CHAPTER 7

WATERSHED PLANNING AND ANALYSIS: SQUAW CREEK

7.1 INTRODUCTION

Squaw Creek runs from Bald Hill Park west of Corvallis and eastward to its conjunction with Marys River at Brooklane Drive. The Squaw Creek watershed contains 2,363 acres. The largest land uses at present consist of low-density residential at 766 acres, and vacant land at 609 acres. There is some industrial and commercial land use in the watershed, although this is mostly limited to the Sunset Research Park and along Philomath Boulevard (Hwy 20/34). In the future, if the watershed is developed according to the City's Comprehensive Plan, all of the vacant land may be developed with most of it converted to residential land use. In addition, medium- and high-density dwellings will make up an increasingly larger portion of the residential land use. As a result of these changes in land use, the amount of impervious land may increase from 762 to 968 acres, an increase of 27 percent.

7.2 WATERSHED FINDINGS

Information on watershed conditions was obtained by collecting public comments at open houses, working with City staff to identify maintenance and operation problems, conducting a technical stream evaluation of selected reaches, and by modeling the conveyance system for the existing and build-out scenarios. This information was compiled by stream reach and is summarized in Section 7.2.5. A map of the Squaw Creek watershed, presented as Figure 7-1, shows the location of the stream within the City and identifies some of the major observations made during the watershed study.

The Squaw Creek watershed is relatively flat and erosion does not appear to be a significant issue. The low gradient has resulted in extensive areas lying within the 100-year floodplain and a large number of wetlands. Flooding is a concern along Squaw Creek. Figure 7-2, Photo 1, shows a low-lying area at Sunset Park with its small channel during normal conditions. Figure 7-2, Photo 2, shows approximately the same location during the February 1996 floods. The 1996 events also caused flooding further downstream at Knollbrook Place as shown in Figure 7-2, Photo 3.

Other issues within Squaw Creek include fish habitat and passage issues, such as the riprap barrier at Brooklane Drive, Figure 7-2, Photo 4. The Squaw Creek watershed also includes extensive parks, bike trails, and open spaces. There are pollution concerns (bacteria from duck wastes) in the Starker Arts Park (Figure 7-2, Photo 5). Recent maintenance efforts have cleared some of the accumulations of debris downstream of Knollbrook Place that impeded flows (Figure 7-2, Photo 6).

At present, Squaw Creek is less urbanized than other Corvallis watersheds, such as Dixon Creek or Sequoia Creek, but rapid development is occurring along the creek's western reaches, resulting in an increase in impervious surfaces. A key strategy for maintaining the health of the Squaw Creek watershed is to preserve and add to the relatively long lengths of natural stream corridor that currently exist along the creek mainstem and its tributaries.

7.2.1 Public Comments

Public input into the watershed planning process has been encouraged and facilitated through a number of public meetings. The first of these meetings was held on March 30, 1999, and the second on April 8, 1999 at Western View Middle School. During those meetings, residents were encouraged to share their knowledge of problem areas and to identify opportunities for improving the health of the Squaw Creek watershed. Reach-specific comments provided by the public are in Section 7.2.5. Some general comments are provided below:

- "Marys River flooding has caused Squaw Creek to back up in the past."
- "Given backwater impact from Marys River, will retention cause a greater problem? Lower portions may need different standards."
- "Piers on Marys River cause several inches of backwater."
- "Should protect natural areas (including wetlands). Natural areas promote wildlife."
- "Squaw Creek subdivision caused channelization. Slow, meanders in the channel may be hindering flows."

7.2.2 City Staff Reports

City Engineering and Utilities Operation staff is familiar with most of the Squaw Creek watershed through their day-to-day activities. They provided input into the planning process by identifying known problem areas, recommending areas for stream enhancement activities, and recounting the extent and duration of flooding during major storm events. For example, the extent of flooding from the February 1996 storm was well documented. During that storm, road closures were reported at several locations from Brooklane Drive to 53rd Street.

7.2.3 Field Study Observations

As part of this project, Watershed Applications, a stream rehabilitation specialty firm, conducted a series of field investigations beginning in November 1997. A summary of their observations is in Section 7.2.5. Detailed descriptions of the field study observations are in Appendix B. The Knollbrook area of Squaw Creek was revisited as part of the City's Flood Mitigation Study in 1999.

