	R3-6	12/10/01	10:45	7.48	120	7	7.5	8.73	WTW Meter	Light rain
13	R4-7	11/30/01	13:50	7.38	70	8.5	53	NM	Colormetric	Heavy rain
13	R4-7	12/10/01	10:03	7.6	120	7	7.5	8.73	WTW Meter	Light rain
14	R4-8	11/30/01	15:38	7.77	80	8	26.2	12	Winkler Titration	Heavy rain
14	R4-8	12/10/01	9:33	7.45	140	7	7.5	8.46	WTW Meter	Light rain
15	R4-9	11/30/01	15:15	7.73	80	8	31.3	5	Winkler Titration	Heavy rain
16	R4-10	11/30/01	15:00	7.85	80	7	32.4	NM	Colormetric	Heavy rain
16	R4-10	12/10/01	9:10	7.2	130	7	14.8	8.23	WTW Meter	Light rain
17	R4-11	12/10/01	8:40	7.28	180	9	7.9	7.62	WTW Meter	Light rain
11	Tributary-Uppar Park Creek	11/30/01	13:05	7.45	70	8	50	6	Colormetric	Heavy rain
12	Tributary-Arnold Creek	11/30/01	13:40	7.41	70	8.8	53	7	Colormetric	Heavy rain
5	Tributary-Iron Mt. Bridge	11/30/01	9:40	7.14	80	8	71	NM	Colormetric	Heavy rain
6	Tributary-Cedar Creek	11/30/01	10:20	7.35	90	8	60	4.5	Colormetric	Heavy rain
7	Tributary-Lower Park Creek	11/30/01	10:40	7.44	90	9	50.4	7	Colormetric	Heavy rain
9	Deleted (on Tryon Creek above High Bridge	11/30/01	NM							

NOTE: ntu =nephelometric turbitidy units, us/cm = microsiemens per centimeter, mg/L. = miligram per liter.

[1] Dissolved oxygen measurements using the LaMotte kit vary due to interpretating the first endpoint (pale yellow) titration of thiosulfate

PART 4

Oregon Department of Fish & Wildlife

Aquatic Inventory Project:

Report prepared by:
Survey Crew:
Tyler Tappenbeck, Alexis Vaivoda

Report prepared for:
City of Portland
October 11- October 12, 2000

TRYON CREEK REACH

(T2S-R1E-S42SE) The primary channel length of reach 1 is 392 meters. Reach 1 begins at the Willamette River confluence, and ends on the west side of the highway 43 culvert crossing. The channel is constrained by multiple
terraces within a broad valley. The average valley width index is 20.0. Land use for the reach is industrial and rural residential. The average unit gradient is 2.3 percent. Stream habitat is dominated by scour pools (47%) and riffles (20%). Stream substrate is equally distributed among fine sediments, gravel and cobble. The average residual pool depth is 0.64 meters. Wood volume is low at 2.8 m^3/100m. Based upon one riparian transect, the trees found most frequently in the riparian zone are deciduous species 15-30 cm and coniferous species 3-15 cm dbh, and the largest trees are 15-30 cm dbh hardwoods.

DESCRIPTIONS

REACH 1 DESCRIPTION

RIPARIAN — The riparian zone in reach 1 is quite poor. Adjacent to the creek on the north side is a backyard with no buffering trees. The south side of the creek is bordered by a sewage treatment plant and industrial area with a very narrow riparian buffer strip of Cedar and Arborvita hedges.

CHANNEL CHARACTERISTICS — The area is incised. Bedrock is not far below the layer of silt sand and gravel, and in areas is exposed. The channel is U-shaped and appears to handle very high flows at times. At the time of this survey there was a beaver dam and associated pool very close to the confluence.

POTENTIAL REFUGIA — The refugia for reach 1 includes deep pools and a few pieces of large wood that serve as flow disruption.

CURRENT BIOLOGICAL USE — Beaver activity is present in reach one. The landowner spoke of extensive rodents in the area. Since this is the confluence with the Willamette, it probably serves as a wildlife corridor to Tryon State Park.

OTHER INFORMATION — The culvert crossing of highway 43 has baffles in it to help fish passage. This culvert is quite steep and ;the baffles give areas for fish to rest within the culvert.

