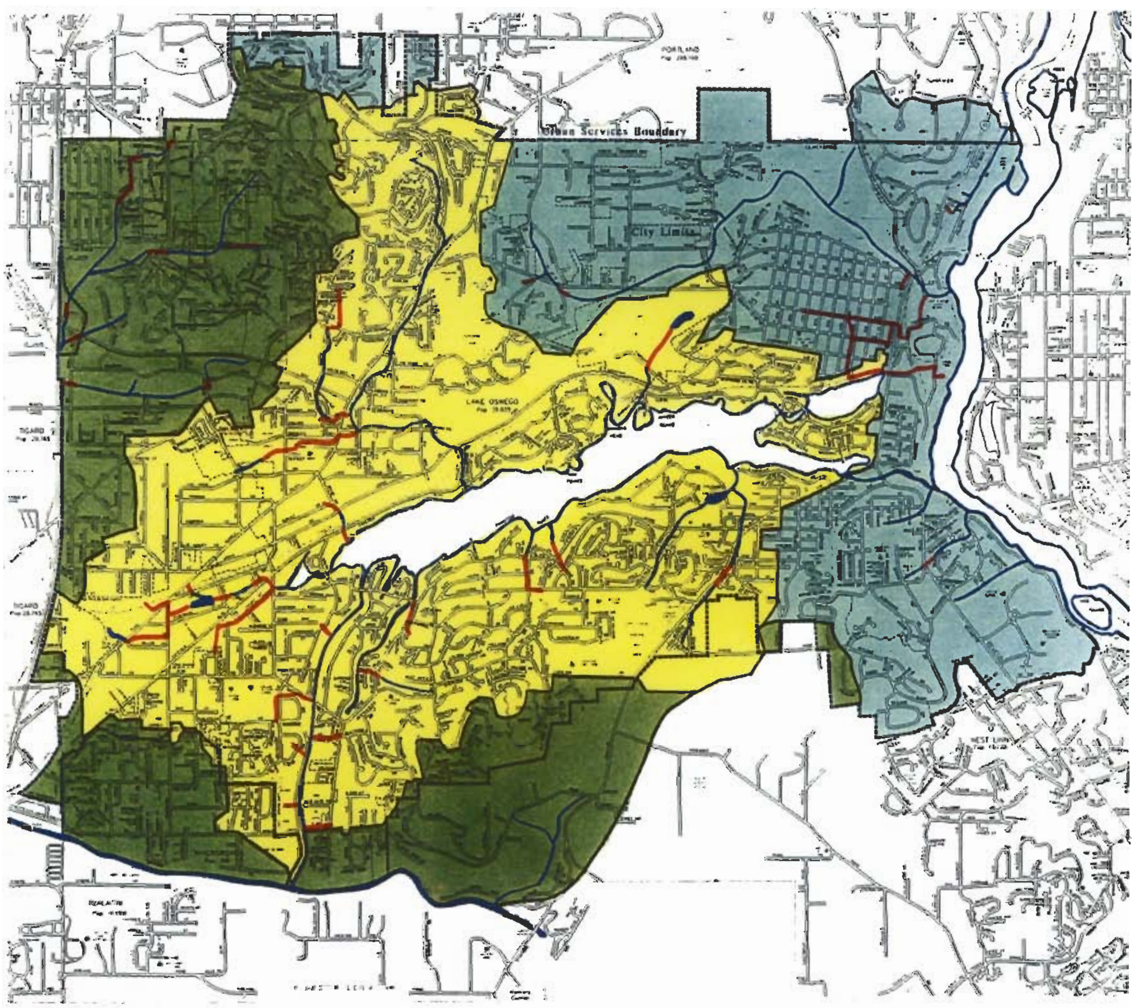
# Lake Oswego
# Surface Water Management

Volume I - Recommended Plan




otak

JULY 1992

# LAKE OSWEGO SURFACE WATER MANAGEMENT MASTER PLAN

**Volume I**

**Recommended Plan**

---

**July 1992**


***City of Lake Oswego***
***Department of Public Works***
*380 A Avenue*
*Lake Oswego, OR 97034*
*(503) 635-0270*

***Clackamas County***
***Department of Utilities***
*902 Abernathy Road*
*Oregon City, OR 97045*
*(503) 650-3323*

***Prepared by:***

***OTAK Incorporated***
*17355 SW Boones Ferry Road*
*Lake Oswego, OR 97035*
*(503) 635-3618*



# LAKE OSWEGO
# SURFACE WATER MANAGEMENT
# MASTER PLAN

Alice Schlenker, Lake Oswego Mayor
Douglas Schmitz, Lake Oswego City Manager

---

**Lake Oswego Department of Public Works**

Jerry Baker P.E., Director/City Engineer
Mark Schoening, P.E., Environmental Engineer
Andy Harris, Engineering Tech
Joe Collins, Engineering Tech

---

**Lake Oswego Department of Maintenance Services**

Duane Cline, Director
Terry Kirkendall, Street Superintendent

---

**Clackamas County Department of Utilities**

Bruce Erickson, P.E. Acting Director
Ela Whelan, P.E., Senior Engineer

---

**Final Report Production**

Roger Sutherland, P.E., Manager
John Houle, P.E., Project Engineer
Seth Jelen, E.I.T., Modeling Specialist
Jan Chandler, Production Assistant
David Dryer, Graphics

Noel Klein, Public Involvement
Shaun Pigott, Financial Plan

---

**Consultant Team**

**OTAK — Prime Consultant**
Roger Sutherland, P.E., Manager
John Houle, P.E., Project Engineer
Seth Jelen, E.I.T., Modeling Specialist
Jan Chandler, Project Assistant
Linda Warner, Project Assistant

**Cascade Earth Sciences**
Stuart Childs, Manager
Peggy Vogue, Wetlands Specialist

**Kramer, Chin and Mayo**
Brad Moore, P.E., Manager
Bob Aldrich, Wetlands Specialist

**Shaun Pigott Associates**
Shaun Pigott, Manager

**Western Advocates**
Noel Klein, Manager
Robin Cusma, Project Assistant

# LAKE OSWEGO
# SURFACE WATER MANAGEMENT
# MASTER PLAN

---

**Policy Committee of Surface Water Management**

Dan Anderson
Bill Holstein
Lake Oswego City Council

Dorothy Atwood
Lynne Black
Lake Oswego Natural Resources Commission

Bruce Erickson
Ela Whelan
Clackamas County Department of Utilities

Don Burdick
Lake Oswego Corporation

Lew Thompson
Lake Oswego Pathway Advisory Committee

Peter Harvey
Lake Oswego Ex-City Manager

Andy Schaedel
Don Yon
Oregon Department of Environmental Quality

---

**Implementation Team**

Mark Schoening
Andy Harris
Joe Collins
City of Lake Oswego Department of Public Works

Duane Cline
City of Lake Oswego Department of Maintenance Services

Max Talbot
Clackamas County Department of Utilities

Fred Van Domelen
Lake Oswego Corporation

Roger Sutherland
OTAK

Noel Klein
Western Advocates

**CITY OF LAKE OSWEGO**
**SURFACE WATER MANAGEMENT MASTER PLAN**

## TABLE OF CONTENTS

# CITY OF LAKE OSWEGO
# SURFACE WATER MANAGEMENT MASTER PLAN

## TABLE OF CONTENTS

## CITY OF LAKE OSWEGO
## SURFACE WATER MANAGEMENT MASTER PLAN

## TABLE OF CONTENTS

# TABLES



** Following Page Indicated*

# TABLES



* *Following Page Indicated*

## FIGURES

# LAKE OSWEGO
# SURFACE WATER MANAGEMENT
# MASTER PLAN
# EXECUTIVE SUMMARY

In March 1991 the City of Lake Oswego contracted with OTAK to prepare a Surface Water Management (SWM) Master Plan for major drainages within the City's Urban Services Boundary (USB). In addition to areas incorporated within the City, the study area includes portions of Rivergrove and unincorporated Clackamas County. Clackamas County participated in the funding for the SWM planning effort. The SWM Master Plan consists of four elements:

- **Public Awareness and Involvement Plan** recommends programs to increase public awareness of water quality and drainage needs and promote volunteer involvement in programs such as streamwalks and stream corridor restoration.

- **Flood Control Management Plan** recommends increased maintenance and cost-effective improvements to undersized major culverts and pipe systems over the next twenty years.

- **Water Quality Management Plan** recommends cost effective levels of street sweeping, storm sewer and catchbasin cleaning, and new development controls, revised phosphorus load allocations for study area basins draining to the Tualatin River or Oswego Lake, and construction of eight major pollution reduction facilities over the next twenty years.

- **Implementation Plan** recommends formation of a Surface Water Utility to implement capital improvements and operations and maintenance functions of the SWM program, including recommendations of these other three plans. Utility rates would be supplemented by a system development charge for new development.

## PUBLIC AWARENESS AND INVOLVEMENT

This plan recommends programs needed to focus the public's attention on problems facing area waters, and how citizens can help. It supports continued efforts to maintain media exposure, cooperate fully with other area governments and agencies, and involve citizens in preventing pollution, maintaining healthy stream corridors, and funding community efforts to mitigate drainage and water quality problems.

### <u>Background</u>

Throughout the SWM master planning effort, public involvement played a key role, beginning with the SWM Policy Committee, a broad-spectrum group which monitored the SWM master planning effort and led the public involvement process. This committee recommended the following **community objectives** to achieve the goals of public safety, minimal property damage, and better water quality and fish and wildlife habitat in a cost effective manner:

- Create opportunities for citizen participation and awareness
- Promote using natural systems, rather than closed pipe, to convey runoff
- Prevent pollution from getting into runoff
- Allocate costs in an equitable manner to all who would benefit from improvements
- Cooperate with other affected communities and agencies

The following accomplishments publicized area drainage and water quality problems and involved citizens in seeking constructive solutions:

- A field trip to Bellevue, Washington exposed how that community's successful SWM program could be adapted to suit Lake Oswego.

- Streamwalks coordinated volunteers who identified areas of erosion, siltation, and debris in area stream corridors.

- Lake Oswego School District students monitored water quality and learned the importance of healthy stream systems.

- Newspaper articles publicized the SWM planning effort and public involvement programs.

- Four stand-alone brochures on various aspects of surface water management provide information and helpful tips to the public.

- A project bulletin, "WaterWays", was prepared and distributed to all residents and businesses in the City's USB. The bulletin provided background information and articles about the SWM planning process.

- Volunteers stenciled catchbasins, warning that they drain to streams. A doorhanger was prepared and used as part of this program.

- A slide show used to describe the SWM program was prepared and presented at several public meetings.

## Recommendations

The SWM Master Plan recommends implementing a Public Awareness and Action Plan supporting programs to raise the public's awareness and encourage their involvement in programs such as streamwalk, catchbasin stenciling, stream corridor cleanup, and public meetings. Actions could include:

- Produce periodic SWM bulletins and brochures to:
  — Promote stewardship role among streamside residents
  — Publicize how residents can prevent or minimize pollution
  — Present need for the SWM master plan and continued community support

- Publish a "stream team" booklet, similar to that of Bellevue, introducing the surface water system and how citizens and the recommended utility can help.

- Continue to coordinate volunteer streamwalks.

- Provide materials and coordinate volunteer efforts to restore and maintain stream corridors.

- Continue to coordinate volunteer catchbasin stenciling efforts.

- Continue public meetings to publicize the need to implement the SWM Master Plan recommendations.

- Cooperate with the Lake Oswego Corporation (LOC) in promoting SWM awareness among shareholders and existing and eligible easement members.

## FLOOD CONTROL MANAGEMENT PLAN

The Flood Control Management Plan (FCMP) recommends increased maintenance and cost-effective improvements to undersized major culverts and pipe systems over the next twenty years. To do this, estimated peak flows throughout the major drainage system are compared with major pipe and culvert capacities. This plan is the drainage element of the Public Facilities Plan required by the Land Conservation and Development Commission for incorporated areas with more than 2,500 people (OAR 660-11-010).

### Background

Urbanization has profound impacts on the land's response to rainfall by reducing infiltration and base flow and increasing runoff volumes and flows; and these higher flows reach stream systems faster. Undersized or blocked culverts only worsen the problem. They can flood road crossings and pose unacceptable risks to lives or property even for a short time.

In 1968, CH2M studied area drainage problems in great detail using topographic maps showing nearly all structures, and considering nearly every pipe and culvert in the public system. They used a simple drainage analysis method and dissected the study area into drainage areas of only a few acres each. However, methods and community values have changed since 1968. Although CH2M identified many undersized culverts at existing crossings and many areas where pipes should be added if development were to occur, their recommendations included:

- Channelize the lower 2 miles of Springbrook Creek
- Channelize the north side of the Hunt Club field and drain the 3-acre wetland to the east
- Channelize the tributary through Waluga Park and drain the large wetlands present
- Drain the wetlands near the railroad tracks and Lower Boones Ferry

In general, wetlands were to be drained, piped systems were encouraged wherever possible, and detention was avoided. However, the maps proved valuable in the current SWM planning process.

### SWM Study Approach

1. The study area was divided into 28 major drainage basins, and these were subdivided into 219 subbasins, for the purpose of modeling. These subbasins ranged in size from 23 to 194 acres and averaged about 80 acres. The major system was defined to include those stream and pipe reaches downstream of one or more subbasins, and the culverts they may flow through. In some cases, major culverts or detention facilities were included since they were near the outlet of a designated subbasin.

2. Design storms which would occur, on average, only once every 10, 25, 50, and 100 years were determined. A year's largest storm would, on average, exceed these design storms only 10%, 4%, 2%, and 1% of the years, respectively. Rainfall data from a gage located in the Fanno Creek basin was used to establish the following design storms:

| Recurrence Interval | 24-Hour Rainfall Depth |
|---|---|
| 10 Years | 3.3 Inches |
| 25 Years | 3.8 Inches |
| 50 Years | 4.3 Inches |
| 100 Years | 4.8 Inches |

3. The hydrologic model HEC-1 was used to translate these storms into runoff events under both existing (1991) and built-out (2012) conditions for each of the 219 delineated subbasins. First, these total depths are distributed over a 24-hour period using the Type I-A design storm established by the Soil Conservation Service (SCS). The rainfall rate is then translated into runoff using a 3 minute simulation timestep and the following information to model infiltration and other losses:

- Soils were grouped into four hydrologic soil classes by the infiltration rate at which water can soak into the ground. Less porous soils generate greater runoff volumes. SCS curves relating rainfall to runoff were used to model the runoff contributed by pervious surfaces. Large areas west of Oswego Canal, including Rivergrove, and northwest of West Bay have porous soils and frequently drain into sumps or drywells, many of which may work well. In any case, however, they would only slightly affect peak flows from the large design storms, and their effect on smaller ones is not clear. They were not considered during either the flood control or water quality planning processes, as little is known about their exact locations or characteristics.

- Land uses were grouped by fraction of impervious surface, as determined from 1990 aerial photos. Impervious surfaces have very little loss during large storms. Five general land use groups were used: Single Family, Multi-Family, Institutional, Commercial and Industrial, and, Undeveloped Land. Streets were included with the land uses.

- Subbasin travel time for water to flow from the furthest point to the outlet was computed using estimates of impervious area, elevation difference, and travel distance. The longer the travel time, the more "spread out" and reduced are the resulting flows.

4. HEC-1 was then used to route the eight sets of subbasin flows through the 29 major drainage systems. Travel time was estimated using slope and field-estimates of channel dimensions and roughness. Flows were delayed by travel through channels or long pipes, but were not found to decrease. Also, culverts and smaller detention or sedimentation ponds were not found to affect the peak flows. While flood water surface elevation might increase, the additional runoff storage volume is a small fraction of the total storm volume. Only the larger wetlands were found to significantly reduce flows.

5. The design event used to evaluate the major pipes and culverts was based on the risk of potential damage. Culverts and stream channels serving larger areas are more expensive to repair or replace, and usually cause damage for longer periods if they overflow. Also, the significance of the crossings ranged from paths to roads to major arterials, with the latter causing the greatest threat if flooded. Finally, long pipe reaches can exceed their gravity flow capacity by forcing more water through under pressure flow. These issues are reflected in the following design criteria:

| Drainage Area: | Design Storm Recurrence Interval (Years) | | | |
|---|---|---|---|---|
| | Open Channel Reach | Long Pipe Reach | Street Culvert | Major Arterial Culvert |
| < 40 Acres | 25 | 10 | 10 | 25 |
| < 640 Acres | 50 | 25 | 50 | 50 |
| > 640 Acres | 50 | Don't Use | 50 | 50 |

Note: Improvements require a 100 year design on waterways with 100-year flood plains designated by the Federal Emergency Management Agency (FEMA).

6. The capacity of each major culvert and pipe reach is compared against the appropriate design flow under both existing and future conditions. Culverts were usually inlet controlled, but a few were so flat that their outlets limited the capacity even more. Long pipe runs were modeled as flowing full with slope balancing friction losses.

7. Identified undersized pipes were arranged into the following groups depending upon their location, relative deficiency and their estimated replacement or improvement cost:

- Some were below paths where flood risk was low, or were private crossings. These were not recommended for improvement. For some (e.g. at detention facilities whose problems could be relieved by removing flash boards) information was provided to the City. None of these were recommended as capital improvements.

- Others were undersized for the design storm but not for the next smaller event. Those pipes and culverts that could pass the next-smaller design event under future built-out conditions were not recommended for improvement within the 20-year Capital Improvement Program (CIP) timeframe.

- The remaining capital improvements would require some capital expenditure to replace or improve the existing structure, although twelve employ solutions that fall short of replacement by either providing a safe spillway for overflows, removing the structure, or enlarging the inlet to allow more water to enter the structure. These low-cost solutions are preferable to replacement whenever feasible.

## Recommended Plan

Forty-four capital improvements are recommended for construction within existing Lake Oswego corporate limits by 2012 at a total project cost of $2.6 million in 1992 dollars. Nine others are recommended for the remaining study area, at an additional $285,000. In scheduling improvements, the following criteria for prioritization are recommended:

- Complete projects within Lake Oswego jurisdiction. Others can be completed later by the City as they are annexed, or by Clackamas County.

- Complete projects which cost less than $10,000 over a shorter term. Many of these less expensive projects can be completed for the cost of one of the larger ones, allowing more areas to see benefits from the SWM plan at an earlier time.

- Prioritize these lower-cost projects by estimated improvement cost.

- Complete projects which cost more than $10,000 by 2012. These larger projects can be spread out over twenty years.

- Prioritize these higher-cost projects by their ratio of improvement cost to relative deficiency. This relative deficiency is the fraction of design flow which can not be conveyed through the existing pipe or culvert, and reflects the flood risk which would be relieved by the project.

The City should continue to regularly maintain and clean its storm water system consisting of an estimated: 150 miles of pipe and open channels, 2880 storm water inlets and catchbasins, and 170 miles of publicly owned streets. In addition, existing drainage sumps and drywells in both the

City and the County should be inventoried, regularly inspected to identify clogging, and periodically cleaned. Finally, any new drywells should include sediment-trapping inlets to reduce drywell clogging.

Increasing regional detention for large (i.e. 10 to 100 year) design storms is not recommended for drainage basins within the study area. Extreme runoff storage volumes are required for any significant reduction in flow, and in order to be effective, these facilities would only begin to fill at very high flows, and could not provide any water quality benefits during more frequent storms.

## WATER QUALITY MANAGEMENT PLAN

This Water Quality Management Plan (WQMP) recommends total phosphorus load allocations for the study area and specific maintenance practices and capital improvements that can significantly reduce sediment and sediment-borne phosphorus and other pollutants from all of the City's major drainage basins. It recommends increased levels of street sweeping, storm sewer and catchbasin cleaning, new development controls, and construction of eight major pollution reduction facilities over the next twenty years. It also recommends continued water quality monitoring to confirm that estimated pollutant reductions are achieved.

This plan is required by DEQ to address specific upland management practices and capital improvements needed to improve water quality and bring the following "water quality limited" (WQL) waters into compliance with DEQ standards for water contact, aquatic life exposure, or aesthetics (OAR 340-41-470):

| Stream or Water Body | Season(s) | Problem(s) |
|---|---|---|
| Springbrook Creek | All | Bacteria |
| Fanno Creek | All | Bacteria |
| Fanno Creek | Summer | Algae (chlorophyll-a) |
| Oswego Lake | Summer | Dissolved Oxygen, pH, Algae |
| Tualatin River | Summer | Dissolved Oxygen, pH, Algae |
| | Fall, Spring | Bacteria |

[From the 1990 Section 305(b) DEQ Clean Water Act status report to EPA]

Lake Oswego Corporation (LOC) has prepared annual Water Quality Management Plans for the lake itself since the Scientific Resources, Inc. (SRI) 1988 study. This plan, for the City and County, addresses pollution sources and specific capital improvements upland. Except for bacteria, for which the new enterococci standard needs new data to assess WQL status, the remaining problems all relate to algae blooms (specifically to levels of chlorophyll-a, the "green" pigment used to quantify algae levels). DEQ has determined that phosphorus is the limiting nutrient and that reducing it is the best way to reduce algae. A maximum total phosphorus concentration of 0.07 mg/l has been set for the lower Tualatin River. Even lower concentrations were required further upstream in order to dilute the large discharges from sewage treatment plants. Total phosphorus must be reduced to 0.025 mg/l in the lake in order to prevent algae growth without chemical treatments.

Actual phosphorus pollutant loads, obtained by multiplying the allowable concentrations times the river or stream flow, have become a serious concern in the study area following a successful 1986 lawsuit by the Northwest Environmental Defense Center over the water quality in the Tualatin River and Oswego Lake. As a result, DEQ has established total maximum daily loads (TMDL's) for total phosphorus (TP) entering these waterways, which must be achieved by June, 1993. Only 1500 pounds of total phosphorus per year would be allowed to enter the lake from ALL sources, including bottom sediment interaction and flow diverted from the Tualatin River. The load allocation (LA) for annual TP entering the lake from its drainage area is now set at 850 pounds. In an apparent oversight by DEQ, no phosphorus LA was established for runoff from the study area draining into the Tualatin River.

The City must also plan to characterize storm water runoff quality as part of the National Pollutant Discharge Elimination System (NPDES) municipal storm water permitting process. Lake Oswego, and Rivergrove have joined the Clackamas County permitting effort. The NPDES effort will include all of the City's drainage basins, including those draining to the Willamette.

## Background

The major water quality issue for Oswego Lake, is the struggle to maintain algae within limits for aesthetics and swimming safety, while continuing to use Tualatin River water to generate electricity, without adding so much copper that conditions become toxic to aquatic life. This concern over lake quality and the need for better influent water quality from both area streams and the Tualatin River largely motivates the concern over the Tualatin basin water quality. SRI reported on the lake algae problem in 1988. Since then, the Lake Oswego Corporation's (LOC) Water Quality Committee has prepared annual Water Quality Management Plans (WQMP's) for the lake in their effort to comply with DEQ water quality standards. These efforts have revealed the following problems from the SWM study area:

- **Excessive Nutrients**, including both nitrogen and phosphorus, elevate algae concentrations beyond acceptable limits. While Tualatin River nutrient sources abound, contributions from the Oswego Lake basin result primarily from urban non-point source runoff. Yard and channel debris, excess fertilizing, detergents, and livestock and pets are all possible sources. Impervious surfaces collect and quickly transport phosphorus-containing storm water runoff to streams and the lake. Without these surfaces, runoff would be slowed, and pollutants removed by topsoil and vegetation.

- **Substantial Algal blooms** would be supported in the lake were it not for the large copper-based herbicide doses applied. Algae reduces water clarity and swimming visibility as it grows, and creates nuisance odors and consumes dissolved oxygen as it decomposes. Ambient Total Phosphorus concentrations must be reduced below 0.025 mg/l to limit algae growth without herbicides. Low-flow dissolved phosphorus levels are higher, indicating that such low phosphorus levels are not feasible.

- **Sediment** from the SWM study area forms large deltas at the mouths of Springbrook, Lost Dog, and Blue Heron Creeks and supports nuisance rooted aquatic plants on 23 acres of lake bed. Suspended sediment should be reduced to 15 mg/l to minimize these problems.

- **Copper** concentrations required to suppress algae and aquatic plants frequently exceed DEQ standards and may be toxic to some species of zooplankton and fish. Alternatives using sodium aluminate are being considered.

- **Fecal coliform bacteria** indicate the potential presence of disease-causing organisms. Levels occasionally exceeded DEQ contact recreation standards. LOC monitoring observed possible study area sources to be the small spring in Bryant Woods Park draining the unsewered areas west of Oswego Canal, the proximity of livestock and manure piles to Springbrook Creek, and excessive water fowl populations, and from the sanitary sewer trunk running beneath the lake surface. However, the standard was changed in 1991 to Enterococci bacteria which is a better indicator of human waste.

Other major pollutants associated with urban runoff include metals such as lead, zinc, and iron; toxic household and industrial chemicals; and oil and grease. None were observed to be serious problems in the lake, but all are potential threats from an urbanized area.

## Approach

OTAK modeled a typical year's storm water total phosphorus contributions for built-out conditions (2012) under three levels of enhanced maintenance practices and compared them with contributions without any maintenance practices under both existing (1991) and built-out conditions. Results from a cost-effective level of maintenance were used to recommend load allocations. OTAK also modeled sediment and phosphorus removal from eight regional pollutant reduction facilities (PRF's). As baseflows contain little particulate phosphorus, no reduction in its load was assumed from any management practice.

1. The first step in any water quality effort is to locate nearby rain gages. Long term hourly precipitation records were required for the computer analysis that was used. These records were available for downtown Portland and the Rex-1-S gage near Newberg. The records from the Rex-1-S gage were selected for use.

2. OTAK used the program RAINEV to isolate significant rainfall events from the continuous 39 year record. These significant events are those large enough to produce runoff during subsequent washoff simulations. Then, instead of modeling washoffs from many years of storms and then averaging the results, OTAK "averaged" the rainfall record first, by assembling monthly records from different years which best represented the monthly averages into an "average" year with 109 significant rainfall events. The following statistics were used:

    - Average event depth
    - Average event duration
    - Average number of events
    - Maximum hourly precipitation
    - Average dry time between events for pollutants to accumulate

3. In order to model pollutant washoffs, the flood control land uses groups were refined into ten categories. These land use categories reflect parameters in addition to impervious area which affect pollutant washoff:

    - **Drainage system:** Grassy swales slow runoff and remove suspended pollution. Significant reduction in storm runoffs and washoffs are possible relative to the traditional curb-and-gutter used to collect runoff.

    - **Street density:** Pollutants generally accumulate along the roadside. Areas with more street per acre allow more pollution to accumulate and wash off. Areas with less street per acre have reduced pollutant loads.

- **Storm inlet density:** More inlets per acre mean less flow into each, less overall sediment-borne pollutant transport, and, if the inlets trap sediment, greater capture efficiency and larger overall available storage volume.

- **Type of land use:** Commercial and industrial areas have higher traffic densities. More sediment is produced, and that sediment usually is much more heavily polluted.

4. OTAK modeled per-acre, or "unit", storm water runoff and solids and phosphorus washoff from each land use category using SIMPTM, a physically-based model that incorporates the processes of accumulation, runoff production, and sediment and pollutant washoff. The following upland control strategies were considered:

   - **Regular street sweeping** to remove phosphorus-laden sediment before it washes off the street surface. Although ten pounds of sediment must be picked up by the sweeper to reduce the seasonal load by one pound, removing litter and debris has popular appeal. But moreover, removing this liter removes phosphorus before it can mobilize and adhere to street dirt.

   - **Sediment trapping catchbasins** to remove coarse sediment and the phosphorus it carries are modeled by SIMPTM. A maximum possible phosphorus reduction of 25% appeared evident.

   - **Grassy Swales** to reduce runoff volume and phosphorus accumulation are modeled by reducing the effective impervious area and phosphorus accumulation rates. Swales work best upstream of pipes, before flow becomes concentrated.

5. Three basin-wide alternative levels of upland water quality control strategies were evaluated along with existing and future conditions. Unit loadings from the previous step (i.e. see 4 above) were combined in proportion to their contributing area to obtain subbasin and basin total loads. Alternative III appeared to be the best of the following five alternatives:

   I. Existing development conditions with existing maintenance practices
   II. Future (2012) development conditions without any maintenance practices
   III. Future development with enhanced maintenance practices
   IV. Future development with twice-as frequent street sweeping
   V. Future development with twice again as frequent street sweeping, and all storm water inlets retrofit with sediment traps

6. Storm water runoffs and solids and phosphorus loads under Alternative III were exported to a separated study of Oswego Lake which was conducted by KCM (1991). The lake study concluded that:

   - The DEQ proposed Oswego Lake total maximum daily loads (Baumgartner, B., 14 March 1991 Memorandum) do not appear attainable.

   - Reduced Tualatin River inflows reduces the loading rate, however, the flushing rate is also reduced.

   - Oswego Lake will remain susceptible to algal blooms without further nutrient reduction. Chemical treatment would thus continue to be needed.

- Lake bottom sediment could provide continuing phosphorus loads internally, irrespective of reduced external contributions.

7. OTAK estimated the phosphorus load reductions likely from regional pollutant reduction facilities (PRF's) located along major stream corridors. As regional sites receive larger flows with finer, harder to remove sediment, wet ponds and wet-dry extended detention are most feasible. However, to match wet-dry performance, wet ponds require extra volume to discourage mixing of inflows and outflows. Wet-dry facilities periodically air the sediment, which helps prevent captured phosphorus from washing out during later storms. Forty potential regional PRF sites were identified which were:

   - Buildable but undeveloped.
   - Located along the major drainage system, downstream of at least one delineated subbasin.

   Of these, only eight feasible (PRF) sites were both:

   - Free of existing significant wetlands, and
   - More than 120 square feet of area per contributing acre, or about 300 cubic feet of volume per acre (established by the project team to allow measurable phosphorus reductions).

8. OTAK modeled PRF performances independently of each other by comparing available storage volume to runoff from each of the 109 "average" year storms, and calculating the total fraction of runoff captured. During an average settling time of 48 hours, 95% of the solids and 50% of the total phosphorus might settle from the captured runoff (Schueler, 1987). Thus the runoff capture was reduced by these ratios for the total solids and total phosphorus removals.

9. These sites were ranked by their estimated construction cost per pound of phosphorus removed. The highest ranked was the large public parcel just east of the Hunt Club on Springbrook creek, which could divert the first several acre-feet of storm water flows exceeding base flow around the north of the Hunt Club. Treated water would slowly be released into the tributary and rejoin the creek downstream of Iron Mountain Blvd.

10. Finally, phosphorus loads estimated from this study were contrasted with the DEQ-required levels. This WQMP concurs with the 1991 KCM Lake Study in concluding that neither the 850 pounds-per-year phosphorus load allocation nor the 0.025 mg/l critical phosphorus concentration in the Lake, nor the no-phosphorus load to the Tualatin, are achievable. It appears that other available, practical methods to limit algae growth must be employed.

## Recommended Plan

- Immediately meet with DEQ to negotiate critical changes in the Oswego Lake TMDL and the Tualatin River Load Allocation for total phosphorus, and to reduce the regulated period for the lake to that of the rest of the Tualatin River basin.

Propose the following achievable total phosphorus load allocations:

| Basin | Jurisdiction | Regulated Period | Load Allocation (lbs TP) Total | Storm | Baseflow |
|---|---|---|---|---|---|
| Oswego | City of Lake Oswego | Annual | 1370 | 990 | 380 |
| Lake | City of Lake Oswego | May 1 - Oct 31 | 400 | 315 | 85 |
| Tualatin | Clackamas County | May 1 - Oct 31 | 120 | 95 | 25 |
| River | City of Lake Oswego | May 1 - Oct 31 | 75 | 60 | 15 |
| | City of Rivergrove | May 1 - Oct 31 | 45 | 35 | 10 |

Propose that the DEQ regulated period for Oswego Lake drainages matched that of the rest of the Tualatin Basin: the dry season of May 1 - October 31.

- Implement the following upland water quality control plan (Alternative III):

  — Sweep curbed residential streets 6 times per year
  — Sweep curbed major streets 12 times per year
  — Clean public and private sediment trapping catchbasins 2 times per year
  — Drain half of new development with grassy swales or on-site retention and infiltration
  — Drain all major arterials using curbs and gutters

- Prioritize regional PRF's based upon project cost per pound of phosphorus removed

- Obtain the five most feasible sites early, while they are still undeveloped. If facilities are not constructed, either maintain sites as open space or resell the property.

- Construct the most favorable PRF, along Springbrook Creek east of the Hunt Club, and monitor its performance to refine the design and construction process.

- Continually monitor water quality and best management practice (BMP) effectiveness using three sites in Springbrook Creek, above and below the highest-priority regional PRF, and further upstream at an outfall from a 90-acre residential area with curbed streets. Coordinate monitoring with the National Pollutant Discharge Elimination System (NPDES) permit application.

- Continue NPDES Permit application with Clackamas County to comply with the NPDES, Part 2, surface water regulations.

- Rehabilitate stream corridors, incorporating riparian corridor enhancement, stream stability, stream bank erosion control, soil bioengineering, and naturescaping.

- Plan for and protect sensitive lands along the riparian corridors.

- Continue to reduce soil erosion problems by inspecting construction site erosion controls, enforcing requirements and responding to complaints.

- Continue to develop and implement industrial pretreatment ordinances and spill response programs for sanitary and storm sewer systems.

- Continue to evaluate WQMP recommendations based upon continued monitoring.

- Implement projects in a timely manner to demonstrate good-faith efforts to comply with DEQ requirements.

## RECOMMENDED IMPLEMENTATION PLAN

This plan recommends the formation of a Surface Water Management (SWM) Utility to implement the SWM Master Plan and improve, operate and maintain the surface water system within Lake Oswego. Monthly utility rates, supplemented by a system development charge for new development, would entirely fund operations and cover revenue bonds which would fund capital improvements.

Since 1988, storm water management in Lake Oswego has been funded through a flat fee of $3.50 attached to each bi-monthly sanitary sewer bill. It was designed to offset costs of some maintenance and the SWM master planning effort, but is insufficient to implement the SWM Master Plan. Although limited City general funds can be increased through higher property taxes, they fail to satisfy the DEQ requirement of a dedicated funding source.

### Recommended Utility Programs

The SWM utility should incorporate the following new or existing programs:

- **Finance and Billing:** Prepare utility billings, track accounts receivable and accounts payable, monitor expenses, and perform other finance related and general administration tasks.

- **Operations and Maintenance:** Regularly maintain and clean the existing storm water system consisting of an estimated 150 miles of pipe and open channels, 2880 storm water inlets and catchbasins, and 170 miles of publicly owned streets.

- **Water Quality Management:** Implement and manage programs that directly benefit surface water quality. Identified programs include:

  - Stream Rehabilitation Engineering Design: Riparian corridor enhancement, stream stability, stream bank erosion control, soil bioengineering, and naturescaping. (Construction is funded as a capital expense.)

  - Sensitive Land Advance Planning: Plan for and protect sensitive lands along the riparian corridors.

  - Monitoring: Monitor area wide water quality and best management practices (BMP's).

  - NPDES Permit: Complete application with Clackamas County for the National Pollutant Discharge Elimination System (NPDES), Part 2, municipal storm water permit.

  - Erosion Control: Inspect construction site erosion controls, enforce regulations and respond to complaints.

- **Plan Review and Construction Inspection:** Review development plans for storm water (quantity and quality) management systems, wetlands, floodplain, stream corridors, and erosion control plans. The plan review commences at pre-application and continues through approval of construction plans. Conduct limited construction inspection (re-vegetation and wetlands). The following tasks are anticipated:

  — Development Plan Review
  — Building Plan Review and Inspection
  — Construction Inspection

- **Regulation:** Develop a Drainage Manual, revise the Erosion Control and Water Quality Manuals, as necessary, and revise the development standards. This task includes staff time to prepare the NPDES permit application including on-going work necessary for compliance. It also includes time needed to administer the National Flood Insurance Program within the City.

- **Small Works:** Solve minor storm water system problems through small construction projects. Provide complaint response to drainage related problems.

- **Public Awareness and Involvement:** Develop programs to raise the public's awareness and educate them through such methods as bulletins, brochures, etc. Encourage involvement in programs such as streamwalk, catchbasin stenciling, stream corridor cleanup, and public meetings.

## Recommended Utility Budget

The project team recommends two budget categories: operating and capital needs. Capital needs fund improvements needed to convey floodwater, the recommended regional PRF's, and some sensitive land acquisition within the stream corridors. Operating needs fund the on-going utility programs. The SWM project team recommends the following budget (1992 dollars):

### OPERATING NEEDS

| Program Element | FTE * | Labor Cost | Direct Expense | Total Cost |
|---|---|---|---|---|
| Finance and Billing | 0.5 | $ 25,250 | $ 20,000 | $ 45,250 |
| Operation and Maintenance | 3.0 | 147,700 | 114,800 | 262,500 |
| Water Quality Management | 0.6 | 34,500 | 50,000 | 84,500 |
| Plan Review and Inspection | 0.3 | -0- | - | -0- |
| Regulation | 0.4 | 23,000 | - | 23,000 |
| Small Works | 0.5 | 28,750 | - | 28,750 |
| Public Involvement | 0.2 | 11,500 | 5,500 | 17,000 |
| TOTALS | 5.5 | $ 270,700 | $ 190,300 | $ 461,000 |

* Full Time Equivalent

Note: Development fees fund Plan Review and Construction Inspection.

It should be noted that the recommended utility budget for both operating needs presented above and the capital needs presented next are based on 1992 dollars. Total program costs will increase due to inflation over the 20-year CIP and the utility rate initially established will have to increase over time also.

## CAPITAL NEEDS

| Program Element | Annual Cost | Total Cost |
|---|---|---|
| I. Water Quantity | | |
| Major Drainages | $ 128,700 | $ 2,574,000 [1] |
| Small Works | 75,000 | 1,500,000 |
| II. Water Quality | | |
| PRF's | 62,500 | 1,250,000 [1] |
| Stream Rehabilitation Construction | 25,000 | 500,000 |
| III. Sensitive Lands Protection | 10,000 | 200,000 |
| TOTAL | $ 301,200 | $ 6,024,000 |

1 These CIP program element costs include 15% for construction contingencies, 12% for engineering design, and 8% for construction inspection.

### Recommended Funding Sources

The SWM Policy Committee considered a number of funding approaches in light of the cap on property tax revenues of Measure 5. Although the caps may allow funding for the recommended capital improvements to exceed the limits, the SWM Policy Committee recommended that any financial structure implemented be entirely outside the bounds of Measure 5. Accordingly, all options discussed during formation of this financial analysis were reviewed to determine whether or not they met the "Measure 5 test" of being "avoidable, controllable and not a direct result of property ownership." The SWM Policy Committee considered a number of funding options, including a "pay-as-you-go" approach of funding capital improvement projects entirely from utility charges as they are built. This would require a higher initial monthly rate, (i.e. $5.00 versus $3.75 for 100% CIP bonding) and CIP monies would have to be accrued before the CIP could be constructed. A system development charge for new development was recommended, but these fees will only fund a small portion of the recommended CIP. The Policy Committee recommended that a SWM utility funded by a dedicated service charge be formed subject to the following additional recommendations:

- Allow adequate time to inform the public about the SWM program, regulatory mandates, costs, and rate approach before implementing the surface water charge.
- Fully fund SWM utility operating expenses. Fund capital improvements which are immediately required through revenue bonds. Fund longer-term capital improvements as they are incurred ("pay as you go").
- Recognize the total impact of increasing water and sewer utility rate when setting the surface water service utility rate.

- Establish a Utilities Advisory Committee of Lake Oswego residents affected by utility fees to advise the City Council on water, sewer, and SWM utility rates. Involve this committee in establishing the SWM credit system.

- Base the SWM utility rate on the amount runoff contributed by impervious area.

- Charge single-family homes as a single a uniform rate based upon their average impervious area, or "Equivalent Service Unit" (ESU), measured to be 3,030 square feet.

- Charge other customers by their impervious surface area contributing, measured in number of ESU's.

- Exempt undeveloped properties from the charge.

- Include all publicly owned property except public streets.

- Allow no exemptions based on property use (other than undeveloped) or tax exempt status.

- Offer credits for existing on-site surface water mitigation facilities constructed and maintained to the City's standards. Credits should only reflect costs which are affected by a customer's on-site management of storm water runoff.

- Provide for those properties within Lake Oswego that fully retain and dispose of all surface water on-site and are not served by the Utility with a "nonservice abatement."

- Consider a "funding mix" with a number of secondary funding sources.

- Assess system improvement costs and adopt a system development charge for new or re-development, based on the SWM Master Plan findings.

The SWM Policy Committee recommended that a monthly SWM Utility rate of $3.75 per ESU area of 3,030 impervious square feet for the first three years. They further recommended that future rate increases be similarly "levelized" and held constant over several years.

# Introduction

# CHAPTER 1

# INTRODUCTION

## 1.1 AUTHORIZATION

In March 1991, the City of Lake Oswego contracted with OTAK, Incorporated to develop a Surface Water Management (SWM) Master Plan for the Tualatin River and Oswego Lake drainages within the City's Urban Services Boundary (USB). In September 1991, the contract was amended to include the Willamette River drainages within the City's USB and the City of Rivergrove. At the same time, the City of Lake Oswego entered into an Intergovernmental Cooperative Agreement with Clackamas County that identified the County's staff and financial participation in the development of the SWM Master Plan. The total study area is approximately 7,690 acres or 12.0 square miles surrounding the 400 acre water surfaces of Oswego Lake, Lakewood Bay and West Bay. The SWM Master Plan identifies how to manage storm and surface water runoff throughout the study area in ways that could:

- Reduce the risk of flooding.
- Protect and enhance natural areas and stream corridors.
- Improve water quality in streams and creeks, for the community's recreational and aesthetic enjoyment and diverse ecosystem.
- Allocate surface water management costs equitable among property owners.

## 1.2 COMMUNITY OBJECTIVES

The Policy Committee on Surface Water Management, made up of City Council members, Natural Resources Commission members, City staff, citizens and representatives from other government agencies, monitored and directed the preparation of the SWM Master Plan. The Committee adopted the following Governing Principle, Goal, and Community Objectives for the Management of Surface Water.

### Governing Principle

The governing principle behind all City policies relating to surface water management is to fully utilize the natural surface water drainage system to convey and dispose of runoff, while protecting and maintaining the natural functions and values of that system.

### Program Goal

The goal is to cost-effectively implement and maintain a surface water drainage system to:

- promote public safety and minimize property damage.
- protect and enhance the quality of water.
- preserve and enhance fish and wildlife habitats.

### Community Objectives

To achieve this goal, the Policy Committee advised the city to develop a surface water management program that incorporates the following community objectives:

- Involve and educate the public in opportunities to improve water quality, enhance the natural drainage system and minimize nonpoint source pollution.
- Emphasize the use of natural systems and non-structural methods which focus on controlling runoff and pollution at the source.
- Integrate both the water quality and drainage control needs for all the rivers, lakes, stream corridors and wetlands in Lake Oswego's watershed areas.
- Protect the physical and biological integrity of rivers, lakes, stream corridors and wetlands in the City's watershed areas.
- Ensure that expenditures are commensurate with their benefits.
- Implement funding mechanisms that allocate costs in an equitable manner to all those that benefit from a managed surface water drainage system.
- Coordinate program activities in a cooperative way with other affected communities and agencies.

## 1.3 PROBLEM STATEMENT

In an urban area, rain falls on impervious areas such as buildings, parking lots, playgrounds, streets, sidewalks and other areas where water cannot seep into the ground. This excess surface water runoff is collected by a combination of storm drains, catchbasins, pipes, culverts, detention ponds and open drainage ditches until it is delivered to a natural stream or waterway.

At times of intense rainfall, the flow capacity of these drainage facilities and natural waterways can be exceeded and flooding can occur. During the master planning process it is imperative to identify the specific location and frequency of flooding throughout the major drainage systems. Then the flooding and its associated problems must be weighed against the cost of reducing the frequency of flooding through a specific capital improvement project.

Surface water runoff also collects sediments and their associated pollutants while enroute to a natural stream or waterway. Pollutants of particular concern include phosphorus, nitrogen, oxygen demanding organic material, disease causing bacteria, oil and grease, heavy metals, and other toxics.

Human behavior also dramatically affects surface water quality. For example, the way people wash their cars, fertilize their lawns, dispose of liquid wastes and apply pesticides and herbicides can significantly affect the water quality of streams, creeks, lakes or other waterways. In addition to increasing public education and awareness, the master planning process must identify methods to reduce pollutant washoff through enhanced maintenance practices, erosion control and changes in development techniques or standards. Also, the plan should identify specific locations where passive storm water treatment facilities can be created or enhanced to develop pollutant reduction facilities (PRF's). Finally, all of these activities must be consolidated into a capital improvements program for funding and implementation.

All of these surface water management activities and improvements described above must be planned and coordinated in a manner that protects the physical and biological integrity of rivers, lakes, stream corridors and wetlands throughout the study area. Thus, a major emphasis of the plan is to use natural systems and, whenever possible, non-structural methods to control runoff volume and pollution at the source.

## 1.4 REGULATORY REQUIREMENTS

### Water Quality

Section 303 of the Federal Clean Water Act (1972) requires that states which have been delegated administrative authority under the act establish total maximum daily loads (TMDLs) for "water quality limited" stream segments. Oregon Department of Environmental Quality (DEQ) has been delegated such authority by U.S. Environmental Protection Agency (EPA) and has designated the Tualatin River as a water quality limited stream. However, as of 1986 the state had not established TMDLs for the Tualatin or any other water quality limited stream or segment.

A TMDL is the maximum amount of a pollutant the state has determined that a water body can receive without violating water quality standards. A "water quality limited" stream or segment is one which will not meet water quality standards even after conventional secondary treatment at the municipal wastewater treatment plants and technology based effluent limits for industrial sources have been applied.

In December 1986 the Northwest Environmental Defense Center (NEDC) sued the EPA for not requiring DEQ to establish TMDLs for the Tualatin River. The NEDC subsequently filed notice to sue in the same manner regarding 27 other water bodies. Although not a party in the suit, DEQ participated with EPA and NEDC in the development of a process and schedule for establishing TMDLs on the listed streams or segments.

In June 1987 a Federal District Court consent decree was issued which required adoption of TMDLs, waste load allocations (WLA), and load allocations (LA) for the Tualatin River, nine other rivers, and one lake. The TMDL portion allocated to a point pollution source is a WLA and the LA is the portion allocated to background and nonpoint pollution sources.

On December 9, 1988, pursuant to the September 9, 1988 Environmental Quality Commission (EQC) rule, DEQ provided a list of the jurisdictions which must submit a Tualatin TMDL program plan along with the interim LAs and WLAs for phosphorus. The cities of Lake Oswego, Rivergrove and Clackamas County were on the list.

DEQ has determined that ammonia nitrogen, which is discharged primarily from wastewater treatment plans, and phosphorus, which is discharged from both treatment plants and nonpoint sources, were the pollutants which required TMDLs. The phosphorus TMDL was set due to impairment of aesthetic and recreational uses caused by excessive levels of nuisance algal growth. Phosphorus is one of the key factors which contribute to algal growth.

In March 1990, these jurisdictions submitted their program plans entitled the Lower Tualatin River-Oswego Lake Subbasins Nonpoint Source (NPS) Watershed Management Plan (KCM, 1990). DEQ's review of this document resulted in a conditional approval by the EQC in June 1990. One condition of this approval requires that the cities of Lake Oswego, Rivergrove, and Clackamas County must submit subbasin plans for controlling the quality of urban runoff to the Tualatin River and Oswego Lake subbasins from their respective jurisdictions (OAR 340-41-490). The plan must include a Capital Improvement Program (CIP) that describes on a site specific basis the various capital improvement projects envisioned, the reasons for their selection, the project costs, funding mechanism(s), the responsible party(s), and the means and timing of implementation. This SWM Master Plan should satisfy all of these DEQ requirements.

**Water Quantity**

Chapter 660, Division 11 of the Oregon Administrative Rules (OAR) enforced by the Land Conservation and Development Commission (LCDC) require a public facilities plan for areas located within an urban growth boundary containing greater than 2,500 persons. This would help assure that urban development in such urban growth boundaries is guided and supported by types and levels of facilities and services appropriate for the needs of the areas to be serviced. The SWM Master Plan presented herein should satisfy the drainage related public facility plan requirements under Oregon Administrative Rules (OAR) 660-11-010.

## 1.5 OSWEGO LAKE STUDY

The DEQ has adopted a nutrient standard for Oswego Lake which gives the pounds of phosphorous the lake can hold and still be free of algae. This standard was determined by a water quality study prepared by Scientific Resources, Inc. in 1987. The study found that the total phosphorus input to the lake was 13,846 kilograms (30,525 pounds) for the year. Approximately 25,800 pounds of this came from the Oswego Canal, 4500 pounds from Oswego Lake drainage basins, and the rest from precipitation. DEQ (working with SRI's data) calculated the annual phosphorus load allocation for the lake to be 650 pounds from lake sediments and water fowl and 850 pounds from Oswego Lake drainage basins. The assumption was also made that no water would be taken from the Tualatin River, except that needed in the summer for irrigation and to maintain the water level of the lake.

At present there are significant unknowns concerning the nutrient dynamics of Oswego Lake. The existing phosphorus load allocation (LA) for the tributary lake drainages is extremely restrictive: it will result in very expensive and perhaps unrealistic control measures, yet is not based on the most current information.

The phosphorus allocation for the lake must be based on a model that is better suited to the exact conditions in Oswego Lake. This information is needed so that DEQ can adopt the final phosphorus (LA) for the lake and the (TMDL's) for the tributary lake drainages. This, in turn, will determine the levels of control measures needed by the City.

Early in the master planning process, it was clear that an updated Oswego Lake study was needed. A primary objective of this study was to develop a revised lake model to clarify the lake algae response to phosphorus loads under various lake management strategies.

In September 1991, OTAK's contract was amended to include a water quality study of Oswego Lake. At the same time, the City of Lake Oswego entered into a Cooperative Agreement with DEQ, Clackamas County, the Unified Sewage Agency (USA) of Washington County and the Lake Oswego Corporation (LOC). The Cooperative Agreement identified the staff and financial commitments of each entity in the development of the Oswego Lake water quality study.

OTAK subcontracted the technical study work to Kramer, Chin and Mayo (KCM) Incorporated which studied the following issues and questions:

- How lake water quality can be maintained or improved to insure the recreational and aesthetic benefits of the lake.

- Whether the existing phosphorus Total Maximum Daily Load for the lake should be revised.

- What months throughout the year sediments and phosphorus should be regulated from either the Oswego Lake or Tualatin River drainages.
- How water rights can optimize water quality and power generation goals.
- How the sediments in the Tualatin River inflow affect phosphorus bioavailability.
- How much dilution benefit is gained by the Tualatin River inflow.
- How internal cycling of phosphorus affects water quality.
- How storm water inflows of sediment and phosphorus from tributary drainages to the lake affects water quality.

The results of the Oswego Lake Study were published in a separate report dated April, 1992.

Public Awareness
and Involvement

## CHAPTER 2

# PUBLIC AWARENESS AND INVOLVEMENT

The City of Lake Oswego, Clackamas County and the Project Team were committed to keeping the general public and other governmental agencies informed about the progress of the SWM Master Plan. They were also anxious to solicit public opinion about surface management issues, in as many different forums as possible. Public awareness to alert citizens about practices that have negative and positive impacts on the quality of surface water was another important concern. To this end, an extensive public awareness and involvement effort was organized and implemented during the master planning process.

Now that the master planning phase is completed, the City and County are committed to keeping the general public and other governmental agencies adequately informed about its progress in implementing the recommendations of the SWM Master Plan.

This chapter will briefly document some of the public awareness and involvement programs developed and implemented during the master planning process. It will also outline a Public Awareness and/Involvement Plan that is recommended for the SWM plan implementation phase.

## 2.1 POLICY COMMITTEE

A key aspect of the development of the Master Plan was the active participation of the Policy Committee on Surface Water Management. The goal of the Committee was to monitor the progress of the SWM Master Plan development and lead the public involvement process. Members of the Policy Committee were encouraged to participate in public meetings, media events and other public forums and activities. The specific objectives of the policy committee were as follows:

1. Develop a Statement of Community Objectives that will shape public policy on the way in which surface water management will be handled in Lake Oswego.

2. Use these Community Objectives to monitor progress of the Master Plan project team and to provide guidance and direction on public policy issues associated with the plan (e.g. CIP prioritization, financing, etc.)

3. Adopt a Public Awareness Action Plan for the master planning process and lead these public awareness/involvement efforts.

4. Help shape the outcome of the master planning process so that the final product will be supported by the community.

## 2.2 IMPLEMENTATION TEAM

Directly supporting is the Policy Committee was an Implementation Team. The Team's goal was to implement the tasks identified in the Public Awareness Action Plan developed for the master planning process. The specific objectives of the Implementation Team were to:

1. Develop visual images and public awareness materials that will help the general public to better understand the issues associated with surface water management.

2. Provide staff support for the Policy Committee.

3. Manage the implementation of the tasks identified in the adopted Public Awareness Action Plan.

4. Meet with the Policy committee on a regular basis and keep them informed of the implementation of the Action Plan and the development of the SWM Master Plan.

The Implementation Team met every two weeks for eight months with the Policy Committee to help the committee and the team achieve their stated goals and objectives. In addition, there were subcommittees on billings and publications that met many times to deal with these specific issues.

## 2.3 PUBLIC AWARENESS AND INVOLVEMENT DURING PLAN DEVELOPMENT

Once appointments to the Policy Committee and Implementation Team were made, members and other interested city officials took a field trip to Bellevue, Washington. The purpose of this April 1991 trip was to learn first hand about that City's successful implementation of a comprehensive surface water management program.

### Public Awareness Program

A project bulletin "WaterWays", was prepared and distributed to all residents and businesses in the Lake Oswego Urban Service Boundary area (approximately 17,000). The bulletin contained background information, volunteer updates, basin features and special articles of interest. Interested parties were asked to return a coupon with name and address and, from this information, a future mailing list will be established.

Articles were prepared and included in newsletters of other organizations including the City of Lake Oswego and the Lake Oswego Corporation. Several media releases were prepared and follow-up stories published in both the Lake Oswego Review and the South Metro section of The Oregonian.

Four stand-alone brochures on various aspects of surface water management — Erosion Control; Tips for Landscaping; Tips for People along Streams and Tips for Auto care, Sidewalks and Driveways — were prepared. A doorhanger was also prepared for use in conjunction with the catchbasin stencilling program.

A presentation about the program and its public awareness/involvement aspects was made at the annual American Water Works Association Conference.

Key contact groups were identified and a mailing list was created. Every neighborhood association and community organization was contacted by letter with an offer for City and project staff to conduct a briefing on the surface water management planning effort. Members of the Policy Committee and Implementation Team were involved in making presentation to neighborhood associations, community service clubs, elementary and secondary school classes and the Lake Oswego Corporation.

A slide presentation, including about 50 slides with a script, was prepared. the slide show has been used to describe the surface water management program at public meetings and presentations.

A City Council workshop on the surface water management program was held on February 4, 1992. The workshop summarized the master planning process and presented preliminary results. A Town Hall meeting was held on March 26, 1992. City staff described the planning process and presented the overall program results to the general public. City Council will hold a first and second reading of the proposed ordinance implementing the program in May and June.

A mailing was sent to all ratepayers with over 30 ESU's (Equivalent Service Units), explaining the potential impacts of the new fee structure and inviting them to meet with city staff to discuss their billings. Inserts will be mailed with the City's water & sewer bills in May and July, explaining the surface water management program and the new rate structure.

### Public Involvement Program

An active "Streamwalk" program was conducted through the plan development phase. This involved neighborhood associations, service clubs , schools and interested individuals from Lake Oswego and elsewhere. Streamwalk is a program where interested citizens collect data on the physical characteristics and relative health of the riparian or stream corridors throughout the study area. Streamwalk training was provided on several occasions throughout the duration of the planning project. The information gathered through the streamwalk program was used by the project team to help identify stream corridor problems and potential solutions.

Two presentations were made to the City's Committee for Citizen Involvement, (CCI). This is the umbrella organization for neighborhood associations in the city and CCI members disseminate information to the various associations.

Mike Goodrich, Science Department Chair at Lake Oswego High School, was an active participant, using the opportunity to have his students "adopt a stream" and teach science in the field. In a cooperative effort, the City, the School District and DEQ have provided students with adequate testing facilities. The Laker Club, a parent support group at the school, allocated $1,600 to buy research materials associated with the project. City and project staff have made classroom presentations to students. In all, about 300 students have been involved in different aspects of the program including classroom presentations, streamwalks; testing and research, wetlands preservation, stream cleaning and stream/riparian area restoration.

A catchbasin stencilling program was implemented using volunteers from various youth group organizations in the community including Boy Scouts and Girl Scouts and a number of elementary schools including Uplands, Lake Grove and Palisades. In addition to stencilling, participants also distributed doorhangers to residents in the area alerting them to the impacts of careless surface water management. This program helps make young people and residents aware of the water quality impacts associated with dumping hazardous waste and materials into storm drain inlets.

## 2.4 RECOMMENDED PUBLIC AWARENESS AND INVOLVEMENT PLAN

Surface water management practices are under review in the Lake Oswego study area, not just by regulatory agencies, but also by the City, County, and citizens interested in preserving and maintaining the quality of the area's natural environment. Public awareness about the benefits of improved storm water runoff management and public involvement in developing and implementing the concepts and recommendations contained in the Master Plan are essential components of a successful, ongoing surface water management program.

The Public Awareness Action Plan, presented herein, recognizes that annual budgetary limitations will shape the surface water management program's public awareness and involvement efforts. It outlines a "menu" approach to providing public awareness and fostering public involvement, in five primary areas.

## Plan Goals

The Action Plan has, as its primary goal, the identification of a range of activities that can help build a broad base of community involvement and support for enhanced levels of surface water management. Heightened community awareness and understanding of the need for, and benefits of, better surface water management measures, will ensure implementation of the Plan.

Key steps in accomplishing this goal are:

1. Translating the technical intricacies and jargon surrounding the subject into visual images and terms the general public can relate to. People don't get excited about pipe in the ground - they can get excited about restoring neighborhood creeks and streams, preserving riparian areas, enhancing fish and wildlife habitats, and developing a linked network of natural area corridors.

2. Implementing master plan recommendations on a city wide basis, working with local interest groups to encourage their long-term involvement in preserving, maintaining and enhancing the value of natural area corridors in the city.

## Plan Elements

Five major plan elements are recommended. A brief overview of each element will then be followed by a detailed description of each element's objectives and suggested work plan.

### Customer Relations

Lake Oswego residents currently pay a storm water management utility fee when they pay their sewer and water bill, so the City already has a large customer base that pays for storm water management services. These customers need to be kept informed about the reasons for changing the financing approach to surface water management, the Master Plan's proposals, and the benefits that will accrue to them in the future, as the Plan is implemented. Storm water management utility rates need revision and new rates, consistent with the mandates of Ballot Measure 5, must be enacted by the City Council. Utility rates will be the principal financing mechanism for the surface water system improvements identified in the SWM Master Plan. The other primary storm water funding source is systems development charges, paid by builders as property develops. Homebuilders and developers are another customer class whose interests must be taken into account as the financing aspect of surface water management unfolds.

### Media Relations

The media, electronic and written, are powerful opinion shapers and need to be provided with sufficient information so that support for implementing SWM Master Plan recommendations is forthcoming from editorial writers and reporters. Support will be aided by being able to demonstrate that the subject is one that has broad community interest.

Intergovernmental Relations

As the Tualatin River clean up effort shows, surface water management efforts involve a multitude of agencies, at all levels of government. The City needs to keep up its efforts to involve, work with, and take advantage of, the intergovernmental resources that can be tapped in the implementation of the SWM Master Plan. Within city government, the Statement of Community Objectives (i.e. see Chapter 1) needs to become a focal point for the coordination of activities affecting the surface drainage system. The objectives statement is being incorporated into the City's Comprehensive Plan as an amendment.

Public Awareness

As many people as possible need to hear the message that Lake Oswego is addressing its surface water management issues in the best long-term interests of the general public. In addition to building support, public presentations and meetings provide opportunities for people to tell us what they think needs fixing and how that should occur. This "instant feedback" can keep the effort focused on the issues that seem most important to the rate paying constituency. Distribution of informative literature is also important.

Public Involvement

It is very important to target involvement efforts "close to home" and literally, for those people abutting streams and creeks, "in their own backyard". A local constituency exists that will champion natural corridor improvements and bring a neighborhood watch focus to surface water management maintenance efforts. Existing neighborhood associations, schools and other community groups are examples of this constituency. They represent a cadre of interested people who can appear in support of the Plan when it is finally presented to the City Council, regulatory bodies and the public.

**Customer Relations**

Objectives:

1. Continually monitor the level of customer awareness of, and interest in, surface water issues. Many public information programs fail because they focus on disseminating information agencies want the public to have, rather than on meeting the information needs of their constituents.

2. Continue to build awareness among utility customers of the current need for surface water management improvements due both to DEQ requirements and the natural area enhancement opportunities they create. Consistent with the Statement of Community Objectives, continue to stress prevention over treatment, non-structural over structural measures and on-site over regional controls.

3. Focus on key user groups in the community as surface water utility fees, systems development charges and other financing tools are considered.

Work Plan

1. Prepare inserts for utility bills that can be distributed to customers during the initial SWM Master Plan implementation phase.

2. Distribute at City Hall, handout materials on erosion control and on-site construction practices prepared for builders and developers.

3. Make presentations to key users and target groups of customers about the SWM Master Plan recommendations, implementation schedule and financing proposals in early 1992.

4. Continue to encourage citizens to report water quantity or water quality problems to City Hall.

## Media Relations

Objectives:

1. To provide to the print and electronic media, information about storm water/surface water-related issues in general and the implementation of SWM Master Plan recommendations in particular.

2. To generate media coverage of, and support for, efforts to address water quantity, water quality and natural area enhancement issues.

3. Keep surface water management issues before the public.

Work Plan

1. Distribute copies of the SWM Master Plan Executive Summary to the media.

2. Meet with editorial writers and reporters at The Oregonian South Metro, The Review and other regional newspapers soon, to discuss the SWM Master Planning process and findings.

3. Continue to issue news releases whenever activity generated throughout the SWM Master Plan implementation process might generate community interest e.g. school and youth group involvement, streamwalk activities. Look for opportunities to use media that people may be interested in.

4. Maintain media list to insure all groups are contacted regularly. Record each contact.

5. Prepare Op-Ed articles for submission to local newspapers on surface water management issues.

6. Prepare material about surface water management issues for submission to firms and organizations with newsletters (e.g. City, School District, County, Lake Oswego Corporation, Safeco etc.)

## Intergovernmental Relations

Objectives:

1. Work with those agencies that may impact, or be impacted by, surface water management activities in Lake Oswego.

2. Gain the support of DEQ for our good faith efforts to meet their mid-1993 timelines in the event that work is not entirely completed by that target date.

3. Maintain effective working relationships with Clackamas County and other agencies involved in Lower Tualatin clean-up efforts.

4. Heighten the awareness of the inter-relationship between good surface water management practices and the activities of other departments in the city e.g. public works, fire etc.

5. Keep other potential support groups in the city informed about progress.

Work Plan

1. Continue to hold regular briefing meetings on implementation strategies with key local and state agency officials.

2. Continue contacts with the established network of representatives of other surface water management utilities throughout the state.

3. Continue working with other surface water management agencies to share relevant public awareness/involvement resources and other material.

4. Continue to scrutinize areas where activities of other city departments impact, and are impacted by, surface water drainage. In a quality circle setting, encourage employees to devise alternate methods that will address departmental needs and mitigate negative impacts on the drainage system.

5. Provide regular briefings for City committees and boards e.g. Budget, Parks, CCI and others, that have a stake in the implementation of SWM Master Plan recommendations.

6. Use the SWM Master Plan to support the establishment of realistic requirements by regulatory agencies such as DEQ.

7. To encourage better public understanding and acceptance, work towards consistency in surface water management regulations and strategies within the watershed area, regardless of the unit of government which carries them out.

8. Explore ways to increase opportunities for decreasing costs in basin management through increased intergovernmental cooperation.

## Public Awareness

Objectives:

1. Implement the public awareness strategies developed as part of the annual budget setting process.

2. Continue to meet with civic groups, community organizations and opinion leaders to develop the understanding of, and support for, improved surface water management.

3. Build public support for implementation efforts.

4. Work with groups within the school system e.g. High School Political Action committees and interested teachers/students to get information into the homes of parents.

Work Plan

1. Maintain a complete list of community organizations, service clubs, forum meetings and other civic groups that host speakers. On at least an annual basis, contact key groups and request opportunity to make a presentation to the group.

2. Utilize and update slide program and script to accompany verbal presentations.

3. Continue to publish periodic editions of "WaterWays" and other informative brochures and fact sheets.

4. Identify organizations in the City that put out newsletters and seek to place relevant articles in their publications.

5. Identify community events during the summer where local people assemble and where it would be appropriate for a group like the Natural Resources Commission, or other support group, to have a booth or display - e.g. Festival of the Arts; events at Hunt Club.

6. Develop and exhibit display material about surface water management efforts that can be placed in local shopping centers for public exposure.

7. Utilize education materials and programs aimed at target sectors e.g. septic tank and other on-site waste disposal systems; auto businesses; hobby farmers; commercial, industrial and manufacturing businesses; retailers.

8. Develop an education component relating to hazardous substances that will include seasonal publications, catch basin stenciling, alternatives for hazardous substance disposal and a citizen hotline for reporting spills, etc.

## Public Involvement

Objectives:

1. To build a network of supporters for more effective surface water management techniques that will enhance the natural environment.

2. On an ongoing basis, seek to build a stewardship stake among people in neighborhoods that abut streams, waterways and natural area corridors.

3. On an ongoing basis seek to increase the level of awareness of citizens about how their actions impact the surface water drainage system, in both positive and negative ways.

Work Plan

1. Continue to encourage participation in "Streamwalk" activities.

2. Place particular emphasis on property owners that abut or have a heavy impact on the natural drainage system areas. Mail or contact these people with specific invitations to participate in "Streamwalk" and other surface water management activities.

3. Involve neighborhood association members in promoting interest in protecting and enhancing the value of stream corridors in their local area. Attend meetings and provide public information materials that neighborhood representatives can use to heighten local interest.

4. Devise, among City staff, ways in which local neighborhood groups might assume responsibility for maintaining sections of natural stream corridors if City provides tools, equipment, etc.

5. Continue to identify and promote voluntary cleanup of sites that are part of the natural drainage system, but which have become neighborhood garbage sites.

6. Continue to emphasize program(s) aimed at youth involvement and targeted towards schools, Scouts, church groups, etc. Focus on ways to be "surface water drainage system friendly" around the home and in the neighborhood.

7. Utilize the Chamber of Commerce and other business/trade associations to promote greater awareness and involvement in ways to improve business responsiveness to better on-site surface water management.

## CHAPTER 3

# STUDY AREA CHARACTERISTICS

The regional setting and the physiographic features of the study area influence its physical characteristics. Knowledge of these elements is important to understand how they affect surface water management. These natural features also influence development that has occurred now and will occur in the future. Solutions to manage surface water and control pollutants depends upon basic understanding of these factors and their interrelationships.

## 3.1 LOCATION

The City of Lake Oswego is located in northwest Oregon, in the eastern portion of the Tualatin Valley, 7 miles south of Portland. The study area for this project is defined by the City's Urban Services Boundary (USB). The majority of this area is within Clackamas County. The area contains approximately 7,690 acres.

The study area is bounded on the east by the Willamette River; on the south by West Linn, Clackamas County and the Tualatin River; on the west by Washington County and the north by the City of Portland. The study area and USB are shown in Figure 3.1.

## 3.2 CLIMATE AND RAINFALL PATTERNS

The study area climate is described as a modified marine type that is characteristic of the weather patterns that dominate the Pacific Northwest region. Warm, moist air moving from the Pacific Ocean 60 miles west, moderates the seasonal weather extremes. Summers tend to be warm and dry; winters are wet with extended periods of cloudiness. Annual precipitation averages approximately 40 inches, the majority (85 percent) which occurs during the period from October to May.

## 3.3 TOPOGRAPHY

The study area, located in an east-west oriented gap in the Portland Hills, enjoys a diverse topography. This breach in the Portland Hills has in the past served as a channel for the ancestral Tualatin River and as an outlet for the glacial torrents that flowed out of the Columbia River Gorge and inundated the Willamette Valley.

Rolling hills, steep hillsides and flat terraces surround Oswego Lake. Elevations range 10 feet (MSL) along the Willamette River to 98 feet (MSL) on the lake to over 970 feet on Mount Sylvania in the north. The surrounding hills are dissected by many natural channels that direct surface water into Oswego Lake and the Tualatin and Willamette Rivers; the most notable of these is Springbrook Creek. Channel slopes draining to the lake range from a minimum of .005 percent serving Jean Road to over .127 percent for a channel draining to Blue Heron Canal.

## 3.4 GEOLOGY AND SOILS

The study area is located in the Portland Hills, a narrow range that parallels the Willamette River and divides it from the Tualatin Valley. Columbia River basalt forms the bedrock of this range. This formation is overlain with Boring Lava that originated from vents occurring throughout the study area. Cooks Butte, Waluga Park and Mount Sylvania are all capped by Boring Lava. Above 300 feet the basalt is covered with wind-blown silt. Along the lake margins where bedrock is at depth and not exposed, sand and gravel deposits occur.

Soils within the Lake Oswego study area have been studied and classified by the Soil Conservation Service (SCS) according to their physical and chemical properties and indicate, in part, their suitability for specific uses.

The SCS has developed four "Hydrologic Soil Groupings" - A, B, C, and D - to categorize various soil abilities to infiltrate water. Group A soils have a high infiltration rate and a low runoff potential, while Group D soils exhibit a low rate of infiltration with a high potential for runoff. The drainage characteristics of A, B, C, and D soils are classified as excellent, good, fair and poor, respectively.

Most soils within the study area are classified as belonging within hydrologic group "C" ( 48 percent). The remaining soils fall within groups "D" ( 30 percent) and "B" ( 22 percent). The distribution of these soils is shown in Figure 3.2. As the map shows, large areas west of Oswego Canal, including Rivergrove, and northwest of West Bay are well-drained. These areas frequently drain stormwater runoff into sumps or drywells, many of which appear to work well. However, they would seldom drain much runoff from the largest storms, and their effect on smaller ones is not clear. They were not considered during either the flood control or water quality planning processes, as little is known about their exact locations or characteristics.

Soils in the Lake Oswego plan area belong to three major soil associations. These are, listed in their descending order of occurrence, Cascade-Powell (55%), Salem-Clackamas (30%) and Aloha-Woodburn (15%). Each is characterized as predominantly poorly draining and moderately erodible.

Approximately 55 percent of the study area has Cascade-Powell soils. This association is comprised of "deep, somewhat poorly drained soils that are underlain by a cemented layer and formed in silty material." Cascade-Powell soils are found on rolling hills and high terraces on the north and south of the lake east of Cook's Butte and Springbrook Creek.

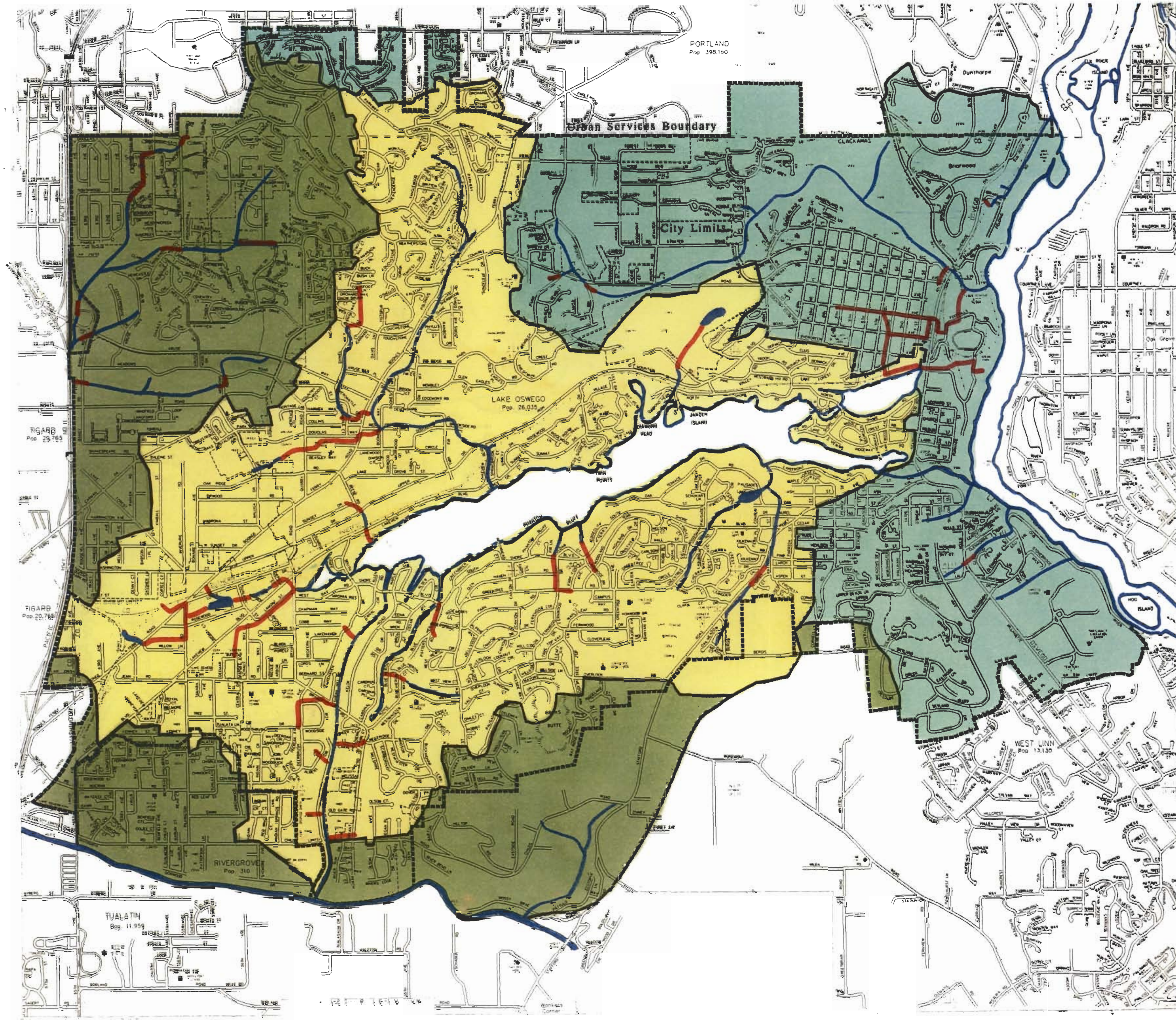
Approximately 30 percent of the study area has Salem-Clackamas soils. These soils are characterized as being "deep, well drained and somewhat poorly drained soils that formed in mixed gravelly alluvium." These soils occur on terraces on both sides of the lake, west of Cooks Butte and south of Waluga Park.

Approximately 15 percent of the study area is made up of Aloha-Woodburn soils. The Aloha-Woodburn series is composed of "deep, somewhat poorly drained and moderately well drained soils that formed in stratified glaciolucrustrine deposits." This series is found on terraces only in the northwest corner of the Springbrook Creek subbasin.

## 3.5 LAND USE

As development replaced rural-agricultural land, the amount of impervious surfaces such as roofs, patios, driveways and roads increased. Rainfall that once was intercepted and held by vegetation and soil became rapidly conducted off the land through structured drainage systems. Increasing the amount of impervious surface has increased the amount of suspended sediment, organic

# Study Area and Vicinity Map




- Oswego Lake Watershed
- Tualatin River Watershed
- Willamette River Watershed
- Major Streams
- Major Pipes

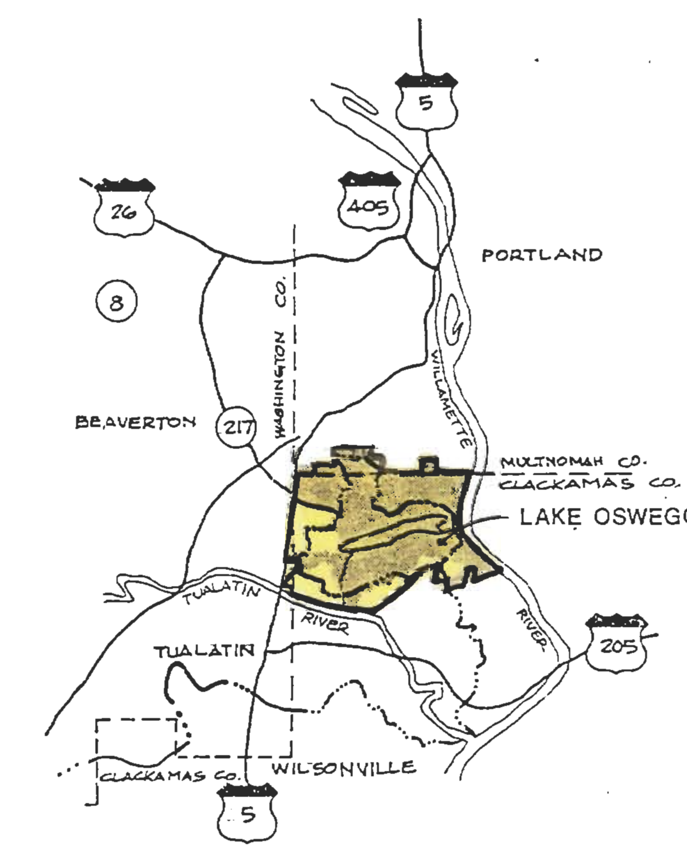
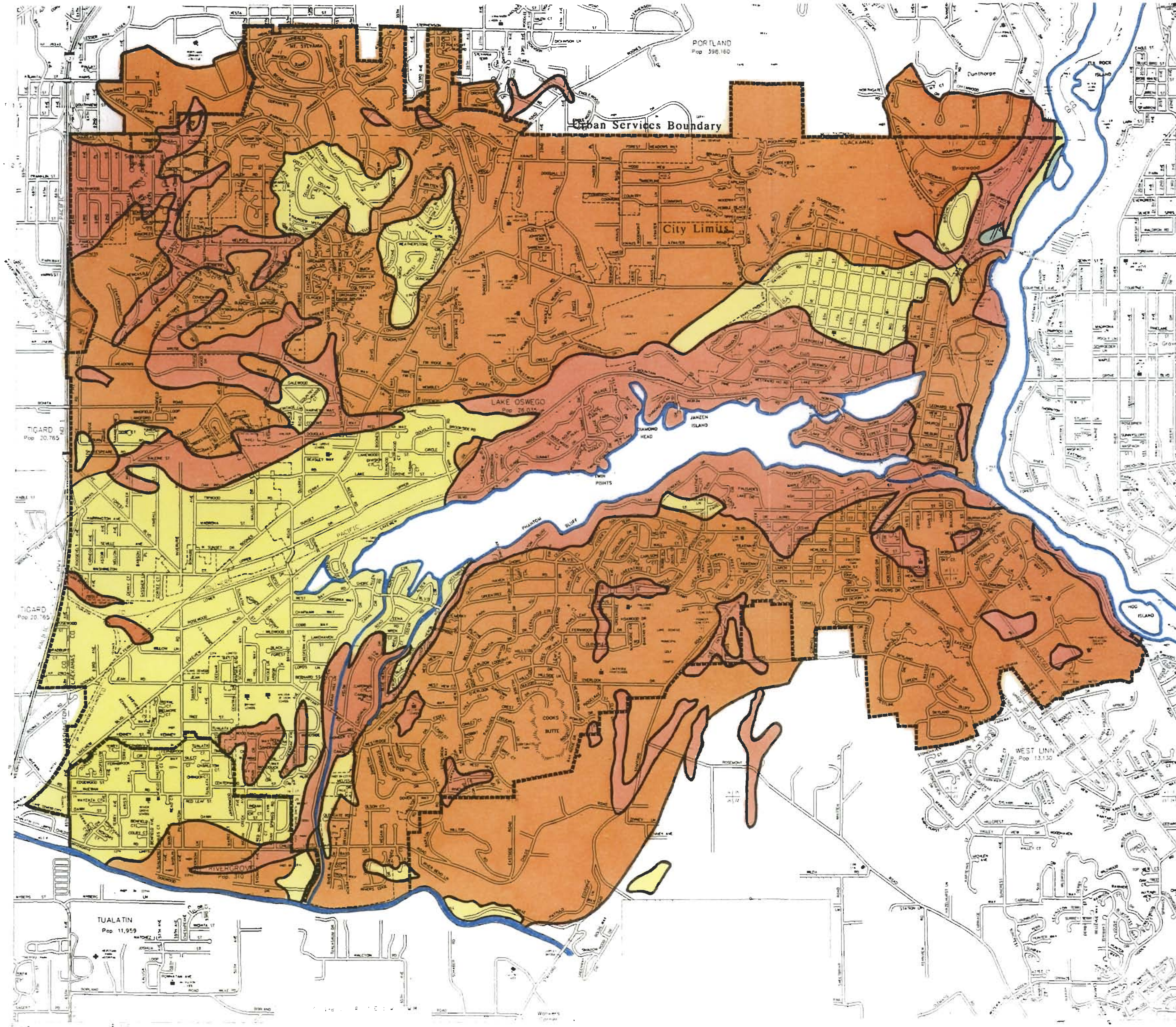



Figure 3.1

0 1200 2400 3600

otak




# Soils

| SCS Hydrologic Soil Group | Curve Number Used | Range of Infiltration Rates (Inch/Hour) |
|---|---|---|
| A | 65 | >0.30 |
| B | 79 | 0.30 - 0.15 |
| C | 85 | 0.15 - 0.05 |
| D | 89 | <0.05 |

Figure 3.2

0 1200 2400 3600

otak

material and other contaminants that are transported by runoff to receiving waters which degrade their water quality.

Commercial and industrial developments have increased along the major transportation corridors such as I-5 and the commercial areas of Lake Oswego. This development, along with the proximity of the study area to the City of Portland, has increased the need for residential development within the City. Land use is largely residential, with some industrial and commercial development. The Comprehensive Plan identifies zoning requirements for all areas within the Urban Growth Boundary (UGB).

There are two significant commercial areas located in the city consisting of downtown Lake Oswego and the Lake Grove District. Some smaller commercial areas are located in Mountain Park, the Palisades area, the Jean Road area and a highway-oriented commercial area along Interstate 5 at Kruse Way and Lower Boones Ferry Road. Industrial land has been limited to a small area along the Willamette River, northeast of downtown Lake Oswego and along Interstate 5, west of Lake Grove. The distribution of land use within the study area is depicted in Figure 3.3.

## 3.6 WATERSHED CHARACTERISTICS

A watershed is an area drained by a stream or water feature. Three natural watersheds occur within the study area: Oswego Lake, Tualatin River and the Willamette River. The Lake and the Tualatin River watersheds have been joined by the construction of the Oswego Canal. The Oswego Canal diverts water from the lower Tualatin River into Oswego Lake. Figure 4.3 maps the following 3 watersheds and the 28 major study area drainage basins:

### Oswego Lake Watershed

The basins draining into Oswego Lake include:

- Blue Heron Canal
- Country Club
- Fernwood
- Jean Road
- Lakewood Bay
- Lower Boones Ferry
- Lake Margin
- Lilly Pond
- Lost Dog Creek
- Oswego Canal
- Palisades Heights
- Reese Road
- Springbrook Creek
- West Bay

### Tualatin River Watershed

The basins within the City's UGB which drain into the Tualatin River include:

- Ball Creek
- Carter Creek
- Pecan Creek
- River Grove
- River Run

**Willamette River Watershed**

The basins that drain directly into the Willamette River include:

- Dunthorpe
- Glenmorrie
- Hallinan Heights
- Lake Oswego-North and South
- Old River Road
- Oswego Creek
- River Margin
- Tryon Creek

## 3.7 FLOODPLAIN

Flooding within the City is directly related to flooding on the Willamette and Tualatin Rivers. Historic records indicate that flooding occurs in winter and spring. The greatest floods on the Willamette and Tualatin Rivers have resulted when abnormally heavy or prolonged rainfall coincide with snowmelt and frozen or nearly saturated ground conditions. The combination of these factors create conditions that produce the maximum amount of runoff and the potential for widespread flooding.

The largest recent flood on the Willamette River occurred in December, 1964. Its peak discharge was observed at the Willamette Locks Upper Gage in Oregon City as 403,000 cubic feet per second (cfs). This discharge exceeded the projected 100-year flood flow of 341,000 cfs established by the Corps of Engineers.

The most recent large flood on the Tualatin River occurred January, 1974, with a peak discharge of 21,400 cfs. The largest flood recorded near the mouth of the Tualatin River at the West Linn Gage occurred December, 1933. The observed flood flow was 23,300 cfs. The flow during this flood at the Oswego Canal was 6,000 cfs. The estimated 100-year flood flow for the Tualatin River is 23,500 cfs.

