Photo: Erosion exposes boulders in stream bank in lower state park.

Small creek cascades down boulders. English ivy overruns the north bank. Location: Marshall Park, west tributary.

Phase 1 Data Review of Hydrologic and Geomorphic Conditions in the Upper Tryon Creek Watershed, 1997

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(Note: This report includes neighborhood conservation planning guidance. For a complete transcript of the original report including maps and graphics, as well as the conservation lands priority map, please refer to the StreamNet Library or the editor of this publication.)

1. Watershed Conditions

1.1 Study Area

The study area for this assessment is the Upper Tryon Creek (UTC) watershed (Figure 1) that includes the Marshall Park neighborhood association and the southern portion of the Multnomah neighborhood association. The UTC watershed is approximately 4.9 square miles in area (BES, 1997).

The City of Portland recently assessed conditions within the UTC watershed. These efforts were focused on documenting existing creek corridor and riparian conditions and developing pIans to improve these areas and water quality by reducing bank erosion (BES, 1997). Acknowledging this recent work, this review is directed more towards reviewing the geomorphic and hydrologic conditions beyond the creek corridors and throughout the watershed.

1.2 Geomorphic Conditions

The UTC watershed is characterized as a palmate-shaped drainage basin. Drainage patterns within the watershed are dendritic with a low drainage density, or length of stream channels per unit area. This type of drainage pattern is indicative of stream networks that have developed in a random manner on flat or gently sloped rock surfaces (Morisawa, 1968). As shown in Figure 2, this combination of basin shape (Type C) and drainage pattern is conducive for creating flood discharges with high and sharper peaks, as compared to a more elongated basin (Type A) that would discharge flood flows with an extended peak flow.

The most recent Soil Conservation Service (SCS)--now the Natural Resource Conservation Service (NRCS)--soil survey identifies most soils within the UTC watershed as urban lands (BES, 1997). This means land areas are predominantly covered with impervious surfaces such that soil identification is not feasible. However, older surveys, made prior to heavy urbanization, do provide these data. The 1922 Soil Survey of Multnomah County (Soil Conservation Service, 1922) indicates the soils in the UTC watershed are predominantly silt loams, including Olympic silt loam, Amity silt loam and Powell silt loam. Olympic silt loam is derived from the weathering of igneous rock and the Amity and Powell silt loams are transported soils derived from old valley deposits.

The creek channels in the UTC watershed are generally characterized in the BES corridor assessment as incised (downcut) with varying degrees of bank erosion. This is a geomorphic process typical of headwater streams where steep channels provide high amounts of gravitational energy to flowing water to erode channel bed and banks. Incised channels gradually widen by scouring and flattening bank slopes to achieve a more stable condition (Figure 3). Depth to bedrock is typically shallow in the UTC watershed and in locations where creek channels have scoured down to bedrock, the only adjustment the channel can make is to erode laterally. Historic and current human interventions in the watershed have changed the natural patterns of runoff to the creek channels and have likely changed the natural stability and evolution of the creek channels.

1.3 Hydrologic and Fisheries Conditions

There is no long-term stream gauge data for the UTC watershed and at the present time (1997) there are no active, continuous recording streamgauges in the UTC watershed. The only historic gauging program was done by the USGS during water years 1975, 1976 and 1977 to record peak flows (Laenen, 1997). The stream gauge was located on a tributary to Tryon Creek at Dolph Court and monitored a 0.36 square mile drainage area in the UTC headwaters north of Interstate-5. Recent stream gauging has been done at the terminus of the UTC watershed at the SW Boones Ferry Road crossing of Tryon Creek and data from this gauge was used to calibrate hydrologic modeling performed during the BES corridor assessment. However, this gauge was destroyed during the February 1996 flood (BES, 1997).
(Ed. note: see Water Quality Section, this Baseline Report, for 2001-03 USGS flow gage data.)

Hydrologic assessments in the 1997 BES corridor assessment were focused on the estimation and evaluation of peak flood flows and drainage system conveyance capabilities and limitations. The BES corridor assessment did not address low seasonal flows (base flows) or flow duration relationships. These hydrologic conditions are important for an understanding of summer water temperature problems, sediment transport, and other watershed geomorphic functions.