7.2.4 Modeling Results

A computer model for the Squaw Creek watershed identified the hydraulic capacity and projected flows in the pipes, culverts, and channels of the conveyance system for existing and future build-out scenarios. Existing conditions are based on the current level of development at the time of modeling. Build-out conditions are based on full development of the watershed in the future as identified

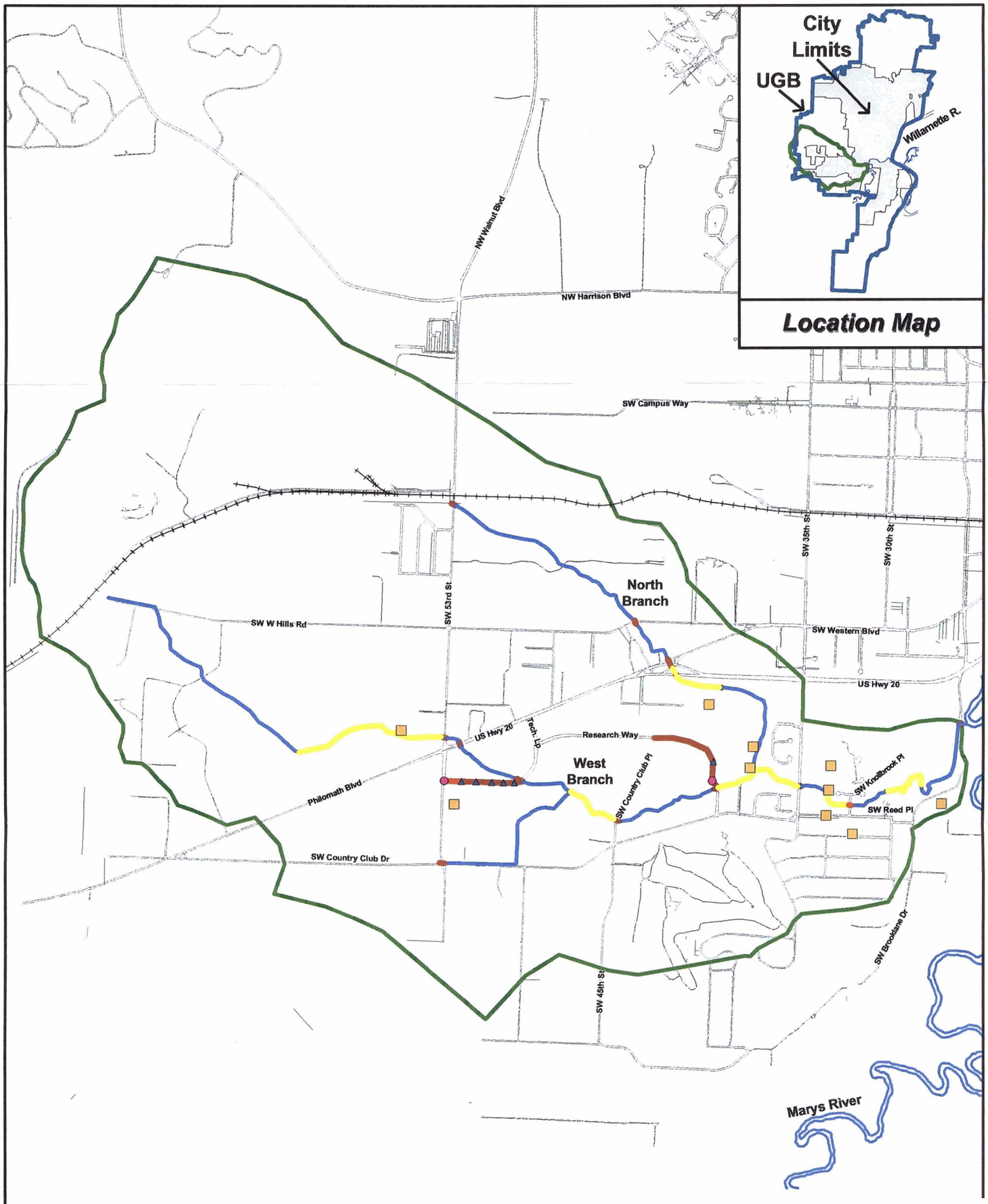

Figure 7-1 Squaw Creek Problem Areas

LEGEND

- Pipes/Bridges
- Channels
- Basin Boundary
- Reported Problems (recorded at open house)
- Surcharged Manholes (10-year future storm)
- Flooded Manholes (10-year future storm)
- High Velocity Areas (> 4 fps, 2-year future storm)
- Undersized Conduits (10-year future storm)
- Undersized Channels (10-year future storm)

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report/figures/final/fig7-1.wor, October 20, 2000, base data from City of Corvallis GIS Department

Figure 7-2. Watershed Photos

Photo 1. Sunset Park ball fields under normal conditions.