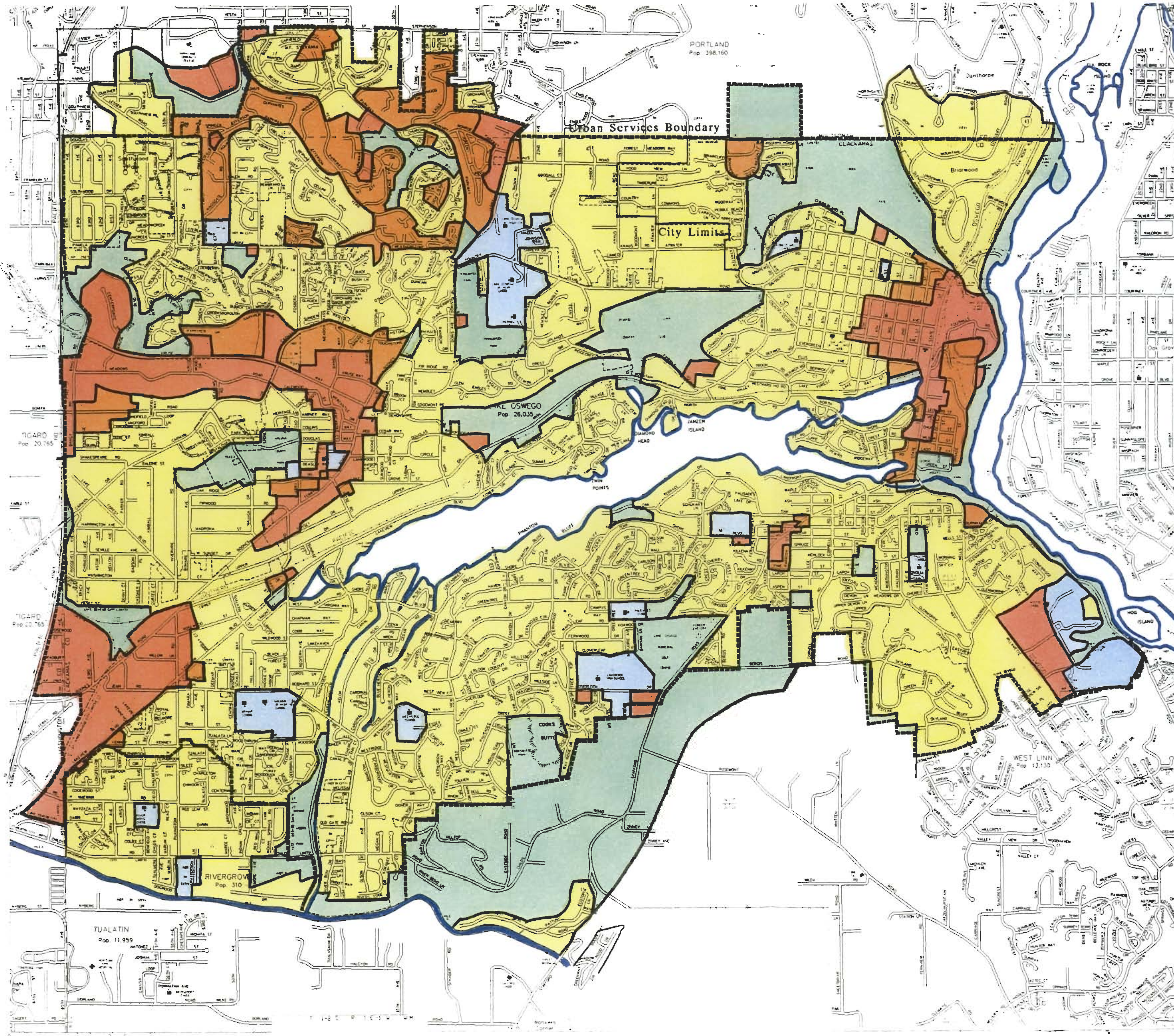
In 1977, the Federal Emergency Management Agency (FEMA) contracted with James Montgomery, Consulting Engineers, Inc. to complete a Flood Insurance Study (FIS) for the City of Lake Oswego. The final results of the study were presented in August, 1986 and the final version of the FIS and its associated maps were published August, 1987. This FIS utilized the analysis performed by the COE to reflect Tualatin River channel improvements completed in 1983 within the reach upstream of River Grove.

The City of Lake Oswego adopted this FIS and wrote a Floodplain Ordinance to comply with all of the requirements established by FEMA for a community to qualify for the regular Flood Insurance Program.

For the purposes of both insurance and the regulation of development within the floodplain, FEMA established the 100-year flood as the base or regulatory flood. This is the minimum level of flooding which the community ordinance is geared to protect against. The 100-year flood event is defined as the flood having a one percent chance of being equalled or exceeded in any given year.

Detailed methods were used to study Lake Oswego, Oswego Canal, the lower portion of Springbrook Creek, Tualatin River and the Willamette River that occur within the corporate City limits. Approximate studies were conducted for flooding caused by the western tributary of

# Land Use and Mapped Impervious Areas




| General Land Use Category - | MIA (Percent) |
|---|---|
| **Single Family Residential** | |
| High Density | 50 |
| Medium Density R-5, R-7.5 | 35-50 |
| Low Density R-10, R-15 | 20 |
| **Multi-Family Residential** R-0, R-3 | 60 |
| **Commercial and Industrial** | |
| MC, OC, CI, CR&D | 70 |
| NC, GC, HC, EC, | 85 |
| I, IP | 85 |
| **Institutional** Schools, Public Bldgs. | 40 |
| **Open Space** | 0 |
| **Major Arterial** | 95-100 |

Figure 3.3

0 1200 2400 3600

otak

Springbrook Creek, Oswego Creek, the main stem and eastern tributary of Lost Dog creek and the southern tributary of Tryon creek (FEMA, 1987).

Figure 3.4 depicts the established 100-year floodplain within the city limits.

## 3.8 STREAM CORRIDORS

The City has identified stream corridors as valuable natural features that are essential elements of the community's drainage system, which affect water quality and represent scenic assets of the community. The city has adopted Development Standards that recognize the importance of these features and establishes measures to control potential erosion hazards, preserve natural features to protect water quality and limit land use necessary to prevent property damage. Protected major stream corridors are depicted on the City's Hydrology Map.

Most stream corridors tend to be naturally unstable due to the local geology and topography and the action of water which together increase erosion. Erosion degrades water quality and increases the damage to property. Urbanization exacerbates erosion by increasing the volume and rate of runoff and reducing the vegetation that protects stream channels and which could act to limit further erosion.

# Floodplain Areas

Published 100-Year Floodplain (FEMA 1987 a,b,c)

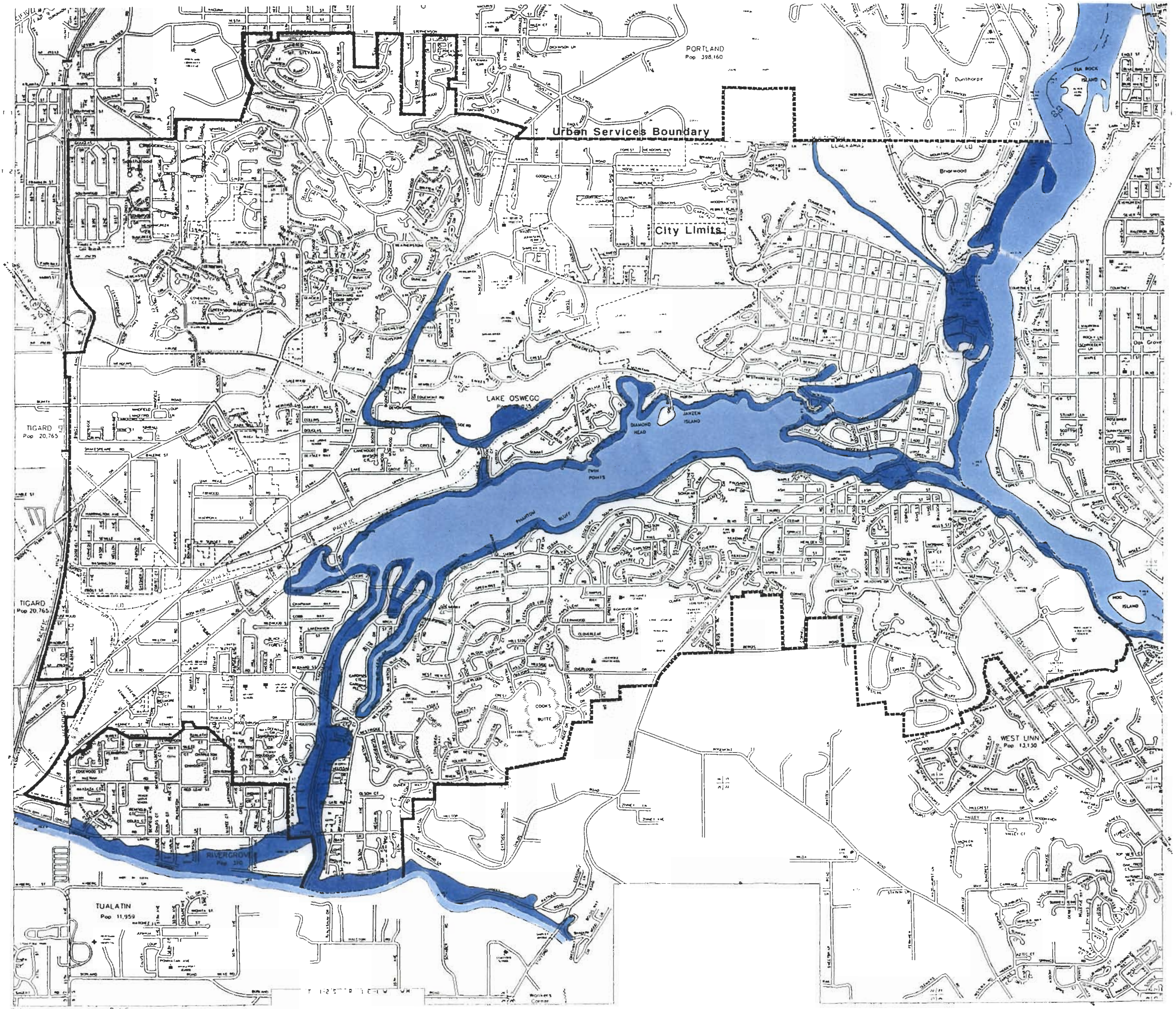



Figure 3.4

otak

Hydrologic/
Hydraulic
Analysis

# CHAPTER 4

# HYDROLOGIC/HYDRAULIC ANALYSIS

Urbanization has profound impacts on the land's response to rainfall by reducing infiltration and base flow and increasing runoff volumes and flows; and these higher flows reach stream systems faster. Undersized or blocked pipes only worsen the problem. They can flood road crossings and pose unacceptable risks to lives or property even for a short time.

In 1968, CH2M studied area drainage problems in intense detail using topographic maps with 2 feet of vertical resolution showing nearly all structures, and considered nearly every pipe and pipe in the public system. They used a simple drainage analysis method and dissected the study area into drainage areas of only a few acres each. However, methods and community values have changed since 1968. They recommended upgrading many undersized pipes at existing crossings and found many areas where pipes should be added if development were to occur, but other recommendations which would not be easily supported today included:

- Channelize the lower 2 miles of Springbrook Creek
- Channelize the north side of the Hunt Club field and drain the 3-acre wetland to the east
- Channelize the tributary through Waluga Park and drain the large wetlands present
- Drain the wetlands near the railroad tracks and Lower Boones Ferry

In general, wetlands were to be drained, piped systems were encouraged wherever possible, and detention was avoided. However, the maps proved valuable in the current SWM planning process.

## 4.1 HYDROLOGIC MODEL (HEC-1) DESCRIPTION

One of the principal objectives of any drainage master planning effort is the computation of peak flows and runoff volumes within a watershed being studied. Peak flows are used to size open channels, pipe systems; runoff volumes, to size detention facilities.

The development of the Lake Oswego Surface Water Management (SWM) Master Plan required hydrologic analysis throughout the major drainage systems of the three major watersheds. A hydrologic model is used to estimate the flood hydrograph, or flow versus time graph, as the result of a hypothetical rainfall event of a known recurrence interval and duration.

The flood hydrograph provides an estimate of the peak discharge that can be expected to occur at select locations within a watershed. This is used to evaluate the hydraulic performance of major pipes and other facilities located along the major drainageways. In preparing this plan, OTAK utilized the Hydrologic Engineering Center's HEC-1 Flood Hydrograph Package developed by the U.S. Army Corps of Engineers. OTAK used Version 4.0 of HEC-1 (USCOE, 1990) that runs on IBM-compatible personal computers.

The HEC-1 model is designed to simulate the surface runoff response of a watershed to precipitation by representing the watershed as an interconnected system of hydrologic and hydraulic components. Each component models an aspect of the precipitation-runoff process for sub-areas within a watershed. A component may represent a surface runoff entity, a stream channel, or a reservoir. The result of the modeling process is the computation of streamflow hydrographs at desired locations throughout the watershed.

The cornerstone for developing a stream network model is the identification and delineation of these components. Initially, the watershed boundary must be delineated. Then the watersheds are refined into major basins and subbasins. Finally, the major drainage system links the subbasins together.

The Lake Oswego study area was delineated into 3 watersheds: Oswego Lake, Tualatin River and Willamette River. Within these watersheds 28 major drainage basins were established. These basins were further divided into subbasins based on topography, and stream and roadway alignments. Topographic maps, drainage system inventory maps and field reconnaissance were used to define subbasin boundaries.

Drainage areas for each of the delineated subbasins were determined by digitizing subareas on 1"-800' scale maps. Subbasin areas varied from 23 to 194 acres; the average subbasin area was about 80 acres. The major drainage system was defined to include those stream and pipe reaches downstream of one or more subbasins, and the culverts they may flow through. In some cases, major culverts or detention basins were included if they were near the outlet of a designated subbasin. These major reaches were defined using topographic maps, drainage inventory maps and field reconnaissance.

## 4.2 INPUT PARAMETERS

In the HEC-1 model, components are used to simulate the rainfall-runoff process as it naturally occurs. These processes are separated into precipitation, interception/infiltration, runoff and flood routing. The key hydrologic parameters for the modeling effort are presented in the following paragraphs.

### Precipitation

A rainfall hyetograph is a hypothetical time-series of rainfall intensities used to simulate a rainstorm. The HEC-1 program uses this rainstorm data and converts it to runoff for each of the subbasins.

The duration of the hyetograph used for drainage planning is extremely important. The rainfall duration will effect both the estimate of peak flow and total runoff volume. The most common rainfall durations used in drainage planning are 6, 12 or 24 hours. A model sensitivity analysis was conducted on several drainage basins throughout the study area. The results established the 24-hour rainfall duration as the one to be used in the drainage master planning effort.

The National Weather Service-National Oceanic and Atmospheric Administration (NWS-NOAA) has published precipitation - frequency maps for the State of Oregon. These data were used by the City of Portland to develop precipitation Intensity-Duration-Frequency (IDF) curves for the Fanno Creek basin. These IDF curves are presented in Figure 4.1. The City of Lake Oswego has used these IDF curves for hydrologic design, therefore, the rainfall depths presented in Table 4.1 were chosen for hydrologic simulations.

TABLE 4.1

RECOMMENDED TOTAL 24-HOUR RAINFALL DEPTH

| Recurrence Interval (year) | Rainfall Depth (inches) |
|---|---|
| 10 | 3.3 |
| 25 | 3.8 |
| 50 | 4.3 |
| 100 | 4.8 |

The Soil Conservation Service's (SCS) Type 1A rainfall distribution was used to distribute the rainfall depths at 60-minute time intervals. This rainfall distribution established by the SCS is representative of storm patterns observed in the portion of Oregon located west of the Cascade range. The hourly Type 1A rainfall distribution for the select recurrence intervals are presented in Appendix B.

Simulations using the HEC-1 model are limited to a single storm that is assumed to occur uniformly over an entire watershed. Precipitation over a large area is variable, however, and locations within a watershed may not experience the same amount of precipitation from the same storm. This is especially true in large watersheds (i.e. greater that 50 square miles). Since each individual watershed is less than 5 square miles no adjustment to the point rainfall depths were made.

### Interception/Infiltration

Land surface interception, depression storage and soil infiltration constitutes the portion of precipitation that does not contribute directly to streamflow. Interception and depression storage includes the water retained by vegetation and in puddles. Infiltration represents the movement of water through the soil surface and into the soil. The HEC-1 model offers many options to estimate interception/infiltration losses. The Soil Conservation Service (SCS) Curve Number (CN) method was selected because of its wide acceptance and use in drainage engineering.

Based on experimentation and experience, the SCS has been able to relate the drainage characteristics of soil groups to a curve number, CN. The major factors used to determine CN are the hydrologic soil group, cover type and antecedent conditions. The SCS provides information relating hydrologic soil group type to the curve number as a function of soil cover, and antecedent moisture conditions.

A curve number value was assigned to each hydrologic soil group in the study area based upon typical vegetation cover, slope and condition. Values represent average antecedent moisture conditions for the soil groups occurring throughout the study area and are shown in Table 4.2. An area-weighted average curve number was calculated based on the percent of each soil groups found within a subbasin. Average ranges of infiltration rates of each major soil group are also tabulated.

## TABLE 4.2

## CURVE NUMBERS ESTABLISHED FOR EACH HYDROLOGIC SOIL GROUP

| SCS Hydrologic Soil Group | Modeled Curve Number | Range Of Infiltration Rates (Inch/Hour) |
|---|---|---|
| A | 65 | > 0.30 |
| B | 79 | 0.30 - 0.15 |
| C | 85 | 0.15 - 0.05 |
| D | 89 | 0.05 - 0.00 |

Runoff

The unit hydrograph technique used in the HEC-1 model transforms rainfall excess to subbasin outflow. Rainfall excess is that portion of the rainfall not retained by interception/infiltration and therefore available for runoff. The SCS Dimensionless Unit Hydrograph method was selected for use in this study.

The input data for the SCS dimensionless unit hydrograph method consists of a single parameter, lag time ($t_L$). Lag time is the time from the center of mass of rainfall to the peak of the hydrograph. Lag times for this study were computed from the following relationship (Sutherland, 1987):

$$t_L = A\ (CL/(CSL)^{0.5})^B$$

where: $t_L$ - lag time (hours)
CL - length of the main channel (miles)
CSL - slope of the main channel (ft/mile)
B - coefficient, a function of the mapped impervious area (MIA), and
A - coefficient, a function of MIA and the type of major drainage collector system.

Complete documentation of this equation and its development has been provided in Appendix A.

Mapped Impervious Area (MIA)

MIA represents those areas of a subbasin that are impervious to the infiltration of rain, including such areas as paved road, parking lots, roofs, driveways and sidewalks. MIA is an important parameter for drainage planning because it affects the amount of rainfall that can become direct runoff. MIA values are usually estimated for both existing conditions of development and ultimately planned development conditions.

Estimate of MIA for existing conditions was determined from aerial photographs taken in April, 1987, field reconnaissance and review of zoning ordinances. MIA was computed based on an area-weighted average of typical impervious area percentages for each land use category that exists within a subbasin. MIA for ultimately planned development conditions was based on the land use data in the Lake Oswego Comprehensive Plan.

The MIA in different subbasins will change depending on the land use and the age of development. For example, in the older part of the study area the MIA is lower than that found in the newer developed areas. In the older neighborhoods, development is characterized with modest homes on relatively large lots. This is in contrast to new developments which is sited on smaller lots but which cover more of the site with impervious surfaces. Furthermore, the infrastructure found in the older areas was build to less stringent design standards. Thus streets are narrower, uncurbed and the drainage system, if present, is rudimentary.

A two step process established land use categories for the purpose of hydrologic simulation. The first step began with examination of aerial photos of the study area to establish the existing land use categories corresponding to the designations found in the Comprehensive Plan Map. Five general land use categories were identified. The final step involved a "windshield survey" to collect site specific data about each general category. The survey data was then consolidated and synthesized to establish subcategories revealing the variable nature of MIA for the different types of development and factors discussed previously. Listed with each category or subcategory is the underlying land use designation(s) corresponding to the City's Comprehensive Plan. Table 4.3 presents the five general land use categories and the corresponding Mapped Impervious Area for each.

**TABLE 4.3**

**MAPPED IMPERVIOUS AREA USED IN LAKE OSWEGO**

| General Land Use Category | Mapped Impervious Area (Percent) |
|---|---|
| **Single Family Residential** | |
| Low Density (R-10, R-15) | 20 |
| Medium (R-5, R-7.5) | 35-50 |
| High Density (R-5, R-7.5) | 50 |
| **Multi-Family Residential** (R-0, R-3) | 60 |
| **Commercial and Industrial** | |
| (MC,OC,CI,CR&D) | 70 |
| (NC,GC,HC,EC,I's) | 85 |
| **Institutional** (Schools, Public Buildings, etc.) | 40 |
| **Major Arterial** | 95-100 |

Effective Impervious Area (EIA)

EIA is a term used to describe the portion of the subbasin's area that is both impervious to rainfall and is also directly linked to the drainage collection system. The HEC-1 model assumes the EIA of a subbasin contributes 100 percent of the rainfall for runoff. EIA includes street surfaces, paved driveways that connect to the street, sidewalks that are adjacent to curbed streets, rooftops if they are directly connected to the curb and parking lots.

EIA is one of the most important parameters because it directly affects the volume of runoff. The direct measurement of EIA is a tedious and costly task which can seldom be accomplished on limited planning budgets.

For this planning effort the OTAK EIA equations were used for estimating effective impervious area. The following general equation describe the relationship established between MIA and EIA (Sutherland,1987):

$$EIA = A\,(MIA)^{B},\ MIA \geq 1$$

Where: A and B are each a function of the degree of urbanization occurring within a subbasin and the drainage collector system.

By varying the parameters A and B, the equation was modified to handle various different land use types served with different drainage systems. Differing values of EIA result depending on the values assigned to A and B. Refer to Table 4.4

**TABLE 4.4**

**FORMS OF THE OTAK EIA EQUATIONS**

| No. | Equation | Drainage System Conditions |
|---|---|---|
| 1 | $EIA = 0.1(MIA)^{1.5}$ | Average |
| 2 | $EIA = 0.4(MIA)^{1.2}$ | Highly Connected |
| 3 | $EIA = (MIA)$ | Extremely Connected |
| 4 | $EIA = 0.4(MIA)^{1.7}$ | Somewhat Disconnected |
| 5 | $EIA = 0.01(MIA)^{2.0}$ | Extremely Disconnected |

The development of each EIA equation and its proper use is described in Appendix A.

### Flood Routing

The HEC-1 program conceptualizes the existing major drainage collector systems as a series of routing reaches that link the subbasin runoff hydrographs and moves them downstream to the watershed outfall. These routing reaches can be simulated as either open channels, closed pipes or open detention ponds.

The HEC-1 model offers many options to simulate flood movement through stream reaches. The Muskingum-Cunge method was used to simulate flood routing in the majority of defined drainage systems. The Modified Puls method was used to simulate the storage detention occurring at select locations throughout the study area.

Muskingum-Cunge

The Muskingum-Cunge method is based on the continuity equation and the storage discharge relationship. This routing technique can be used to route lateral inflow from collector channels and/or an upstream hydrograph through a main channel. This technique utilizes a diffusion wave model in the development of the governing equations. This method, therefore, accounts for hydrograph attenuation as a peak flood is routed downstream.

The model provides three options for describing the geometry of the routing reach. One is a closed circular pipe where pipe length, slope and diameter must be specified. The remaining two are open channel shapes (i.e. trapezoidal and rectangular). Data requirements for modeling these shapes include: channel cross section, length, Manning roughness coefficient and slope. All of these data are obtained from topographic maps and other sources.

Modified Puls

This method is used to simulate the storage detention occurring at designated points throughout the study area. The Modified Puls method is based on solving the continuity equation by defining the unique relationship between storage volume and outflow. The estimated storage volume is obtained from the topographic maps, and then used to develop an elevation versus storage volume relationship.

Working with pipe hydraulic charts or the weir equation a relationship is developed for the elevation versus outflow curve. These two relationships are combined to create the storage versus outflow curve required to use this technique.

## 4.3 MODEL CALIBRATION

Peak discharge and runoff volume data for calibration and verification were obtained from a U.S. Geological Survey (USGS) report (USGS, 1980). As part of their study the USGS collected rainfall and runoff data from 24 streamflow sites throughout the Portland metropolitan area. These sites were selected to represent the full spectrum of urban land uses within the Portland area. A USGS digital model was calibrated using the collected rainfall and runoff data for each basin. The model generated a synthetic set of flood peaks based on 70 years of storm data which were then used to define individual peak flow values for each gage site.

A scatter diagram of these data was developed which plotted the basin area (square miles) versus its unit-area 100 year basin peak flow. This diagram suggested limits for the simulation results. Next the 100 year peak flows for select basins within the study area were superimposed on these data in Figure 4.2. The Lake Oswego data fall within the established limits of the USGS data. Furthermore, each basin's EIA is comparable to the USGS data.

## TABLE 4.5

## SUBBASIN PARAMETERS AND PEAK FLOWS

| WATERSHED BASIN SUBBA | Drainage Area mi^2 | acres | CN | EIA % now | EIA % future | MIA % now | MIA % future | TLAG (hrs) now | TLAG (hrs) future | Existing cfs Q10 3.3 | Existing cfs Q25 3.8 | Existing cfs Q50 4.3 | Existing cfs Q100 4.5 | Future cfs * Q10 | Future cfs * Q25 | Future cfs * Q50 | Future cfs * Q100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OSWEGO LAKE** | | | | | | | | | | | | | | | | | |
| Springbrook Creek | | | | | | | | | | | | | | | | | |
| SB10 | 0.038 | 24 | 89 | 6 | 10 | 18 | 25 | 0.73 | 0.51 | | | | | | | | |
| SB20 | 0.172 | 110 | 82 | 9 | 10 | 24 | 25 | 0.74 | 0.69 | 29 | 37 | 46 | 49 | | | | |
| SB50 | 0.095 | 61 | 84 | 37 | 37 | 48 | 49 | 0.14 | 0.14 | 32 | 39 | 46 | 49 | | | | |
| SB60 | 0.211 | 135 | 84 | 17 | 24 | 27 | 38 | 0.72 | 0.44 | 41 | 52 | 62 | 66 | 52 | 64 | 77 | 82 |
| SB70 | 0.147 | 94 | 85 | 22 | 25 | 35 | 41 | 0.46 | 0.36 | 37 | 45 | 54 | 57 | 41 | 50 | 59 | 63 |
| SB80 | 0.085 | 54 | 82 | 32 | 34 | 42 | 45 | 0.29 | 0.25 | 24 | 30 | 36 | 38 | | | | |
| SB100 | 0.106 | 68 | 84 | 35 | 35 | 46 | 46 | 0.29 | 0.29 | 32 | 39 | 46 | 49 | | | | |
| SB110 | 0.155 | 99 | 85 | 33 | 33 | 44 | 44 | 0.20 | 0.20 | 51 | 62 | 73 | 77 | | | | |
| SB210 | 0.164 | 105 | 88 | 1 | 2 | 4 | 6 | 2.61 | 2.34 | 22 | 27 | 32 | 34 | | | | |
| SB310 | 0.184 | 118 | 84 | 36 | 36 | 45 | 45 | 0.51 | 0.51 | 48 | 58 | 68 | 72 | | | | |
| SB320 | 0.199 | 127 | 84 | 8 | 12 | 21 | 27 | 1.75 | 1.33 | 25 | 32 | 39 | 42 | 30 | 37 | 45 | 48 |
| SB410 | 0.062 | 40 | 83 | 49 | 49 | 59 | 59 | 0.19 | 0.19 | 22 | 26 | 31 | 32 | | | | |
| SB420 | 0.076 | 49 | 86 | 34 | 60 | 37 | 65 | 0.28 | 0.08 | 24 | 29 | 35 | 37 | 30 | 37 | 43 | 45 |
| SB425 | 0.035 | 23 | 85 | 54 | 54 | 60 | 60 | 0.08 | 0.08 | 14 | 16 | 19 | 20 | | | | |
| SB430 | 0.050 | 32 | 84 | 39 | 39 | 51 | 51 | 0.17 | 0.17 | 17 | 21 | 24 | 26 | | | | |
| SB910 | 0.125 | 80 | 85 | 54 | 54 | 61 | 62 | 0.13 | 0.12 | 49 | 58 | 67 | 71 | | | | |
| TOTAL | 1.904 | 1219 | | | | | | | | | | | | | | | |
| Reese Rd. | 0.120 | 77 | 79 | 35 | 35 | 46 | 46 | 0.32 | 0.32 | 31 | 38 | 45 | 49 | | | | |
| TOTAL | 0.120 | 77 | | | | | | | | | | | | | | | |
| Oswego Canal | | | | | | | | | | | | | | | | | |
| OC100 | 0.149 | 96 | 82 | 15 | 15 | 36 | 36 | 0.61 | 0.61 | 28 | 35 | 43 | 46 | | | | |
| OC200 | 0.105 | 67 | 80 | 21 | 21 | 37 | 37 | 0.49 | 0.49 | 21 | 26 | 32 | 34 | | | | |
| OC210 | 0.062 | 39 | 88 | 21 | 21 | 35 | 35 | 0.78 | 0.78 | 14 | 17 | 20 | 21 | | | | |
| OC300 | 0.125 | 80 | 84 | 30 | 32 | 44 | 46 | 0.35 | 0.32 | 36 | 44 | 52 | 56 | | | | |
| OC400 | 0.113 | 73 | 83 | 14 | 22 | 22 | 36 | 0.92 | 0.50 | 20 | 25 | 30 | 32 | 26 | 33 | 39 | 42 |
| OC500 | 0.088 | 57 | 84 | 16 | 21 | 27 | 36 | 0.50 | 0.34 | 20 | 25 | 30 | 32 | 23 | 29 | 34 | 37 |
| OC600 | 0.115 | 74 | 82 | 9 | 11 | 15 | 23 | 1.23 | 0.86 | 16 | 20 | 24 | 26 | 18 | 23 | 28 | 31 |
| TOTAL | 0.758 | 485 | | | | | | | | | | | | | | | |
| Blue Heron Canal | | | | | | | | | | | | | | | | | |
| BHC10 | 0.157 | 101 | 85 | 15 | 15 | 30 | 30 | 0.59 | 0.59 | 34 | 43 | 51 | 55 | | | | |
| BHC20 | 0.056 | 36 | 85 | 20 | 20 | 35 | 35 | 0.36 | 0.36 | 15 | 19 | 22 | 24 | | | | |
| BHC300 | 0.077 | 49 | 87 | 28 | 28 | 44 | 44 | 0.24 | 0.24 | 26 | 31 | 37 | 39 | | | | |
| BHC310 | 0.053 | 34 | 85 | 21 | 21 | 35 | 35 | 0.42 | 0.42 | 12 | 14 | 17 | 18 | | | | |
| BHC320 | 0.099 | 63 | 85 | 21 | 21 | 35 | 35 | 0.32 | 0.32 | 27 | 34 | 40 | 43 | | | | |
| BHC500 | 0.105 | 67 | 84 | 18 | 18 | 35 | 35 | 0.38 | 0.38 | 26 | 32 | 39 | 42 | | | | |
| TOTAL | 0.546 | 350 | | | | | | | | | | | | | | | |
| Fernwood Rd. | | | | | | | | | | | | | | | | | |
| F10 | 0.043 | 27 | 85 | 12 | 12 | 29 | 29 | 0.53 | 0.53 | 20 | 25 | 30 | 32 | | | | |
| F20 | 0.080 | 51 | 85 | 19 | 19 | 36 | 36 | 0.41 | 0.41 | 10 | 12 | 14 | 15 | | | | |
| TOTAL | 0.122 | 78 | | | | | | | | | | | | | | | |
| Lily Pond | 0.068 | 44 | 89 | 15 | 15 | 27 | 27 | 1.29 | 1.29 | 13 | 16 | 19 | 20 | | | | |
| Country Club | | | | | | | | | | | | | | | | | |
| CC10 | 0.131 | 84 | 87 | 5 | 6 | 10 | 12 | 2.81 | 2.45 | 16 | 20 | 24 | 26 | | | | |
| CC20 | 0.110 | 71 | 86 | 3 | 3 | 7 | 7 | 1.71 | 1.71 | 15 | 19 | 23 | 25 | | | | |
| TOTAL | 0.242 | 155 | | | | | | | | | | | | | | | |

# TABLE 4.5

## SUBBASIN PARAMETERS AND PEAK FLOWS

| WATERSHED BASIN SUBBA | Drainage Area mi^2 | acres | CN | EIA % now | EIA % future | MIA % now | MIA % future | TLAG (hrs) now | TLAG (hrs) future | Existing cfs Q10 3.3 | Q25 3.8 | Q50 4.3 | Q100 4.5 | Future cfs * Q10 | Q25 | Q50 | Q100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Palisades | 0.129 | 83 | 86 | 17 | 17 | 34 | 34 | 0.46 | 0.46 | 37 | 45 | 53 | 56 | | | | |
| Lost Dog Creek | | | | | | | | | | | | | | | | | |
| LD30 | 0.041 | 26 | 88 | 16 | 18 | 28 | 32 | 0.60 | 0.52 | 10 | 13 | 15 | 16 | | | | |
| LD40 | 0.140 | 90 | 85 | 21 | 21 | 34 | 34 | 0.41 | 0.41 | 36 | 44 | 53 | 56 | | | | |
| LD50 | 0.119 | 76 | 85 | 12 | 12 | 24 | 24 | 0.83 | 0.83 | 22 | 28 | 34 | 36 | | | | |
| LD210 | 0.099 | 64 | 88 | 28 | 28 | 45 | 45 | 0.30 | 0.30 | 32 | 39 | 46 | 48 | | | | |
| LD220 | 0.105 | 67 | 85 | 22 | 28 | 32 | 43 | 0.59 | 0.36 | 24 | 30 | 35 | 37 | 30 | 36 | 43 | 45 |
| LD230 | 0.130 | 83 | 86 | 3 | 5 | 5 | 9 | 2.06 | 1.64 | 16 | 21 | 25 | 27 | 19 | 23 | 28 | 30 |
| LD240 | 0.078 | 50 | 86 | 5 | 5 | 8 | 9 | 1.23 | 1.18 | 13 | 16 | 19 | 21 | | | | |
| TOTAL | 0.712 | 455 | | | | | | | | | | | | | | | |
| Lake Mar | 0.613 | 392 | 87 | | | | | | | | | | | | | | |
| Lakewood | 0.142 | 91 | 89 | 19 | 19 | 39 | 39 | 0.37 | 0.37 | | | | | | | | |
| Lower Boones Ferry Rd. | | | | | | | | | | | | | | | | | |
| LBF10 | 0.053 | 34 | 79 | 11 | 13 | 25 | 27 | 0.96 | 0.85 | 7 | 10 | 12 | 13 | | | | |
| LBF20 | 0.057 | 36 | 79 | 27 | 27 | 39 | 39 | 0.43 | 0.43 | 12 | 15 | 18 | 19 | | | | |
| LBF40 | 0.143 | 91 | 79 | 65 | 71 | 70 | 76 | 0.18 | 0.13 | 53 | 62 | 72 | 76 | 57 | 67 | 78 | 82 |
| LBF50 | 0.138 | 88 | 80 | 43 | 70 | 47 | 74 | 0.36 | 0.11 | 37 | 45 | 54 | 57 | 56 | 65 | 75 | 80 |
| LBF210 | 0.170 | 109 | 79 | 7 | 7 | 22 | 22 | 1.04 | 1.04 | 20 | 26 | 33 | 36 | | | | |
| LBF310 | 0.059 | 38 | 79 | 26 | 35 | 36 | 48 | 0.50 | 0.29 | 12 | 15 | 18 | 19 | 15 | 19 | 22 | 24 |
| TOTAL | 0.619 | 396 | | | | | | | | | | | | | | | |
| West Bay | | | | | | | | | | | | | | | | | |
| WB10 | 0.121 | 78 | 79 | 27 | 27 | 28 | 40 | 0.67 | 0.38 | 27 | 33 | 40 | 43 | | | | |
| WB20 | 0.054 | 35 | 79 | 15 | 15 | 11 | 36 | 1.34 | 0.42 | 10 | 13 | 16 | 17 | | | | |
| TOTAL | 0.176 | 113 | | | | | | | | | | | | | | | |
| Jean Rd. | | | | | | | | | | | | | | | | | |
| JR10 | 0.065 | 42 | 79 | 14 | 14 | 28 | 28 | 0.82 | 0.82 | 10 | 12 | 15 | 16 | | | | |
| JR20 | 0.117 | 75 | 79 | 14 | 16 | 28 | 30 | 0.95 | 0.85 | 17 | 22 | 27 | 29 | | | | |
| TOTAL | 0.182 | 117 | | | | | | | | | | | | | | | |

# TABLE 4.5

# SUBBASIN PARAMETERS AND PEAK FLOWS

| WATERSHED BASIN SUBBA | Drainage Area mi^2 | acres | CN | EIA % now | EIA % future | MIA % now | MIA % future | TLAG (hrs) now | TLAG (hrs) future | Existing cfs Q10 3.3 | Q25 3.8 | Q50 4.3 | Q100 4.5 | Future cfs * Q10 | Q25 | Q50 | Q100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **TUALATIN RIVER** | | | | | | | | | | | | | | | | | |
| Ball Creek | | | | | | | | | | | | | | | | | |
| B10 | 0.089 | 57 | 85 | 13 | 59 | 17 | 66 | 1.48 | 0.17 | 13 | 17 | 20 | 21 | 35 | 41 | 48 | 50 |
| B30 | 0.073 | 47 | 87 | 15 | 53 | 22 | 61 | 0.92 | 0.16 | 15 | 18 | 22 | 23 | 29 | 34 | 40 | 42 |
| B40 | 0.124 | 80 | 85 | 36 | 41 | 45 | 53 | 0.28 | 0.20 | 39 | 48 | 56 | 59 | 43 | 52 | 61 | 64 |
| B50 | 0.054 | 35 | 84 | 20 | 35 | 28 | 50 | 0.48 | 0.18 | 13 | 16 | 19 | 20 | 18 | 22 | 26 | 27 |
| B60 | 0.138 | 88 | 84 | 31 | 34 | 40 | 45 | 0.36 | 0.28 | 38 | 47 | 56 | 59 | 42 | 51 | 60 | 64 |
| B110 | 0.139 | 89 | 87 | 33 | 41 | 43 | 54 | 0.41 | 0.25 | 42 | 50 | 59 | 62 | 49 | 59 | 69 | 72 |
| B210 | 0.145 | 93 | 87 | 31 | 37 | 43 | 51 | 0.30 | 0.21 | 47 | 57 | 66 | 70 | 52 | 62 | 73 | 77 |
| B220 | 0.163 | 104 | 86 | 15 | 17 | 26 | 28 | 0.76 | 0.68 | 36 | 44 | 53 | 56 | | | | |
| B230 | 0.159 | 102 | 85 | 34 | 34 | 37 | 37 | 0.30 | 0.30 | 49 | 60 | 70 | 75 | | | | |
| B510 | 0.145 | 93 | 81 | 36 | 37 | 47 | 49 | 0.19 | 0.18 | 45 | 55 | 65 | 69 | | | | |
| TOTAL | 1.227 | 786 | | | | | | | | | | | | | | | |
| Carter Creek | | | | | | | | | | | | | | | | | |
| C10 | 0.157 | 100 | 85 | 33 | 59 | 38 | 66 | 0.48 | 0.14 | 42 | 51 | 60 | 64 | 63 | 74 | 86 | 90 |
| C20 | 0.090 | 58 | 86 | 8 | 31 | 19 | 44 | 0.97 | 0.32 | 28 | 34 | 40 | 42 | | | | |
| C30 | 0.092 | 59 | 86 | 27 | 43 | 35 | 52 | 0.42 | 0.19 | 25 | 31 | 37 | 39 | 34 | 40 | 47 | 50 |
| C50 | 0.140 | 90 | 87 | 22 | 22 | 31 | 31 | 0.60 | 0.60 | 34 | 42 | 50 | 53 | | | | |
| C110 | 0.098 | 63 | 82 | 9 | 9 | 25 | 25 | 0.82 | 0.82 | 16 | 20 | 24 | 26 | | | | |
| C210 | 0.094 | 60 | 88 | 34 | 54 | 41 | 62 | 0.31 | 0.12 | 31 | 38 | 44 | 47 | 39 | 46 | 53 | 56 |
| C410 | 0.079 | 50 | 86 | 24 | 46 | 31 | 56 | 0.57 | 0.19 | 19 | 24 | 28 | 30 | 29 | 35 | 41 | 43 |
| TOTAL | 0.750 | 480 | | | | | | | | | | | | | | | |
| River Grove | | | | | | | | | | | | | | | | | |
| RG100 | 0.050 | 32 | 79 | 21 | 21 | 35 | 35 | 0.42 | 0.42 | 6 | 6 | 8 | 10 | | | | |
| RG200 | 0.133 | 85 | 79 | 19 | 19 | 34 | 34 | 0.72 | 0.72 | 12 | 13 | 17 | 21 | | | | |
| RG300 | 0.116 | 74 | 80 | 15 | 15 | 31 | 31 | 1.04 | 1.04 | 8 | 10 | 12 | 15 | | | | |
| RG400 | 0.064 | 41 | 82 | 5 | 5 | 21 | 21 | 1.17 | 1.17 | 4 | 4 | 6 | 7 | | | | |
| RG500 | 0.181 | 116 | 84 | 2 | 5 | 6 | 21 | 2.14 | 1.05 | 5 | 6 | 8 | 10 | 14 | 16 | 21 | 25 |
| TOTAL | 0.543 | 347 | | | | | | | | | | | | | | | |
| River Run | 0.334 | 214 | 85 | 8 | 23 | 11 | 37 | 1.55 | 0.48 | | | | | | | | |
| Pecan Creek | | | | | | | | | | | | | | | | | |
| P10 | 0.303 | 194 | 85 | 2 | 2 | 4 | 4 | 2.38 | 2.38 | 34 | 43 | 52 | 55 | | | | |
| P30 | 0.277 | 177 | 86 | 10 | 11 | 14 | 15 | 1.45 | 1.38 | 44 | 55 | 66 | 70 | | | | |
| P210 | 0.167 | 107 | 85 | 5 | 5 | 9 | 9 | 1.13 | 1.13 | 26 | 33 | 40 | 43 | | | | |
| TOTAL | 0.747 | 478 | | | | | | | | | | | | | | | |

# TABLE 4.5

# SUBBASIN PARAMETERS AND PEAK FLOWS

| WATERSHED / BASIN / SUBBA | Drainage Area mi^2 | acres | CN | EIA % now | EIA % future | MIA % now | MIA % future | TLAG (hrs) now | TLAG (hrs) future | Existing cfs Q10 3.3 | Existing cfs Q25 3.8 | Existing cfs Q50 4.3 | Existing cfs Q100 4.5 | Future cfs * Q10 | Future cfs * Q25 | Future cfs * Q50 | Future cfs * Q100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **WILLAMETTE RIVER** | | | | | | | | | | | | | | | | | |
| **Tryon Creek** | | | | | | | | | | | | | | | | | |
| T 110 | 0.087 | 56 | 85 | 4 | 4 | 20 | 20 | 0.83 | 0.83 | 15 | 19 | 24 | 25 | | | | |
| T 105 | 0.073 | 47 | 85 | 30 | 30 | 38 | 38 | 0.40 | 0.40 | 20 | 25 | 29 | 31 | | | | |
| T 910 | 0.069 | 44 | 85 | 4 | 4 | 20 | 20 | 0.68 | 0.68 | 13 | 17 | 20 | 22 | | | | |
| T 90 | 0.127 | 82 | 85 | 23 | 23 | 34 | 34 | 0.60 | 0.60 | 29 | 36 | 43 | 45 | | | | |
| T 80 | 0.096 | 62 | 85 | 7 | 7 | 23 | 23 | 0.73 | 0.73 | 18 | 23 | 28 | 30 | | | | |
| T 70 | 0.083 | 53 | 85 | 4 | 4 | 20 | 20 | 0.92 | 0.92 | 14 | 18 | 22 | 23 | | | | |
| T 610 | 0.099 | 64 | 85 | 5 | 5 | 21 | 21 | 1.04 | 1.04 | 16 | 20 | 25 | 26 | | | | |
| T 510 | 0.099 | 64 | 85 | 7 | 7 | 23 | 23 | 0.97 | 0.97 | 17 | 21 | 26 | 27 | | | | |
| T 45 | 5.167 | 3307 | 85 | 12 | 12 | 27 | 27 | 2.30 | 2.30 | 633 | 788 | 947 | 1012 | | | | |
| T 40 | 0.162 | 104 | 85 | 19 | 19 | 33 | 33 | 0.64 | 0.64 | 35 | 44 | 52 | 55 | | | | |
| T 310 | 0.115 | 74 | 85 | 4 | 4 | 20 | 20 | 0.80 | 0.80 | 21 | 26 | 31 | 34 | | | | |
| T 210 | 0.085 | 55 | 83 | 24 | 24 | 42 | 42 | 0.38 | 0.38 | 21 | 26 | 31 | 34 | | | | |
| T 20 | 0.263 | 168 | 85 | 12 | 12 | 27 | 27 | 0.88 | 0.88 | 48 | 60 | 72 | 77 | | | | |
| T 10 | 0.030 | 19 | 85 | 30 | 30 | 33 | 33 | | | | | | | | | | |
| TOTAL | 6.554 | 4195 | | | | | | | | | | | | | | | |
| **Dunthorpe** | | | | | | | | | | | | | | | | | |
| D 30 | 0.084 | 54 | 86 | 4 | 4 | 20 | 20 | 0.75 | 0.75 | 16 | 20 | 25 | 26 | | | | |
| D 20 | 0.061 | 39 | 85 | 4 | 4 | 20 | 20 | 0.69 | 0.69 | 18 | 23 | 27 | 29 | | | | |
| D 10 | 0.063 | 40 | 89 | 4 | 4 | 20 | 20 | | | | | | | | | | |
| TOTAL | 0.207 | 133 | | | | | | | | | | | | | | | |
| **Lake Oswego N&S Downtow** | | | | | | | | | | | | | | | | | |
| LO 40 | 0.097 | 62 | 81 | 11 | 11 | 30 | 30 | 0.65 | 0.65 | 16 | 21 | 26 | 28 | | | | |
| LO 30 | 0.039 | 25 | 79 | 35 | 35 | 51 | 51 | 0.19 | 0.19 | 11 | 14 | 16 | 17 | | | | |
| LO 210 | 0.088 | 56 | 82 | 28 | 28 | 42 | 42 | 0.43 | 0.43 | 21 | 26 | 31 | 33 | | | | |
| LON 20 | 0.048 | 31 | 83 | 78 | 78 | 81 | 81 | 0.05 | 0.05 | 21 | 25 | 28 | 30 | | | | |
| LON 10 | 0.040 | 26 | 85 | 71 | 71 | 54 | 54 | 0.07 | 0.07 | 17 | 20 | 23 | 24 | | | | |
| LOS 20 | 0.080 | 51 | 85 | 31 | 31 | 46 | 46 | 0.29 | 0.29 | 24 | 30 | 35 | 37 | | | | |
| LOS 10 | 0.085 | 55 | 85 | 68 | 69 | 70 | 71 | 0.09 | 0.09 | 36 | 43 | 49 | 51 | | | | |
| TOTAL | 0.477 | 305 | | | | | | | | | | | | | | | |
| **Oswego Creek** | | | | | | | | | | | | | | | | | |
| O 210 | 0.124 | 80 | 86 | 13 | 20 | 34 | 45 | 0.53 | 0.33 | 29 | 36 | 43 | 46 | 35 | 43 | 52 | 55 |
| O 30 | 0.091 | 59 | 86 | 19 | 19 | 38 | 38 | 0.42 | 0.42 | 24 | 29 | 35 | 37 | | | | |
| O 10 | 0.101 | 65 | 87 | 21 | 35 | 41 | 49 | 0.16 | 0.11 | 34 | 42 | 49 | 52 | 38 | 45 | 53 | 56 |
| TOTAL | 0.316 | 203 | | | | | | | | | | | | | | | |
| **Hallinan Heights** | | | | | | | | | | | | | | | | | |
| H 20 | 0.063 | 41 | 86 | 27 | 28 | 41 | 42 | 0.29 | 0.28 | 20 | 24 | 28 | 30 | | | | |
| H 10 | 0.046 | 30 | 86 | 14 | 22 | 31 | 38 | 0.54 | 0.39 | 11 | 13 | 16 | 17 | 13 | 15 | 18 | 20 |
| TOTAL | 0.109 | 70 | | | | | | | | | | | | | | | |
| **Glenmorrie** | | | | | | | | | | | | | | | | | |
| G 20 | 0.088 | 57 | 85 | 8 | 8 | 23 | 23 | 0.67 | 0.67 | 17 | 22 | 26 | 28 | | | | |
| G 10 | 0.116 | 74 | 85 | 9 | 9 | 25 | 25 | 0.83 | 0.83 | 21 | 27 | 32 | 35 | | | | |
| TOTAL | 0.204 | 131 | | | | | | | | | | | | | | | |

## TABLE 4.5

# SUBBASIN PARAMETERS AND PEAK FLOWS

| WATERSHED BASIN SUBBA | Drainage Area mi^2 | acres | CN | EIA % now | EIA % future | MIA % now | MIA % future | TLAG (hrs) now | TLAG (hrs) future | Existing cfs Q10 3.3 | Existing cfs Q25 3.8 | Existing cfs Q50 4.3 | Existing cfs Q100 4.5 | Future cfs * Q10 | Future cfs * Q25 | Future cfs * Q50 | Future cfs * Q100 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Old River Road | | | | | | | | | | | | | | | | | |
| ORR 20 | 0.127 | 82 | 85 | 5 | 15 | 21 | 37 | 0.99 | 0.47 | 21 | 27 | 32 | 35 | 30 | 37 | 45 | 48 |
| ORR 10 | 0.088 | 56 | 86 | 14 | 50 | 27 | 49 | 0.60 | 0.22 | 20 | 25 | 29 | 31 | 33 | 39 | 45 | 48 |
| TOTAL | 0.215 | 138 | | | | | | | | | | | | | | | |
| Willamette River Margin | | | | | | | | | | | | | | | | | |
| T N | 0.059 | 38 | 81 | 4 | 4 | 20 | 20 | | | | | | | | | | |
| T S | 0.031 | 20 | 86 | 71 | 71 | 64 | 64 | | | | | | | | | | |
| O N | 0.049 | 32 | 86 | 35 | 56 | 49 | 61 | | | | | | | | | | |
| O S | 0.016 | 11 | 86 | 51 | 51 | 58 | 58 | | | | | | | | | | |
| ORR N | 0.030 | 20 | 86 | 4 | 4 | 20 | 20 | | | | | | | | | | |
| ORR S | 0.135 | 87 | 86 | 31 | 90 | 39 | 75 | | | | | | | | | | |
| TOTAL | 0.322 | 206 | | | | | | | | | | | | | | | |

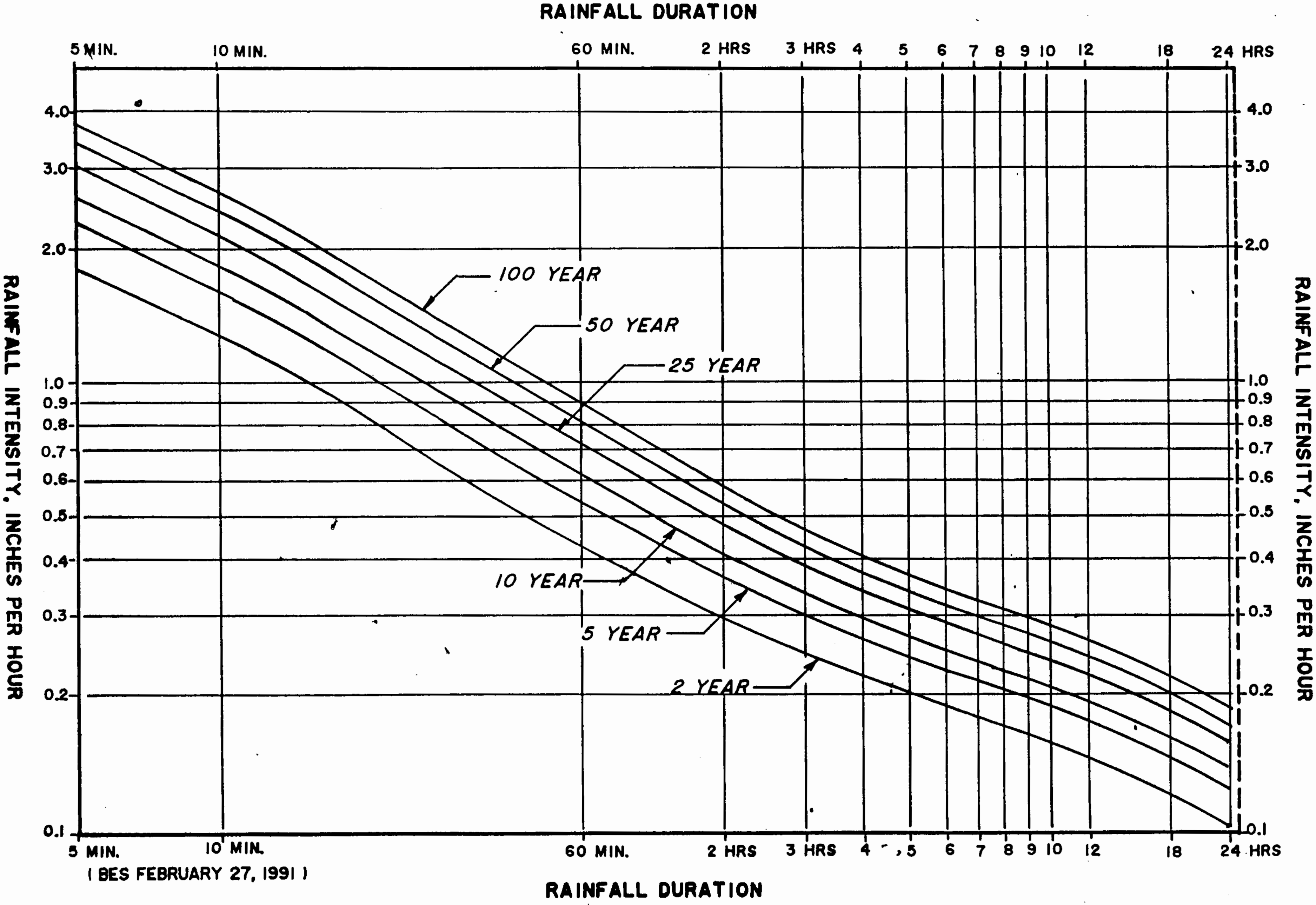
NOTES:
1. CN – SCS Curve Number
2. EIA – Effective Impervious Area (percent)
3. MIA – Mapped Impervious Area (percent)
4. TLAG – Subbasin Lag Time (hours)
5. Q10 – Peak flow for 10 year recurrence interval
3.3 – 24-hour total rainfall depth (inches)

* FUTURE FLOWs are left blank if they are the same as the existing flows to clearly distinguish fully developed basins.

# FIGURE 4.1

## RAINFALL INTENSITY - DURATION - FREQUENCY CURVES

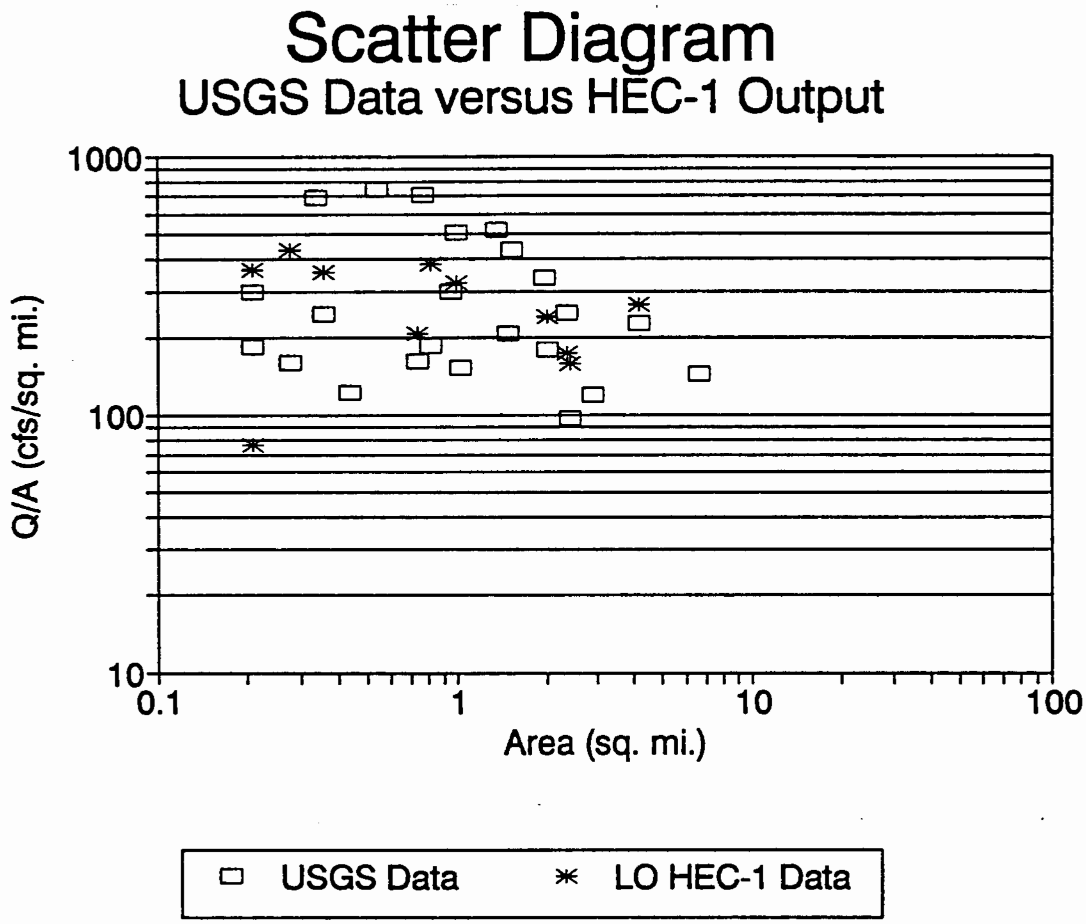
AT FANNO CREEK STUDY AREA




(BES FEBRUARY 27, 1991)

This graphical comparison demonstrates that these basin models simulate the rainfall-runoff process occurring in urban basins having differing levels of development. And since the results of these simulations are consistent and comparable to the long-term regional data, it was concluded that no further calibration of the models is necessary.

FIGURE 4.2




## 4.4 SUBBASIN PARAMETERS AND PEAK FLOWS

The hydrologic parameters used for the HEC-1 model simulations were estimated for each of the subbasins identified within the three watersheds. Table 4.5 presents a summary of these hydrologic parameters and the resulting peakflows. For each subbasin the following parameters are itemized: watershed, major drainage basin, subbasin ID, drainage area (square miles and acres), SCS curve number (CN), impervious area and its expected future increase, existing and future subbasin lag time (TLAG) and peak flows.

Following tabulation of these subbasin data, hydrologic models were developed and simulations completed for the major drainageways within each watershed. Since there are numerous hydraulic structures in a watershed each subject to different design storm recurrence intervals, simulations were performed for the 10-, 25- 50-, and 100-year events. Table 4.6 presents flows for each recurrence interval under existing and future development conditions.

TABLE 4.6

# PEAK NODAL FLOWS

| WATERSHED Basin Name Node | Drainage Area Mi^2 | acres | Existing flows Q10 | Q25 | Q50 | Q100 | Future Flows * Q10 | Q25 | Q50 | Q100 |
|---|---|---|---|---|---|---|---|---|---|---|
| **OSWEGO LAKE** | | | | | | | | | | |
| Springbrook Creek | | | | | | | | | | |
| 110 | 0.155 | 99 | 51 | 62 | 73 | 77 | | | | |
| 100 | 0.261 | 167 | 82 | 100 | 118 | 125 | | | | |
| 910 | 0.125 | 80 | 49 | 58 | 67 | 71 | | | | |
| 90 | 0.386 | 247 | 128 | 154 | 181 | 192 | | | | |
| 80 | 0.470 | 301 | 152 | 184 | 216 | 229 | | | | |
| 70 | 0.617 | 395 | 184 | 222 | 262 | 278 | 191 | 231 | 273 | 290 |
| 60 | 0.828 | 530 | 199 | 242 | 285 | 302 | 220 | 266 | 312 | 331 |
| 50 | 0.923 | 591 | 217 | 263 | 310 | 328 | 237 | 287 | 337 | 358 |
| 430 | 0.050 | 32 | 17 | 21 | 24 | 26 | | | | |
| 425 | 0.086 | 55 | 27 | 33 | 38 | 39 | | | | |
| 420 | 0.163 | 104 | 52 | 62 | 72 | 76 | 57 | 68 | 79 | 83 |
| 410 | 0.225 | 144 | 72 | 87 | 101 | 107 | 78 | 93 | 109 | 115 |
| 40 | 1.148 | 735 | 260 | 314 | 369 | 391 | 278 | 334 | 392 | 416 |
| 320 | 0.198 | 127 | 25 | 32 | 39 | 42 | 30 | 37 | 45 | 48 |
| 310 | 0.383 | 245 | 49 | 60 | 71 | 75 | | | | |
| 30 | 1.531 | 980 | 308 | 372 | 437 | 464 | 326 | 394 | 462 | 490 |
| 210 | 0.164 | 105 | 22 | 27 | 32 | 34 | | | | |
| 20 | 1.867 | 1195 | 337 | 409 | 483 | 513 | 357 | 433 | 511 | 542 |
| 10 | 1.905 | 1219 | | | | | | | | |
| Reese Road | | | | | | | | | | |
| 10 | 0.120 | 77 | 31 | 38 | 45 | 49 | | | | |
| 1 | 0.120 | 77 | 28 | 33 | 37 | 39 | | | | |
| Oswego Canal | | | | | | | | | | |
| 100 | 0.149 | 96 | 28 | 35 | 43 | 46 | | | | |
| 210 | 0.061 | 39 | 14 | 17 | 20 | 21 | | | | |
| 200 | 0.166 | 106 | 32 | 40 | 48 | 52 | | | | |
| 300 | 0.125 | 80 | 36 | 44 | 52 | 56 | | | | |
| 400 | 0.113 | 73 | 20 | 25 | 30 | 32 | 26 | 33 | 39 | 42 |
| 500 | 0.088 | 57 | 20 | 25 | 30 | 32 | 23 | 29 | 34 | 37 |
| 600 | 0.115 | 74 | 16 | 20 | 24 | 26 | 18 | 23 | 28 | 31 |
| Blue Heron Canal | | | | | | | | | | |
| 20 | 0.056 | 36 | 15 | 19 | 22 | 24 | | | | |
| 10 | 0.213 | 137 | 49 | 62 | 73 | 79 | | | | |
| 320 | 0.098 | 63 | 27 | 34 | 40 | 43 | | | | |
| 310 | 0.152 | 97 | 38 | 47 | 56 | 59 | | | | |
| 300 | 0.228 | 146 | 61 | 75 | 89 | 95 | | | | |
| Fernwood | | | | | | | | | | |
| 20 | 0.080 | 51 | 20 | 25 | 30 | 32 | | | | |
| 10 | 0.122 | 78 | 30 | 37 | 44 | 47 | | | | |
| Country Club | | | | | | | | | | |
| 20 | 0.111 | 71 | 15 | 19 | 23 | 25 | | | | |
| 10 | 0.242 | 155 | 28 | 34 | 40 | 42 | | | | |
| Palisades Heights | | | | | | | | | | |
| 10 | 0.129 | 83 | 37 | 45 | 53 | 56 | | | | |
| Lost Dog Creek | | | | | | | | | | |
| 50 | 0.119 | 76 | 22 | 28 | 34 | 36 | | | | |
| 40 | 0.259 | 166 | 48 | 60 | 72 | 77 | | | | |
| 30 | 0.297 | 190 | 58 | 72 | 86 | 92 | | | | |

TABLE 4.6

# PEAK NODAL FLOWS

| WATERSHED<br>Basin Name<br>Node | Drainage Area<br>Mi^2 | acres | Existing flows<br>Q10 | Q25 | Q50 | Q100 | Future Flows *<br>Q10 | Q25 | Q50 | Q100 |
|---|---|---|---|---|---|---|---|---|---|---|
| 240 | 0.078 | 50 | 13 | 16 | 19 | 21 | | | | |
| 230 | 0.208 | 133 | 27 | 34 | 41 | 44 | 31 | 38 | 46 | 49 |
| 220 | 0.313 | 200 | 40 | 50 | 60 | 64 | 42 | 52 | 63 | 67 |
| 210 | 0.413 | 264 | 55 | 74 | 91 | 97 | 66 | 87 | 105 | 112 |
| 20 | 0.708 | 453 | 106 | 133 | 160 | 171 | 110 | 137 | 165 | 176 |
| Lower Boones Ferry Rd. | | | | | | | | | | |
| 54 | 0.138 | 88 | 37 | 45 | 54 | 57 | 56 | 65 | 75 | 80 |
| 50 | 0.138 | 88 | 10 | 12 | 14 | 15 | 13 | 15 | 18 | 18 |
| 40 | 0.280 | 179 | 57 | 68 | 79 | 83 | 65 | 77 | 89 | 93 |
| 310 | 0.059 | 38 | 12 | 15 | 18 | 19 | 15 | 19 | 22 | 24 |
| 30 | 0.339 | 217 | 58 | 68 | 74 | 84 | 73 | 86 | 99 | 105 |
| 210 | 0.170 | 109 | 20 | 26 | 33 | 36 | | | | |
| 20 | 0.566 | 362 | 85 | 104 | 124 | 132 | 96 | 117 | 138 | 147 |
| 10 | 0.619 | 396 | 80 | 100 | 120 | 129 | 89 | 110 | 131 | 139 |
| Jean Rd. | | | | | | | | | | |
| 20 | 0.117 | 75 | 12 | 22 | 27 | 29 | | | | |
| 10 | 0.183 | 117 | 27 | 34 | 42 | 45 | | | | |
| **TUALATIN RIVER** | | | | | | | | | | |
| Ball Creek | | | | | | | | | | |
| 60 | 0.138 | 88 | 38 | 47 | 56 | 59 | 42 | 51 | 60 | 64 |
| 510 | 0.145 | 93 | 45 | 55 | 65 | 69 | | | | |
| 50 | 0.338 | 216 | 86 | 104 | 129 | 138 | 97 | 121 | 146 | 155 |
| 40 | 0.463 | 296 | 124 | 151 | 183 | 196 | 138 | 169 | 205 | 218 |
| 30 | 0.536 | 343 | 134 | 163 | 192 | 211 | 165 | 199 | 239 | 255 |
| 230 | 0.159 | 102 | 49 | 60 | 70 | 75 | | | | |
| 220 | 0.322 | 206 | 75 | 91 | 108 | 115 | 78 | 96 | 113 | 120 |
| 210 | 0.467 | 299 | 100 | 126 | 160 | 174 | | | | |
| 20 | 1.003 | 642 | 229 | 282 | 345 | 377 | 260 | 313 | 381 | 408 |
| 110 | 0.139 | 89 | 42 | 50 | 59 | 62 | 49 | 59 | 69 | 72 |
| 10 | 1.228 | 786 | 254 | 331 | 407 | 440 | 305 | 388 | 471 | 504 |
| Carter Creek | | | | | | | | | | |
| 50 | 0.141 | 90 | 34 | 42 | 50 | 53 | | | | |
| 410 | 0.078 | 50 | 19 | 24 | 28 | 30 | 29 | 35 | 41 | 43 |
| 40 | 0.219 | 140 | 54 | 66 | 78 | 83 | | | | |
| 30 | 0.311 | 199 | 76 | 93 | 110 | 117 | 76 | 99 | 119 | 127 |
| 210 | 0.094 | 60 | 31 | 38 | 44 | 47 | 39 | 46 | 53 | 56 |
| 20 | 0.495 | 317 | 121 | 152 | 181 | 192 | 140 | 173 | 203 | 216 |
| 110 | 0.098 | 63 | 16 | 20 | 24 | 26 | | | | |
| 10 | 0.750 | 480 | 174 | 217 | 259 | 276 | 203 | 244 | 292 | 309 |
| Pecan Creek | | | | | | | | | | |
| 30 | 0.277 | 177 | 44 | 55 | 66 | 70 | | | | |
| 210 | 0.167 | 107 | 26 | 33 | 40 | 43 | | | | |
| 20 | 0.444 | 284 | 70 | 87 | 105 | 112 | | | | |
| 10 | 0.747 | 478 | 96 | 121 | 146 | 156 | | | | |
| **WILLAMETTE RIVER** | | | | | | | | | | |
| Tryon Creek | | | | | | | | | | |
| 110 | 0.088 | 56 | 15 | 19 | 24 | 25 | | | | |
| 105 | 0.073 | 47 | 20 | 25 | 29 | 31 | | | | |
| 100 | 0.161 | 103 | 31 | 38 | 46 | 49 | | | | |
| 910 | 0.069 | 44 | 13 | 17 | 20 | 22 | | | | |
| 90 | 0.358 | 229 | 73 | 90 | 109 | 116 | | | | |
| 80 | 0.455 | 291 | 91 | 113 | 136 | 145 | | | | |
| 70 | 0.538 | 344 | 104 | 130 | 156 | 167 | | | | |
| 610 | 0.100 | 64 | 16 | 20 | 25 | 26 | | | | |
| 60 | 0.638 | 408 | 119 | 149 | 179 | 191 | | | | |

TABLE 4.6

# PEAK NODAL FLOWS

| WATERSHED Basin Name | Drainage Area | | Existing flows | | | | Future Flows * | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Node | Mi^2 | acres | Q10 | Q25 | Q50 | Q100 | Q10 | Q25 | Q50 | Q100 |
| 510 | 0.100 | 64 | 17 | 21 | 26 | 27 | | | | |
| 50 | 0.738 | 472 | 135 | 169 | 204 | 218 | | | | |
| 40 | 6.067 | 3883 | 720 | 896 | 1076 | 1149 | | | | |
| 310 | 0.116 | 74 | 21 | 26 | 31 | 34 | | | | |
| 30 | 6.183 | 3957 | 731 | 909 | 1092 | 1166 | | | | |
| 210 | 0.086 | 55 | 21 | 26 | 31 | 34 | | | | |
| 20 | 6.531 | 4180 | 764 | 950 | 1141 | 1281 | | | | |
| 10 | 6.555 | 4195 | | | | | | | | |
| Dunthorpe | | | | | | | | | | |
| 30 | 0.084 | 54 | 16 | 20 | 25 | 26 | | | | |
| 20 | 0.145 | 93 | 27 | 34 | 41 | 44 | | | | |
| Lake Oswego Downtown | | | | | | | | | | |
| 40 | 0.097 | 62 | 16 | 21 | 26 | 28 | | | | |
| 30 | 0.136 | 87 | 22 | 28 | 35 | 37 | | | | |
| 210 | 0.088 | 56 | 21 | 26 | 31 | 33 | | | | |
| N20 | 0.272 | 174 | 56 | 69 | 82 | 87 | | | | |
| N10 | 0.313 | 200 | 72 | 88 | 104 | 110 | | | | |
| S20 | 0.080 | 51 | 24 | 30 | 35 | 37 | | | | |
| S10 | 0.164 | 105 | 56 | 67 | 78 | 82 | | | | |
| Oswego Creek | | | | | | | | | | |
| 30 | 0.092 | 59 | 24 | 29 | 35 | 37 | | | | |
| 20 | 0.217 | 139 | 52 | 65 | 77 | 82 | 59 | 72 | 86 | 92 |
| 10 | 0.317 | 203 | 77 | 95 | 113 | 120 | 89 | 109 | 129 | 137 |
| Hallinan Heights | | | | | | | | | | |
| 20 | 0.064 | 41 | 20 | 24 | 28 | 30 | | | | |
| 10 | 0.109 | 70 | 29 | 36 | 42 | 45 | 32 | 39 | 46 | 49 |
| Glenmorrie | | | | | | | | | | |
| 20 | 0.089 | 57 | 17 | 22 | 26 | 28 | | | | |
| 10 | 0.205 | 131 | 39 | 48 | 58 | 62 | | | | |
| Old River Rd. | | | | | | | | | | |
| 20 | 0.128 | 82 | 21 | 27 | 32 | 35 | 30 | 37 | 45 | 48 |
| 10 | 0.216 | 138 | 38 | 47 | 57 | 61 | 56 | 69 | 81 | 86 |

NOTE:

* FUTURE FLOWs are left blank if they are the same as the existing flows to clearly distinguish fully developed basins.

## 4.5 DRAINAGE PLANNING CRITERIA

The establishment of drainage planning criteria used in the development of a master plan is an important process. These planning criteria establish an acceptable level of protection against flooding. This acceptable level of protection is then compared against the estimated risk of flooding throughout the major drainage system. When the estimated flood risk is greater than that established to be acceptable, the engineer must analyze the various alternatives available to mitigate flooding. The choices are then to either increase the level of protection such that it satisfies the criteria or to do nothing and consciously accept a lower level of protection than that specified in the criteria.

### Storm Recurrence Interval

In hydrologic simulation and drainage planning, both flood risks and level of protection against those risks are measured using the concept of storm recurrence interval or return period and its reciprocal function, the probability of exceedance.

If one designs a hydraulic structure using a 100-year storm recurrence interval, the probability that the design flow will be exceeded in any given year is only 1 percent, so the level of protection against flooding would be very high. If the design was based on a 2-year storm recurrence interval, the probability of exceedance would be very high 50 percent probability in any given year) and the level of protection would be low. The obvious trade-off in the planning and design of drainage facilities is the cost of the facility. A facility designed to withstand a 100-year flood peak will cost considerably more than one designed to only pass the 2-year flood.

Table 4.7 presents the recommended storm recurrence intervals for the planning and design of drainage improvements. These storm recurrence intervals are based on factors that define the various levels of flood risks. The factors include drainage area and the type of drainage improvement. The basic concept is to increase the recurrence interval to match increasing levels of potential flood damage risk.

Contributing drainage area is the most important factor since greater drainage areas will provide greater estimates of peak flow. Three categories of contributing drainage area have been identified in Table 4.7. As drainage area increases the potential for flood damage, the design storm recurrence interval increases also.

The type of drainage improvement is also important. As a general rule, open channels which include roadside ditches or swales should be designed for greater recurrence intervals when compared to closed pipe systems because of the increased risk of damage when failure occurs. In traditional practice, the closed pipe storm sewer designs are based on full flow conditions. This design practice is conservative in that extra capacity usually exists within the system when it is operating under infrequent pressure flow conditions. Pipes and bridges which cross major arterial roadways should be designed for a greater return interval than those crossing local collector streets. This provides a higher level of protection needed to keep the major transportation system accessible during a general condition of flooding.

To clarify various items contained in the table, several footnotes have been included. Footnote "f" is of particular interest because of its management and design implications. Footnote "f" allows the City to approve the use of the next lower design recurrence interval for a facility, if it can be shown that the cost of improving a facility is exceptionally greater than the corresponding benefits resulting from reduced flooding. This provides the City flexibility in drainage design for unusual circumstances that can arise throughout the study area.

## TABLE 4.7

## STORM RECURRENCE INTERVALS FOR PLANNING AND DESIGN OF STORM CONVEYANCE SYSTEM

| Drainage Area (acres) | | | *Type of Drainage Improvement* | | | | Design Storm Recurrence Interval In Years (e) |
|---|---|---|---|---|---|---|---|
| | | | | | (3) Culverts and Bridges | | |
| <40 | 40 to 640 | >640 | (1) Open Channel (a) | (2) Pipe (b) | Collectors (c) | Major Arterials (d) | |
| X | | | | X | X | | 10 |
| X | | | X | | | X | 25 |
| | X | | | X | | | 25 |
| | X | | X | | X | X | 50 |
| | | X | X | N/A | X | X | 50 |
| All improvements on waterways with FEMA 100-year flood plain | | | | | | | 100 |

a) Includes roadside ditches, drainage swales and streams.

b) Storm drains or a closed conduit whose length exceeds that of a normal culverted crossing of a single roadway.

c) Includes local or residential streets, local collectors, and any other roadways up to a major arterial.

d) Major arterial or better within the City's right-of-way maintenance.

e) Assuming ultimately planned development conditions (i.e. impervious cover).

f) Use the next lower recurrence interval if unusual site conditions would result in an exceptionally high cost differential without realizing a significant reduction of flood damage risks.

g) All detention facilities shall be designed to detain the maximum runoff volume difference between the 50-year post-development condition and the 10-year pre-development condition. Spillways shall be designed to safely pass a 50-year recurrence internal storm.

In the development of the Capital Improvements Program (CIP) footnote "f" has been interpreted as follows. In the following situation, a 25-year recurrence interval is required for design. An existing drainage structure is considered adequate, if:

(1) the existing structure can pass a 10-year future flow but cannot pass a 25-year future flow; and
(2) minor flooding impacts will result when the structure fails to pass the 25-year future flow.

In this case, the cost of achieving the 25-year protection is clearly more costly than achieving the 10-year protection since the existing structure already conveys this later design event.

### Intensity Duration Frequency Curves

Once the storm recurrence interval or design frequency is established, the engineer must be able to estimate the rainfall intensity to be used for design purposes. For this study the precipitation IDF curves for the Fanno Creek basin (City of Portland, 1976) are assumed to describe the rainfall patterns throughout the Lake Oswego study area. Figure 4.2 presents the IDF curves developed using the technique published in the NOAA Precipitation Atlas No. 2, Volume X (NOAA, 1973).

## 4.6 HYDRAULIC ANALYSES

Determination of the hydraulic capacity of conveyance structures requires site specific analysis. In order to maintain consistency during development of the capital improvement projects and agreement between the various users of this master plan, the following criteria were established to guide hydraulic analysis. Because limited data was available for this analysis both non-uniform flow and critical depth were not explicitly analyzed. Refer to Hydraulic Engineering textbooks for this information.

### Open Channel and Long Pipe Capacities

The Manning's equation was used to calculate the velocity and flow for various channel and pipe shapes. Application of this equation assumes steady and uniform flow. The general form of this equation is:

$$Q = 1.486/n * a * r^{2/3} * s^{1/2}$$

where:
- Q - discharge, cfs
- a - cross sectional flow area, $ft^2$
- n - Manning roughness coefficient
- r - Hydraulic radius, ft (i.e flow area divided by wetted perimeter
- s - slope, ft/ft

Manning roughness values presented in the Oregon Department of Transportation (ODOT) Hydraulic Manual should be used.

Non-uniform flow conditions were not analyzed. The most common type of non-uniform flow problems can be classified as backwater type. This occurs when a downstream constriction (e.g. pipe or bridge) limits the flow of water and causes water to backup in the channel above the constriction. There are numerous simulation models, such as HEC-2 and StormPlus, to aid in the analysis of these types of problems.

Critical depth in open channels is essential for determining where non-uniform control sections occur. Open channels should not be designed to operate at or near critical depth because of the instability of flow in these areas. The ODOT manual contains critical depth versus discharge charts for various geometric channels and conduits.

### Culvert Capacities

Either inlet control or outlet control may limit flow capacity in pipes, depending upon pipe type, size, slope, length, and tailwater elevation. Whichever section would result in the higher headwater elevation will govern. Determination of the control section requires more detailed, site specific data than was generally obtained during the field survey. Pipe slope was estimated to be channel slope, or, for longer pipes, surface slope. Most pipes were assumed to operate under inlet control, as their slope was so steep that tailwater effects would be negligible. However, a handful of the flatter or sediment-blocked pipes were found to be outlet control. Long pipes were modeled using Manning's equation, as described above.

Headwater is the total flow depth at the pipe inlet. In general allowable ponding upstream of a pipe is site specific and is influenced by several factors which include: the height of an embankment, impacts on the adjacent landowners, and traffic interruption. Allowable headwater was established to coincide with maintaining 1 foot of freeboard for open channels and embankments. The structural integrity of embankments was not evaluated and must be established prior to ponding water.

Performance curves for pipes operating under inlet control were developed for each facility based on nomographs found in the ODOT Hydraulics Manual.

## 4.7 HYDRAULIC INVENTORY AND PERFORMANCE EVALUATION

Evaluating the hydraulic performance of the City's major drainage system requires knowledge of the natural drainageways and an understanding of the hydraulic facilities located along these drainageways.

The delineation of the existing drainage system into the major system was completed using the City's aerial orthophotos and the drainage system inventory maps. Identification of the major system establishes the drainageways and facilities that were analyzed for hydraulic capacity and performance. Figure 4.3 presents the major drainage systems analyzed throughout the Lake Oswego study area.

A physical inventory of individual facilities along the major drainage system was completed during the months of October and November, 1991. The purpose was to collect data at each facility and to obtain missing physical information not shown on the inventory maps. Site specific data collected at each facility included: type of structure, physical dimensions, type of material, allowable head, length, slope and other pertinent data. This information was used to complete the hydraulic analysis and to identify deficiencies that could result in flooding, erosion or other related problems.

Table 4.8 provides an itemized summary of the performance of the existing hydraulic structures in each major basin within the 3 watersheds. Each hydraulic component is listed with its Node ID, location and the physical characteristics necessary to determine its approximate capacity (i.e. length, slope, size, type and allowable head). Node ID's are assigned at each facility inlet and increase upstream.