Where Coho salmon, steelhead and cutthroat trout once populated Tryon Creek streams, now the perennial streams are considered habitat for resident fish species (Portland State University, 1995). Tryon Creek is the only west-side urban stream amenable to fish migration, being without culverts or natural barriers in its lower reaches along the Willamette River. However, there is a concern that the fish ladder under highway 43 near the mouth of the creek presents a barrier to some migratory fish. The quality of the fisheries habitat in the lower reaches of Tryon Creek is directly influenced by the quality of water provided from the headwaters in the UTC watershed. Perennial streams provide the necessary habitat for resident or anadromous fish.

1.4 Geologic and Ground Water Conditions

Recent geologic mapping of the Lake Oswego quadrangle (Figure 4) includes the UTC watershed (Beeson et al, 1989 and Madin, 1990). The mapping indicates the western half of the watershed is underlain by Boring lavas [QTb]. Lower elevation portions of the watershed, to the east and below 450-feet, NGVD, along Tryon and Arnold Creeks, are underlain with older rock including the Sandy River Mudstone equivalent [Qts] and the Columbia River Basalt Group [Tcr]. The Boring lavas are assumed to have flowed from volcanic vents, one of which formed Mt. Sylvania (Hart and Newcomb, 1965). A geologic cross section in the vicinity of the UTC watershed shows the lavas deposited on top of the older rocks which dip to the southwest (Beeson et al, 1989). Rock units under the entire UTC watershed are overlain by more than five feet of Loess [Ql] (Madin, 1990).

The Loess, Columbia River basalt, and Boring lavas are all described as being "sufficiently permeable" to accept recharge of the groundwater body (Hart and Newcomb, 1965). The UTC watershed is transected by the Sylvania and Oatfield Faults that run from northwest to southeast (Beeson et at, 1989). Tectonic structures control the recharge of groundwater into the basalts allowing water to more readily enter porous zones of the rock through gravel bed streams traversing beveled edges of the basalt layers (Hart and Newcomb, 1965).

There is limited information available specifically describing the groundwater hydrology of the UTC watershed. Perched water tables (Figure 5) have been observed in wells drilled near Mt. Sylvania (Hart and Newcomb, 1965). These conditions are characteristic of groundwater in this area, where the water table in the Boring lavas is typically perched above the regional water table (Hart and Newcomb, 1965). Summer flows in the small creeks of the UTC watershed were identified by the USGS to be sustained by groundwater discharges from small seeps and springs along the ravines and escarpments that intersect perched or unconfined groundwater (Hart and Newcomb, 1965). The headwater portions of Tryon, Falling and Arnold Creeks in the UTC watershed that are underlain by Boring lavas, can therefore be characterized as areas of local groundwater flow, as opposed to regional groundwater flow that occurs in the older and deeper rock (Figure 6).

2. Impacted Watershed Conditions

2.1 Historic Land Use Changes

Early mapping of the UTC watershed is available from 1905 (Figure 7). Mapping made from 1911- 12 aeriaphotographs (Figure 8) show a noticeable lack of forest cover within the UTC watershed. This isthe northern end of Tryon Creek canyon caused by lightning at the turn of the century (Portland State University, 1995). Mapping made from 1952 aerial photographs (Figure 9) show significant areas of forested regrowth, even with the accelerated level of development. Current hillslope and creek channel conditions may be partially attributed to these dramatic impacts to the watershed at the turn of the century.

Both maps show perennial creek segments (solid blue lines), where flows occur throughout the year, and ephemeral creek segments (dashed blue lines), where flows do not occur in the drier summer months. There is a noticeable reduction in the length of blue line ephemeral stream lengths between the two maps. This occurs on Arnold Creek, along the northeast flank of Mt. Sylvania at the intersection of SW Stephenson Street and SW 35th Avenue, and on Tryon Creek near the Collins School and along SW 18th Place.

The capture of runoff from impervious surfaces and direct discharge to creeks may have resulted in a lowering of the seasonal water tables such that perennial stream reaches behave more like intermittent reaches (Figure 10) or ephemeral reaches disappear.

The older maps show both Arnold and Falling Creeks as ephemeral streams and the recent mapping indicates these tributaries are perennial. Also, extended perennial and ephemeral headwater reaches of Tryon Creek, in the Multnomah Neighborhood near Multnomah School, are shown in the 1952 mapping and not in the older mapping. Similar observations of lost ephemeral channels in other urbanized areas have been attributed to grading, construction and piping and new "artificial" perennial channels to increased road crossings and drainage outfalls (Dunne and Leopold, 1978 and May *et at,* 1997). The loss of ephemeral channels in urbanizing watersheds reduces the natural ability of runoff and sediment to be dispersed to slow the movement of flood peaks and buildup of sediment deposits (Dunne and Leopold, 1978).