Photo 2. Flooding at Sunset Park ball fields

Photo 3. Flooding downstream of Knollbrook Place

Photo 4. Fish passage concern at Brooklane Drive

Photo 5. Bacteria concerns at Starker Arts Pond

Photo 6. Stream blockage downstream of Knollbrook Place

in the City's Comprehensive Plan. A full range of storm events was modeled for the existing and future scenarios, including the 2-, 10-, 25-, and 100-year storm events.

Table 7-1 shows the hydraulic structures (pipes, culverts, bridge crossings, etc.) that are undersized for the City's 10-year design storm. Undersized structures are defined as being surcharged (under pressure) or experiencing flooding. In some cases a structure may be surcharged due to effects from a downstream constriction that results in backwater, rather than too much flow from upstream. Recommendations to address the undersized structures are in Section 7.3 of this chapter. A complete summary of all modeled segments is in Appendix C.

Flooding of the Marys River impacts the capacity of the lower reaches of Squaw Creek. For example, the Marys River 100-year floodwater elevation covers the area up to an elevation of 225 feet; consequently, the capacity of the channels downstream and immediately upstream of elevation 225 is reduced. The model was constructed to determine the capacity of the channel with and without the backwater effects of Marys River during flood stage.

The modeling results shown in Tables 7-1 and 7-2 are for Squaw Creek without impacts from Marys River floodwaters. The modeling shows eight channel sections where water elevations from the design storm will overtop the streambank. At several of these locations, the channel cross-sections used in the model were estimated, since surveyed cross-section information was not available. The piped systems along 35th Street to Country Club Place and Technology Loop to 53rd Street are shown as undersized due to instream high water conditions.

Table 7-1. Modeled Flow for Undersized Hydraulic Structures within the Squaw Creek Watershed, cubic feet per second

Reach/Location/Model segment	Full pipe or channel capacity[1]	10-year storm flows		Flooding predicted by model	Flooding reported by staff or public
		Existing	Future		
Marys River to Reed Place/ Overflow in channel downstream of Reed Place/SQW010	84	174	174	Yes	Yes
Reed Place to 35th Street/Overflow in channel between Reed Place and Knollbrook Place/SQW015	225	232	232	Yes	Yes
Reed Place to 35th Street/ Undersize bridge at Knollbrook Place/ SQW020	276	204	204	Yes	Yes
35th Street to Country Club Place (West Branch)/ Overflow in channel between 35th Place and Research Way/ SQW035	65	373	373	Yes	Yes
35th Street to Country Club Place (West Branch)/ Overflow in channel between 35th Place and Research Way/ SQW040	27	194	196	Yes	Yes
35th Street to Country Club Place (West Branch)/ Undersized pipe along Research Way/SQW175	24	5.0	5.2	Yes	No
35th Street to Country Club Place (West Branch)/ Undersized pipe along Research Way that outfalls into stream/SQW170	25	8.7	9.0	Yes	No
Country Club Place to Technology Loop (West Branch)/Overflow in channel at Sunset Park ball fields/SQW060	118	175	179	Yes	Yes
Technology Loop to 53rd Street (West Branch)/ Undersized pipe at 53rd Street and Technology Loop/SQW120	5.4	8.6	8.6	Yes	No
Technology Loop to 53rd Street (West Branch)/ Undersized pipe along Technology Loop/SQW110	9.0	8.6	8.6	No	No
Technology Loop to 53rd Street (West Branch)/ Undersized pipe along Technology Loop/SQW105	14	8.5	8.4[2]	No	No
Technology Loop to 53rd Street (West Branch)/ Undersized pipe along Technology Loop/SQW100	15	8.5	8.4[2]	No	No
Technology Loop to 53rd Street (West Branch)/ Undersized pipe along Technology Loop/SQW095	14	8.5	8.4[2]	No	No
Technology Loop to 53rd Street (West Branch)/ Undersized pipe along Technology Loop that outfalls into stream/SQW090	25	8.5	8.4[2]	No	No
53rd Street to Headwaters (West Branch)/ Overflow in channel upstream of 53rd Street/ SQW150	48	86	87	Yes	Yes
Confluence with West Branch to Philomath Boulevard (North Branch)/ Overflow in channel at ODOT facility/SQW210	105	167	171	Yes	Yes
Philomath Boulevard to West Hills Road (North Branch)/Overflow in channel at Philomath Boulevard/SQW220	13	169	173	Yes	Yes

[1] The full pipe or channel capacity is based on Manning's equation. It does not account for a reduced hydraulic capacity resulting from downstream constrictions that may cause backwater conditions.

[2] The apparent decrease in flows in within the model tolerance. The higher flow should be used for design purposes.

The hydrologic/hydraulic model also estimated velocities occurring in channel segments to determine areas at risk for channel or streambank erosion. The velocities during the 2-year storm—the storm size most responsible for determining the channel configuration—were compared to the velocity criteria presented in Chapter 3. In general, the criteria identify that velocities in excess of 4 feet per second may cause erosion of the streambank or streambed. There were no segments with velocities in excess of the criteria.