TABLE 4.8

## Hydraulic Inventory and Performance Evaluation

| LOCATION: WATERSHED Basin | Node ID | Location | STRUCTURE: Length ft | Slope ft/ft | Number & | Size (in) | Type | Head ft | DESIGN FLOW: Event Yr | Now cfs | Fut. cfs | CAPACITY: Flow cfs | Max cfs | DEFICIENT: Now? Yr | Fut? Yr | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **OSWEGO LAKE** | | | | | | | | | | | | | | | | |
| Springbrook Creek | | | | | | | | | | | | | | | | |
| SB | -106 | Path opposite Mozarteum Ct. | | | 3- | 24 | MC | 3 | 50 | 73 | 73 | 54 | | 25 | 25 | OK |
| SB | -104 | Cirque Rd. | | | | 54 | MC | 5 | 50 | 73 | 73 | 100 | | | | |
| SB | -102 | Kerr Pkwy (uppermost) | 50 | | | 24 | MC | 5 | 50 | 73 | 73 | 26 | 32 | 10 | 10 | |
| SB | -100 | Kerr Pkwy (middle) | 50 | | | 30 | CC | 8 | 50 | 118 | 118 | 70 | 92 | 10 | 10 | |
| SB | -910 | Berm (Old Kerr Rd.) | | | | 36 | MC | 10 | 50 | 67 | 67 | 80 | | | | |
| SB | -82 | Kerr Pkwy (lowermost) | 50 | | 2- | 30 | CC | 10 | 50 | 181 | 181 | 160 | | 50 | 50 | COST |
| SB | -80 | Boones Ferry Rd. | | | | 48 | CC | 10 | 100 | 229 | 229 | 370 | | | | |
| SB | -80a | | | | | 60 | MC | 10 | | | | | | | | |
| SB | -74 | Path from Tempest to Sherbrook | | | | 48 | CC | 15 | 100 | 229 | 229 | 240 | | | | |
| SB | -72 | Sherbrook Pl. | | | | 60 | MC | 10 | 100 | 229 | 229 | 250 | | | | |
| SB | -70 | WET DET (5B) and Rainbow Dr. | | | 72x | 96 | CB | 7 | 100 | 242 | 250 | 300 | | | | |
| SB | -60 | Twin Fir Rd. (upper) | 30 | | | 36 | MC | 3 | 100 | 328 | 358 | 32 | | 10 | 10 | |
| SB | -50 | WET DET (8D) and Spring Wy. | | 0.020 | 2- | 60 | CC | 8 | 100 | 328 | 358 | 310 | 400 | 100 | 50 | Boards |
| SB | -430 | PIPE | 1230 | 0.069 | | 18 | CC | | 10 | 17 | 17 | 28 | | | | |
| SB | -425 | SED BASIN | | | | 18 | CC | 8 | 50 | 19 | 19 | 22 | | | | |
| SB | -422 | Kruse Way Pl. | | | | 30 | CC | 4 | 50 | 37 | 37 | 40 | | | | |
| SB | -420 | Kruse Way | 100 | | | 30 | MC | 4 | 50 | 72 | 79 | 28 | 36 | 10 | 10 | |
| SB | -412 | Mercantile Dr. | 50 | | | 30 | CC | 4 | 50 | 72 | 79 | 37 | | 10 | 10 | |
| SB | -410 | WET DET 8C | | | | | | 5 | 50 | 101 | 109 | 40 | | 10 | 10 | IN |
| SB | -409 | PIPE | 250 | 0.004 | | 36 | CC | | 25 | 87 | 93 | 42 | | 10 | 10 | |
| SB | -408 | PIPE | 150 | 0.004 | | 30 | CC | | 25 | 87 | 93 | 26 | | 10 | 10 | |
| SB | -407 | PIPE | 300 | 0.004 | | 36 | CC | | 25 | 87 | 93 | 42 | | 10 | 10 | |
| SB | -32 | Boones Way | 30 | | | 48 | MC | 4 | 100 | 391 | 416 | 68 | | 10 | 10 | |
| SB | -321 | WET DET | | | | | | | | | | | | | | |
| SB | -320 | Waluga Way | 30 | | 36x | 19 | MA | 3 | 50 | 25 | 25 | 16 | | 25 | 25 | Clean |
| SB | -319 | WET DET | | | | | | | 50 | 25 | 25 | | | | | |
| SB | -318 | Perimeter Trail, Waluga Park | | | 20x | 16 | ME | 2 | 50 | 16 | 16 | 8 | | 25 | 25 | OK |
| SB | -316 | PIPE @ Waluga Park Playi | 2140 | 0.001 | | 24 | CC | 3 | 25 | 10 | 10 | 7 | | 25 | 25 | COST |
| SB | -310 | PIPE | 600 | 0.023 | | 36 | CC | | 25 | 60 | 60 | 101 | | | | |
| SB | -26 | Twin Fir Rd. (lower) | 30 | | | 42 | MC | 5 | 100 | 510 | 537 | 80 | | 10 | 10 | |
| SB | -24 | Brookside Rd. | 30 | | 2- | 36 | CC | 4 | 100 | 510 | 537 | 100 | | 10 | 10 | |
| SB | -22 | Iron Mountain Bv. (W) | 50 | | 36x | 54 | ME | 5 | 100 | 510 | 537 | 80 | | 10 | 10 | |
| SB | -211 | WET DET | | | | | | | | | | | | | | |
| SB | -210 | Iron Mountain Bv. (E) | 50 | | | 15 | MC | 3 | 50 | 30 | 30 | 10 | | 10 | 10 | |
| SB | -18 | SP Rail Road (20'H tot) | | | 72x | 78 | CA | -8 | 100 | 513 | 542 | 360 | | 25 | 25 | IN |
| Reese Road | | | | | | | | | | | | | | | | |
| RR | -12 | PIPE @ outlet control culvert | 300 | 0.067 | 27x | 17 | CA | 5 | 25 | 38 | 38 | 35 | | 25 | 25 | Clean |
| RR | -10 | PIPE @ SP Rail Road | 100 | 0.04 | | 20 | DC | 5 | 25 | 33 | 33 | 28 | | 25 | 25 | COST |
| RR | -9 | PIPE @Swim Park | 50 | 0.04 | | 18 | CC | | 25 | 33 | 33 | 21 | | 10 | 10 | |
| RR | -8 | PIPE @Swim Park | 300 | 0.04 | | 24 | CC | | 25 | 33 | 33 | 44 | | | | |
| Oswego Canal | | | | | | | | | | | | | | | | |
| OC | -100 | PIPE @ OC100 | 250 | 0.027 | | 18 | CC | 5 | 25 | 35 | 35 | 17 | | 10 | 10 | |
| OC | -210 | PIPE | 1100 | 0.019 | | 33 | CC | 5 | 25 | 17 | 17 | 73 | | | | |
| OC | -200 | PIPE | 700 | 0.023 | | 15 | CC | 5 | 25 | 40 | 40 | 10 | | 10 | 10 | |
| OC | -300 | PIPE @ OC300 | 880 | 0.03 | | 24 | CC | 5 | 25 | 44 | 44 | 39 | | 25 | 25 | COST |
| Blue Heron Canal | | | | | | | | | | | | | | | | |
| BHC | -20 | SED BASIN 17C (Side Out) | | | | | | | 50 | 22 | 22 | 22 | | | | |
| BHC | -19 | PIPE @ Blue Heron Rd. | 630 | 0.089 | | 15 | CC | 6 | 25 | 17 | 17 | 19 | | | | |
| BHC | -10 | PIPE @ S Shore | 0 | 0.089 | | 30 | CC | | 25 | 59 | 59 | 123 | | | | |

TABLE 4.8

## Hydraulic Inventory and Performance Evaluation

| LOCATION: WATERSHED Basin | Node ID | Location | STRUCTURE: Length ft | Slope ft/ft | Number & | Size (in) | Type | Head ft | DESIGN FLOW: Event Yr | Now cfs | Fut. cfs | CAPACITY: Flow cfs | Max cfs | DEFICIENT: Now? Yr | Fut? Yr | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| BHC | -310 | SED BASIN (17D) and Blue Heron Way | | | | 30 | | | 50 | 56 | 56 | 40 | | 25 | 25 | IN |
| BHC | -309 | PIPE | 450 | 0.051 | | 24 | CC | 4 | 25 | 47 | 47 | 51 | | | | |
| Fernwood | | | | | | | | | | | | | | | | |
| F | -16 | East Driveway off Greentree | | | | 30 | MC | 3 | 50 | 30 | 30 | 30 | | | | |
| F | -14 | West Driveway off Greentree | | | | 30 | MC | 4 | 50 | 30 | 30 | 37 | | | | |
| F | -12 | PIPE @ Greentree | 1050 | 0.072 | | 18 | CC | 3.5 | 25 | 37 | 37 | 28 | | 10 | 10 | |
| F | -10 | WET (SED) | 300 | 0.472 | | | | | 50 | 44 | 44 | | | | | |
| Lily Pond | | | | | | | | | | | | | | | | |
| Oswego Lake Country Club | | | | | | | | | | | | | | | | |
| CC | -20 | POND outlet | | | | | | | 50 | 23 | 23 | | | | | |
| CC | -19 | PIPE to Pond by Fairway Rd. | 900 | 0.02 | | 18 | CC | 4 | 25 | 14 | 14 | 15 | | | | |
| CC | -10 | Iron Mountain Bv. | | | | 24 | CC | 6 | 50 | 40 | 40 | 40 | | | | |
| CC | -8 | SP Rail Road | | | | 30 | DC | 8 | 50 | 40 | 40 | 65 | | | | |
| CC | -6 | North Shore Rd. | | | | 30 | CC | 12 | 50 | 40 | 40 | 90 | | | | |
| CC | -4 | Driveway off North Shore Rd | 100 | | | 18 | CC | 3 | 50 | 40 | 40 | 13 | 28 | 10 | 10 | PR |
| Palisades Heights | | | | | | | | | | | | | | | | |
| PH | -10 | PIPE | 540 | 0.072 | | 24 | MC | | 25 | 45 | 45 | 33 | | 10 | 10 | |
| Lost Dog Creek | | | | | | | | | | | | | | | | |
| LD | -50 | DRY DET (16A) and Sunny Hill Dr. | | | | 36 | MC | 6 | 50 | 34 | 34 | 70 | | | | |
| LD | -44 | Greentree Rd. | | | | 24 | CC | 10 | 50 | 32 | 32 | 45 | | | | |
| LD | -42 | Wall St. | | | | 24 | CC | 12 | 50 | 32 | 32 | 50 | | | | |
| LD | -40 | DRY DET and South Shor | | | | | | 7 | 50 | 72 | 72 | 110 | | | | |
| LD | -33 | Ped. Bridge (8x1 ft) | | | | | Br | | 50 | 86 | 86 | | | | | |
| LD | -32 | WET DET: Upper Palisade | | | | | | | 50 | 76 | 76 | | | | | |
| LD | -31 | WET DET (Lower Palisade | | | | | | | 50 | 76 | 76 | | | | | |
| LD | -30 | Palisades Terr. | | | | 36 | MC | 4 | 50 | 76 | 76 | 55 | 81 | 25 | 25 | IN |
| LD | -240 | Oak Meadow Ct. | | | | 30 | CC | 5 | 50 | 19 | 19 | 45 | | | | |
| LD | -234 | Oak Meadow Ln. | | | | 24 | CC | 4 | 50 | 19 | 19 | 26 | | | | |
| LD | -232 | Bergis Rd. | | | | 24 | CC | 5 | 50 | 19 | 19 | 25 | | | | |
| LD | -224 | PIPE Along McVey by Aspen | 0 | 0.036 | | 27 | CC | 3 | 50 | 41 | 46 | 59 | | | | |
| LD | -222 | Patton St. | 30 | | | 30 | CC | 4 | 50 | 60 | 63 | 42 | 92 | 25 | 25 | IN |
| LD | -220 | McVey Ave.->2d culvert | 50 | | | 36 | MC | 4.5 | 50 | 60 | 63 | 55 | 81 | 50 | 50 | COST |
| LD | -214 | South Shore Bv. | | | | 36 | CC | 4.5 | 50 | 60 | 63 | 63 | | | | |
| LD | -212 | Laurel St. | | | | 36 | CC | 4.5 | 50 | 60 | 63 | 63 | | | | |
| LD | -210 | Oak St. Inlet | | | | 24 | CC | 15 | 50 | 60 | 63 | 63 | | | | |
| LD | -209 | PIPE under Oak St. | | 0.05 | | 36 | CC | | 25 | 76 | 89 | 149 | | | | |
| LD | -10 | Lakefront | | | 6 x | 4 | CB | 4.5 | 50 | 160 | 165 | 168 | | | | |
| Lakewood Bay | | | | | | | | | | | | | | | | |
| Lower Boones Ferry | | | | | | | | | | | | | | | | |
| LBF | -54 | SP Rail Road (8' H tot) | | | | 24 | MC | -5 | 50 | 54 | 75 | 33 | | 10 | 10 | PR |
| LBF | -52 | WET DET and Newburg to Portland SP Rail Road | | | | 24 | MC | 8 | 50 | 14 | 18 | 33 | | | | |
| LBF | -50 | WET DET and Boones Ferry Rd. | | | | | | | 50 | 14 | 18 | 33 | | | | |
| LBF | -49 | PIPE (Boones Ferry Rd.) | 300 | 0.003 | | 24 | CC | | 25 | 68 | 77 | 13 | | 10 | 10 | |
| LBF | -48 | PIPE (Boones Ferry Rd.) | 780 | 0.003 | | 24 | CC | | 25 | 68 | 77 | 14 | | 10 | 10 | |
| LBF | -40 | PIPE (Pilkington) | 320 | 0.005 | | 27 | CC | | 25 | 68 | 77 | 23 | | 10 | 10 | |
| LBF | -39 | PIPE (Pilkington) | 270 | 0.008 | | 27 | CC | | 25 | 68 | 77 | 28 | | 10 | 10 | |
| LBF | -310 | PIPE | 520 | 0.016 | | 15 | CC | | 25 | 15 | 19 | 8 | | 10 | 10 | |
| LBF | -309 | PIPE (Pilkington) | 250 | 0.002 | | 30 | CC | | 25 | 15 | 19 | 20 | | | | |
| LBF | -30 | PIPE (Line A) | 860 | 0.004 | | 36 | CC | | 25 | 68 | 86 | 42 | | 10 | 10 | |
| LBF | -210 | SP Rail Road | 50 | | | 24 | MC | 3 | 50 | 33 | 33 | 18 | | 10 | 10 | |
| LBF | -208 | Lower Dr. | 30 | | | 18 | MC | 2 | 50 | 33 | 33 | 9 | | 10 | 10 | |
| LBF | -20 | DRY DET 18B | | | | | | 4 | 50 | 112 | 122 | 33 | | 10 | 10 | Remo |
| LBF | -19 | PIPE (Tualatin) | 311 | 0.002 | | 30 | CC | 4 | 25 | 93 | 103 | 22 | | 10 | 10 | |
| LBF | -12 | PIPE @ Depot St. | 500 | 0.04 | | 48 | CC | 5 | 25 | 100 | 110 | 110 | | | | |

TABLE 4.8

## Hydraulic Inventory and Performance Evaluation

| LOCATION: WATERSHED Basin | Node ID | Location | STRUCTURE: Length ft | Slope ft/ft | Number & Size | (in) | Type | Head ft | DESIGN FLOW: Event Yr | Now cfs | Fut. cfs | CAPACITY: Flow cfs | Max cfs | DEFICIENT: Now? Yr | Fut? Yr | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LBF | -10 | Bryant Rd. | | | | 42 | CC | 7 | 25 | 100 | 110 | 175 | | | | |
| West Bay | | | | | | | | | | | | | | | | |
| Jean Rd. | | | | | | | | | | | | | | | | |
| JR | -20 | PIPE (Lamont Wy) | 2530 | 0.006 | | 30 | CC | | 25 | 22 | 22 | 32 | | | | |
| JR | -10 | PIPE @ Bryant Rd. | 200 | 0.035 | | 24 | CC | 7 | 25 | 34 | 34 | 42 | | | | |

## TUALATIN RIVER

| Basin | Node ID | Location | Length ft | Slope ft/ft | Number & Size | (in) | Type | Head ft | Event Yr | Now cfs | Fut. cfs | Flow cfs | Max cfs | Now? Yr | Fut? Yr | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ball Creek | | | | | | | | | | | | | | | | |
| B | -62 | Vermeer | | | | 48 | CC | 5 | 50 | 56 | 60 | 260 | | | | |
| B | -60 | DRY DET (6B) and Peters and Galen Rds | | | | 36 | CC | 5.5 | 50 | 55 | 60 | 50 | 70 | 50 | 50 | Boards |
| B | -54 | Cascara Ln at Streamside Ct. | | | 36x | 40 | ME | 5.5 | 50 | 65 | 73 | 75 | | | | |
| B | -52 | SIPHON @ Melrose Rd. W of Peters | | | | 36 | CC | 2.5 | 50 | 74 | 86 | 90 | | | | |
| B | -510 | PIPE @ Melrose | 800 | 0.025 | | 30 | CC | | 25 | 55 | 55 | 65 | | | | |
| B | -509 | SIPHON @ Melrose Rd. W of Peters | | | | 36 | CC | 2.5 | 50 | 65 | 65 | 90 | | | | |
| B | -40 | Westlake | | | | 48 | CC | 3 | 50 | 129 | 146 | 146 | | | | |
| B | -39 | PIPE @ Westlake Dr. | 60 | 0.028 | | 42 | CC | 5 | 25 | 104 | 121 | 168 | | | | |
| B | -38 | PIPE near Westlake Dr. | 342 | 0.033 | | 48 | SC | 6 | 25 | 151 | 169 | 263 | | | | |
| B | -37 | PIPE near Westlake Dr. | 100 | 0.101 | | 36 | CC | 10 | 25 | 151 | 169 | 212 | | | | |
| B | -36 | PIPE near Westlake Dr. | 68 | 0.010 | | 42 | CC | 12 | 25 | 151 | 169 | 205 | | | | |
| B | -30 | Kruse Oaks Bv. S. | | | | 48 | CC | 17 | 50 | 192 | 239 | 240 | | | | |
| B | -230 | PIPE @ Fosberg and Jeffers | 550 | 0.036 | | 30 | CC | 5 | 25 | 60 | 60 | 78 | | | | |
| B | -222 | PIPE @ Rogers Rd. | 1067 | 0.035 | | 42 | CC | 6 | 25 | 60 | 60 | 189 | | | | |
| B | -220 | PIPE cont. | 270 | 0.033 | | 48 | CC | | 25 | 91 | 96 | 262 | | | | |
| B | -218 | Southwood St. at Deerfield Ct. | | | 48x | 54 | MC | 6.5 | 50 | 108 | 113 | 113 | | | | |
| B | -216 | WET DET (#) at end of Twin Creeks | | | | | | 4 | 50 | 108 | 113 | 60 | | 10 | 10 | OF |
| B | -214 | WET DET (6G) and path at end of Suncreek Dr. | | | | | | 4 | 50 | 107 | 112 | 92 | | 50 | 50 | COST, |
| B | -212 | Berm below path at end of S | 40 | | 36x | 24 | ME | 5 | 50 | 107 | 112 | 40 | | 10 | 10 | Remov |
| B | -210 | Kruse Oaks Bv. N | | | | 36 | CC | 15 | 50 | 160 | 160 | 160 | | | | |
| B | -16 | DRY STRUCT and trail from Centerp | | 0.010 | | 48 | CC | 15 | 50 | 345 | 381 | 300 | | 50 | 25 | OF |
| B | -16a | DRY STRUCT and trail from Centerp | | 0.010 | | 36 | MC | 7 | | | | | | | | |
| B | -14 | Onramp to Interstate 5 | | | | 84 | MC | 10 | 50 | 345 | 381 | 450 | | | | |
| B | -12 | Kruse Way | | | | 84 | MC | 10 | 50 | 345 | 381 | 450 | | | | |
| B | -114 | DRY DET (6E#1) and Centerpointe Dr. | | | | 27 | CC | 7 | 50 | 24 | 28 | 42 | | | | |
| B | -112 | DRY DET (6E#2) and path by Centerpointe Vl | | | | 27 | CC | 7 | 50 | 57 | 57 | 58 | | | | |
| B | -110 | Kruse Way and Bangy Rd. | | | | 36 | MC | 10 | 50 | 57 | 57 | 100 | | | | |
| B | -10 | Interstate 5 | | | | 72 | CB | 10 | 50 | 407 | 471 | 480 | | | | |
| Carter Creek | | | | | | | | | | | | | | | | |
| C | -50 | WET DET and Kruse Way | | | | 36 | CC | 4 | 50 | 50 | 50 | 28 | 50 | 10 | 10 | Boards |
| C | -49 | PIPE | 100 | 0.04 | | 27 | MC | 4 | 25 | 42 | 42 | 34 | | 25 | 25 | COST |
| C | -410 | Kruse Way | 100 | 0.033 | | 24 | MC | 5 | 50 | 28 | 41 | 22 | | 25 | 10 | |
| C | -34 | Old Irrigation Structure by K | 20 | | | 44 | SC | 4 | 50 | 78 | 78 | 70 | | 50 | 50 | Remov |
| C | -32 | Inlet at Meadows Rd. | 31 | 0.001 | | 18 | MC | 3 | 50 | 78 | 78 | 10 | | 10 | 10 | |
| C | -30 | PIPE @ Meadows Rd. | 240 | 0.002 | | 36 | CC | | 25 | 93 | 99 | 33 | | 10 | 10 | |
| C | -210 | Meadows Rd. | | | | 57 | MC | 10 | 50 | 44 | 53 | 215 | | | | |
| C | -208 | SED BASIN downstream | | | | | | | 50 | 44 | 53 | 210 | | | | |
| C | -14 | Berm above Kruse Meadows | 20 | | | 48 | MC | 4 | 50 | 211 | 246 | 68 | | 10 | 10 | Remov |
| C | -12 | Kruse Meadows Mall and Ba | 150 | 0.030 | | 48 | MC | 7 | 50 | 211 | 246 | 95 | | 10 | 10 | |
| C | -10 | Interstate 5 | 200 | | | 48 | MC | 8 | 50 | 259 | 292 | 125 | | 10 | 10 | |
| River Grove | | | | | | | | | | | | | | | | |
| River Run | | | | | | | | | | | | | | | | |
| Pecan Creek | | | | | | | | | | | | | | | | |
| P | -30 | Childs Rd. E | 50 | | | 24 | CC | 4 | 50 | 66 | 66 | 27 | 60 | 10 | 10 | |

TABLE 4.8

## Hydraulic Inventory and Performance Evaluation

| LOCATION: WATERSHED Basin | Node ID | Location | STRUCTURE: Length ft | Slope ft/ft | Number & | Size (in) | Type | Head ft | DESIGN FLOW: Event Yr | Now cfs | Fut. cfs | CAPACITY: Flow cfs | Max cfs | DEFICIENT: Now? Yr | Fut? Yr | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P | –210 | Childs Rd. W | 40 | 0.020 | | 30 | CC | 10 | 50 | 40 | 40 | 60 | | | | |
| P | –10 | Mossy Brae Rd. | 30 | 0.020 | | 36 | CC | 5 | 50 | 146 | 146 | 65 | 95 | 10 | 10 | |
| **WILLAMETTE RIVER** | | | | | | | | | | | | | | | | |
| Tryon Creek | | | | | | | | | | | | | | | | |
| T | –112 | Driveway E of Goodall #16 | | | | 24 | MC | 2 | 50 | 24 | 24 | 13 | 21 | 10 | 10 | PR |
| T | –110 | Goodall #17 | 60 | 0.035 | | 24 | MC | 2.5 | 50 | 24 | 24 | 17 | 23 | 25 | 25 | |
| T | –102 | Driveway W of Goodall #18 | | | | 24 | CC | 10 | 50 | 24 | 24 | 45 | | | | |
| T | –101 | outlet pond 50x30x2 | 400 | 0.055 | | | | | 50 | 24 | 24 | | | | | |
| T | –105 | Country Club Rd. (west) #19 | 250 | 0.152 | 2– | 15 | CC | 4 | 50 | 29 | 29 | 29 | 159 | | | |
| T | –92 | PIPE @ Country Club Rd. (m | 400 | 0.005 | 30x | 16 | CA | 10 | 25 | 74 | 74 | 20 | 30 | 10 | 10 | |
| T | –910 | Uplands #14 | 200 | 0.025 | | 24 | CC | 5 | 50 | 20 | 20 | 30 | | | | |
| T | –902 | DRY DET & Dolph Ct. | 200 | 0.065 | | 24 | CC | 5 | 50 | 20 | 20 | 30 | | | | |
| T | –82 | WET POND | | | | | | | | | | | | | | |
| T | –80 | Country Club (east) #12 | 500 | 0.010 | | 48 | CC | 10 | 50 | 136 | 136 | 170 | | | | |
| T | –70 | Atwater #9 | 100 | | | 48 | MC | 12 | 50 | 156 | 156 | 200 | | | | |
| T | –610 | Boca Raton (south) #10 | 100 | 0.050 | | 30 | MC | 12 | 50 | 25 | 25 | 70 | | | | |
| T | –510 | Boca Raton (north) #11 | 100 | 0.050 | | 36 | MC | 15 | 50 | 26 | 26 | 130 | | | | |
| T | –50 | Stoney Bridge #8 | | | | 60 | CC | 2 | 50 | 204 | 204 | 25 | | 10 | 10 | OK |
| T | –310 | Terwilliger Ext #4 | | | | 36 | CC | 6 | 50 | 31 | 31 | 70 | | | | |
| T | –210 | PIPE | 1100 | 0.033 | | 24 | CC | 5 | 25 | 26 | 26 | 41 | | | | |
| T | –20 | 43 @ Terwilliger [#20] . | | | | 96 | CB | 20 | 50 | 1141 | 1141 | 1200 | | | | |
| Dunthorpe | | | | | | | | | | | | | | | | |
| D | –30 | Rail Road #3 | | | 24x | 12 | CA | 2 | 50 | 12 | 12 | 12 | | | | |
| D | –22 | Briarwood #2a | | | | 12 | CC | 2 | 50 | 25 | 25 | 26 | | | | |
| D | –20 | Rail Road #2 | | | | 36 | DC | 4 | 50 | 41 | 41 | 50 | | | | |
| Downtown Lake Oswego North | | | | | | | | | | | | | | | | |
| LON | –40 | PIPE | 1300 | 0.029 | | 12 | CC | | 25 | 28 | 28 | 6 | | 10 | 10 | |
| LON | –30 | PIPE | 1000 | 0.050 | | 12 | CC | | 25 | 37 | 37 | 8 | | 10 | 10 | |
| LON | –210 | PIPE | 1500 | 0.017 | | 24 | CC | | 25 | 30 | 30 | 30 | | | | |
| LON | –20 | PIPE | 400 | 0.150 | | 24 | CC | | 25 | 65 | 65 | 88 | | | | |
| LON | –12 | PIPE | 300 | 0.073 | | 24 | CC | | 25 | 65 | 65 | 61 | | 25 | 25 | COST |
| LON | –10 | PIPE | 750 | 0.013 | | 24 | CC | | 25 | 88 | 88 | 26 | | 10 | 10 | |
| Downtown Lake Oswego South | | | | | | | | | | | | | | | | |
| LOS | –20 | PIPE under Bay | 1100 | 0.001 | | 12 | CC | | 25 | 30 | 30 | 1 | | 10 | 10 | |
| LOS | –19 | PIPE | 1400 | 0.043 | | 30 | CC | | 25 | 69 | 69 | 85 | | | | |
| LOS | –10 | PIPE | 500 | 0.010 | | 42 | CC | | 25 | 69 | 69 | 101 | | | | |
| Oswego Creek | | | | | | | | | | | | | | | | |
| O | –20 | PIPE (small) Maple #34 | 300 | 0.120 | | 18 | CC | 4 | 50 | 35 | 35 | 36 | | | | |
| Hallinan Heights | | | | | | | | | | | | | | | | |
| H | –20 | Obrien Trail #24 | | | | 24 | CC | 2 | 50 | 28 | 28 | 13 | | 10 | 10 | OK |
| H | –14 | Lund #23 | | | | 30 | MC | 4 | 50 | 28 | 28 | 38 | | | | |
| H | –12 | Bullock #22 | | | | 30 | MC | 5 | 50 | 28 | 28 | 45 | | | | |
| H | –10 | Hwy 43 #21 | 50 | | | 36 | CC | 7 | 50 | 42 | 46 | 80 | | | | |
| H | –8 | PIPE By Burnham #25 | | | | 18 | MC | 4 | 25 | 36 | 39 | 15 | | 10 | 10 | PR |
| H | –6 | Rogers Park Trail #36 | | | | 24 | MC | 3 | 50 | 42 | 46 | 20 | | 10 | 10 | OK |
| Glenmorrie | | | | | | | | | | | | | | | | |

TABLE 4.8

## Hydraulic Inventory and Performance Evaluation

| LOCATION: WATERSHED Basin | Node ID | Location | STRUCTURE: Length ft | Slope ft/ft | Number & Size (in) | Type | Head ft | DESIGN FLOW: Event Yr | Now cfs | Fut. cfs | CAPACITY: Flow cfs | Max cfs | DEFICIENT: Now? Yr | Fut? Yr | Notes |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| G | -22 | Cherrie Ln #26 | 200 | | 15 | CC | 2 | 50 | 26 | 26 | 12 | | 10 | 10 | |
| G | -20 | PIPE @ Hwy 43 [#27] | 500 | 0.100 | 15 | CC | | 25 | 22 | 22 | 24 | | | | |
| G | -16 | Off Glenwood Ct | | | 24 | CC | 3 | 50 | 26 | 26 | 26 | | | | |
| G | -14 | Off Glenmorrie Tr | | | 24 | MC | 4 | 50 | 26 | 26 | 26 | | | | |
| G | -12 | Ivy Ln #30 | | | 24 | CC | 10 | 50 | 26 | 26 | 45 | | | | |
| Old River Rd. | | | | | | | | | | | | | | | |
| ORR | -20 | Hwy 43 near Marylhurst #28 | 100 | 0.060 | 12 | CC | 3 | 50 | 32 | 45 | 45 | | | | |
| ORR | -20a | | | | 18 | CC | 3 | | | | (14) | | | | |
| ORR | -20b | | | | 24 | CC | 3 | | | | (23) | | | | |
| ORR | -10 | Old River Rd north #32 | 30 | 0.060 | 24 | VC | 5 | 50 | 57 | 81 | 35 | 56 | 10 | 10 | |
| | | | | | | | | | | | | COUNT: | 72 | 72 | |

**Key to NOTES Column:**

Reason if not included as CIP:

- OK — Minimal flood risk, no improvement required
- COST — Cost too high, next lower recurrence interval flow conveyed, no improve
- Boards — Lower or remove outlet flashboards to increase capacity
- Clean — Remove accumulated sediment or debris
- PR — Privately owned facility

Included only as minor-modification CIP

- IN — Enlarge inlet to increase efficiency
- Remove — Remove obstructing structure, berm, and/or pipe
- OF — Improve overflow spillway

Deficiencies without NOTEs are to be replaced with circular concrete pipe, as noted in Table 5.3

**2-Letter TYPE Codes:**

| | | | |
|---|---|---|---|
| Br | Bridge | C* | Concrete |
| *C | Circular | M* | Corr. Metal |
| *A | Arch | D* | Ductile Iron |
| *E | Elliptical | V* | Vitreous Clay |
| *B | Box | S* | Smooth Metal |

City of Lake Oswego
SWM Master Plan

# Major Drainage System

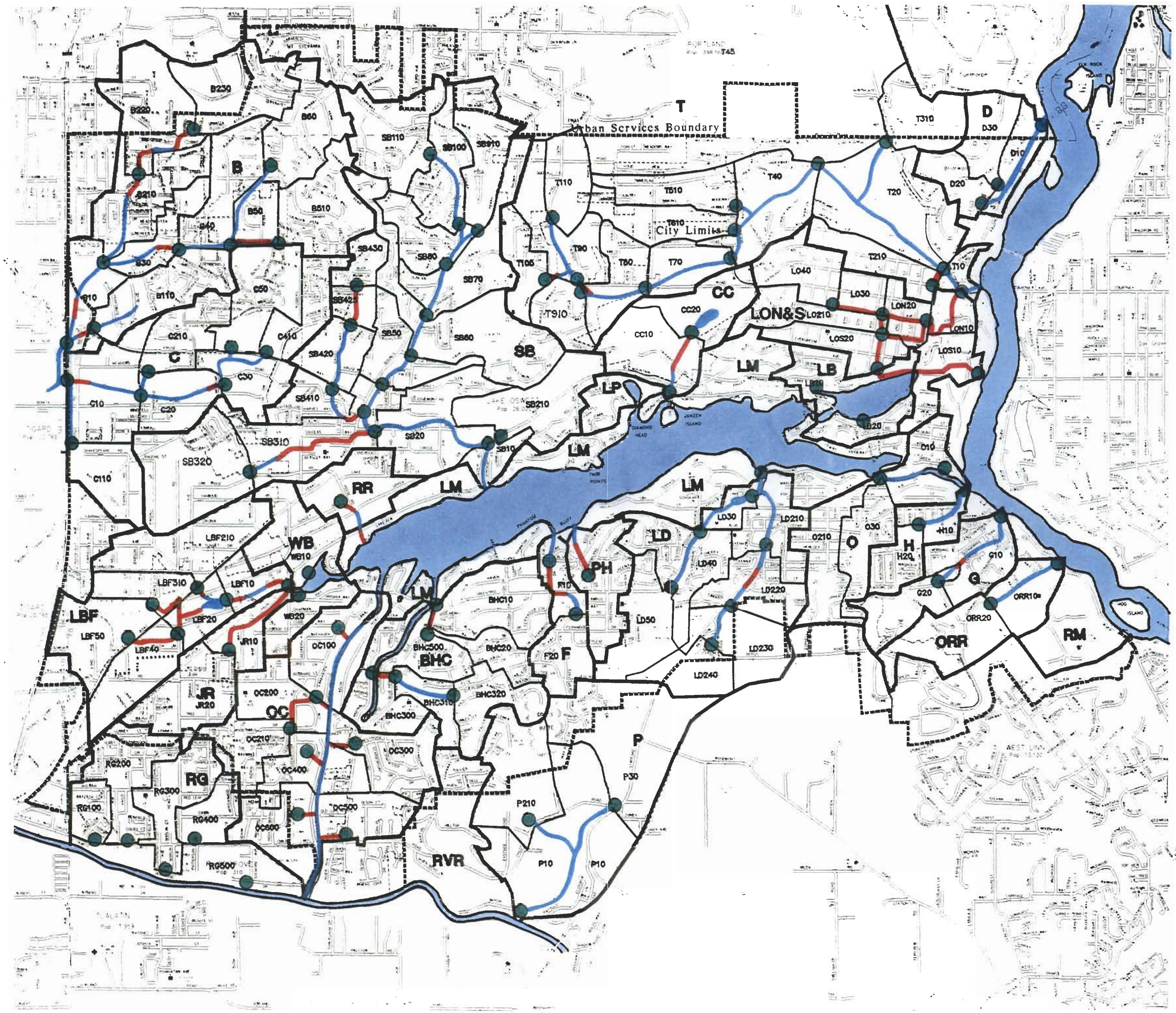



Figure 4.3

0 1200 2400 3600

otak

The design flow for each facility is listed after the physical information. The appropriate design recurrence interval event is based on the criteria presented in Table 4.7. The peak nodal design flows are presented for both existing and future development conditions.

The hydraulic capacity of each element follows the design flow. Two categories of capacity are identified "Flow" and "Max." Data in the column titled "Flow" is the capacity estimated for the conditions found during the inventory. Data under "Max" is the capacity that could be possible if the inlet were enlarged or the culvert cleaned.

Some of the hydraulic components in the table have a note in the far right column. This note indicates that the particular facility has unique features that would reduce the need to replace the entire existing structure. Either the deficiency could be mitigated through improved maintenance practices or enlarged inlet, among others, or the deficiency appears to have a low enough priority that construction funds could be better spend on other projects.

Flood Control
Management
Plan

# CHAPTER 5

# FLOOD CONTROL MANAGEMENT PLAN

Flood control management seeks to develop a unified land drainage and flood control program. Such a program can reduce future flooding while systematically eliminating annual flooding through implementing capital improvements and developing policies that preserve natural drainageways and floodplains. Existing problems can be mitigated by applying the proper combination of nonstructural and structural measures. Nonstructural components recognize the natural drainage system and seek to preserve these features. Structural components change floodwater distribution by conveying it, storing it or a combination of these strategies.

Developing this Flood Control Management Plan involves a four step process:

1) Establish the program goals.

2) Identify the primary techniques for implementing drainage/flood control.

3) Apply these techniques to control flood impacts, comply with the adopted design criteria and develop a management plan for each major drainage basin.

4) Document unit cost data for developing CIP construction costs.

## 5.1 FLOOD CONTROL MANAGEMENT GOALS

The Flood Control Management program should be consistent with the Community Objectives established by the Policy Committee for the management of surface water.

These objectives state "that the governing principle behind all ... policies relating to surface water management is to fully utilize the natural water drainage system to convey and dispose of runoff, while protecting and maintaining the natural functions and values of that system." Furthermore, this program is to cost-effectively implement and maintain a surface water drainage system that "promotes public safety and minimizes property damage, protects and enhances the quality of water and preserves and enhances fish and wildlife habitats."

The project team also established four secondary planning principles conforming with the Community Objectives to guide the development of the SWM Master Plan document. These principles assured the plan is:

- Technically acceptable and reliable.

- Compatible with all City departments that share administrative responsibility for Flood Control Management.

- Environmentally sound.

- Flexible so it can be adopted as the study area develops.

## 5.2 MANAGEMENT TECHNIQUES

The primary techniques for managing drainage and reducing flood damage that result from urbanization are:

- Increase conveyance or capacity of pipes, culverts, and open channels to carry peak storm water flows quickly through the drainage system.
- Increase storage both on-site and regionally to delay or reduces runoff peak flows downstream.
- Combine conveyance and storage, considering that reduction in the peak flow reduces the need to enlarge downstream facilities.
- No action, maintaining the existing system as-is, provides a baseline against which to compare costs and benefits of the other three techniques.

### Increased Conveyance

Every watershed has a storm water conveyance system whether it is natural or manmade, planned or unplanned. When the existing system cannot accommodate existing or future runoff, conveyance system improvements may be warranted.

This technique focuses on increasing the capacity of the downstream conveyance system to carry the increased runoff from urbanizing upstream areas. Conveyance improvements should be designed taking full advantage of the natural system, without impacting property, streams, wetlands or receiving water. However, when the natural system is inadequate because site specific factors limit its utility, it may be necessary to construct structural conveyance devices.

Conveyance devices are designed for routing flows, improving the flow carrying capacity of a drainageway, controlling erosion or diverting flow away from problem or sensitive areas. These improvements involve either replacing existing pipes and storm drains systems with larger facilities, armoring to prevent erosion, removing debris or installing smooth liners that reduce channel friction and increase capacity.

These features do not improve water quality except by reducing erosion. Many structural facilities increase the concentration of storm water pollutants by directly discharging to streams and bypassing natural filtration processes available in drainageways. In most instances these devices move flood peaks through a basin faster and worsen flooding in the downstream areas. Regardless of these shortcomings, structural conveyance improvements are sometimes necessary and therefore constitute viable options in the formulation of this plan.

The decision to construct a conveyance facility is based primarily on economic factors. The costs associated with improving existing drainage systems or stabilizing natural channels to handle increased flows escalates rapidly in some areas. The decision to build improvements is very site specific and is a function of many factors, including available land, size of upstream basin and the extent that flooding impacts that would be mitigated by the improvement.

## Increased Storage

Storage reduces downstream peak flows where potential conveyance system deficiencies can occur. There are several types of storage, depending upon the threshold design flows and the length of detention, and they usually can not share storage volume. Flood control storage would only begin to fill during the largest events, while water quality storage would fill much more often, but would fill far too soon to reduce peak flood control flows. Storage may either be in-stream and fill as streamflow increases, or off-line and fill after a stream reaches a certain threshold stage and spills into it.

These facilities perform differently depending upon when they fill and how they are drained:

- Retention is long-term storage that reduces the total volume of runoff by capturing it and lets it infiltrate or evaporate. They have no outlet other than an emergency drain and spillway, and can either be in-stream or off-line (to allow a base flow to bypass the facility). This is usually most feasible for the frequent, small storms that are more important to water quality.

- Extended detention is also long-term storage that may appear to reduce the total volume of runoff, as the outlets release only a tiny amount of flow. It functions otherwise much as retention, and is also most feasible for smaller, more frequent storms.

- Detention is temporary storage to reduce peak flows during the largest but infrequent events, and release it after the storm peak has passed. Off-line facilities are optimal for reducing peak flows, as the entire storage volume can fill when flows exceed some design threshold. The water may be stored for short or long periods of time, depending upon the outlet design.

The concept of detention is simple: store the excess storm water upstream above the locations that cause downstream flooding problems and release the detained water at a lower rate than the inflow. This is desirable in watersheds where land use changes in the headwater areas cause flows that strain already-developed downstream drainage systems. Two types of detention storage facilities are feasible within the service area:

- Local detention - represents low volume storage designed into storm drainage systems within developments to limit runoff at a mandated value. This may include ponding at storm drain inlets, ponds in channels, and storage upstream of pipes or in below ground facilities.

- Regional Detention - consist of medium to large facilities with relatively large storage volumes that are available for capturing storm runoff volumes. Regional facilities serve large portions of a drainage basin and are not associated with any single development. Regional detention facilities are usually publicly owned and maintained.

Providing detention storage is a sound management approach to reduce drainage and flood control problems. Most drainage systems have storage available within them which through proper planning and design can reduce drainage problems. The proper placement of detention storage facilities can effectively mitigate the impacts of urbanization on drainage systems.

## Combined Conveyance and Storage

In many cases, a combination of increased conveyance storage would provide the most cost-effective solution to flood control problems. Only enlarging the conveyance system to carry peak discharges becomes costly, especially in the lower reaches of a watershed where large upland areas contribute runoff. Moreover, peak flows can impair water quality through increased channel erosion and transport of sediments and debris. Impacts on downstream development may also be severe.

Implementing regional detention storage along the major system can significantly reduce peak storm discharges and reduce the need to enlarge the conveyance system. Secondary water quality benefits can also be achieved by delaying storm water runoff in storage basins before being released into the receiving water.

### No Action

This approach implies no changes will be made to the present drainage system. It is included in the evaluation process as a baseline for comparison. Simply maintaining the existing system could result in continued damage and inconvenience caused by inadequately sized facilities within the drainage system. However, if adequate drainage capacity exists within the existing system for both existing and ultimately planned development conditions, the no action alternative is appropriate.

## 5.3 DRAINAGE PLAN DEVELOPMENT PROCESS

Development of the flood control management plan followed a set process. All major drainage system components were evaluated to determine how well the management techniques address and correct problems at a specific location. Each technique was tested against a number of factors such as: peak flow magnitude, existing hydraulic capacity, topographical constraints, downstream impacts and effectiveness in achieving the project objectives.

The technique selected was the control measure which optimized the benefits (e.g. project objectives and design criteria) and minimized negative factors within the identified site specific conditions. The result of this process constitutes the recommended drainage plan for each major basin identified.

## 5.4 DEVELOPMENT OF COSTS

The SWM Master Plan is a planning document that guides implementation of the flood control and water quality management plan within the service area. Cost estimates presented throughout this document are planning level. Their accuracy should fall within the construction contingency.

Typically, a planning estimate is established during a project's preliminary design phase to determine feasibility, evaluate alternate solutions, and establish financial need. This type of estimate is based on available planning/engineering data and limited cost information and does not involve detailed data gathering or analysis.

The costs have been developed on current construction price data and trends. For this report, all estimated construction costs are based on the Engineering News Record-Construction Cost Index (ENR-CCI) of 5134 (Seattle, January, 1992). Future costs can be obtained by applying the ratio of the prevailing ENR-CCI for Seattle to the established base index.

### Unit Construction Costs

The estimated storm sewer construction costs is based on the use of concrete pipe with gasketed joints. Unit costs include excavation, pipe, select import bedding and backfill, pavement replacement, testing and cleanup. Pavement replacement was developed for each pipe size and is included in the unit cost. This cost is based on cutting the existing road surface to a specified width prior to excavation and placement of 8 inches of granular rock followed by 3 inches of asphalt concrete paving.

| TABLE 5.1<br>UNIT COSTS FOR IMPROVEMENTS | | | |
|---|---|---|---|
| ITEM | | UNIT | COST $ |
| 1 | MOBILIZATION | | |
| | PROJECT <=$25000 | LS | 2000 |
| | PROJECT >=$25000 | LS | 8% |
| 2 | TRAFFIC CONTROL | LS | 3% |
| 3 | BULK EXCAVATION | | |
| | PROJECT<=1000 CYD | CYD | 15 |
| | 1001 CYD<=PROJECT<=10000 CYD | CYD | 12 |
| | 10001 CYD<=PROJECT<=50000 CYD | CYD | 6 |
| | PROJECT>=50000 CYD | CYD | 3.5 |
| 4 | DITCH EXCAVATION | CYD | 7 |
| 5 | EMBANKMENT IN PLACE | CYD | 6 |
| 6 | SAWCUTTING PAVEMENT | LF | 1 |
| 7 | TOPSOIL FURNISHING AND PLACING | CYD | 12 |
| 8 | STRUCTURAL EXCAVATION | CYD | 16 |
| 9 | ASPHALT PAVING 3" CLASS C | SYD | 4.25 |
| 10 | REINFORCED CONCRETE | | |
| | BOX CULVERT | LF | SEE TABLE C-1 |
| 11 | CONCRETE HEADWALLS, INLETS & OUTLETS | CYD | 425 |
| 12 | METAL PIPE | | |
| | CIRCULAR CULVERTS | | SEE TABLE C-2 |
| | ARCH PIPE PLATE | | SEE TABLE C-3 |
| 13 | STORM SEWER CONCRETE | LFT | SEE TABLE C-4 |
| 14 | MANHOLES | EA | 2100 |
| 15 | WATER QUALITY CONTROL MANHOLE | EA | 3200 |
| 16 | INLET TYPE P | EA | |
| | SINGLE | | 500 |
| | DOUBLE | | 650 |
| 17 | STANDARD CATCHBASIN | EA | 600 |
| 18 | DRAINAGE GEOTEXTILE FABRIC | SYD | 1.29 |
| 19 | RIPRAP LOOSE | | |
| | CLASS 50 | CYD | 40 |
| | CLASS 100 | CYD | 23 |
| 20 | EROSION CTRL (MATTING, SED. FENCES,ETC) | SYD | 3 |
| 21 | SEEDING MULCHING AND FERTILIZING | AC | 1000 |
| 22 | BOULDER WEIRS | EA | 1000 |
| 23 | EMBANKMENT,IN-PLACE,USING BORROW MTRL | CYD | 6 |
| 24 | OVERSIZED CATCH BASIN | EA | 1100 |
| 25 | OVERSIZED SIDE INLET CATCH BASIN | EA | 800 |

Allowances for difficult conditions, traffic control and utility interference must be added to the basic costs where applicable. Costs for special structures must be estimated individually.

Table 5.1 summarizes the unit costs developed and used in the capital improvements cost estimates presented later. Further documentation of unit cost data is provided in Appendix C.

### Project Construction Costs

The total project construction cost is comprised of the accumulated costs for all project components and includes construction contingency, engineering design, and construction inspection costs. These factors are typically estimated as a percentage of the construction cost. Each of these factors is discussed below.

#### Construction Contingency

This allowance covers unknown conditions that may occur during the project that cannot be determined at the project outset. It is the intent of the contingency to build a level of conservatism to account for unforeseen or unknown conditions. Fifteen percent of the estimated construction cost is attributed to the construction contingency.

#### Engineering Design

This factor considers all activities required for engineering the project from its inception through construction management and project closeout. The total engineering services are estimated to be 12% of the construction cost.

#### Construction Inspection

This factor covers the cost expected to be realized by the City administering a construction project. Associated costs can include legal fees with executing the contract, inspection services and other miscellaneous activities. This cost is estimated to be 8 percent of the construction cost.

**TABLE 5.2**

**Construction Cost Adjustment Factors**

| | |
|---|---|
| Construction Contingency | 15% |
| Engineering Design | 12% |
| Construction Inspection | 8% |

Total Construction Cost = (estimated construction cost x 1.15) x 1.20

## 5.5 RECOMMENDED CAPITAL IMPROVEMENTS PROGRAM

The ultimate goal of a drainage master plan is the identification of potential problems in a drainage system and the development of a means to mitigate or, when possible, eliminate the effects of the problems. The physical components of these solutions are specified as projects that form the capital improvements program (CIP).

Working with the hydraulic performance evaluation presented in Chapter 4, the hydrologic models of each basin and the various management techniques outlined in Section 5.2, cost effective solutions to flood control problems were identified throughout the major drainage collector systems studied in the Lake Oswego area. These recommended solutions or capital improvement projects form the basis of the water quantity related or flood control capital improvements program.

Table 5.3 prioritizes the fifty three recommended flood control CIPs throughout the Lake Oswego study area. Projects were prioritized to correct problems that would yield the greatest benefit for the estimated capital expenditure. Forty-four are recommended for construction within existing Lake Oswego corporate limits by 2012 at a total project cost of $2.574 million in 1992 dollars. Nine others are recommended for the remaining study area, at an additional $285,000. Costs include the adjustment factors described previously. Figures 5.1a through 5.1d show the location of identified major drainage facilities, highlighting the recommended CIPs in red.

In scheduling improvements, the following priorities are recommended:

- Complete projects within Lake Oswego jurisdiction. Others can be completed later by the City as they are annexed, or by Clackamas County.

- Complete projects which cost less than $10,000 over a shorter term. Many of these less expensive projects can be completed for the cost of one of the larger ones, allowing more areas to see benefits from the SWM plan at an earlier time.

- Prioritize these lower-cost projects by estimated improvement cost.

- Complete projects which cost more than $10,000 by 2012. These larger projects can be spread out over twenty years.

- Prioritize these higher-cost projects by their ratio of improvement cost to relative deficiency. This relative deficiency is the fraction of design flow which can not be conveyed through the existing pipe or culvert, and reflects the flood risk which would be relieved by the project.

The City should continue to regularly maintain and clean its storm water system consisting of an estimated: 150 miles of pipe and open channels, 2880 storm water inlets and catchbasins, and 170 miles of publicly owned streets. The County should also maintain and clean the storm water systems within its jurisdiction throughout the study area. In addition, existing drainage sumps and drywells in both the City and the County should be inventoried, regularly inspected to identify clogging, and periodically cleaned. Finally, any new drywells should include sediment-trapping inlets to reduce drywell clogging.

Increasing regional detention for large (i.e. 10 to 100 year) design storms is not recommended for drainage basins within the study area. Extreme runoff storage volumes are required for any significant reduction in flow, and in order to be effective, these facilities would only begin to fill at very high flows, and could not provide any water quality benefits during more frequent storms.

TABLE 5.3

# Flood Control Capital Improvement Projects

| LOCATION Basin | ID | Description | STRUCTURE Length ft | Slope ft/ft | Number & | Size (in) | Type | Head ft | DESIGN FLOW Event Yr | Now cfs | Fut. cfs | CAPACITY Flow cfs | DEFICIENT Now? Yr | Fut? Yr | IMPROVEMENT Type | Size (in) | Cost ($1,000) | Total ($1,000) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Inside City of Lake Oswego** | | | | | | | | | | | | | | | | | | |
| B | -16 | DRY STRUCT and trail from Centerp | | 0.010 | | 48 | CC | 15 | 50 | 345 | 381 | 300 | 50 | 25 | OF | | $4 | $4 |
| B | -216 | WET DET (#) at end of Twin Creeks | | | | | | 4 | 50 | 108 | 113 | 60 | 10 | 10 | OF | | $4 | $8 |
| B | -212 | Berm below path at end of S | 40 | | 36x | 24 | ME | 5 | 50 | 107 | 112 | 40 | 10 | 10 | Remove | | $4 | $12 |
| BHC | -310 | SED BASIN (17D) and Blue Heron Way | | | | 30 | | | 50 | 56 | 56 | 40 | 25 | 25 | IN | 42 | $7 | $19 |
| SB | -18 | SP Rail Road (20'H tot) | | | 72x | 78 | CA | -8 | 100 | 513 | 542 | 360 | 25 | 25 | IN | 8x8 | $7 | $26 |
| LBF | -20 | DRY DET 18B | | | | | | 4 | 50 | 112 | 122 | 33 | 10 | 10 | IN | | $7 | $33 |
| SB | -410 | WET DET 8C | | | | | | 5 | 50 | 101 | 109 | 40 | 10 | 10 | IN | 54 | $7 | $40 |
| LD | -222 | Patton St. | 30 | | | 30 | CC | 4 | 50 | 60 | 63 | 42 | 25 | 25 | IN | 42 | $7 | $47 |
| LD | -30 | Palisades Terr. | | | | 36 | MC | 4 | 50 | 76 | 76 | 55 | 25 | 25 | IN | 42 | $7 | $54 |
| ORR | -10 | Old River Rd north #32 | 30 | 0.060 | | 24 | VC | 5 | 50 | 57 | 81 | 35 | 10 | 10 | | 48 | $8 | $62 |
| LBF | -208 | Lower Dr. | 30 | | | 18 | MC | 2 | 50 | 33 | 33 | 9 | 10 | 10 | | 30 | $5 | $67 |
| LBF | -210 | SP Rail Road | 50 | | | 24 | MC | 3 | 50 | 33 | 33 | 18 | 10 | 10 | | 30 | $8 | $75 |
| RR | -9 | PIPE @ Swim Park | 50 | 0.04 | | 18 | CC | | 25 | 33 | 33 | 21 | 10 | 10 | | 24 | $6 | $81 |
| SB | -60 | Twin Fir Rd. (upper) | 30 | | | 36 | MC | 3 | 100 | 328 | 358 | 32 | 10 | 10 | BOX | 2-7X | $48 | $129 |
| SB | -26 | Twin Fir Rd. (lower) | 30 | | | 42 | MC | 5 | 100 | 510 | 537 | 80 | 10 | 10 | BOX | 2-8X | $53 | $182 |
| SB | -22 | Iron Mountain Bv. (W) | 50 | | 36x | 54 | ME | 5 | 100 | 510 | 537 | 80 | 10 | 10 | BOX | 2-8X | $89 | $271 |
| SB | -32 | Boones Way | 30 | | | 48 | MC | 4 | 100 | 391 | 416 | 68 | 10 | 10 | BOX | 2-7X | $48 | $320 |
| LOS | -20 | PIPE under Bay | 1100 | 0.001 | | 12 | CC | | 25 | 30 | 30 | 5 | 10 | 10 | | 42 | $261 | $581 |
| LBF | -49 | PIPE (Boones Ferry Rd.) | 300 | 0.003 | | 24 | CC | | 25 | 68 | 77 | 13 | 10 | 10 | | 48 | $83 | $663 |
| LBF | -48 | PIPE (Boones Ferry Rd.) | 780 | 0.003 | | 24 | CC | | 25 | 68 | 77 | 14 | 10 | 10 | | 48 | $215 | $796 |
| SB | -24 | Brookside Rd. | 30 | | 2- | 36 | CC | 4 | 100 | 510 | 537 | 100 | 10 | 10 | BOX | 2-8X | $53 | $849 |
| LBF | -19 | PIPE (Tualatin) | 311 | 0.002 | | 30 | CC | 4 | 25 | 93 | 103 | 22 | 10 | 10 | | 54 | $98 | $947 |
| LON | -40 | PIPE | 1300 | 0.029 | | 12 | CC | | 25 | 28 | 28 | 6 | 10 | 10 | | 24 | $162 | $1,108 |
| LON | -30 | PIPE | 1000 | 0.050 | | 12 | CC | | 25 | 37 | 37 | 8 | 10 | 10 | | 24 | $124 | $1,233 |
| OC | -200 | PIPE | 700 | 0.023 | | 15 | CC | 5 | 25 | 40 | 40 | 10 | 10 | 10 | | 27 | $114 | $1,346 |
| T | -92 | PIPE @ Country Club Rd. (m | 400 | 0.005 | 30x | 16 | CA | 10 | 25 | 74 | 74 | 20 | 10 | 10 | | 48 | $110 | $1,457 |
| SB | -408 | PIPE | 150 | 0.004 | | 30 | CC | | 25 | 87 | 93 | 26 | 10 | 10 | | 48 | $41 | $1,498 |
| LON | -10 | PIPE | 750 | 0.013 | | 24 | CC | | 25 | 88 | 88 | 26 | 10 | 10 | | 36 | $150 | $1,648 |
| LBF | -40 | PIPE (Pilkington) | 320 | 0.005 | | 27 | CC | | 25 | 68 | 77 | 23 | 10 | 10 | | 48 | $88 | $1,737 |
| SB | -210 | Iron Mountain Bv. (E) | 50 | | | 15 | MC | 3 | 50 | 30 | 30 | 10 | 10 | 10 | | 36 | $10 | $1,746 |
| SB | -420 | Kruse Way | 100 | | | 30 | MC | 4 | 50 | 72 | 79 | 28 | 10 | 10 | | 48 | $28 | $1,774 |
| SB | -102 | Kerr Pkwy (uppermost) | 50 | | | 24 | MC | 5 | 50 | 73 | 73 | 26 | 10 | 10 | | 42 | $12 | $1,786 |
| LBF | -39 | PIPE (South,Pilkington) | 270 | 0.008 | | 27 | CC | | 25 | 68 | 77 | 28 | 10 | 10 | | 48 | $74 | $1,860 |
| LBF | -310 | PIPE | 520 | 0.016 | | 15 | CC | | 25 | 15 | 19 | 8 | 10 | 10 | | 24 | $65 | $1,925 |
| SB | -407 | PIPE | 300 | 0.004 | | 36 | CC | | 25 | 87 | 93 | 42 | 10 | 10 | | 48 | $83 | $2,007 |
| SB | -409 | PIPE | 250 | 0.004 | | 36 | CC | | 25 | 87 | 93 | 42 | 10 | 10 | | 48 | $69 | $1,994 |
| G | -22 | Cherrie Ln #26 | 200 | | | 15 | CC | 2 | 50 | 26 | 26 | 12 | 10 | 10 | | 30 | $33 | $2,026 |
| SB | -412 | Mercantile Dr. | 50 | | | 30 | CC | 4 | 50 | 72 | 79 | 37 | 10 | 10 | | 48 | $14 | $2,040 |

Cost < $10,000 (rows B -16 through RR -9)

Cost > $10,000 (rows SB -60 through SB -412)

TABLE 5.3

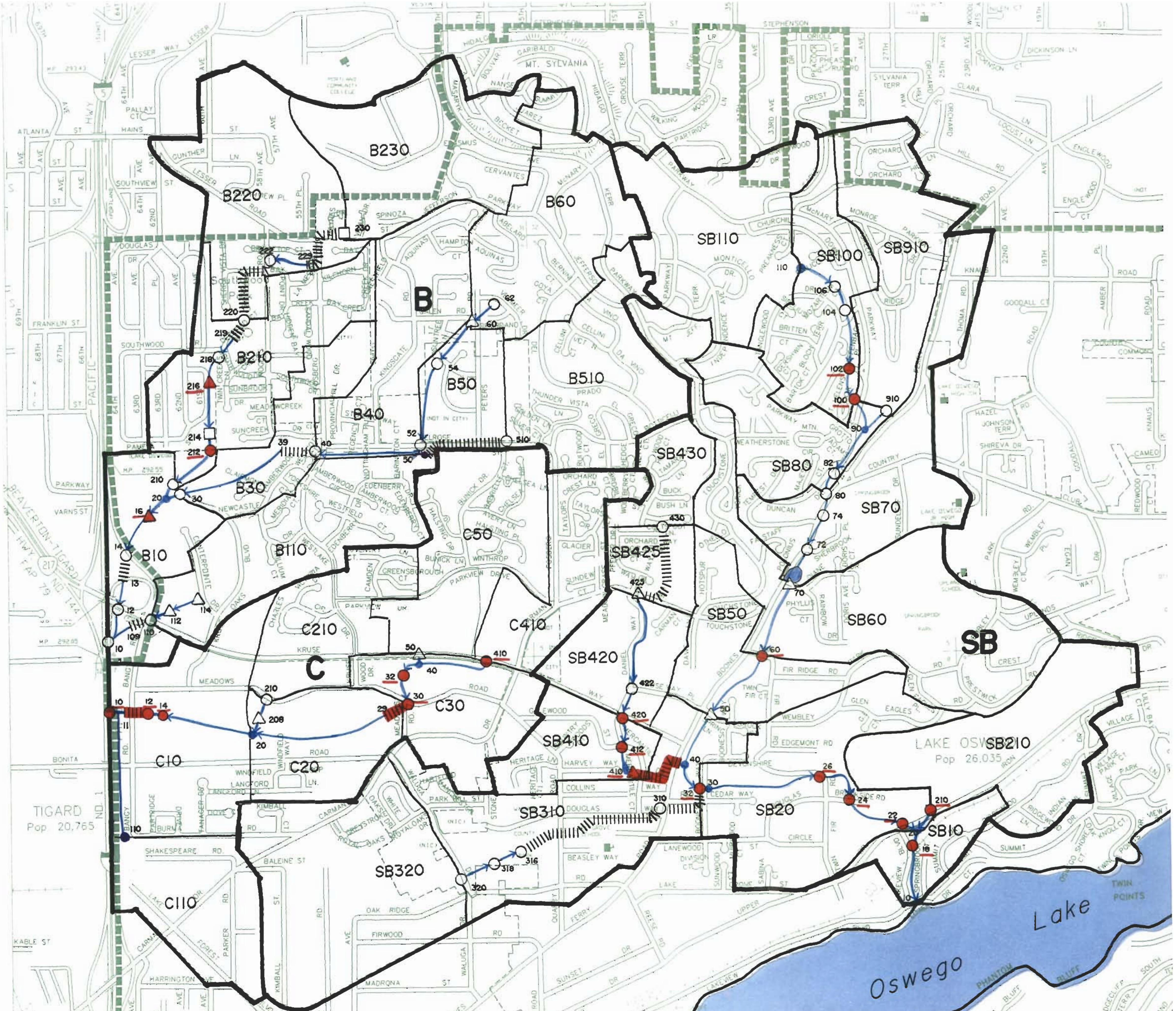
## Flood Control Capital Improvement Projects

| LOCATION Basin | ID | Description | STRUCTURE Length ft | Slope ft/ft | Number & Size (in) | Type | Head ft | DESIGN FLOW Event Yr | Now cfs | Fut. cfs | CAPACITY Flow cfs | DEFICIENT Now? Yr | Fut? Yr | IMPROVEMENT Type | Size (in) | Cost ($1,000) | Total ($1,000) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| OC | -100 | PIPE @ OC100 | 250 | 0.027 | 18 | CC | 5 | 25 | 35 | 35 | 17 | 10 | 10 | | 24 | $31 | $2,071 | |
| LBF | -30 | PIPE (Line A) | 860 | 0.004 | 36 | CC | | 25 | 68 | 86 | 42 | 10 | 10 | | 48 | $237 | $2,308 | |
| C | -410 | Kruse Way | 100 | 0.033 | 24 | MC | 5 | 50 | 28 | 41 | 22 | 25 | 10 | | 30 | $16 | $2,324 | Cost > $10,000 |
| SB | -100 | Kerr Pkwy (middle) | 50 | | 30 | CC | 8 | 50 | 118 | 118 | 70 | 10 | 10 | | 42 | $12 | $2,336 | |
| PH | -10 | PIPE | 540 | 0.072 | 24 | MC | | 25 | 45 | 45 | 33 | 10 | 10 | | 24 | $67 | $2,403 | |
| F | -12 | PIPE @ Greentree | 1050 | 0.072 | 18 | CC | 3.5 | 25 | 37 | 37 | 28 | 10 | 10 | | 27 | $171 | $2,574 | |
| **Outside City of Lake Oswego** | | | | | | | | | | | | | | | | | | |
| C | -14 | Berm above Kruse Meadows | 20 | | 48 | MC | 4 | 50 | 211 | 246 | 68 | 10 | 10 | Remove | | $4 | $4 | |
| C | -34 | Old Irrigation Structure by K | 20 | | 44 | SC | 4 | 50 | 78 | 78 | 70 | 50 | 50 | Remove | | $4 | $8 | Cost < $10,000 |
| C | -32 | Inlet at Meadows Rd. | 31 | 0.001 | 18 | MC | 3 | 50 | 78 | 78 | 10 | 10 | 10 | | 48 | $8 | $17 | |
| C | -30 | PIPE @ Meadows Rd. | 240 | 0.002 | 36 | CC | | 25 | 93 | 99 | 33 | 10 | 10 | | 60 | $84 | $101 | |
| C | -12 | Kruse Meadows Mall and Ba | 150 | 0.030 | 48 | MC | 7 | 50 | 211 | 246 | 95 | 10 | 10 | | 72 | $64 | $165 | |
| P | -30 | Childs Rd. E | 50 | | 24 | CC | 4 | 50 | 66 | 66 | 27 | 10 | 10 | | 42 | $12 | $176 | |
| C | -10 | Interstate 5 | 200 | | 48 | MC | 8 | 50 | 259 | 292 | 125 | 10 | 10 | | 72 | $85 | $261 | Cost > $10,000 |
| P | -10 | Mossy Brae Rd. | 30 | 0.020 | 36 | CC | 5 | 50 | 146 | 146 | 65 | 10 | 10 | two: | 42 | $14 | $276 | |
| T | -110 | Goodall #17 | 60 | 0.035 | 24 | MC | 2.5 | 50 | 24 | 24 | 17 | 25 | 25 | | 30 | $10 | $285 | |

NOTE: Type of improvement is replacement by circular concrete pipe unless otherwise noted by the following:

BOX Replace by concrete box culvert
OF Improve overflow spillway
Remove Remove obstructing structure, berm, and/or pipe
IN Enlarge inlet to increase efficiency

# Recommended Capital Improvement Projects in the Northwest Portion of the Study Area




**Major Basins:**

**Oswego Lake**
SB Springbrook Creek

**Tualatin River**
B Ball Creek
C Carter Creek

**SB** Major Basin Name
SB10 Subbasin/Name
Major Streams/ Node ID

Existing Major Facility with Node#

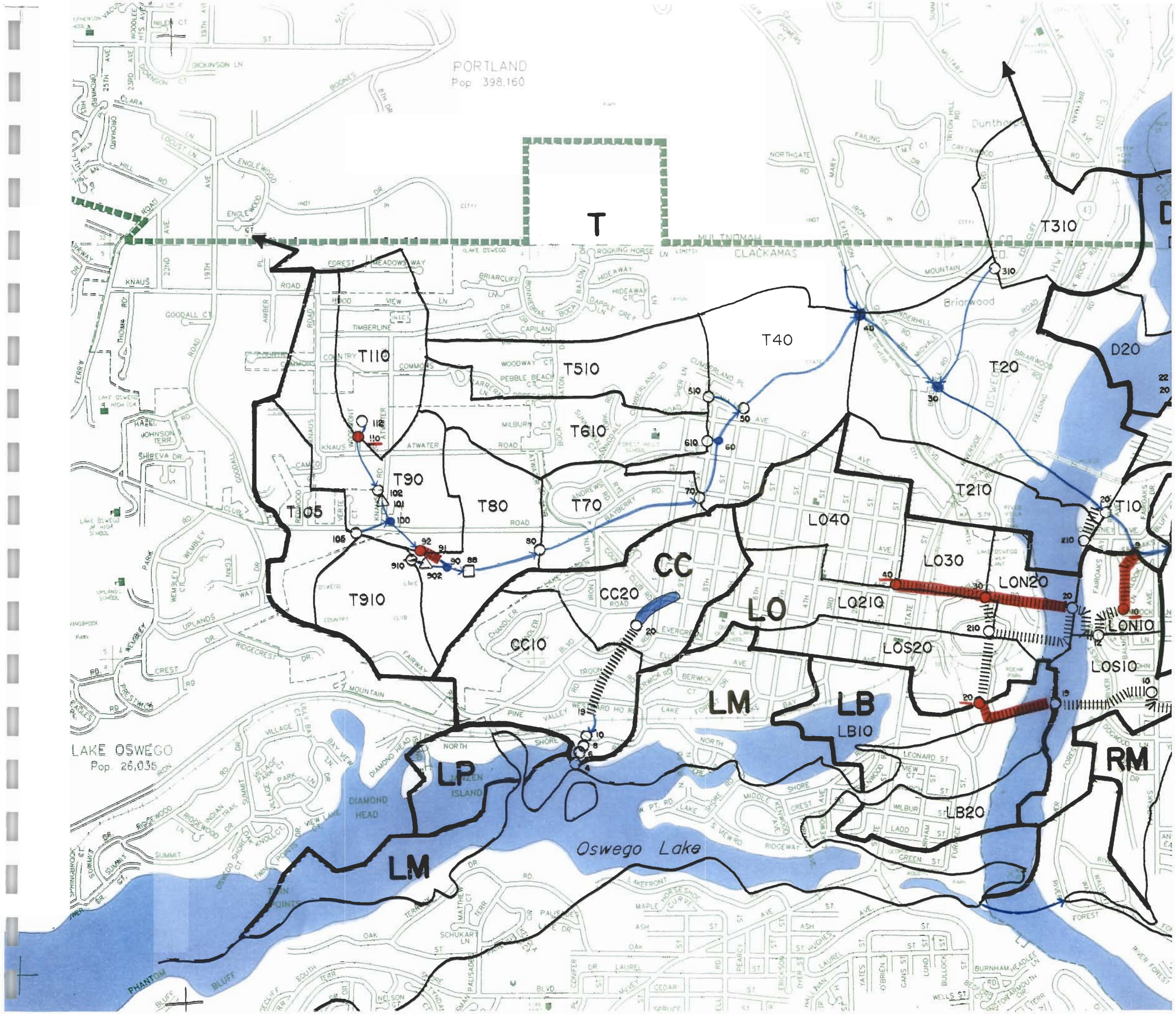
| Not CIP | Proposed CIP | Facility Type: |
|---|---|---|
| ○ | ● | Pipe |
| ○ | ● | Culvert Inlet |
| △ | ▲ | Detention |
| □ | ■ | Sediment Basin |

Figure 5.1a

0 600 1200 1800

ota

# Recommended Capital Improvement Projects in the Northeast Portion of the Study Area




**Major Basins:**

**Oswego Lake**
CC Country Club
LB Lakewood Bay
LM Lake Margin
LP Lily Pond

**Willamette River**
D Dunthorpe
LO(N,S) Lake Oswego (North, South)
RM River Margin
T Tryon Creek

SB Major Basin Name
SB10 Subbasin/Name
Major Streams/Node ID

Existing Major Facility with Node#

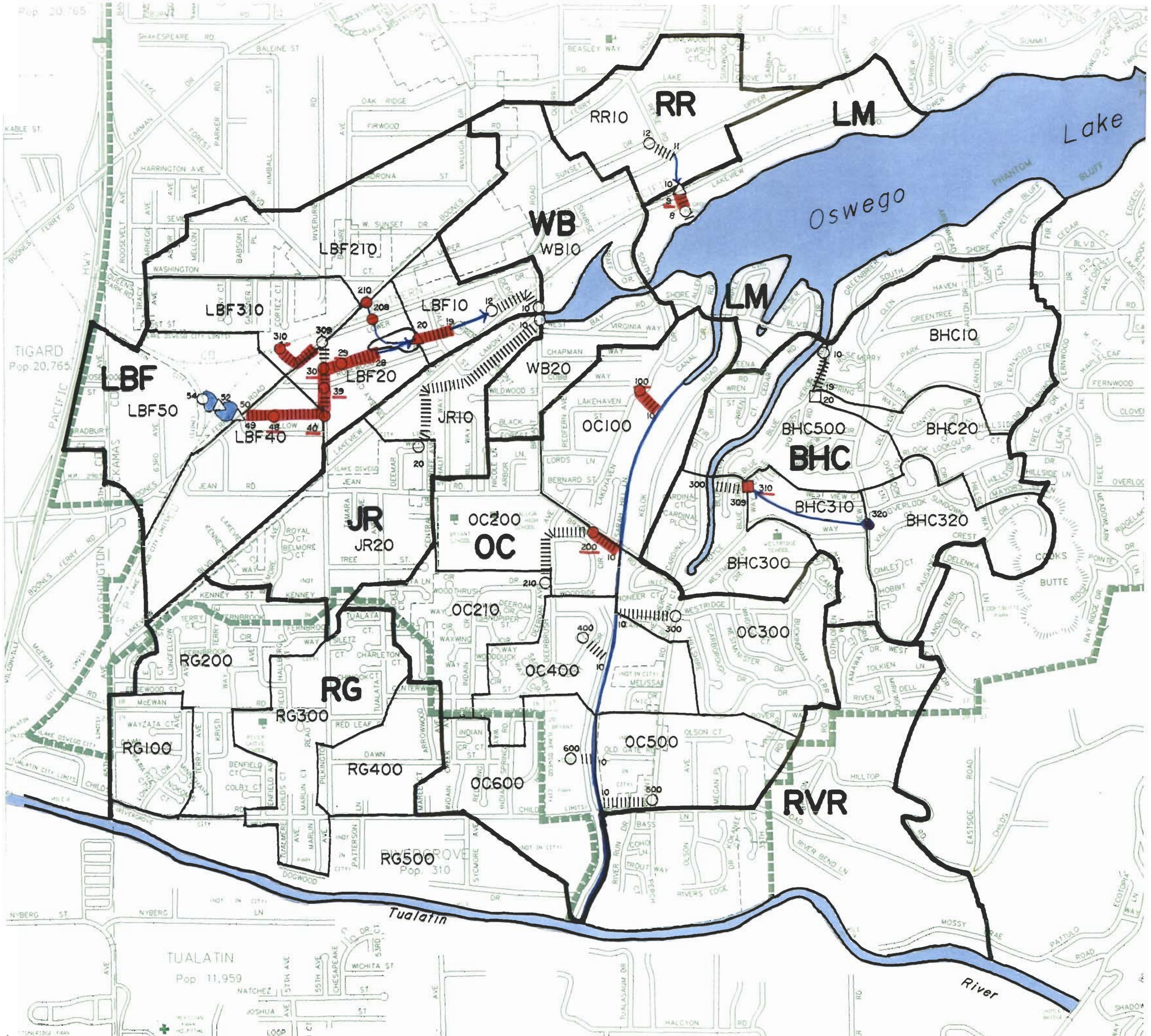
| Not CIP | Proposed CIP | Facility Type: |
|---|---|---|
| # | # | Pipe |
| # | # | Culvert Inlet |
| # | # | Detention |
| # | # | Sediment Basin |

Figure 5.1b

0 600 1200 1800

otak

# Recommended Capital Improvement Projects in the Southwest Portion of the Study Area




**Major Basins:**

**Oswego Lake**

| | |
|---|---|
| BHC | Blue Heron Canal |
| JR | Jean Road |
| LBF | Lower Boones Ferry |
| LM | Lake Margin |
| OC | Oswego Canal |
| RR | Reese Road |
| WB | West Bay |

**Tualatin River**

| | |
|---|---|
| RG | River Grove |
| RVR | River Run |

**SB** Major Basin Name

SB10 Subbasin/Name

Major Streams/ Node ID

Existing Major Facility with Node#

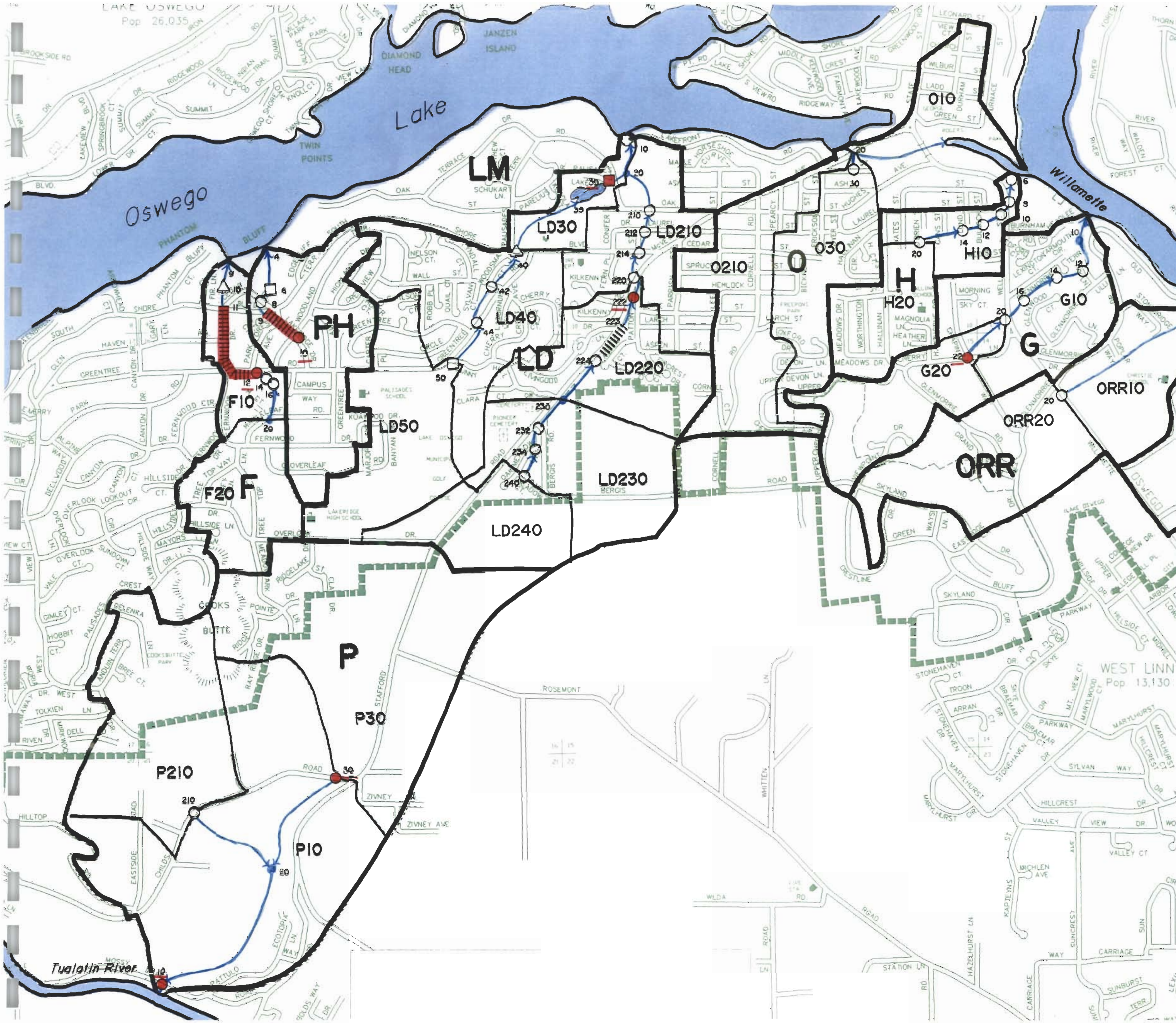
| Not CIP | Proposed CIP | Facility Type: |
|---|---|---|
| | | Pipe |
| | | Culvert Inlet |
| | | Detention |
| | | Sediment Basin |

Figure 5.1c

0 600 1200 1800

otak

# Recommended Capital Improvement Projects in the Southeast Portion of the Study Area




**Major Basins:**

**Oswego Lake**
F Fernwood
LD Lost Dog Creek
LM Lake Margin
PH Palisades Heights

**Tualatin River**
P Pecan Creek

**Willamette River**
G Glenmorrie
H Hallinan Heights
O Oswego Creek
ORR Old River Road
RM River Margin

**SB** Major Basin Name
SB10 Subbasin/Name
# Major Streams/Node ID

Existing Major Facility with Node#

| Not CIP | Proposed CIP | Facility Type: |
|---|---|---|
| # | # | Pipe |
| # | # | Culvert Inlet |
| # | # | Detention |
| # | # | Sediment Basin |

Figure 5.1d

0 600 1200 1800

otak

Water Quality
Management
Practices

## CHAPTER 6

# WATER QUALITY MANAGEMENT PRACTICES

The major water quality issue for Oswego Lake is the struggle to maintain algae within limits for aesthetics and swimming safety without adding so much copper that conditions become toxic to aquatic life. Scientific Resources Inc. (SRI) reported on the lake algae problem in 1988. Since then, the Lake Oswego Corporation's (LOC) Water Quality Committee has prepared annual Water Quality Management Plans (WQMP's) for the lake in their effort to comply with DEQ water quality standards. These efforts have revealed the following problems from the SWM study area:

- **Excessive Nutrients**, including both nitrogen and phosphorus, elevate algae concentrations beyond acceptable limits. While Tualatin River nutrient sources abound, contributions from the study area result primarily from urban non-point source runoff. Yard and channel debris, excess fertilizing, detergents, and livestock and pets are all possible sources. Impervious surfaces collect and quickly transport phosphorus-containing storm water runoff to streams and the lake. Without these surfaces, runoff would be slowed, and pollutants removed by topsoil and vegetation.

- **Substantial Algal blooms** would be supported in the lake were it not for the large herbicide doses applied. Algae reduces water clarity and swimming visibility as it grows, and creates nuisance odors and consumes dissolved oxygen as it decomposes. Ambient Total Phosphorus concentrations must be reduced below 0.025 mg/l to limit algae growth without herbicides. Low-flow dissolved phosphorus levels suggest that any nutrient reductions could never be less than twice this amount. Thus controlling algae by reducing nutrient loads alone is not feasible.

- **Sediment** from the SWM study area formed large deltas at the mouths of Springbrook, Lost Dog, and Blue Heron Creeks and supported nuisance rooted aquatic plants on 23 acres of lake bed. Suspended sediment should be reduced to 15 mg/l to minimize these problems.

- **Copper** concentrations required to suppress algae and aquatic plants frequently exceed DEQ standards and may be toxic to some species of zooplankton and fish. Alternatives using sodium aluminate are being considered.

- **Fecal coliform bacteria** indicate the potential presence of disease-causing organisms. Levels occasionally exceeded DEQ contact recreation standards. LOC monitoring observed possible study area sources to be the small spring in Bryant Woods Park draining the unsewered areas around Indian Creek, the proximity of livestock and manure piles to Springbrook Creek, and excessive water fowl populations, and from the sanitary sewer trunk running beneath the lake surface. However, the standard was changed in 1991 to Enterococci.

Other major pollutants associated with urban runoff include metals such as lead, zinc, and iron; toxic household and industrial chemicals; and oil and grease. None were observed to be serious problems in the lake, but all are potential threats from an urbanized area.

This water quality management plan (WQMP) is required by DEQ to address specific upland management practices and capital improvements needed to improve water quality and bring the following "water quality limited" waters into compliance with DEQ standards for water contact, aquatic life exposure, or aesthetics (OAR 340-41-470):

| Stream or Water Body | Season(s) | Problem(s) |
|---|---|---|
| Springbrook Creek | All | Bacteria |
| Willamette River | All | Bacteria |
| Fanno Creek | All | Bacteria |
| Fanno Creek | Summer | Algae (chlorophyll-a) |
| Oswego Lake | Summer | Dissolved Oxygen, pH, Algae |
| Tualatin River | Summer | Dissolved Oxygen, pH, Algae |
| | Fall, Spring | Bacteria |

[From the 1990 305(b) DEQ Clean Water Act status report to EPA.]

Lake Oswego Corporation (LOC) has prepared annual Water Quality Management Plans for the lake itself; this plan must address the pollution sources and specific capital improvements possible upland. The new enterococci standard will require more data to assess the current status of waters limited by bacteria presence. The remaining problems all relate to algae blooms (specifically to levels of chlorophyll-a, the "green" pigment used to quantify algae levels). DEQ has determined that phosphorus is the required nutrient in shortest supply, and that reducing it is the best way to reduce algae. A maximum total phosphorus concentration of 0.07 mg/l has been set for the Tualatin River and its streams. Even lower concentrations were required further upstream in order to dilute the large discharges from sewage treatment plants.

Actual phosphorus pollutant loads, obtained by multiplying the allowable concentrations times the river or stream flow, have become a serious concern in the study area following a successful 1986 lawsuit by the Northwest Environmental Defense Center over the water quality in the Tualatin River and Oswego Lake. As a result, DEQ has established total maximum daily loads (TMDL's) for total phosphorus (TP) entering these waterways, which must be achieved by June, 1993. However, specific load allocations have not been set for any of the study area drainage basins.

This WQMP will recommend total phosphorus load allocations for the study area and specific maintenance practices and capital improvements that can significantly reduce sediment and sediment-borne phosphorus and other pollutants. It also recommends continued water quality monitoring to confirm that the estimated pollutant reductions are achieved.

In addition, it supports the plan to characterize storm water runoff quality as part of the National Pollutant Discharge Elimination System (NPDES) municipal storm water permitting process. Lake Oswego, and Rivergrove have joined the Clackamas County effort.

## 6.1 MODELING URBAN STORM WATER POLLUTION

Urban storm water pollution results primarily from the accumulation and transport of contaminated material on paved surfaces such as streets and parking lots. Most street sediment is from local soil erosion; the rest, from automobile track-out and pavement deterioration. The automobile is a major contributor of many toxic pollutants, including heavy metals, and oil and grease. Vegetative litter can be a significant contributor of organic material and nutrients. Feces of pets, livestock and water fowl are major contributors of bacteriological pollutants. As contaminants accumulated over time, they are removed by wind, traffic, runoff, or street cleaning.

The ability of storm water runoff to transport sediment and sediment-borne pollutants depends upon many factors, such as the distribution of particle size and weight, the intensity and duration

TABLE 6.1

# Parameter Values for Each Land Use Category under Existing Conditions

| General | | | | | | | Hydraulics | | | | STCB Storage | | | Sediment Deposition | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| No. | Drainage System | Slope | MIA | EIA | | CurbDN | Flow | N | CBDN | Z,W | DIA | Hmax | Hint | Pint | Pmax | Rate |
| **Single Family Residential:** | | | | | | | | | | | | | | | | |
| 1 | Ditch, Low Dens | 2.5 | 20 | #5 | 4.0 | --- | OF | 0.12 | 0.35 | 58 | --- | --- | --- | 120 | 130 | 0.045 |
| 2 | Ditch, Med Den | 2.5 | 35 | #5 | 12.3 | --- | OF | 0.12 | 0.35 | 178 | --- | --- | --- | 160 | 220 | 0.045 |
| 3 | Curbed, Med De | 2.5 | 35 | #1 | 20.7 | 286 | C&G | 0.08 | 0.52 | 48 | --- | --- | --- | 360 | 630 | 0.045 |
| 4 | Curbed, High D | 2.5 | 50 | #1 | 35.4 | 300 | C&G | 0.08 | 0.63 | 48 | --- | --- | --- | 470 | 840 | 0.045 |
| **Multi-family Residential** | | | | | | | | | | | | | | | | |
| 5 | Roof/Parking Lo | 2.0 | 60 | #2 | 54.4 | --- | OF | 0.12 | 0.70 | 60 | 2.14 | 1.75 | 0.9 | 170 | 270 | 0.045 |
| 5a | Same with swal | 2.0 | 60 | #4 | 42.2 | --- | OF | 0.12 | 0.70 | 60 | | | | 130 | 210 | 0.045 |
| **Institutional** | | | | | | | | | | | | | | | | |
| 6 | Roof/Parking Lo | 2.0 | 40 | #2 | 33.5 | --- | OF | 0.12 | 0.28 | 60 | 2.14 | 1.75 | 0.9 | 170 | 270 | 0.045 |
| 6a | Same with swal | 2.0 | 40 | #4 | 21.2 | --- | OF | 0.12 | 0.28 | 60 | | | | 130 | 210 | 0.045 |
| **Commercial and Industrial** | | | | | | | | | | | | | | | | |
| 7 | Campus/Office | 2.0 | 70 | #2 | 65.5 | --- | OF | 0.12 | 0.82 | 60 | 2.14 | 1.75 | 0.9 | 190 | 300 | 0.045 |
| 8 | Strip/Mall/Indust | 2.0 | 85 | #2 | 82.7 | --- | OF | 0.12 | 0.93 | 60 | 2.14 | 1.75 | 0.9 | 190 | 300 | 0.045 |
| 7a | Same with swal | 2.0 | 70 | #4 | 54.8 | --- | OF | 0.12 | 0.82 | 60 | | | | 160 | 250 | 0.045 |
| 8a | Same with swal | 2.0 | 85 | #4 | 76.2 | --- | OF | 0.12 | 0.93 | 60 | | | | 160 | 250 | 0.045 |
| **Major Arterial:** | | | | | | | | | | | | | | | | |
| 9 | Ditches | 2.5 | 95 | #1 | 92.6 | --- | OF | 0.12 | 5.00 | 40 | --- | --- | --- | 310 | 340 | 0.177 |
| 10 | Gutters | 2.5 | 100 | #3 | 100.0 | 1980 | CG | 0.08 | 5.00 | 48 | --- | --- | --- | 750 | 900 | 0.177 |

NOTE: The following OTAK EIA Equations were used:

| | | |
|---|---|---|
| #1 | EIA = 0.10 x MIA^1.5 | (average) |
| #2 | EIA = 0.40 x MIA^1.2 | (highly connected) |
| #3 | EIA=MIA | (completely connected) |
| #4 | EIA = 0.04 x MIA^1.7 | (somewhat disconected) |
| #5 | EIA = 0.01 x MIA^2.0 | (extremely disconnected) |

Key to column headings:

| | |
|---|---|
| Slope | Typical slope of paved flowpath (%) |
| EIA | Effective impervious area (%) |
| MIA | Mapped impervious area (%) |
| CurbDN | Curbed feet per acre |
| Flow | C&G – Curb & gutter |
| | OF – Overland Flow |
| N | Manning's N value for shallow flow |
| Z | (C&G) – Cross slope (run/rise) |
| W | (OF) – Width (ft/catchbasin) |
| CBDN | Number of catchbasins per acre |
| STCB | Sediment trapping catch basin |
| DIA | Effective circular STCB diameter (ft) |
| Hmax | Available sediment storage depth in STCB's (ft) |
| Hint | Average starting depth of sediment in STCB's (ft) |
| Pmax, Pint | Maximum and initial sediment found on pavement (C&G – lbs/curb mile; OF – lbs/paved acre) |
| Rate | Exponential accumulation rate (per day) |

3333\report\tab6-1
03/24/92

of runoff, and the physical characteristics of the urban catchment. Sources farther from the storm drainage system, and which experience more pervious overland flow, have a much smaller impact than do parking lots or street surfaces that are directly connected to the drainage system.

The typical curb and gutter storm sewer design concentrates pollutants in street sediment, and concentrates runoff, resulting in high contaminant transport. Distributing storm water runoff in grassy swales or other pervious areas can greatly reduce pollutant loads. Cleaning sediment deposits in catchbasin traps and street gutters, and capturing runoff in storm water treatment facilities, also can reduce pollution.

These processes were simulated with a storm water quality planning model. OTAK used the Simplified Particulate Transport Model (SIMPTM, Sutherland, Jelen, and Green, 1992) to model a typical year's storm water contributions of runoff, sediment, and total phosphorus under built-out conditions (2012) with three levels of enhanced maintenance practices and compared them with contributions without any maintenance practices under both existing (1991) and built-out conditions. Results from a cost-effective level of maintenance were used to recommend load allocations. OTAK also modelled sediment and phosphorus removal from eight regional PRF's. As baseflow contains little particulate phosphorus, no reduction in its load was assumed from any management practice. Soil erosion and transport from construction activities were not modeled.