ANALYTICAL ARTIFACTS — None

TRYON CREEK REACH DESCRIPTIONS

REACH 2 DESCRIPTION

(T2S-R1 E-S42SE) The primary channel length of reach 2 is 1,309 meters. Reach 2 begins at the west side of the highway 43 culvert crossing, and ends at the first tributary shown on the USGS topo map. The channel is constrained by alternating terraces and hillslopes within a broad valley. The average valley width index is 43, and ranges between 1.5 and 7.5. Land use for the reach is designated green space (Tryon Creek State Park). The average unit gradient is 1.3 percent. Stream habitat is dominated by scour pools (51%), dammed pools (25%), and riffles (17%). Stream substrate is equally distributed among fine sediments, gravel, and cobble. The average residual pooi depth is 0.59 meters. Wood volume is low at 2.8 m3/lOOm. Based upon two riparian transects, the trees found most frequently in the riparian zone are deciduous species 15-30 cm, and the largest trees are 50-90 cm dbh conifers.

RIPARIAN — Very good. This reach is in Tryon Creek State Park, and the riparian buffer is wide and relatively undisturbed. There are areas where the hiking trail is very close to the creek which encourages lots of contact between the creek, people and animals (dogs) which can be detrimental to water quality, bank stabilization, and induce substrate disturbance.

CHANNEL CHARACTERISTICS — There are many seeps and springs throughout this reach. The channel is quite variable in this area. There are areas of beaver activity, steep banks, wide areas for water storage, and everything in between. This indicates that the creek is allowed to interact with its floodplain much more than a typical urban creek.

POTENTIAL REFUGIA — Despite the interaction with the floodplain there is very little off channel habitat. This reach has some large wood that will act as areas of refuge for fish.

CURRENT BIOLOGICAL USE — Beaver activity, and the presence of numerous beaver ponds were noted.

OTHER INFORMATION — In the lower section of reach 2, there is a fully exposed sewer pipe that is supported by large concrete pillars. This runs for approximately the first quarter of the reach, and then disappears into the hillslope.

ANALYTICAL ARTIFACTS - none

TRYON CREEK REACH DESCRIPTIONS

REACH 3 DESCRIPTION

(T2S-R1E-S42NW) The primary channel length of reach 3 is 2,621 meters. Reach 3 begins at the first tributary shown on the USGS topo map, and ends at the Arnold Creek tributary junction, near the SW Boones Ferry culvert crossing. The channel is constrained by terraces within a broad valley. The average valley width index is 9.2, and ranges between 4.0 and 16.0. Land use for the reach is designated green space (Tryon Creek State Park). The average unit gradient is 0.6 percent. Stream habitat is dominated by scour pools (57%) and riffles (29%). Stream substrate is equally distributed among fine sediments, gravel, and cobble. The average residual pool depth is 0.62 meters. Wood volume is low at 3.2 m3/lOOm. Based upon four riparian transects, the trees found most frequently in the riparian zone are deciduous species 3-15 cm, and the largest trees are 90+ cm dbh hardwoods and conifers.

RIPARIAN — The riparian zone for reach 3 is very similar to reach 2, since it is also within the Tryon State Park.

CHANNEL CHARACTERISTICS — Channel characteristics are also like those of reach 2, but there is evidence of more erosion in reach 3.

POTENTIAL REFUGIA— There are many small tributaries that will serve as good off channel habitat in periods of high flow.

CURRENT BIOLOGICAL USE — There was lots of evidence of rodent activity (beaver, mink, and muskrat nutria), and fish were noted in reach 3. •

OTHER INFORMATION — The SW Boones Ferry Rd. crossing is not particularly fish friendly. The culvert is long and quite steep. It was not listed in the report as a passage barrier, but it is not encouraging connectedness between reach 3 and reach 4.

ANALYTICAL ARTIFACTS - none

TRYON CREEK REACH DESCRIPTIONS

REACH 4 DESCRIPTION

(T1S-R1E-S28SE) The primary channel length of reach 4 is 2,157 meters. Reach 4 begins at the Arnold Creek tributary junction, near the SW Boones Ferry culvert crossing, and ends at the tributary junction just upstream of SW Lancaster. The channel is constrained.by terraces within a broad valley. The average valley width index is 6.3, and ranges between 2.0 and 14.0. Land use for the reach is green space (Marshall City Park) and rural residential. The average unit gradient is 2.9 percent. Stream habitat is dominated by rapids (37%) and scour pools (30%). Stream substrate is equally distributed among fine sediments, gravel, and cobble. The average residual pooi depth is 0.46 meters. Wood volume is low at 2.1 m3/lOOm. Based upon five riparian transects, the trees found most frequently in the. riparian zone are deciduous species 30-50 cm, and the largest trees are 50-90 cm' dbh hardwoods and conifers.

RIPARIAN — The riparian buffer in reach 4 becomes narrower. Marshall Park only encompasses 113 of this reach, the rest is in a rural residential area. In this rural residential area there are some larger trees left standing, however the houses are encroaching on the stream channel.