2.2 Urbanization and Imperviousness

The magnitude of environmental impacts in an urban watershed is largely related to the increased imperviousness of the band areas (Schueler, 1990). Recent research suggests that physical and
biological conditions in a watershed change at an increasing rate as urbanization begins and exceeds 5- to 10-percent total impervious area (TIA). With continued urbanization, degradation to habitat and biologic integrity tend to occur at a more constant rate (May *et at*, 1997). Table 1 summarizes major stream impacts caused by urbanization. Table 2 summarizes changes to urban streams that can be expected after watershed imperviousness exceeds 10 percent.

2.3 Hydrologic and Geomorphic Impacts

An increase in impervious surfaces from urbanization decreases the ability of the watershed soils to absorb and infiltrate storm water runoff. This change in hydrologic conditions results in an increase in the peak rate of runoff and the total runoff volume to local streams (Chow et al, 1988, Leopold, 1968). Urbanization also shortens the lag time, or the time it takes for stream flows to peak after the most concentrated part of a rainstorm has occurred (Figure 11). In a natural watershed, rainfall is slowed as it moves towards a stream (Figure 12). At the early part of a rainstorm, rainfall is initially held in the soil where it falls through infiltration, surface storage, and soil moisture storage; then it flows to streams through the soil and overland. The relative effect of these storage and flow mechanisms as a rainfall event progresses are shown in Figure 13 by visualizing vertical slices through the figure. Impervious surfaces, and storm sewers that drain these surfaces, intercept precipitation where it falls and eliminate much of the natural hydrologic conditions available for attenuating runoff

Leopold (1968) compiled data from urban watersheds across the United States and developed relationships to demonstrate the effects of urbanization on mean annual flood flows (the 2~.3-year flood recurrence interval). Figure 14 shows that, for a one square mile drainage area, these flows increase dramatically for increasing areas of imperviousness, increasing areas served by storm sewers, and combinations of these two factors.

A similar assessment of the effects of urbanization on hydrology was done in 1980 by the USGS for the Portland metropolitan area. A significant finding from the study was that a completely urbanized basin in the Portland metropolitan area could have a three-fold increase in peak discharge, and storm runoff volumes could be twice as much as from a natural basin (Laenen, 1980). The effect of storage and impervious area was also evaluated in this study and the results are graphically shown in Figure 15. The figure shows that increasing the storage of runoff has beneficial effects for a range of imperviousness. For example, assume a one square mile urban Portland drainage area with 20- percent effective impervious area (impervious areas directly connected to storm sewer systems) has areas increased for runoff storage from zero to 10-percent. The 25-year peak flow (0.04 exceedence value) from this basin would decrease from approximately 290 cfs to 90 cfs.

Recent research of urban streams in the Puget Sound lowlands (PSL) documented significant changes in the hydrologic and biologic, conditions of urban streams (May *et* at, 1997). Figure 16a shows how the ratio of estimated 2-year flood flows to the mean winter baseflows increases with increasing imperviousness; i.e., flood peaks become higher and baseflows lower. The same study showed interesting relationships between increasing imperviousness and biotic integrity (the condition of macro invertebrates) and coho/cutthroat ratio (a measure of salmonid integrity) (Figure 16b). These two biological indicators were high for relatively undeveloped watersheds with imperviousness of *5*- percent or less. Significant losses of biological integrity appear to occur with relatively low urbanization.

3. Watershed Protection and Conservation Planning

3.1 Stream and Watershed Protection Strategies

There has been a significant amount of research concerning impacts and protection of urban watersheds. Schueler (1992) provides a comprehensive listing of fundamental elements for a stream protection strategy (Table 3). Recommendations for ensuring natural stream quality for Puget Sound lowland streams are presented in May et al (1997) (Table 4). Watershed tools to guide the siting of new development in a watershed are graphically shown in Figure 17. The economic and environmental aspects of these tools are described on Table *5*.