## 6.2 STUDY AREA CHARACTERISTICS

Land use and other catchment characteristics, such as the amount of effective impervious area, its slope and pavement texture, and the nature of the local drainage system, will affect the accumulation and washoff of storm water pollutants. Considerable research has been conducted to establish relationships between urban land use and storm water quality. The Nationwide Urban Runoff Program (NURP) concluded that land use alone is not a reliable indicator of the quality of urban runoff.

However, land use must be considered when projecting storm water pollutant discharges because of its relationship to other more important factors, and because land use data is readily available and can be easily cross-referenced to the various drainage basins within a given study area. Other important factors, such as paved area slope and the upland characteristics of the local drainage systems serving these land uses, should be examined so that significant variation in these factors can be included in the projection of storm water quality.

### Analysis Objectives

The objective of the Land Use Characteristics Analysis was to model stormwater runoff volumes and total solids and phosphorus washoffs from developed areas throughout the study area. Up to ten land use categories. Each of the unique physical characteristics would be used. The land use categories selected for the upland water quality analyses must also be compatible with those described in the water quantity assessments (i.e. Chapters 4 and 5).

### Land Use Category Selection

A two-step process was used to determine the ten land use categories for the study area. The first step was to categorize and define the various land uses in the study area. The second step was to classify the data from the site analysis and aerial photographs into ten distinct land use/physical characteristic categories.

The first step started with an examination of aerial photos to determine what general land use categories that exist in the study area. The five general land use categories that were selected are as follows:

## TABLE 6.2

## Representative Year Rainfall Statistics

| Event | CALHR | MO | DA | YR | HR | DUR hrs | DEP in | TDRY hrs | AvgInt in/hr | A hrs | B hrs | C hrs | H in/hr | PMAX in/hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 54 | 1 | 3 | 3 | 6 | 7 | 0.14 | 5 | 0.020 | 0 | 0 | 7 | 0.02 | 0.04 |
| 2 | 73 | 1 | 4 | 3 | 1 | 19 | 0.93 | 12 | 0.049 | 3.96 | 1.02 | 14.02 | 0.056 | 0.14 |
| 3 | 104 | 1 | 5 | 3 | 8 | 2 | 0.17 | 12 | 0.085 | 0 | 0.12 | 1.88 | 0.088 | 0.09 |
| 4 | 140 | 1 | 6 | 3 | 20 | 26 | 1.24 | 34 | 0.048 | 0 | 3.98 | 22.02 | 0.052 | 0.10 |
| 5 | 208 | 1 | 9 | 3 | 16 | 3 | 0.13 | 42 | 0.043 | 0 | 3 | 0 | 0.087 | 0.10 |
| 6 | 239 | 1 | 10 | 3 | 23 | 4 | 0.27 | 28 | 0.067 | 4 | 0 | 0 | 0.135 | 0.14 |
| 7 | 255 | 1 | 11 | 3 | 15 | 1 | 0.08 | 12 | 0.080 | 0 | 0 | 1 | 0.08 | 0.08 |
| 8 | 261 | 1 | ·11 | 3 | 21 | 8 | 0.33 | 5 | 0.041 | 1.47 | 0 | 6.53 | 0.045 | 0.13 |
| 9 | 295 | 1 | 13 | 3 | 7 | 3 | 0.10 | 26 | 0.033 | 0.65 | 0 | 2.35 | 0.037 | 0.04 |
| 10 | 307 | 1 | 13 | 3 | 19 | 16 | 1.21 | 9 | 0.076 | 2.09 | 0 | 13.91 | 0.081 | 0.15 |
| 11 | 497 | 1 | 21 | 3 | 17 | 1 | 0.05 | 174 | 0.050 | 0 | 0 | 1 | 0.05 | 0.05 |
| 12 | 513 | 1 | 22 | 3 | 9 | 7 | 0.34 | 15 | 0.049 | 0 | 1.47 | 5.53 | 0.054 | 0.09 |
| 13 | 628 | 1 | 27 | 3 | 4 | 11 | 0.62 | 108 | 0.056 | 0 | 8.79 | 2.21 | 0.094 | 0.11 |
| 14 | 745 | 2 | 1 | 3 | 1 | 3 | 0.16 | 106 | 0.053 | 0.72 | 0 | 2.28 | 0.061 | 0.07 |
| 15 | 765 | 2 | 1 | 3 | 21 | 35 | 1.77 | 17 | 0.051 | 6.51 | 0 | 28.49 | 0.056 | 0.23 |
| 16 | 828 | 2 | 4 | 3 | 12 | 9 | 0.20 | 28 | 0.022 | 0.2 | 0 | 8.8 | 0.022 | 0.06 |
| 17 | 871 | 2 | 6 | 3 | 7 | 1 | 0.05 | 34 | 0.050 | 0 | 0 | 1 | 0.05 | 0.05 |
| 18 | 877 | 2 | 6 | 3 | 13 | 4 | 0.16 | 5 | 0.040 | 0 | 0 | 4 | 0.04 | 0.09 |
| 19 | 1078 | 2 | 14 | 3 | 22 | 6 | 0.13 | 197 | 0.022 | 0 | 0 | 6 | 0.022 | 0.05 |
| 20 | 1095 | 2 | 15 | 3 | 15 | 4 | 0.10 | 11 | 0.025 | 0 | 0.41 | 3.59 | 0.026 | 0.03 |
| 21 | 1142 | 2 | 17 | 3 | 14 | 10 | 0.31 | 43 | 0.031 | 0 | 0 | 10 | 0.031 | 0.06 |
| 22 | 1168 | 2 | 18 | 3 | 16 | 6 | 0.17 | 16 | 0.028 | 0.83 | 0.7 | 4.47 | 0.032 | 0.05 |
| 23 | 1190 | 2 | 19 | 3 | 14 | 2 | 0.16 | 16 | 0.080 | 0 | 2 | 0 | 0.16 | 0.14 |
| 24 | 1334 | 2 | 25 | 3 | 14 | 8 | 0.70 | 142 | 0.087 | 0 | 5.16 | 2.84 | 0.129 | 0.21 |
| 25 | 1406 | 2 | 28 | 3 | 14 | 3 | 0.20 | 64 | 0.067 | 0.81 | 1.04 | 1.15 | 0.096 | 0.13 |
| 26 | 1477 | 3 | 3 | 3 | 13 | 9 | 0.17 | 68 | 0.019 | 0 | 0 | 9 | 0.019 | 0.04 |
| 27 | 1497 | 3 | 4 | 3 | 9 | 13 | 0.34 | 11 | 0.026 | 0 | 4.14 | 8.86 | 0.031 | 0.06 |
| 28 | 1513 | 3 | 5 | 3 | 1 | 5 | 0.15 | 3 | 0.030 | 0 | 0 | 5 | 0.03 | 0.05 |
| 29 | 1527 | 3 | 5 | 3 | 15 | 7 | 0.18 | 9 | 0.026 | 1.14 | 0 | 5.86 | 0.028 | 0.08 |
| 30 | 1556 | 3 | 6 | 3 | 20 | 1 | 0.08 | 22 | 0.080 | 0 | 0 | 1 | 0.08 | 0.08 |
| 31 | 1578 | 3 | 7 | 3 | 18 | 2 | 0.09 | 21 | 0.045 | 0.12 | 0 | 1.88 | 0.046 | 0.05 |
| 32 | 1583 | 3 | 7 | 3 | 23 | 13 | 0.66 | 3 | 0.051 | 13 | 0 | 0 | 0.102 | 0.13 |
| 33 | 1600 | 3 | 8 | 3 | 16 | 1 | 0.40 | 4 | 0.400 | 0 | 0 | 1 | 0.4 | 0.40 |
| 34 | 1625 | 3 | 9 | 3 | 17 | 1 | 0.05 | 24 | 0.050 | 0 | 0 | 1 | 0.05 | 0.05 |
| 35 | 1641 | 3 | 10 | 3 | 9 | 1 | 0.07 | 15 | 0.070 | 0 | 0 | 1 | 0.07 | 0.07 |
| 36 | 1682 | 3 | 12 | 3 | 2 | 18 | 0.73 | 40 | 0.041 | 2.72 | 1.1 | 14.18 | 0.045 | 0.15 |
| 37 | 1779 | 3 | 16 | 3 | 3 | 7 | 0.47 | 79 | 0.067 | 0 | 1.14 | 5.86 | 0.073 | 0.18 |
| 38 | 1916 | 3 | 21 | 3 | 20 | 3 | 0.08 | 130 | 0.027 | 0.38 | 0.38 | 2.24 | 0.031 | 0.04 |
| 39 | 2191 | 4 | 2 | 3 | 7 | 1 | 0.10 | 272 | 0.100 | 0 | 0 | 1 | 0.1 | 0.10 |
| 40 | 2315 | 4 | 7 | 3 | 11 | 1 | 0.30 | 123 | 0.300 | 0 | 0 | 1 | 0.3 | 0.30 |
| 41 | 2517 | 4 | 15 | 3 | 21 | 10 | 0.32 | 201 | 0.032 | 3.49 | 1.92 | 4.58 | 0.044 | 0.09 |
| 42 | 2584 | 4 | 18 | 3 | 16 | 8 | 0.17 | 57 | 0.021 | 0.36 | 0 | 7.64 | 0.022 | 0.04 |
| 43 | 2681 | 4 | 22 | 3 | 17 | 10 | 0.40 | 89 | 0.040 | 0.26 | 0.36 | 9.38 | 0.041 | 0.06 |
| 44 | 2708 | 4 | 23 | 3 | 20 | 2 | 0.13 | 17 | 0.065 | 0 | 0.48 | 1.52 | 0.074 | 0.08 |
| 45 | 2714 | 4 | 24 | 3 | 2 | 7 | 0.29 | 4 | 0.041 | 0 | 0.7 | 6.3 | 0.044 | 0.07 |
| 46 | 2740 | 4 | 25 | 3 | 4 | 4 | 0.15 | 19 | 0.037 | 0.66 | 0 | 3.34 | 0.041 | 0.05 |
| 47 | 3118 | 5 | 10 | 3 | 22 | 2 | 0.11 | 374 | 0.055 | 0.32 | 0 | 1.68 | 0.06 | 0.07 |
| 48 | 3123 | 5 | 11 | 3 | 3 | 3 | 0.10 | 3 | 0.033 | 0 | 0.41 | 2.59 | 0.036 | 0.04 |
| 49 | 3198 | 5 | 14 | 3 | 6 | 5 | 0.40 | 72 | 0.080 | 0.87 | 1.2 | 2.93 | 0.101 | 0.17 |
| 50 | 3226 | 5 | 15 | 3 | 10 | 7 | 0.16 | 23 | 0.023 | 0.76 | 0 | 6.24 | 0.024 | 0.05 |
| 51 | 3238 | 5 | 15 | 3 | 22 | 1 | 0.05 | 5 | 0.050 | 0 | 0 | 1 | 0.05 | 0.05 |
| 52 | 3253 | 5 | 16 | 3 | 13 | 3 | 0.18 | 14 | 0.060 | 0.78 | 0 | 2.22 | 0.069 | 0.12 |
| 53 | 3328 | 5 | 19 | 3 | 16 | 1 | 0.20 | 72 | 0.200 | 0 | 0 | 1 | 0.2 | 0.20 |
| 54 | 3434 | 5 | 24 | 3 | 2 | 6 | 0.20 | 105 | 0.033 | 0 | 3.47 | 2.53 | 0.047 | 0.09 |
| 55 | 3685 | 6 | 3 | 3 | 13 | 2 | 0.11 | 245 | 0.055 | 0.1 | 0 | 1.9 | 0.056 | 0.06 |
| 56 | 3733 | 6 | 5 | 3 | 13 | 1 | 0.05 | 46 | 0.050 | 0 | 0 | 1 | 0.05 | 0.05 |
| 57 | 3894 | 6 | 12 | 3 | 6 | 9 | 0.42 | 160 | 0.047 | 0.31 | 1.7 | 6.99 | 0.053 | 0.11 |
| 58 | 4114 | 6 | 21 | 3 | 10 | 3 | 0.10 | 211 | 0.033 | 0 | 0.85 | 2.15 | 0.039 | 0.06 |
| 59 | 4228 | 6 | 26 | 3 | 4 | 8 | 0.37 | 111 | 0.046 | 0 | 1.87 | 6.13 | 0.052 | 0.11 |
| 60 | 4245 | 6 | 26 | 3 | 21 | 2 | 0.14 | 9 | 0.070 | 0 | 0.96 | 1.04 | 0.092 | 0.10 |

Column Headings: EVT=Event Number CALHR=Calendar Hour MO,DA,YR,HR=time of event
DUR=duration (hrs) DEP=depth of rainfall (in) TDRY=antecedent dry time (hrs) AVGINT=average rainfall rate (in/hr)
A,B,C,H=trapezoidal hyetograph dimensions (rising hrs, falling hrs, steady hrs, and height (in/hr)
PMAX=maximum hourly precipitation rate (in/hr)

Representative year from REX-1-S gage, 1948-1988. For months 1-12:

## TABLE 6.2

## Representative Year Rainfall Statistics

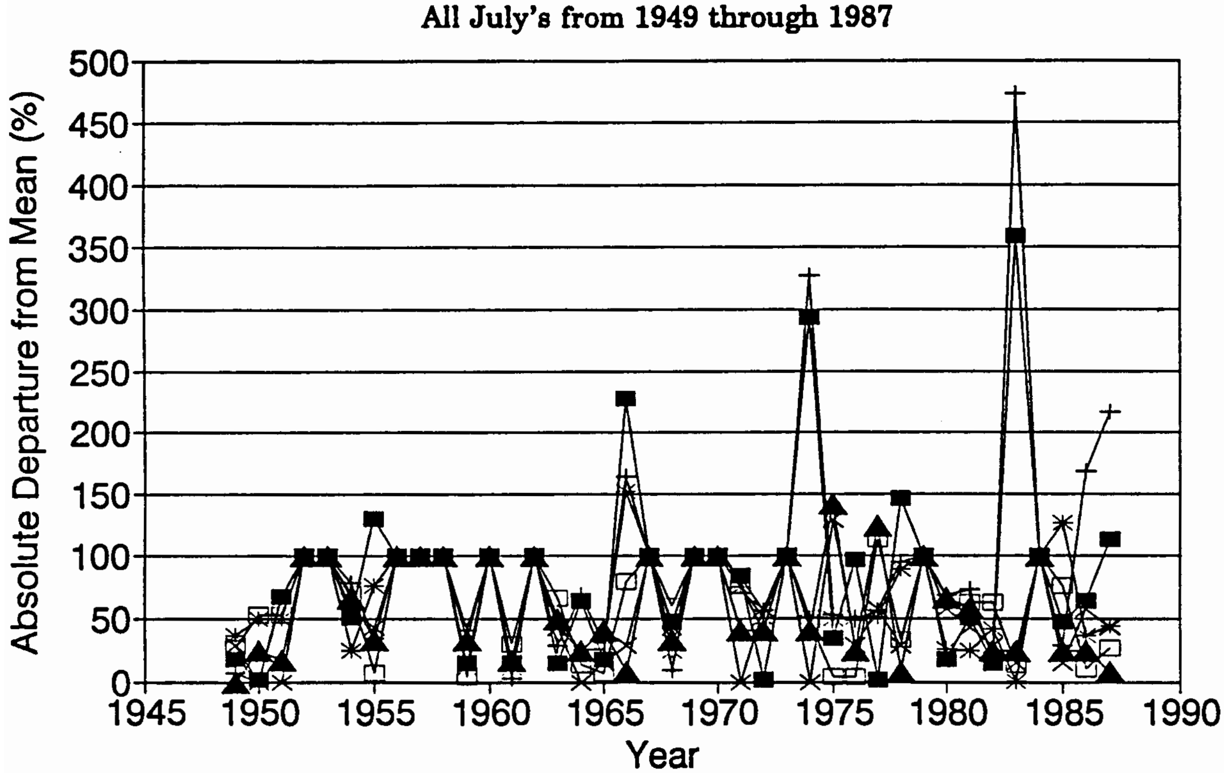
| Event | CALHR | MO | DA | YR | HR | DUR hrs | DEP in | TDRY hrs | AvgInt in/hr | A hrs | B hrs | C hrs | H in/hr | PMAX in/hr |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 61 | 4444 | 7 | 5 | 3 | 4 | 4 | 0.16 | 197 | 0.040 | 0 | 1.64 | 2.36 | 0.05 | 0.06 |
| 62 | 4453 | 7 | 5 | 3 | 13 | 3 | 0.26 | 5 | 0.087 | 0 | 0 | 3 | 0.087 | 0.22 |
| 63 | 5513 | 8 | 18 | 3 | 17 | 1 | 0.21 | 1057 | 0.210 | 0 | 0 | 1 | 0.21 | 0.21 |
| 64 | 5648 | 8 | 24 | 3 | 8 | 10 | 0.44 | 134 | 0.044 | 0 | 0 | 10 | 0.044 | 0.12 |
| 65 | 5939 | 9 | 5 | 3 | 11 | 13 | 1.00 | 281 | 0.077 | 2.49 | 4.16 | 6.35 | 0.103 | 0.24 |
| 66 | 5968 | 9 | 6 | 3 | 16 | 4 | 0.11 | 16 | 0.027 | 0.45 | 0 | 3.55 | 0.029 | 0.03 |
| 67 | 6087 | 9 | 11 | 3 | 15 | 2 | 0.20 | 115 | 0.100 | 0 | 0.64 | 1.36 | 0.119 | 0.13 |
| 68 | 6343 | 9 | 22 | 3 | 7 | 2 | 0.11 | 254 | 0.055 | 0 | 1.67 | 0.33 | 0.095 | 0.09 |
| 69 | 6351 | 9 | 22 | 3 | 15 | 1 | 0.07 | 6 | 0.070 | 0 | 0 | 1 | 0.07 | 0.07 |
| 70 | 6653 | 10 | 5 | 3 | 5 | 3 | 0.11 | 301 | 0.037 | 0.74 | 0.35 | 1.91 | 0.045 | 0.06 |
| 71 | 6665 | 10 | 5 | 3 | 17 | 1 | 0.11 | 9 | 0.110 | 0 | 0 | 1 | 0.11 | 0.11 |
| 72 | 6847 | 10 | 13 | 3 | 7 | 4 | 0.20 | 181 | 0.050 | 1.14 | 0.48 | 2.38 | 0.063 | 0.10 |
| 73 | 7015 | 10 | 20 | 3 | 7 | 6 | 0.32 | 164 | 0.053 | 1.06 | 1.75 | 3.19 | 0.07 | 0.10 |
| 74 | 7055 | 10 | 21 | 3 | 23 | 15 | 1.13 | 34 | 0.075 | 0 | 0 | 15 | 0.075 | 0.18 |
| 75 | 7083 | 10 | 23 | 3 | 3 | 7 | 0.21 | 13 | 0.030 | 0 | 0.38 | 6.62 | 0.031 | 0.05 |
| 76 | 7111 | 10 | 24 | 3 | 7 | 5 | 0.20 | 21 | 0.040 | 1.82 | 0 | 3.18 | 0.049 | 0.07 |
| 77 | 7203 | 10 | 28 | 3 | 3 | 5 | 0.29 | 87 | 0.058 | 0.9 | 0 | 4.1 | 0.064 | 0.08 |
| 78 | 7251 | 10 | 30 | 3 | 3 | 3 | 0.15 | 43 | 0.050 | 0.21 | 1.1 | 1.69 | 0.064 | 0.08 |
| 79 | 7394 | 11 | 5 | 3 | 2 | 4 | 0.20 | 140 | 0.050 | 0 | 0.41 | 3.59 | 0.053 | 0.07 |
| 80 | 7405 | 11 | 5 | 3 | 13 | 5 | 0.10 | 7 | 0.020 | 0 | 1.26 | 3.74 | 0.023 | 0.05 |
| 81 | 7525 | 11 | 10 | 3 | 13 | 2 | 0.13 | 115 | 0.065 | 0.26 | 0 | 1.74 | 0.07 | 0.08 |
| 82 | 7638 | 11 | 15 | 3 | 6 | 1 | 0.25 | 111 | 0.250 | 0 | 0 | 1 | 0.25 | 0.25 |
| 83 | 7649 | 11 | 15 | 3 | 17 | 18 | 1.37 | 10 | 0.076 | 5.8 | 1.04 | 11.16 | 0.094 | 0.23 |
| 84 | 7676 | 11 | 16 | 3 | 20 | 2 | 0.09 | 9 | 0.045 | 0.12 | 0 | 1.88 | 0.046 | 0.05 |
| 85 | 7733 | 11 | 19 | 3 | 5 | 6 | 0.22 | 55 | 0.037 | 4.22 | 0 | 1.78 | 0.057 | 0.10 |
| 86 | 7786 | 11 | 21 | 3 | 10 | 1 | 0.20 | 47 | 0.200 | 0 | 0 | 1 | 0.2 | 0.20 |
| 87 | 7792 | 11 | 21 | 3 | 16 | 8 | 0.87 | 5 | 0.109 | 3.15 | 0.8 | 4.05 | 0.144 | 0.20 |
| 88 | 7804 | 11 | 22 | 3 | 4 | 22 | 1.18 | 4 | 0.054 | 1.37 | 0.11 | 20.52 | 0.056 | 0.17 |
| 89 | 7886 | 11 | 25 | 3 | 14 | 5 | 0.33 | 60 | 0.066 | 0.48 | 0.48 | 4.03 | 0.073 | 0.10 |
| 90 | 7914 | 11 | 26 | 3 | 18 | 4 | 0.25 | 23 | 0.062 | 0.1 | 0.02 | 3.88 | 0.063 | 0.10 |
| 91 | 7956 | 11 | 28 | 3 | 12 | 1 | 0.05 | 38 | 0.050 | 0 | 0 | 1 | 0.05 | 0.05 |
| 92 | 7993 | 11 | 30 | 3 | 1 | 2 | 0.11 | 36 | 0.055 | 0 | 0.18 | 1.82 | 0.058 | 0.06 |
| 93 | 8083 | 12 | 3 | 3 | 19 | 7 | 0.15 | 88 | 0.021 | 0.93 | 0.38 | 5.69 | 0.024 | 0.06 |
| 94 | 8132 | 12 | 5 | 3 | 20 | 14 | 0.56 | 42 | 0.040 | 14 | 0 | 0 | 0.08 | 0.24 |
| 95 | 8152 | 12 | 6 | 3 | 16 | 2 | 0.09 | 6 | 0.045 | 0.41 | 0 | 1.59 | 0.05 | 0.06 |
| 96 | 8202 | 12 | 8 | 3 | 18 | 2 | 0.09 | 48 | 0.045 | 0.41 | 0 | 1.59 | 0.05 | 0.06 |
| 97 | 8246 | 12 | 10 | 3 | 14 | 9 | 0.52 | 42 | 0.058 | 0 | 3.7 | 5.3 | 0.073 | 0.12 |
| 98 | 8287 | 12 | 12 | 3 | 7 | 9 | 0.60 | 32 | 0.067 | 0.95 | 5.23 | 2.82 | 0.102 | 0.16 |
| 99 | 8305 | 12 | 13 | 3 | 1 | 3 | 0.07 | 9 | 0.023 | 0 | 0 | 3 | 0.023 | 0.05 |
| 100 | 8321 | 12 | 13 | 3 | 17 | 11 | 0.34 | 13 | 0.031 | 1.14 | 0.18 | 9.68 | 0.033 | 0.05 |
| 101 | 8350 | 12 | 14 | 3 | 22 | 5 | 0.11 | 18 | 0.022 | 1.55 | 0 | 3.45 | 0.026 | 0.06 |
| 102 | 8360 | 12 | 15 | 3 | 8 | 2 | 0.08 | 5 | 0.040 | 0 | 0.53 | 1.47 | 0.046 | 0.05 |
| 103 | 8399 | 12 | 16 | 3 | 23 | 1 | 0.09 | 37 | 0.090 | 0 | 0 | 1 | 0.09 | 0.09 |
| 104 | 8467 | 12 | 19 | 3 | 19 | 14 | 0.89 | 67 | 0.064 | 0 | 5.45 | 8.55 | 0.079 | 0.15 |
| 105 | 8489 | 12 | 20 | 3 | 17 | 2 | 0.09 | 8 | 0.045 | 0 | 0.23 | 1.77 | 0.048 | 0.05 |
| 106 | 8499 | 12 | 21 | 3 | 3 | 6 | 0.47 | 8 | 0.078 | 0 | 6 | 0 | 0.157 | 0.29 |
| 107 | 8512 | 12 | 21 | 3 | 16 | 8 | 0.14 | 7 | 0.018 | 0.68 | 0 | 7.32 | 0.018 | 0.04 |
| 108 | 8627 | 12 | 26 | 3 | 11 | 18 | 1.43 | 107 | 0.079 | 0 | 2.54 | 15.46 | 0.085 | 0.30 |
| 109 | 8704 | 12 | 29 | 3 | 16 | 6 | 0.28 | 59 | 0.047 | 0 | 0 | 6 | 0.047 | 0.11 |
| TOTALS: | | | | | | 665 | 34.3 | | | | | | | |
| AVG's: | | | | | | 6.1 | 0.31 | 73 | 0.052 | | | | | 0.11 |

Column Headings: EVT=Event Number CALHR=Calendar Hour MO,DA,YR,HR=time of event
DUR=duration (hrs) DEP=depth of rainfall (in) TDRY=antecedent dry time (hrs) AVGINT=average rainfall rate (in/hr)
A,B,C,H=trapezoidal hyetograph dimensions (rising hrs, falling hrs, steady hrs, and height (in/hr)
PMAX=maximum hourly precipitation rate (in/hr)

Representative year from REX-1-S gage, 1948-1988. For months 1-12:

**FIGURE 6.1**

# Selecting the Best Historical July for Use in the Representative Dry Season Record



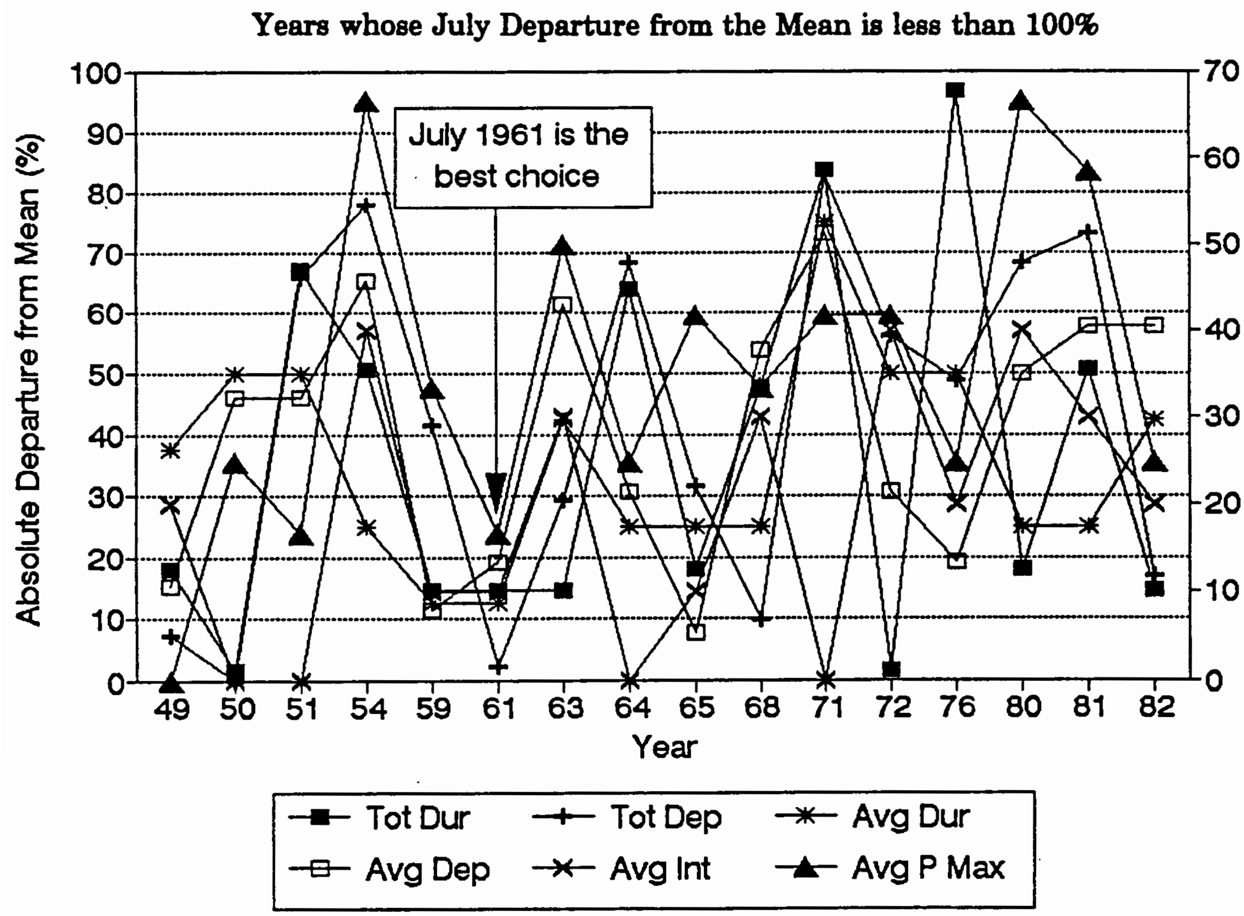
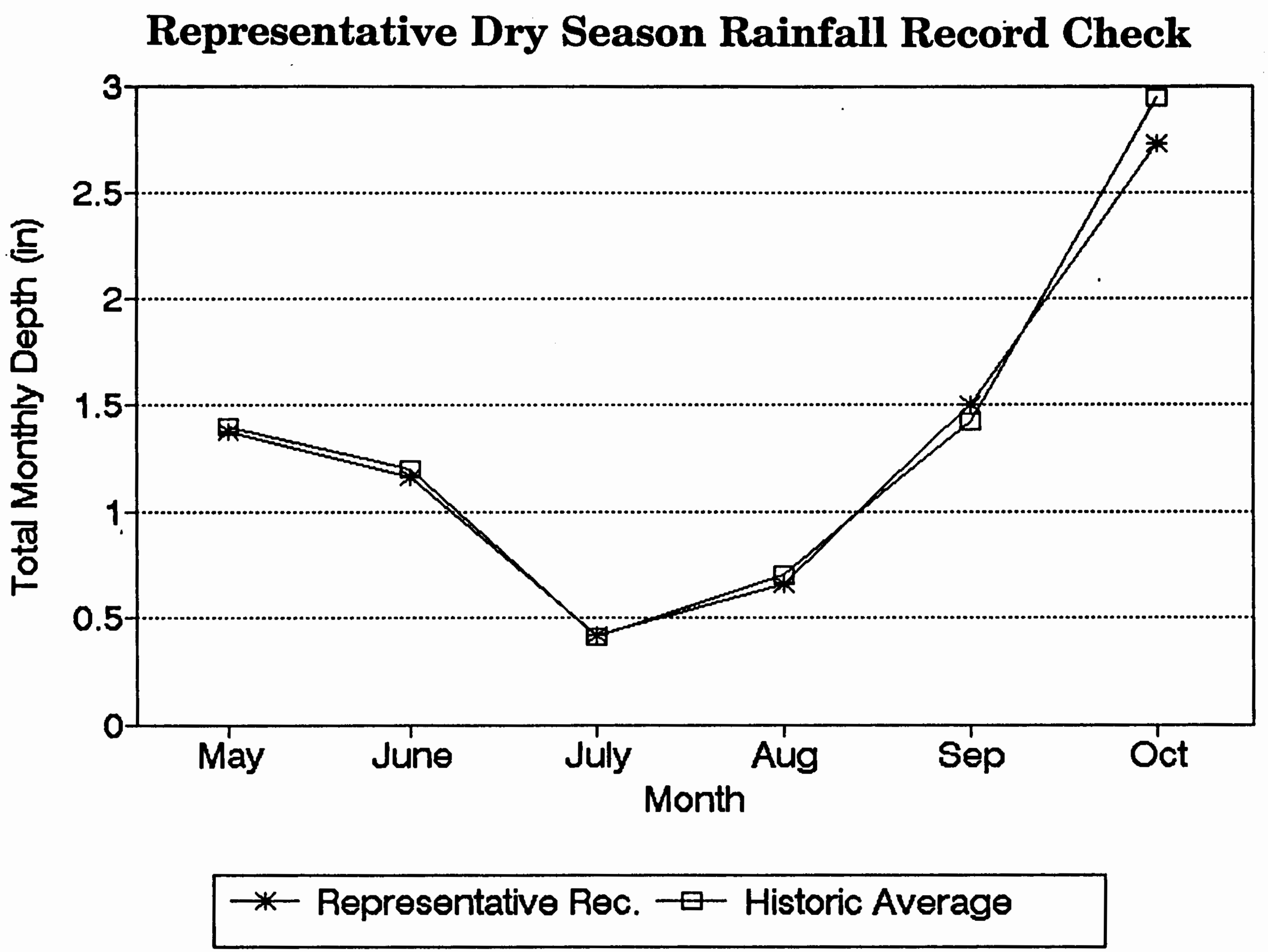



FIGURE 6.2


Representative Dry Season Rainfall Record Check
Total Monthly Depth (in)
3
2.5
2
1.5
1
0.5
0
May
June
July
Aug
Sep
Oct
Month
Representative Rec.
Historic Average

- Single-family residential
- Multifamily residential
- Institutional
- Commercial and Industrial
- Major Arterials

A "windshield" survey was conducted to collect site specific data about each of the general land use categories. Data was recorded on a form developed specifically for this purpose. A "windshield" survey refers to the collection of data gathered from an automobile traveling about the area of study.

The data was consolidated and synthesized into the ten land use categories shown in Table 6.1. Working with recent aerial maps, the amount of area occupied by each land use category within each of the delineated subbasins was measured. A similar process was used to establish future land use amounts based on the comprehensive plan.

## 6.3 RAINFALL ANALYSIS

The use of models, such as SIMPTM, requires use of a long-term rainfall record that represents the rainfall characteristics of a study area. EARTHINFO's CD-ROM Climatic Database was used to identify all NOAA-NWS stations in or near the Tualatin River Basin with multi-year hourly rainfall records. Of these, Rex-1-South, sited just east of Newberg, has the longest hourly precipitation records.

Rex-1-South's 39 years of continuous records, 1949-1987, were used to define the study area's rainfall characteristics and then to synthesize a historic rainfall record which best represents average annual rainfall conditions. The regulated phosphorus washoff period for the Tualatin River drainages within the study area has been established by DEQ to be May 1 through October 31. However, the regulated period for the Oswego Lake drainages within the study area has been established by DEQ to be the entire year. The Willamette drainage basins are not regulated at this time and they have been excluded from the upland water quality analysis.

### Runoff Producing Events

The rainfall analysis program, RAINEV, was used to analyze specific rainfall events from the Rex-1-South hourly precipitation records. For this study, the following rain event selection criteria were specified: minimum rainfall depths of 0.05" in one hour; 0.08" in three hours; or 0.1" in six hours which are both preceded by, and followed by, at least three continuous rain-free hours. Research (Pitt, 1987) has shown that these criteria above generally define the threshold of runoff generation in an urban area. Therefore, rainfall events of lesser depths than those specified within the durations noted will not produce runoff and need not be considered in an urban runoff study.

### Representative Record Development

After processing the station rainfall records, the following six parameters were determined for each month of record:

- Total duration of rainfall.
- Total depth of rainfall.
- Duration of rainfall per event (averaged by month).
- Depth of rainfall per event (averaged by month).
- Average intensity of rainfall per event (averaged by month).
- Maximum rainfall intensity per event (averaged by month).

## TABLE 6.3

## EXISTING ANNUAL UNIT POLLUTANT LOADINGS

| CATEGORIES | RUNOFF | TOTAL SOLIDS | | TOTAL PHOSPHORUS | |
|---|---|---|---|---|---|
| | ac-ft/acre | lbs/acre | mg/l | lbs/acre | mg/l |
| Single Family Residential | | | | | |
| 1 Ditch, Low Density | 0.11 | 29 | 99 | 0.03 | 0.10 |
| 2 Ditch, Med Density | 0.29 | 81 | 101 | 0.08 | 0.10 |
| 3 Curbed, Med Density | 0.66 | 186 | 104 | 0.18 | 0.10 |
| 4 Curbed, High Density | 1.00 | 278 | 102 | 0.27 | 0.10 |
| Multi-Family Residential | | | | | |
| 5 Roof/Parking Lot | 1.24 | 672 | 199 | 0.67 | 0.20 |
| Institutional | | | | | |
| 6 Roof/Parking Lot | 0.77 | 414 | 198 | 0.41 | 0.20 |
| Commercial and Industrial | | | | | |
| 7 Campus/Office | 1.49 | 911 | 225 | 0.91 | 0.22 |
| 8 Strip/Mall/Industrial | 1.88 | 1209 | 237 | 1.21 | 0.24 |
| Major Arterial | | | | | |
| 9 Ditches | 2.10 | 1605 | 281 | 1.60 | 0.28 |
| 10 Gutters | 2.27 | 2900 | 470 | 2.86 | 0.46 |

Figure 6.1 illustrates how these select parameters were graphically analyzed to establish the "best" average month out of the 39 historic months available for each month (i.e., January-December) to be included in SIMPTM simulation period. The following example describes the two-step process for the month of July using the full 39 years of record. The technique graphs the absolute departure from the long-term mean of each year of each month. Using this criteria, the best historic month would have the lowest absolute departure from the long-term mean.

As an initial screening step, all years were plotted (Figure 6.1, top), and only those years below a threshold value of 100% were analyzed further. For this example, the original data was reduced to fifteen years of data. Figure 6.1, bottom, graphs this reduced set. Visual inspection of the plotted data shows that July 1961 most closely mimics the long-term average July rainfall for the years of record.

In this manner, an hourly rainfall record was synthesized for the dry season regulation period by combining the following "best" months: May 1974; June 1982; July 1961; August 1963; September 1984, and October 1963. Figure 6.2 compares the total monthly rainfall depth of the synthetic or representative dry season record with the long-term historic averages.

The same procedure was used to establish the entire representative year which was needed in the examination of the Oswego Lake drainages. The characteristics of the 109 runoff producing events that comprise the representative year are shown in Table 6.2. This representative year was used to drive the SIMPTM simulation of storm water volumes and pollutant mass loadings from the ten land use categories.

## 6.4 ANNUAL UNIT AREA WASHOFF

The SIMPTM Program was calibrated to urban runoff data collected in the early 1980's in Bellevue, Washington. Data collected in Lake Oswego during the 1986-1987 water year was used to verify the calibration results (SRI, 1988).

The SIMPTM Program was used along with the representative rainfall year to simulate existing unit area runoff volumes and pollutant washoff values for total solids (i.e., total sediments) and total phosphorus. Table 6.3 presents these results for each of the ten land use categories described earlier.

For land use categories 1 through 8 shown in Table 6.3, the runoff volumes and washoff loads are tabulated on a per-acre basis. Simulated unit washoffs for categories 9 and 10 (i.e., Major Arterials) are tabulated on a per mile of roadway basis. Note that annual totals are shown in Table 6.3 for unit runoff volume and unit pollutant loadings. Also, overall annual average pollutant washoff concentrations are shown for both total solids and total phosphorus. These pollutant concentrations can be described as volume weighted annual event mean concentrations (EMC).

For comparison purposes, note that the lower Tualatin River total phosphorus (TP) concentration to be achieved by June 1993 is 0.07 mg/l. The data suggests that the urban storm water runoff exceeds this "standard" throughout the entire year for all categories of land use development. This emphasizes the importance of avoiding "concentration based standards" for urban runoff and focusing on actual mass load and its reduction.

## 6.5 UPLAND WATER QUALITY CONTROL STRATEGIES

One of the advantages of the SIMPTM program is its ability to reflect the changes in storm water pollutant loadings that can result from the application of upland water quality management control strategies. These strategies include maintenance activities such as street sweeping and catchbasin cleaning. Street sweeping is only modelled on land use categories that have streets with curbs. Catchbasin cleaning can only be used if sediment trapping capabilities exist within the storm water inlets or catchbasins. When dealing with future development conditions, the program assumes that trapped catchbasins will be constructed and it evaluates the benefits of varying the amount of sediment storage and the schedule for cleaning catchbasins.

Other upland control measures simulated by SIMPTM deal with the manner in which existing or future development is drained. If curb and gutter drainage does not exist, the program uses overland flow hydraulics to simulate pollutant washoff. Provided all other variables were equal, the washoff that occurs from overland flow hydraulics is significantly less that which would occur from curb and gutter hydraulics. This is an important issue considering that over half of the existing single family residential development in the study area does not have traditional curb and gutter drainage systems.

A land use characteristic that greatly effects both the volume and resulting quality of the storm water draining from development is the effective impervious area (EIA). EIA is the portion of land that is both impervious to storm water and effectively connected to the system that drains a development. EIA is not easily measured, but it has been shown to be related to both mapped impervious are (MIA) and the characteristics of the local drainage system that serves the area (Sutherland, 1987).

Alternate drainage systems such as grass-lined roadside swales instead of roadside curbs and gutters essentially reduce the amount of mapped impervious area that is directly connected or effective. SIMPTM models the effect of grass-lined swales or other forms of somewhat disconnected local drainage systems by using overland flow washoff hydraulics and lowering the assumed value for EIA.

This section summarizes the five comprehensive alternatives used to evaluate the effectiveness and associated cost of implementing upland water quality control strategies throughout the Lake Oswego service area. These alternatives combine various development assumptions and Best Management Practices (BMP) for each of the ten identified land use categories.

The five defined strategies or alternatives are identified below:

| Alternative | Title |
|---|---|
| 1 | Existing Development Conditions-With No Controls Applied |
| 2 | Full Development - Maximum Potential Loading With No Controls Applied |
| 3 | Current Trends - Apply the Current Strategies for Controlling Storm Water Quality |
| 4 | Revised Trends - Increase Application of Strategies for Controlling Storm Water Quality |
| 5 | Retrofit Existing Development - Maximum Effort to Reduce Pollutant Loads |

**Alternative 1 - Existing Development Conditions With No Controls Applied**

This alternative establishes the potential level of pollutant loadings now occurring throughout the study area that would result from existing development without any management practices.

The street sweeper is used to respond to large storm events that scatter debris throughout the City. The street sweeper is also used to remove sanding materials following snow or ice storms. Both curbed and uncurbed public streets are swept following these two conditions described above. In addition, curbed streets are periodically swept as needed.

Existing private development (multifamily, commercial and industrial) is required, by application of the Unified Plumbing Code (UPC), to provide sediment trapping catchbasins (STCB's). The sediment that accumulates in these facilities is not now being removed by cleaning on a periodic basis.

Approximately two-thirds of the storm water inlets located within the public rights-of-way do provide some sediment trapping capability. These STCB's are not cleaned on a regular basis because maintenance funding is not adequate. The important general characteristics of the existing condition are:

- Current land uses and development conditions were established from field surveys and aerial photos.
- STCBs occur in almost all of the existing private development designed to UPC requirements.
- STCBs occur in approximately two-thirds of the City's public right-of-ways.
- STCBs located in both private development and public rights-of-way are not being cleaned on a regular basis.
- No BMPs are in place except for de facto ditch and swale systems located in some single-family residential and major arterial areas (i.e, Categories 1,2, and 9)

**ALTERNATIVE 1**

| CATEGORY | LAND USE | |
|---|---|---|
| | EXISTING DEVELOPMENT | NEW DEVELOPMENT |
| 1 | Ditch and swale systems | N/A |
| 2 | Ditch and swale systems | N/A |
| 3 | No regular sweeping or CB cleaning | N/A |
| 4 | No regular sweeping or CB cleaning | N/A |
| 5 | No regular sweeping or CB cleaning | N/A |
| 6 | No regular CB cleaning | N/A |
| 7 | No regular CB cleaning | N/A |
| 8 | No regular CB cleaning | N/A |
| 9 | Ditch and swale systems | N/A |
| 10 | No regular sweeping or CB cleaning | N/A |

**Alternative 2 - Full Development - Maximum Potential Loading**

The second alternative is the future baseline against which the remaining alternatives were compared. It assumes full development according to the ultimately planned land use condition (i.e., Comprehensive Plan) within the study area. This alternative assumes that new single-family residential development will be at the currently established densities presented in the comprehensive plan. This alternative assumes that approximately one-half of the very low, single-family residential areas served by swales (i.e., Category 1) will develop to their maximum allowable density.

In addition, it is assumed that the disconnected drainage system that exists in these redeveloped low density, single-family residential areas will be replaced with curbed streets and sediment trapping catch basins (STCBs) as per current City and County standards.

Private development will continue to be designed according to the UPC and will be built with sediment trapping catchbasins (STCBs) which are assumed to be cleaned on an infrequent basis.

Arterials currently drained by ditches and swale storm systems will be replaced with curbed streets. STCBs and piped storm systems will replace existing roadside ditches. However, these new facilities will not be cleaned on a regular basis.

This alternative is expected to establish the greatest pollutant loadings which will be used to estimate potential load reductions associated with other alternatives that include BMPs. This alternative has the following important characteristics:

- Comprehensive plan land uses and densities realized throughout the study area.

- Approximately one-half of the very low density residential areas are redeveloped to higher densities with curbed streets and STCBs.

- All of the major arterials currently drained by ditch and swale systems are converted to curbed arterials with STCBs.

- No regularly scheduled street sweeping or STCB cleaning occurs throughout the study area.

## ALTERNATIVE 2

| CATEGORY | LAND USE | |
|---|---|---|
| | EXISTING DEVELOPMENT | NEW DEVELOPMENT |
| 1 | 50% of category #1 (exist) converted to #3 | N/A |
| 2 | Ditch and swale systems | N/A |
| 3 | No regular sweeping of CB cleaning | Category #3 (new) + 50% of Cat. #1 (exist) No regular sweeping or CB cleaning |
| 4 | No regular sweeping or CB cleaning | No regular sweeping or CB cleaning |
| 5 | No regular CB cleaning | No regular CB cleaning |
| 6 | No regular CB cleaning | N/A |
| 7 | No regular CB cleaning | No regular CB cleaning |
| 8 | No regular CB cleaning | No regular CB cleaning |
| 9 | NA (Converted to #10) | N/A |
| 10 | No regular sweeping or CB cleaning | Category #9 (exist) No regular sweeping or CB cleaning |

### Alternative 3 - Current Trends - Apply the Current Strategies for Controlling Storm Water Quality

This alternative assumes that one half of the very low density, single-family residential (i.e., Category 1) areas will be redeveloped to higher densities, but uncurbed streets and disconnected storm systems serving these areas are preserved. Furthermore, this alternative was developed to emulate application of nonstructural nonpoint control strategies in both existing and future development areas.

In this alternative, all STCBs (i.e., private and public in both existing and new development) will be cleaned twice yearly. Curbed streets in single-family residential areas will be swept every two months throughout the year. Curbed arterials will be swept monthly.

In addition, this alternative assumes that approximately one-half of the new single-family residential, multifamily residential and commercial and industrial areas are developed with grass swale drainage instead of the traditional curbed drainage with STCBs. This assumption allows the model to emulate the current trends that have evolved as a result of the permanent storm water quality control rules adopted by the Environmental Quality Commission (EQC) in December, 1989 (OAR 340-41-455(3)(e)).

These rules apply to any new land development within the Tualatin River and Oswego Lake subbasin whose completed application for approval is received by the local jurisdiction after June 1, 1990. They specify a phosphorus removal efficiency that is related directly to a development's impervious area and the manner in which that impervious area will be drained.

Recent revisions to this rule now require a 65% total phosphorus removal from all newly created impervious area for 0.36 inches of rainfall occurring over four hours. If infiltration or extended wet basins are used, they will have to drain within 96 hours.

In summary, Alternative 3 includes a revised future land use condition and the following important characteristics.

- Approximately one-half of the very low density residential areas are redeveloped to higher densities with swale drained systems preserved.
- Approximately one-half of the new single-family residential, multifamily residential, and commercial and industrial areas are developed with grass swale drainage or on-site retention/infiltration facilities.
- All of the major arterials currently drained by ditch and swale systems are converted to curbed arterials with STCBs.
- All STCBs (i.e., private and public) are cleared twice yearly.
- Curbed single-family residential streets are swept every two months.
- Curbed arterials are swept monthly.

**ALTERNATIVE 3**

| CATEGORY | LAND USE | |
|---|---|---|
| | EXISTING DEVELOPMENT | NEW DEVELOPMENT |
| 1 | 50% of Cat. #1 (exist) Converted to #2 | N/A |
| 2 | Ditch and swale systems | 50% (Category #1 (exist) + Cat. #3 (new) + Cat. #4 (new)) |
| 3 | Sweep 6 times per year Clean STCBs twice yearly | 50% of Cat. #3 (new) with swales Sweep 6 times per year Clean STCBs twice yearly |
| 4 | Sweep 6 times per year Clean STCBs twice yearly | 50% of Cat. #4(new) with swales Sweep 6 times per year Clean STCBs twice yearly |
| 5 | Clean STCBs twice yearly | 50% Category #5 (new) with swales Clean STCBs twice yearly |
| 6 | Clean STCBs twice yearly | N/A |
| 7 | Clean STCBs twice yearly | 50% Category #7 (new) with swales Clean STCBs twice yearly |
| 8 | Clean STCBs twice yearly | 50% Category #8 (new) with swales Clean STCBs twice yearly |
| 9 | N/A (Converted to #10) | N/A |
| 10 | Sweep monthly Clean STCBs twice yearly | Category #9 (exist) Sweep monthly, clean STCBs twice yearly |

**Alternative 4 - Revised Trends - Increase Application of Strategies for Controlling Storm Water Quality**

Alternative 4 is almost identical to 3 but has been developed to expand the application of street sweeping of curbed public streets. Single-family residential areas will be swept monthly and major arterials will be swept every two weeks. All of the other assumptions are identical to those documented in Alternative 3.

**ALTERNATIVE 4**

| CATEGORY | LAND USE | |
|---|---|---|
| | EXISTING DEVELOPMENT | NEW DEVELOPMENT |
| 1 | 50% of Cat. #1 (exist)<br>Converted to #2 | N/A |
| 2 | Ditch and swale systems | 50% (Cat. #1 (exist) + Cat. #3 (new)<br>+ Cat. #4 (new) |
| 3 | Sweep monthly<br>Clean STCBs twice yearly | 50% of Cat. #3 (new) with swales<br>Sweep monthly<br>Clean STCBs twice yearly |
| 4 | Sweep monthly<br>Clean STCBs twice yearly | 50% of Cat. #4 (new) with swales<br>Sweep monthly<br>Clean STCBs twice yearly |
| 5 | Clean STCB's twice yearly | 50% Cat. #5 (new) with swales<br>Clean STCBs twice yearly |
| 6 | Clean STCBs twice yearly | N/A |
| 7 | Clean STCB's twice yearly | 50% Category #7 (new) with swales<br>Clean STCBs twice yearly |
| 8 | Clean STCBs twice yearly | 50% Category #8 (new) with swales<br>Clean STCBs twice yearly |
| 9 | N/A (Converted to #10) | N/A |
| 10 | Sweep every two weeks<br>Clean STCBs twice yearly | Category #9 (exist)<br>Sweep every two weeks<br>Clean STCBs twice yearly |

**Alternative 5 - Retrofit Existing Development - Maximum Effort to Reduce Pollutant Loading**

This last alternative is developed to achieve the greatest amount of sediment and phosphorous washoff reduction through the use of source control strategies in the upland drainage areas.

This alternative includes all of the components described earlier as part of Alternative 3. Additionally, Alternative 5 includes several other significant revisions. It has been estimated by the City that approximately one third of the curbed single-family residential areas (i.e., Categories #3 and #4) are being served by storm water inlets that do not have any sediment trapping capabilities. This alternative assumes that these areas will be retrofitted with STCBs or sediment trapping manholes which will be cleaned twice annually. This alternative also assumes that major arterials drained by roadside ditches and swales are being preserved in the future and not converted to curbed streets with underground storm water systems.

In summary, the last alternative includes the following important characteristics:

- Retrofit with STCBs all curbed single-family residential areas where sediment trapping inlets do not exist.
- Major arterials drained by roadside ditches and swales are preserved in the future.
- All STCBs in both public and private developments are cleaned twice yearly.
- Curbed single-family residential streets are swept every two weeks.
- Curbed major arterial streets are swept weekly.
- Approximately one-half of the very low density residential areas are redeveloped to higher densities with swale drained systems preserved.
- Approximately one-half of the new single-family residential, multifamily residential, and commercial and industrial areas are developed with grass swale drainage or on-site retention/infiltration facilities.

**ALTERNATIVE 5**

| CATEGORY | LAND USE | |
|---|---|---|
| | EXISTING DEVELOPMENT | NEW DEVELOPMENT |
| 1 | 50% Converted to #2 | N/A |
| 2 | Ditch and swale systems | 50% (Cat. #1 (exist) + Cat. #3(new) + Cat #4 (new)) |
| 3 | 33% Retrofitted with STCBs<br>Sweep every two weeks<br>Clean STCBs twice yearly | 50% of Category #3(new) with swales<br>Sweep every two weeks<br>Clean STCBs twice yearly |
| 4 | 33% Retrofitted with STCBs<br>Sweep every two weeks<br>Clean STCBs twice yearly | 50% of Category #4 (new) with swales<br>Swept every two weeks<br>Clean STCBs twice yearly |
| 5 | Clean STCBs twice yearly | 50% of Category #5 (new) with swales<br>Clean STCBs twice yearly |
| 6 | Clean STCBs twice yearly | N/A |
| 7 | Clean STCBs twice yearly | 50% of Category #7 (new) with swales<br>Clean STCBs twice yearly |
| 8 | Clean STCBs twice yearly | 50% of cat. #8 (new) with swales<br>Clean STCBs twice yearly |
| 9 | Ditch and swale systems | N/A |
| 10 | Sweep weekly<br>Clean STCBs twice yearly | N/A |

## 6.6 AREA WIDE POLLUTANT WASHOFFS

SIMPTM was used to evaluate the area wide pollutant washoffs associated with these five alternatives presented in the previous section. The selection of the most appropriate upland control strategy should be based on its estimated cost effectiveness in reducing total phosphorus

## TABLE 6.4

### Runoff Volumes and Pollutant Washoffs Under Various Upland Control Strategies

| Alternative | Annual Totals: Runoff acre-ft | Annual Totals: Solids tons | Annual Totals: Phosphorus lbs | May-Oct Totals: Runoff acre-ft | May-Oct Totals: Solids tons | May-Oct Totals: Phosphorus lbs |
|---|---|---|---|---|---|---|
| **OSWEGO LAKE** | | | | | | |
| I | 2402 | 607 | 1202 | 504 | 202 | 402 |
| II | 3007 | 749 | 1477 | 635 | 250 | 495 |
| III | 2749 | 499 | 990 | 579 | 159 | 315 |
| IV | 2749 | 481 | 956 | 579 | 152 | 302 |
| V | 2738 | 448 | 895 | 576 | 142 | 283 |
| **TUALATIN RIVER** | | | | | | |
| I | 1218 | 287 | 567 | 256 | 97 | 192 |
| II | 2016 | 472 | 929 | 426 | 159 | 315 |
| III | 1822 | 297 | 588 | 384 | 96 | 189 |
| IV | 1822 | 285 | 566 | 384 | 91 | 180 |
| V | 1814 | 269 | 537 | 382 | 86 | 170 |

FIGURE 6.3

# Upland Control Strategy Analysis:

## Oswego Lake

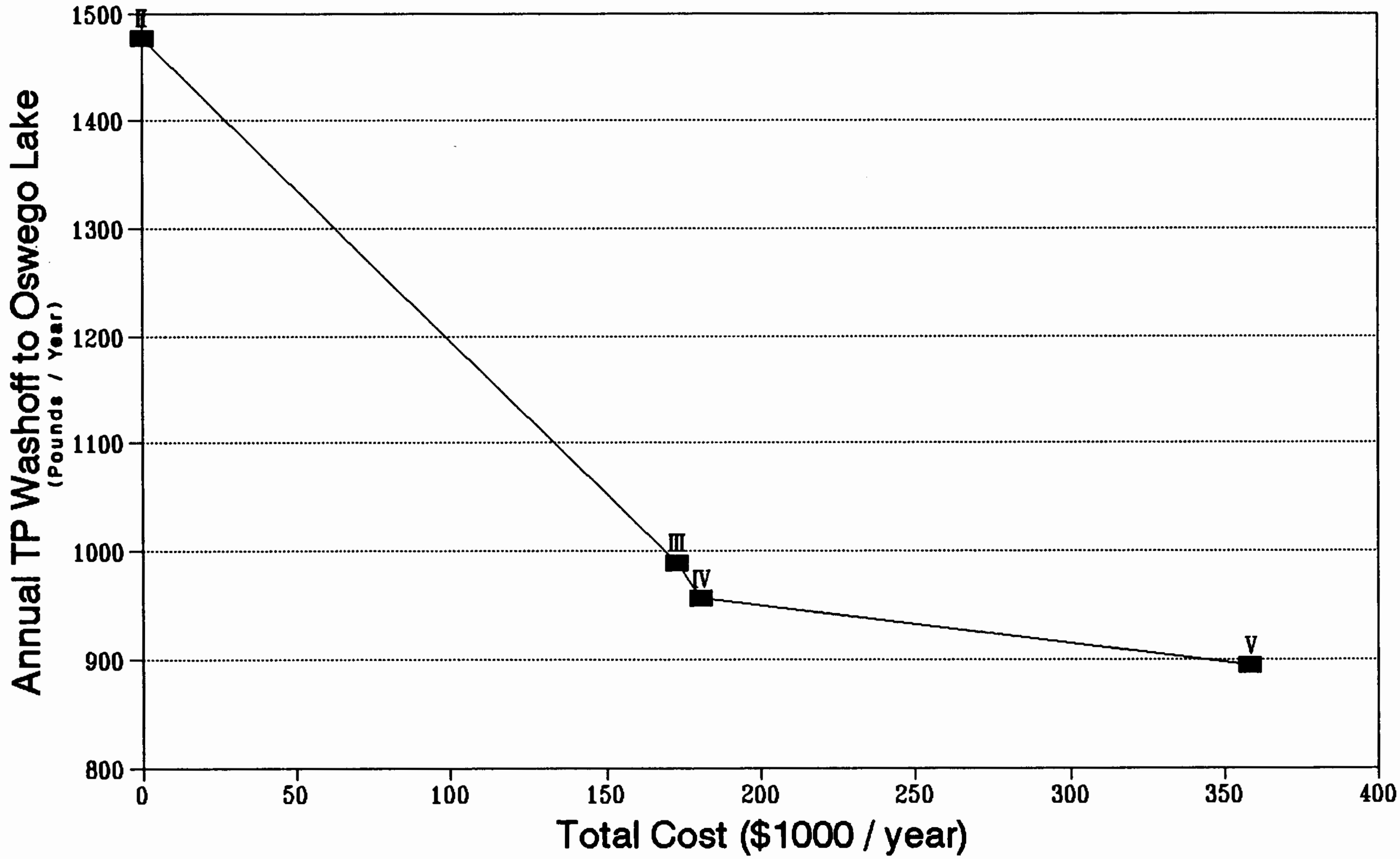
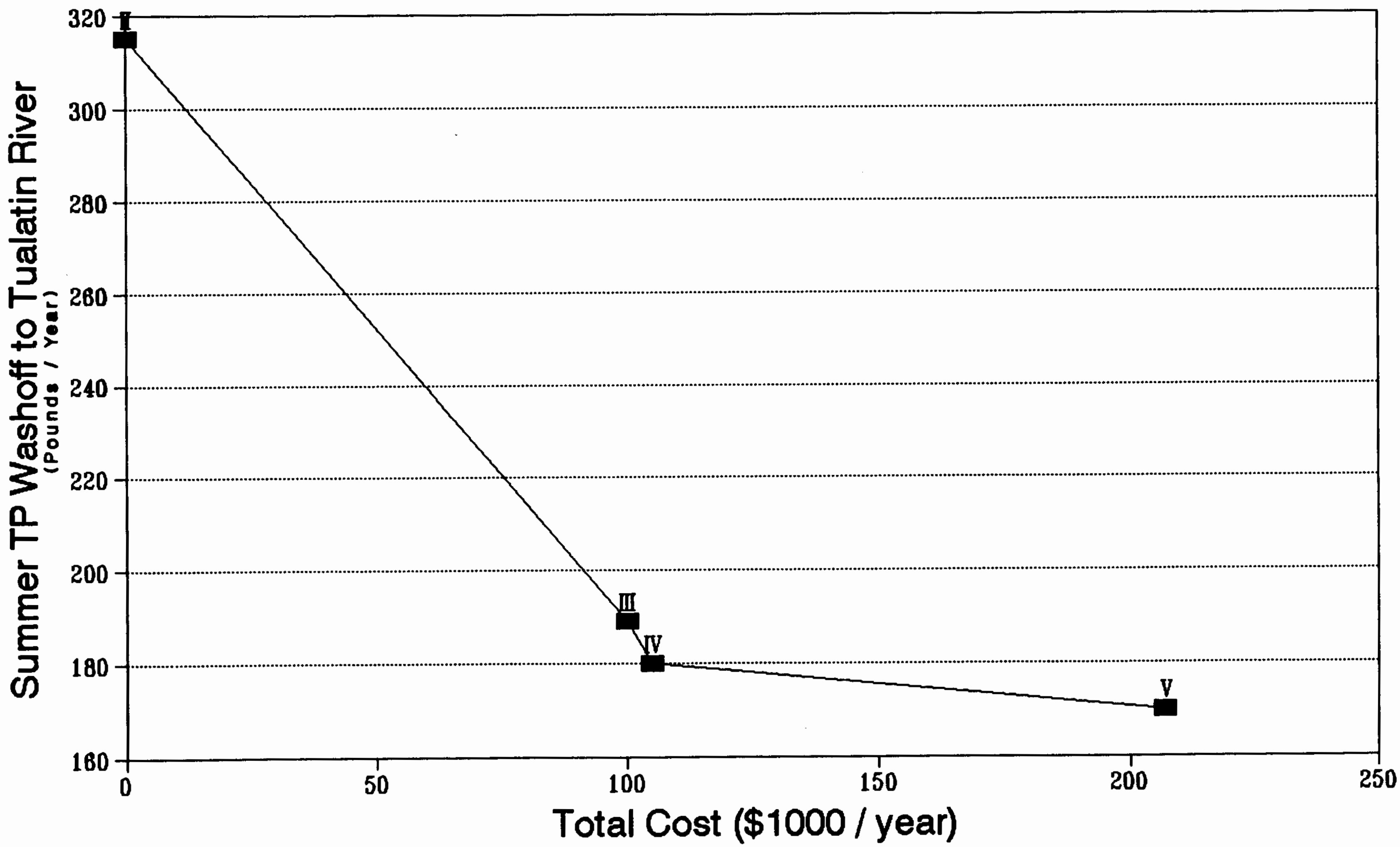


FIGURE 6.4

## Upland Control Strategy Analysis:

### Tualatin River



washoff throughout the study area. The strategy that provides significant phosphorus washoff reductions with the lowest cost per pound removed should be selected.

**Phosphorus Load Allocation**

As discussed in Chapter 1, the Northwest Environmental Defense Center's (NEDC's) 1986 lawsuit under Section 303 of the Clean Water Act (CWA) has forced DEQ to establish phosphorus Total Maximum Daily Loads (TMDL's) and Load Allocations (LA's) for the Tualatin River basin including the Oswego Lake subbasin. The total phosphorus (TP) load allocation for the Oswego Lake drainages has been established at 850 pounds per year. The phosphorus regulated period for Oswego Lake is the entire year. Whereas, the regulated period for the Tualatin River drainages is May 1 through October 31. One of the objectives of the separate Oswego Lake Study, discussed in Chapter 1, is to provide DEQ with the data or information needed to shorten the time frame of regulation for the Oswego Lake drainages.

During the SWM planning process, it was discovered that neither Clackamas County nor the City of Lake Oswego was assigned a total phosphorus load allocation for their Fanno Creek drainage which includes both Ball Creek and Carter Creek. DEQ indicated that this appeared to be an oversight on its part and they asked both jurisdictions to suggest a phosphorus load allocation for the 1,260 acres that were affected. It should also be noted that the City of Rivergrove does not have a load allocation for phosphorus either so one will be suggested later in this section.

SIMPTM was used to estimate the average annual total phosphorus washoff from the Oswego Lake drainages under both existing conditions of developments and existing public works practices (i.e. Alternative 1 described in the previous section). Approximately 1,200 pounds of total phosphorus was estimated to washoff during the average year. This exceeds the existing load allocation by 350 pounds or 41%. This area wide washoff does not include any total phosphorus contributions from baseflow which is another important issue.

**Baseflow**

Baseflow is defined as the magnitude of flow observed in a natural stream after several days of no measurable rainfall. Baseflow varies significantly from one drainage to the next and throughout the year. Continuous flow monitoring for two different residential sites in Bellevue, Washington concluded that annual baseflow volumes easily exceed and almost double the annual volumes directly contributed by surface washoff.

Mass pollutant contributions from baseflow can also be quite significant especially for pollutants such as total phosphorus which exists naturally in association with soil. Soil phosphorus availability mapping for the study area presented in Appendix G concluded that the highest phosphorus availability soil groups are located on the steep slopes adjacent to Oswego Lake which also have a very high erosion potential.

Limited baseflow data collected on Springbrook Creek by SRI during the 1987 water year, (SRI, 1988) indicated that total phosphorus concentrations averaged about 0.03 mg/l. It should be noted that the TMDL's are based on a lower Tualatin River TP concentration of 0.07 mg/l. High TP concentrations of baseflow observed in Springbrook Creek show that baseflow appears to be a significant contributor to TP mass loadings.

As part of the separate Oswego Lake Study (KCM, 1992), it was estimated that during an average rainfall year, approximately 380 pounds of total phosphorus enters the lake from baseflow contributions associated with its 4029 acres of drainage area. However, it was estimated that only 23% of this baseflow loading occurs during the dry season period of May 1 through October 31.

TABLE 6.5

**Area Wide Runoff Volumes and Pollutant Washoffs Under the Recommended Upland Control Strategy**

| Basin | AREA acres | Annual Totals Runoff acre-ft | Annual Totals Solids tons | Annual Totals Phosphorus lbs | May-Oct Totals Runoff acre-ft | May-Oct Totals Solids tons | May-Oct Totals Phosphorus lbs |
|---|---|---|---|---|---|---|---|
| **OSWEGO LAKE** | | | | | | | |
| SB | 1224 | 1026 | 202 | 401 | 216 | 66 | 131 |
| LBF | 387 | 436 | 102 | 204 | 92 | 34 | 68 |
| WB | 111 | 76 | 18 | 35 | 16 | 6 | 11 |
| RR | 75 | 84 | 22 | 44 | 18 | 7 | 14 |
| JR | 117 | 55 | 8 | 16 | 11 | 2 | 5 |
| LM | 392 | 125 | 16 | 33 | 26 | 4 | 8 |
| OC | 485 | 287 | 33 | 65 | 60 | 10 | 19 |
| BHC | 350 | 216 | 23 | 46 | 46 | 7 | 14 |
| F | 78 | 41 | 5 | 10 | 9 | 1 | 3 |
| LP | 44 | 22 | 2 | 4 | 5 | 1 | 1 |
| CC | 153 | 37 | 11 | 22 | 8 | 3 | 7 |
| LB | 91 | 42 | 6 | 12 | 9 | 2 | 3 |
| PH | 83 | 43 | 6 | 11 | 9 | 2 | 3 |
| LD | 440 | 269 | 46 | 90 | 57 | 14 | 28 |
| TOTALS | 4029 | 2759 | 500 | 993 | 581 | 159 | 316 |
| **TUALATIN RIVER** | | | | | | | |
| B | 781 | 763 | 121 | 239 | 161 | 40 | 80 |
| C | 480 | 502 | 101 | 201 | 106 | 34 | 67 |
| RG | 347 | 143 | 18 | 35 | 30 | 5 | 10 |
| RVR | 214 | 121 | 12 | 24 | 25 | 4 | 7 |
| P | 504 | 292 | 45 | 88 | 62 | 13 | 26 |
| TOTALS | 2327 | 1822 | 297 | 588 | 384 | 96 | 189 |
| STUDY AREA: | 6356 | 4580 | 797 | 1581 | 964 | 255 | 505 |

The area wide runoff volume and pollutant loads simulated by SIMPTM and presented in this section do not include baseflow contributions. On an annual basis, baseflow volume is approximately 1.9 times the storm water runoff volume and baseflow TP loading is approximately 0.3 to 0.4 of the storm water washoff loading. On a dry season basis, baseflow volume is approximately 1.8 times the storm water volume and baseflow TP loading is approximately .2 to .3 times the storm water TP loadings. Baseflow phosphorus was not ignored but, most baseflow phosphorus is dissolved with the rest associated with the finest sediment, and often is contributed by groundwater, plan management practices, and in-stream treatment offers little benefit.

**Simulation Results**

Table 6.4 summarizes the SIMPTM simulation results for the five upland control strategies or alternatives presented in the previous section. Washoff results from two regulated periods are shown for the contributing study area draining to the regulated waterways - - Oswego Lake and the Tualatin River. The results show that uncontrolled washoff from future development (i.e. Alt. II) in the Oswego Lake drainages would increase both total solids (TS) and total phosphorus (TP) annual loadings by 23% over existing development (Alt. I). However, uncontrolled future washoff in the Tualatin River drainages would increase pollutant annual loadings by 64%. These results reflect the greater amount of development anticipated for the Tualatin River drainages.

Upland control alternatives III, IV, and V are expected to reduce uncontrolled annual TP loadings in the Oswego Lake drainages by 33%, 35%, and 39%, respectively from the baseline (Alternative II). Annual TP load reductions in the Tualatin River drainages for the same alternatives are estimated at 37%, 39%, and 42%, respectively. Dry season TP load reductions in the Tualatin River drainage for the same alternatives are slightly better at 40%, 43%, and 46%, respectively.

The selection of the most appropriate alternative should be based on cost effectiveness. As part of the planning process, detailed cost estimates of the maintenance related practices associated with each of these alternatives were developed. These cost estimates were developed for the City of Lake Oswego's existing incorporated area and included the portions of the City that drain directly to the Willamette River which were not included in the SIMPTM simulations.

Figures 6.3 and 6.4 present the results of the cost effectiveness analysis for the two regulated waterways. The figures show that Alternatives III and IV are almost identical in both cost and effectiveness and Alternative V is not very cost effective. The greater costs assigned to Alternative V reflect the annualized capital costs associated with retrofitting existing storm water inlets or connecting non-sediment trapping inlets to pollution control (PC) manholes.

On a dollars per pound of TP removed basis, Alternative IV is slightly lower than Alternative III in both drainages evaluated. However, the differences between these two alternatives is clearly within the expected error of the estimates themselves. The only real difference between these two alternatives in practices would be a greater level of street sweeping in Alternative IV when compared to Alternative III.

The results of the upland control strategy analysis were presented to the Policy Committee with a recommendation from the Project Team to implement Alternative III. The Project Team felt that the level of effort associated with street sweeping in Alternative III was more appropriate than that in Alternative IV and still reflected a dramatic increase in sweeping when compared to the City and County's existing programs. After considerable discussion, the recommendation of the Project Team was endorsed by the Policy Committee. Thus, the upland control strategy entitled "Current Trends" and described in the previous section will be implemented throughout the study area as part of the SWM Master Plan.

Table 6.5 presents the estimated area wide runoff volumes and pollutant washoffs under the recommended upland control strategy throughout each of the drainage basins studied. Both annual and dry season totals have been presented in the table. As noted earlier, baseflow contributions are not included in the numbers represented in Table 6.5. Baseflow estimates were be made using the recommended ratios of baseflow to storm water presented earlier under the baseflow subsection of 6.5. Average pollutant concentrations can also be estimated using the following conversion.

$$mg/l = (lbs/acre\text{-}ft)(0.3677)$$

Note that total solids (TS) washoffs presented in Table 6.5 are in tons.

### Suggested TP Load Allocations

Both the Project Team and Policy Committee believe that TP load allocations should be based on cost effective and achievable upland control strategies and should include a realistic estimate of baseflow or background conditions. The Oswego Lake Study concluded that ...."the Oswego Lake watershed load allocations do not appear attainable based on current assessment of new and old data sets." The Lake Study recommended that discussions with DEQ be initiated to revise the load allocations for both the lake drainages and the canal intake.

To help facilitate these discussions, the following TP load allocations are suggested for the entire study area.

**TABLE 6.6**

**SUGGESTED TOTAL PHOSPHORUS LOAD ALLOCATION (LA)**

| Basin | Jurisdiction | Regulated Period | Total Phosphorus LA (lbs) Washoff | Baseflow | Total |
|---|---|---|---|---|---|
| Oswego Lake | City of Lake Oswego | Annual | 990 | 380 | 1370 |
| Oswego Lake | City of Lake Oswego | Dry Season | 315 | 85 | 400 |
| Tualatin River | Clackamas County | Dry Season | 95 | 25 | 120 |
| Tualatin River | City of Lake Oswego | Dry Season | 60 | 15 | 75 |
| Tualatin River | City of Rivergrove | Dry Season | 35 | 10 | 45 |
| Tualatin River Totals ........................................ | | | 190 | 50 | 240 |

The Project Team also recommends that the regulated period for the Oswego Lake drainages be changed to the dry season period of May 1 through October 31 specified throughout the rest of the Tualatin River drainages. However, suggested annual load allocations have also been tabulated in the event that the regulated period is not changed. The suggested load allocations are based on the implementation of the enhanced maintenance practices and water quality controls on future development described in the recommended upland control strategy(Alternative III). The suggested load allocations do not reflect any further load reductions that may be achieved through the development of regional pollutant reduction facilities (PRF's) or passive storm water treatment facilities that are determined to be cost effective. However, the SWM Master Plan will include these type of facilities where they are warranted. This topic is addressed in the next chapter.

Water Quality
Control Facilities

# CHAPTER 7

# WATER QUALITY CONTROL FACILITIES

Urbanization has profound effects upon the hydrology and water quality of Oswego Lake and the Tualatin River. Development increases peak flood flows, runoff volumes and stream velocities and decreases the time needed for runoff to reach receiving waters. Stream channels respond with wider channels, wider floodplain, increased erosion and larger sediment deposits in receiving waters.

Pollutant exports also increase dramatically. Initially, exposed soils contribute the bulk of nutrients and organic matter bound to soil particles. After development, impervious surfaces collect and export atmospheric pollutants and trace metals. Other pollutant sources include fertilizers, pesticides, herbicides, pet droppings, vegetative matter, litter and organic debris. Urban pollutants degrade the quality of receiving waters and adversely impact aquatic organisms by increasing suspended sediment and the levels of nutrients and bacteria, depleting dissolved oxygen and increasing the occurrence of oils, grease, toxic chemicals and trace metals.

Much of this pollution can be prevented, and controlled before it washes off; or it can be treated using natural processes in-stream or at large-scale facilities which are designed to mitigate the impact pollutants have upon sensitive receiving water bodies. Approaches that accomplish these objectives include:

**Public awareness** programs increase residents understanding how their lifestyles can impact water quality. These can prevent wastes like motor oil, antifreeze, or detergents and phosphorus-rich organic litter from entering storm sewer inlets and being washing off during rainfall events. The Public Awareness Action Plan (Chapter 2) develops this approach.

**Development standards** can be revised to require alternatives to curb and gutter streets and focus on managing water quality and flood control. Erosion of exposed soil can be minimized through better planning and design, and more stringent erosion control measures for site construction. Storm runoff volumes can be reduced by limiting the impervious area in new development.

**Upland management practices** reduce pollutant export before it reaches stream corridors. Street sweeping, storm sewer sediment traps, on-site infiltration and extended detention and alternative landscaping with grass swales or filter strips can remove suspended pollutants from the storm water runoff. In addition, sedimentation basins can trap coarser suspended pollutants before they enter stream corridors and re-associate with finer, harder to capture sediment. Little runoff or fine sediment is captured and stored between storms. Chapter 6 documents the selected upland management strategy.

**Stream rehabilitation efforts** include the stabilization and protection of stream banks against scour and erosion through both vegetative or structural means. Reductions occur in sediment transported which improves water quality and aquatic habitat within the stream and decreases sediment deposition in the stream's receiving water.

**Regional pollution reduction facilities (PRFs)** treat storm water runoff along the major stream system using extended detention and marshes, or wet ponds, to capture and store storm event runoff. Between storms, fine suspended pollutants can settle out and dissolved pollutants can soak through topsoil or be absorbed by aquatic vegetation.

## 7.1 OVERVIEW OF FACILITY TYPES CONSIDERED

Because regional PRFs would be located in or near major stream corridors where the shallow water table and low-permeability soils limit absorption, infiltration facilities are usually not feasible.

Pond-marsh or extended detention-marsh PRFs can effectively remove many sediment-borne pollutants by storing portions of runoff volume long after a rainfall event ends, allowing much of the fine sediment and associated pollutants to settle out. However removals of nutrients like phosphorus and nitrogen are much lower, as large dissolved fractions never settle out, and are only slightly removed by aquatic plant growth.

In extended detention, large influent flows are captured and slowly released between storms while in wet ponds, captured runoff displaces existing water; outflow equals inflow. While both allow pollutants to settle between storm events, for both to be equally effective, wet ponds must prevent "short circuiting" or mixing of influent with effluent. Therefore, larger facilities would be required. In addition, it is difficult to keep the dissolved oxygen level above 2 mg/l to limit phosphorus re-mobilization. Finally, sedimentation basins should not be confused with regional pollutant reduction facilities. however they store little or no runoff; little fine sediment would be able to settle out during the event. They only be productive upland, before stormwater enters the stream corridors. All sites were thus evaluated for extended detention-marsh suitability, as any existing wet ponds would contain which would limit feasibility with natural wetlands.

## 7.2 SITE FEASIBILITY

Regional PRF sites must be vacant, must drain greater than 50 acres, must pose no flood hazard potential, and must provide sufficient storage volume to achieve worthwhile pollutant removals. The project team searched for promising PRF sites along the major drainage systems studied in all of the nineteen major basins discharging to Oswego Lake or the Tualatin River. They used aerial photographs, detailed topographic maps and field reconnaissance. Thirty-nine sites were identified as having characteristics suitable for PRF construction in 8 basins:

- Springbrook Creek
- Lost Dog Creek
- Ball Creek
- Carter Creek
- Country Club
- Reese Road
- Blue Heron Canal
- Lower Boones Ferry

Kramer, Chin and Mayo (KCM) and Cascade Earth Sciences (CES) initially ranked these sites using criteria presented in Appendix F to establish their potential and to identify any constraints that would limit their use as a PRF. The screening criteria included both site specific and basin wide considerations. Basin wide considerations included: 1) soil erosion potential, 2) soil phosphorus availability, 3) estimated total phosphorus loadings, 4) contributing drainage area and 5) the ratio of available facility surface area to the theoretical surface area that is needed. Appendix G presents the soil erosion potential and phosphorus availability mapping conducted throughout the study area and used in this PRF screening.

Site specific screening criteria included: 1) wetlands, 2) land slope, 3) tree cover, 4) soil depth, 5) natural resources enhancement potential and 6) site ownership. KCM rejected one site each in Lost Dog Creek, Country Club, and Springbrook Creek where wetlands promised to limit PRF development.

One of the most important parameters in the PRF screening process is the ratio of available facility surface area to the theoretical surface area that is needed. The surface area that is needed was assumed to be 3.5% of the contributing drainage area of the site. This "needed surface area" computation was based on the recommendation of the National Urban Runoff Program (USEPA, 1983). This translates to 1,525 square feet per acre of drainage which is rarely available in urbanized areas. Because volume, not area, is the most important design parameter, the project team felt that the minimum acceptable site area given the local conditions is 120 square feet per acre of contributing drainage area. This represents only 8% of the theoretical value suggested by NURP. Twenty-nine of the remaining 36 sites were rejected for failing this criterion, leaving seven eligible sites.

A new eligible site which satisfied the wetlands and minimum area tests was later identified in Springbrook Creek just east of the Hunt Club. These eight highly ranked sites were considered for implementation. The estimated cost to build each regional PRF site was compared with its estimated pollutant reduction. This information was later used to rank the PRFs by the cost-per-pound of total phosphorus removed and, establishing the schedule for their implementation.

Figure 7.1 maps these eight high-priority sites and the areas treated:

**Springbrook Creek**

| | |
|---|---|
| SB 120 | east of the Hunt Club |
| SB 102 | north of Twin Fir Road |
| SB 108 | north of Monroe Parkway |

**Lower Boones Ferry**

| | |
|---|---|
| LBF 2 | west of Tualatin Street |
| LBF 3 | north of Boones Ferry Road |

**Lost Dog Creek**

| | |
|---|---|
| LD 2 | south of South Shore Blvd. |
| LD 3 | south of Sunny Hill Drive |

**Reese Road**

| | |
|---|---|
| RR 1 | north of S.P. Rail Road |

In addition to the preliminary natural resources potential criteria of wetlands and area, the soil depth, erodibility and phosphorus availability, of the sites must also be considered, as must the natural resources potential. CES and KCM examined these during their initial screening (Appendix F), but more detailed site assessments will be required during final design and construction.

## 7.3 POLLUTANT REMOVALS

Every attempt was made to maximize the pollutant removal efficiency of a PRF by utilizing the total area of a site for storage and treatment volumes. In some instances, maximizing the use of the site area created facilities whose dimensions departed from the design guidelines available in numerous handbooks. All of the selected sites have characteristics that assure beneficial pollutant removals that would improve water quality.

OTAK modeled PRF performance using the representative year storms described in Chapter 6 to relate the fraction of runoff treated to PRF storage volume. Runoff in excess of the available storage volume was calculated for each of the 109 significant rainfall events. No in-stream minimum flow was provided for.

OTAK estimated each facility's annual removal of sediment and phosphorus from the fraction of annual runoff volume captured and treated. The total acre-feet of runoff and pounds of total solids (TS) and total phosphorus (TP) entering each of the eight PRFs were calculated using the area wide loads from the recommended upland management strategy, described in Chapter 6. The total acreage and total effective impervious acreage contributing to each of the eight PRFs were compared with estimated available storage volumes to arrive at the fraction of storm water runoff treated.

Table 7.1 reports the contributing areas, runoffs and annual loads and the resulting removals of TS and TP for each of the eight recommended PRFs.

A site was ranked independently of others as if it were the only one functioning. The removals for facilities in series involve slightly more complex accounting for the small discharges from an upper facility being treated by the one downstream. However, multiple PRF's in series can approach the effectiveness of a single, larger PRF. As their outflows are much smaller than their inflow and their performance is based upon the volume of extended detention available, there is little "overlap" between sequential PRF's.

## 7.4 ESTIMATED CONSTRUCTION COSTS

Construction costs for each PRF was determined from data presented in Table 5.1. A contingency factor of 15 percent was added to the construction cost to reflect unknowns of each project. A non-construction cost factor of 20 percent was applied to the sum of the construction cost with contingency for costs associated with the engineering design and construction services.

Assumptions about the type and extent of improvements necessary to construct a specific PRF facility are based upon general design concepts presented in the Surface Water Quality Facilities Handbook (Brown and Caldwell, 1991) and the estimated facility dimensions presented therein. These costs are for planning purposes only.

Table 7.2 itemizes the construction costs for the recommended sites by the following work components:

- **Clearing and grubbing** will be necessary to remove vegetative material and debris to facilitate excavation and final site grading to create a low flow channel and areas for storing and treating runoff.
- **Bulk Excavation** involves soil removal required to enlarge the facility's storage volume. Excavated material can also be used for constructing embankments and landscaping purposes.
- **Imported Fill** could be required at sites containing undesirable soils i.e. highly erosive soils or soils with a high phosphorus potential. Also imported fill may be needed to construct under drain systems for infiltration facilities.
- **Edge Treatment** is applied to the borders around the facility that may require shaping and reseeding to limit erosion and to meet safety requirements.
- **Construct Swales** primarily as a pretreatment strategy to capture pollutants before they enter the facility. This would be an effective measure for treating runoff from commercial area draining into facility LBF-3.
- **Construct check dams** is an auxiliary technique used in conjunction with swales to limit flow velocity and trap sediment before runoff it enters a PRF facility.