CHANNEL CHARACTERISTICS — There is more bedrock exposed in reach 4. Marshall City Park has some waterfalls and rapids that were considered to be natural fish passage barriers. There is lots of erosion and many areas that have been stabilized by landowners with retaining walls.

POTENTIAL REFUGIA — There is very little refugia in this reach.

CURRENT BIOLOGICAL USE — None noted.

OTHER INFORMATION — This reach has quite a bit of human influence and backyard "adjustments" to the channel.

ANALYTICAL ARTIFACTS - none

STREAM ORDER: 2
BASINAREA: 3.0 km2
FIRST ORDER TRIBUTARIES: I
USGS MAPS: Lake Oswego
ECOREG ION: Willamette Valley Plains - Foothills
HUC NUMBER: 17090012
LLID: 1226877454471

ARNOLD CREEK GENERAL DESCRIPTION:

The 2000 Arnold Creek survey began at the confluence with Tryon Creek, and ended just upstream of the first tributary junction on the USGS topo map. This survey was comprised of one reach that stretched almost 2 km, and was subdivided into 113 habitat units based upon instream fish habitat variables.

This area is similar to Tryon Creek, and traverses similar topography. There are steep water-falls, and areas of decent riffle-pool sequences. Creek side property is currently being developed, and there are areas of houses very close to the channel. The riparian buffer is great in a few areas, and in others Arnold Rd. is very close, as well as houses and backyards.

ARNOLD CREEK REACH DESCRIPTION

(TI S-RI E-S28SE) The primary channel length of reach I is 1,982 meters. Reach I begins at the Tryon Creek confluence, and ends just upstream of the first tributary junction on the USGS topo map. The channel is constrained by alternating terraces and hillslopes within a broad valley. The average valley width index is 6.7, and ranges between 1.0 and 15.0. Land use for the reach is rural residential. The average unit gradient is 3.6 percent. Stream habitat is dominated by riffles (50%) and scour pools (25%). Stream substrate is equally distributed among fine sediments, gravel, and cobble. The average residual poql 'depth is 0.38 meters. Wood volume is low at 1..5 *m3/100m* Based upon four riparian transects, the trees found most frequently in the riparian zone are deciduous species 3-15 cm, and the largest trees are 90+ cm dbh conifers.

RIPARIAN — The riparian buffer through the surveyed section of Arnold Creek is decent. There are some areas where the buffer is very narrow due to the close proximity of SW Arnold Rd., and they are a few instances of houses very close to the channel.

CHANNEL CHARACTERISTICS — The geomorphology is very similar to Tryon Creek. Arnold has the same large bedrock waterfalls, which pose a natural fish passage barrier. These falls are near SW 18th Dr., in a backyard setting.

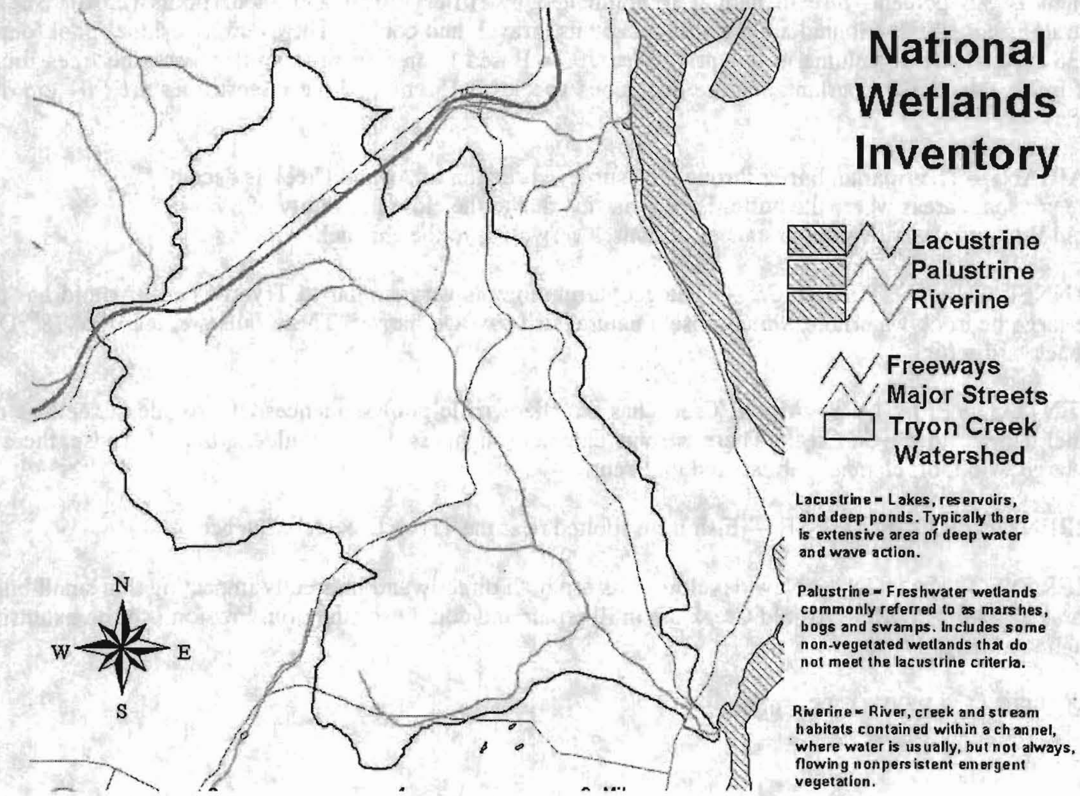
POTENTIAL REFUGIA — Arnold Creek has excellent riffle-pool sequences. It provides excellent off channel habitat for Tryon Creek. There is some channel roughness due to boulders, but otherwise, there is little large wood, off channel habitat, and undercut.