3.2 Preliminary METRO GIS Analysis

A preliminary GIS analysis was conducted by METRO GIS staff with direction from PWA. The intent of the analysis was to create one composite GIS map to assist in the identification of areas within the UTC watershed that would be appropriate for land conservation. The objective of land conservation would be to protect groundwater recharge areas that serve to attenuate peak winter flood flows and sustain summer low flows.

The analysis involved the evaluation of available GIS soils data as indicators of groundwater conditions. Several soil characteristics were evaluated, such as depth to water table, water table type (perched, artesian, apparent), natural drainage condition, hydric soils, depth to bedrock and soil permeability. Only soil permeability provided a range of data values within the UTC watershed, all the other soils data presented a uniform value across the watershed. Permeability refers to the capacity of a soil for transmitting a fluid and can be an indicator of infiltration and groundwater recharge. Three categories of soil permeability were defined for analysis including: 0.06 inches per hour or less, 0.06 to 0.2 inches per hour and 0.6 to 2.0 inches per hour.

Soil permeability values were then assigned to undeveloped land parcels within the UTC watershed. It was assumed that land conservation and significant development infill interests would be focused on these land areas. Undeveloped land is defined as land appearing unimproved on aerial photography. On partially developed tax lots, only undeveloped areas a half acre or larger are included. City of Portland "environmental conservation" and "environmental protection" overlay zones, the boundaries for the Marshall Park and Multnomah neighborhood associations, and the UTC watershed boundary were also composited on the map.

The GIS map (Attachment A) provides an indication of soil infiltration capacities of undeveloped lands in the UTC watershed. Land parcels with higher permeability rates represent areas that can better absorb storm water runoff. Conservation of these lands would help to not increase winter peak rates of runoff over existing conditions. Land parcels with higher permeability rates adjacent to perennial and ephemeral streams represent potential areas for groundwater recharge and conservation of these lands would help to not reduce the source of summer low stream flows that sustain biological processes and cooler water temperatures in the streams. Infiltration may be increased on higher permeable soils than on gentler slopes because overland runoff occurs more slowly and there is more opportunity for water to seep into the ground.

Within the UTC watershed there are more undeveloped land parcels in the Marshall Park neighborhood than in the Multnomah neighborhood. Undeveloped land parcels in the Multnomah neighborhood are few and far between and tend to be of a relatively moderate permeability (0.06-0.2 inches per hour). The Marshall Park neighborhood has more undeveloped land parcels that generally coincide with the city environmental zones. Soil permeability tends to be higher along the north and east sides of the mainstem Tryon Creek and along the north and east tributaries. The spatial variability and quality of the available soil information used in this GIS analysis should be checked before proceeding to further detailed assessments.

3.3 Upper Tryon Creek Watershed Conservation Plan Preliminary Recommendations

These recommendations are preliminary in nature and have been developed from a brief review of available information. They represent conceptual considerations for actions that could be considered to maintain and improve the watershed health of the UTC.

3.3.1 Stormwater Management

Limit the amount of impervious surfaces. Paving, roofs, and roads in the UTC watershed result in increased stormwater runoff. Limit the use of pavement with new development and consider ways to reduce the amount of existing impervious area. "The concept is quite simple: more paving means more runoff which means more storm water management" (Untermann and Small, 1977).

Prioritize storm water runoff source control. Recent assessments in the UTC seem focused on evaluating the ability of the creeks to convey future increased streamflows from increased development. Prioritization should be given to reducing the hydrologic impacts of development at the runoff stage of the hydrologic cycle, where rainfall lands and where the development occurs, as opposed to treating the symptoms of the impacts--typically increased peak flows and runoff volumes-- within the more sensitive confines of the downstream creek channels. One insurance against impacting the geomorphic functioning of the creeks is to simply maintain post-development runoff quantities to pre-development levels (Untermann and Small, 1977). (Note: emphasis added by editor)

Critically review the use of instream detention. The main characteristics of a flood event include the peak discharge and the total volume of water. Detention is used to reduce the peak discharge of an event, but it does not typically reduce the total volume of water associated with the flood event; i.e., detention just stretches out the time, or duration, of a flood event. Even if flows are lower in magnitude, an increased duration of the lower flow may still contribute to channel erosion and instability. Priority should be placed on allowing for infiltration of rainfall where it lands so that it does not need to be "handled" further downstream.