# Recommended Pollutant Reduction Facilities

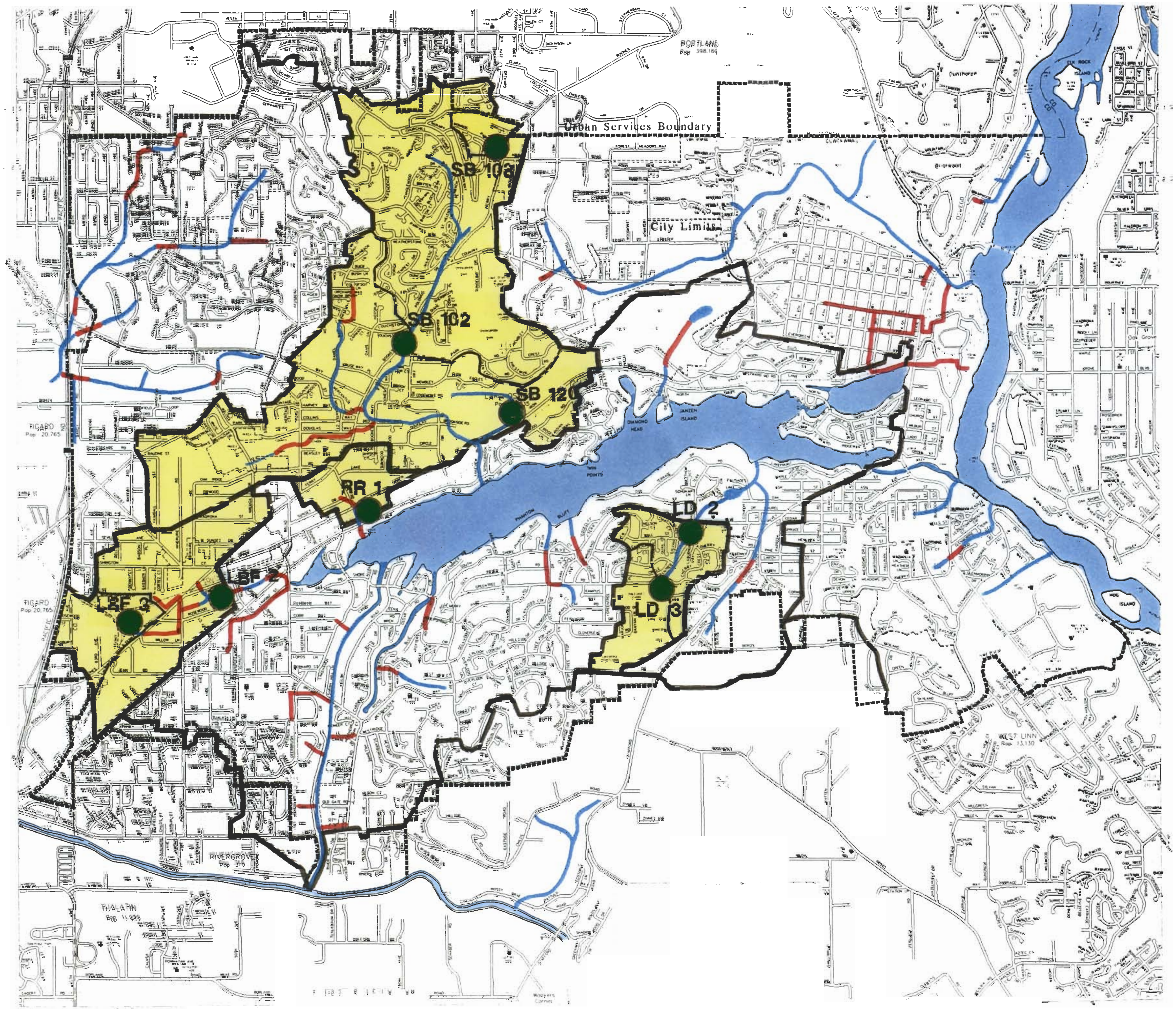



Figure 7.1

# TABLE 7.1

## Estimated PRF Performance

| PRF Site Location | Facility Size | | | Contributing Areas | | Runoff | Fractions Removed | | Annual Intake | | | Removals | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Area Acres | Depth ft | Volume Acre-ft | Total acres | EIA acres | Fraction Treated | Solids | Phos. | Runoff acre-ft | Solids tons | Phos. lbs | Solids tons | Phos. lbs |
| **Springbrook Creek** | | | | | | | | | | | | | |
| SB 120 | 5 | 3 | 15 | 1200 | 404 | 0.72 | 0.68 | 0.43 | 1018 | 201 | 399 | 172 | 137 |
| SB102 | 3.5 | 3 | 10.5 | 521 | 210 | 0.8 | 0.76 | 0.48 | 536 | 106 | 211 | 101 | 81 |
| SB 108 | 0.8 | 4 | 3.2 | 40 | 22 | 1 | 0.95 | 0.60 | 53 | 10 | 19 | 12 | 9 |
| **Lower Boones Ferry** | | | | | | | | | | | | | |
| LBF 2 | 1.1 | 3 | 3.3 | 337 | 173 | 0.55 | 0.52 | 0.33 | 413 | 99 | 197 | 65 | 52 |
| LBF 3 | 3.2 | 4 | 12.8 | 87 | 67 | 1 | 0.95 | 0.60 | 152 | 37 | 73 | 44 | 35 |
| **Lost Dog Creek** | | | | | | | | | | | | | |
| LD 2 | 0.5 | 2 | 1 | 166 | 28 | 0.7 | 0.66 | 0.42 | 91 | 12 | 23 | 10 | 8 |
| LD 3 | 1.5 | 2 | 3 | 76 | 9 | 1 | 0.95 | 0.60 | 33 | 6 | 11 | 7 | 5 |
| **Reese Road** | | | | | | | | | | | | | |
| RR1 | 0.2 | 6 | 1.2 | 75 | 35 | 0.7 | 0.66 | 0.42 | 84 | 22 | 44 | 19 | 15 |

NOTES:

1. Performance of each PRF is as if it were acting alone. No interference effects are considered.

2. Annual Intakes are for upland control strategy III practices using representative year.

3. Ratios of fractions of solids and phosphorus removed to runoff volume treated from Schueller (1987): 95% for TS, 60% for TP.

4. Treated fraction of runoff volume determined using OTAK's PRF Performance Model.

## Table 7.2
## Pollutant Reduction Facility Costs

| Work Description | Unit | Unit Cost | LBF-3 | LBF-2 | SB-102 | SB-120 | SB-108 | RR-1 | LD-3 | LD-2 |
|---|---|---|---|---|---|---|---|---|---|---|
| Clearing and Grubbing | Acre | $1,000 | $3,200 | $1,100 | $3,500 | $800 | $800 | $200 | $300 | $300 |
| Bulk Excavation | cyd | Varies | 0 | 24000 | 116500 | 0 | 0 | 51600 | 61800 | 113600 |
| Imported Fill | cyd | 15 | 0 | 0 | 0 | 0 | 0 | 60000 | 0 | 0 |
| Edge Treatment | Acre | 1000 | 1000 | 500 | 500 | 500 | 0 | 500 | 500 | 500 |
| Construct Swales | lf | 7 | 9800 | 0 | 0 | 5600 | 0 | 2100 | 7000 | 0 |
| Construct Check Dams | each | 1000 | 4000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Pipe | lf | Varies | 32000 | 38660 | 0 | 10400 | 0 | 0 | 0 | 0 |
| Inlet Works (flow spreader) | each | 5000 | 0 | 5000 | 5000 | 5000 | 10000 | 0 | 0 | 0 |
| Outlet structure | each | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 | 10000 |
| Spillway | each | 2500 | 0 | 0 | 2500 | 2500 | 2500 | 2500 | 2500 | 0 |
| | | Subtotal | $60,000 | $79,260 | $138,000 | $34,800 | $23,300 | $126,900 | $82,100 | $124,400 |
| Construction Contingency | | 0.15 | 9000 | 11889 | 20700 | 5220 | 3495 | 19035 | 12315 | 18660 |
| | | Subtotal | 69000 | 91149 | 158700 | 40020 | 26795 | 145935 | 94415 | 143060 |
| Engineering Design | | 0.12 | 8280 | 10938 | 19044 | 4802 | 3215 | 17512 | 11330 | 17167 |
| Construction | | 0.08 | 5520 | 7292 | 12696 | 3202 | 2144 | 11675 | 7553 | 11445 |
| | | Subtotal | $82,800 | $109,379 | $190,440 | $48,024 | $32,154 | $175,122 | $113,298 | $171,672 |
| Land Purchase | | | | | | | | | | |
| Total Acreage | | | 3.2 | 1.1 | 3.5 | 5.0 | 0.8 | 0.2 | 1.5 | 0.5 |
| Private Acreage | | | 0.6 | 0.6 | 1.0 | 1.2 | 0.0 | 0.2 | 1.5 | 0.0 |
| Cost to Acquire | | $65,000 | $39,000 | $39,000 | $65,000 | $78,000 | $0 | $13,000 | $97,500 | $0 |
| | | Total | $121,800 | $148,379 | $255,440 | $126,024 | $32,154 | $188,122 | $210,798 | $171,672 |

- **Pipe** is an item required at locations where an existing inlet/outlet pipe or spillway is undersized and requires enlargement to pass the peak design flow.

- **Inlet works** involves a constructed facility for the purpose to slow and evenly distribute inflow entering the facility. The objective of this structure is to limit short circuiting and thereby assure full treatment of incoming runoff.

- **Outlet works** include new construction or modifying an existing structure to control flow and storage performance of the facility.

- **Spillway** must be correctly sized and sited outlet facility to safely route the peak design flows through a facility and deliver them to a proper point of disposal.

In addition, the table divides a selected site into publicly and privately owned acres. At the special request of the SWM Policy Committee and the City, OTAK included the cost of purchasing private land in addition to the usual construction costs. OTAK estimated the cost of private, undeveloped (and often unbuildable) land to be $65,000 per acre.

## 7.5 RECOMMENDED WATER QUALITY FACILITIES

OTAK ranked the 8 recommended PRFs by their cost per pound of phosphorus removed. Table 7.3 presents the prioritized recommended water quality facilities with their cost-per-pound of phosphorus removed. In addition, the construction and acquisition costs were included separately to support implementation scheduling. The total estimated capital improvement cost for completing the water quality control facilities, all of which are located within the City, is $1.25 million.

Given that resources are limited and the study area is so built out, suitable sites may not remain vacant for long. Purchasing the most promising sites early ensures their availability for later construction. The implementation schedule presented in Appendix H assumes that sites SB120, LBF2, SB102 and LBF3 will be acquired within the first two years of the recommended SWM utility's operation.

For the three basins containing more than one PRF site (Springbrook, Lower Boones Ferry and Lost Dog Creek), building the highest ranked, most downstream site earlier may reduce the need for future PRFs upstream. This must be assessed during the implementation scheduling to ensure the most productive use of the recommended Surface Water Utility's resources. The monitoring program presented in Appendix I supports the recommendation of building a single highly ranked PRF site and monitoring its performance before proceeding with the next PRF construction.

Figure 7.2 shows a conceptual sketch of a possible configuration for the SB-102 site on Springbrook Creek north of Twin Fir Rd. The facility is off line: base flow remains in the channel, but flow above a certain point, about 150 cfs, is diverted into the facility and kept quietly for up to 96 hours while suspended pollution can settle. The outlet would allow the facility to slowly drain by that time. More than one basin allows pre-settling of coarser suspended pollution, and reflects the elevation drop across the site.

During high flows, the facility would quickly fill, and excess flow would be directed away by the orientation of the berms near the inlet. An emergency spillway would allow flow to safely re-enter the stream away from the outlet works. Many other configurations are also possible, and more detailed preliminary design work must be performed before any conclusions can be drawn regarding any particular site.

## TABLE 7.3

# Recommended PRF Implementation Priority

| Water Quality Control Facility Priority | Name | Contributing Areas Total acres | Contributing Areas EIA acres | Pollutant Removal Solids tons/yr | Pollutant Removal Phos. lbs/yr | Cost Estimate Const. $1000 | Cost Estimate Land $1000 | Cost Estimate Total $1000 | Cost per Removal Solids $/ton | Cost per Removal Phos. $/lb | Cumulative Program Cost Const. $1000 | Cumulative Program Cost Land $1000 | Cumulative Program Cost Total $1000 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | SB 120 | 1200 | 404 | 137 | 172 | $48 | $78 | $126 | $918 | $731 | $48 | $78 | $126 |
| 2 | LBF 2 | 337 | 173 | 52 | 65 | $109 | $39 | $148 | $2,865 | $2,274 | $157 | $117 | $274 |
| 3 | SB102 | 521 | 210 | 81 | 101 | $190 | $65 | $255 | $3,162 | $2,521 | $347 | $182 | $529 |
| 4 | SB 108 | 40 | 22 | 9 | 12 | $32 | $0 | $32 | $3,463 | $2,742 | $379 | $182 | $561 |
| 5 | LBF 3 | 87 | 67 | 35 | 44 | $83 | $39 | $122 | $3,495 | $2,768 | $462 | $221 | $683 |
| 6 | RR1 | 75 | 35 | 15 | 19 | $175 | $13 | $188 | $12,740 | $10,135 | $637 | $234 | $871 |
| 7 | LD 2 | 166 | 28 | 8 | 10 | $172 | $0 | $172 | $22,313 | $17,948 | $809 | $234 | $1,043 |
| 8 | LD 3 | 76 | 9 | 5 | 7 | $113 | $98 | $211 | $39,211 | $31,351 | $922 | $332 | $1,254 |

NOTES:

1. Pollutant removals are based on the representative year using upland control strategy III.

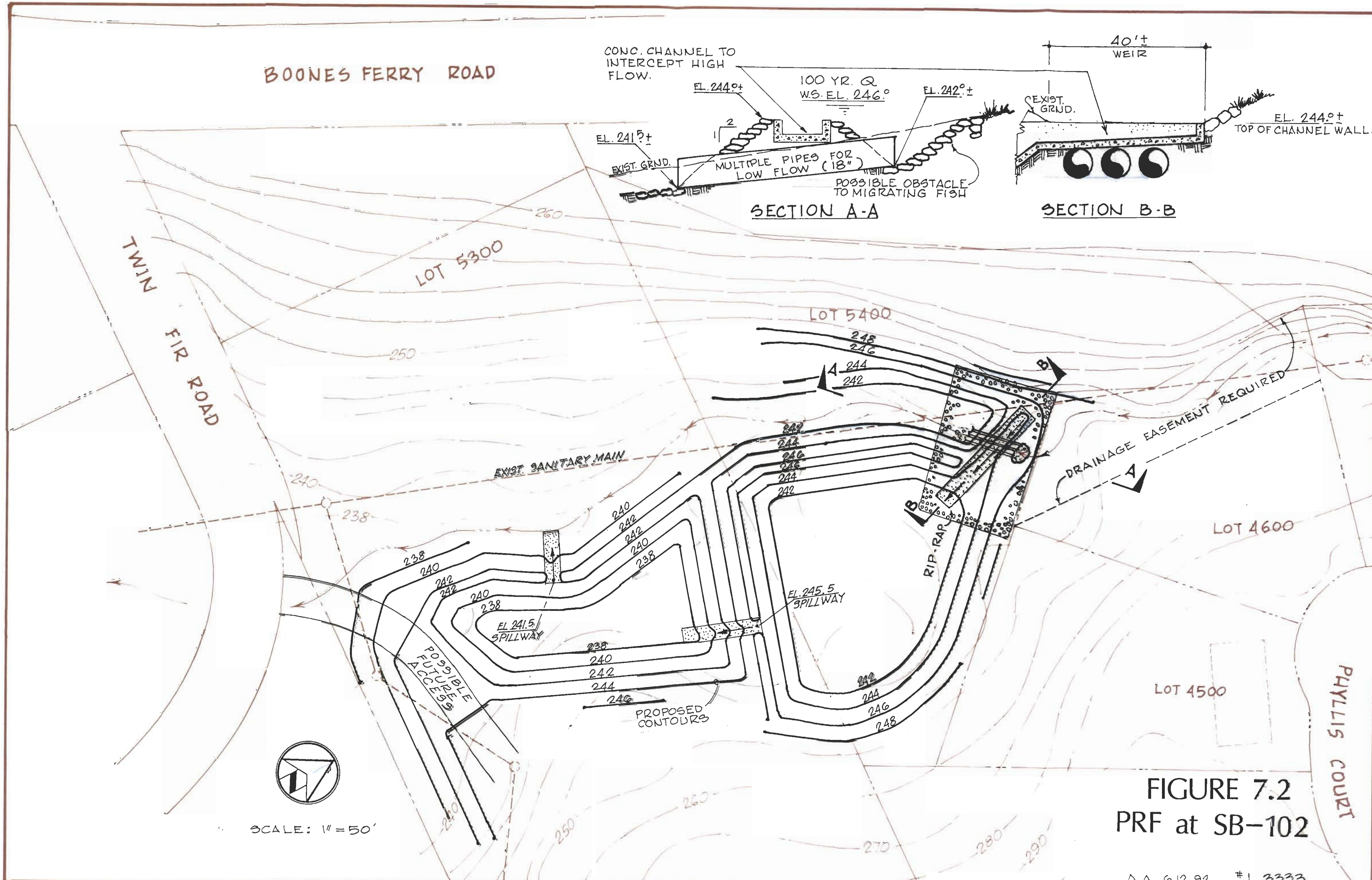


FIGURE 7.2
PRF at SB-102

**Recommended Surface Water Program**

# CHAPTER 8

# RECOMMENDED SURFACE WATER PROGRAM

The Master Planning process has established two categories of program requirements: operating needs and capital needs. Operating needs refer to the ongoing program requirements related to Finance and Billing, Operations and Maintenance, Water Quality Management, Plan Review and Construction Inspection, Regulation, Small Works and Public Involvement. Capital needs relate to the water quantity facilities, water quality facilities, small works and stream rehabilitation construction, and some sensitive land acquisitions.

The Surface Water Management (SWM) needs and recommended implementation costs identified in the Master Plan are considered to be the minimum amount required to satisfy both the community objectives and the regulatory mandates for a SWM program.

## 8.1 OPERATING NEEDS

As part of the technical and engineering analysis, numerous categories of facility and operations and maintenance needs were identified. A brief description of each of these operating categories now follows:

### Finance and Billing

Prepare utility billings, track accounts receivable and accounts payable, monitor expenses, and perform other finance related and general administration tasks.

### Operations and Maintenance

Incorporate and expand upon City efforts to maintain and clean the existing storm water system consisting of an estimated: 150 miles of pipe and open channels, 2880 storm water inlets and catchbasins, and 170 miles of publicly owned streets. This program element involves 22 separate field activities that are identified in Table 8.1 which details the recommended maintenance program service levels. The costs in this table assume that the City continues to inexpensively dispose of cleaning debris at nearby Tigard. These service levels were identified as part of the "Current Trends" upland control strategy discussed and recommended in Chapter 6.

### Water Quality Management

Implement and manage programs that directly benefit surface water quality. Identified programs include:

- Stream Rehabilitation Engineering & Design: Riparian corridor enhancement, stream stability, stream bank erosion control, soil bioengineering, and naturescaping. Actual construction costs are included under capital needs.
- Sensitive Land Advance Planning: Plan for and protect sensitive lands along the riparian corridors.

- Monitoring: Area wide water quality monitoring and best management practice (BMP) monitoring.

- NPDES Permit: Permit application, with Clackamas County, to comply with the National Pollutant Discharge Elimination System (NPDES), Part 2, surface water regulations.

- Erosion Control: Inspection of construction site erosion controls, enforcement and complaint response.

Stream Rehabilitation

All of the items listed above are important and have their place in the program. However, stream rehabilitation efforts can provide multiple benefits beyond improvements in water quality. These efforts can improve fish and wildlife habitat, reduce sediment deposition in receiving waters, and involve the public through "hands-on" activities in stream corridor enhancement.

Stream rehabilitation efforts usually include the stabilization and protection of stream banks against scour and erosion through both vegetative and structural means. Vegetative means include plantings and naturescaping to stabilize slopes and protect against erosion. They also include the use of soil bioengineering, which involves combinations of soils and live stakings to stabilize banks and improve fish habitat. Structural means can involve the use of logs, riprap and check dams constructed of various materials to slow stream velocities and create pools and riffles which control sediment transport and create fish habitat and spawning areas.

Figure 8.1 highlights the major stream corridors throughout the study area that were considered in the SWM planning process, and that may have the greatest erosion threat and potential for major stream rehabilitation efforts. These were identified, in part, from the data collected during the volunteer streamwalks conducted as part of the master planning effort. As noted earlier, streamwalk is a program where interested citizens collect data on the physical characteristics and relative health of the riparian or stream corridors throughout the study area. Citizen participation is important because funding limitations will probably force the City to rely heavily on volunteer labor efforts and the program will provide guidance, materials, and equipment. In the future, a detailed natural resources inventory and continued streamwalks will identify and prioritize specific reaches for rehabilitation.

Monitoring Program

Figure 8.1 also shows the location of the eleven existing monitoring stations and the three proposed future monitoring stations throughout the study area. Since August 1990, the City has been collecting monthly data on the total phosphorus (TP) concentrations occurring within several major streams throughout the study area. Through March 1992, approximately 165 grab samples had been analyzed from the stations located on Lost Dog Creek, Springbrook Creek, Blue Heron Creek, Ball Creek and the Lower Boones Ferry drainageway. The data have an average TP concentration of 0.23 mg/l and a median of 0.094 mg/l, but TP concentrations range from 3.50 to 0.008 mg/l.

The future stations and the recommended water quality monitoring program presented in Appendix I propose a significant change in emphasis from the current program. The current program relies on single grab samples taken without any corresponding observations of streamflow, and has established some baseline information for TP concentrations throughout the study area. The recommended program targets fewer stations but emphasizes flow-weighted sampling to monitor the effectiveness of both enhanced maintenance practices and PRF implementation.

City of Lake Oswego
SWM Master Plan

# Rehabilitation Areas and Water Quality Monitoring Stations

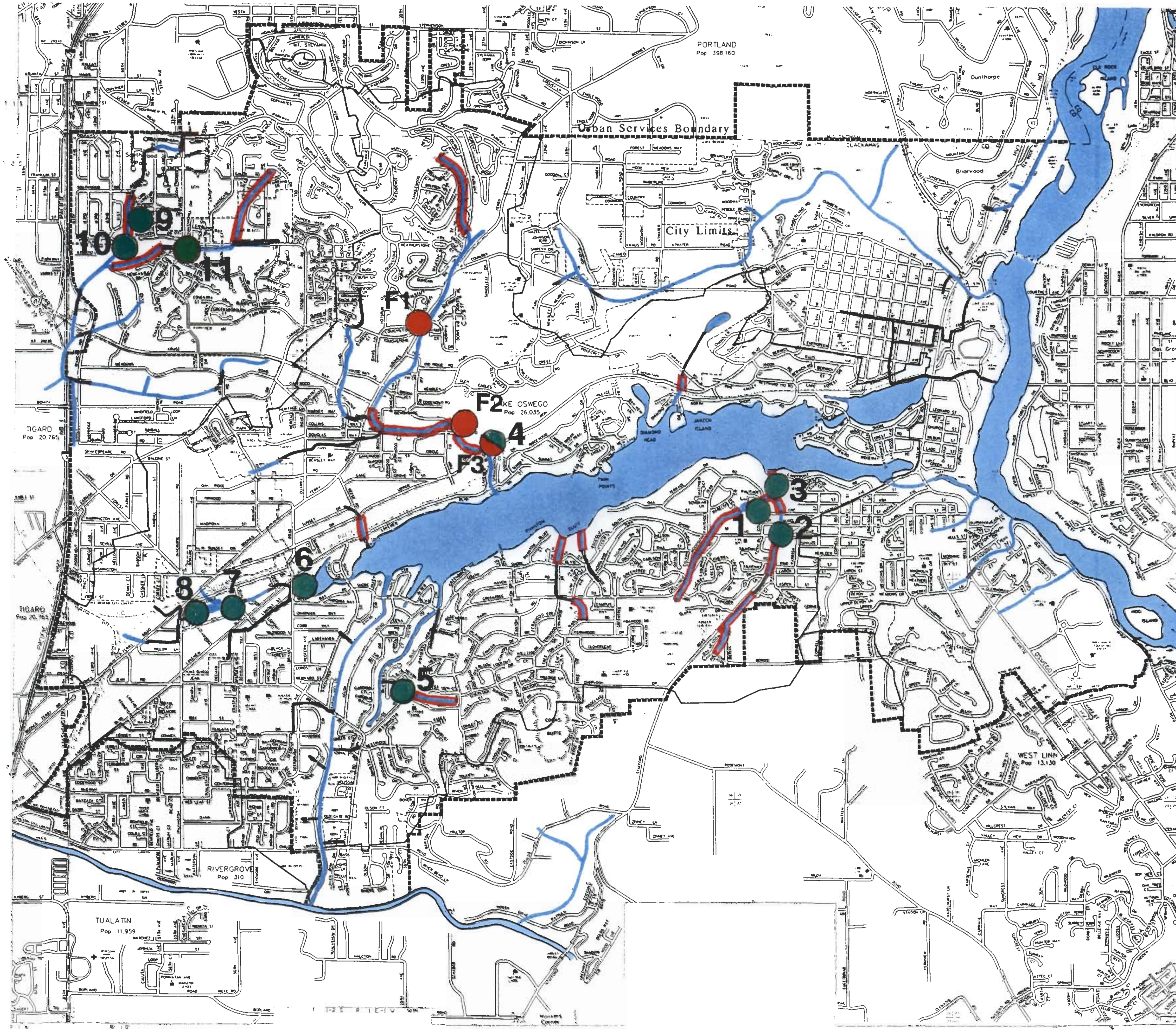



Figure 8.1

otak

# TABLE 8.1
## Recommended Maintenance Program
## Service Levels

| No. | Category | Maintained | Frequency (No. Times/ Year) | Standard | Crew Size | Total Days Annually | Unit Labor Cost* | Preliminary Cost Estimate: Labor* | Materials | Equipment | Totals | Percent of Total Program Cost | Labor Require-ment |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Roadside Ditch Maintenance | 2000 LF | 1.00 | 200 LF/DA | 3 | 10 | 480 | 4,800 | | 1,000 | 5,800 | 2.7% | |
| 2 | Clean Catch Basins (STCB) – Public | 1300 EA | 2.00 | 15 EA/DA | 1 | 173 | 160 | 27,730 | | 17,333 | 45,060 | 20.6% | |
| 3 | Clean Inlets – Public | 700 EA | 2.00 | 45 EA/DA | 1 | 31 | 160 | 4,980 | | 3,111 | 8,090 | 3.7% | |
| 4 | Clean Pollution Control MH – Public | 80 EA | 2.00 | 5 EA/DA | 1 | 32 | 160 | 5,120 | | 3,200 | 8,320 | 3.8% | |
| 5 | Clean Catch Basins (STCB) – Private | 800 EA | 2.00 | 15 EA/DA | 1 | 107 | 160 | 17,070 | | 10,667 | 27,740 | 12.7% | |
| 6 | Clean Inlets – Private | 0 EA | 2.00 | 45 EA/DA | 1 | 0 | 160 | 0 | | 0 | 0 | 0.0% | |
| 7 | Clean Pollution Control MH – Private | 0 EA | 2.00 | 5 EA/DA | 1 | 0 | 160 | 0 | | 0 | 0 | 0.0% | |
| 8 | Storm Line Cleaning | 528000 LF | 0.20 | 1000 LF/DA | 2 | 106 | 320 | 33,790 | | 10,560 | 44,350 | 20.3% | |
| 9 | Detention Pond Maintenance | 21 EA | 2.00 | 1 EA/DA | 1 | 42 | 160 | 6,720 | | 4,200 | 10,920 | 5.0% | |
| 10 | Sedimentation Pond Cleaning | 4 EA | 5.00 | 4 EA/DA | 2 | 5 | 320 | 1,600 | | 500 | 2,100 | 1.0% | |
| 11 | Detention Tank Cleaning | 30 EA | 2.00 | 7 EA/DA | 1 | 9 | 160 | 1,370 | | 857 | 2,230 | 1.0% | |
| 12 | Culvert/Trash Rack Cleaning | 35 EA | 30.00 | 35 EA/DA | 1 | 30 | 160 | 4,800 | | 3,000 | 7,800 | 3.6% | |
| 13 | Repair Culverts | 5 EA | 1.00 | 1 EA/DA | 2 | 5 | 320 | 1,600 | | 500 | 2,100 | 1.0% | |
| 14 | Repair Storm Lines | 100 LF | 1.00 | 20 LF/DA | 2 | 5 | 320 | 1,600 | | 500 | 2,100 | 1.0% | |
| 15 | Retrofit Catch Basins | 0 EA | 1.00 | 2 EA/DA | 1 | 0 | 160 | 0 | | 0 | 0 | 0.0% | |
| 16 | Roadside Vegetation Mgmt. | 80 MI | 2.00 | 10 MI/DA | 1 | 16 | 160 | 2,560 | | 1,600 | 4,160 | 1.9% | |
| 17 | Complaint Response | 450 EA | 1.00 | 20 EA/DA | 1 | 23 | 160 | 3,600 | | 2,250 | 5,850 | 2.7% | |
| 18 | Ditch to Swale Conversion | 0 LF | 0.00 | 1 LF/DA | 1 | 0 | 160 | 0 | | 0 | 0 | 0.0% | |
| 19 | Illegal Connect./Inspect | 0 LF | 0.00 | 1 LF/DA | 1 | 0 | 160 | 0 | | 0 | 0 | 0.0% | |
| 20 | Open Channel/Ravine Mgmt | 15.4 EA | 2.00 | 0.5 EA/DA | 2 | 62 | 320 | 19,710 | | 6,160 | 25,870 | 11.8% | |
| 21 | Street Sweeping – Curbed Residential | 69.5 MI | 6.00 | 15 MI/DA | 1 | 28 | 160 | 4,450 | | 2,780 | 7,230 | 3.3% | |
| 22 | Street Sweeping – Curbed Arterial | 19.5 MI | 12.00 | 15 MI/DA | 1 | 16 | 160 | 2,500 | | 1,560 | 4,060 | 1.9% | |
| 23 | Street Sweeping – Noncurbed streets | 81.0 MI | 2.00 | 15 MI/DA | 1 | 11 | 160 | 1,730 | | 1,080 | 2,810 | 1.3% | |
| 22 | Surface Water Sampling | 11 EA | 12.00 | 11 EA/DA | 1 | 12 | 160 | 1,920 | | | 1,920 | 0.9% | |
| 23 | | | | | | | | 0 | | | 0 | | |
| 24 | | | | | | 721 | | | | | 0 | | |
| | Sub-Total: All Maintenance Categories >>>>>>>>>>>>>>>>>>>>>>>> | | | | | | | $147,700 | $20,000 | $70,858 | $238,600 | 100.0% | |
| | Grand Total** >>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>>> | | | | | | | | | | $262,500 | | |

Note:
*– average combined labor cost/crew-day
**–includes adminstrative overhead

Each future installation would have a continuous flow monitor along with a composite sampler for water quality. This allows the City to collect a single flow-weighted composite sample during a runoff event that could be compared to the event mean concentrations (EMC's) simulated in Chapter 6 with the SIMPTM program.

The F1 station would drain a 90 acre single family residential site whose data could be used to verify the estimated effectiveness of the recommended enhanced maintenance program. Stations F2 and F3 would be located upstream and downstream, respectively, of the highest ranked PRF SB 120, to estimate the performance of this future facility. Were another facility built first, the actual locations of F2 and F3 should be moved to just upstream and downstream of it.

### Plan Review and Construction Inspection

Incorporate and expand upon existing City efforts to review development plans for storm water (quantity and quality), wetlands, floodplain, stream corridors, and erosion control, from pre-application through approval of construction plans. This would involve limited construction inspection for revegetation and wetlands. The following tasks are anticipated:

- Development Plan Review
- Construction Review and Inspection
- Building Plan Review and Inspection

### Regulation

Develop a Drainage Manual, revise the Erosion Control and Water Quality Manual, as necessary, and revise the development standards. Includes staff time to prepare the NPDES permit application including on-going work necessary for compliance. It also includes time needed to administer the National Flood Insurance Program within the City.

### Small Works

Incorporate and expand City efforts to solve minor storm water system problems through small construction projects. Provide complaint response to drainage related problems. The flood control management program identified in Chapter 5 only addressed the major drainage systems throughout the study area. Other drainage problems are known to exist and the small works program provides the means needed to plan and design solutions for these known drainage problems.

### Public Involvement

Continue and expand upon programs to raise the public's awareness through such methods as bulletins, brochures, presentations and public meetings. Encourage involvement in programs such as streamwalk, catchbasin stenciling, stream corridor cleanup, and public meetings. The Public Awareness Action Plan presented in Chapter 2 should be used to drive this program.

## 8.2 CAPITAL NEEDS

Capital costs relate to physical improvements to the surface water system recommended in the Flood Control and Water Quality Management Plans. The following categories of capital needs have been identified:

Water Quantity (Flood Control)
- Major Drainages
- Small Works

Water Quality (Pollutant Reduction)
- Pollutant Reduction Facilities
- Stream Rehabilitation Construction

Sensitive Lands Reserve

Projects in the CIP were prioritized to correct problems that would yield the greatest benefit for the estimated capital expenditure. All of these Capital Improvements Project (CIP) costs discussed in this chapter and Chapter 9 involve projects currently located within the City's corporate limits. Elsewhere, Clackamas County is the responsible party.

Water quantity of flood control projects correct problems related to flooding of both public and private lands. Projects include improvement to stream channels and storm water facilities to convey the identified peak flow. Small works rectify deficiencies on the storm water systems that were not studied in detail. Forty-four flood control capital improvement projects are recommended for construction within existing Lake Oswego corporate limits by 2012 at a total project cost of $2.6 million in 1992 dollars. Thirteen cost less than $10,000; the remaining thirty-one cost between $10,000 and $255,000, with $80,900 the average. In scheduling improvements, the following priority is recommended:

1. Complete projects within the City jurisdiction. Others can be completed later by the city as they are annexed, or by Clackamas County.

2. Complete the thirteen projects which cost less than $10,000 over a shorter term. Many of these less expensive projects can be completed for the cost of one of the larger ones, allowing more areas to see benefits from the SWM plan at an earlier time. Prioritize these lower-cost projects by estimated improvement cost.

3. Complete the remaining thirty-one higher-cost projects by 2012. Prioritize these by their ratio of cost to relative deficiency, or fraction of design flow exceeding the existing pipe or culvert capacity. This reflects the flood risk which would be relieved by the project.

Water quality projects include both pollutant reduction facilities (PRF) and stream rehabilitation work. Both of these measures involve constructing facilities or stabilizing stream channels to limit and control the discharge of sediment and pollutants. There are eight priority sites in the study area where PRF's might be located. Three sites are in the Springbrook Creek Basin, two are in the Lower Boones Ferry Basin, two are in the Lost Dog Creek Basin and one is in the Reese Road Basin. Costs for these PRF's range from $32,000 to $256,000. Land acquisition accounts for approximately 27% of the estimated total cost of these PRF's. Recommended Pollutant Reduction Facilities (PRF's) were ranked by cost effectiveness, as the ratio of an estimated dollar per pound of phosphorus removed. The project team recommends a high priority for acquiring the top five PRF sites early (within the first two years).

Sensitive Land costs are related to the purchase of property and acquisition of easements needed to protect lands beneficial to water quality or flood control concerns. These could be identified as part of a subsequent and more detailed Natural Resources Inventory.

## 8.3 RECOMMENDED PROGRAM BUDGET

The project team recommends two budget categories: operating and capital needs. Capital needs fund improvements needed to convey floodwater, the recommended regional PRF's, and some sensitive land acquisition within the stream corridors. Operating needs fund the on-going utility programs. The SWM project team recommends the following budget (1992 dollars):

**TABLE 8.2**

**RECOMMENDED PROGRAM BUDGET**

**OPERATING NEEDS**

| Program Element | FTE * | Labor Cost | Direct Expense | Total Cost |
|---|---|---|---|---|
| Finance and Billing | 0.5 | 25,250 | $ 20,000 | $ 45,250 |
| Operation and Maintenance | 3.0 | $ 147,700 | 114,800 | 262,500 |
| Water Quality Management | 0.6 | 34,500 | 50,000 | 84,500 |
| Plan Review and Inspection | 0.3 | -0- | - | -0- |
| Regulation | 0.4 | 23,000 | - | 23,000 |
| Small Works | 0.5 | 28,750 | - | 28,750 |
| Public Involvement | 0.2 | 11,500 | 5,500 | 17,000 |
| TOTALS | 5.5 | $ 270,700 | $ 190,300 | $ 461,000 |

* Full Time Equivalent

Note: Development fees fund Plan Review and Inspection.

**CAPITAL NEEDS**

| Program Element | Annual Cost | Total Cost |
|---|---|---|
| I. Water Quantity | | |
| Major Drainages | $ 128,700 | $ 2,574,000 [1] |
| Small Works | 75,000 | 1,500,000 |
| II. Water Quality | | |
| PRF's | 62,500 | 1,250,000 [1] |
| Stream Rehabilitation Construction | 25,000 | 500,000 |
| III. Sensitive Lands Protection | 10,000 | 200,000 |
| TOTAL | $ 301,200 | $ 6,024,000 |

[1] OTAK CIP costs include 15% for construction contingencies, 12% for engineering design, and 8% for construction inspection.

In terms of the TOTAL annual operating requirements for Lake Oswego's surface water program, annual expenditures are anticipated to be approximately $762,200. Operating requirements constitute an annual expenditure of $461,000 with an annual capital cost of approximately $301,200. Detailed scheduling of the entire CIP has not been done. Therefore, the total CIP cost of $6,024,000 has been allocated evenly over the entire 20-year implementation period. This annual capital expenditure does not include inflationary factors that will affect the final budget. However, for planning purposes and lacking any specific construction schedule, this approach was considered appropriate. The actual rate model prepared as part of this project will calculate these inflationary factors once the CIP is scheduled.

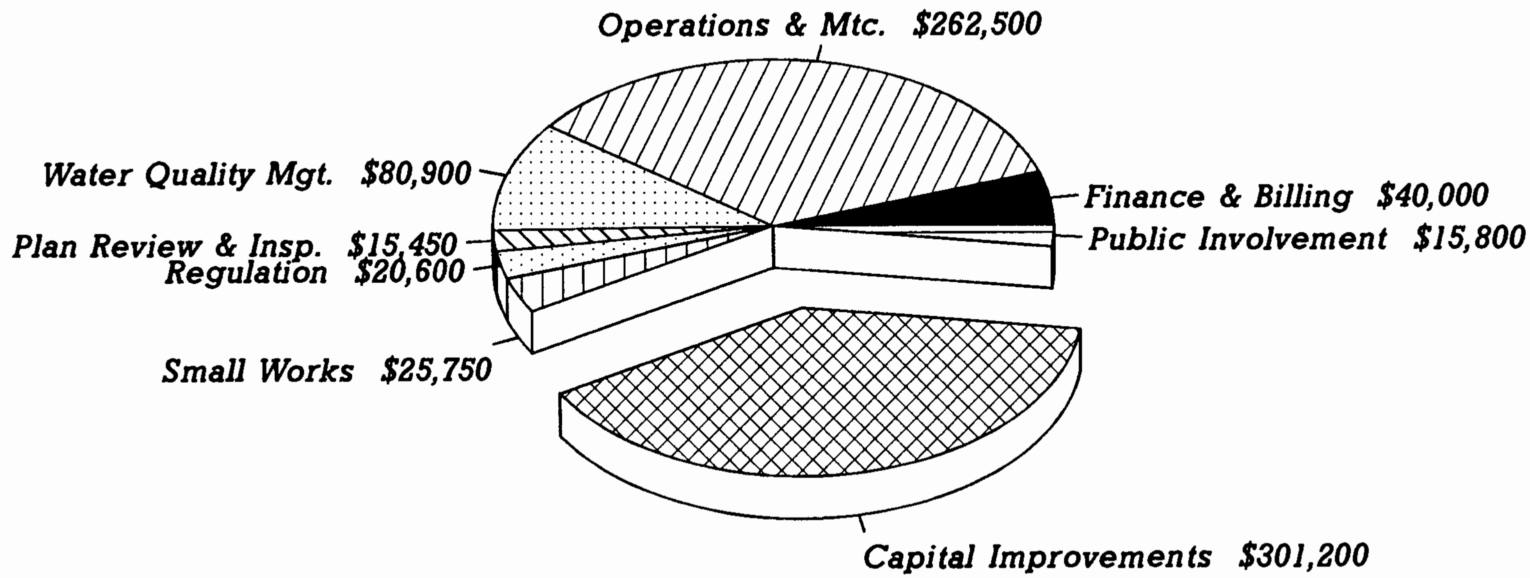
FIGURE 8.2

# City of Lake Oswego

## Surface Water Management Program

## Expenditure Category Breakdown for Fiscal 1992

***Total Base Case Cost for Fiscal 1992 = $762,200***



**Recommended Surface Water Utilities**

## CHAPTER 9

# RECOMMENDED SURFACE WATER UTILITY

This chapter discusses the funding options considered during development of Lake Oswego's Surface Water Management (SWM) Master Plan. A number of funding approaches were presented to the "Policy Committee on Surface Water Management" within the context of the revenue required to support the program and the equity necessary to assure that the funding structure was fair. It was also considered imperative that the financial structure implemented through this process be outside the bounds of Measure 5. Accordingly, all options discussed during formation of this financial analysis were reviewed to determine whether they met the "Measure 5 test" of being "avoidable, controllable and not a direct result of property ownership." In addition to these concerns, the Project Team was also guided by the community objectives established by the Policy Committee for Surface Water Management. One of these objectives was directed at the issue of surface water funding:

> Implement funding mechanisms that allocate costs in an equitable manner to all those that benefit from a managed surface water drainage system.

A number of mechanisms were reviewed by the Committee. It was emphasized that while the service charge approach would be the primary revenue stream, a number of secondary funding sources should also be considered in order to form a "funding mix" for the surface water program. Many surface water programs have successfully funded their surface water management programs with a combination of these mechanisms. The majority of the options support capital improvements, while a relative minority are geared to support ongoing maintenance activities.

## 9.1 BACKGROUND INFORMATION

As this project began, storm water funding in Lake Oswego was done through a flat fee of $3.50 attached to each bi-monthly sanitary sewer bill. This charge, begun in 1988, was designed to generate the revenue necessary to offset some surface water related maintenance costs and undertake the SWM Master Plan. As the master plan was prepared and more was understood regarding the City's actual funding requirements, a revised financing program was developed. The development of this revised funding program is the subject of this financial analysis.

The City is an active participant in the regionalized approach toward surface water management within Clackamas County. At present, Lake Oswego and the County are working together in terms of regional surface water planning and preparation of the Part 1-National Pollutant Discharge Elimination System (NPDES) permit. This regional approach can be complementary to the formation of a surface water utility in Lake Oswego as the regional surface water district will likely focus its efforts on water quality issues, large facility development (regional detention ponds) and managing flood control efforts requiring multi-jurisdiction coordination. The City's focus would be on its rate payers through management of water quality, enhanced drainage complaint response, on-going storm water system maintenance, a regulatory scheme consistent with the City's comprehensive plan and a program for constructing local storm water improvements.

This study has also determined that Lake Oswego's location in both the Tualatin Basin and the Willamette Basin places it in a very dynamic position regarding current and pending nonpoint source pollution mandates. These rules will require a significant and as yet, largely unknown, commitment of resources for surface water maintenance and improvements during the 10 year planning horizon. Clearly, state and federal regulations are requiring more sophisticated surface water management programs at the local level to reduce urban nonpoint source pollutant loadings.

## 9.2 FUNDING RECOMMENDATIONS

It is within this overall context that the Policy Committee for Surface Water Management made the following funding recommendations to the City Council:

1. Seven specific policies should be reflected in the surface water service charge:

    - The rate be based on the contribution of runoff to the system as estimated through impervious area.

    - Single family homes be treated as a single rate classification and uniformly charged for one "Equivalent Service Unit"; non-single family customers be charged based on their measured amount of imperviousness.

    - Undeveloped properties would not be included in the service charge.

    - All publicly owned property be included in the surface water service charge, except publicly owned streets that are operated as part of the City's surface water conveyance system.

    - Credits be made available to those customers who have built surface water mitigation facilities. A policy requirement is that these facilities be constructed and maintained to the City's standards AND that credits will be applicable to only those system improvement costs which are affected by a customer's on site management of storm water runoff.

    - No exemptions be allowed from the rate based on property use (other than undeveloped) or tax exempt status.

    - Consider development of a "non-service abatement" provision within the rate that recognizes that some properties within Lake Oswego may fully retain and dispose of all surface water on-site and are not served by the Utility.

2. The surface water service charge should be set at a level that recognizes the cumulative impact of increases in utility rates for water and sewer.

3. Implementation of the surface water rate should be done in a manner that allows adequate time to inform the public about the program, regulatory mandates, costs and rate approach.

4. The surface water utility should fully fund the operating needs identified in the master plan and that immediate capital improvements necessary to meet the Oregon (DEQ) requirements should be funded through revenue bonds. The preferred option for funding of long-term capital improvements is "pay as you go", however, revenue bonding for these projects could be used when "pay as you go" is not consistent with the timing or need for a given project.

5. Based on the SWM Master Plan, the City should prepare an analysis of system improvement costs and prepare a resolution adopting a system and structure for surface water system development charges for new or re-development.

6. A "Lake Oswego Utilities Advisory Committee" be established and made up of Lake Oswego residents affected by utility fees. This committee should review all utility rates and make recommendations to the City Council. This committee would also be involved with establishing the structure of the surface water credit system.

Based on these policy directives, an "Equivalent Service Unit" (ESU) rate methodology was prepared for the City which employs impervious area as the foundation for the service charge. After review of numerous financial strategies, the Policy Committee determined that a rate of $3.75 per ESU per month would support the operations, maintenance, water quality and capital improvement recommendations contained in the SWM Master Plan. This rate assumes debt financing of the capital portion of the utility's budget.

## 9.3 FUNDING STRUCTURE ANALYSIS

In reviewing the options available to fund Lake Oswego's surface water management program, the Policy Committee considered a number of financial strategies. Basic to all of these, was the fact that the current sanitary sewer related surface water charge could not support the service levels identified in the SWM Master Plan. Also, this flat rate approach could be construed as a tax within the Measure 5 definition of a tax. The Policy Committee reviewed the following approaches toward funding both operations and maintenance and capital improvements for the City's surface water program. A brief description of the options tested during this project follow:

Capital

- Debt Financing
- In-Lieu-Of Construction Fees
- System Development Charges (SDC's)
- Service Charges/Utility (both capital and O & M)

Operations and Maintenance

- Plan Review and Inspection Fees
- General Fund/Street Fund
- Service Charges/Utility (described under Capital)

### Capital Options

Debt Financing

General Obligation Bonds are issued by the City and supported by its "full faith and credit." They typically require voter authorization for issuance, although in some cases, a limited amount of "councilmanic" debt can be issued without voter authorization. However, ORS 221.410 states that "no city, unless authorized to do so by its electors, shall contract a voluntary floating indebtedness in excess of the sum of $5,000 for general city purposes. A city official or employee who creates or officially approves such an indebtedness in excess of the limitation shall be liable for the amount of the excess". G. O. Bonds are used for capital improvements. These bonds are typically the lowest cost form of long term fixed rate financing, in terms of interest charges. This is due to their low risk as they are obligations of the City as a whole. The amount of G.O. Bond debt is limited which can restrict its availability for various applications.

Revenue Bonds are also long-term debt obligations which must be used for capital improvements. Unlike G.O. Bonds, they are not backed by the City as a whole, but constitute a lien against the revenues from the Utility. The reduced security offered by these bonds mandates that a higher interest rate be paid. In addition, there are security requirements included such as reserve funds and debt coverage. The coverage is essentially a requirement that funds in excess of those needed for expenses and debt service be collected based on a defined formula. Once the utility demonstrates that the requirement has been met, the excess funds can be used for any utility capital application. Oregon Revised Statue 225.020 gives incorporated cities the authority to form municipal utilities to "acquire water systems and use, sell and dispose of its water for domestic, recreational, industrial, and public use and for irrigation and other purposes within and without its boundaries."

In-Lieu-Of Construction Fees

In-lieu-of construction fees preserve new development's front-end financial participation in storm water control systems while enhancing the city's ability to build regional facilities. Most in-lieu-of fees are collected as an alternative to on-site detention. Developers are offered the option of building an on-site system or paying the in lieu-of-fee. Problems associated with this approach revolve around the lag between the fee being paid and actual facility construction. This problem can be mitigated by using service charge revenues to build facilities and repaying these funds as in-lieu-of fees are collected. It should be emphasized that the in-lieu approach is best used in an urbanizing basin as opposed to one that is largely built out. Accordingly, there may be limited application of in-lieu funding for Lake Oswego's storm water facilities.

In-lieu-of fees can either be a regulatory requirement or a development option that enables Lake Oswego to offer developers the opportunity to construct on-site detention/retention facilities in accordance with the City's design criteria or pay a fee into a fund dedicated to the construction and maintenance of an off-site (regional) detention facility serving multiple properties. This approach has the potential to generate dedicated revenues and as an added benefit, act as a vehicle to guide development patterns within a basin and encourage comprehensive surface water planning. However, their construction cost and properties served must be known for this concept to work.

A shortcoming associated with in-lieu-of construction fees is that the customary fee for a single property or development is rarely large enough to fund the construction of a regional facility. Therefore, either multiple developments must occur simultaneously in a given area to generate enough revenue to fund the construction of a regional facility, or more realistically, the project must be initially funded from alternative sources. Many communities across the country have successfully used alternative funding sources such as service charge revenues, general fund borrowings, etc., on a short-term basis to fund initial construction and then repay the indebtedness as the in-lieu-of fees are collected.

System Development Charges

These charges offer a means for balancing participation in the cost of storm water facilities. Storm water systems are often built to accommodate conditions 20 years or more into the future. Some of these systems might be built and paid for before development actually occurs. System development charges (SDC's) can provide a means whereby owners of property which develop in the future share in the costs of projects built today. Usually, the structure of a system development charge will attempt to mirror the distribution of costs among the various types of property involved. ORS 223 establishes the guidelines to be followed in designing and administering a system development charge in Oregon. An SDC for surface water has been calculated based on the master planning completed through this project. The recommended SDC structure and fee is currently being reviewed by the City and is expected to be part of the overall surface water funding mix.

Service Charges/Utility

The surface water "utility" concept supported by user service charges has become a generally accepted form of surface water funding. Historically, very few communities have considered fees or service charges for surface water management programs. However, as conventional funding sources became more difficult to access (such as those discussed above), the fee concept has generated greater appeal among officials in local governments. To a greater extent, fee structures have become recognized and accepted as a viable method to fund programs that control increased runoff from urban development. There are numerous combinations and variations of rate structures for applying surface water service charges, but all of these call on three basic methods. These methods are:

1. Amount of impervious surface - the rates under this approach are set in direct proportion to the measured, estimated, or assumed extent of impervious area for each parcel of land. Impervious surface is that land occupied by building footprints, pavement or other non-permeable surfaces.

2. Density of Development - under this approach rates are determined by a runoff factor or coefficient which is deemed to be appropriate for the type of land and the nature of the improvements on each parcel.

3. Flat fee - this mechanism utilizes a constant or uniform fee levied against each customer on a community-wide basis. In most cases, the flat fee is used mainly because of its administrative simplicity.

The next section of this Chapter addresses specific service charge issues that the Policy Committee considered in constructing the primary revenue source for the City's surface water program. The Policy Committee agreed that the funding approach should reflect the rationale that those who use the storm water system or contribute runoff to it should logically contribute to the cost of providing mitigative services. This philosophy forms the basis for Lake Oswego's primary revenue stream.

## Operations and Maintenance Options

Plan Review and Inspection Fees

These fees are intended to recoup the expense of examining development plans to ensure consistency with comprehensive or master plans, and to insure that construction standards and regulations are met in the field. These fees are not designed to be primary revenue generating sources. Specific tasks are usually limited to engineering review and field inspection/certifications. In theory, a detailed cost accounting system can determine the actual costs of providing these services to developers. However, in practice, most storm water authorities monitor the accumulated cost of providing this service so that the resulting fee is based on an average of the total cost.

Four fee structures are commonly applied to this process. These four approaches are as follows:

1. Based on a flat or fixed rate for all projects reviewed and inspected, regardless of size, complexity, or actual costs incurred.

2. A variable or sliding scale fee based on the size of the development or project (i.e., acres, square feet, etc.).

3. A variable or sliding scale fee based on the permitted construction cost of the development or project.

4. Based on the fixed and variable costs to provide the review and inspection service. The fixed portion is usually a statistical estimation of the administrative costs required to provide the service while the variable portion reflects the actual time and materials required to perform the project specific reviews and inspections.

General Fund/Street Fund

This funding source is unrestricted in its use for general municipal purposes and, therefore, can be applied to surface water funding. The accessibility of this fund to numerous interests makes it in high demand. Normally these funds are used for purposes where users/beneficiaries cannot be as easily defined as is the case with storm and surface water utility customers.

In the past, funding for storm water improvements and maintenance has, in part, been handled via Lake Oswego's street fund. However, these improvements have been generally built and maintained to mitigate the adverse storm water impacts produced from the impervious surfaces of the transportation systems and not for comprehensive surface water management programs. Prime examples of this type of activity are roadside ditches or curb and gutter systems. By law, Cities are obligated to build and maintain these facilities to comply with transportation safety standards for draining paved roads, bridges, and streets.

## 9.4 SURFACE WATER RATE AND BILLING DETAILS

The storm water system, program and facilities to be provided by the City of Lake Oswego will directly serve real property within the City limits, and the relationship between runoff quantity and the cost of service is the demonstrable link in developing the utility rate structure. The Policy Committee and City Council felt that there exists a reasonable connection between how much a surface water customer in Lake Oswego should pay AND the amount of impervious surface on a given site. These concepts have been consistently upheld in legal proceedings as fair and reasonable approximations of use of the storm water systems, and appropriate bases of distinctions among classes of users and between individual properties (Teter vs Clark County (WA); Longrun Baptist Association vs the Metropolitan Sewer District (KY)). Given the unique provisions of Measure 5 in the state of Oregon and the current litigation in Gresham regarding its surface water utility, final definition of the service charge's legality in Oregon is now under review by the State Tax Court. However, statutes in several states recognize the relationship between the intensity of property development and the peak flow of storm water discharged from properties. The influence of runoff quantity on the cost of providing services and facilities can be reasonably reflected in service charges.

**Surface Water Rate Structures**

Typical surface water service charges involve some measurement of surface area and an estimate of how the development condition or use of each property affects its runoff. A common objective of surface water rate structures is to charge a higher rate to properties which discharge a higher peak flow and/or greater volume of storm water than to similarly sized properties which generate less runoff. The intent of such rate policies is to reflect the significance of runoff quantity as the primary determinant in the cost of surface water services, water quality management and system maintenance. A variety of ways have been used by cities and counties to accomplish this objective.

Surface water rate structure concepts used by other communities include:

- The measured or estimated amount of "impervious surface" on each property.

- A formula using the gross area of each property and a factor reflecting the intensity of development.

- The gross area and impervious area of each property.

- The gross area and the percentage of impervious coverage of each property.

- A formula incorporating the gross area, impervious area, and percentage of impervious coverage of each property.

All of these approaches employ an underlying rate philosophy based on the amount of service rendered in the context of each property's contribution to the runoff flow. The rate-making philosophy typical of surface water service charge concepts usually advances the idea that service (in one sense or another) is provided to virtually every property. Service is balanced with use and contribution in broadly defined terms. Service, for example, can be described in terms of collecting and safely transporting runoff from upland properties or protecting downstream parcels.

<u>General and Special Benefits</u>

Most rate structure concepts also recognize that both general and special benefits are realized by individual properties and the general population through provision of an adequate storm water control system. However, inclusion of special and general benefit is usually minimized in surface water rate structure design because the historical association of benefit with local district assessments may cloud the valid distinction of a service charge approach.

<u>Additional Considerations</u>

In addition to the basic methods of calculating charges noted above, some communities have employed special factors or additional considerations in determining charges. The additional factors most commonly used are associated with:

- The use of "uniform" or "base" charges per account for uniform costs of service that do not vary with the size or development condition of each property.

- Special charges to fund local improvements not subject to area-wide financing.

- Credits reflecting on-site detention which reduces peak runoff.

- Credits for on-site water quality facilities.
- Credits for other surface water charges paid by a subject property, for example, through a pre-existing special district.
- Credits for system maintenance which reduces City costs.
- Non-service abatement for areas which do not drain to the City system.

Flat Rates

Another special adjustment in rate concepts is the use of flat rates for some classes of property in a rate structure that otherwise employs measurement or estimation of conditions on individual parcels. The most common example of this is the use of flat rates for single-family residential properties in rate structures which generate charges for other types of property (commercial, multi-family, etc.) based on impervious area, gross area, impervious percentage, intensity of development factors, or other measurable parameters. Service charges have become a more common method of funding urban surface water management.

Recommendations

In evaluating all of these variables, Lake Oswego's Policy Committee considered that service charge financing fits well with the surface water needs identified through the master planning process. Since water and sewer have been funded through user charges for years, it was felt that the surface water program, particularly in light of Total Maximum Daily Loads (TMDL) and NPDES requirements, also have a dedicated source of revenue.

The Policy Committee determined that Lake Oswego's surface water utility rate should be based on the "Equivalent Service Unit" (ESU) approach. This methodology is based on the total impervious surface area of a site. In Lake Oswego there is a certain amount of the land's surface area that can absorb rain (pervious surface) and a certain amount that cannot (impervious surface). Pervious surface is characterized by undeveloped land, parks, or lawns while impervious surface is characterized by paving, roofs, and other vestiges of development. The rates that are derived from this approach are set based on either the estimated or measured level of impervious surface on each parcel within the community's limits. Given this direction, the Policy Committee established the following elements in the rate structure for Lake Oswego:

- All single family residential customers will be charged based on a uniform flat rate. Analysis of a sample distribution of impervious area on single family homes determined that most homes (90%) are within one standard deviation of the mean value of 3,030 square feet of impervious area. Measurement of all single family homes to identify the outlying 10% of homes would be costly and would not significantly increase the equity of the rate structure.
- Multi-Family Residential, Commercial, Industrial, and Institutional Properties will be charged based on their measured amount of impervious area.

$$\text{Fee} = \frac{\text{Measured Impervious}}{\text{ESU}} \times \text{Monthly Rate}$$

The value of the base Equivalent Service Unit (ESU) in Lake Oswego is 3,030 square feet of impervious area. This measurement is based on a statistical sampling of 108 single family homes within the City.

- A credit formula will be established within the rate structure in order to credit the service charge of customers who provide mitigation facilities. This credit should be conditioned upon the fact that these facilities are built to City standards and maintained to operate at design capacity. Both on-site flood control detention and water quality facilities should be considered.

### Billing Issues

The first task toward implementing this rate structure was completion of the analysis establishing the base value for an ESU. The results of this evaluation established that the average amount of impervious surface on a single family residence in Lake Oswego is 3,030 square feet. This value resulted from a random sampling of 108 properties in the City and established, with a 95% confidence level, that the mean value was 3,030. Given the similarity of properties in the single family classification, it was recommended that all single family residences in the City be rated as 1 ESU.

The next step toward implementation of the service charge required the physical measurement of all non-single family developed parcels within the City. This process involved the use of aerial photography, assessor base maps and computer measurement of impervious area polygons. The result is an accurate interpretation and measurement of impervious area within each non single family property. In all, 478 accounts were measured resulting in a total of 5,197 ESU's within the commercial/industrial rate classification. Based on the City's count of 8,000 single family residences and the 5,197 commercial ESU's, Lake Oswego is estimated to have a total of 13,197 ESU's. Figure 9.1 relates these total ESU's to annual revenue at alternative monthly rates. These monthly rates reflect the charge applicable to a single family home in Lake Oswego. Non-single family properties would be charged a multiple of this base rate depending on the measured amount of impervious area.

All measurement data has been transferred to the City in both hard copy and disk format. Each parcel requiring measurement of impervious area has been identified in terms of site address, location on aerial photo and relation to an existing utility account number. All properties not having a corresponding utility account number have been reviewed with the City in order to resolve any discrepancies. The surface water utility customer account file is ready for downloading into the City's utility billing environment. A key billing issue that remains outstanding, however, is the ability of the current utility billing hardware/software to incorporate the surface water fee. While the City is currently in the process of upgrading its utility billing system, the timeframe for this upgrade is inconsistent with the scheduled implementation of the service charge. Therefore, the Project Team is evaluating options to "make" the existing system accept the surface water billing. Efforts along these lines will continue through the implementation process.

## 9.5 IMPLEMENTATION

### Surface Water Rate Model

Given the rate structure recommended by the Policy Committee, the next step toward implementation was finalizing the monthly rate and overall financial strategy. This process required the construction of a surface water rate model that could incorporate the capital, operating, maintenance and program costs identified in the master plan and convert this data into the monthly rate requirement. Based on these evaluations, the Policy Committee formulated the following recommendation to Council:

> The surface water utility should fully fund the operating needs identified in the master plan and that immediate capital improvements necessary to meet DEQ requirements should be funded through revenue bonds. The preferred option for funding of long-term capital improvements is "pay as you go", however, revenue bonding for these projects could be used when "pay as you go" is not consistent with the timing or need for a given project.

## Rate Recommendation

This Committee recommendation resulted in the funding scenario which established an initial $3.75 per ESU monthly rate with revenue bond financing of the CIP. This bonding is based on an estimated annual capital expenditure of $301,200 over a 20 year construction period. Future subsequent rate increases to reflect inflation and increased debt could be similarly "levelized" over several years to minimize the frequency of rate increases. It is expected that construction schedule will be refined as prioritization of the City's capital needs. It should be noted that this rate analysis does not take into account the mitigating effects of potential secondary funding sources accessible to the City. Sources such as system development fees could be used to decrease the estimated rate per ESU.

In addition to categorizing and inflating project capital costs over time, the rate model also reports capital fund activity as calculated by the model. The key assumption behind the capital fund logic is that all surplus revenues generated by the utility in any fiscal year (via rates, fees or other contributions) are applied to the ensuing year's scheduled capital projects. This logic is consistent with the concept of a dedicated surface water utility (i.e., revenues received are spent only on storm water improvements). This dedication of funding was another directive established by the Policy Committee.

## CIP Funding Recommendation

For the recommended approach, 20 year, 7% revenue bonds were used to fund the recommended short-term capital improvement program. Given these assumptions, the model calculates the total indebtedness required to yield enough proceeds to fund each year's capital improvement program. Revenue bonds were the only instrument used. Debt servicing requirements for the surface water program were broken down into two subtopics including:

- debt service alone (which is the sum of interest expense and principal repayment). This represents the cash outflow to the utility each year associated with debt instrument financing.

- total coverage and reserve funding requirements. Although these items are not cash outflows, they are liquidity requirements placed on the utility as defined by the debt instrument covenants.

### Utility Obligations

The final step in the financial analysis established whether rates charged for surface water services would be sufficient to meet the obligations of the utility under any of the three following tests:

- projection of net income
- projection of net cash flow
- test of bond coverage requirements

In the recommended case study, no revenue deficiencies exist in the forecasted years 1992 through 1994 (assuming a basic service charge rate of $3.75 per month per ESU). However, in the years beyond 1994, increases to $4.06, $4.42 and $4.79 respectively would be required assuming no change of the base rate, capital project scheduling or refinancing of bonded indebtedness. Therefore, given program operating costs along with capital needs, a rate of $3.75 per ESU per month is required to fund Lake Oswego's Surface Water Utility. The model output for the recommended financial approach is contained in the 3 pages of Tables 9.1, 9.2 and 9.3.

Implementation of this rate requires preparation of an ordinance establishing the surface water utility and a system/structure for rates. This ordinance language has been drafted and is currently being reviewed by the City's Legal Counsel. Running parallel to the ordinance development is a public outreach and hearing process sponsored by the City. Larger ratepayers have received individual notices regarding the service charge and a "Town Hall" meeting was held to present the Master Plan and funding approach.

### Implementation Schedule

Once the recommended surface water utility has been established and funded, the implementation of the policies, procedures and activities of the SWM Master Plan can occur. The initial focus would be to schedule the completion of tasks needed to meet DEQ's requirements for control of nonpoint pollution sources with the Oswego Lake and Tualatin river drainages. However, the schedule has been expanded to provide a framework that includes all programs and activities of the surface water utility.

# TABLE 9.1
## *City of Lake Oswego*
## *Surface Water Management Plan*
## *Projection of Revenue Requirements & Monthly Rates*

## Projection of Cash Flow:

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| Operating Revenues | $593,865 | $602,773 | $611,815 | $620,992 | $630,307 | $639,761 |
| Interest on Reserve | 457 | 1,247 | 2,454 | 4,178 | 6,454 | 8,857 |
| less: Operating Expenses | 461,000 | 484,050 | 508,253 | 533,685 | 560,348 | 588,366 |
| less: Debt Service | 30,459 | 52,655 | 80,494 | 114,801 | 151,825 | 190,699 |
| less: Reserve Funding | 6,092 | 10,531 | 16,099 | 22,960 | 30,365 | 32,048 |
| Net Cash | $96,771 | $56,783 | $9,423 | ($46,259) | ($105,778) | ($162,495) |
| Net Deficiency (Surplus) | ($96,771) | ($56,783) | ($9,423) | $46,259 | $105,778 | $162,495 |

## Test of Coverage Requirement:

| | | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|---|
| Operating Expenses | | $461,000 | $484,050 | $508,253 | $533,665 | $560,348 | $588,366 |
| Debt Service – Revenue Bonds | | 30,459 | 52,655 | 80,494 | 114,801 | 151,825 | 190,699 |
| G.O. Bonds | | 0 | (0) | 0 | 0 | 0 | (0) |
| Reserve Funding for New Debt | | 6,092 | 10,531 | 16,099 | 22,960 | 30,385 | 32,048 |
| Additional Coverage at | 1.25 | 1,523 | 2,633 | 4,025 | 5,740 | 7,591 | 15,627 |
| Total Revenue Req. with Coverage | | $499,074 | $549,869 | $608,870 | $677,167 | $750,129 | $826,740 |
| Total Revenues | | $594,322 | $604,020 | $614,269 | $625,168 | $636,760 | $648,618 |
| Net Revenue Req. Incl. Coverage | | ($95,248) | ($54,151) | ($5,399) | $51,999 | $113,369 | $178,121 |
| Coverage Realized: | | 4.38 | 2.28 | 1.32 | 0.80 | -0.50 | 0.32 |
| Revenue Deficiency (Surplus): | | ($95,248) | ($54,151) | ($5,399) | $51,999 | $113,369 | $178,121 |

## Projection of Revenue Sufficiency:

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| Maximum Deficiency | $0 | $0 | $0 | $51,999 | $113,369 | $178,121 |
| Percent Increase Required Over Current Revenues | 0.00% | 0.00% | 0.00% | 8.37% | 17.99% | 27.84% |
| Annual Percent Increase Required | 0.00% | 0.00% | 0.00% | 8.37% | 8.87% | 8.35% |

| | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| Estimated Monthly Rate w/o Rate Increase | $3.75 | $3.75 | $3.75 | $3.75 | $3.75 | $3.75 |
| Estimated Rate with Required Increase | $3.75 | $3.75 | $3.75 | $4.06 | $4.42 | $4.79 |

# TABLE 9.2

## *City of Lake Oswego*
## *Surface Water Management Plan*
## *Statement of Revenues and Expenses*
## *– Estimates Only –*

**Economic Assumptions:**

| | |
|---|---|
| Monthly ESU Charge | $3.75 |
| % Growth in ESU's per Year | 1.50% |
| Annual O&M Cost Inflation | 5.00% |

| Revenue & Expense Category | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 |
|---|---|---|---|---|---|---|
| Equivalent Service Units | 13,197 | 13,395 | 13,596 | 13,800 | 14,007 | 14,217 |
| Operating Revenue: | | | | | | |
| Charges for Services | $593,865 | $602,773 | $611,815 | $620,992 | $630,307 | $639,761 |
| Operating Expenses: | | | | | | |
| Finance & Billing | 40,000 | 42,000 | 44,100 | 46,305 | 48,620 | 51,051 |
| Operations & Maintenance | 262,500 | 275,625 | 289,406 | 303,877 | 319,070 | 335,024 |
| Water Quality Management | 80,900 | 84,945 | 89,192 | 93,652 | 98,334 | 103,251 |
| Plan Review & Construction Inspection | 15,450 | 16,223 | 17,034 | 17,885 | 18,780 | 19,719 |
| Regulation | 20,600 | 21,630 | 22,711 | 23,847 | 25,039 | 26,291 |
| Small Works | 25,750 | 27,038 | 28,389 | 29,809 | 31,299 | 32,864 |
| Rate Financed Cap. Improvement Program | 0 | 0 | 0 | 0 | 0 | 0 |
| Public Involvement | 15,800 | 16,590 | 17,420 | 18,290 | 19,205 | 20,165 |
| Total Operating Expenses | 461,000 | 484,050 | 508,253 | 533,665 | 560,348 | 588,366 |
| Net Operating Contingency | $132,865 | $118,723 | $103,562 | $87,327 | $69,958 | $51,395 |

**Calculation of ESU's:**

| | |
|---|---|
| Square Feet per ESU: | 3,030 |

| Land Use Category | Developed Acreage | Percent Impervious | Impervious Acreage | Impervious Square Footage | Equivalent Service Units |
|---|---|---|---|---|---|
| Single Family Residential | 1,200 | NA | NA | NA | 8,000 |
| Commercial & Industrial (*) | NA | 70.00% | NA | NA | 5,197 |
| Total | | | | | 13,197 |

(*) – Based on Impervious Area Measurement

# TABLE 9.3

## *City of Lake Oswego*
## *Surface Water Management Plan*
## *Listing of Capital Projects – Systemwide Improvements*
## *– Estimates Only –*

Cost Escalation Rate 5.00%

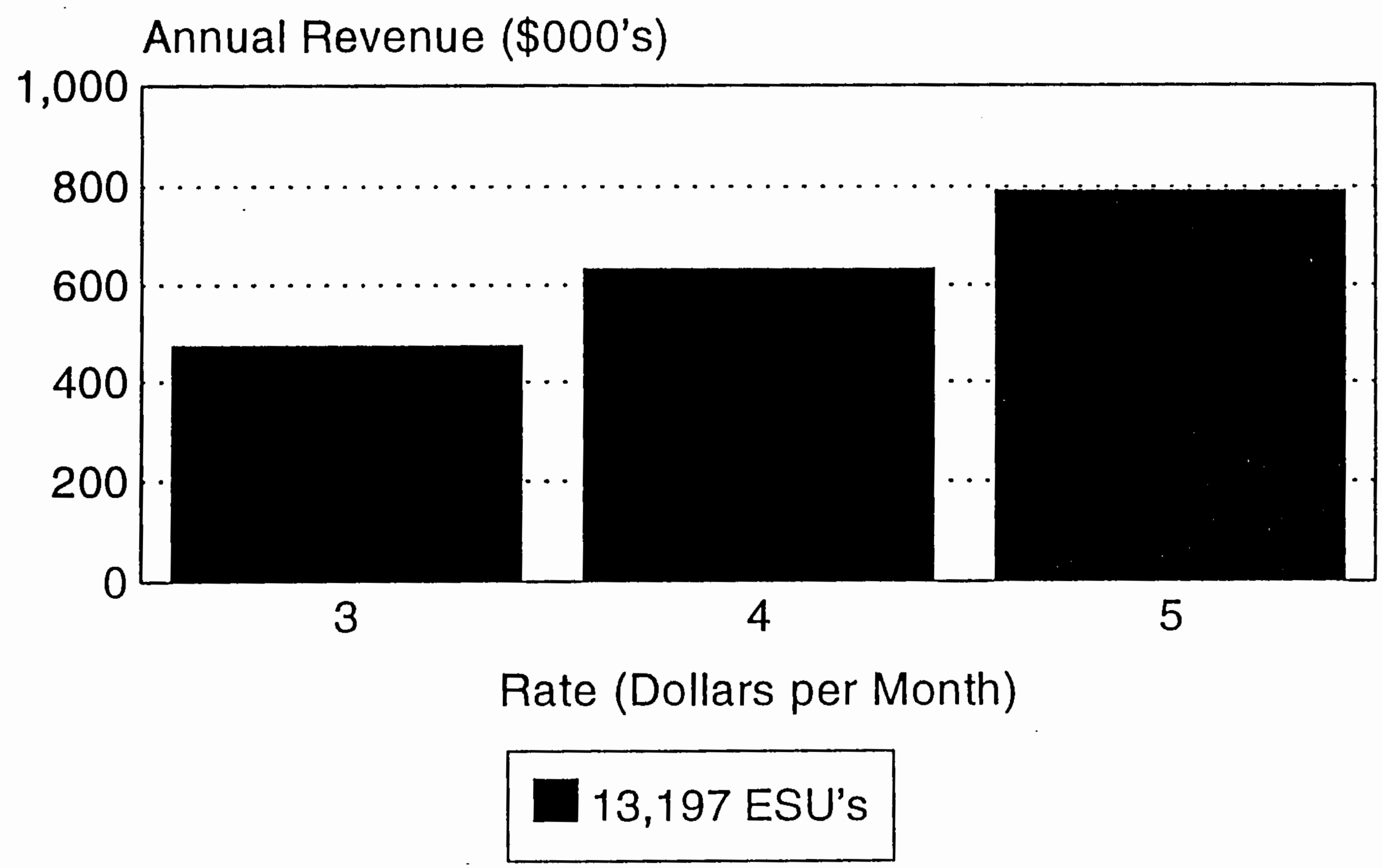
| Rank | Cost In Fiscal Year 1992 | Year | Description | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | TOTAL |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | 203,700 | 1992 | H2O Qty (Major Drainage & Sm Wks) | $203,700 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $203,700 |
| 2 | 203,700 | 1993 | H2O Qty (Major Drainage & Sm Wks) | 0 | 213,885 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 213,885 |
| 3 | 203,700 | 1994 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 224,579 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 224,579 |
| 4 | 203,700 | 1995 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 235,808 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 235,808 |
| 5 | 203,700 | 1996 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 247,599 | 0 | 0 | 0 | 0 | 0 | 0 | 247,599 |
| 6 | 203,700 | 1997 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 0 | 259,979 | 0 | 0 | 0 | 0 | 0 | 259,979 |
| 7 | 203,700 | 1998 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 0 | 0 | 272,977 | 0 | 0 | 0 | 0 | 272,977 |
| 8 | 203,700 | 1999 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 286,626 | 0 | 0 | 0 | 286,626 |
| 9 | 203,700 | 2000 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 300,958 | 0 | 0 | 300,958 |
| 10 | 203,700 | 2001 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 316,006 | 0 | 316,006 |
| 11 | 203,700 | 2002 | H2O Qty (Major Drainage & Sm Wks) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 331,806 | 331,806 |
| 12 | 87,500 | 1992 | H2O Qual (PRF's & Stream Rehab.) | 87,500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 87,500 |
| 13 | 87,500 | 1993 | H2O Qual (PRF's & Stream Rehab.) | 0 | 91,875 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 91,875 |
| 14 | 87,500 | 1994 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 96,469 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 96,469 |
| 15 | 87,500 | 1995 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 101,292 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 101,292 |
| 16 | 87,500 | 1996 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 106,357 | 0 | 0 | 0 | 0 | 0 | 0 | 106,357 |
| 17 | 87,500 | 1997 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 0 | 111,675 | 0 | 0 | 0 | 0 | 0 | 111,675 |
| 18 | 87,500 | 1998 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 0 | 0 | 117,258 | 0 | 0 | 0 | 0 | 117,258 |
| 19 | 87,500 | 1999 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 123,121 | 0 | 0 | 0 | 123,121 |
| 20 | 87,500 | 2000 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 129,277 | 0 | 0 | 129,277 |
| 21 | 87,500 | 2001 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 135,741 | 0 | 135,741 |
| 22 | 87,500 | 2002 | H2O Qual (PRF's & Stream Rehab.) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 142,528 | 142,528 |
| 23 | 10,000 | 1992 | Sensitive Land Reserve | 10,000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10,000 |
| 24 | 10,000 | 1993 | Sensitive Land Reserve | 0 | 10,500 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 10,500 |
| 25 | 10,000 | 1994 | Sensitive Land Reserve | 0 | 0 | 11,025 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11,025 |
| 26 | 10,000 | 1995 | Sensitive Land Reserve | 0 | 0 | 0 | 11,576 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 11,576 |
| 27 | 10,000 | 1996 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 12,155 | 0 | 0 | 0 | 0 | 0 | 0 | 12,155 |
| 28 | 10,000 | 1997 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 0 | 12,763 | 0 | 0 | 0 | 0 | 0 | 12,763 |
| 29 | 10,000 | 1998 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 0 | 0 | 13,401 | 0 | 0 | 0 | 0 | 13,401 |
| 30 | 10,000 | 1999 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14,071 | 0 | 0 | 0 | 14,071 |
| 31 | 10,000 | 2000 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 14,775 | 0 | 0 | 14,775 |
| 32 | 10,000 | 2001 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 15,513 | 0 | 15,513 |
| 33 | 10,000 | 2002 | Sensitive Land Reserve | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 16,289 | 16,289 |
| 34 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 35 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 36 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 37 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 38 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 39 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 40 | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | $3,313,200 | | Net Construction Cost | $301,200 | $316,260 | $332,073 | $348,677 | $366,110 | $384,416 | $403,637 | $423,819 | $445,010 | $467,260 | $490,623 | $4,279,084 |

| Capital Fund Activity | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Initial Balance | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |
| plus: Excess Cash From Prior Year | | 96,771 | 56,783 | 9,423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| less: Contribution to Project | 0 | 96,771 | 56,783 | 9,423 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| plus: Fund Earnings | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Ending Balance | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 | $0 |

FIGURE 9.1

# City of Lake Oswego

## Surface Water Management Plan
## Revenue Profile



# References

# REFERENCES


Brown and Caldwell Consultants, Surface Water Quality Facilities Technical Guidance Handbook, prepared for Portland, Lake Oswego, Clackamas County, Unified Sewerage Agency, August, 1991.

Corp of Engineers, Hydrologic Engineering Center, HEC-1 Flood Hydrograph Package, User's Manual, U.S. Department of the Army, September, 1990.

Federal Emergency Management Agency, Flood Insurance Study, City of Lake Oswego, Oregon Clackamas, Multnomah, and Washington Counties, Flood Insurance Administration, August 4, 1987.

______, Flood Insurance Study, Clackamas County, Unincorporated Areas, Flood Insurance Administration, August 4, 1987.

______, Flood Insurance Study, City of Rivergrove, Oregon, Clackamas and Washington Counties, Flood Insurance Administration, August 4, 1987.

Highway Division, Hydraulics Manual, Oregon Department of Transportation, January, 1990.

Lake Oswego, City of, Comprehensive Plan, June, 1988.

Kramer, Chin & Mayo, Inc/URS Consultants., Lower Tualatin River Oswego Lake Subbasins, Nonpoint Watershed Management, prepared for the City of Lake Oswego, Oregon, March, 1990.

Kramer, Chin & Mayo, Inc., Oswego Lake Study, Final Report prepared for City of Lake Oswego, Oregon Department of Environmental Quality, Clackamas County, Unified Sewerage Agency and Lake Oswego Corporation, March, 1992.

Metro Service District, Storm Water Management Design Manual, Spring, 1980.

National Oceanic and Atmospheric Administration, National Weather Service, Precipitation-Frequency Atlas of Western United States - Volume X - Oregon, NOAA Atlas 2, prepared by J.F. Miller, R.H. Frederick and R.J. Tracey, Washington, D.C., 1973.

Pitt, R.E., Small Storm Urban Flow and Particulate Washoff Contributions to Outfall Discharges, Ph.D. Dissertation, Civil and Environmental Engineering Department, University of Wisconsin, Madison, Wisconsin, November, 1987.

Portland, City of, Sewer Design Manual, Bureau of Environmental Services, 1991.

Schueler, Thomas R., Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban BMP's, prepared for Washington Metropolitan Water Resources Planning Board, July, 1987.

Scientific Resources, Inc., Lake Oswego Lake and Watershed Assessment 1986-1987, Diagnostic and Restoration Analysis, Volume 1: Final Report, prepared for Lake Oswego Corporation, Unified Sewerage Agency and Oregon Department of Environmental Quality, 1988.

Soil Conservation Service, National Engineering Handbook, Section 4, Hydrology, Washington, D.C., U.S. Department of Agriculture, August, 1972.

# REFERENCES

_____, Soil Survey of Clackamas County, Oregon, U.S. Department of Agriculture, November, 1975.

_____, Urban Hydrology for Small Watersheds Technical Release No. 55, Engineering Division, U.S. Department of Agriculture, January, 1975.

Sutherland, R.C., Jelen, S., and Green, D., Simplified Particulate Transport Model, Version 3.1, User's Manual, March, 1992.

Sutherland, R.C., "Methodology for Estimating Effective Impervious Area for Natural, Partially Urbanized and Urban Watersheds Based on Published USGS Data for Watersheds Throughout the Metropolitan Areas of Portland and Salem, Oregon," May, 1987.

USGS, Water Resources Investigations, Open-File Report 80-689, Storm Runoff As Related To Urbanization in the Portland, Oregon-Vancouver, Washington Area, 1980.

U.S. Environmental Protection Agency, Results of the National Urban Runoff Program, Volume 1- Final Report, Washington, D.C., December, 1983.

Schoening

# Lake Oswego Surface Water Management Master Plan

Volume II - Appendices

otak

JULY 1992

# LAKE OSWEGO SURFACE WATER MANAGEMENT MASTER PLAN

**Volume II**

**Appendices**

---

**July 1992**


*City of Lake Oswego*
*Department of Public Works*
*380 A Avenue*
*Lake Oswego, OR 97034*
*(503) 635-0270*

*Clackamas County*
*Department of Utilities*
*902 Abernathy Road*
*Oregon City, OR 97045*
*(503) 650-3323*

*Prepared by:*

*OTAK Incorporated*
*17355 SW Boones Ferry Road*
*Lake Oswego, OR 97035*
*(503) 635-3618*


REGISTERED PROFESSIONAL ENGINEER 12,015 OREGON Feb 17, 1933 ROGER C. SUTHERLAND

REGISTERED PROFESSIONAL ENGINEER 13266 OREGON JULY 17, 1986 JOHN M. HOULE

# APPENDICES

# METHODOLOGY FOR ESTIMATING LAG TIME OF NATURAL, PARTIALLY URBANIZED AND URBAN WATERSHEDS BASED ON PUBLISHED U.S.G.S. DATA FOR WATERSHEDS THROUGHOUT THE METROPOLITAN AREAS OF PORTLAND AND SALEM, OREGON

**By**

**Roger C. Sutherland, P.E.**
**OTAK, Incorporated**

## Introduction

**Lag time** ($t_L$) of a watershed can be defined as **the time measured between the center of mass of the rainfall occurring on the watershed and the center of mass of the runoff observed to occur at the watershed outlet.** Numerous studies (Leopold, 1968; Anderson, 1970; Laenen, 1980; Laenen, 1983; et al.) have shown that as a watershed urbanizes (i.e. the mapped impervious area (MIA) of the watershed increases) the lag time of the watershed will decrease.

Anderson (1970) analyzed the rainfall to runoff response of over 80 watersheds located throughout Northern Virginia; Baltimore, Maryland; and Louisville, Kentucky. The mapped impervious areas of these watersheds ranged from less than 1 percent to 100 percent. Anderson concluded that the measured lag time of these watersheds could be directly related to their physical characteristics which included the length and slope of their main channels and their mapped impervious areas (see Figure 1).

Anderson (1970) developed several equations that could be used to estimate the lag time of a watershed based on the degree of urbanization that existed within the basin. They are as follows:

For **natural basins** (Class N) with **MIA $\leq$ 3 percent,**

$$t_L = 4.64\ (L/S^{0.5})^{0.42} \tag{1}$$

For **fully urbanized basins** (Class U) with **33 $\leq$ MIA $\leq$ 100** and **fully sewered including main channels,**

$$t_L = 0.56\ (L/S^{0.5})^{0.52} \tag{2}$$

For **highly urbanized basins** (Class B) with **20 $\leq$ MIA $\leq$ 30** and **main channels open,**

$$t_L = 0.9\ (L/S^{0.5})^{0.50} \tag{3}$$

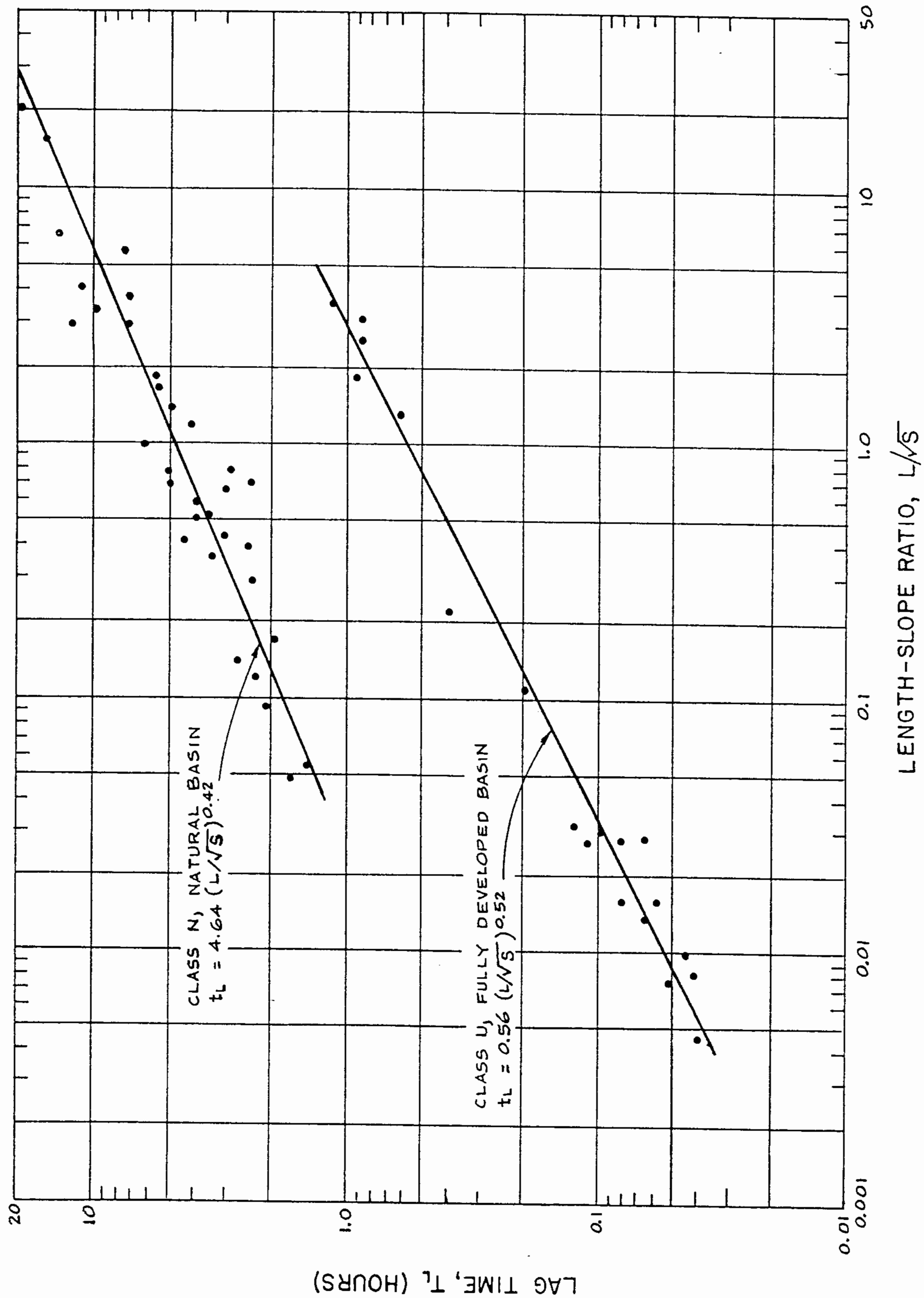



Figure 1 – Relationship Between Lag Time and Basin Length-Slope Ratio (From Anderson 1970)

otak incorporated
INC. ARCHITECTS, P.C.
17355 SW Boones Ferry Rd Lake Oswego, OR 97035 (503) 635-3618
101 E 8th Street, Vancouver WA 98660 (206) 695-0357

For Equations (1), (2), and (3):

$t_L$ = lag time of the basin (hrs)

**L** = length of the main water course (i.e. most defined course) measured from the basin outlet upstream to the watershed divide (mi)

**S** = slope of the main water course measured between points located at 10 percent and 85 percent of L, respectively (ft/mi)

All of Anderson's regression equations fit the observed data quite well with the standard error of estimates ranging from 17.7 to 26.0 percent. Additionally, all of the equations have the same form which can be rewritten as:

$$\mathbf{t_L = A\ (L/S^{0.5})^B} \qquad (4)$$

In Equation (4), A and B are coefficients whose values are based on the relative amount of imperviousness within the basin and the characteristics of the drainage collector systems within the basin. Note that A decreases as impervious area increases, whereas B increases with increasing impervious area.