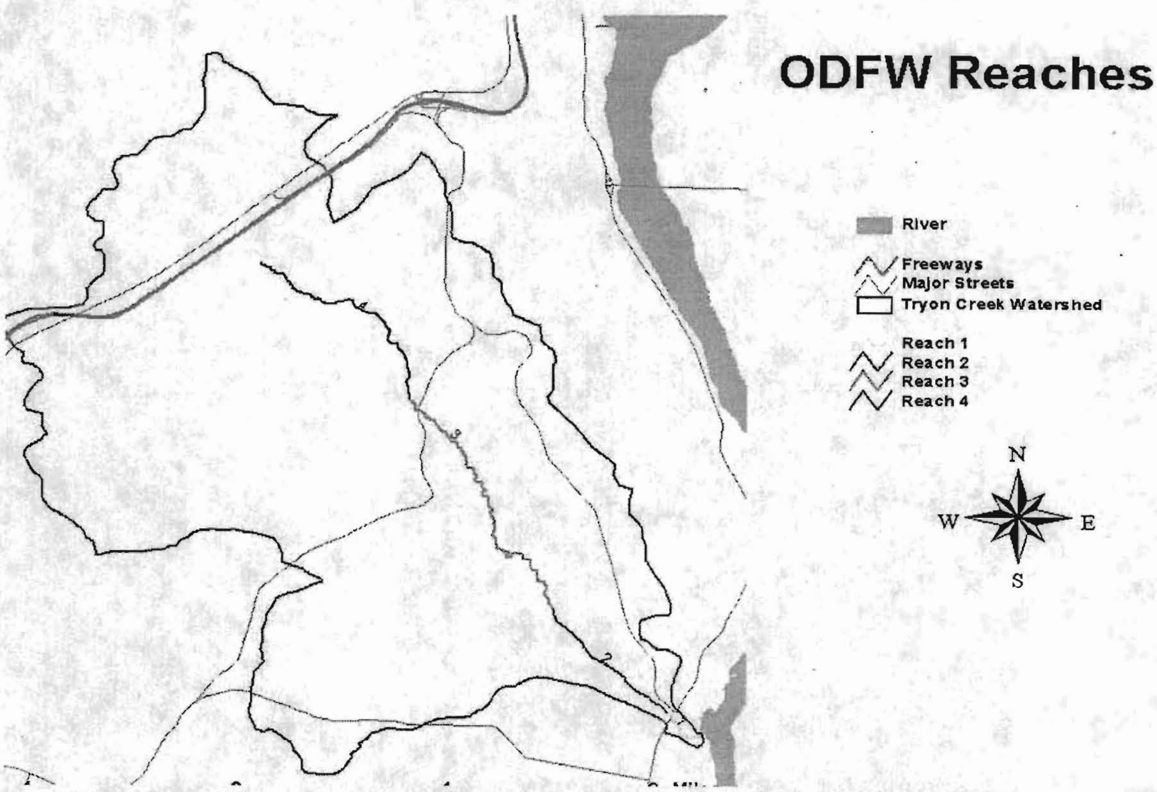
CURRENT BIOLOGICAL USE — Fish were spotted near the Tryon Creek confluence.

OTHER INFORMATION — New developments are both directly and indirectly impacting this small body of water. Culverts crossing Arnold Creek are in ill repair and could use attention. Erosion is quite extensive throughout Arnold Creek.

ANALYTICAL ARTIFACTS - none

Map Comparison: NWI Streams (top); ODFW Stream Reach Survey (lower).





Topographic map, with ODFW Reaches 1-4 noted. (Arnold Creek reach was not itemized on this map.)