Remove creek culvert constrictions. Replace constrictive creek culverts with bridges or open-bottom, oversized culverts that span the width of the natural creek channel. Sediment buildup may occur at the upstream side of a channel constriction and concentrated flow velocities may scour a channel on the downstream side. Both of these conditions may exacerbate local geomorphic changes in the creek channels and lead to continued instability.

Increase infiltration of precipitation on permeable soils. Methods that can decrease runoff and increase infiltration include (Figure 18): 1) keeping road widths and parking areas as small as possible; 2) substituting roadside swales for curb and gutters; 3) constructing dry wells and drain fields under roads or parking areas; 4) using plantings to increase moisture retention; and *5)* identifying, conserving and directing runoff (where appropriate) to permeable soils and groundwater recharge locations.

3.3.2 Land Conservation

Conserve lands adjacent to and upslope from creek channel seeps and springs. These land areas should be conserved because they are the likely recharge areas for local groundwater flow to the creeks. The areas that readily allow groundwater recharge and discharge supply streamflow during dry weather should be conserved instead of being paved or polluted so that they might continue this function (McHarg, 1969).

Conserve lands along and adjacent to fault zones. Besides being a potential seismic hazard to development, faulting was identified in a USGS study as locations where rock units may be more permeable for groundwater recharge, dependent on the permeability of the overlying soils.

Local groundwater recharge considerations. Prioritize conservation of undeveloped lands with these four combined attributes: 1) land adjacent to creek corridors; 2) land on permeable soils; 3) land having gentle slopes; and, 4) land at topographic low elevations. These areas may be the most conducive for local groundwater recharge.

Conserve lands at topographic low points. These land areas should be conserved for opportunities to increase areas for runoff storage in the watershed to decrease peak flows to the creek channels and increase the potential for groundwater recharge.

Regional groundwater recharge considerations. Prioritize conservation of lands underlaid by Boring lavas in the western portion of the UTC watershed. These rock units have a higher recharge capability than other rock units present in the watershed, depending on the permeability of the overlying soils

Conserve steep lands. Sedimentation and erosion is sensitive to the slope of the land (Leopold, 1968). Recent earthquake hazard mapping for the UTC watershed area utilized topographic slope information as an indicator of slope instability for landslide analyses (Mabey *et al, 1995).* Slope categories ranged from *15*- to 30-percent (least hazard) to 30- to 45-percent (moderate hazard) to greater than 45-percent (high hazard). Lands greater than a 30-percent slope should be considered for conservation, or development that allows for more infiltration.

3.3.3 Additional Basic Data Needs

Develop creek channel profiles. The BES corridor assessment provides a significant amount of mapped data. From a geomorphic perspective, the development and analysis of channel profiles are fundamental to assessing the morphology and distribution of energy along the length of the watercourse. Sedimentation and erosion is sensitive to the slope of the land (Leopold, 1968) and a visual display of creek profiles can provide an easy and comprehensive assessment of sensitive creek reaches. Concentrated discharges from the storm drainage outfalls and bedrock outcrop locations are the likely places where the geomorphic conditions in the creek channels can be impacted from increased water velocities.

Inventory seeps and springs. The BES UTC corridor study should be augmented to include an assessment of the locations of groundwater seeps and springs along the creek banks and riparian areas. The identification and protection of these streamside discharge and associated upland recharge areas should be a key criterion for land conservation efforts to help preserve these hydrologic functions that contribute cooler water and sustain summer seasonal low flows.

Develop watershed streamflow gauging information. Streamflow gauges should be established on the tributary streams within the UTC watershed to enable the assessment of hydrologic responses to existing and planned development. Historic gauge data in the headwaters of the Tyron Creek watershed is too minimal. The recent corridor assessment relied on gauged streamflows at the terminus of the UTC watershed, at Boones Ferry Road, to calibrate hydrologic models. High water marks could be recorded at the many culvert crossings in the watershed to calibrate future hydraulic modeling efforts.

Assess base flow/summer water temperature relationships. Tryon Creek was listed as water quality limited for summer temperatures by DEQ in 1996. The recent BES corridor assessment focused on peak flood flows, as opposed to summer base flows when water temperature problems are more acute.

Identify a control watershed(s). Undeveloped, or less developed, watersheds having similar characteristics to the UTC watershed, should be identified and used as reference cases to provide a way to assess hydrologic and geomorphic impacts from development in the UTC watershed (Anacostia Restoration Team, 1991).

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