## Study Objectives

Working with the form of the equations developed by Anderson and the U.S.G.S. data for metropolitan Portland and Salem, Oregon (Laenen, 1980 and 1983), the **major objective** of the study was to **develop a method that could be used to estimate the lag time of a watershed as a function of its physical characteristics**. It was desired to develop a technique to estimate lag times based on physical characteristics of the watershed which could be easily measured or estimated. The final requirement was that the method would provide reasonably accurate estimates of the actual measured lag time published by the U.S.G.S.

The final methodology, presented below, can be used to quickly estimate the subbasin lag time as a function of easily measured physical basin characteristics. This technique can be used in the drainage master planning process to provide an estimate of the change in subbasin lag time which will result from the ultimately planned development within the subbasin. This method allows the modeler to utilize the simple SCS unit hydrograph technique included in HEC-1 as part of the drainage planning process, as it will provide reasonable estimates of the single parameter required for application of the SCS unit hydrograph; the subbasin lag time. Finally, it will be especially helpful in subbasins where little or no urbanization has occurred to date, but for which considerable urban development is planned for the future.

## Lag Time Estimation Technique

The detailed description of the analysis methods used to develop this technique is not included herein. It will be the subject of an additional technical paper to be published in the near future.

The technique is based on the following general equation:

$$\mathbf{t_L = K\ A\ (CL/(CSL)^{0.5})^B} \qquad (5)$$

where:

$t_L$ = lag time of the watershed (hrs)

CL = length of the main channel (i.e. most well defined water course) measured from the basin outlet upstream to the basin divide (mi)

CSL= slope of the main channel (ft/mi) measured from 0.1 CL to 0.85 CL as follows:

$$\mathbf{CSL = \frac{EL85 - EL10}{0.75\ CL}} \qquad (6)$$

where:

**EL10** = flow line elevation (ft) of the main channel measured at a location which is approximately 10 percent of the distance CL from the basin outlet

**EL85** = same as above (ft) with measurement taken at approximately 85 percent of the distance CL from the basin outlet

In Equation (5), **K** is a calibration factor used to uniformly adjust the computed subbasin lag times when observed rainfall and runoff data are available at the outfall of a multiple subbasin watershed. Within each subbasin, the K factor appears to be related to the percentage of the urbanized subbasin area that is served by storm sewer systems (i.e. urban sewered area, USA).

For a **partially urbanized drainage basin** (P basin), whose sewered area **(USA)**, measured as a percentage of the urban area, **is less than 40 percent**, and whose mapped impervious area **(MIA) is between 6 and 50 percent**, the following equation can be used to estimate K:

$$\mathbf{K = 1.3 + 0.02\ (MIA) - 0.02\ (USA)} \qquad (7)$$

if $K < 1.0$ use $K = 1.0$

where:

**MIA** = mapped impervious area measured as percentage of total basin area (%)

**USA** = urban sewered area measured as a percentage (%) of the urban area that is sewered as follows:

$$\mathbf{USA = 100\ (SA/UA)} \qquad (8)$$

where:

**SA** = sewered area measured as a percentage of the total basin area (%)

**UA** = urban area measured as a percentage of the total basin area (%)

In Equation (5), B is a coefficient whose value is based on the mapped impervious area (MIA) of the basin as follows:

$$\mathbf{B = 0.42\ (MIA)^{0.053}} \qquad (9)$$

if MIA < 1, then use MIA = 1

Equation (9) was based on the variation of this B parameter observed by Anderson (1970). It was assumed that if **MIA = 1** then **B = 0.42** and if **MIA = 60** then **B = 0.52**. There were not enough local data throughout Oregon to establish a different relationship for B. Equation (9) was used to determine the B coefficient for any value of MIA so the A coefficient could be properly evaluated.

In Equation (5), A is a coefficient whose value is based on the mapped impervious area and the type of major drainage collector system that serves the basin or subbasin as follows:

1. **Natural** (N), **partially urbanized** (P) and **urban** (U) basins where the major tributaries and main stem are open channels (the local drainage collectors in the urban area can be storm sewered):

$$\mathbf{A = 12.0\ e^{-0.042(MIA)}}, \ MIA \geq 1 \qquad (10)$$

2. **Highly urbanized basins** (U) where both the local drainage collectors and the major tributaries are closed pipes (the main stem can be open channel):

$$\mathbf{A = 3.6\ e^{-0.031(MIA)}}, \ MIA \geq 1 \qquad (11)$$

3. A single simplified equation that can be used for **all types of basins** without concern for the type of drainage collector systems:

$$\mathbf{A = 13.2\ e^{-0.055(MIA)}}, \ MIA \geq 1 \qquad (12)$$

**Equation (12)** will provide the best fit to all data combined, but it will under-estimate the A values for Condition 1 above and over-estimate the A values for Condition 2 above. Equation (12) is **not recommended for use** unless a quick, less accurate, planning level estimate is desired.

## U.S.G.S. Published Data

The U.S.G.S. watershed characteristics collected for basins located throughout the greater Portland and Salem, Oregon areas are tabulated in Table 1. Table 1 also presents the estimated values of K, A, B, and $t_L$ (computed) based on the lag time estimation technique outlined above. The error of estimate in both absolute hours and percent of measured lag time is also shown.

It should be noted that six drainage basins (i.e. basin numbers 3, 7, 11, 14, 25, and 41) were eliminated from the analysis for a number of reasons. The first and foremost was the existence of excessive storage within the basins which resulted in a dramatic increase in the measured lag time at the outlet of the basins. Basins that have excessive storage behind high embankment culverts and contain numerous natural depressions that provided considerable storage include Beaverton Creek (3), Singer Creek (7), Kellogg Creek (11), and Johnson Creek (14). The Little Pudding River tributary at Lardon Road (41) was eliminated because approximately 80 percent of the basin contained agricultural tiles (i.e. underground drains) which dramatically decreased the measured lag time. Croisan Creek (25) in the Salem area was also eliminated due to a dramatic decrease in measured lag time. The reason for the unusually quick response to rainfall has not yet been determined. It may contain agricultural tiles or perhaps the predominantly downstream location of its existing urban area could explain the rapid response of this long, narrow, steep drainage.

The results of the comparison of computed lag time versus the published "measured" values are presented in Figure 2. The computed lag times in Figure 2 are based on values for the parameter A obtained from Equation (10) for basins classified as natural (N) or partially urbanized (P), and Equation (11) for basins classified as urban (U). Basin numbers 3, 7, 11, 14, 25, and 41 have been eliminated from Figure 2.

TABLE 1

Watershed Characteristics for Basins Throughout the Metropolitan Portland and Salem, Oregon Area (Laenen, 1980 and 1983)

| STATION NUMBER | STATION NAME | BASIN NO. | DRAINAGE AREA (MI^2) | MAP IMP AREA MIA | USGS MODEL EIA | TOTAL SEWERED AREA SA | TOTAL URBAN AREA UA | URBAN SEWERED AREA USA | STORAGE AREA ST | UA LOCAL DRAINAGE SYSTEM | MAJOR TRIBS | MAIN STEM | MIA + SA | BASIN CATEGORY |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142580 | KELLY CREEK | 1 | 4.16 | 16 | 12 | 25.0 | 16 | 100 | 0.1 | S | O | O | 41 | P1 |
| 144690 | VANCOUVER SEWER OUTFALL | 2 | 1.00 | 49 | 16 | 86.0 | 75 | 100 | 0.0 | S | S | S | 135 | U2 |
| 206320 | BEAVERTON CREEK | 3 | 6.63 | 23 | 22 | 54.0 | 72 | 75 | 2.0 | S | O | O | 77 | P2 |
| 206330 | BEAVERTON CREEK TRIB. | 4 | 0.21 | 19 | 15 | 75.0 | 58 | 100 | 1.1 | S | S | O | 94 | U1 |
| 206470 | BUTTERNUT CREEK | 5 | 0.82 | 12 | 10 | 15.0 | 22 | 68 | 0.3 | S | O | O | 27 | P1 |
| 206900 | FANNO CREEK | 6 | 2.37 | 32 | 17 | 57.0 | 87 | 66 | 0.0 | S | O | O | 89 | P2 |
| 207800 | SINGER CREEK | 7 | 0.28 | 28 | 15 | 20.0 | 82 | 24 | 3.7 | S | O | O | 48 | P1 |
| 210400 | NOYER CREEK | 8 | 2.04 | 6 | 6 | 1.0 | 7 | 14 | 0.0 | O | O | O | 7 | N |
| 211110 | WILL R.(ROBINWOOD) TRIB. | 9 | 1.03 | 10 | 4 | 0.0 | 31 | 0 | 0.0 | O | O | O | 10 | N |
| 211120 | WILL R.(OAK GROVE) TRIB. | 10 | 0.74 | 36 | 12 | 0.4 | 86 | 0 | 0.3 | O | O | O | 36 | P1 |
| 211130 | KELLOGG CREEK | 11 | 2.42 | 22 | 15 | 5.0 | 65 | 8 | 7.0 | O | O | O | 27 | P1 |
| 211301 | TRYON CREEK TRIB. | 12 | 0.36 | 32 | 25 | 29.0 | 88 | 33 | 0.6 | S | O | O | 61 | P2 |
| 211450 | JOHNSON CREEK TRIB. | 13 | 0.21 | 16 | 7 | 14.0 | 41 | 34 | 0.0 | S | O | O | 30 | P1 |
| 211500 | JOHNSON CREEK | 14 | 26.50 | 7 | 7 | 3.4 | 14 | 24 | 0.3 | O | O | O | 10 | N |
| 211604 | N.W. 11TH-EVERETT SEWER | 15 | 1.98 | 36 | 32 | 73.0 | 69 | 100 | 0.0 | S | S | S | 109 | U1 |
| 211610 | S.E. 9TH-MADISON SEWER | 16 | 1.53 | 39 | 41 | 89.0 | 96 | 93 | 0.0 | S | S | S | 128 | U2 |
| 211614 | N.E. HANCOCK-FLINT SEWER | 17 | 1.36 | 43 | 43 | 90.0 | 98 | 92 | 0.0 | S | S | S | 133 | U2 |
| 211617 | N.ALBINA-KIRKPATRICK SWR | 18 | 0.95 | 44 | 22 | 88.0 | 94 | 94 | 0.0 | S | S | S | 132 | U2 |
| 211618 | N. VANCOUVER-OWRSN SWR | 19 | 0.34 | 46 | 18 | 85.0 | 98 | 87 | 0.0 | S | S | S | 131 | U2 |
| 211625 | S.E. 27TH-BYBEE SEWER | 20 | 0.77 | 26 | 28 | 91.0 | 93 | 98 | 0.0 | S | S | S | 117 | U1 |
| 211630 | S.E. 27TH-BELMONT SEWER | 21 | 0.54 | 35 | 35 | 94.0 | 99 | 95 | 0.0 | S | S | S | 129 | U2 |
| 211800 | SALTZMAN CREEK | 22 | 1.48 | 1 | 4 | 0.0 | 1 | 0 | 0.2 | O | O | O | 1 | N |
| 211950 | VANCOUVER LAKE TRIB. | 23 | 0.44 | 30 | 12 | 43.0 | 70 | 61 | 2.2 | S | S | O | 73 | U2 |
| 213040 | COUGAR CREEK | 24 | 2.88 | 25 | 11 | 41.0 | 50 | 82 | 3.8 | S | O | O | 66 | P2 |
| 190840 | CROISAN CREEK | 25 | 4.54 | 4 | 8 | 7.0 | 12 | 58 | 0.9 | S | O | O | 11 | P1 |
| 190930 | UPPER PRINGLE CREEK | 26 | 2.93 | 2 | 4 | 0.0 | 0 | 0 | 0.9 | O | O | O | 2 | N |
| 190955 | W.F. PRINGLE CREEK | 27 | 3.16 | 30 | 18 | 44.0 | 73 | 60 | 2.5 | S | O | O | 74 | P2 |
| 190960 | CLARK CREEK | 28 | 1.69 | 34 | 20 | 44.0 | 88 | 50 | 2.5 | S | O | O | 78 | P2 |
| 190970 | PRINGLE CREEK | 29 | 12.60 | 22 | 15 | 21.0 | 45 | 47 | 4.5 | S | O | O | 43 | P2 |
| 191440 | BATTLE CREEK | 30 | 5.56 | 2 | 3 | 0.0 | 0 | 0 | 3.9 | O | O | O | 2 | N |
| 191460 | WALN CREEK | 31 | 1.47 | 22 | 9 | 34.0 | 23 | 100 | 1.5 | S | O | O | 56 | P2 |
| 192100 | GLENN CR. @OOAKS FY.RD | 32 | 2.51 | 8 | 6 | 8.0 | 12 | 67 | 0.3 | S | O | O | 16 | P1 |
| 192120 | GLENN CR. @ORCHARD HT.RD | 33 | 3.31 | 10 | 8 | 11.0 | 20 | 55 | 0.3 | S | O | O | 21 | P1 |
| 192150 | GIBSON CREEK | 34 | 0.54 | 2 | 3 | 0.0 | 0 | 0 | 0.1 | O | O | O | 2 | N |
| 192210 | CLAGGETT CREEK | 35 | 3.08 | 27 | 20 | 72.0 | 61 | 100 | 2.7 | S | S | O | 99 | U1 |
| 192215 | HAWTHORNE D. @D ST. | 36 | 0.48 | 43 | 12 | 60.0 | 73 | 82 | 0.0 | S | S | O | 103 | U2 |
| 192220 | HAWTHORNE D. @SUNNYSIDE | 37 | 0.80 | 53 | 28 | 76.0 | 82 | 93 | 0.1 | S | S | O | 129 | U2 |
| 192225 | HAWTHORNE D. @EASTGATE PK | 38 | 1.40 | 45 | 25 | 86.0 | 84 | 100 | 0.4 | S | S | O | 131 | U1 |
| 192230 | HAWTHORNE D.@HYACINTH ST | 39 | 1.68 | 43 | 23 | 88.0 | 84 | 100 | 0.4 | S | S | O | 131 | U1 |
| 199655 | L.PUDDING R.TR.@CORDON RD | 40 | 0.79 | 15 | 12 | 36.0 | 51 | 71 | 9.9 | S | O | O | 51 | P1 |
| 199855 | L.PUDDING R.TR.@LARDON RD | 41 | 0.27 | 1 | 2 | 0.0 | 0 | 0 | 1.5 | O | O | O | 2 | N |
| 200050 | L.PUDDING R.TR.@KALE RD | 42 | 0.75 | 20 | 8 | 66.0 | 60 | 100 | 7.4 | S | O | O | 86 | P2 |

*NOTES O-OPEN S-SEWERED N-NATURAL P-PARTIALLY URBANIZED U-URBANIZED

TABLE 1 (Continued)

Watershed Characteristics for Basins Throughout the Metropolitan
Portland and Salem, Oregon Area (Laenen, 1980 and 1983)

| STATION NUMBER | STATION NAME | BASIN NO. | BASIN SLOPE (FT/MI) BSL | CHANNEL SLOPE (FT/MI) CSL | CHANNEL LENGTH (MILES) CL | CL/ SQRT CSL | "K" | "A" | "B" | LAG TIME (HOURS) TLAG MEASURED | LAG TIME (HOURS) TLAG COMPUTED | ERROR OF ESTIMATE (HRS) | ERROR OF ESTIMATE (PERCENT) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 142580 | KELLY CREEK | 1 | 260 | 48 | 4.70 | 0.678 | 1.00 | 6.13 | 0.49 | 4.96 | 5.07 | 0.11 | 2 |
| 144690 | VANCOUVER SEWER OUTFALL | 2 | 270 | 108 | 2.20 | 0.212 | 1.00 | 0.79 | 0.52 | 0.35 | 0.35 | 0.00 | 1 |
| 206320 | BEAVERTON CREEK | 3 | 400 | 150 | 5.70 | 0.465 | 1.00 | 4.57 | 0.50 | 14.00 | 3.13 | -10.87 | -78 |
| 206330 | BEAVERTON CREEK TRIB. | 4 | 380 | 180 | 0.62 | 0.046 | 1.00 | 2.00 | 0.49 | 0.43 | 0.44 | 0.01 | 3 |
| 206470 | BUTTERNUT CREEK | 5 | 510 | 240 | 2.40 | 0.155 | 1.00 | 7.25 | 0.48 | 3.00 | 2.97 | -0.03 | -1 |
| 206900 | FANNO CREEK | 6 | 860 | 200 | 2.50 | 0.177 | 1.00 | 3.13 | 0.50 | 1.87 | 1.31 | -0.56 | -30 |
| 207800 | SINGER CREEK | 7 | 580 | 310 | 0.77 | 0.044 | 1.86 | 3.70 | 0.50 | 4.20 | 1.43 | -2.77 | -66 |
| 210400 | NOYER CREEK | 8 | 320 | 175 | 1.90 | 0.144 | 1.42 | 9.33 | 0.46 | 4.75 | 5.41 | 0.66 | 14 |
| 211110 | WILL R.(ROBINWOOD) TRIB. | 9 | 890 | 400 | 2.10 | 0.105 | 1.50 | 7.88 | 0.47 | 4.55 | 4.06 | -0.49 | -11 |
| 211120 | WILL R.(OAK GROVE) TRIB. | 10 | 280 | 160 | 1.80 | 0.142 | 2.02 | 2.65 | 0.51 | 2.12 | 1.99 | -0.13 | -6 |
| 211130 | KELLOGG CREEK | 11 | 320 | 16 | 2.70 | 0.675 | 1.74 | 4.76 | 0.49 | 10.70 | 6.82 | -3.88 | -36 |
| 211301 | TRYON CREEK TRIB. | 12 | 440 | 210 | 0.88 | 0.061 | 1.94 | 3.13 | 0.50 | 0.93 | 1.48 | 0.55 | 59 |
| 211450 | JOHNSON CREEK TRIB. | 13 | 300 | 95 | 1.10 | 0.113 | 1.62 | 6.13 | 0.49 | 1.88 | 3.43 | 1.55 | 83 |
| 211500 | JOHNSON CREEK | 14 | 580 | 32 | 13.80 | 2.440 | 1.44 | 8.94 | 0.47 | 25.00 | 19.51 | -5.49 | -22 |
| 211604 | N.W. 11TH-EVERETT SEWER | 15 | 608 | 230 | 3.40 | 0.224 | 1.00 | 1.18 | 0.51 | 0.75 | 0.55 | -0.20 | -26 |
| 211610 | S.E. 9TH-MADISON SEWER | 16 | 136 | 66 | 2.30 | 0.283 | 1.00 | 1.07 | 0.51 | 0.51 | 0.56 | 0.05 | 11 |
| 211614 | N.E. HANCOCK-FLINT SEWER | 17 | 89 | 58 | 2.80 | 0.368 | 1.00 | 0.95 | 0.51 | 0.56 | 0.57 | 0.01 | 1 |
| 211617 | N.ALBINA-KIRKPATRICK SWR | 18 | 120 | 92 | 1.60 | 0.167 | 1.00 | 0.92 | 0.51 | 0.32 | 0.37 | 0.05 | 15 |
| 211618 | N. VANCOUVER-OWRSN SWR | 19 | 223 | 107 | 1.50 | 0.145 | 1.00 | 0.86 | 0.51 | 0.28 | 0.32 | 0.04 | 14 |
| 211625 | S.E. 27TH-BYBEE SEWER | 20 | 317 | 166 | 1.20 | 0.093 | 1.00 | 1.61 | 0.50 | 0.28 | 0.49 | 0.21 | 76 |
| 211630 | S.E. 27TH-BELMONT SEWER | 21 | 146 | 42 | 1.20 | 0.185 | 1.00 | 1.22 | 0.51 | 0.28 | 0.52 | 0.24 | 85 |
| 211800 | SALTZMAN CREEK | 22 | 1980 | 580 | 2.10 | 0.087 | 1.00 | 11.51 | 0.42 | 4.70 | 4.13 | -0.57 | -12 |
| 211950 | VANCOUVER LAKE TRIB. | 23 | 140 | 40 | 1.10 | 0.174 | 1.00 | 1.42 | 0.50 | 0.28 | 0.59 | 0.31 | 110 |
| 213040 | COUGAR CREEK | 24 | 270 | 50 | 4.00 | 0.566 | 1.00 | 4.20 | 0.50 | 3.83 | 3.16 | -0.67 | -17 |
| 190840 | CROISAN CREEK | 25 | 807 | 118 | 5.21 | 0.480 | 1.00 | 10.14 | 0.45 | 4.00 | 7.28 | 3.28 | 82 |
| 190930 | UPPER PRINGLE CREEK | 26 | 526 | 51 | 3.29 | 0.461 | 1.00 | 11.03 | 0.44 | 7.00 | 7.87 | 0.87 | 12 |
| 190955 | W.F. PRINGLE CREEK | 27 | 317 | 78 | 3.90 | 0.442 | 1.00 | 3.40 | 0.50 | 3.20 | 2.26 | -0.94 | -29 |
| 190960 | CLARK CREEK | 28 | 394 | 118 | 2.82 | 0.260 | 1.00 | 2.88 | 0.51 | 1.80 | 1.45 | -0.35 | -19 |
| 190970 | PRINGLE CREEK | 29 | 151 | 30 | 6.38 | 1.165 | 1.00 | 4.76 | 0.49 | 5.20 | 5.14 | -0.06 | -1 |
| 191440 | BATTLE CREEK | 30 | 712 | 86 | 4.71 | 0.508 | 1.00 | 11.03 | 0.44 | 9.70 | 8.21 | -1.49 | -15 |
| 191460 | WALN CREEK | 31 | 500 | 70 | 2.27 | 0.271 | 1.00 | 4.76 | 0.49 | 2.30 | 2.50 | 0.20 | 9 |
| 192100 | GLENN CR. @OAKS FY.RD | 32 | 702 | 232 | 3.22 | 0.211 | 1.00 | 8.58 | 0.47 | 3.50 | 4.14 | 0.64 | 18 |
| 192120 | GLENN CR. @ORCHARD HT.RD | 33 | 926 | 180 | 4.43 | 0.330 | 1.00 | 7.88 | 0.47 | 3.20 | 4.66 | 1.46 | 46 |
| 192150 | GIBSON CREEK | 34 | 622 | 360 | 1.85 | 0.098 | 1.00 | 11.03 | 0.44 | 3.50 | 4.00 | 0.50 | 14 |
| 192210 | CLAGGETT CREEK | 35 | 68 | 11 | 4.82 | 1.453 | 1.00 | 1.56 | 0.50 | 2.20 | 1.88 | -0.32 | -15 |
| 192215 | HAWTHORNE D. @D ST. | 36 | 54 | 5 | 1.65 | 0.753 | 1.00 | 0.95 | 0.51 | 0.50 | 0.82 | 0.32 | 64 |
| 192220 | HAWTHORNE D. @SUNNYSIDE | 37 | 52 | 8 | 2.40 | 0.833 | 1.00 | 0.70 | 0.52 | 0.80 | 0.63 | -0.17 | -21 |
| 192225 | HAWTHORNE D. @EASTGATE PK | 38 | 55 | 10 | 3.40 | 1.086 | 1.00 | 0.89 | 0.51 | 1.40 | 0.93 | -0.47 | -34 |
| 192230 | HAWTHORNE D.@HYACINTH ST | 39 | 56 | 12 | 4.24 | 1.224 | 1.00 | 0.95 | 0.51 | 1.80 | 1.05 | -0.75 | -42 |
| 199655 | L.PUDDING R.TR.@CORDON RD | 40 | 61 | 15 | 1.86 | 0.480 | 1.00 | 6.39 | 0.48 | 5.30 | 4.48 | -0.82 | -15 |
| 199855 | L.PUDDING R.TR.@LARDON RD | 41 | 41 | 3 | 0.84 | 0.477 | 1.00 | 11.51 | 0.42 | 2.40 | 8.43 | 6.03 | 251 |
| 200050 | L.PUDDING R.TR.@KALE RD | 42 | 29 | 5 | 1.57 | 0.702 | 1.00 | 5.18 | 0.49 | 3.10 | 4.35 | 1.25 | 40 |
| | | | | | | | | | | | | 0.03 | 11 |

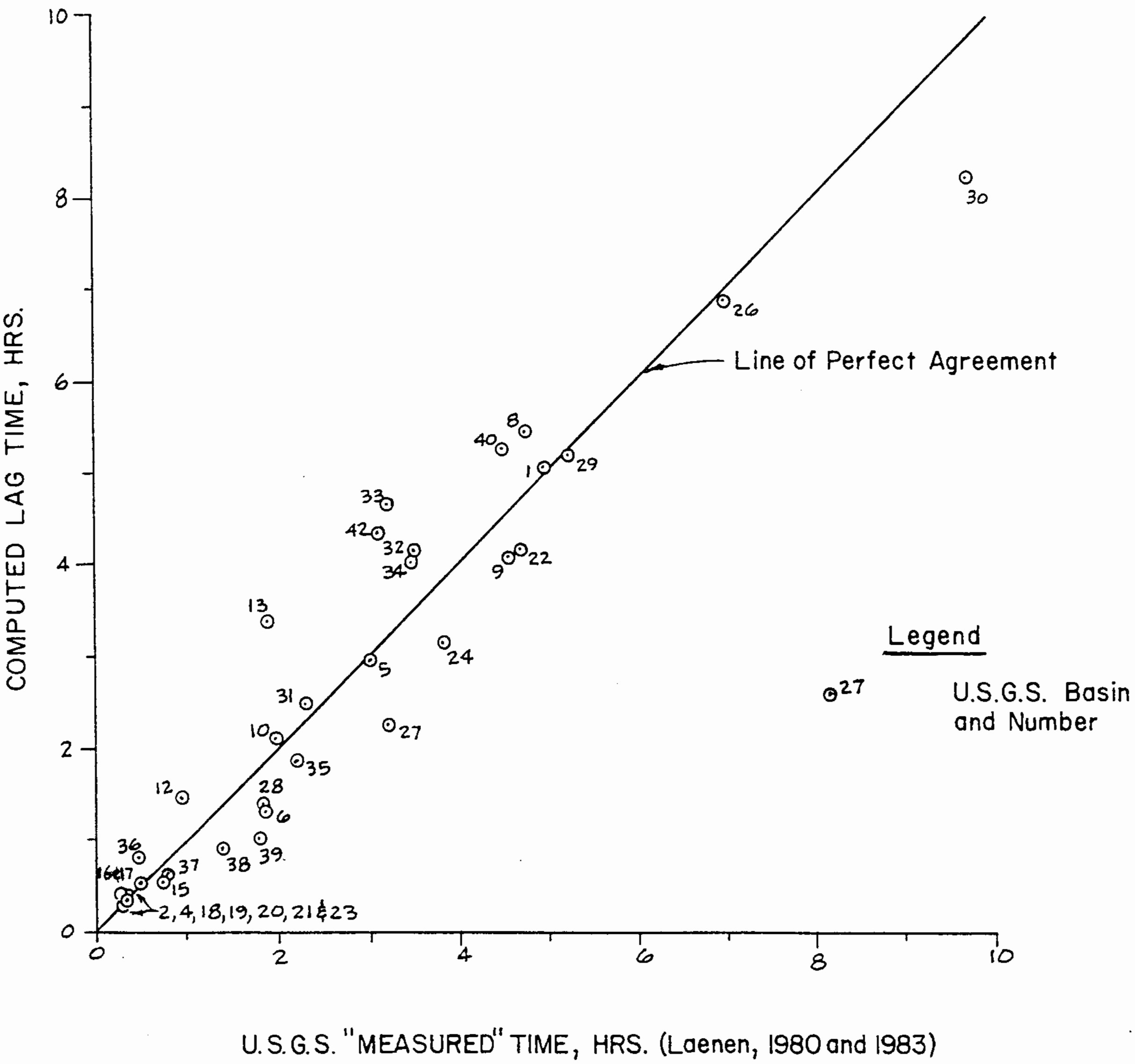



Figure 2 – Computed Versus Measured Lag Times for Metropolitan Portland and Salem, Oregon


otak incorporated
INC. ARCHITECTS, P.C.
17355 S.W. Boones Ferry Rd., Lake Oswego, OR 97035 (503) 635-3618
101 E. 8th Street, Vancouver, WA 98660 (206) 695-0357
11058 Main Street #215, Bellevue, WA 98004 (206) 455-5340

**References**

Anderson, D.G., "Effects of Urban Development on Floods in Northern Virginia," U.S.G.S. Water Supply Paper 2001-C, 1970.

Leopold, L.B., "Hydrology for Urban Land Planning: A Guidebook on the Hydrologic Effect of Urban Land Use," U.S.G.S. Circular 554, 1968.

Laenen, A., "Storm Runoff as Related to Urbanization in the Portland, Oregon - Vancouver, Washington Area," U.S.G.S. Water Resource Investigations Open File Report 80-689, 1980.

Laenen, A., "Storm Runoff as Related to Urbanization Based on Data Collected in Salem and Portland and Generalized for the Willamette Valley, Oregon," U.S.G.S. Water Resources Investigations Open File Report 83-4143, 1983.

# METHODOLOGY FOR ESTIMATING EFFECTIVE IMPERVIOUS AREA FOR NATURAL, PARTIALLY URBANIZED AND URBAN WATERSHEDS BASED ON PUBLISHED U.S.G.S. DATA FOR WATERSHEDS THROUGHOUT THE METROPOLITAN AREAS OF PORTLAND AND SALEM, OREGON

**By**

**Roger C. Sutherland, P.E.**
**OTAK, Incorporated**

## Introduction

One of the most difficult and important parameters that must be estimated during the drainage master planning process is the **effective impervious area (EIA)** of a basin or subbasin of interest. **Effective impervious area (EIA) is the portion of the mapped impervious area (MIA) within a basin that is directly connected to the drainage collection system.** EIA includes street surfaces, paved driveways connecting to the street, sidewalks adjacent to curbed streets, rooftops which are hydraulically connected to the curb, and parking lots.

**EIA** is usually measured as a percentage of total basin or subbasin area. In traditional urban runoff modeling, the EIA for a given basin is usually less than the MIA. However, in highly urbanized basins, EIA values can approach and equal MIA values.

The **EIA** of a basin is an important parameter in the rainfall to runoff process because it directly affects the volume of runoff. In hydrologic models like HEC-1, the EIA of a subbasin is the impervious area value that should be used on the LU, LM, LS, and LH precipitation loss records. Models like HEC-1 assume that no precipitation losses occur on impervious subbasin areas. Thus, the portion of the precipitation landing on the area specified as impervious will become direct runoff. In actuality, the precipitation falling on impervious areas which are not hydraulically connected to the drainage collection system will not result in direct runoff. The impervious area that does <u>not</u> contribute to runoff should be subtracted from the MAPPED impervious area to obtain the EFFECTIVE impervious area, which is used in the model.

## Determination of Effective Impervious Area

The direct measurement of EIA is a tedious exercise which is rarely undertaken as drainage planning budgets cannot afford the excessive associated labor cost. To actually measure the EIA of a basin, it would be necessary to catalog and evaluate the effectiveness of the hydraulic connection between each of the impervious areas and the major collector systems. This extremely time consuming exercise is impractical for most drainage planning and design activities.

If a basin is gaged, the effective impervious area can be estimated by employing a rainfall to runoff model like HEC-1 to calibrate the EIA parameter. This calibration is performed by fixing reasonable estimates of the precipitation loss components for the pervious portions of the basin and, subsequently, adjusting the value of EIA to correlate computed and observed runoff volumes. The calibration process should be undertaken for several observed rainfall events, with the final estimate of EIA representing an average or weighted average of those values calibrated for each individual storm.

Unfortunately, in the real world, observed rainfall to runoff data are rarely available. Therefore, empirical equations must be developed to compute realistic values of EIA based on physical basin parameters which may be conveniently acquired. The **U.S.G.S.** developed estimates of EIA for over forty watersheds throughout the metropolitan areas of Portland and Salem, Oregon (Laenen, 1980 and 1983). Working with this data base, the **U.S.G.S.** also developed an empirical equation to estimate EIA as a function of MIA.

## U.S.G.S. EIA Equation

The U.S.G.S. investigated the EIA parameter for the 42 drainage basins located throughout the Portland and Salem metropolitan areas. As part of their rainfall to runoff modeling, the U.S.G.S. optimized the EIA parameter for each of the drainage basins. The measured mapped impervious areas (MIA) and the resulting optimized, modeled EIAs are presented in Table 1.

It should be noted that the modeling technique used by the U.S.G.S. lumped all of the precipitation excess into a single optimized percentage of the basin area that was assumed to be contributing runoff. This optimized value was defined as the effective impervious area. A potential problem with this technique is that it will over-estimate the "true" EIA for values of MIA less than 10 percent. However, for MIA values greater than 10 percent and less than 50 percent, it will provide reasonable estimates of the EIA parameter.

Working with these optimized values of EIA and their corresponding MIA values, the U.S.G.S (Laenen, 1983) developed the following equation:

$$\mathbf{EIA = 3.6 + 0.43\ (MIA)} \qquad (1)$$

Equation (1) has been found to work well for MIA values greater than 10 percent and less than 50 percent. A problem with Equation (1) is that it provides unrealistic EIA values for MIA values less than 10 percent and greater than 50 percent. In drainage master planning, one commonly deals with small subbasins (i.e. 20 to 70 acres) in which the ultimately planned mapped impervious area may range from as much as 60 to 90 percent. The U.S.G.S. equation does not provide reasonable estimates for EIA in this range.

Therefore, there is a need to develop a relationship between MIA and EIA such that if MIA = 1 then EIA = 0, and if MIA = 100 then EIA = 100. Several equations were developed, based upon the U.S.G.S. data, to satisfy this need.

## OTAK EIA Equations

The form of the equation chosen by OTAK, Incorporated to describe the relationship between MIA and EIA is as follows:

$$\mathbf{EIA = A\ (MIA)^{B}} \qquad (2)$$

In Equation (2), A and B are a unique combination of numbers such that the following criteria are satisfied:

1. If **MIA = 1** then **EIA = 0**

2. If **MIA = 100** then **EIA = 100**

Based upon the U.S.G.S. calibrated values of EIA for all basins with MIA $\geq$ 4, several empirical equations (i.e. same form as Equation 2) were developed to apply to various generalized conditions of subbasins which may be encountered in the drainage master planning process. The first equation presented below provided the best fit for all of the MIA versus EIA data used in the analysis. The remaining equations were based primarily on engineering judgement and experience as it relates to the various subbasin conditions which affect EIA.

The **OTAK EIA Equations** are as follows:

1. **Average basins** where the local collector systems for the urban areas within the basin are predominantly storm sewered with curb and gutter inlets, no dry wells or other drainage retention areas are known to exist, and the rooftops in the single family residential areas are not connected or piped directly to the street curb.

$$\mathbf{EIA = 0.1\,(MIA)^{1.5}\,,\ MIA \geq 1} \qquad (3)$$

2. **Highly connected basins** where everything in Condition 1 applies except the residential rooftops are predominantly connected to the streets or storm sewer system.

$$\mathbf{EIA = 0.4\,(MIA)^{1.2}\,,\ MIA \geq 1} \qquad (4)$$

3. **Totally connected basins** where 100 percent of the urban area within the basin is storm sewered with all impervious surfaces appearing to be directly connected to the system.

$$\mathbf{EIA = MIA} \qquad (5)$$

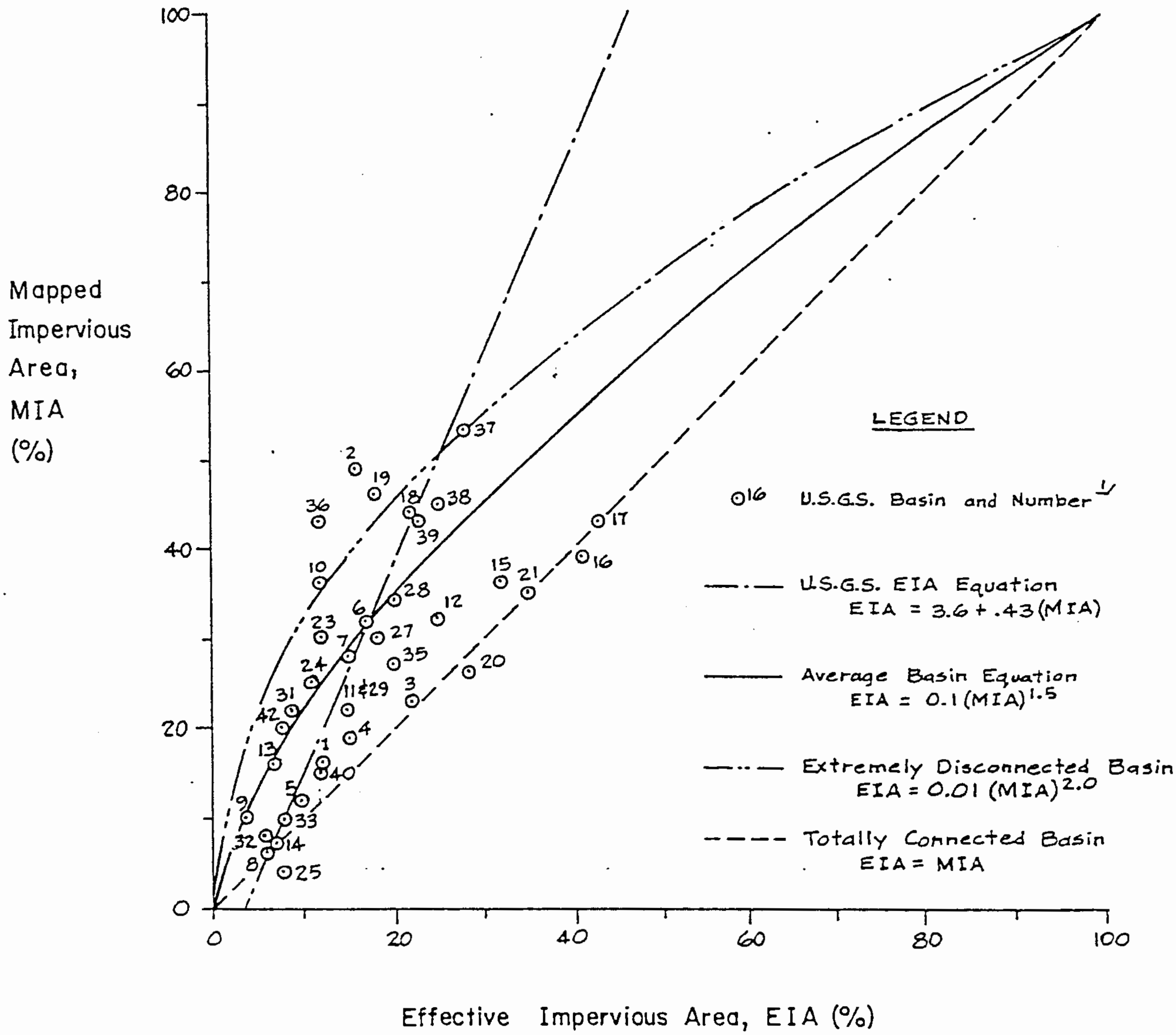
4. **Somewhat disconnected basins** where at least 50 percent of the urban areas within the basin are not storm sewered, but are served by roadside ditches, and the residential rooftops are not directly connected. Alternatively, Condition 1 may apply, but the basin is known to have a few dry wells or other retention areas.

$$\mathbf{EIA = 0.04\,(MIA)^{1.7}\,,\ MIA \geq 1} \qquad (6)$$

5. **Extremely disconnected** basins where only a small percentage of the urban area within the basin is storm sewered, or a significant portion of the basin area drains to dry wells or other retention areas.

$$\mathbf{EIA = 0.01\ (MIA)^{2.0}\ ,\ MIA \geq 1} \qquad (7)$$

Figure 1 illustrates the U.S.G.S. data used in the development of the OTAK EIA Equations along with lines described by the U.S.G.S. Equation (1) and OTAK Equations (3), (5), and (7). The variation in the data presented in Figure 1 demonstrates the difficulty in accurately estimating the EIA of a drainage basin. It is imperative that the drainage planner or engineer performs some degree of on-site investigation of the basin to determine which EIA equation may apply to the given circumstance. The greatest strength of the **OTAK EIA Equations** presented above is their consistency in providing reasonable estimates of EIA for all values of MIA. Therefore, they can be used in the drainage planning process to estimate the change in EIA which will occur as a basin becomes urbanized.




1/ EIA valves were based on a U.S.G.S. rainfall to runoff model study. Only points with MIA ≥ 4 were plotted (Laenen, 1980 and 1983).

Figure 1 - Relationships Between MIA and EIA Developed by the U.S.G.S. and OTAK

otak incorporated
INC. ARCHITECTS, P.C.
17355 SW Boones Ferry Rd., Lake Oswego, OR 97035, (503) 635-3618
101 E 8th Street Vancouver, WA 98660, (206) 695-0357
11058 Main Street #215, Bellevue, WA 98004 (206) 455-5340

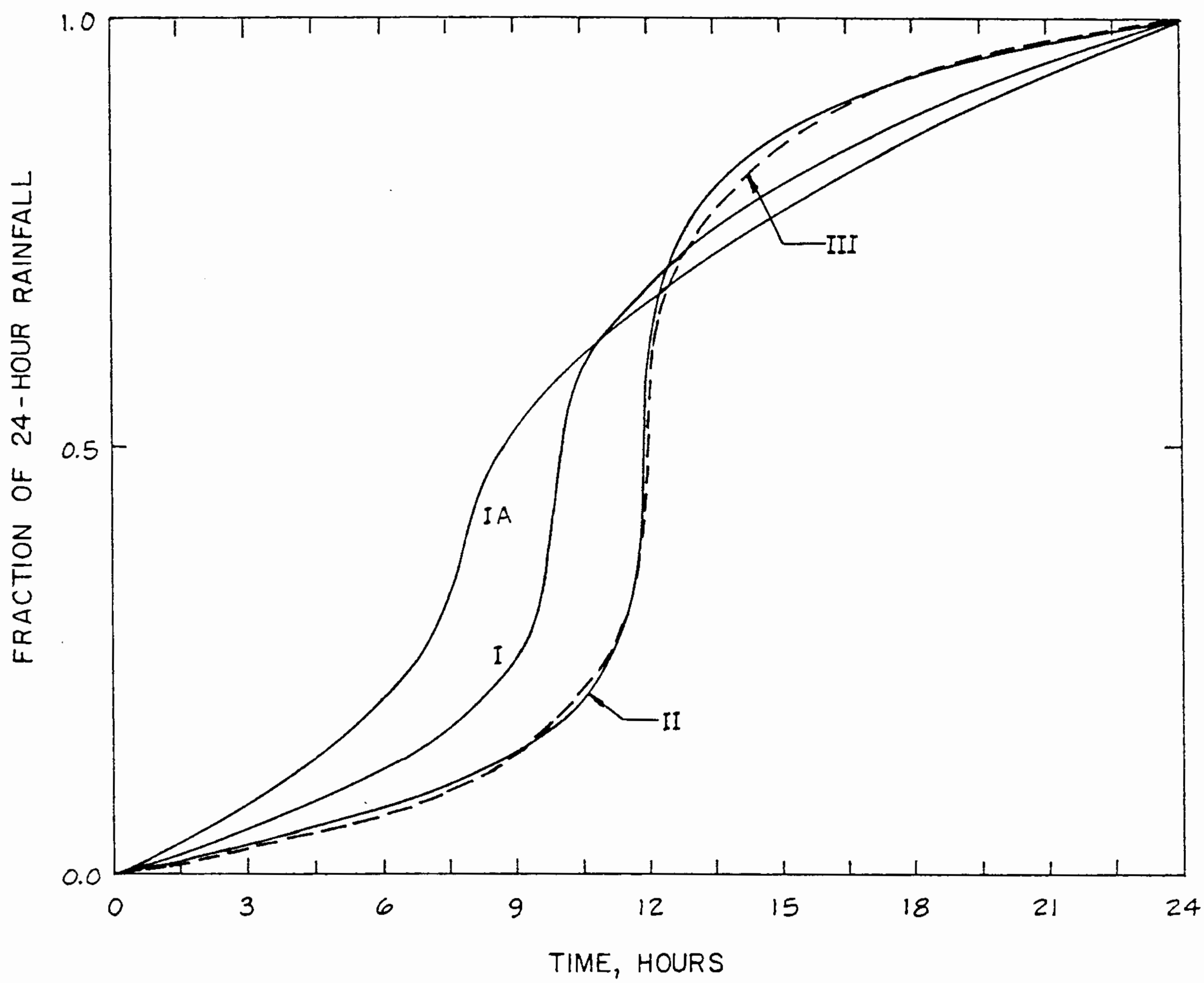



Figure B-1 - SCS 24-Hour Rainfall Distributions

otak incorporated
INC. ARCHITECTS, P.C.
17355 S.W. Boones Ferry Rd Lake Oswego OR 97035 (503) 635-3618
101 E 8th Street Vancouver WA 98660 (206) 695-0357
11058 Main Street #215 Bellevue WA 98004 (206) 455-5340

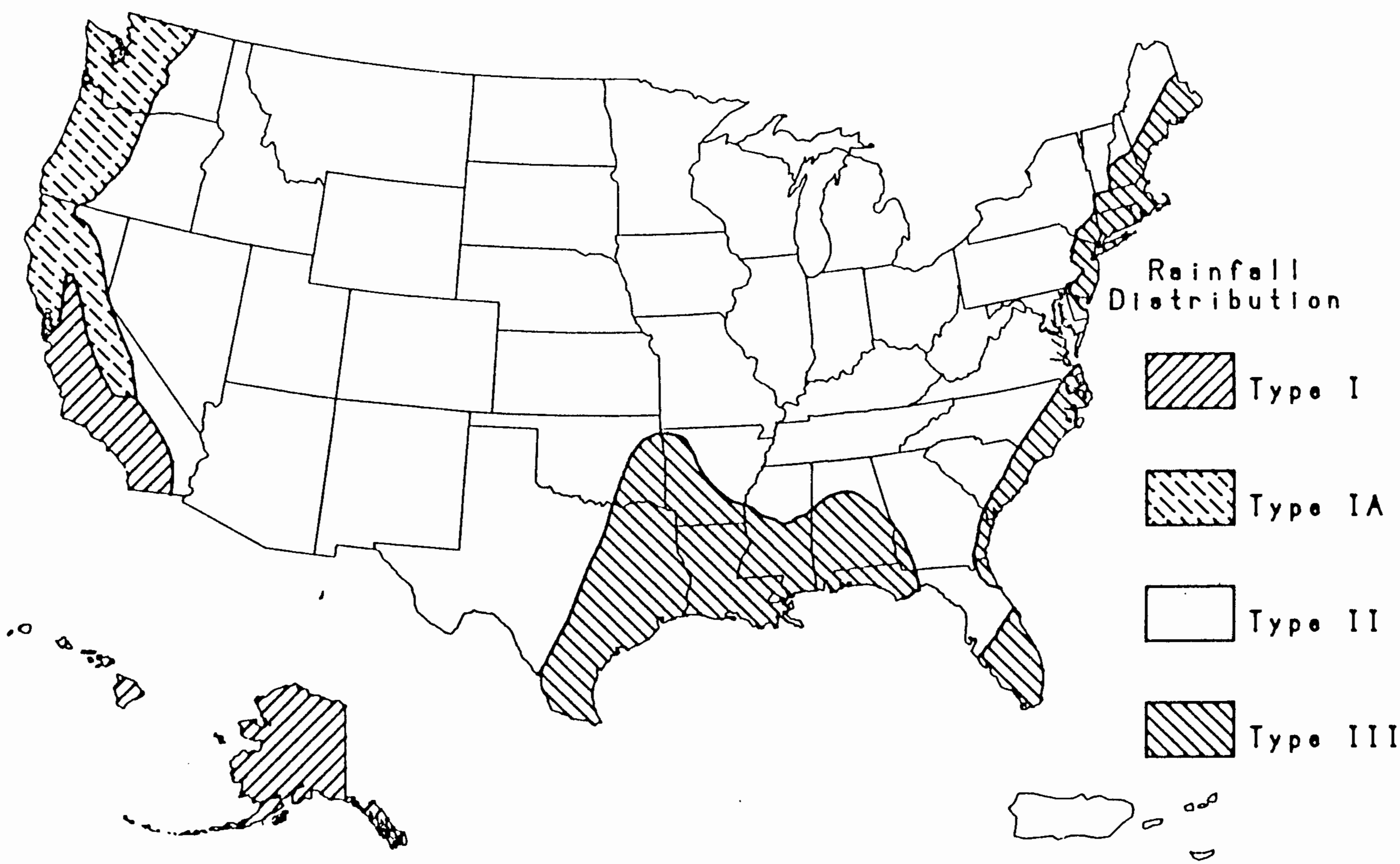



Figure B-2.—Approximate geographic boundaries for SCS rainfall distributions.

# RAINFALL TABLE 1

## STANDARD SCS 24-HOUR, TYPE I DISTRIBUTION
CUMULATIVE RAINFALL TABLE
(REVISED MAY 1982)

| TABLE NO. | | TIME INCREMENT | | | |
|---|---|---|---|---|---|
| 5 RAINFL 1 | | 0.5000 | | | |
| 8 | 0.0 | 0.0080 | 0.0170 | 0.0260 | 0.0350 |
| 8 | 0.0450 | 0.0550 | 0.0650 | 0.0760 | 0.0870 |
| 8 | 0.0990 | 0.1120 | 0.1260 | 0.1400 | 0.1560 |
| 8 | 0.1740 | 0.1940 | 0.2190 | 0.2540 | 0.3030 |
| 8 | 0.5150 | 0.5830 | 0.6240 | 0.6550 | 0.6820 |
| 8 | 0.7060 | 0.7280 | 0.7480 | 0.7660 | 0.7830 |
| 8 | 0.7990 | 0.8150 | 0.8300 | 0.8440 | 0.8570 |
| 8 | 0.8700 | 0.8820 | 0.8930 | 0.9050 | 0.9160 |
| 8 | 0.9260 | 0.9360 | 0.9460 | 0.9560 | 0.9650 |
| 8 | 0.9740 | 0.9830 | 0.9920 | 1.0000 | 1.0000 |
| 9 ENDTBL | | | | | |

Note: On Executive Control use Rainfall Depth in inches and Rainfall Duration of 1.0. The format for this table is Form #271, Page F-7.

# RAINFALL TABLE 2

## STANDARD SCS 24-HOUR, TYPE II DISTRIBUTION
## CUMULATIVE RAINFALL TABLE
## (REVISED MAY 1982)

| | TABLE NO. | | TIME INCREMENT | | | |
|---|---|---|---|---|---|---|
| 5 | RAINFL 2 | | 0.2500 | | | |
| 8 | | 0.0 | 0.0020 | 0.0050 | 0.0080 | 0.0110 |
| 8 | | 0.0140 | 0.0170 | 0.0200 | 0.0230 | 0.0260 |
| 8 | | 0.0290 | 0.0320 | 0.0350 | 0.0380 | 0.0410 |
| 8 | | 0.0440 | 0.0480 | 0.0520 | 0.0560 | 0.0600 |
| 8 | | 0.0640 | 0.0680 | 0.0720 | 0.0760 | 0.0800 |
| 8 | | 0.0850 | 0.0900 | 0.0950 | 0.1000 | 0.1050 |
| 8 | | 0.1100 | 0.1150 | 0.1200 | 0.1260 | 0.1330 |
| 8 | | 0.1400 | 0.1470 | 0.1550 | 0.1630 | 0.1720 |
| 8 | | 0.1810 | 0.1910 | 0.2030 | 0.2180 | 0.2360 |
| 8 | | 0.2570 | 0.2830 | 0.3870 | 0.6630 | 0.7070 |
| 8 | | 0.7350 | 0.7580 | 0.7760 | 0.7910 | 0.8040 |
| 8 | | 0.8150 | 0.8250 | 0.8340 | 0.8420 | 0.8490 |
| 8 | | 0.8560 | 0.8630 | 0.8690 | 0.8750 | 0.8810 |
| 8 | | 0.8870 | 0.8930 | 0.8980 | 0.9030 | 0.9080 |
| 8 | | 0.9130 | 0.9180 | 0.9220 | 0.9260 | 0.9300 |
| 8 | | 0.9340 | 0.9380 | 0.9420 | 0.9460 | 0.9500 |
| 8 | | 0.9530 | 0.9560 | 0.9590 | 0.9620 | 0.9650 |
| 8 | | 0.9680 | 0.9710 | 0.9740 | 0.9770 | 0.9800 |
| 8 | | 0.9830 | 0.9860 | 0.9890 | 0.9920 | 0.9950 |
| 8 | | 0.9980 | 1.0000 | 1.0000 | 1.0000 | 1.0000 |
| 9 | ENDTBL | | | | | |

Note: On Executive Control use Rainfall Depth in inches and Rainfall Duration of 1.0. The format for this table is Form #271, Page F-7.

# RAINFALL TABLE 3

## STANDARD SCS 24-HOUR, TYPE IA DISTRIBUTION
CUMULATIVE RAINFALL TABLE
(REVISED MAY 1982)

| | TABLE NO. | TIME INCREMENT | | | | |
|---|---|---|---|---|---|---|
| 5 | RAINFL 3 | | 0.5000 | | | |
| 8 | | 0.0 | 0.0100 | 0.0220 | 0.0360 | 0.0510 |
| 8 | | 0.0670 | 0.0830 | 0.0990 | 0.1160 | 0.1350 |
| 8 | | 0.1560 | 0.1790 | 0.2040 | 0.2330 | 0.2680 |
| 8 | | 0.3100 | 0.4250 | 0.4800 | 0.5200 | 0.5500 |
| 8 | | 0.5770 | 0.6010 | 0.6230 | 0.6440 | 0.6640 |
| 8 | | 0.6830 | 0.7010 | 0.7190 | 0.7360 | 0.7530 |
| 8 | | 0.7690 | 0.7850 | 0.8000 | 0.8150 | 0.8300 |
| 8 | | 0.8440 | 0.8580 | 0.8710 | 0.8840 | 0.8960 |
| 8 | | 0.9080 | 0.9200 | 0.9320 | 0.9440 | 0.9560 |
| 8 | | 0.9670 | 0.9780 | 0.9890 | 1.0000 | 1.0000 |
| 9 | ENDTBL | | | | | |

Note: On Executive Control use Rainfall Depth in inches and Rainfall Duration of 1.0. The format for this table is Form #271, Page F-7.

# APPENDIX C

UNIT COSTS FOR
CIRCULAR CONCRETE PIPE

| SIZE (INCHES) | INSTALLED COST $ / LF |
|---|---|
| 12 | $35 |
| 15 | $48 |
| 18 | $62 |
| 24 | $88 |
| 30 | $115 |
| 36 | $142 |
| 42 | $168 |
| 48 | $195 |
| 54 | $222 |
| 60 | $248 |
| 66 | $275 |
| 72 | $301 |

CONCRETE BOX CULVERT

SIZE (Height in feet X Width in feet)

| | |
|---|---|
| 7 X 5 | $570 |
| 8 X 5 | $628 |

# TASK 3 DEVELOP DRAINAGE CRITERIA AND STANDARDS

## INTRODUCTION

This memorandum summarizes the work to complete Task 3 of the project plan. The primary objective of this work is to develop and document drainage planning and design criteria necessary for completing the Surface Water Management (SWM) Master Plan.

Because the SWM Master Plan is to be consistent with the Nonpoint Source (NPS) Watershed Plan (KCM, 1990), two secondary objectives were identified:

1. Provide guidance to the City to prepare a drainage criteria and standards manual. This manual, when complete, will establish a comprehensive document that identifies drainage plan review procedures, methods for analysis, design standards and other requirements.

2. Review specific sections of the Development Code related to drainage and where possible provide drainage criteria or reference to the drainage manual for implementing these standards.

This memorandum is divided into two major sections.

Section 1 - Drainage Planning and Design Criteria, presents information for accomplishing the primary objective. This information is presented in an outline format that can be adapted as a table of contents for a design manual. This is followed with specific design criteria and other information related to select topics in the outline that fulfill the primary objective. (Note at this time not all of the outline sections contain information. It is expected that as work is done to the manual, these will be completed.)

Section 2 - Review of Development Code, summarizes the review and evaluation of two sections from the Development Code related to drainage management. The two sections were: 11.005 - "Drainage Standard for Major Developments" and 12.005 - "Drainage Standard for Minor Developments". These sections were selected because they contain the standards frequently referred to by City staff when reviewing development plans for compliance with drainage management issues. This information is presented in a format that relates the Development Code to specific design criteria to assist the City with review and evaluation of proposed plans and assure compliance with drainage policy.

## SECTION 1 - DRAINAGE PLANNING AND DESIGN CRITERIA (MANUAL FORMAT)

The following outline can be adopted for use as a table of contents for a Design Criteria and Standards Manual. The starred sections identify those sections that contain specific criteria necessary for completing the SWM Master Plan.

# TASK 3 DEVELOP DRAINAGE CRITERIA AND STANDARDS

# TASK 3 DEVELOP DRAINAGE CRITERIA AND STANDARDS

## 1.0 Introduction

### 1.1 Purpose

The Drainage Design Criteria and Standards Manual (after this referred to as Manual) provides consistent requirements and standards for designing, constructing and maintaining surface water management facilities in the City of Lake Oswego and the surrounding Urban Service Area.

### 1.2 Goals

This Manual has been developed to guide the design and construction of facilities to meet the goals and objectives of the community as they relate to surface water management.

### 1.3 Standard Construction Specifications and Drawings

Except where the Manual states otherwise, design detail, workmanship and materials shall be in accordance with the City's currently adopted edition of Standard Construction Specifications and Drawings.

## 2.0 Applicability

This Manual shall govern the design of all new and existing surface water management facilities in the City of Lake Oswego including both incorporated and unincorporated areas.

## 3.0 Drainage Plan Requirements

Storm drainage for any development must include provisions to adequately control runoff and water quality from all public and private streets, buildings including the roof, footing and area drains and to insure future extension of the drainage system to serve upstream areas in conformance with the adopted Drainage Master Plan. The following requirements shall apply to every project that requires drainage plan review.

1. The drainage plan shall be prepared by a registered engineer and shown to meet City Standards and Specifications.

2. Discharge from developed property must occur at its natural location and cause no adverse impacts to downstream properties.

3. Every drainage plan must include analysis of off-site impact. Evaluation must identify areas both upstream and downstream from the project. The plan shall demonstrate that a project is designed to mitigate any negative affects resulting from the project.

4. The plan shall provide runoff quantity controls by limiting peak runoff rates to their predevelopment levels.

5. All conveyance system elements shall be sized for the peak runoff rate for the design storm event assuming full development. Conveyance elements shall be designed to pass all off-site runoff received from upstream property assuming full development.

6. All drainage plans shall include erosion control plans (see Erosion Control Technical Guidance Handbook) to prevent sediment from leaving the site during and after development.

7. Submittal of drainage plans shall include all design calculations, assumptions, and references cited.

## 4.0 Hydrology

### 4.1 General

This section presents the acceptable methods for estimating the quantity and flow characteristics of surface runoff for the analysis of existing facilities and the design of proposed improvements.

### 4.2 Precipitation

Precipitation Intensity - Duration - Frequency curves developed for the Fanno Creek basin shall be used for hydrologic modeling and hand calculation methods (e.g. Regression Equations and Rational Method).

### 4.3 Soils

Hydologic Soil Groupings can be found in the SCS, Soils Survey of Clackamas County (1975).

### 4.4 Computation Methods

- Major and Minor Drainage Systems

Major drainage system improvements shall be implemented according to the recommendations presented in the adopted Drainage Master Plan. For design of additional drainage facilities required along the major drainage system the peak discharge for the appropriate design recurrence interval tabulated in the master plan shall be used.

For design of facilities required along the minor drainage system the peak discharge for the appropriate design recurrence interval shall be designed using the following regression equations (developed in Appendix E):

$$Q\text{-}10 = 31.8\ DA^{0.91}\ EIA^{0.39}\ CSL^{0.12}$$
$$Q\text{-}25 = 43.0\ DA^{0.91}\ EIA^{0.38}\ CSL^{0.11}$$
$$Q\text{-}50 = 59.3\ DA^{0.91}\ EIA^{0.35}\ CSL^{0.10}$$
$$Q\text{-}100 = 68.5\ DA^{0.91}\ EIA^{0.34}\ CSL^{0.09}$$

Where:

DA - Total upstream drainage area, square miles
EIA - Effective Impervious Area From OTAK EIA Equations (Appendix A)
CSL - Slope of the main channel in feet per mile from points 10% to 85% upstream of the point of interest along the main channel

Exception: The Rational Method can be used to size a new conveyance facility. For tributary drainage basin areas on the minor system less than 25 acres.

- Detention/Retention Facilities

All detention facilities will be analyzed using the HEC-1 Hydrologic Model (version 4.0, 1990) or other computer models approved by the City.

Exception: For new on-site stormwater detention facilities for tributary drainage basins less than 10 acres the required detention volume will be computed based on a triangular hydrograph method.

This method is base on the following equation:

$$V = ((T_d/2)*(1-[Q_e/Q_u])*(Q_u-Q_r))+((T_r/2)*(Q_e-Q_r))$$

Where:

$V =$ Design Detention volume in cfs - hrs (multiply by 3600 to obtain volume in cubic feet).

$Q_e =$ Existing peak discharge (cfs) from the site. (EIA $\geq$ 4)

$Q_u =$ Ultimate future peak discharge (cfs) from the site.

And:

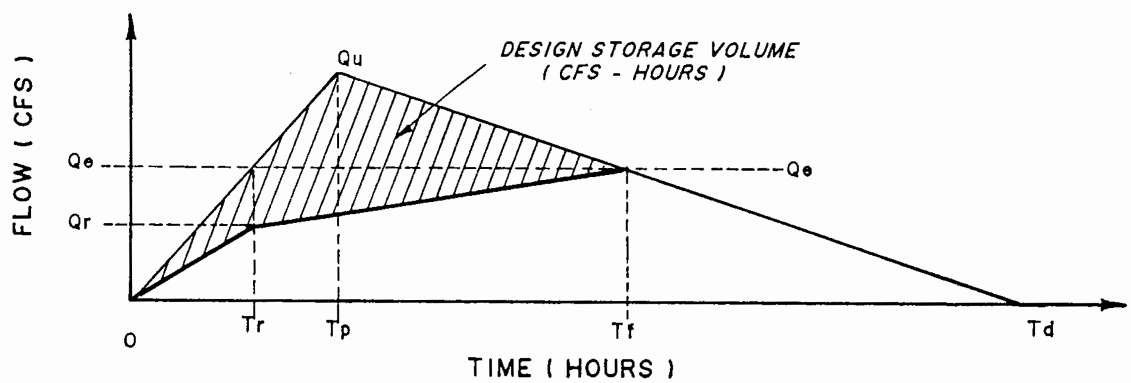
$$T_p = .05 + TLAG$$

$$T_d = 2.67\ T_p$$

$$T_r = Q_e\ T_p\ /\ Q_u$$

$$T_f = T_d - (1.67\ Q_e\ T_p\ /\ Q_u)$$

$$Q_r = Q_e\ T_r\ /\ T_f$$




TRIANGULAR HYDROGRAPH

- Detention/Retention Facility Performance

  The release rate for a stormwater detention facility shall be designed to limit the developed peak runoff rate to predevelopment conditions based upon a 10 year storm.

  Exception: Larger outlet release rates for a detention facility may be allowed if it can be demonstrated that the rate does not exceed the conveyance capacity of any downstream system element and if approved by the City Engineer.

## 5.0 Hydraulic Analysis and Design

### 5.1 General

This section presents approved methods and design criteria for hydraulic analysis and design of surface water conveyance systems and detention/retention facilities.

### 5.2 Design Storm

Table 1 presents the recommended storm recurrence intervals for the planning and design of drainage management facilities.

- Conveyance Facilities

All conveyance elements shall be designed to pass peak design storm flows using the criteria presented in Table 1.

- Detention/Retention Facilities

The required storage volume is calculated to limit the developed peak runoff rate to the predevelopment level. The volume is established as the maximum difference between the runoff produced from a 50-year-24 hour storm for developed conditions and runoff produced from a 10-year-24 hour storm for predevelopment conditions.

### 5.3 Location

a. Route design for new conveyance facilities must consider the natural topography of a site, legal property boundaries and public rights-of-ways.

b. New conveyance facilities within a public right-of-way shall be located within 4 feet of the curb line on the low side of the street, if feasible.

c. New conveyance facilities on private property shall be adjacent and parallel to property lines, as is feasible, to provide the least restriction to development.

d. All public maintained conveyance systems shall be located in drainage easements. Easements shall be located on one lot rather than centered over a lot line.

TABLE 1

STORM RECURRENCE INTERVALS FOR PLANNING
AND DESIGN OF STORM CONVEYANCE SYSTEM

| Drainage Area (acres) | | | ----- *Type of Drainage Improvement* ----- | | | | Design Storm Recurrence Interval In Years (e) |
|---|---|---|---|---|---|---|---|
| | | | | | (3) Culverts and Bridges | | |
| <40 | 40 to 640 | >640 | (1) Open Channel (a) | (2) Pipe (b) | Collectors (c) | Major Arterials (d) | |
| X | | | | X | X | | 10 |
| X | | | X | | | X | 25 |
| | X | | | X | | | 25 |
| | X | | X | | X | X | 50 |
| | | X | X | N/A | X | X | 50 |
| All improvements on waterways with FEMA 100-year floodplain | | | | | | | 100 |

a) Includes roadside ditches, drainage swales and streams.

b) Storm drains or a closed conduit whose length exceeds that of a normal culverted crossing of a single roadway.

c) Includes local or residential streets, local collectors, and any other roadways up to a major arterial.

d) Major arterial or better within the City's right-of-way maintenance.

e) Assuming ultimately planned development conditions (i.e. impervious cover).

f) Use the next lower recurrence interval if unusual site conditions would result in an exceptionally high cost differential without realizing a significant reduction of flood damage risks.

g) All detention facilities shall be designed to detain the maximum runoff volume difference between the 50-year post-development condition and the 10-year pre-development condition. Spillways shall be designed to safely pass a 100-year recurrence interval storm.

5.4 Storm Conveyance Facilities

a. Materials

Pipe materials shall conform to the Standard Construction Specifications and Drawings.

Table 2 presents the acceptable types of pipe material and their corresponding standards.

TABLE 2

PIPE MATERIAL AND STANDARDS

| Material | Standards |
|---|---|
| Non Reinforced Concrete Pipe | ASTM C-14, Class 3 (Maximum size = 18") |
| Reinforced Concrete Pipe | ASTM C-76, Class III |
| Plastic Pipe | |
| Polyvinyl Chloride | ASTM D 2412 Series 14, DR 51 |
| High Density Polyethylene | AASHTO M-294 |
| Metal Pipe | |
| Aluminum Coated Steel | AASHTO M 36-86 |
| Aluminum Alloy | 3004-H34 Core with 7072 Cladding |

Allowable joints: Concrete pipe shall be rubber gasketed.

Approval of alternate materials will be reviewed on a case-by-case basis.

b. Size, Slope and Velocities

Table 3 presents the pipe size, minimum slope and velocities between hydraulic structures.

TABLE 3

MINIMUM HYDRAULIC CRITERIA FOR STRUCTURES

| | Pipe Diameter (inches) | Minimum Slope (percent) | Minimum Velocity (fps) |
|---|---|---|---|
| Inlet to CB/MH | 10 | .58 | 3.0 |
| Mainline CB/MH to CB/MH | 12 or greater | .44 | 3.0 |

c. Method of Analysis

Mannings Equation can be applied to analyze most conveyance elements encountered in urban drainage systems. The equation can be applied to pipes with free or partially free outfall.

The equation, when combined with the continuity equation has the following form:

$$Q = \frac{1.49}{n} AR^{2/3} S^{1/2}$$

Where:

- $Q$ = discharge rate, cfs
- $A$ = flow area, $ft^2$
- $n$ = Mannings roughness coefficient
- $R$ = hydraulic radius, ft
- $S$ = slope, ft/ft

Roughness coefficient's (Manning's "n" values) for design of closed conduits are presented in Table 4.

TABLE 4

| SUGGESTED VALUES OF MANNING'S ROUGHNESS COEFFICIENT | |
|---|---|
| DESCRIPTION | "N" |
| Concrete, steel trowled or smooth-form finish | .014 |
| Concrete pipe, precast or cast-in-place | .013 |
| Concrete, wood flat, or broomed finish | .016 |
| Asphaltic concrete | .016 |
| Corrugated metal pipe (aluminum) | .024 |
| Polyvinylchloride pipe or polyethylene pipe | .011 |

Storm conveyance pipes shall be designed to operate flowing full or partially full.

Other methods are available to complete pipe system analysis when design considerations warrant their use.

Other values of Manning Roughness values listed in Appendix 3.1, Manning Roughness Coefficients(n) ODOT, Hydraulics Manual shall be used.

d. Alignment

Storm drains shall be laid on a straight alignment and grade, whenever possible.

Exception: Storm drains may be laid to conform to vertical and horizontal curves when justified by field conditions and as approved by the City Engineer. The following criteria shall be followed for curved alignments:

1. Pipe deflections shall be in accordance with the manufacturer's recommendations.

2. Prefabricated bends shall not exceed 11¼ degrees. Grade breaks or change in pipe material shall occur only at catchbasins or manholes.

3. The total deflection (horizontal and vertical) shall not exceed 22½ degrees between manholes.

e. Connection

Connection to a pipe system shall be made only at catchbasins or manholes.

f. Cover

All storm drains shall be laid at a depth sufficient to protect against damage by traffic and to drain building footings where practical. Sufficient depth shall mean the minimum cover from the top of the pipe or pipe bell to the finished grade elevation.

The minimum cover shall be 30 inches. Exceptions to this shall be designed to meet specific site conditions with the approval of the City Engineer.

g. Structures

All manholes, catchbasins and inlets shall conform to the City Standard Drawings.

- Manholes

Manholes shall be located as follows unless otherwise approved by the City Engineer:

1. at pipe intersections (existing and future)
2. changes in pipe grade or slope
3. changes in pipe alignment,
4. changes in pipe size, and
5. at end of main lines.

Manholes shall be placed at maximum intervals of 500 feet.

- Catchbasins

Catchbasins should be located as follows:

1. just upstream of curb returns, where possible,
2. to avoid curb ramps, wheels chair ramps, potential driveways, etc.,
3. at sags or low points,
4. at intersections, and
5. at points where superelevation directs the gutter flow across the pavement.

Catchbasins shall be spaced such that the gutter flow width between catchbasins does not exceed the following limits:

1. Four feet where there is a 10-foot parking lane or shoulder.
2. Two feet where the travel lane is adjacent to the curb.

Spacing between catchbasins shall be as follows:

1. maximum 300 feet on slopes less than 8 percent.
2. maximum 200 feet on slopes equal to or greater than 8 percent.

Side inlets shall be provided on all curb line catchbasins.

Oversized catchbasins shall be used under the following conditions:

1. When the catchbasin is over 3 feet deep.
2. When the lateral is over 40 feet long.
3. When used as a flow-through catchbasin.
4. When located in a sag or low point of a street.

5.5 Culverts

Culverts typically consist of relatively short segments of pipe placed under road embankments to safely pass water through the embankment.

Method of Analysis

The design methodology set forth in Chapter 4, Hydraulic Design of Culverts, Oregon Department of Transportation, Highway Division, Hydraulics Manual shall be followed in designing and analyzing culverts for all drainage plans submitted to the City for review.

5.6 Open Channels

Surface water drainage routes will be classified according to two general categories: artificial (manmade) watercourses and natural creeks.

Artificial (Manmade) Watercourse

a. Manmade channels shall be designed with a variable side slope not greater than two horizontal to one vertical (2:1). The channel shall include a low flow channel as described in "c" below and will be reviewed on a case-by-case basis for approval.

b. Channel design along curves shall be curvilinear with a 100 foot minimum radius. Tighter curves may be used if the City Engineer determines that sufficient erosion control has been incorporated into the design to maintain stable bank conditions following development.

c. A low flow channel shall be designed to carry 10 percent of the design storm. Low flow channel slopes shall not exceed 2:1 and shall be stabilized to the satisfaction of the City Engineer. In general, bank stabilization will be required in any channel with a design flow velocity in excess of 5 feet per second (fps).

d. Capacity of channels shall be determined by the Manning Formula. Mannings roughness valves listed in Appendix 3.1, Mannings Roughness Coefficients (n), ODOT Hydraulics Manual shall be used.

e. All ditches shall be designed with a minimum freeboard of 0.5 feet when the design discharge is 10 cfs or less and 1 foot when the design discharge is greater than 10 cfs but less than 100 cfs.

f. Existing ditches approved for the point of disposal for storm drains and culverts shall be provided with rock-lined bottoms and side slopes at the discharge point of storm drain or culvert. The rock shall extend for a minimum distance of eight feet downstream from the end of the storm drain or culvert, or to where flow velocities are less than 10 fps whichever is greater.

g. All channel sides and bottoms shall be seeded, sodded, or armored (rip rap, gabinons, etc.) immediately following construction. Bank stabilization measures shall be consistent with Section 6, Erosion and Sediment Control, unless the City Engineer determines other proposed methods provide equal or greater erosion control.

h. Points of discharge from culverts and storm drains into ditches and swales having grades 15 percent or greater shall be rock-lined with boulders with one face a minimum of 24 inches in dimension. Said rock lining shall extend for a distance of 10 feet minimum from the point of culvert or storm drain discharge and shall have a width 3 feet in excess of the diameter of the culvert or storm sewer. Special energy dissipators may be substituted for boulders at the discretion of the City Engineer.

Natural Watercourses (Creeks)

a. Natural watercourses shall be preserved and all work in and adjacent to creeks shall incorporate both temporary and permanent erosion control measures in accordance with the Erosion Control Technical Guidance Handbook. No alterations will be permitted that reduces the overall creek capacity.

b. Creek channel design and construction practices shall be such that the cumulative incremental effects of creek work considered alone or together with existing or similar projects in the vicinity will not result in substantial damage to existing waterways and surface waters by erosion, siltation or sedimentation, significant changes in water quality, increased downstream water velocity, significant harmful deterioration of groundwater drainage, or significant deterioration of aquatic wildlife habitat as determined by the City Engineer.

c. Creek construction, relocation and/or reconstruction may be approved if the City Engineer determines that such a proposal will result in an overall benefit to or maintenance of a surface water system of equal quality in terms of water quantity and quality control.

d. Any and all stream work shall be consistent with the floodplain management policies and regulations set forth in local City ordinances.

e. Any and all stream work shall be consistent with the SWM Master Plan.

5.7 Floodway/Floodplain

Development to meet requirements of Development Standard Section 17 Floodplain.

5.8 Detention/Retention Facilities

General Requirements

a. All stormwater runoff originating from and/or draining to any proposed development shall be controlled and/or conveyed in accordance with all standards and policies described in these Standards. When existing conditions make stormwater detention impossible for a portion of a site, the City Engineer may permit compensatory storage volume to be provided on another portion of the site, provided the total site area is tributary to one drainage basin both prior to and after development. In no case shall the runoff from the total site exceed the allowable release rate.

b. Detention facilities shall be open as basins or ponds, parking lot ponding, or underground storage (pipe/chamber), or combinations of any of the above.

c. The design storage volume for each detention facility will be based on the methodology presented in Section 4.

d. Drainage plans shall include a plan and profile of the facilities. The submittal shall include the following minimum hydraulic and physical data:

   1. grades, bottom elevations of ditches, channels, ponds and swales, parking lots, and recharge trenches;
   2. inverts of pipes;
   3. inverts and tops of all structures such as manholes, catch basins, chambers or similar structures; and
   4. size, length and slope of all pipes or other detention or conveyance facilities, including the invert elevations of the existing or any other storm drainage system which the subject drainage proposes to discharge.

Hydrologic and hydraulic calculations shall be submitted along with the detention facility drainage plans.

e. All aspects of public health, safety, maintenance, nuisance abatement, and vector control must be carefully reviewed in every drainage control system plan. Protective measures are often necessary and shall be required whenever appropriate.

f. Facility design must incorporate maintenance considerations to minimize any anticipated problems.

g. Discharges from the detention facility shall be to a storm drain, drainage channel, or other approved drainage course. Downstream impacts shall be analyzed and submitted to the City Engineer along with the facility plans.

Additional Requirements for Open Detention Basins

a. Slopes on all interiors shall not exceed 4:1. If, because of site constraints, it is necessary for an interior to exceed 3:1, it shall be either a retaining wall designed by a licensed structural engineer or a design submitted by a licensed engineer experienced in soils mechanics. Slopes on pond exteriors shall not exceed 2:1.

b. The bottom of all ponds less than 3 feet deep shall have 6 feet as a minimum dimension. The bottom of all ponds 3 feet or more deep shall have 15 feet as a minimum dimension.

c. Ponds suited to multiple use are encouraged. Examples of multiple uses are sport courts, play areas, neighborhood parks, and picnic areas. Such ponds may be designed with engineered walls with slopes exceeding 3:1 as approved by the City Engineer on a case-by-case basis.

d. All ponds shall be landscaped so as to provide slope stability and pleasant appearance by utilizing sodding, seeding, and planting of trees and shrubbery. Under no circumstances shall use of easily floatable or erodible materials (such as "bark dust") be permitted in pond interiors.

e. Maintenance of surface ponds shall be the responsibility of the City.

f. All City maintained detention pond control structures not abutting a public right-of-way shall be accessible to City staffs for maintenance and operation. Control structures shall be designed to operate automatically.

g. Vehicular access must be provided to the bottom of the retention/detention pond when the bottom width of the pond is 20 feet or greater and/or when the height of the pond interior wall exceeds 5 feet. This will generally be multiuse ponds that require access for mowing.

h. The access grade into the proposed detention/retention pond shall be no steeper than 5:1.

i. All detention ponds shall have a minimum of 1 foot of freeboard above the maximum design water surface.

j. Any embankment for a detention pond must be designed by a qualified soils engineer, experienced in soils mechanics, who shall inspect and certify the construction of any such berm and state that the berm has low permeability and that the pond is safe for the intended use. Notes to the effect of the above shall be shown on the plans submitted for approval.

k. Any embankment less than 3 feet in height, including 1 foot of freeboard, forming one or more sides of a detention/retention pond shall have a minimum 6 foot wide top of berm with a back slope not to exceed 2:1 unless otherwise approved by the City Engineer, and designed by and construction being certified by a licensed engineer experienced in soils mechanics.

l. All constructed and graded detention ponds shall be sloped no flatter than 0.01 foot/foot (1 percent) towards the outlets for drainage.

m. The design of an open detention basin or pond shall include an emergency spillway to discharge into an approved drainage course. The spillway shall be designed to safely pass the 100-year recurrence interval peak flow based on post development conditions.

n. Outlets of all detention ponds shall be provided with suitable debris barriers designed to protect the outlet from blockage or plugging.

The design volume of the detention pond shall be shown on the plan and the pond volume inspected prior to landscaping (a note to this effect shall be shown on the plans submitted for approval).

Easements

a. All detention ponds are required to be located in separate tracts dedicated to the City with access easements for maintenance where required.

b. Where a detention facility is located within the boundaries of a residential lot and not in a separate dedicated tract, the peak design discharge water surface elevation shall be shown as an easement on the final plat hard copy. Restrictions shall be added to the final plat hard copy and appear on the face of the plat.

c. A written restriction shall be added to the final plat hard copy to the effect that approval shall be obtained from the City Engineer before any structures, fill, or obstructions (including fences) are located within any drainage easement or delineated 100-year floodplain area.

d. A gate for access roads may be required and shall be structurally and aesthetically acceptable for the use and location proposed, or an acceptable alternative to control traffic must be provided.

e. A 10 foot wide (minimum) drainage easement shall be required for all public closed storm drainage detention systems. The City Engineer may require wider easements where pipe diameter or vault widths exceed 4 feet.

f. All publicly maintained stormwater drainage systems including collection, conveyance, and flow restrictors not located in right-of-way shall be located in drainage easements.

g. Permanent access and drainage easements shall be granted to the City for any stormwater detention facility to be maintained by the City maintenance personnel. The minimum access easement width shall be 15 feet wide and shall accommodate vehicular traffic.

## 6.2 Storm Runoff Water Quality

### 6.1 General

a. Provide measures for controlling runoff and prevent the degradation of water quality during all three phases of construction:

1. Prior to excavation or construction.
2. During excavation and construction.
3. After construction until the site is stabilized.

b. Both major and minor developments shall include temporary erosion control measures to be utilized during installation of buildings and other site improvements.

c. Prior to the initial clearing and grading of any land development, provisions shall be made for the interception of all potential silt-laden runoff that could result from said clearing and grading. Said interception shall preclude any silt-laden runoff from discharging from the proposed land approved by the City Engineer. Said interception shall cause all silt-laden runoff to be conveyed by open ditch or other means to whatever temporary facility is necessary to remove silt prior to discharge to downstream properties and drainageways.

6.2 Erosion/Sediment Control Plan

An Erosion/Sediment Control Plan (ESCP) is required unless otherwise approved by the City.

b. During the ESCP design stages, certain potential water problems that should be considered include:

1. Disturbance of ground water tables.
2. Construction on or near potential landslide areas and extent of vegetation removal necessary.
3. Installation of adequate stream crossing structures where stream fordings are necessary.
4. Encroachments on stream flow by landfills, culverts dikes, and buildings.
5. Influences of increased stormwater runoff as imposed by cleared surface areas and of impervious streets, parking lots, and buildings.
6. Changes in drainage areas caused by diversions and gradings.
7. Development of on-site borrow pits.
8. Floodplain excavation work.
9. Stream channel improvement
10. Disposal of petroleum wastes, pesticides, cement washings, and other chemicals.
11. Construction of access and haul roads.
12. Nearness of the construction site to streams, lakes, and other vulnerable areas.

The ESCP for a proposed construction shall be prepared in compliance with the methodology set forth in the Erosion Control Technical Guidance Handbook, January, 1991.

## 7.0 Glossary of Terms

## SECTION 2 - REVIEW OF DEVELOPMENT CODE

| Development Standards | Review Comments and Recommendations |
|---|---|
| 11.005 Title | No change |
| 11.010 Applicability | Define "major developments" |
| 11.015 Definition | Add to definition "major development" |
| 11.020 Standards for Approval | |
| 11.020-1 Easements & Accessibility | Drainage manual will define easement widths and associate requirements for water courses and drainage facilities throughout City. The issue of accessibility is addressed in General Drainage Plan Requirements.<br><br>Manual - Easements Section<br>Manual - Accessibility Section |
| 11.020-2 Stormwater Runoff Quality | Manual - Stormwater Quality Section |
| 11.020-3 Drainage Pattern Alteration | Manual - Drainage Plan Submittal -- Erosion Control and sedimentation detention and erosion control. |
| 11.020-4 Stormwater Detention | Manual - Design and Analysis<br>Detention/Retention Facilities |
| 11.020-5 Stormwater Management Measures | |
| 11.025 Standards for Construction | Delete entire section from Code -- Place specific sections in design manual where applicable. |
| 11.025-1 Landscaping and Topography | Manual - Detention/Retention Facilities<br>General Requirements |

## TASK 3 DEVELOP DRAINAGE CRITERIA AND STANDARDS

| Development Standards | Review Comments and Recommendations |
|---|---|
| 11.025-2 Outlet Structures | Manual - Detention/Retention Facilities<br>Facility Design |
| 11.025-3 Side Slopes | Manual - Detention/Retention Facilities<br>Facility Design |
| 11.025-4 Emergency Overflow or Bypass | Manual - Detention/Retention Facilities<br>Facility Design |
| 11.025-5 Secondary Uses | Manual - Detention/Retention Facilities<br>General Requirements |
| 11.025-6 Release Rate Outlet | Manual - Detention/Retention Facilities<br>General Requirements |
| 11.025-7 Required Detention Volume | Manual - Detention/Retention facilities<br>General requirements |
| 11.025-8 Detention Basins | Manual - Detention/Retention facilities<br>General Requirements |
| 11.025-9 Retention Ponds | Manual - Detention/Retention<br>General Requirements |
| 11.030 <u>Standards for Maintenance</u> | Manual - Drainage Plan Submittal<br>General Requirements |
| 11.035 <u>Procedures</u> | |
| 11.035-1 Submittal Requirements | Manual - Drainage Plan Submittal<br>General Requirements |
| 11.035-2 Submittal Requirements | Manual - Drainage Plan Submittal<br>General Requirements |

## TASK 3 DEVELOP DRAINAGE CRITERIA AND STANDARDS

| Development Standards | Review Comments and Recommendations |
|---|---|
| 11.035-3 Stormwater Detention Feasibility | |
| 11.040 Miscellaneous Information | Delete - Provide guidance in drainage manual regarding individual versus regional facilities |
| 12.005 Title | No change. Drainage manual will contain the requirements and standards necessary to prepare a plan for a minor development, meeting the specific criteria. There should be differences between the requirements for minor and master plan. The existing standards imply a minor development is 1 lot. |
| 12.010 Applicability | Define "minor developments" |
| 12.015 Definite | Manual |
| 12.020 Standards for Approval | Manual |
| 12.025 Standards for Construction | Manual |
| 12.030 Standards for Maintenance | Manual |
| 12.035 Procedures | Manual - Drainage Plan Submittal<br>General Requirements |
| 12.040 Miscellaneous Information | Delete |

## APPENDIX E
### Design Flows for Minor Drainage System

Regression Equations were developed to predict flows for drainages greater than 25 acres for which the Rational Method is not appropriate. HEC-1 flows for 214 subbasins ranging from 23 to 194 acres within the study area were examined to predict design flows for drainages throughout the Lake Oswego area. Log-log linear regressions followed by least-squares regressions of HEC-1 peak flows suggest the following predictions for the four design events:

$$Q(10\text{ year}) = 31.8\ DA^{0.91}\ EIA^{0.39}\ CSL^{0.12}$$
$$Q(25\text{ year}) = 43.0\ DA^{0.91}\ EIA^{0.38}\ CSL^{0.11}$$
$$Q(50\text{ year}) = 59.3\ DA^{0.91}\ EIA^{0.35}\ CSL^{0.10}$$
$$Q(100\text{ year}) = 68.5\ DA^{0.91}\ EIA^{0.34}\ CSL^{0.09}$$

Where:

DA = Total contributing drainage area at the point of interest, in square miles, (1 square mile = 640 acres) obtained from topographic maps.

EIA = Effective Impervious Area, in percent of DA, computed from the appropriate equation presented in Appendix A.

CSL = Slope in feet per mile measured between points 10% and 85% upstream of the point of interest along the main channel. This channel is the longest length of the most well-defined open channel or closed pipe drainageway, including the overland flow pathway, from the point of interest to the basin divide.

Figure E.1 compares the HEC-1 and regression peak flows for each design event, while Figure E.2 compares the 100-year flows by drainage area. Note that for clarity, this figure sorts the flows EVENLY by drainage area, not proportionally.

**FIGURE E.1**

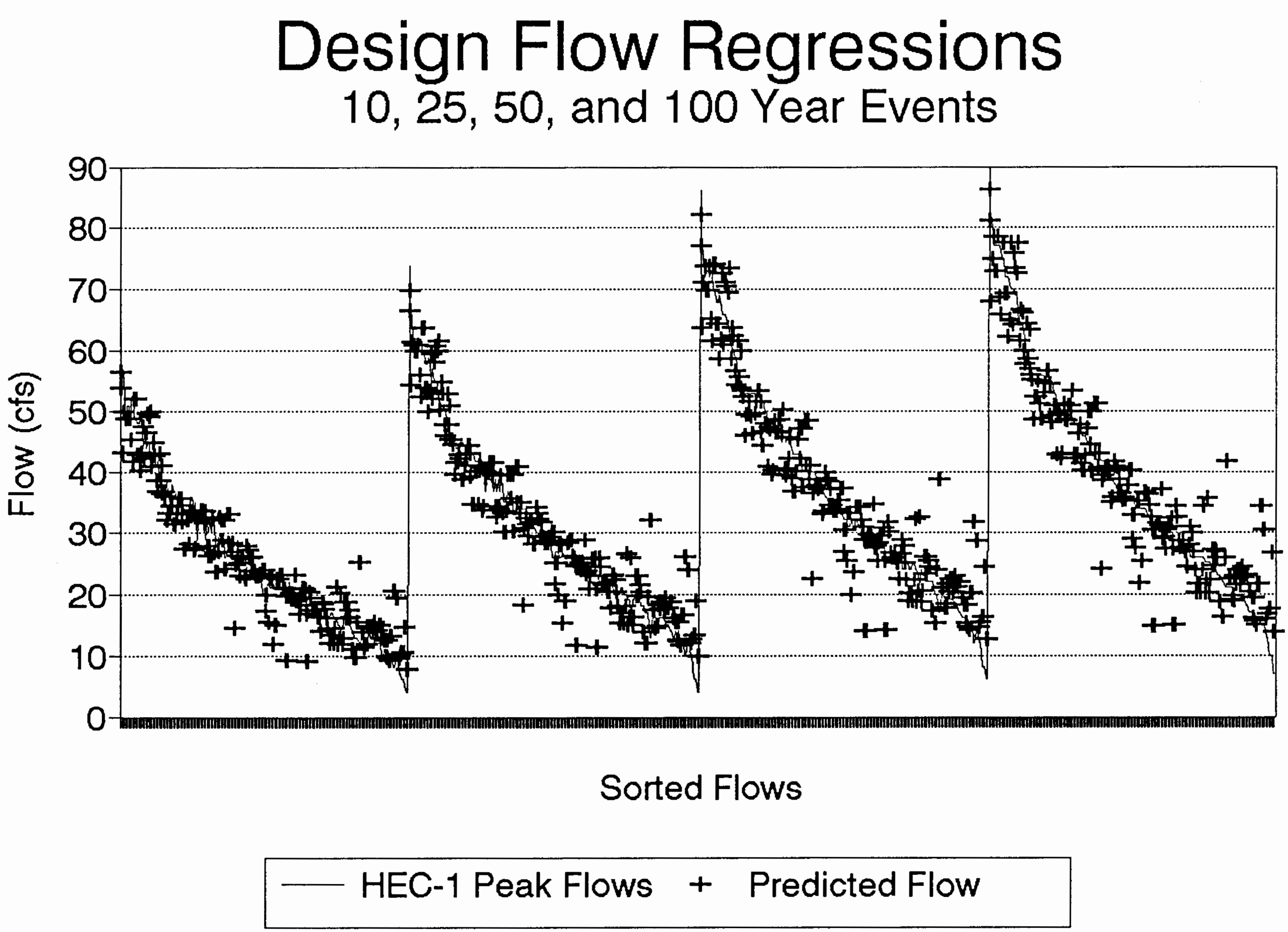
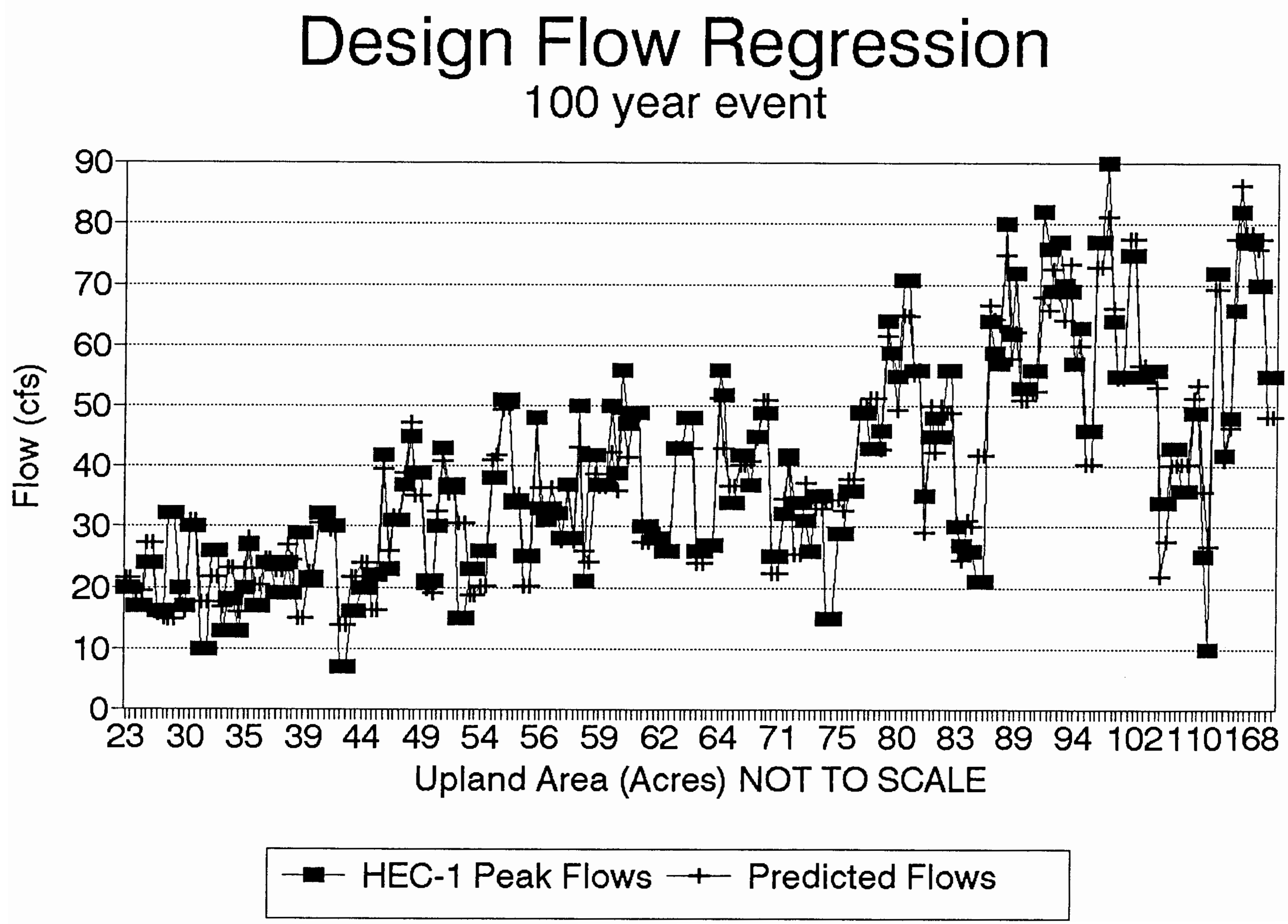

Design Flow Regressions
10, 25, 50, and 100 Year Events
Flow (cfs)
0
10
20
30
40
50
60
70
80
90
Sorted Flows
HEC-1 Peak Flows
Predicted Flow

**FIGURE E.2**



Design Flow Regression
100 year event
Flow (cfs)
90
80
70
60
50
40
30
20
10
0
23 30 35 39 44 49 54 56 59 62 64 71 75 80 83 89 94 102 110 168
Upland Area (Acres) NOT TO SCALE
HEC-1 Peak Flows
Predicted Flows

Date: March 10, 1992

To: Roger Sutherland

From: Brad Moore

Subject: Lake Oswego Storm and Surface Water Management Master Plan OTAK Project No. 3333.9
Technical Memorandum (Tasks #2, #4 and #8)
*(12/26/91 Memo revised to reflect additional field investigations and actual proposed PRFs for Lake Oswego capital improvement program)*

Job No.: 3105-03

*c: Stuart Childs, CES*
*Bob Aldrich, KCM*

## Lake Oswego Study Area
## Potential Pollutant Reduction Facilities (PRFs)

This technical memorandum presents the results of field observations and office evaluations conducted by Cascade Earth Sciences in conjunction with Kramer, Chin & Mayo, related to the potential for implementing pollutant reduction facilities(PRFs) within the 16 major drainage basins discharging to Oswego Lake within the Lake Oswego Study Area. Following initial evaluation of these basins, only eight of these basins contained sites with characteristics suitable for constructing PRFs. These major drainage basins are listed below:

Springbrook Creek
Lost Dog Creek
Ball Creek
Carter Creek
Country Club
Reese Road
Blue Heron Creek
Lower Boones Ferry

All potential facilities were evaluated from a low(1) to a high(5) score, with respect to the parameters as given in **Figure 1.**

Each potential site/facility was given a score for each of the above identified parameters and a cumulative score was determined by multiplying each parameter score by a relative weighting as determined by the project team and City of Lake Oswego Staff. Results of this analysis are summarized in **Table 1**. *(Fully shaded columns indicate values of Aa/An less than 0.08 and shaded boxes for parameter F indicate potential wetland conflicts).* Also, individual worksheets with field estimates are presented in the attached appendix.

Of the 39 sites investigated, 3 sites had potential wetland conflicts and another 29 were eliminated from primary consideration due to size limitations. The remaining 7 sites have the best potential for pollutant reduction facilities and have been ranked as shown in **Table 2**.

**Springbrook Creek** has 2 eligible PRF sites (SC102, SC108) which should receive primary consideration.

**Lower Boones Ferry** has two eligible sites, and both LBF2 and LBF3 are highly ranked (89 and 93, respectively) and recommended for further consideration as PRFs.

**Reese Road** (R1) is highly ranked and warrants further consideration for PRF implementation.

**Lost Dog Creek** has 2 identified sites (LD2, LD3) which should receive primary consideration for PRF implementation.

**Figure 1** | **Regional Pollutant Reduction Facilities (PRFs)** | Facility Site Number:
**City of Lake Oswego** | **Site Evaluation Matrix**

Subbasin Name: | Subbasin ID:

## Initial Screening

| | Yes | No |
|---|---|---|
| Is Site Unstable and/or Unsuitable for Construction? | | |
| Is Contributing Watershed < 50 acres? | | |
| Is There Insufficient Surface Area (Aa/An < 0.08)? | | |
| Is There Flood Hazard Potential? | | |

NOTE: Any Yes above reduces the site to very low priority

| Evaluation | Parameter | PRF Suitability Value Range Low | PRF Suitability Value Range High | Weight Factor | Assigned Value | Weighted Value | Max |
|---|---|---|---|---|---|---|---|
| Basin-Wide Parameters | A) Watershed Soil Erodibility | 1 | 5 | 2 | | 0 | 10 |
| | B) Watershed Soil Phosphorus Availability | 1 | 5 | 2 | | 0 | 10 |
| | C) Water Quality (Total Phosphorus Loadings) | 1 | 5 | 2 | | 0 | 10 |
| | D) Watershed Area | 1 | 5 | 4 | | 0 | 20 |
| | E) Surface Area Ratio (Aa/An) | 1 | 5 | 5 | | 0 | 25 |
| | Subtotal | | | | | 0 | 75 |
| Site-Specific Parameters | F) Wetlands | 0 | 5 | 3 | | 0 | 15 |
| | G) Slope | 0 | 5 | 1 | | 0 | 5 |
| | H) Tree Cover | 1 | 5 | 2 | | 0 | 10 |
| | I) Soil Depth | 1 | 5 | 1 | | 0 | 5 |
| | J) Natural Resource Enhancement Potential | 1 | 5 | 2 | | 0 | 10 |
| | K) Site Ownership | 1 | 5 | 1 | | 0 | 5 |
| | Subtotal | | | | | 0 | 50 |
| Total Points | | | | | | 0 | 125 |

## Value Assignment Guidelines

### Basin-Wide Parameters

A See Soil Erodibility Maps

B See Soil Phosphorus Maps

C Total Phosphorus Unit Loadings (lbs/acre) from SIMPTM Simulations

| TP | TP Rating |
|---|---|
| TP < 0.15 | 1 |
| 0.15 < TP < 0.25 | 2 |
| 0.25 < TP < 0.35 | 3 |
| 0.35 < TP < 0.45 | 4 |
| 0.45 < TP | 5 |

D Watershed Acreage Aw

| Aw | Rating |
|---|---|
| 50 < Aw < 75 | 1 |
| 75 < Aw < 100 | 2 |
| 100 < Aw < 150 | 3 |
| 150 < Aw < 200 | 4 |
| 200 < Aw | 5 |

E Ratio of Surface Area Available to Needed

| Aa/An | Aa/An Rating |
|---|---|
| 0.08 < Aa/An < 0.15 | 1 |
| 0.15 < Aa/An < 0.27 | 2 |
| 0.27 < Aa/An < 0.45 | 3 |
| 0.45 < Aa/An < 0.55 | 4 |
| 0.55 < Aa/An | 5 |

Aa - Maximum surface area available

An - Theoretical surface area needed = 0.035*Aw

### Site Specific Parameters

| F Wetlands Present? | Rating |
|---|---|
| Yes | 0 |
| Emergent | 3 |
| No | 5 |

| G Slope, Percent | Rating |
|---|---|
| > 15 | 0 |
| 5 - 15 | 3 |
| 0 - 5 | 5 |

| H Tree Cover, Percent | Rating |
|---|---|
| 80 - 100 | 1 |
| 60 - 80 | 2 |
| 40 - 60 | 3 |
| 20 - 40 | 4 |
| 0 - 20 | 5 |

| I Soil Depth | Rating |
|---|---|
| Shallow, <2' | 1 |
| Moderate, 2-5' | 3 |
| Deep, >5' | 5 |

| J Natural Resource Enhancement Potential | | Rating |
|---|---|---|
| | Low | 1 |
| | Mod | 3 |
| | High | 5 |

| K Site Ownership | Rating |
|---|---|
| Private | 1 |
| PDE/POS | 3 |
| Public | 5 |

## Table 2
## PRF Ranking and Distribution

| | Major Basin | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Lost Dog Creek | Country Club | Reese Road | Carter Creek | Lower Boones Ferry | Spring-brook Creek | Ball Creek | Blue Heron Creek | Total |
| Total No. of Potential PRF Sites | 6 | 1 | 1 | 3 | 2 | 15 | 9 | 2 | 39 |
| Eliminated from primary consideration due to: | | | | | | | | | |
| potential wetland conflicts | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 3 |
| Aa/An < 0.08 | 3 | 0 | 0 | 3 | 0 | 12 | 9 | 2 | 29 |
| No. of Remaining PRF Sites for further consideration | 2 | 0 | 1 | 0 | 2 | 2 | 0 | 0 | 7 |
| Rank/ Score | Facility Site No. | | | | | | | | |
| 95 | | | | | | | | | |
| 94 | | | | | | | | | |
| 93 | | | | | LBF3 | | | | 1 |
| 92 | | | | | | | | | |
| 91 | | | | | | | | | |
| 90 | | | | | | | | | |
| 89 | | | | | LBF2 | | | | 1 |
| 88 | | | | | | | | | |
| 87 | | | | | | | | | |
| 86 | | | | | | | | | |
| 85 | | | | | | | | | |
| 84 | | | | | | SC102 | | | 1 |
| 83 | | | | | | | | | |
| 82 | | | | | | | | | |
| 81 | | | | | | SC108 | | | 1 |
| 80 | | | | | | | | | |
| 79 | LD2 | | | | | | | | 1 |
| 78 | | | | | | | | | |
| 77 | | | | | | | | | |
| 76 | | | | | | | | | |
| 75 | | | | | | | | | |
| 74 | | | | | | | | | |
| 73 | | | | | | | | | |
| 72 | | | | | | | | | |
| 71 | | | | | | | | | |
| 70 | | | | | | | | | |
| 69 | | | | | | | | | |
| 68 | | | | | | | | | |
| 67 | | | | | | | | | |
| 66 | | | RR1 | | | | | | 1 |
| 65 | LD3 | | | | | | | | 1 |
| 64 | | | | | | | | | |
| 63 | | | | | | | | | |
| 62 | | | | | | | | | |
| 61 | | | | | | | | | |

| Table 1 - Potential PRFs | | | R | W | Carter Creek | | | | | | Blue Heron Creek | | | | Lower Boones Ferry | | | | Cntry Club | | Reese Rd | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Matrix Evaluation Summary | | | a | e | C 1 | | C 2 | | C 3 | | BHC 1 | | BHC 2 | | LBF 2 | | LBF 3 | | CC 1 | | RR 1 | |
| | Aw | | t | i | 89.7 | | 60.0 | | 417.0 | | 97.0 | | 36.0 | | 216.0 | | 88.4 | | 70.5 | | 65.0 | |
| | Aa | Range | i | g | 0.2 | | 0.1 | | 0.4 | | 0.0 | | 0.0 | | 1.1 | | 3.2 | | 0.8 | | 0.2 | |
| | An | | n | h | 3.1 | | 2.1 | | 14.6 | | 3.4 | | 1.3 | | 7.6 | | 3.1 | | 2.5 | | 2.3 | |
| | Aa/An | | g | t | 0.06 | | 0.05 | | 0.03 | | 0.00 | | 0.01 | | 0.15 | | 1.03 | | 0.32 | | 0.09 | |
| | | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | 1 | 2 | 1 | 2 | | 0 | 1 | 2 |
| | Watershed | 2 | 2 | 2 | 2 | 4 | 2 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| A | Soil | 3 | 3 | 2 | | 0 | | 0 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | | 0 | | 0 | | 0 |
| | Erodibility | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 4 | 8 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 1 | 2 | | 0 |
| B | Soil | 2 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Phosphorous | 3 | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | | 0 | | 0 | | 0 |
| | Availability | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | 4 | 8 | 4 | 8 | | 0 | 4 | 8 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Total | <0.15 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| C | Phosphorous | 0.15-0.25 | 2 | 2 | | 0 | | 0 | | 0 | 2 | 4 | 2 | 4 | | 0 | | 0 | 2 | 4 | | 0 |
| | Unit | 0.25-0.35 | 3 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Loadings | 0.35-0.45 | 4 | 2 | 4 | 8 | 4 | 8 | 4 | 8 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (lbs/acre) | >0.45 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | 5 | 10 | 5 | 10 | | 0 | 5 | 10 |
| | | 50-75 | 1 | 4 | | 0 | 1 | 4 | | 0 | | 0 | 0 | 0 | | 0 | | 0 | 1 | 4 | 1 | 4 |
| D | Watershed | 75-100 | 2 | 4 | 2 | 8 | | 0 | | 0 | 2 | 8 | | 0 | | 0 | 2 | 8 | | 0 | | 0 |
| | Area | 100-150 | 3 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Acres) | 150-200 | 4 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | >200 | 5 | 4 | | 0 | | 0 | 5 | 20 | | 0 | | 0 | 5 | 20 | | 0 | | 0 | | 0 |
| | | 0.08-0.15 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | | 0 | | 0 | 1 | 5 |
| | Surface | 0.15-0.27 | 2 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| E | Area | 0.27-0.45 | 3 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 15 | | 0 |
| | Ratio | 0.45-0.55 | 4 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Aa/An | >0.55 | 5 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 5 | 25 | | 0 | | 0 |
| | Wetlands | Yes | 0 | 3 | 0 | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 0 | 0 | | 0 |
| F | Present? | Emergent | 3 | 3 | | 0 | 3 | 9 | 3 | 9 | | 0 | | 0 | | 0 | 3 | 9 | | 0 | | 0 |
| | | No | 5 | 3 | | 0 | | 0 | | 0 | 5 | 15 | 5 | 15 | 5 | 15 | | 0 | | 0 | 5 | 15 |
| | Slope | >15 | 0 | 1 | | 0 | | 0 | | 0 | | 0 | 0 | 0 | | 0 | | 0 | | 0 | 0 | 0 |
| G | (Percent) | 5-15 | 3 | 1 | | 0 | | 0 | 3 | 3 | 3 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 0-5 | 5 | 1 | 5 | 5 | 5 | 5 | | 0 | | 0 | | 0 | 5 | 5 | 5 | 5 | 5 | 5 | | 0 |
| | | 80-100 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | 1 | 2 | | 0 | | 0 | | 0 | | 0 |
| | Tree | 60-80 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| H | Cover | 40-60 | 3 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 6 | | 0 | | 0 | | 0 |
| | (Percent) | 20-40 | 4 | 2 | | 0 | | 0 | | 0 | 4 | 8 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 0-20 | 5 | 2 | 5 | 10 | 5 | 10 | 5 | 10 | | 0 | | 0 | | 0 | 5 | 10 | 5 | 10 | 5 | 10 |
| | Soil | <2' | 1 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| I | Depth | 2-5' | 3 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Feet) | >5' | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | Natural | Low | 1 | 2 | | 0 | | 0 | | 0 | 1 | 2 | 1 | 2 | | 0 | | 0 | | 0 | | 0 |
| J | Resources | Mod | 3 | 2 | | 0 | 3 | 6 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 6 | 3 | 6 |
| | Enhancement | High | 5 | 2 | 5 | 10 | | 0 | 5 | 10 | | 0 | | 0 | 5 | 10 | 5 | 10 | | 0 | | 0 |
| | Site | Private | 1 | 1 | | 0 | 1 | 1 | 1 | 1 | | 0 | | 0 | | 0 | 1 | 1 | 1 | 1 | 1 | 1 |
| | Ownership | PDE/POS | 3 | 1 | 3 | 3 | | 0 | | 0 | 3 | 3 | 3 | 3 | 3 | 3 | | 0 | | 0 | | 0 |
| K | | Public | 5 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| PRF Rating Total | | | | | | 59 | | 58 | | 78 | | 60 | | 43 | | 89 | | 93 | | 60 | | 66 |

| Table 1 - Potential PRFs<br>Matrix Evaluation Summary | | | Rating | Weight | Lost Dog Creek | | | | | | Lost Dog Creek | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | LD 1 | | LD 2 | | LD 3 | | LD 101 | | LD 102 | | LD 103 | |
| | Aw | | | | 189.9 | | 166.0 | | 76.2 | | 245.4 | | 49.6 | | 132.5 | |
| | Aa | Range | | | 0.6 | | 0.5 | | 0.3 | | 0.04 | | 0.03 | | 0.1 | |
| | An | | | | 6.6 | | 5.8 | | 2.7 | | 8.6 | | 1.7 | | 4.6 | |
| | Aa/An | | | | 0.09 | | 0.09 | | 0.11 | | 0.00 | | 0.02 | | 0.02 | |
| | | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 2 | 2 | 2 | | 0 | | 0 | 2 | 4 | | 0 | | 0 | | 0 |
| A | Soil | 3 | 3 | 2 | | 0 | 3 | 6 | | 0 | | 0 | 3 | 6 | 3 | 6 |
| | Erodibility | 4 | 4 | 2 | 4 | 8 | | 0 | | 0 | 4 | 8 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| B | Soil | 2 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Phosphorous | 3 | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Availability | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Total | <0.15 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| C | Phosphorous | 0.15-0.25 | 2 | 2 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 | 2 | 4 |
| | Unit | 0.25-0.35 | 3 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Loadings | 0.35-0.45 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (lbs/acre) | >0.45 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 50-75 | 1 | 4 | | 0 | | 0 | | 0 | | 0 | 0 | 0 | | 0 |
| D | Watershed | 75-100 | 2 | 4 | | 0 | | 0 | 2 | 8 | | 0 | | 0 | | 0 |
| | Area | 100-150 | 3 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 12 |
| | (Acres) | 150-200 | 4 | 4 | 4 | 16 | 4 | 16 | | 0 | | 0 | | 0 | | 0 |
| | | >200 | 5 | 4 | | 0 | | 0 | | 0 | 5 | 20 | | 0 | | 0 |
| | | 0.08-0.15 | 1 | 5 | 1 | 5 | 1 | 5 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Surface | 0.15-0.27 | 2 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| E | Area | 0.27-0.45 | 3 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Ratio | 0.45-0.55 | 4 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Aa/An | >0.55 | 5 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Wetlands | Yes | 0 | 3 | 0 | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| F | Present? | Emergent | 3 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 9 |
| | | No | 5 | 3 | | 0 | 5 | 15 | 5 | 15 | 5 | 15 | 5 | 15 | | 0 |
| | Slope | >15 | 0 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| G | (Percent) | 5-15 | 3 | 1 | 3 | 3 | 3 | 3 | 3 | 3 | | 0 | 3 | 3 | | 0 |
| | | 0-5 | 5 | 1 | | 0 | | 0 | | 0 | 5 | 5 | | 0 | 5 | 5 |
| | | 80-100 | 1 | 2 | | 0 | | 0 | | 0 | 1 | 2 | | 0 | | 0 |
| | Tree | 60-80 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| H | Cover | 40-60 | 3 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Percent) | 20-40 | 4 | 2 | | 0 | | 0 | 4 | 8 | | 0 | | 0 | 4 | 8 |
| | | 0-20 | 5 | 2 | 5 | 10 | 5 | 10 | | 0 | | 0 | 5 | 10 | | 0 |
| | Soil | <2' | 1 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| I | Depth | 2-5' | 3 | 1 | 3 | 3 | | 0 | | 0 | 3 | 3 | | 0 | | 0 |
| | (Feet) | >5' | 5 | 1 | | 0 | 5 | 5 | 5 | 5 | | 0 | 5 | 5 | 5 | 5 |
| | Natural | Low | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| J | Resources | Mod | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 |
| | Enhancement | High | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | 5 | 10 |
| | Site | Private | 1 | 1 | | 0 | | 0 | 1 | 1 | 1 | 1 | | 0 | 1 | 1 |
| | Ownership | PDE/POS | 3 | 1 | 3 | 3 | 3 | 3 | | 0 | | 0 | 3 | 3 | | 0 |
| K | | Public | 5 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| PRF Rating Total | | | | | | 64 | | 79 | | 65 | | 70 | | 58 | | 66 |

| Table 1 - Potential PRFs Matrix Evaluation Summary | | | Rating | Weight | Ball Creek | | | | | | | | Ball Creek | | | | | | | | Ball Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | B 1 | | B 2 | | B 3 | | B 4 | | B 5 | | B 6 | | B 7 | | B 8 | | B 9 | |
| | Aw | Range | | | 71.0 | | 88.8 | | 298.4 | | 296.0 | | 298.4 | | 252.0 | | 102.0 | | 88.0 | | 642.0 | |
| | Aa | | | | 0.1 | | 0.1 | | 0.4 | | 0.3 | | 0.3 | | 0.5 | | 0.2 | | 0.1 | | 1.0 | |
| | An | | | | 2.5 | | 3.1 | | 10.4 | | 10.4 | | 10.4 | | 8.8 | | 3.6 | | 3.1 | | 22.5 | |
| | Aa/An | | | | 0.04 | | 0.03 | | 0.04 | | 0.02 | | 0.03 | | 0.06 | | 0.06 | | 0.03 | | 0.04 | |
| | | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 2 | 2 | 2 | 2 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| A | Soil | 3 | 3 | 2 | | 0 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | | 0 | 3 | 6 |
| | Erodibility | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 4 | 8 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 5 | 10 | | 0 | | 0 |
| | Watershed | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| B | Soil | 2 | 2 | 2 | | 0 | | 0 | | 0 | 2 | 4 | | 0 | | 0 | | 0 | 2 | 4 | | 0 |
| | Phosphorous | 3 | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | 3 | 6 |
| | Availability | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Total | <0.15 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| C | Phosphorous | 0.15-0.25 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Unit | 0.25-0.35 | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Loadings | 0.35-0.45 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (lbs/acre) | >0.45 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 50-75 | 1 | 4 | 1 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| D | Watershed | 75-100 | 2 | 4 | | 0 | 2 | 8 | | 0 | | 0 | | 0 | | 0 | | 0 | 2 | 8 | | 0 |
| | Area | 100-150 | 3 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 12 | | 0 | | 0 |
| | (Acres) | 150-200 | 4 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | >200 | 5 | 4 | | 0 | | 0 | 5 | 20 | 5 | 20 | 5 | 20 | 5 | 20 | | 0 | | 0 | 5 | 20 |
| | | 0.08-0.15 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 5 | 1 | 5 | 0 | 0 | 0 | 0 |
| | Surface | 0.15-0.27 | 2 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| E | Area | 0.27-0.45 | 3 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Ratio | 0.45-0.55 | 4 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Aa/An | >0.55 | 5 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Wetlands | Yes | 0 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 | 0 | 0 | | 0 | | 0 | 0 | 0 |
| F | Present? | Emergent | 3 | 3 | | 0 | | 0 | | 0 | | 0 | 3 | 9 | | 0 | | 0 | | 0 | | 0 |
| | | No | 5 | 3 | 5 | 15 | 5 | 15 | 5 | 15 | 5 | 15 | | 0 | | 0 | 5 | 15 | 5 | 15 | | 0 |
| | Slope | >15 | 0 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 0 | 0 |
| G | (Percent) | 5-15 | 3 | 1 | | 0 | | 0 | 3 | 3 | | 0 | | 0 | | 0 | 3 | 3 | 3 | 3 | | 0 |
| | | 0-5 | 5 | 1 | 5 | 5 | 5 | 5 | | 0 | 5 | 5 | 5 | 5 | 5 | 5 | | 0 | | 0 | | 0 |
| | | 80-100 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 1 | 2 |
| | Tree | 60-80 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 2 | 4 | | 0 |
| H | Cover | 40-60 | 3 | 2 | 3 | 6 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Percent) | 20-40 | 4 | 2 | | 0 | 4 | 8 | | 0 | 4 | 8 | 4 | 8 | 4 | 8 | | 0 | | 0 | | 0 |
| | | 0-20 | 5 | 2 | | 0 | | 0 | 5 | 10 | | 0 | | 0 | | 0 | 5 | 10 | | 0 | | 0 |
| | Soil | <2' | 1 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| I | Depth | 2-5' | 3 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Feet) | >5' | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | Natural | Low | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| J | Resources | Mod | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Enhancement | High | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | 5 | 10 | | 0 | | 0 | | 0 |
| | Site | Private | 1 | 1 | | 0 | | 0 | 1 | 1 | | 0 | | 0 | | 0 | 1 | 1 | | 0 | | 0 |
| | Ownership | PDE/POS | 3 | 1 | 3 | 3 | 3 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 3 |
| K | | Public | 5 | 1 | | 0 | | 0 | | 0 | 5 | 5 | 5 | 5 | 5 | 5 | | 0 | 5 | 5 | | 0 |
| PRF Rating Total | | | | | | 60 | | 68 | | 78 | | 80 | | 76 | | 76 | | 79 | | 64 | | 54 |

| Table 1 - Potential PRFs Matrix Evaluation Summary | | | Rating | Weight | Springbrook Creek | | | | | | | | | | | | | | Springbrook Creek | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SC 2 | | SC 3 | | SC 7 | | SC 100 | | SC 102 | | SC 103 | | SC 104 | | SC 105 | | SC 106 | |
| | Aw | | | | 590.0 | | 395.0 | | 143.3 | | 758.9 | | 530.0 | | 395.0 | | 301.0 | | 79.7 | | 126.1 | |
| | Aa | Range | | | 0.5 | | 0.6 | | 0.1 | | 0.05 | | 3.5 | | 0.3 | | 0.1 | | 0.1 | | 0.1 | |
| | An | | | | 20.7 | | 13.8 | | 5.0 | | 26.6 | | 18.6 | | 13.8 | | 10.5 | | 2.8 | | 4.4 | |
| | Aa/An | | | | 0.02 | | 0.04 | | 0.02 | | 0.00 | | 0.19 | | 0.02 | | 0.01 | | 0.02 | | 0.01 | |
| | | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 2 | 2 | 2 | 2 | 4 | | 0 | 2 | 4 | 2 | 4 | 2 | 4 | | 0 | | 0 | | 0 | | 0 |
| A | Soil | 3 | 3 | 2 | | 0 | 3 | 6 | | 0 | | 0 | | 0 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Erodibility | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| B | Soil | 2 | 2 | 2 | | 0 | 2 | 4 | | 0 | | 0 | | 0 | 2 | 4 | 2 | 4 | | 0 | | 0 |
| | Phosphorous | 3 | 3 | 2 | 3 | 6 | | 0 | 3 | 6 | 3 | 6 | 3 | 6 | | 0 | | 0 | 3 | 6 | 3 | 6 |
| | Availability | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Total | <0.15 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| C | Phosphorous | 0.15-0.25 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Unit | 0.25-0.35 | 3 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Loadings | 0.35-0.45 | 4 | 2 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 |
| | (lbs/acre) | >0.45 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 50-75 | 1 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| D | Watershed | 75-100 | 2 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 2 | 8 | | 0 |
| | Area | 100-150 | 3 | 4 | | 0 | | 0 | 3 | 12 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 12 |
| | (Acres) | 150-200 | 4 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | >200 | 5 | 4 | 5 | 20 | 5 | 20 | | 0 | 5 | 20 | 5 | 20 | 5 | 20 | 5 | 20 | | 0 | | 0 |
| | | 0.08-0.15 | 1 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Surface | 0.15-0.27 | 2 | 5 | | 0 | | 0 | | 0 | | 0 | 2 | 10 | | 0 | | 0 | | 0 | | 0 |
| E | Area | 0.27-0.45 | 3 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Ratio | 0.45-0.55 | 4 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Aa/An | >0.55 | 5 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Wetlands | Yes | 0 | 3 | | 0 | 0 | 0 | 0 | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| F | Present? | Emergent | 3 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 9 |
| | | No | 5 | 3 | 5 | 15 | | 0 | | 0 | 5 | 15 | 5 | 15 | 5 | 15 | 5 | 15 | 5 | 15 | | 0 |
| | Slope | >15 | 0 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| G | (Percent) | 5-15 | 3 | 1 | 3 | 3 | 3 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 0-5 | 5 | 1 | | 0 | | 0 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | | 80-100 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Tree | 60-80 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | 2 | 4 | 2 | 4 | | 0 | 2 | 4 | | 0 |
| H | Cover | 40-60 | 3 | 2 | | 0 | | 0 | | 0 | 3 | 6 | | 0 | | 0 | 3 | 6 | | 0 | | 0 |
| | (Percent) | 20-40 | 4 | 2 | 4 | 8 | 4 | 8 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | 4 | 8 |
| | | 0-20 | 5 | 2 | | 0 | | 0 | 5 | 10 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Soil | <2' | 1 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| I | Depth | 2-5' | 3 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Feet) | >5' | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 |
| | Natural | Low | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| J | Resources | Mod | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Enhancement | High | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Site | Private | 1 | 1 | | 0 | 1 | 1 | | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | | 0 |
| | Ownership | PDE/POS | 3 | 1 | | 0 | | 0 | 3 | 3 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 3 |
| K | | Public | 5 | 1 | 5 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| PRF Rating Total | | | | | | 80 | | 61 | | 59 | | 76 | | 84 | | 74 | | 76 | | 64 | | 68 |

| Table 1 - Potential PRFs<br>Matrix Evaluation Summary | | | Rating | Weight | Springbrook Creek | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | SC 107 | | SC 108 | | SC 109 | | SC 111 | | SC 113 | | SC 114 | |
| | Aw | Range | | | 150.0 | | 34.9 | | 103.6 | | 91.4 | | 134.0 | | 55.0 | |
| | Aa | | | | 0.0 | | 0.8 | | 0.3 | | 0.01 | | 0.5 | | 0.0 | |
| | An | | | | 5.3 | | 1.2 | | 3.6 | | 3.2 | | 4.7 | | 1.9 | |
| | Aa/An | | | | 0.01 | | 0.61 | | 0.07 | | 0.00 | | 0.11 | | 0.00 | |
| | | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 2 | 2 | 2 | | 0 | 2 | 4 | 2 | 4 | 2 | 4 | | 0 | 2 | 4 |
| A | Soil | 3 | 3 | 2 | 3 | 6 | | 0 | | 0 | | 0 | 3 | 6 | | 0 |
| | Erodibility | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Watershed | 1 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| B | Soil | 2 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Phosphorous | 3 | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Availability | 4 | 4 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | (Mapped) | 5 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Total | <0.15 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| C | Phosphorous | 0.15-0.25 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Unit | 0.25-0.35 | 3 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Loadings | 0.35-0.45 | 4 | 2 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 | 4 | 8 |
| | (lbs/acre) | >0.45 | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 50-75 | 1 | 4 | | 0 | 0 | 0 | | 0 | | 0 | | 0 | 1 | 4 |
| D | Watershed | 75-100 | 2 | 4 | | 0 | | 0 | | 0 | 2 | 8 | | 0 | | 0 |
| | Area | 100-150 | 3 | 4 | | 0 | | 0 | 3 | 12 | | 0 | 3 | 12 | | 0 |
| | (Acres) | 150-200 | 4 | 4 | 4 | 16 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | >200 | 5 | 4 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | | 0.08-0.15 | 1 | 5 | 0 | 0 | | 0 | 1 | 5 | 0 | 0 | 1 | 5 | 0 | 0 |
| | Surface | 0.15-0.27 | 2 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| E | Area | 0.27-0.45 | 3 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Ratio | 0.45-0.55 | 4 | 5 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Aa/An | >0.55 | 5 | 5 | | 0 | 5 | 25 | | 0 | | 0 | | 0 | | 0 |
| | Wetlands | Yes | 0 | 3 | | 0 | | 0 | | 0 | | 0 | 0 | 0 | | 0 |
| F | Present? | Emergent | 3 | 3 | | 0 | 3 | 9 | | 0 | | 0 | | 0 | | 0 |
| | | No | 5 | 3 | 5 | 15 | | 0 | 5 | 15 | 5 | 15 | | 0 | 5 | 15 |
| | Slope | >15 | 0 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| G | (Percent) | 5-15 | 3 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | 3 | 3 |
| | | 0-5 | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 0 |
| | | 80-100 | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Tree | 60-80 | 2 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| H | Cover | 40-60 | 3 | 2 | 3 | 6 | | 0 | 3 | 6 | | 0 | | 0 | | 0 |
| | (Percent) | 20-40 | 4 | 2 | | 0 | | 0 | | 0 | 4 | 8 | 4 | 8 | 4 | 8 |
| | | 0-20 | 5 | 2 | | 0 | 5 | 10 | | 0 | | 0 | | 0 | | 0 |
| | Soil | <2' | 1 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| I | Depth | 2-5' | 3 | 1 | | 0 | | 0 | | 0 | | 0 | 3 | 3 | | 0 |
| | (Feet) | >5' | 5 | 1 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | 5 | | 0 | 5 | 5 |
| | Natural | Low | 1 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| J | Resources | Mod | 3 | 2 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 | 3 | 6 |
| | Enhancement | High | 5 | 2 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| | Site | Private | 1 | 1 | | 0 | | 0 | 1 | 1 | | 0 | 1 | 1 | | 0 |
| | Ownership | PDE/POS | 3 | 1 | 3 | 3 | 3 | 3 | | 0 | 3 | 3 | | 0 | 3 | 3 |
| K | | Public | 5 | 1 | | 0 | | 0 | | 0 | | 0 | | 0 | | 0 |
| PRF Rating Total | | | | | | 76 | | 81 | | 73 | | 68 | | 60 | | 62 |

# Springbrook Creek

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC2 (Upstream of Node 50)

**Subbasin: Springbrook Creek**
**Cross Street: Krause Way Place**

2. Proposed Treatment Facility Type: dry detention

3. Approximate Catchment Area (Acres): 590.0

4. Approximate Available Surface Area for: dry detention - 1 acre

5. Approximate Volume of Facility: 131,000 cu. ft. (3.0 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses (50), shrubs (10), trees (40)

7. Outlet/Drainage Status:
   a. Slope (%): 0-5
   b. Vegetation (percent as): same as border
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No - dry area along creek

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 25-30
   g. Coarse fragments/gravel: No
   h. Slope (%): 5-15
   i. Soil Structure: Undisturbed soil
   j. Average seasonal water table depth (feet): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (80), shrubs (10), trees (10)

11. Comments :

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC3 (Upstream of Node 70)    **Subbasin: Springbrook Creek**
   **Cross Street: Rainbow Drive**

2. Proposed Treatment Facility Type: Pond

3. Approximate Catchment Area (Acres): 395.0

4. Approximate Available Surface Area for: pond, 1-1/2 acre

5. Approximate Volume of Facility: 87,000 cu. ft. (2 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses, shrubs (20), trees (80)

7. Outlet/Drainage Status:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses (30), shrubs (40), trees (30)
   c. Emergency Spillway or Overflow Room Available: Yes
   Well designed weir detention wall in front of outflow on west side of street, drops off to an area available along Springbrook creek.

8. Wetlands already present: Yes, pond

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): <0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 25-30
   g. Coarse fragments/gravel: No
   h. Slope (%): >15
   i. Soil Structure: Undisturbed soil
   j. verage seasonal water table depth (feet): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): bare (water), grasses (20), shrubs (40), trees (40)

11. Comments :

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC7 (Upstream of Node 410) **Subbasin: Springbrook Creek**
**Cross Street: Mercantile Drive**

2. Proposed Treatment Facility Type: Wet detention pond, wetland pond

3. Approximate Catchment Area (Acres): 143.3

4. Approximate Available Surface Area for: 1/4 acre wetland, 1/4 acre infiltration facility

5. Approximate Volume of Facility: 87,000 cu. ft. (2 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses (60), fencing (40)

7. Outlet/Drainage Status:
   a. Slope (%): 0-5
   b. Vegetation (percent as): grasses (85), shrubs (10), trees (5)
   c. Emergency Spillway or Overflow Room Available: Yes
      Culvert, well designed outflow

8. Wetlands already present: Yes, pond and cattails

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr.): <0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 25-30
   g. Coarse fragments/gravel:
   h. Slope (%): 0-5
   i. Soil Structure: fill material and undisturbed soil
   j. Average seasonal water table depth (feet): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (90), shrubs (10)

11. Comments: well designed site in place - just fertilizer and weed control on sides

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC100 (Upstream of Node 30) **Subbasin: Springbrook Creek**
**Cross Street: Boones Way**

2. Proposed Treatment Facility Type: off-channel detention pond

3. Approximate Catchment Area (Acres): 758.9

4. Approximate Available Surface Area for: 2000 sq ft.

5. Approximate Volume of Facility: 20 ft. wide x 100 ft. upstream (.05 ac-ft)

6. Borders of Facility:
   a. Slope: (%) 5 - 15
   b. Vegetation (percent as): shrubs (40), trees (60)

7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): bare (50), grasses (20), shrubs (15), trees (15)
   c. Emergency Spillway or Overflow Room Available: no

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: 13C Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil: 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth: 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (40), trees (60)

11. Comments: Currently a creek channel - PRF maybe on northside of culvert - manicured stream on south side of culvert. No room - really for even an off-channel detention pond.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC101 (Downstream of Node 60) **Subbasin: Springbrook Creek**
**Cross Street: Twin Fir Court**

2. Proposed Treatment Facility Type: pond, but not useful - see comments.

Comments: Creek channel, not useful - better to use SC102.

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: SC102 (Upstream of Node 60) **Subbasin: Springbrook Creek**
   **Cross Street: Twin Fir Court**

2. Proposed Treatment Facility Type: pond

3. Approximate Catchment Area (Acres): 530.0

4. Approximate Available Surface Area for: 1000 x 250; wetland

5. Approximate Volume of Facility: 1,000,000 cu. ft. (23 ac-ft)

6. Borders of Facility:
   a. Slope: (%) 0 - 5
   b. Vegetation (percent as): shrubs (30), trees (70)

7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): shrubs (30), trees (70)
   c. Emergency Spillway or Overflow Room Available: yes

8. Wetlands already present: <u>No</u>

9. Soil Conditions:
   a. Soil series: 13C Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil: 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth (ft): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (30), trees (70)

11. Comments: Currently a creek - room available for building a pond in tree area, isolated area.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC103 (Upstream of Node 70) **Subbasin: Springbrook Creek**
   **Cross Street: Rainbow Drive**
2. Proposed Treatment Facility Type: channel storage pond
3. Approximate Catchment Area (Acres): 395.0
4. Approximate Available Surface Area for: channel 300 ft. long x 40 ft. wide; pond
5. Approximate Volume of Facility: 36,000 cu. ft. (.83 ac-ft)
6. Borders of Facility:
   a. Slope: (%) 5 - 15
   b. Vegetation (percent as): shrubs (40), trees (60)
7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): shrubs (40), trees (60)
   c. Emergency Spillway or Overflow Room Available: maybe - hard to tell
8. Wetlands already present: No
9. Soil Conditions:
   a. Soil series: 13D Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil: 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth: 1-2
10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (40), trees (60)
11. Comments: Steep drop from culvert to creek - could do an off-channel routing.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC104 (Downstream of Node 74) **Subbasin: Springbrook Creek**
   **Cross Street: Tempest Drive**

2. Proposed Treatment Facility Type: Pond

3. Approximate Catchment Area (Acres): 301.0

4. Approximate Available Surface Area for: 40 x 80; wetland

5. Approximate Volume of Facility: 25,600 cu. ft. (.59 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5-15
   b. Vegetation (percent as): shrubs (60), trees (40)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): shrubs (40), trees (60)
   c. Emergency Spillway or Overflow Room Available: yes

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: 13D Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil: 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth: 1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (60), trees (40)

11. Comments: Area for pond on side towards house - away from road.

## CITY OF LAKE OSWEGO
## PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC105 (Upstream of Node 910) **Subbasin: Springbrook Creek**
   **Cross Street: Boones Ferry Road**

2. Proposed Treatment Facility Type: pond - off channel

3. Approximate Catchment Area (Acres): 79.7

4. Approximate Available Surface Area for: 60 x 40; wetland

5. Approximate Volume of Facility : 7,200 cu. ft. (.17 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): shrubs (25), trees (75)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): shrubs (25), trees (75)
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: no

9. Soil Conditions:
   a. Soil series: 13D Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: None
   h. Slope (%): 0 - 5
   i. Soil Structure : undisturbed soil
   j. Average seasonal water table depth (ft): 1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (30), trees (70)

11. Comments : Good area for pond, room for side overflow - away from road.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC106 (Upstream of Node 104) **Subbasin: Springbrook Creek**
   **Cross Street: Cirque Street**

2. Proposed Treatment Facility Type: overland flow - pond

3. Approximate Catchment Area (Acres): 126.1

4. Approximate Available Surface Area for: pond, 50 x 50

5. Approximate Volume of Facility : 5,000 cu. ft. (.11 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5 - 15
   b. Vegetation (percent as): grasses (50), shrubs (10), trees (40)

7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): bare - culvert (100)
   c. Emergency Spillway or Overflow Room Available: no

8. Wetlands already present: <u>Yes</u>, emergent

9. Soil Conditions:
   a. Soil series: 13D Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: None
   h. Slope (%): 0 - 5
   i. Soil Structure : undisturbed soil (80%) & fill material (20%)
   j. Average seasonal water table depth (ft): 1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (50), shrubs (10), trees (40)

11. Comments:

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: SC107 (Upstream of Node 102) **Subbasin: Springbrook Creek**
**Cross Street: Kerr Parkway**
2. Proposed Treatment Facility Type: could pond - but too close to houses
3. Approximate Catchment Area (Acres): 150.0
4. Approximate Available Surface Area for: 70 x 30; pond
5. Approximate Volume of Facility : 5,250 cu. ft. (.11 ac-ft)
6. Borders of Facility:
   a. Slope (%): 5 - 15
   b. Vegetation (percent as): grasses (20), shrubs (25), trees (55)
7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5 (culvert)
   b. Vegetation (percent as): grasses (20), shrubs (25), trees (55)
   c. Emergency Spillway or Overflow Room Available: no
8. Wetlands already present: No
9. Soil Conditions:
   a. Soil series: 13D Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: None
   h. Slope (%): 0 - 5
   i. Soil Structure: undisturbed soil (70%) & fill material (30%)
   j. Average seasonal water table depth (ft): 1 - 2
10. Vegetation on Site:
    a. Vegetation (percent as): grasses (40), shrubs (20), trees (40)
11. Comments: Not feasible because of residences.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC108 (Upstream of Node 910) **Subbasin: Springbrook Creek**
**Cross Street: Monroe Parkway**

2. Proposed Treatment Facility Type: detention pond & wetland

3. Approximate Catchment Area (Acres): 34.9

4. Approximate Available Surface Area for: 3/4 acre

5. Approximate Volume of Facility : 65,340 cu. ft. (1.5 ac-ft)

6. Borders of Facility:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): bare, road & parking lot (40), grasses (30), shrubs (30)

7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5 (culvert)
   b. Vegetation (percent as): bare, culvert (100)
   c. Emergency Spillway or Overflow Room Available: no

8. Wetlands already present: <u>Yes, emergent</u>

9. Soil Conditions:
   a. Soil series: B/13C Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: None
   h. Slope (%): 0 - 5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth (ft): 1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (80), shrubs (20)

11. Comments: Can't do much with it - already functioning as is.

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: SC109 (Upstream of Node 420) **Subbasin: Springbrook Creek**
   **Cross Street: Kruse Way**

2. Proposed Treatment Facility Type: Infiltration

3. Approximate Catchment Area (Acres): 103.6

4. Approximate Available Surface Area for: 40 X 1000 ft = 40,000 sq. ft. (at least)

5. Approximate Volume of Facility: 120,000 cu. ft. (2.75 ac-ft)

6. Borders of Facility:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): grasses ( 50), trees (50)

7. Outlet/Drainage Status:
   a. Slope (%): 0 - 5
   b. Vegetation (percent as): Culvert under Kruse Way
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: <u>No</u>

9. Soil Conditions:
   a. Soil series: 13 B; Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr.): 0.2 - 0.6
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure: 50/50 fill:undisturbed soil, next to road
   j. Average seasonal water table depth (ft): 1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (50), trees (50)

11. Comments:

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC110 (Near Node 420) **Subbasin: Springbrook Creek**
**Cross Street: Kruse Way**

2. Proposed Treatment Facility Type: depressional area in Safeco lawn. - Not practical

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: **SC111** (Upstream of Node 422) **Subbasin: Springbrook Creek**
   **Cross Street: Kruse Way Place**
2. Proposed Treatment Facility Type: Infiltration - presently a ditch
3. Approximate Catchment Area (Acres): 91.4
4. Approximate Available Surface Area for: 5 X 100 = 500 sq. ft.
5. Approximate Volume of Facility: 1500 cu. ft. (.03 ac-ft)
6. Borders of Facility:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (25), trees (75)
7. Outlet/Drainage Status: culvert under road
   a. Slope (%) 0 - 5
   b. Vegetation (percent as):grasses ( 25), shrubs (10), trees (65)
   c. Emergency Spillway or Overflow Room Available: No
8. Wetlands already present: No
9. Soil Conditions:
   a. Soil series: 13 B; Cascade Silt Loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr.): 0.2 - 0.6
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: No
   h. Slope (%): 0 - 5
   i. Soil Structure: 50/50 fill:undisturbed soil
   j. Average seasonal water table depth (ft): 1 - 2
10. Vegetation on Site:
    a. Vegetation (percent as): grasses (95), shrubs (5)
11. Comments :

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: SC112 (Downstream of Node 26) **Subbasin: Springbrook Creek**
**Cross Street: Twin Fir Road**

2. Proposed Treatment Facility Type: none - house exists on-site

Comments: Brown house over creek and open area - no feasible place for treatment

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC113 (Upstream of Node 20) **Subbasin: Springbrook Creek**
   **Cross Street: Iron Mountain Blvd.**
2. Proposed Treatment Facility Type:Infiltration basin or swale
3. Approximate Catchment Area (Acres): 134
4. Approximate Available Surface Area for: 2 Acres
5. Approximate Volume of Facility: 87,000-174,000 cu. ft.
6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as):shrubs (10), trees (90)
7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as):grasses (30), shrubs (70)
   c. Emergency Spillway or Overflow Room Available: yes
8. Wetlands already present: Yes
9. Soil Conditions:
   a. Soil series: 93E; Xerocrept- probably not correct- level area probably Nekia or Saum
   b. Soil depth (feet): 2 - 5
   c. Estimated Permeability of Soil (in/hr.): 0.2 - 0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil:
   g. Coarse fragments/gravel:
   h. Slope (%): 0 - 5 (for area not xerocrept)
   i. Soil Structure: mostly undisturbed soil, some road fill
   j. Average seasonal water table depth (ft): unknown
10. Vegetation on Site:
    a. Vegetation (percent as): grasses (60), shrubs (20), trees (20)
11. Comments: Field check soil for confirmation

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: SC114 (Upstream Node 425) **Subbasin: Springbrook Creek**
   **Cross Street: Carman Drive**

2. Proposed Treatment Facility Type: Wet detention

3. Approximate Catchment Area (Acres): 55

4. Approximate Available Surface Area for: .5 acre pond

5. Approximate Volume of Facility : 108,900 cu. ft. (2.5 ac-ft)

6. Borders of Facility:
   a. Slope (%) >15
   b. Vegetation (percent as): bare (10), grasses (5), shrubs (45), trees (40)

7. Outlet/Drainage Status:
   a. Slope (%) 5-15
   b. Vegetation (percent as): bare (10), grasses (5), shrubs (75), trees (10)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: No
   h. Slope (%): 5-15
   i. Soil Structure : combination of fill and natural
   j. Average seasonal water table depth (ft): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (10), shrubs (80), trees (10)

11. Comments:

# Lost Dog Creek

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: LD1 (Upstream of Node 30) **Subbasin: Lost Dog Creek**
   **Cross Street: Palisades Lake Driv**

2. Proposed Treatment Facility Type:Wet detention

3. Approximate Catchment Area (Acres): 189.9

4. Approximate Available Surface Area for: 1/2 acre pond

5. Approximate Volume of Facility: 54,000 cu. ft. (1.2 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): grasses (5), shrubs (10), trees (85)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): bare (culvert)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: Yes - pond & cattail border

9. Soil Conditions:
   a. Soil series: Xerochrepts - rock outcrop complex
   b. Soil depth (feet): 2 - 5
   c. Estimated Permeability of Soil: 0.2 - 0.6 in/hr
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Loam, gravelly loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: gravel
   h. Slope (%): > 15
   i. Soil Structure: combination of fill & soil

j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
    a. Vegetation (percent as): bare (water - 75), grasses (15), trees (10)

11. Comments: Well manicured and taken care of.

## CITY OF LAKE OSWEGO
## PRF SITE EVALUATION MATRIX

1. Facility Site Number: LD2 (Upstream of Node 40) **Subbasin: Lost Dog Creek**
**Cross Street: South Shore Blvd.**

2. Proposed Treatment Facility Type: wet detention

3. Approximate Catchment Area (Acres): 166.0

4. Approximate Available Surface Area for: 1/2 acre wet detention pond

5. Approximate Volume of Facility: 98,000 cu. ft. (2.25 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): grasses (5), shrubs (50), trees (45)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): bare (10), grasses (30), shrubs (30), trees (30)
   c. Emergency Spillway or Overflow Room Available: No, road

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): < 0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 25 - 30
   g. Coarse fragments/gravel: No
   h. Slope (%): 5 - 15
   i. Soil Structure: Mix fill and undisturbed soil
   j. Average seasonal water table depth (ft): 1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (15), shrubs (75), trees (10)

11. Comments:

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

**Subbasin:Lost Dog Creek**
**Cross Street: Sunny Hill Drive**

1. Facility Site Number: LD3 (Upstream of Node 50)

2. Proposed Treatment Facility Type: Wet detention

3. Approximate Catchment Area (Acres): 76.2

4. Approximate Available Surface Area for:~ 3 acres

5. Approximate Volume of Facility: 174,000 - 348,000 cu. ft. (4-8 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): shrubs (30), trees (70)

7. Outlet/Drainage Status:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): grasses (5), shrubs (70), trees (25)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Powell silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): < 0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: No
   h. Slope (%): 0 - 5
   i. Soil Structure: Mostly undisturbed soil
   j. Average seasonal water table depth (ft): 1- 2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (5), shrubs (70), trees (25)

11. Comments: Good site - no overflow

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

Subbasin: Lost Dog
Cross Street: Oak Street

1. Facility Site Number: LD101 (Upstream of Node 210)

2. Proposed Treatment Facility Type: Pond - if anything

3. Approximate Catchment Area (Acres): 245.4

4. Approximate Available Surface Area for: 40 X 40; pond

5. Approximate Volume of Facility: 6400 cu. ft. (.15 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): shrubs (5) trees (95)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): shrubs (5), trees (95)
   c. Emergency Spillway or Overflow Room Available: no

8. Wetlands already present: no

9. Soil Conditions:
   a. Soil series: 93 E; Xerochrepts - rock outcrop
   b. Soil depth (feet): 2 - 5
   c. Estimated Permeability of Soil (in/hr.): 0.2 - 0.6
   d. Presence of Impermeable Layer: no
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: < 30
   g. Coarse fragments/gravel: gravelly
   h. Slope (%): 0 - 5
   i. Soil Structure: Undisturbed material
   j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
   a. Vegetation (percent as):grasses (25), trees (75)

11. Comments :

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: LD102 (Upstream of Node 232)

   **Subbasin: Lost Dog**
   **Cross Street: Oak Meadow Lane and Bergis Road**

2. Proposed Treatment Facility Type: Swale

3. Approximate Catchment Area (Acres): 49.6

4. Approximate Available Surface Area for: 1500 sq ft.; infiltration facility

5. Approximate Volume of Facility: 4500 cu. ft. (.1 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): grasses (50), shrubs (50)

7. Outlet/Drainage Status:
   a. Slope (%) 5 - 15
      (culvert under road)
   b. Vegetation (percent as): grasses (20), shrubs (80)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Borges silty clay loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr.): 0.2 - 0.6
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silty clay loam
   f. Estimated Percent Clay of Soil: 35 - 40
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure: 50/50 fill and undisturbed soil
   j. Average seasonal water table depth (ft): 0 - 1

10. Vegetation on Site:
    a. Vegetation (percent as):grasses (80), shrubs (20)

11. Comments :

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: LD103 (Upstream of Node 230) **Subbasin: Lost Dog**
   **Cross Street: Along Stafford Road**
2. Proposed Treatment Facility Type: Swale
3. Approximate Catchment Area (Acres): 132.5
4. Approximate Available Surface Area for: 50 X 100; wetland
5. Approximate Volume of Facility : 10,000 cu. ft. (.23 ac-ft)
6. Borders of Facility:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (50), shrubs (10), trees (40)
7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (20), shrubs (40), trees (40)
   c. Emergency Spillway or Overflow Room Available: Yes
8. Wetlands already present: Yes - Emergent
9. Soil Conditions:
   a. Soil series: Borges silty clay loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr.): 0.2 - 0.6
   d. Presence of Impermeable Layer: yes
   e. Soil Texture: silt clay loam
   f. Estimated Percent Clay of Soil: 35 - 40
   g. Coarse fragments/gravel: none
   h. Slope (%): 0 - 5
   i. Soil Structure : undisturbed with some fill from road
   j. Average seasonal water table depth (ft): 0 - 1
10. Vegetation on Site:
    a. Vegetation (percent as):grasses (50), shrubs (30), trees (20)
11. Comments: Nice, small wetland -- do able

# Ball Creek

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B1 (Upstream of Node 116) **Subbasin: Ball Creek**
**Cross Street: Center Pointe Drive**
2. Proposed Treatment Facility Type: 2 Dry detentions with man-made creek channel between them.

3. Approximate Catchment Area (Acres): 71.0

4. Approximate Available Surface Area for: dry detention; 1-2 acre riparian area

5. Approximate Volume of Facility : 261,000 cu. ft. (6 ac-ft)

6. Borders of Facility: not much free board
   a. Slope (%): 0-5
   b. Vegetation (percent as): grasses (10), shrubs (30), trees (60)

7. Outlet/Drainage Status: culvert
   a. Slope (%): 0-5
   b. Vegetation (percent as): goes to culvert - to channeled manmade creek bare (rocks), grasses (70), shrubs (20), trees (10)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Cornelius silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.6-6.0
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 30
   g. Coarse fragments/gravel: No
   h. Slope (%): 0-5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth (feet): >2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (50), trees (50)

11. Comments : manicured lawns adjacent to creek outflow -- watch for pesticides and fertilizers

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: B2 (Upstream of Node 110) **Subbasin: Ball Creek**
   **Cross Street: Kruse Way**
2. Proposed Treatment Facility Type: Dry detention and infiltration (gravel)

3. Approximate Catchment Area (Acres): 88.8

4. Approximate Available Surface Area for: 60ft x 7ft - gravel bed (1/2 acre max)

5. Approximate Volume of Facility: 150,000 cu. ft. (3.4 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses (75), shrubs (25)

7. Outlet/Drainage Status: immediately adjacent to creek (culvert under freeway)
   a. Slope (%): 0-5
   b. Vegetation (percent as): grasses (75), shrubs (25)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No (man made creek)

9. Soil Conditions:
   a. Soil series: Aloha silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: Silt Loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: No
   h. Slope (%): 0-5
   i. Soil Structure: Fill material (landscaped lawn area)
   j. Average seasonal water table depth (feet): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): bare (gravel), grasses (60), shrubs (15)

11. Comments : gravel infiltration bed, careful of pesticides and fertilizer applied to lawn.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B3 (Upstream of Node 210) **Subbasin: Ball Creek**
**Cross Street: Kruse Oaks Blvd.**

2. Proposed Treatment Facility Type: Dry detention

3. Approximate Catchment Area (Acres): 298.4

4. Approximate Available Surface Area for: 1/2 acre

5. Approximate Volume of Facility: 87,000 cu. ft. (4ft x 1/2 acre) (2 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses (15), shrubs (15), trees (70)

7. Outlet/Drainage Status: Culvert under Kruse Oaks Boulevard
   a. Slope (%): 0-5
   b. Vegetation (percent as): grasses (15), shrubs (15), trees (20)
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Woodburn silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.6-6.0
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: No
   h. Slope (%): 5-15
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth (feet): >2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (75), shrubs (15), trees (10)

11. Comments : suitable, could get some runoff of fertilizer and pesticides from adjacent lawn

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B4 (Upstream of Node 40)

   **Subbasin: Ball Creek**
   **Cross Street: Westlake Drive and Melrose Street**

2. Proposed Treatment Facility Type: Pond, wetland area

3. Approximate Catchment Area (Acres): 296.0

4. Approximate Available Surface Area for: detention pond, 1/4 acre wetland

5. Approximate Volume of Facility : 98,000 cu. ft. (2.25 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): shrubs (50), trees (50)

7. Outlet/Drainage Status: Culvert
   a. Slope (%): 0-5
   b. Vegetation (percent as): culvert under road
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No (small stream - riparian area)

9. Soil Conditions:
   a. Soil series: Helvetia siltloam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 30
   g. Coarse fragments/gravel: No
   h. Slope (%): 0-5
   i. Soil Structure: undisturbed soil
   j. Average seasonal water table depth (feet): >2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (50), shrubs (25), trees (25)

11. Comments : Riparian area of a channelized stream - to a culvert.
    Surrounded by houses - careful of fertilizer and pesticides.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B5 (Upstream of Node 214) **Subbasin: Ball Creek**
**Cross Street: Suncreek Drive**

2. Proposed Treatment Facility Type: Wet detention/wetland

3. Approximate Catchment Area (Acres): 298.4

4. Approximate Available Surface Area for: 1 acre - pond, wetland

5. Approximate Volume of Facility : 218,000 cu. ft. (5 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): bare (gravel walkway 15), grasses (10), shrubs (10), Trees (65)

7. Outlet/Drainage Status: Incised culvert, grated catch top
   a. Slope (%): 0-5
   b. Vegetation (percent as): grasses (40), shrubs (40), trees (20)
   c. Emergency Spillway or Overflow Room Available: Yes

   Walkway at lower slope end, very possibly could go over to next vegetation area, already had overflow.

8. Wetlands already present: Yes, emergent

9. Soil Conditions:
   a. Soil series: Quatama loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: Loam
   f. Estimated Percent Clay of Soil: 25
   g. Coarse fragments/gravel: No
   h. Slope (%): 0-5
   i. Soil Structure: some fill
   j. Average seasonal water table depth (feet): >2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (40), shrubs (40), trees (20)

11. Comments: May receive phosphorus from surrounding neighborhood.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B6 (Upstream of Node 216) **Subbasin: Ball Creek**
**Cross Street: Twin Creek Lane**

2. Proposed Treatment Facility Type: Wet detention pond

3. Approximate Catchment Area (Acres): 252.0

4. Approximate Available Surface Area for: 1 acre

5. Approximate Volume of Facility: 261,000 cu. ft. (approximate 6 feet depth) (6 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): grasses (60), trees (40)

7. Outlet/Drainage Status: Constructed weir and culvert
   a. Slope (%): 0-5
   b. Vegetation (percent as): bare (house), grasses (60), trees (40)
   c. Emergency Spillway or Overflow Room Available: Yes
   Culvert, partial towards weir

8. Wetlands already present: Yes, small pond and cattails

9. Soil Conditions:
   a. Soil series: Quatama loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: 25
   g. Coarse fragments/gravel: No
   h. Slope (%): 0-5
   i. Soil Structure: Partial fill material
   j. Average seasonal water table depth (feet): >2

10. Vegetation on Site:
    a. Vegetation (percent as): bare (5 - rocks), grasses (95)

11. Comments :

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B7 (Upstream of Node 230) **Subbasin: Ball Creek**
**Cross Street: Jefferson Parkway**

2. Proposed Treatment Facility Type: Wet detention pond

3. Approximate Catchment Area (Acres): 102.0

4. Approximate Available Surface Area for: pond - 1/2 acre

5. Approximate Volume of Facility: 109,000 cu. ft. (2.5 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15%
   b. Vegetation (percent as): grasses (85), trees (15)

7. Outlet/Drainage Status: Culvert, weir
   a. Slope (%): 0-5
   b. Vegetation (percent as): bare (25), grasses (75)
   c. Emergency Spillway or Overflow Room Available: Yes, only if bermed next to road

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): <0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 25-30
   g. Coarse fragments/gravel: No
   h. Slope (%): 5-15
   i. Soil Structure: some fill material, mostly undisturbed soil
   j. Average seasonal water table depth (feet): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (95), trees (5)

11. Comments : In middle of developed area - will probably be developed around.

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B8 (Upstream of Node 60) **Subbasin: Ball Creek**
**Cross Street: Rembrandt Drive**

2. Proposed Treatment Facility Type: Dry detention

3. Approximate Catchment Area (Acres): 88.0

4. Approximate Available Surface Area for: dry detention 4500 sq ft

5. Approximate Volume of Facility: 18,000 cu. ft. (.4 ac-ft)

6. Borders of Facility:
   a. Slope (%): 5-15
   b. Vegetation (percent as): bare (25), grasses (50), shrubs (25)

7. Outlet/Drainage Status: weir and culvert
   a. Slope (%): 0-5
   b. Vegetation (percent as): 0-culvert
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: no - just channel

9. Soil Conditions:
   a. Soil series: Cascade silt loam
   b. Soil depth (feet): >5
   c. Estimated Permeability of Soil (in/hr): <0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 25-30
   g. Coarse fragments/gravel: No
   h. Slope (%): 5-15
   i. Soil Structure: partial fill material
   j. Average seasonal water table depth (feet): 1-2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (20), trees (80)

11. Comments: Surrounded by houses - P source
    Soil is better for wet detention

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: B9 (Upstream Node 16-20) **Subbasin: Ball Creek**
**Cross Street: Center Pointe Drive**
2. Proposed Treatment Facility Type: Dry detention/infiltration

3. Approximate Catchment Area (Acres): 642

4. Approximate Available Surface Area for: 1 acres - infiltration facility

5. Approximate Volume of Facility : cu. ft. ( ac-ft)

6. Borders of Facility:
   a. Slope (%) >15
   b. Vegetation (percent as): shrubs (5), trees (95)

7. Outlet/Drainage Status:
   a. Slope (%) >15
   b. Vegetation (percent as): shrubs (5), trees (95)
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: Yes; Forested, Palustrine

9. Soil Conditions:
   a. Soil series:Quatama
   b. Soil depth(feet): >5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: 25
   g. Coarse fragments/gravel: None
   h. Slope (%): 5-15
   i. Soil Structure : undisturbed soil
   j. Average seasonal water table depth (ft): 0-1

10. Vegetation on Site:
   a. Vegetation (percent as): shrubs (1), trees (99)

11. Comments : Not a particularly good site because of presence of forested wetland-type on site. Pond, of sorts, already exists at this location.

# Carter Creek

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: C1 (Upstream Node 50) **Subbasin: Carter Creek**
**Cross Street: Kruse Way**

2. Proposed Treatment Facility Type: Wet detention

3. Approximate Catchment Area (Acres): 89.7

4. Approximate Available Surface Area for: 3/4 - 1 acre pond

5. Approximate Volume of Facility : 98,000 cu. ft. (2.25 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): bare(25), grasses (75)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses - > 80
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: Yes - pond & grasses

9. Soil Conditions:
   a. Soil series: Huberly silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr):< 0.2
   d. Presence of Impermeable Layer: Yes
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: Approximately 20
   g. Coarse fragments/gravel: None
   h. Slope (%): 0 - 5
   i. Soil Structure : constructed pond
   j. Average seasonal water table depth (ft):1 - 2

10. Vegetation on Site:
    a. Vegetation (percent as): bare(75), grasses (15)

11. Comments : Existing catchment facility for area housing, constructed wetland

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: C2 ( Upstream Node 20-210 )

**Subbasin: Carter Creek**
**Cross Street: Meadows Road**

2. Proposed Treatment Facility Type: Wet pond/wetland

3. Approximate Catchment Area (Acres): 60

4. Approximate Available Surface Area for: 1 acre pond; 1 acre wetland

5. Approximate Volume of Facility : 435,600 cu. ft. (10 ac-ft)

6. Borders of Facility:
   a. Slope (%) 0-5
   b. Vegetation (percent as): grasses (80), trees (20)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (90), shrubs (5), trees (5)
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: Yes - emergent, Palustrine

9. Soil Conditions:
   a. Soil series: Quatama loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: approximately 25
   g. Coarse fragments/gravel: None
   h. Slope (%): 5-15
   i. Soil Structure: fill material
   j. Average seasonal water table depth (ft):>2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (90), shrubs (5), trees (5)

11. Comments :

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: C3 ( Upstream Node 12-20) **Subbasin: Carter Creek**
**Cross Street: Meadows Road**

2. Proposed Treatment Facility Type: Constructed wetland/wet pond

3. Approximate Catchment Area (Acres): 417

4. Approximate Available Surface Area for: 1.5 acre wetland; 1 acre pond

5. Approximate Volume of Facility : 217,800 cu. ft. (5 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): grasses (80), shrubs (10), trees (10)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (95), shrubs (5)
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: Yes - emergent, Palustrine

9. Soil Conditions:
   a. Soil series: Quatama
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2-0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: 25
   g. Coarse fragments/gravel: None
   h. Slope (%): 5-15
   i. Soil Structure: fill material/undisturbed soil
   j. Average seasonal water table depth (ft):>2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (90), shrubs (5), trees (5)

11. Comments :

# Country Club

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

**Subbasin: Country Club**
**Cross Street: Private Lake**

1. Facility Site Number: CC1 (Upstream Node 20)

2. Proposed Treatment Facility Type: Pond

3. Approximate Catchment Area (Acres): 70.5

4. Approximate Available Surface Area for: pond 1/2 acre

5. Approximate Volume of Facility : 65,000 cu. ft. (1.5 ac-ft)

6. Borders of Facility:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (100)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as):grasses (100)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: Yes, Pond, Golf Course?

9. Soil Conditions:
   a. Soil series: Laurelwood silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.6 - 6.0
   d. Presence of Impermeable Layer: No
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: ~ 27 average
   g. Coarse fragments/gravel: No
   h. Slope (%): 5 - 15
   i. Soil Structure: Fill material
   j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
    a. Vegetation (percent as): grasses (100)

11. Comments: Extensive fertilizer and pesticide use.

# Reese Road

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: RR1 (Upstream Node 10) **Subbasin: Reese Road** **Cross Street: SPRR**

2. Proposed Treatment Facility Type: Wet Detention & pond

3. Approximate Catchment Area (Acres): 65.0

4. Approximate Available Surface Area for: 1/2 acre pond

5. Approximate Volume of Facility: 327,000 cu. ft. (7.5 ac-ft)

6. Borders of Facility:
   a. Slope (%) > 15
   b. Vegetation (percent as): bare (RR) (10), grasses (5), shrubs (75), trees (10)

7. Outlet/Drainage Status:
   a. Slope (%) > 15
   b. Vegetation (percent as): grasses (20), shrubs (65), trees (15)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Salem silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.6 - 6.0
   d. Presence of Impermeable Layer: No
   e. Soil Texture: Silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: Gravel at > 8 inches
   h. Slope (%): 5 - 15
   i. Soil Structure: undisturbed soil, fill material on sides & RR track
   j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (90), trees (10)

11. Comments :

# Blue Heron Creek

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

**Subbasin: Blue Heron Creek**
**Cross Street: Blue Heron Way**

1. Facility Site Number: BHC1 (Upstream Node 310)

2. Proposed Treatment Facility Type: Sediment pond

3. Approximate Catchment Area (Acres): 97

4. Approximate Available Surface Area for: wetland 100 $ft^2$

5. Approximate Volume of Facility : 300 cu. ft. (.007 ac-ft)

6. Borders of Facility:
   a. Slope (%) >15
   b. Vegetation (percent as): bare (2), grasses (10), shrubs (20), trees (30)

7. Outlet/Drainage Status:
   a. Slope (%) 5-15
   b. Vegetation (percent as): bare (2), grasses (10), shrubs (20), trees (30)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Xerochrepts
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: <40
   g. Coarse fragments/gravel: gravelly
   h. Slope (%): 5 - 15
   i. Soil Structure: Undisturbed soil
   j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
    a. Vegetation (percent as): bare (2), grasses (10), shrubs (20), trees (30)

11. Comments:

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

**Subbasin: Blue HeronCreek**
**Cross Street: Blue Heron Way**

1. Facility Site Number: BHC2 (Upstream Node 20)

2. Proposed Treatment Facility Type: Sediment

3. Approximate Catchment Area (Acres): 36

4. Approximate Available Surface Area for:

5. Approximate Volume of Facility : 360 cu. ft. (.008 ac-ft)

6. Borders of Facility:
   a. Slope (%) >15
   b. Vegetation (percent as): shrubs (10), trees (90)

7. Outlet/Drainage Status:
   a. Slope (%) >15
   b. Vegetation (percent as): shrubs (10), trees (90)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: No

9. Soil Conditions:
   a. Soil series: Xerochrepts
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: loam
   f. Estimated Percent Clay of Soil: <40
   g. Coarse fragments/gravel: gravelly
   h. Slope (%): >15
   i. Soil Structure: Fill material
   j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (10), trees (90)

11. Comments:

# Lower Boones Ferry

CITY OF LAKE OSWEGO
PRF SITE EVALUATION MATRIX

1. Facility Site Number: LBF1 **Subbasin: Lower Boones Ferry**

2. Proposed Treatment Facility Type: swale

3. Comments : Basically - no access; housing on top of it. Large - well developed outfall.

## CITY OF LAKE OSWEGO
## PRF SITE EVALUATION MATRIX

1. Facility Site Number: LBF2 (Upstream Node 20) **Subbasin: Lower Boones Ferry**
   **Cross Street: Tualatin Street**

2. Proposed Treatment Facility Type: Grass Swale

3. Approximate Catchment Area (Acres): 216.0

4. Approximate Available Surface Area for: 1.1 acres

5. Approximate Volume of Facility : 1.25 million cu. ft. (28.7 ac-ft)

6. Borders of Facility:
   a. Slope (%) 5 - 15
   b. Vegetation (percent as): bare (40), grasses (60)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): bare (<5), grasses (5 - 10), shrubs (45), trees (45)
   c. Emergency Spillway or Overflow Room Available: No

8. Wetlands already present: <u>No</u>

9. Soil Conditions:
   a. Soil series:Multnomah cobbly silt loam
   b. Soil depth(feet): >5
   c. Estimated Permeability of Soil (in/hr): > 6.0
   d. Presence of Impermeable Layer: No
   e. Soil Texture: Cobbly silt loam
   f. Estimated Percent Clay of Soil: 20
   g. Coarse fragments/gravel: Cobbles
   h. Slope (%): 0 - 5
   i. Soil Structure : fill material on sides, mostly undisturbed soil
   j. Average seasonal water table depth (ft): > 2

10. Vegetation on Site:
    a. Vegetation (percent as): shrubs (50), trees (50)

11. Comments :

**CITY OF LAKE OSWEGO**
**PRF SITE EVALUATION MATRIX**

1. Facility Site Number: LBF3 (Upstream Nodes 50 & 52) **Subbasin: Lower Boones Ferry**
   **Cross Street: Lower Boones Ferry Road**
2. Proposed Treatment Facility Type: Treatment wetland/wet pond

3. Approximate Catchment Area (Acres): 88.4

4. Approximate Available Surface Area for: 3.2 acres

5. Approximate Volume of Facility : 261,000 cu. ft. (6 ac-ft)

6. Borders of Facility:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): bare (5), grasses (80), shrubs (10), trees (5)

7. Outlet/Drainage Status:
   a. Slope (%) 0 - 5
   b. Vegetation (percent as): grasses (40), shrubs (40), trees (20)
   c. Emergency Spillway or Overflow Room Available: Yes

8. Wetlands already present: Yes, emergent/pond

9. Soil Conditions:
   a. Soil series: Clackamas silt loam
   b. Soil depth (feet): > 5
   c. Estimated Permeability of Soil (in/hr): 0.2 - 0.6
   d. Presence of Impermeable Layer: No
   e. Soil Texture: silt loam
   f. Estimated Percent Clay of Soil: 30
   g. Coarse fragments/gravel: No
   h. Slope (%): 0 - 5
   i. Soil Structure : combination of fill and natural
   j. Average seasonal water table depth (ft): 0 - 1

10. Vegetation on Site:
    a. Vegetation (percent as): bare (5), grasses (80), shrubs (10), trees (5)

11. Comments: South of LBF3 - LBF3 between RR
    This one is South of RR
    Inlet - probably west of pond - culvert under LBF Rd.
    Connector between LBF3 and this one - under RR ?
    Also a connector from car wash & their detention pond.

Cascade Earth Sciences, Ltd.

3425 Spicer Drive - Albany, Oregon 97321 - (503) 926-7737 - FAX (503) 926-7758

MEMORANDUM

**DATE:** October 29, 1991

**TO:** Roger Sutherland, OTAK

**FROM:** Peggy Vogue

**RE:** **LAKE OSWEGO STORM AND SURFACE WATER MANAGEMENT MASTER PLAN - TASKS 4.1 AND 4.2 SOIL EROSION POTENTIAL AND PHOSPHORUS AVAILABILITY CATEGORIES.**

As part of the sensitive lands survey and problem areas identification for the Lake Oswego drainage basin, CES has defined those areas with high soil erosion potential and soil phosphorus availability. These areas are shown in the two maps provided (Figures 1 and 2). The following memo summarizes the procedures used in determining the soil erosion and phosphorus categories and the results. Two diskettes are provided which have the maps in a GenericCad file. If there are any problems with these files, please give Vicki Lorang of my office a call (926-7737).

## SOIL EROSION CATEGORIES AND MAPPING

Erosion hazard categories (1(low) through 5(high)) were developed for soils in the project area using the method outlined in Childs, et.al. (1991). The soils in the project site were identified using an existing soil survey (SCS 1985) map. The mapping done in the published soil survey was taken to be accurate. Twenty-six soils were identified in the study area (Table 1). Some field verification was performed during sampling for soil phosphorus. The erosion scale is relative for this area only.

Categories were developed using a modification of the Universal Soil Loss Equation (USLE) approach (Wischmeier and Smith, 1978). The soil erosion K factors (Table 1) were used with slope and slope length values developed for soil map unit slope categories to calculate partial USLE soil loss estimates. The slope length factors are shown below:

| Slope Class % | LS Factor |
|---|---|
| 0-3 | 0.132 |
| 3-8 | 0.561 |
| 8-15 | 1.544 |
| 15-30 | 2.880 |
| >30 | >5 |

The resulting categories were modified to account for the potential for saturated soil conditions to increase erosion potential. This modification was based on the depth to restrictive layer and minimum profile permeability (Table 1). The erosion hazard rankings are relative and therefore, only suitable for use in the local area.

Those soils with steep slopes and/or a very shallow depth to a restrictive layer were placed in the higher erosion categories such as Cascade (13E), Cornelius (10D and 23D), and Xerochrepts (92F and 93E). The Xerochrept soils are adjacent to Lake Oswego (Figure 1). Soils such as Amity, Clackamas, and Wapato in the Lake Oswego Area have no restrictive layers and were placed in the lowest erosion hazard category.

## SOIL PHOSPHORUS AVAILABILITY MAPPING

Five soil phosphorus availability categories were developed to delineate soils with the highest values (category 5) through soils with the lowest values (category 1). The scale is relative and is suitable for the soils in the study area and closely related surrounding areas.

Soil samples from the major soil types in the study area were collected for analysis. Laboratory analyses were conducted to determine total, organic, and water soluble phosphorus. Total phosphorus is not all available, but it is a useful measurement because it provides an upper limit for potentially available phosphorus. Organic phosphorus is measured so that both organic and inorganic components of total phosphorus can be quantified. Water soluble phosphorus gives information about the phosphorus concentration in the water that moves through or over the soil.

Soil phosphorus availability categories were developed based on measurements taken in the project area as well as available data for nearby areas in Washington and Multnomah Counties. Table 2 shows data collected in the project area. These soils were preliminarily ranked into categories based on surface inorganic phosphorus levels. It is of note that there is excellent correlation among surface inorganic phosphorus, surface water soluble phosphorus, and subsurface values for both. The preliminary rankings for each soil was compared with other data for the area (Table 3). This larger data set was used to set final rankings for soils. For cases where no measured data were available, values were assigned based on knowledge of the soils that allowed grouping them with other similar soils.

Several soils are ranked in the high phosphorus availability category; Woodburn, Multnomah, and the Xerochrepts. Woodburn and Multnomah are heavily used agricultural soils. The high phosphorus may come from current and past agricultural practices.

Categories 3 and 4 are the largest phosphorus availability groups in the Lake Oswego area (Figure 2). The Xerochrept soils (category 5) are located on the steep slopes (high erosion categories) adjacent to Lake Oswego. The Xerochrept soils are the only soils which are both in high erosion and phosphorus categories. Development on these soils may release phosphorus and sediment into the Lake if erosion is not controlled.

## REFERENCES

Childs, S.W., H.T. Davis, and W.M. Jarrell. 1991. Soil Erosion Hazard and Chemical Characteristics Mapping to Minimize Water Quality Impacts in Urban Areas. Conference Proceedings: Nonpoint Source Pollution: The Unfinished Agenda for the Protection of Our Water Quality. Tacoma, WA. March 1991.

Soil Conservation Service. 1985. Soil Survey of Clackamas County Area, Oregon. USDA Soil Conservation Service, Portland, Oregon.

Wischmeier, W.H., and D.D. Smith. 1978. Predicting rainfall erosion losses - a guide to conservation planning. Agriculture Handbook No. 537. U.S. Department of Agriculture, Washington, DC.

PV:seb
att: Tables
Figures - on disk
cc: Stuart Childs - CES
CES file (1)
PN: 913005
Doc: 54.17

## Table 1. Soil Properties in Lake Oswego Study Area (SCS 1985)

| Map Symbol | Soil Name | Slope, % | Restrictive Layer | | | Soil Erosion K factor | Soils Erosion Hazard Category |
|---|---|---|---|---|---|---|---|
| | | | Type | Depth, Inches | Permeability, Inches/hr. | | |
| 1A | Aloha Silt Loam | 0 - 3 | none | -- | -- | 0.43 | 1 |
| 1B | Aloha Silt Loam | 3 - 8 | none | -- | -- | 0.43 | 2 |
| 3 | Amity Silt Loam | | none | -- | -- | 0.32 | 1 |
| 4[1] | Briedwell Silt Loam | 0 - 7 | none | -- | -- | 0.28 | 1 |
| 5[1] | Briedwell Silt Loam | 0 - 7 | none | -- | -- | 0.28 | 1 |
| 7B[2] & 13B | Cascade Silt Loam | 3 - 8 | Fragipan | 27 - 60 | 0.06 - 0.2 | 0.37 | 1 (2) |
| 7C[2] & 13C | Cascade Silt Loam | 8 - 15 | Fragipan | 27 - 60 | 0.06 - 0.2 | 0.37 | 2 (3) |
| 13D | Cascade Silt Loam | 15 - 30 | Fragipan | 27 - 60 | 0.06 - 0.2 | 0.37 | 4 (5) |
| 13E | Cascade Silt Loam | 30 - 60 | Fragipan | 27 - 60 | 0.06 - 0.2 | 0.37 | 5 |
| 17 | Clackamas Silt Loam | | none | -- | -- | 0.32 | 1 |
| 10B[2] & 23B | Cornelius Silt Loam | 3 - 8 | Fragipan | 34 - 60 | 0.06 - 0.2 | 0.37 | 1 (2) |
| 10C[2] & 23C | Cornelius Silt Loam | 8 - 15 | Fragipan | 34 - 60 | 0.06 - 0.2 | 0.37 | 2 (3) |
| 10D[2] & 23D | Cornelius Silt Loam | 15 - 30 | Fragipan | 34 - 60 | 0.06 - 0.2 | 0.37 | 5 |
| 25 | Cove Silty Clay Loam | | Clay | 8 - 60 | < 0.06 | 0.28 | 3 |
| 29 | Dayton Silt Loam | | Clay | 16 - 39 | < 0.06 | 0.43 | 1 (2) |
| 14C | Delena Silt Loam | 3 - 12 | Fragipan | 22 - 60 | < 0.06 | 0.43 | 3 (4) |
| 37B | Helvetia Silt Loam | 3 - 8 | none | -- | -- | 0.43 | 2 |
| 37C | Helvetia Silt Loam | 8 - 15 | none | -- | -- | 0.43 | 4 |
| 37D | Helvetia Silt Loam | 15 - 30 | none | -- | -- | 0.43 | 5 |
| 21C[1] | Hillsboro Loam | 7 - 12 | none | -- | -- | 0.49 | 4 |
| 41 | Huberly Silt Loam | | Fragipan | 25 - 60 | 0.06 - 0.2 | 0.37 | 1 |
| 42 | Humaquepts, ponded[3] | | | | . | | 1 |
| 48C | Kinton Silt Loam | 8 - 15 | Fragipan | 35 - 60 | 0.06 - 0.2 | 0.43 | 4 (5) |
| 48D | Kinton Silt Loam | 15 - 30 | Fragipan | 35 - 60 | 0.06 - 0.2 | 0.43 | 5 |
| 53A | Latourell Loam | 0 - 3 | none | -- | -- | 0.37 | 1 |
| 53B | Latourell Loam | 3 - 8 | none | -- | -- | 0.37 | 1 |

## Table 1. Soil Properties in Lake Oswego Study Area (cont.)

| Map Symbol | Soil Name | Slope, % | Restrictive Layer | | | Soil Erosion K factor | Soil Erosion Hazard Category |
|---|---|---|---|---|---|---|---|
| | | | Type | Depth, Inches | Permeability, Inches/hr. | | |
| 54C | Laurelwood Silt Loam | 8 - 15 | none | -- | -- | 0.43 | 4 |
| 54D | Laurelwood Silt Loam | 15 - 30 | none | -- | -- | 0.43 | 5 |
| 54E | Laurelwood Silt Loam | 30 - 60 | none | -- | -- | 0.43 | 5 |
| 56 | McBee Silty Clay Loam | | none | -- | -- | 0.28 | 1 |
| 62B | Multnomah Cobbly Silt Loam | 0 - 7 | none | -- | -- | 0.28 | 1 |
| 70B | Powell Silt Loam | 0 - 8 | Fragipan | 15 - 60 | 0.06 - 0.2 | 0.28 | 1 (2) |
| 71B | Quatama Loam | 3 - 8 | none | -- | -- | 0.32 | 2 |
| 71C | Quatama Loam | 8 - 15 | none | -- | -- | 0.32 | 3 (4) |
| 76B | Salem Silt Loam | 0 - 7 | none | -- | -- | 0.28 | 1 |
| 76C | Salem Silt Loam | 7 - 12 | none | -- | -- | 0.28 | 2 |
| 78B | Saum Silt Loam | 3 - 8 | Basalt Bedrock | 50 | -- | 0.32 | 2 |
| 78C | Saum Silt Loam | 8 - 15 | Basalt Bedrock | 50 | -- | 0.32 | 3 |
| 78D | Saum Silt Loam | 15 - 30 | Basalt Bedrock | 50 | -- | 0.32 | 4 |
| 78E | Saum Silt Loam | 30 - 60 | Basalt Bedrock | 50 | -- | 0.32 | 5 |
| 84 | Wapato Silty Clay Loam | | none | -- | -- | 0.32 | 1 |
| 91A | Woodburn Silt Loam | 0 - 3 | Fragipan | 31 - 60 | 0.06 - 0.2 | 0.43 | 1 |
| 91B | Woodburn Silt Loam | 3 - 8 | Fragipan | 31 - 60 | 0.06 - 0.2 | 0.43 | 2 (3) |
| 91C | Woodburn Silt Loam | 8 - 15 | Fragipan | 31 - 60 | 0.06 - 0.2 | 0.43 | 3 (4) |
| 92F | Xerochrepts and Haploxerolls | Very Steep | none | -- | -- | 0.43 | 5 |
| 93E | Xerochrepts rock outcrop, complex | Moderately Steep | Basalt Bedrock | 15 - 40 | -- | 0.43 | 5 |

1 Briedwell and Hillsboro soils are located in Washington County.
2 Cascade and Cornelius soils have a different map symbol in Multnomah county than in Clackamas County.
3 Humaquepts do not have a slope class or K factor, but are regarded as a low erosion hazard by the SCS (1985)

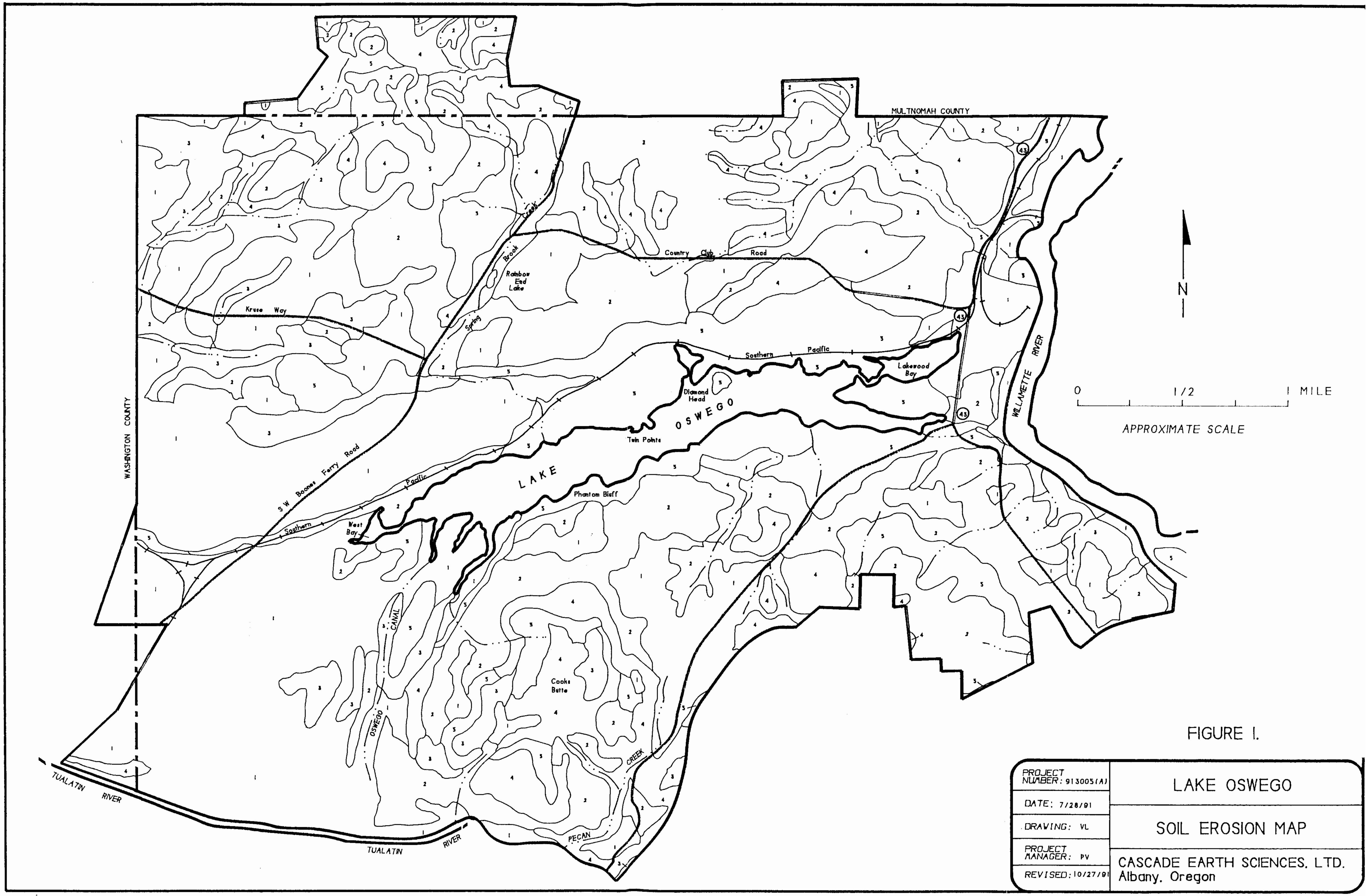



FIGURE I.

| | |
|---|---|
| PROJECT NUMBER: 913005(A) | LAKE OSWEGO |
| DATE: 7/28/91 | |
| DRAWING: VL | SOIL EROSION MAP |
| PROJECT MANAGER: PV | CASCADE EARTH SCIENCES, LTD. Albany, Oregon |
| REVISED: 10/27/91 | |

**Table 2. Soil Phosphorus Analysis for Lake Oswego Basin Soils**

| Soils | Surface Layer | | | | Subsurface Layer | | | | Phosphorus Availability Category[4] |
|---|---|---|---|---|---|---|---|---|---|
| | Inorganic P[1] mg/Kg soil[2] | Total P mg/kg soil | Water Soluble | | Inorganic P mg/kg Soil | Total P mg/kg Soil | Water Soluble | | |
| | | | mg/kg Soil | ppm Soln[3] | | | mg/kg Soil | ppm Soln | |
| Aloha | 668 | 1030 | 0.025 | 0.5 | 660 | 830 | 0.025 | 0.5 | 3 |
| Cascade | 1840 | 2300 | 0.16 | 3.2 | 973 | 1020 | 0.045 | 0.9 | 3 |
| Cornelius | 1130 | 1440 | 0.075 | 1.5 | 973 | 1040 | 0.025 | 0.5 | 3 |
| Cove | 550 | 940 | 0.015 | 0.3 | 425 | 520 | 0.02 | 0.4 | 1 |
| Helvetia | 715 | 1080 | 0.03 | 0.6 | 948 | 1020 | 0.025 | 0.5 | 3 |
| Huberly | 705 | 920 | 0.035 | 0.7 | 575 | 700 | 0.005 | 0.1 | 2 |
| Kinton | 1225 | 1660 | 0.07 | 1.4 | 918 | 1070 | 0.035 | 0.7 | 3 |
| Laurelwood | 693 | 840 | 0.045 | 0.9 | 615 | 740 | 0.06 | 1.2 | 1 |
| Multnomah | 1740 | 2060 | 0.13 | 2.6 | 2090 | 2340 | 0.225 | 4.5 | 5 |
| Quatama | 1303 | 1640 | 0.24 | 4.8 | 973 | 1060 | 0.11 | 2.2 | 4 |
| Salem | 1468 | 1590 | 0.13 | 2.6 | 1075 | 1490 | 0.375 | 7.5 | 4 |
| Saum | 783 | 1070 | 0.095 | 1.9 | 668 | 790 | 0.08 | 1.6 | 2 |
| Xerochrept - 92 | 1948 | 2530 | 0.475 | 9.5 | 1765 | 2240 | 0.205 | 4.1 | 5 |
| Xerochrept - 93 | 1513 | 2020 | 0.255 | 5.1 | 1908 | 2310 | 0.185 | 3.7 | 5 |

1 Inorganic P was calculated as the difference between Organic P (not shown) and Total P.
2 mg/kg soil = milligrams of phosphorus per kilogram of soil.
3 soln = solution.
4 Phosphorus availability category may be the result of averaging Lake Oswego values with those of previously sampled drainages near Lake Oswego (see Table 3).

Table 3. Soil Phosphorus Availability Categories

| Soil Series | Soil Phosphorus Availability Category | Data Source |
|---|---|---|
| Aloha | 3 | Lake Oswego, Butternut Creek |
| Amity | 3 | Not Sampled[1] |
| Briedwell | 4 | Not Sampled[1] |
| Cascade | 3 | Lake Oswego, Fanno Creek |
| Clackamas | 4 | Not Sampled[1] |
| Cornelius | 3 | Lake Oswego, Butternut and Fanno Creeks |
| Cove | 1 | Lake Oswego |
| Dayton | 2 | Not Sampled[1] |
| Delena | 2 | Fanno Creek |
| Helvetia | 3 | Lake Oswego |
| Hillsboro | 3 | Hedges Creek |
| Huberly | 2 | Lake Oswego, Fanno and Hedges Creeks |
| Humaquepts | 1 | Not Sampled[1] |
| Kinton | 3 | Lake Oswego |
| Latourell | 4 | Not Sampled[1] |
| Laurelwood | 1 | Lake Oswego |
| McBee | 2 | Not Sampled[1] |
| Multnomah | 5 | Lake Oswego |
| Powell | 3 | Not Sampled[1] |
| Quatama | 4 | Lake Oswego, Butternut and Hedges Creeks |
| Salem | 4 | Lake Oswego |
| Saum | 2 | Lake Oswego, Fanno and Hedges Creeks |
| Wapato | 2 | Fanno Creek |
| Woodburn | 5 | Butternut Creek |
| Xerochrepts - 92 | 5 | Lake Oswego |
| Xerochrepts - 93 | 5 | Lake Oswego |

1 The soil phosphorus availability category for soils not sampled was estimated using the values of other sampled soils in the soil association group for this soil.

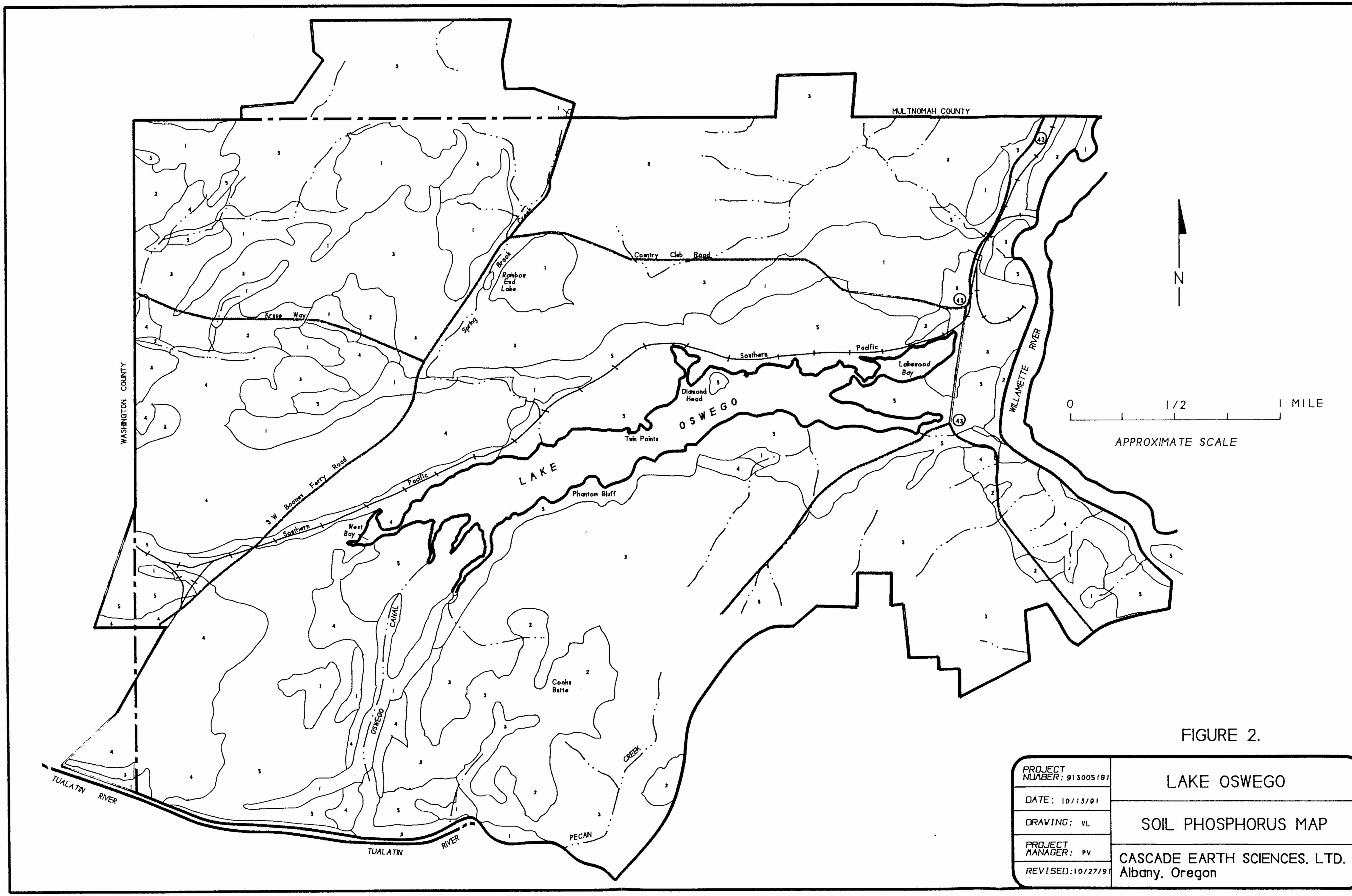



FIGURE 2.

| | |
|---|---|
| PROJECT NUMBER: 913005(B) | LAKE OSWEGO |
| DATE: 10/13/91 | |
| DRAWING: VL | SOIL PHOSPHORUS MAP |
| PROJECT MANAGER: PV | CASCADE EARTH SCIENCES, LTD.<br>Albany, Oregon |
| REVISED:10/27/91 | |

**Date:** March 24, 1992

**To:** Roger Sutherland

**From:** Brad Moore

**Subject:** Lake Oswego Storm and Surface Water Management Master Plan OTAK Project No. 3333.9 Technical Memorandum (Task #7)

**Job No.:** 3105-03

# CITY OF LAKE OSWEGO SURFACE WATER MANAGEMENT PROGRAM IMPLEMENTATION SCHEDULE

This memorandum presents a schedule for implementation of specific non-structural and structural activities in conjunction with the recommended surface water management program for the City of Lake Oswego, Oregon. The purpose of the schedule is to demonstrate tasks completed and tasks remaining to be completed as part of the City's program to meet Department of Environmental Quality(DEQ) requirements for control of nonpoint pollution sources within the Tualatin River Basin.

The attached schedule presents non-structural (operating program) elements of the proposed stormwater utility including :

**Finance and Billing**
**Operations and Maintenance**
**Water Quality Management**
**Plan Review and Construction Inspection**
**Regulation**
**Public Involvement**

The schedule also presents structural (capital improvement program) elements of the stormwater utility including:

**Water Quantity**
*Major Drainages*
*Small Works*

**Water Quality**
*Pollutant Reduction Facilities*
*Stream Rehabilitation*

## Tasks Completed

It should also be noted that certain other tasks, not present on the attached schedule, have already been or are concurrently being completed by the City of Lake Oswego. These include the following:

| | |
|---|---|
| **Subbasin Plans (SWM Master Plan)** | March 1992 |
| **Oswego Lake Study** | March 1992 |
| **Water Quality Monitoring Plan** | March 1992 |
| **Implementation Plan** | March 1992 |
| **Best Management Practices(BMP) Handbook** | August 1991 |
| **Erosion Control Handbook** | January 1991 |
| **Nonpoint Source Management Plan** | March 1990 |

## Associated Functions

### Septic Tank Program

The City is currently reinitiating its septic tank hook-up program in the City. Also, the City is currently reviewing and updating the sanitary sewer master plan for the area within the urban services boundary.

### Emergency Spill Response

The City has developed an industrial pretreatment ordinance and and an emergency spill response for spills into the sanitary sewer system. The City will be developing a similar emergency spill response for the storm sewer system.

| CITY OF LAKE OSWEGO<br>SWM IMPLEMENTATION SCHEDULE | 1992 | 1993 | 1994 | 1995 | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 |
|---|---|---|---|---|---|---|---|---|---|---|
| **I. OPERATING PROGRAM** | | | | | | | | | | |
| A. Finance and Billing | | | | | | | | | | |
| 1 Implement Utility | | | | | | | | | | |
| 2 Implement System Dev. Charge | | | | | | | | | | |
| 3 Collect Utility and System Dev. Charge | | | | | | | | | | |
| B. Operations and Maintenance | | | | | | | | | | |
| 1 Catch Basin Cleaning | | | | | | | | | | |
| 2 Street Sweeping | | | | | | | | | | |
| 3 Storm Line Cleaning | | | | | | | | | | |
| 4 Open Channel Maintenance | | | | | | | | | | |
| 5 Miscellaneous Activities | | | | | | | | | | |
| C. Water Quality Management | | | | | | | | | | |
| 1 Sensitive Land Planning | | | | | | | | | | |
| a. Stream Corridor Dev. Standard | | | | | | | | | | |
| b. Wetlands Dev. Standard | | | | | | | | | | |
| c. Identify and Prioritize Sens. Lands | | | | | | | | | | |
| 2 Water Quality Monitoring | | | | | | | | | | |
| a. Grab Samples | | | | | | | | | | |
| b. Composite Samples | | | | | | | | | | |
| 3 NPDES Permit | | | | | | | | | | |
| a. Part I | | | | | | | | | | |
| b. Part II | | | | | | | | | | |
| c. Implementation | | | | | | | | | | |
| 4 Erosion Control | | | | | | | | | | |
| D. Plan Review and Construction Inspection | | | | | | | | | | |
| 1 Development Plan Review | | | | | | | | | | |
| 2 Construction Inspection | | | | | | | | | | |
| 3 Building Plan Review and Inspection | | | | | | | | | | |
| E. Regulation | | | | | | | | | | |
| 1 Erosion Control Standard | | | | | | | | | | |
| 2 Drainage Standard | | | | | | | | | | |
| 3 Drainage Manual | | | | | | | | | | |
| 4 Administer Flood Insurance Program | | | | | | | | | | |
| 5 SW Admendments to Comp Plan | | | | | | | | | | |
| F. Public Involvement | | | | | | | | | | |
| 1 Stream Walk | | | | | | | | | | |
| 2 Catch Basin Stenciling | | | | | | | | | | |
| 3 Stream Corridor Cleanup | | | | | | | | | | |
| 4 Publications | | | | | | | | | | |
| 5 Backyard Stream Rehabilitation | | | | | | | | | | |
| **II. CAPITAL IMPROVEMENT PROGRAM** | | | | | | | | | | |
| A. Water Quantity | | | | | | | | | | |
| 1 Major Drainages | | | | | | | | | | |
| 2 Small Works | | | | | | | | | | |
| B. Water Quality | | | | | | | | | | |
| 1 Pollution Reduction Facilities | | | | | | | | | | |
| Springbrook Creek - SC 120 | Buy | Des. Bld. | | | | | | | | |
| Lower Boones Ferry - LBF 2 | | Buy | | Des. Bld. | | | | | | |
| Springbrook Creek - SC 102 | | | Buy | | | Des. Bld. | | | | |
| Springbrook Creek - SC 108 | | | Buy | | | | | Des. Bld. | | |
| Lower Boones Ferry - LBF 3 | | | Buy | | | | | | | Des. Bld. |
| Reese Road - RR 1 | | | | | | | | | | *Buy 2004, Bld. 2007* |
| Lost Dog Creek - LD 2 | | | | | | | | | | *Buy 2004, Bld. 2009* |
| Lost Dog Creek - LD 3 | | | | | | | | | | *Buy 2004, Bld. 2011* |
| 2 Stream Rehabilitation | | | | | | | | | | |
| C. Senstive Lands Protection | | | | | | | | | | |

Date: March 17, 1992

To: Roger Sutherland

From: Brad Moore

Subject: Lake Oswego Surface Water Management Master Plan
OTAK Project No. 3333.9
Technical Memorandum (Task #7)

Job No.: 3105-03

# CITY OF LAKE OSWEGO
# WATER QUALITY MONITORING PROGRAM

The purpose of this memorandum is to set forth guidance for a water quality monitoring program designed to meet DEQ requirements. As such the monitoring program is specifically designed to monitor the effectiveness of both future enhanced maintenance practices and implementation of pollutant reduction facilities for water quality control and improvement within the Lake Oswego study area.

Of particular concern within the study area is control of phosphorous and sediments. It is beyond the scope of this memorandum to define a specific program for pollutant source identification and specific equipment recommendations and costs. However, the last section of this memorandum presents budget level costs for sampling equipment and analysis.

The following pages present an initial outline, suggested monitoring approach and figures/tables presenting the City's current monitoring efforts.

# MONITORING PROGRAM

## General Approach

## Monitoring Considerations

### *Field Investigation*

### *Sampling Period and Frequency*

*First Flush*
*Peak Flow*
*Base Flow*

### *Sampling Locations*

### *Sampling Parameters*

*Pollutants of Concern*
*Flows*

### *QA/QC Measures*

## Budget-Level Costs

# CITY OF LAKE OSWEGO
# WATER QUALITY MONITORING PROGRAM

## MONITORING PROGRAM

The primary objectives of a long-term water quality monitoring program for the City of Lake Oswego are as follows:

- Provide water quality data necessary to demonstrate compliance with State Department of Environmental Quality (DEQ) Load Allocation(LA) requirements;

- Determine the effectiveness of implemented non-structural and structural best management practices (BMPs).

To meet the aforementioned objectives, it is necessary to identify pollutants of concern under both existing and future conditions of system maintenance and structural controls. Therefore, a phased approach is necessary.

### General Approach

A phased monitoring approach to water quality monitoring is recommended for the Lake Oswego study area. Initial phases of the program will provide baseline data for pollutant concentrations and loadings under existing land use, maintenance practices and structural system conditions. Subsequent phases will provide similar data to evaluate the relative effectiveness of enhanced maintenance practices and pollutant reduction facilities.

The long-term water quality monitoring program is an extension of the efforts included within the Lake Oswego Surface Water Management Master Plan (LOSWMMP) and water quality monitoring efforts currently being conducted by City staff. The following sections provide recommendations for conducting a water quality monitoring program in the Lake Oswego study area.

### Monitoring Considerations

The primary features of the monitoring program that need to be defined include additional investigative activities, sampling period and frequency, sampling locations, water quality parameters, and quality assurance/quality control (QA/QC) measures. These features are discussed further in the following sections.

#### *Field Investigation*

Results of the current study (LOSWMMP) and previous water quality grab samples form the basis for selecting monitoring locations. As such, much of the field investigation necessary to support location selection has been completed.

*Sampling Period and Frequency*

Peak runoff periods, and therefore the bulk of pollutant loadings, generally occur during intense rainfall events. Sample collection should occur during several storm events (5 to 6) annually to obtain representative contaminant loadings at the selected sampling stations. A dry-weather sampling session should also be conducted to characterize water quality and pollutant loadings during baseflow conditions.

Flow-proportional composites as well as first-flush grab samples should be collected at selected stations. First-flush samples are subject to less dilution because they are collected prior to peak discharges.

Samples should be collected during one dry-weather event and five to six wet-weather events. The dry-weather samples should be collected following a period during which there had been no precipitation for at least 120 hours. The following criteria should be used for the wet-weather sampling:

- The storm event should have an intensity of at least 0.1 inches per hour during the first hour and a duration of several hours.
- The storm event should be preceded by a dry period of at least 96 hours.

*Sampling Locations*

Currently, the City is taking monthly grab samples at 10 locations as given in **Table 1** and **Figures 1 - 5**. It is suggested that future sampling be limited to a few sites with varying objectives in mind.

First, it is suggested that one sampling location be established to simply monitor the effectiveness of enhanced maintenance practices in an area of homogeneous land use. It is suggested that the upper watershed area of Springbrook Creek affords this opportunity at a location downstream of Rainbow Drive. A 24-inch outfall drains an area approximately 90 acres in size and comprised predominantly of R7.5 to R10 residential density land use. Flow-weighted composite samples should be collected during the wet-weather sampling sessions.

Secondly, it is suggested that existing Station No. 4 be used to monitor water quality from the Springbrook Creek watershed. Again, flow-weighted composite samples should be collected during the wet-weather sampling sessions.

Thirdly, once the proposed pollutant reduction facility is in place near the mouth of Springbrook Creek a third monitoring station should be installed upstream of the pollutant reduction facility to monitor stormwater inflow concentrations and loadings.

This approach should provide good baseline data, as well as the water quality response to implementation of best management practices. This data could in turn be compared to the volume-weighted Event Mean Concentrations(EMCs) published in the LOSWMMP and then projected to similar areas and management practices on a City-wide basis.

*Sampling Parameters*

Currently the City is monitoring drainages for total phosphates (PO4) as given in **Table 2** and **Figures 6 - 9**. The only apparent trend is that total phosphates appear to be higher during dry weather periods(Aug.-Oct.). The deviations in the previous grab sample data indicate that it will be necessary to collect composite samples for future monitoring efforts, however the grab sample data may be useful in siting future water quality sampling locations. It should be noted that total phosphorous(TP) concentrations are three times the total phosphates(PO4) concentrations (PO4 = 3 * TP). Future sampled parameters should consist of total phosphorus(TP), Total Kjeldahl Nitrogen(TKN), suspended solids(SS), biochemical oxygen demand(BOD), chemical oxygen demand(COD), fecal coliform(FC), pH, hardness, conductivity, oil and grease, surfactants, and total organic carbon(TOC). These parameters should be measured in both grab(dry-weather) and composite(wet-weather) samples. The importance of these parameters is demonstrated in **Table 3.**

Measurement of flows or the use of a rating curve (i.e., calibrated relationship between stream height and measured discharges) is also necessary to obtain composite samples that are weighted for flows. Flow data are essential for proper data interpretation because high flows dilute pollutant concentrations, masking the actual high loadings that can occur during storm events. It will not be necessary to collect rainfall data as a nearby rain gage already exists at Portland Community College(PCC)-Sylvania campus.

The concentrations of the water quality parameters measured should be expressed in milligram per liter (mg/L) or microgram per liter (ug/L). A concentration of 1 mg/L is approximately equal to 1 part per million (ppm) and 1 ug/L is approximately equal to 1 part per billion (1 ppb).

Recommended detection limits for parameters analyzed are presented in **Table 4.** These parameters have been recommended for analysis by U.S. EPA under the NPDES regulations. The laboratory testing procedures for these parameters reflect the stringent and precise level of analysis required to detect environmental concentrations that pose a risk for aquatic life or other beneficial uses. Detection limits are generally defined as the lowest measurable concentration reliably detectable by a particular methodology.

*Sample Collection*

It is recommended that composite samplers be used to conduct the wet-weather portion of the water quality monitoring. This is in response to the fact that pollutant concentrations <u>and</u> loadings will be important both in the short-term and long-term. The dry-weather sampling session can consist of grab samples and could be conducted by two people.

Grab samples should be collected from the middle of the stream. A rod with a bottle attached to the end can be used when the middle of the channel is inaccessible. The sample bottle should be rinsed three times with stream water before the sample is collected.

Sample collection, storage, and analytical procedures should follow U.S. EPA quality assurance protocols (U.S. EPA 1979, 1982). All samples should be stored in coolers with ice and maintained at $4^{o}$ C during transit to the laboratory.

*QA/QC Measures*

A quality assurance/quality control program should be developed and implemented as part of the long-term monitoring program to provide assessment of techniques used during sample collection, storage, and analysis (U.S. EPA 1979, 1982). The QA/QC plan should specify sample collection and preservation methods, maximum sample holding times, chain-of-custody procedures, analytical techniques, accuracy and precision checks, detection limits, and data recording and documentation procedures.

## Budget-Level Costs

Automatic composite sampling stations such as an ISCO 3200 series flow meter combined with an ISCO series 3700 sampler are expected to have a budget level installed cost of approximately $10,000. With two sites anticipated in the first year of monitoring, and an additional site anticipated after construction of the first pollutant reduction facility, $30,000 should be budgeted for the first 2 to 3 year period of sampling for equipment only. Recommended future sampling locations are shown in **Figures 10 and 11.** Budget level sample analysis costs are as follows:

| Parameter | Cost |
|---|---|
| pH | $10.00 |
| Fecal Coliform | $20.00 |
| BOD | $40.00 |
| COD | $30.00 |
| TSS | $25.00 |
| TP | $30.00 |
| TKN | $40.00 |
| TOC | $40.00 |
| Surfactants | $40.00 |
| Oil and Grease | $45.00 |
| Hardness | $15.00 |
| **Total** | **$335.00** |

Therefore, a budget level sample cost per site per event is approximately $350. Assuming six events sampled annually at three sites, annual costs for analysis would be approximately $6300. Over the course of time and as sampling indicates, the City may elect to eliminate some parameters found to be non-significant.

# References

# REFERENCES

American Public Health Association. 1989. Standard Methods for the Examination of Water and Wastewater. 17th ed. APHA, Washington, DC.

Krenkel, P.A. , and V. Novotny. 1980. Water Quality Management. Academic Press, NY. p. 225.

Lager, J.A., W.G. Smith, W.G. Lynard, R.M. Finn, and J.E. Finnemore. 1977. Urban Stormwater Management and Technology: Update and User's Guide. EPA/600/8/77/014. Prepared by Metcalf and Eddy, Inc., Palo Alto, Calif., for U.S. EPA Municipal Environmental Resource Laboratory, Cincinnati, OH.

Nationwide Urban Runoff Program. 1983. Results of the Nationwide Urban Runoff Program. Volume 1-Final Report. U.S. Environmental Protection Agency, Office of Water Program Operations, Washington, DC.

Novotny, V., and G. Chesters. 1981. Handbook of Nonpoint Pollution. Van Nostrand Reinhold Company, New York, NY. p. 555.

Pitt, R., and P. Bissonette. 1984. Bellevue Urban Runoff Program, Summary Report. Prepared for U.S. Environmental Protection Agency, City of Bellevue, WA.

Schueler, T.R. 1987. Controlling Urban Runoff: A Practical Manual for Planning and Designing Urban Best Management Practices. Prepared for the Washington Metropolitan Water Resources Planning Board. Metropolitan Washington Council of Governments, Department of Environmental Programs.

U.S. Environmental Protection Agency. 1976. Quality Criteria for Water. U.S. EPA, Washington, D.C.

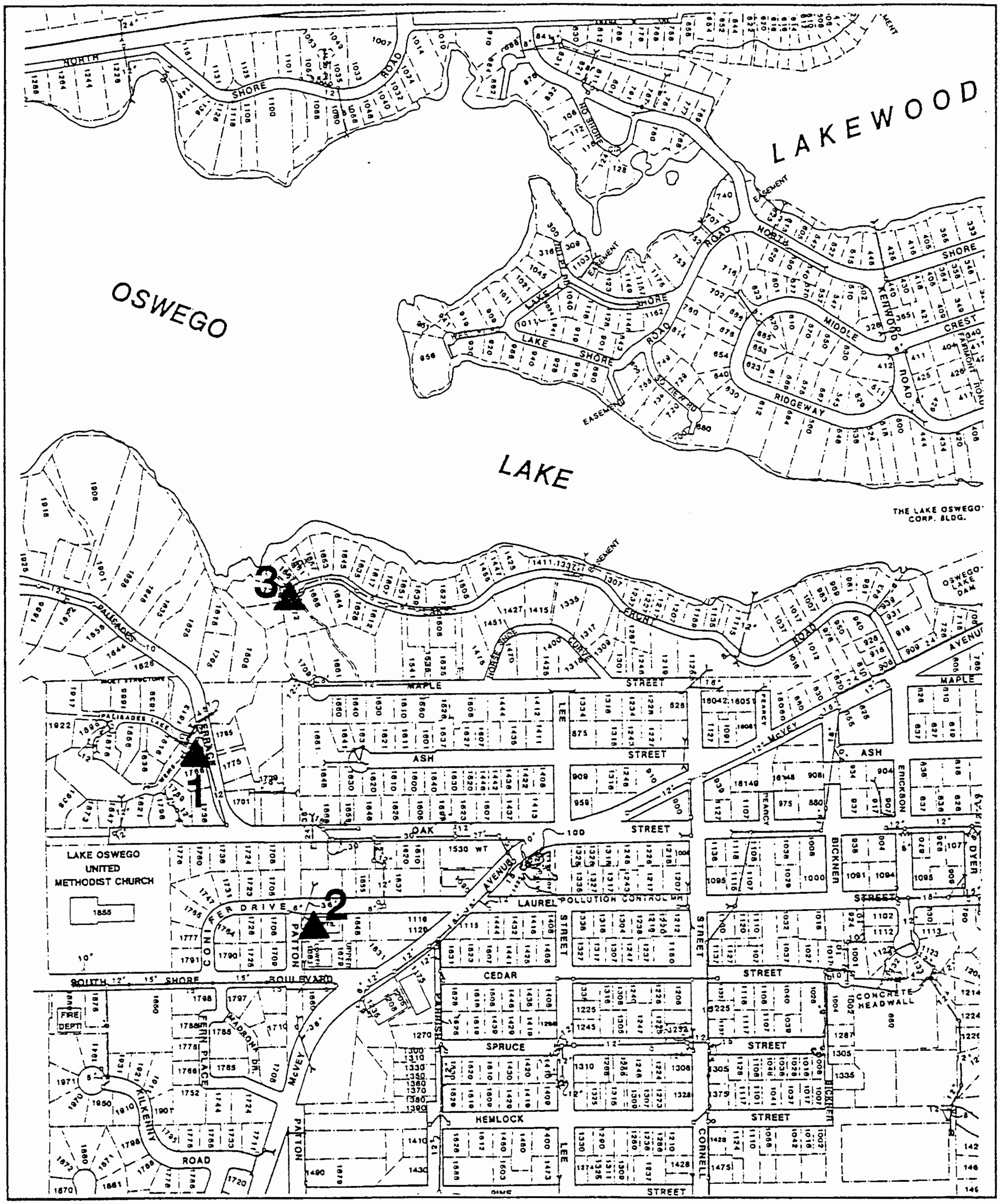
U.S. Environmental Protection Agency. 1979. Handbook for analytical quality control in water and wastewater laboratories. EPA-600/4-79-019. U.S. EPA Environmental Monitoring and Support Laboratory, Cincinnati, OH.

U.S. Environmental Protection Agency. 1982. Handbook for Sampling and Sample Preservation of Water and Wastewater. EPA-600-82-029. U.S. EPA, Environmental Monitoring and Support Laboratory, Cincinnati, OH. 402 pp.

U.S. Environmental Protection Agency. 1986. Quality criteria for water. Update #2 - 1987. EPA 440/5-86-0001. U.S. EPA, Office of Water Regulations and Standards, Washington, DC.

U.S. Environmental Protection Agency. 1988. National Water Quality Inventory 1988. Draft Report to the U.S. Congress. Prepared by U.S. EPA Headquarters, Washington, DC.

# Figures

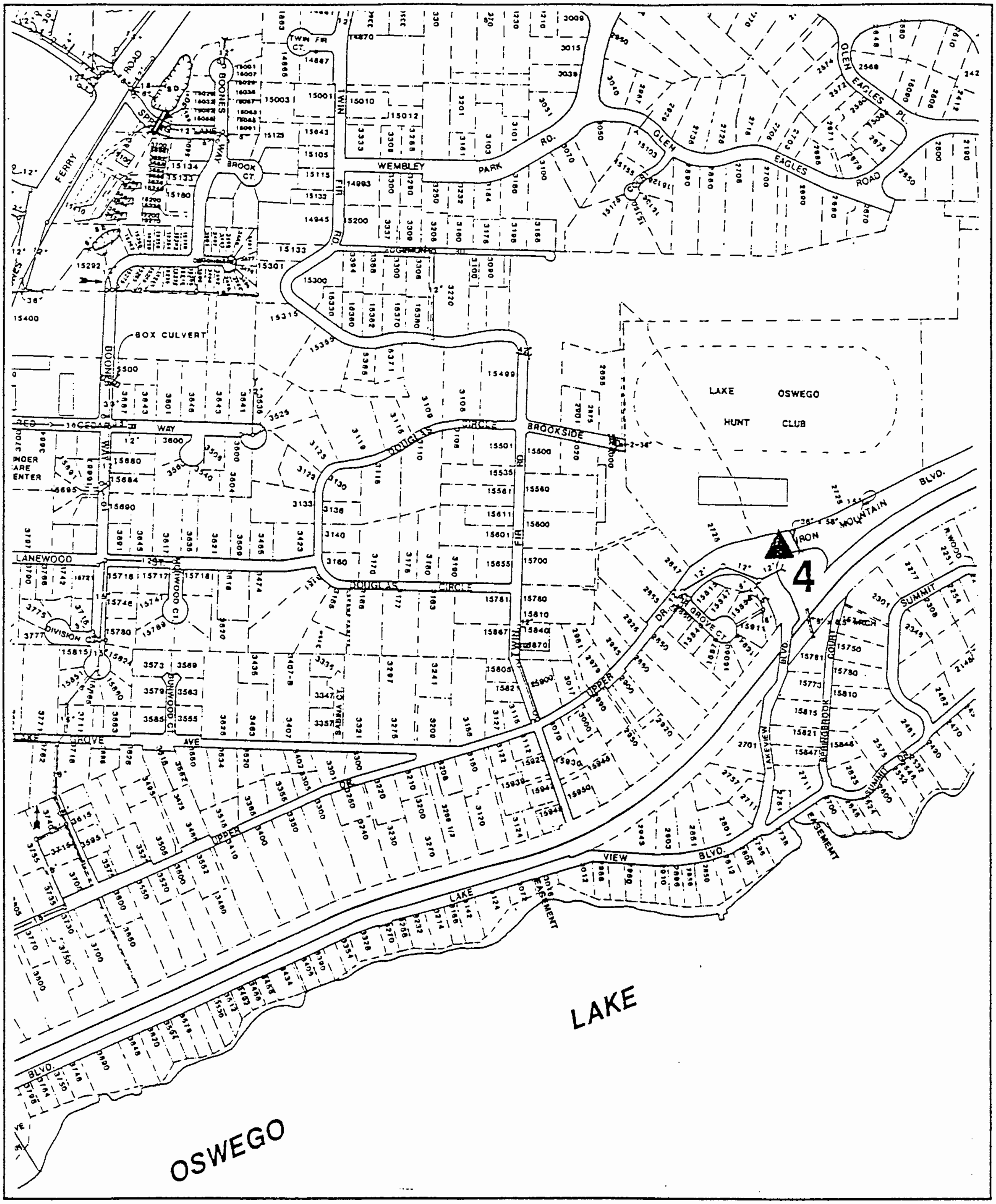



KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

CITY OF LAKE OSWEGO

FIGURE 1 Water Quality Sampling Locations
Lost Dog Creek

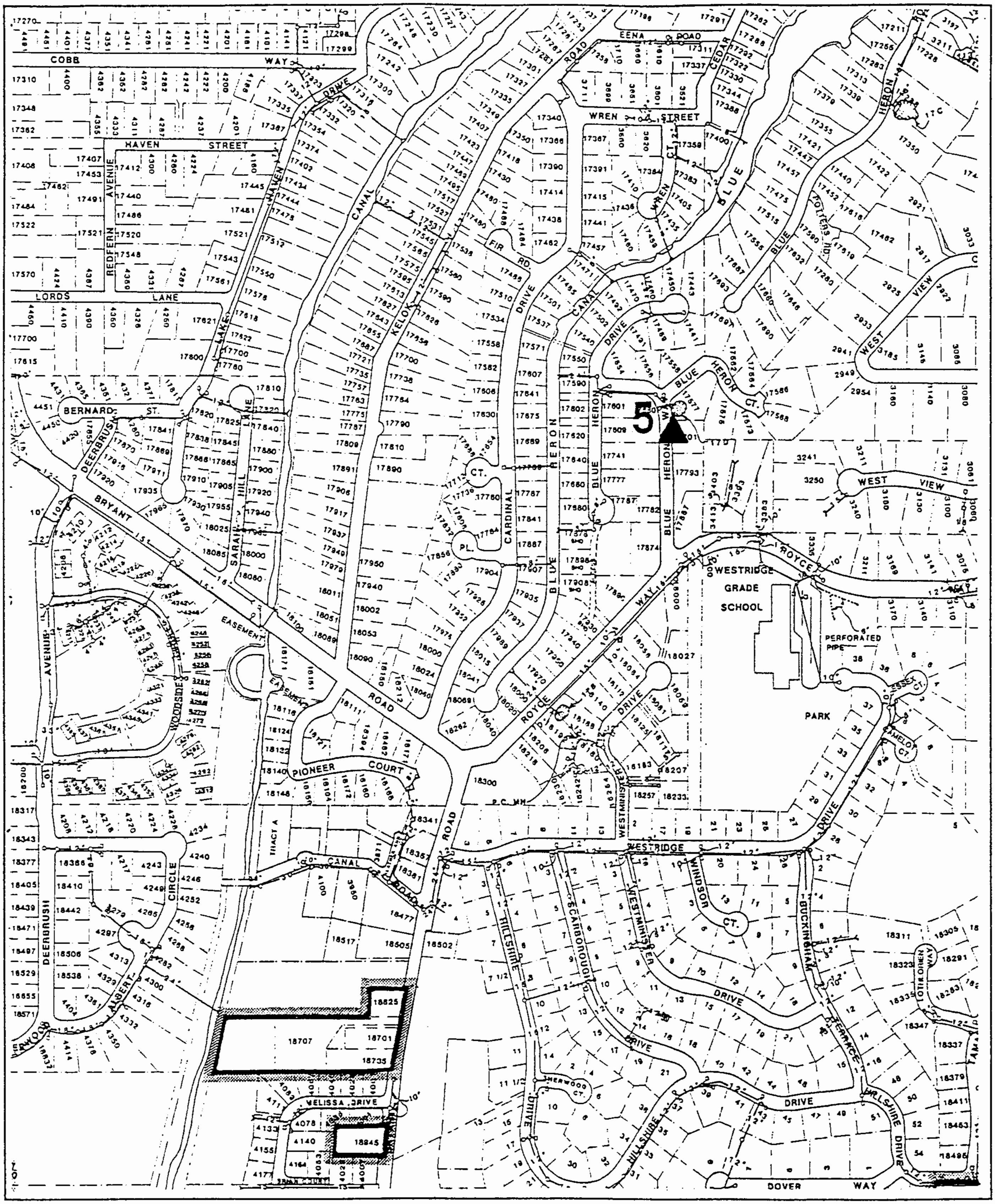



KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

CITY OF LAKE OSWEGO

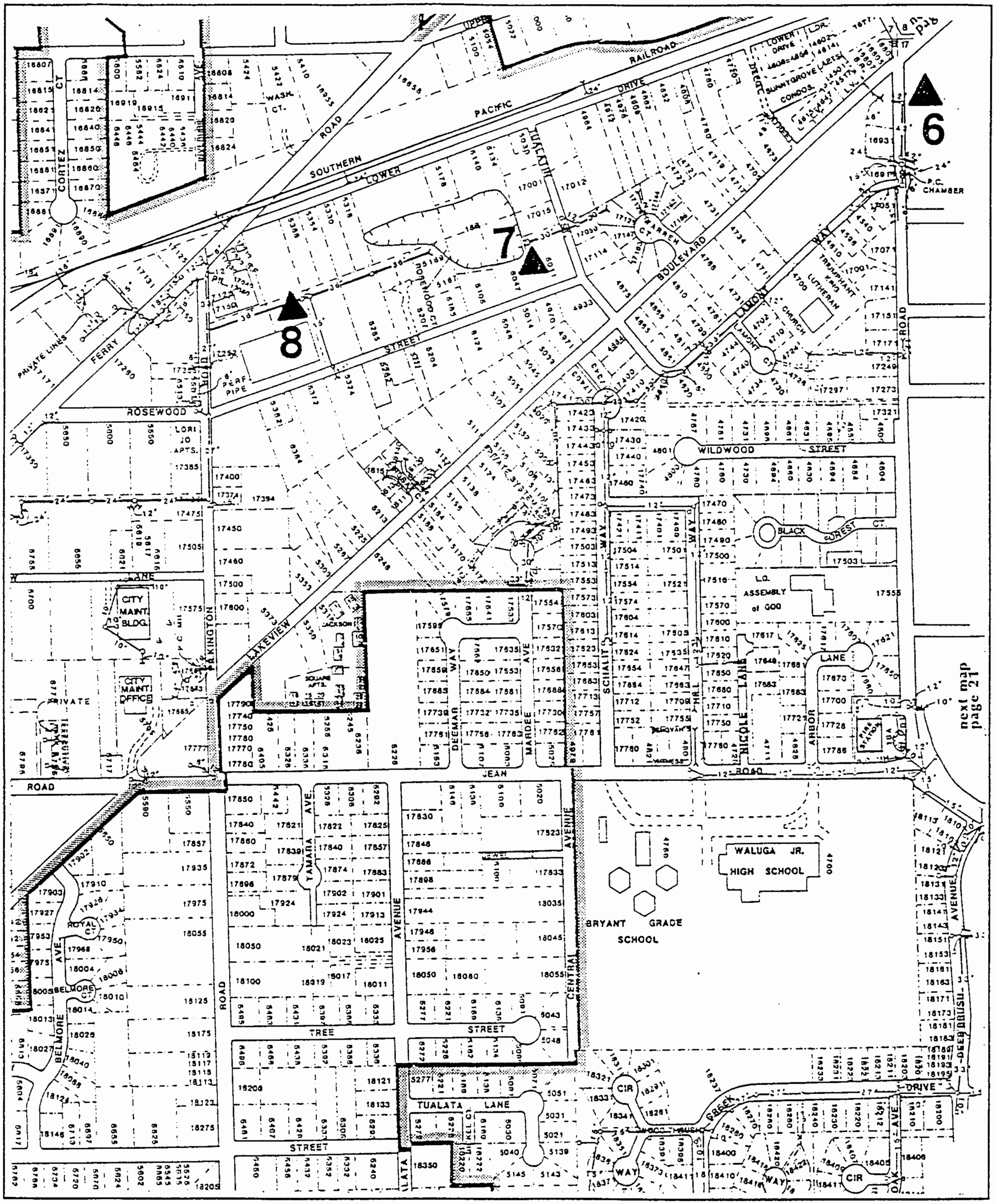
FIGURE 2 Water Quality Sampling Locations
Springbrook Creek




KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

CITY OF LAKE OSWEGO
FIGURE 3 Water Quality Sampling Locations
Blue Heron Creek

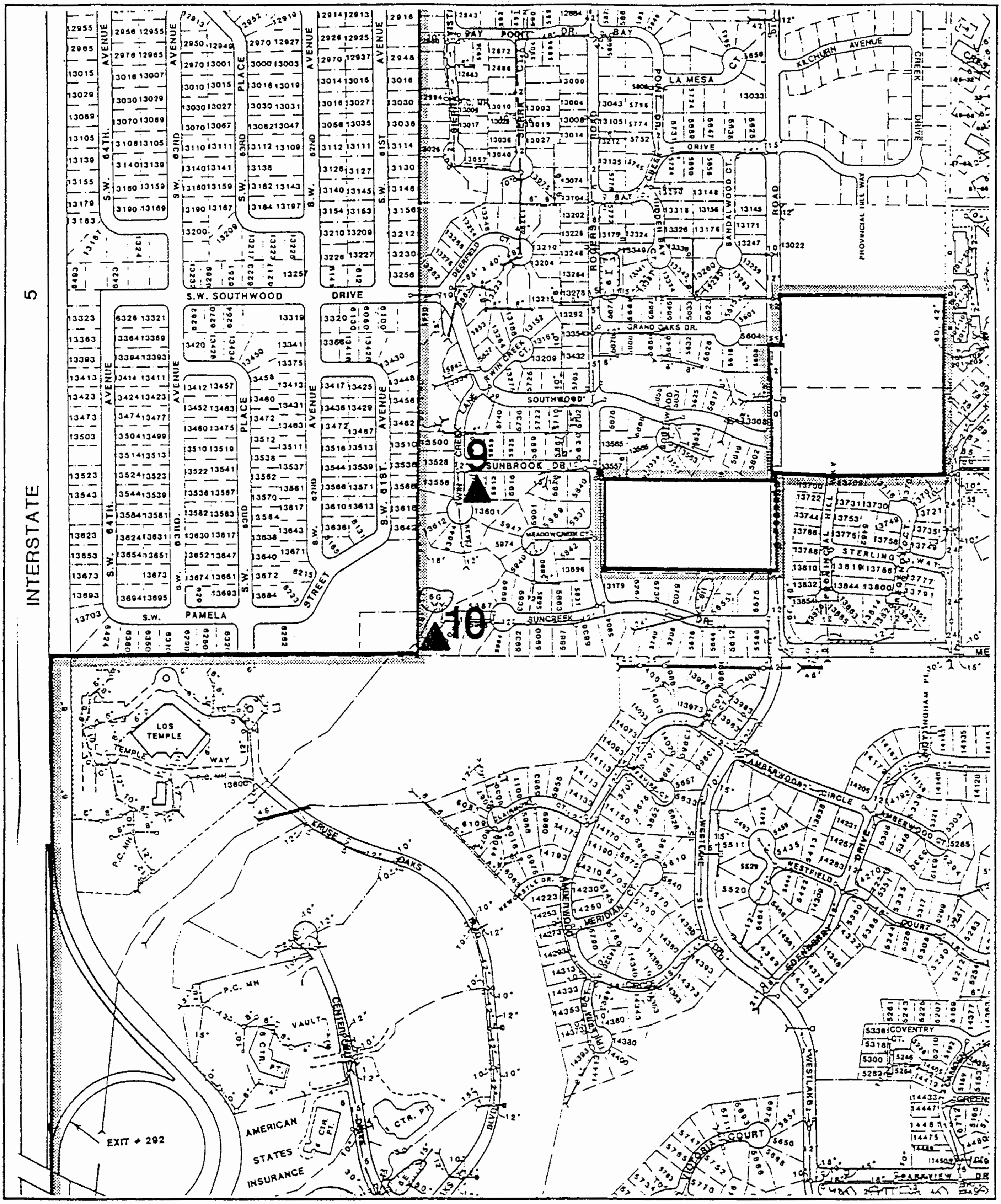



KCM


Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223


CITY OF LAKE OSWEGO

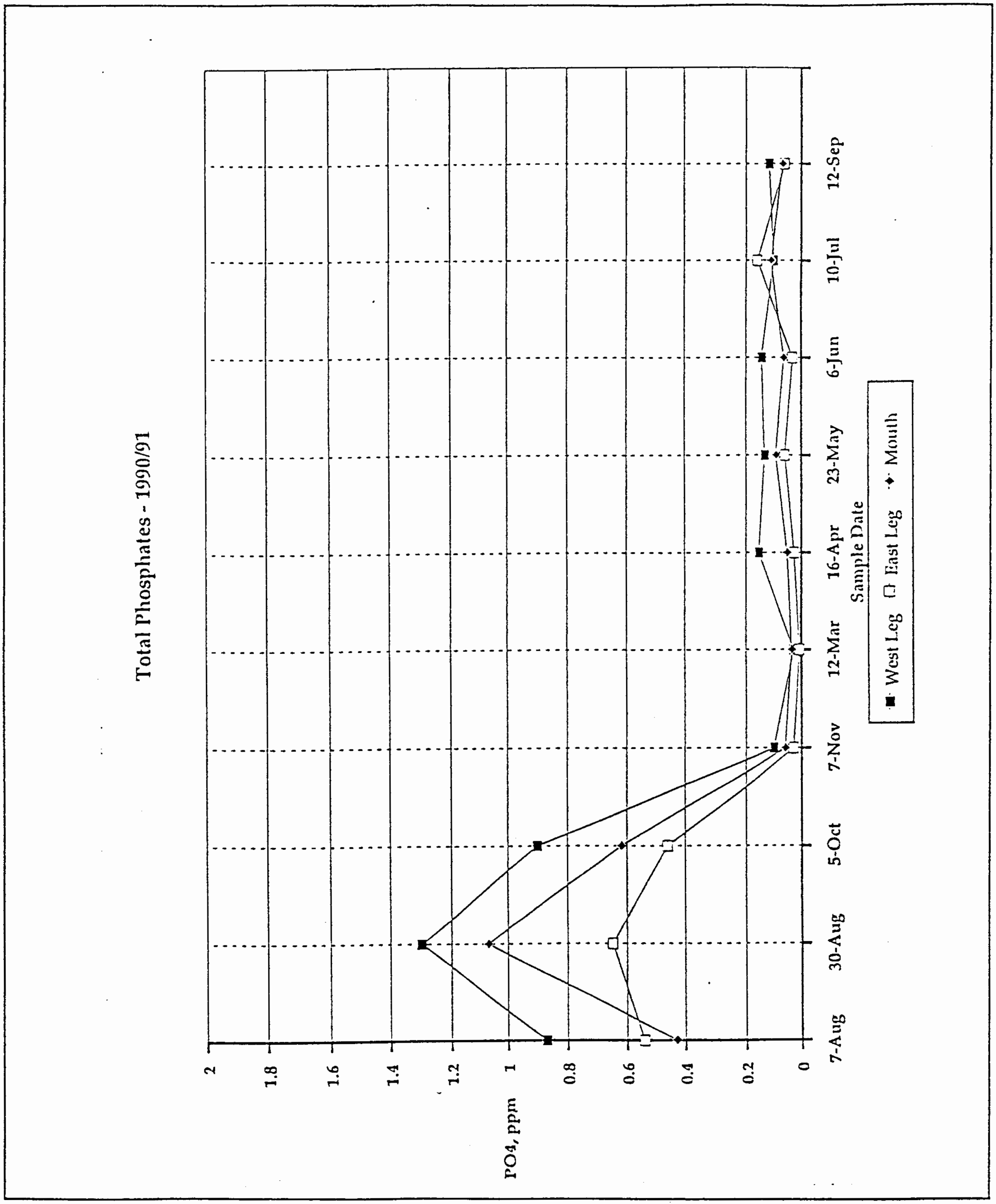
FIGURE 4 Water Quality Sampling Locations
Lower Boones Ferry



**KCM**

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

CITY OF LAKE OSWEGO
FIGURE 5 Water Quality Sampling Locations
Ball Creek

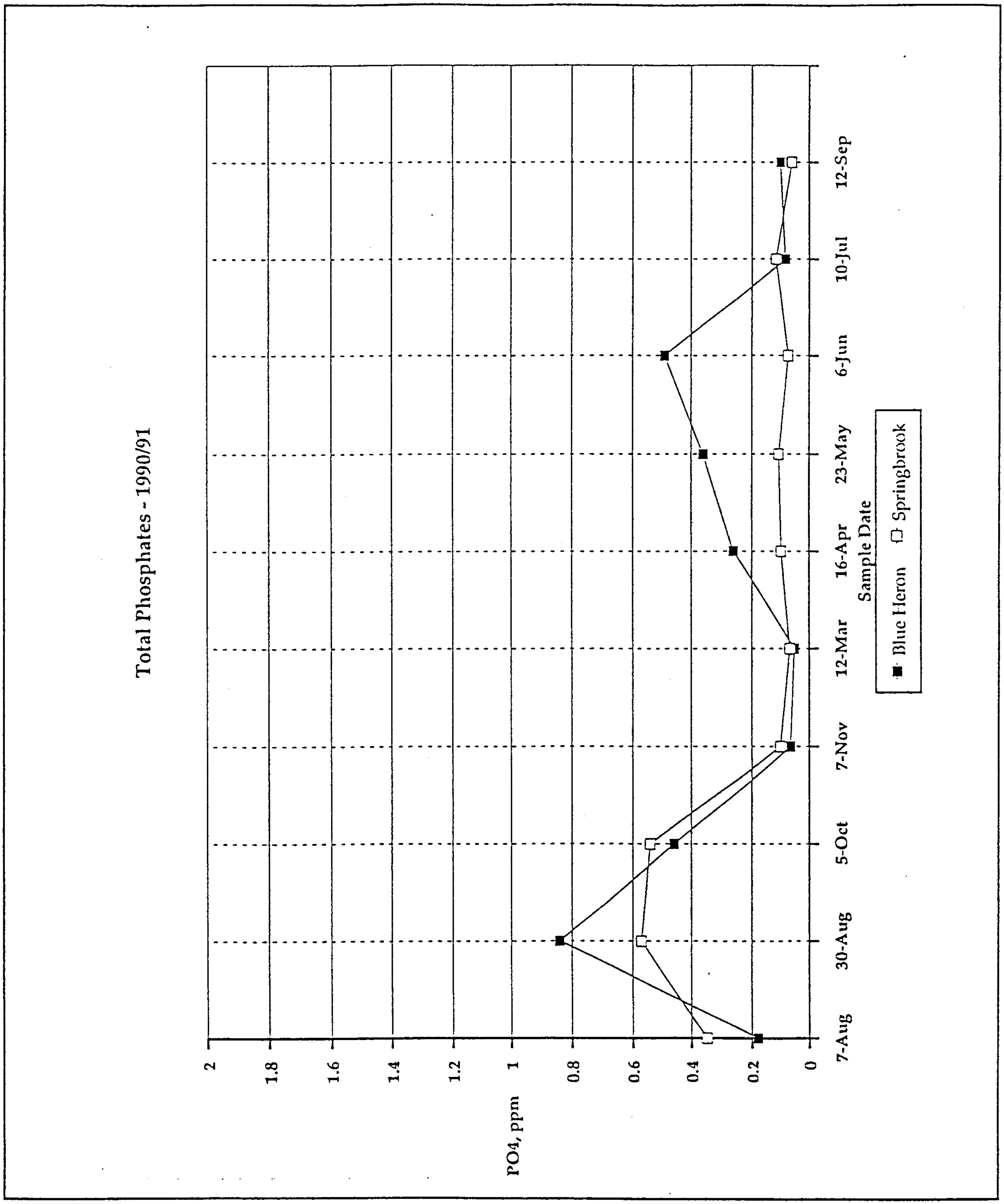



KCM


Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

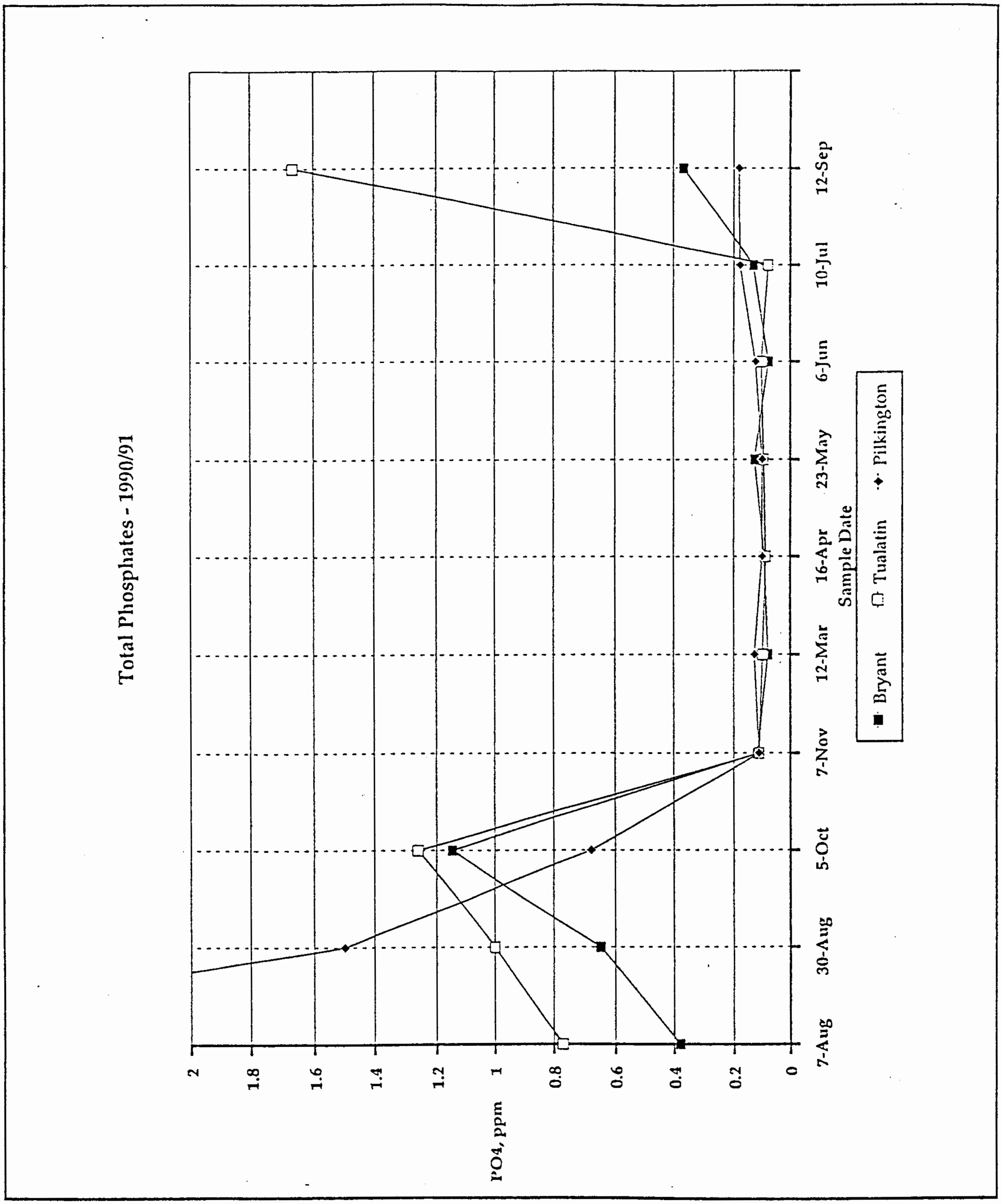

CITY OF LAKE OSWEGO

FIGURE 6 Surface Water Quality Samples
Lost Dog Creek




KCM
Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

FIGURE 7 CITY OF LAKE OSWEGO
Surface Water Quality Samples
Springbrook/Blue Heron Creek

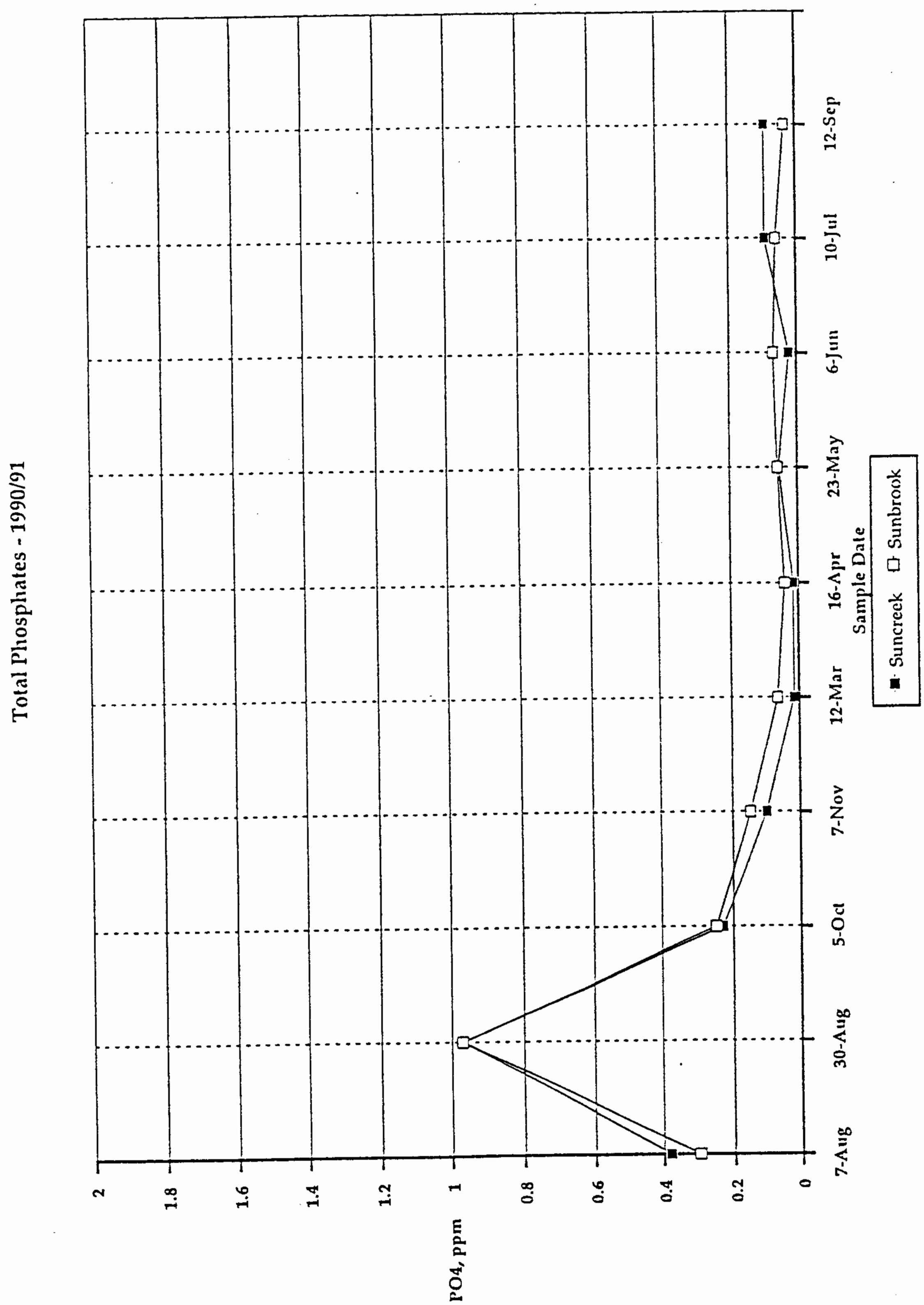



KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

FIGURE 8

CITY OF LAKE OSWEGO
Surface Water Quality Samples
Lower Boones Ferry





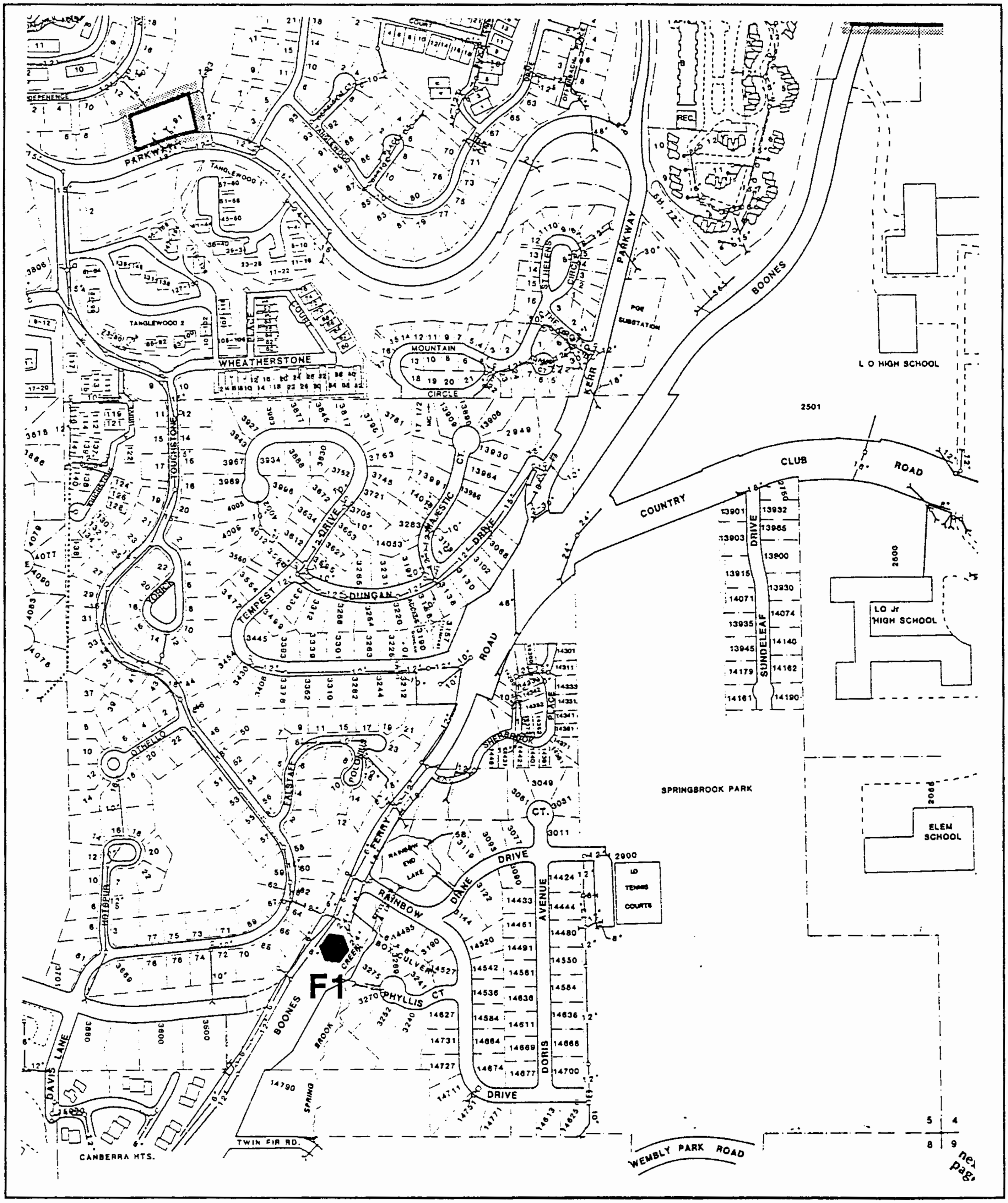
KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223


CITY OF LAKE OSWEGO

FIGURE 9 Surface Water Quality Samples

Ball Creek

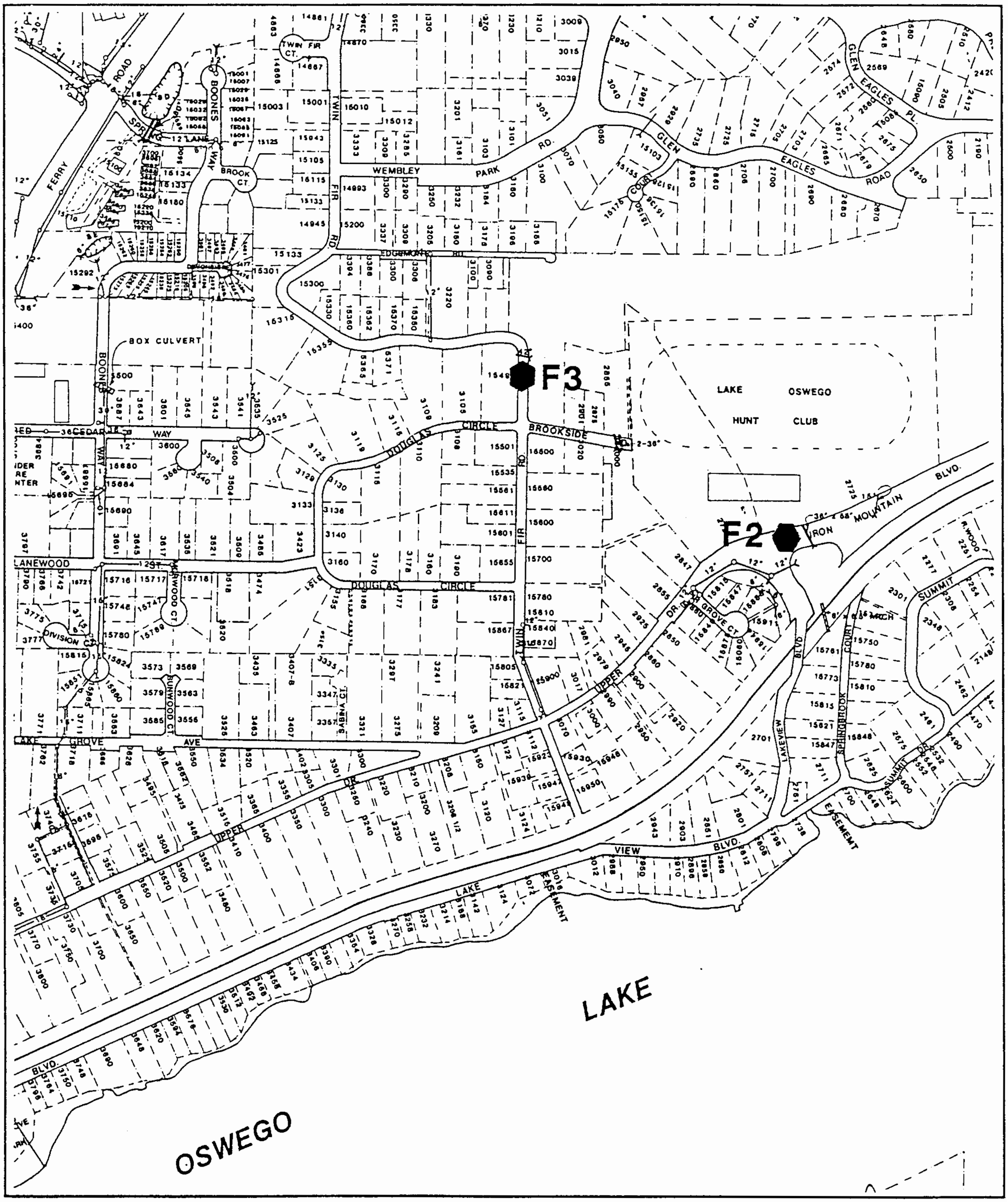



KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

FIGURE 10

CITY OF LAKE OSWEGO
Future Sampling Locations
Springbrook Creek




KCM

Kramer, Chin & Mayo
7080 SW Fir Loop
Portland, Oregon 97223

FIGURE 11 CITY OF LAKE OSWEGO
Future Sampling Locations
Springbrook Creek

# Tables

# TABLE 1
# CITY OF LAKE OSWEGO
# SURFACE WATER QUALITY SAMPLE LOCATIONS

| Site No. | Basin | Description | Location |
|---|---|---|---|
| 1 | Lost Dog Creek | West Leg | Outlet at Palisades Lake |
| 2 | Lost Dog Creek | East Leg | Culvert at Patton & Conifer |
| 3 | Lost Dog Creek | Mouth | Box Culvert at Lake Front Road |
| 4 | Springbrook Creek | Hunt Club | Culvert at Iron Mountain Road |
| 5 | Blue Heron Creek | Sediment Basin | Blue Heron Way |
| 6 | Lower Boones Ferry | Inlet | Bryant south of Lake View |
| 7 | Lower Boones Ferry | Outlet | Detention west of Tualatin Street |
| 8 | Lower Boones Ferry | Manhole | Parking Lot 17252 Pilkington Road |
| 9 | Ball Creek | Outlet | 5912 Sunbrook Drive |
| 10 | Ball Creek | Outlet | Detention at end of Suncreek Drive |

## TABLE 2
## CITY OF LAKE OSWEGO
## SURFACE WATER QUALITY SAMPLES

| Sample Date | Lost Dog Creek | | | Spring-brook Creek | Blue Heron Creek | Lower Boones Ferry | | | Ball Creek | |
|---|---|---|---|---|---|---|---|---|---|---|
| | West | East | Mouth | | | Bryant | Tualatin | Pilkington | Sun-brook | Sun-Creek |
| 7-Aug-90 | 0.870 | 0.540 | 0.430 | 0.350 | 0.180 | 0.380 | 0.770 | 3.500 | 0.300 | 0.380 |
| 30-Aug-90 | 1.300 | 0.650 | 1.070 | 0.570 | 0.840 | 0.650 | 1.000 | 1.500 | 0.970 | 0.970 |
| 5-Oct-90 | 0.900 | 0.460 | 0.620 | 0.540 | 0.460 | 1.150 | 1.260 | 0.680 | 0.250 | 0.230 |
| 7-Nov-90 | 0.100 | 0.029 | 0.060 | 0.101 | 0.065 | 0.119 | 0.112 | 0.114 | 0.148 | 0.100 |
| 12-Mar-91 | 0.029 | 0.008 | 0.036 | 0.067 | 0.052 | 0.080 | 0.100 | 0.130 | 0.063 | 0.015 |
| 16-Apr-91 | 0.155 | 0.027 | 0.052 | 0.098 | 0.264 | 0.094 | 0.089 | 0.102 | 0.040 | 0.014 |
| 23-May-91 | 0.133 | 0.059 | 0.093 | 0.106 | 0.361 | 0.130 | 0.097 | 0.102 | 0.059 | 0.054 |
| 6-Jun-91 | 0.144 | 0.032 | 0.064 | 0.073 | 0.490 | 0.079 | 0.104 | 0.125 | 0.069 | 0.022 |
| 10-Jul-91 | 0.100 | 0.160 | 0.110 | 0.117 | 0.083 | 0.133 | 0.080 | 0.180 | 0.060 | 0.093 |
| 12-Sep-91 | 0.117 | 0.060 | 0.067 | 0.060 | 0.100 | 0.367 | 1.667 | 0.183 | 0.033 | 0.093 |

TABLE 3
WATER QUALITY SAMPLING PARAMETERS
INDICATORS AND IMPACTS

| Pollutant | Indicator | Impacts |
|---|---|---|
| **Suspended Solids (SS)** | Indicator of turbidity, impairment of photosynthetic activity. | Impairment of in-stream beneficial uses such as fish/wildlife habitat and recreation. |
| pH | Indicator of buffering capacity "ability to neutralize additions of acids or bases without appreciable change" and toxicity of certain chemical compounds. | Receiving water has greater sensitivity to the addition of pollutants. Diminished "buffering capacity". |
| **Fecal Coliform (FC)** | Indicator of bacteria from intestinal tract of warmblooded animals. | Disease transmission, possible from failing septic systems/drainfields. |
| **Phosphorous (TP)** | Indicator of surface runoff, return flow from irrigation, cattle feedlots, duck populations, tree leaves, atmospheric fallout, phosphate detergents. | Stimulates aquatic plant growth and eutrophication. As phosphate, is one of the major nutrients for plant nutrition. |
| **Hardness** | Indicates presence of calcium and magnesium as carbonates. | Relative toxicity of various heavy metals may be reduced or increased depending on hardness. |
| **Oil and Grease** | Indicator of surface runoff from rooftops, parking lots, commercial automotive and industrial areas. | Impairment of in-stream beneficial uses such as fish and wildlife habitat degradation. |
| **Total Kjeldahl Nitrogen (TKN)** | Indicator of surface runoff from farm sites, animal waste, lawn fertilizer, leachate from sanitary landfills, septic tanks, automotive exhaust, and atmos- pheric fallout. | Impairment of fish habitat and public water supplies. |
| **Dissolved Oxygen (DO)** | Indicator of the ability of a water body to support a balanced aquatic habitat. | Insufficient oxygen causes anaerobic decomposition of organic materials, and subsequent destruction of fish habitat. |
| **Bichemical Oxygen Demand (BOD) Chemical Oxygen Demand (COD)** | Indicator of the presence of oxygen demanding substances or processes. | High BOD/COD will leave less remaining oxygen available in-stream for beneficial uses. |

## TABLE 4
## RECOMMENDED DETECTION LIMITS
## FOR WATER QUALITY PARMETERS

| Water Quality Variable | Abbreviation | Detection Limit | |
|---|---|---|---|
| | | Quantity | Units |
| Chemical Oxygen Demand | COD | 5 | mg/L |
| Biochemical Oxygen Demand | BOD | 1 | mg/L |
| Nonfiltrable Residue | NFR | 1 | mg/L |
| Total Organic Carbon | TOC | 1 | mg/L |
| Oil & Grease | Oil & Grease | 1 | mg/L |
| Methylene Blue Activated Substances | MBAS | 1 | mg/L |
| Total Kjeldahl Nitrogen | TKN | 1000 | ug/L |
| Ammonia-Nitrogen | NH3-N | 100 | ug/L |
| Nitrate-Nitrogen | NO3-N | 100 | ug/L |
| Nitrite-Nitrogen | NO2-N | 100 | ug/L |
| Total Soluble Phosphorous | TSP | 100 | ug/L |
| Total Phosphorous | TP | 100 | ug/l |
| Lead | Pb | 20 | ug/L |
| Chromium | Cr | 10 | ug/L |
| Nickel | Ni | 10 | ug/L |
| Total Cyanide | Total Cn | 10 | ug/L |
| Phenolics | Phenolics | 10 | ug/L |
| Copper | Cu | 5 | ug/L |
| Zinc | Zn | 5 | ug/L |
| Cadmium | CD | 5 | ug/L |
| Silver | Ag | 5 | ug/L |
| Antimony | Sb | 5 | ug/L |
| Selenium | Se | 1 | ug/L |
| Arsenic | As | 1 | ug/L |
| Beryllium | Be | 0.5 | ug/L |
| Conductivity | Cond. | 1 | umhos/cm |
| Fecal Coliform Bacteria | FC | 1 | colony |
| Fecal Streptococcus Bacteria | FS | 1 | colony |

mg/L - milligrams per liter
ug/L - Micrograms per liter
umhos/cm - micromhos per centimeter