Water elevations predicted by the model were compared to surveyed channel cross-sections to assess points of flooding along the open channels. Reaches where flows from the 10-year storm event overtop the base channel were identified as undersized channels in Figure 7-1. Recommendations for these reaches varied. If the overtopping would flood an area containing vulnerable structures, such as buildings, a recommendation was made to reduce the flooding. If the flooding was confined to an undeveloped area, recommendations for preservation, enhancement, and reconnection of the channel and floodplain were made.

The model showed eight segments where the design storm flows (10-year storm event) would overtop the streambanks. The segments from Marys River to Knollbrook Place are predicted to flood, as are segments within the following reaches: 35th Street to Country Club Place, Country Club Place to Technology Loop, upstream of 53rd Street along the west branch of the stream, the confluence of the west and north branches up to Philomath Boulevard, and Philomath Boulevard to West Hills Road. All of these segments reported high water or road closings during the February 1996 storm. In the areas upstream of Knollbrook Place, there appears to be enough overbank storage available to prevent flooding of roads or houses.

7.2.5 Stream Reach Summaries

For study purposes, Squaw Creek was divided into a number of reaches based on physical characteristics of the stream, property ownership, and any other unique characteristics that might distinguish one section of the stream from the rest. The study findings are summarized in the following sections by reach description. The public comments are shown as they were recorded during public meetings.

Marys River to Reed Place

Public Comments: "Brooklane – barriers too close to stream, development encroached on stream."

"Low areas along stream. Water seems to leave Marys River and run across Brooklane under high-flow conditions. House sinking on west side. Erosion along outside meander. Floods in 1996 had higher levels. Over bridge and into houses. Used to be crawdads, nothing now. Wood ducks, kingfisher, woodpeckers, nutria."

City Staff Reports: Brooklane Drive flooded in 1996. Backwater from Marys River causes flooding during extreme events. This section of the stream has poor canopy cover from Marys River up through the riprapped channel that extends 300 feet upstream of Brooklane Drive. The streambed in the area of the riprapped channel is of poor quality and needs improvement to provide better habitat.

Field Observations: A concrete structure near the Brooklane Drive bridge creates a 4-foot vertical drop in the channel that is a fish passage barrier. The stream channel has a number of sharp meanders in the area near Reed Place that affect hydraulic capacity. Himalayan Blackberry is present at multiple locations on the banks and overbank areas. Debris at the top of the banks in the wooded area may impede flows during high-flow events. The channel has incised over time, exposing soft bedrock at a number of locations. Some lateral undercutting of the banks is apparent.

Modeling Results: Modeling shows flooding during the 10-year storm event due to the channel configuration near Reed Place. Modeled velocities during the 2-year storm event are below the 4-feet-per-second criteria. This reach is in the Marys River 100-year floodplain. During high river flows, the water surface elevation reaches 225 feet above mean sea level. As a result of this backwater condition, the water surface elevation throughout the downstream reaches of Squaw Creek will be impacted by Marys River flood events.

Reed Place to 35th Street

Public Comments: "Knollbrook Bridge flooded because of intense rainfall."

"1676 S.W. Knollbrook. Flooding in 1996."

"1689 S.W. Knollbrook. Pipes under bridge collect debris. Need more capacity."

"3255 S.W. Knollbrook. Three inches in garage. Storm drain back flows into street."

"Vernal pool on school (Western View Middle School) stays wet through June."

"3403 S.W. Knollbrook. One and a half acres that crosses creek. Part across the creek is useless, would the city like to use it? Twenty years ago could jump across channel, now is much wider."

City Staff Reports: The area flooded during the 1996 storm, including high water at the intersection of Willamette Avenue and Longhill Street, and high water at the low areas around the Knollbrook Place bridge. The quality of the canopy in this reach varies. Many of the property owners in this reach mow vegetation to the top of bank or to the summer flow water surface elevation. The Adams School property (north bank of Squaw Creek) is mowed down to the summer channel, limiting habitat value and affecting wetlands area.

Field Observations: The stream becomes more incised in the downstream direction with bank erosion at selected locations. Encroachment by houses is limited to just a few properties within this reach due to the generally wide setbacks. The stream flows through a wet area at the edge of the Adams School grounds. This 600-foot area appears to be little used by the school, but habitat value is limited by groundskeepers mowing to the top of the bank. The south side banks are oversteep and failing in places near the Knollbrook Christian Reformed Church property. Near Knollbrook Place the floodplain is narrow, although functional, with supporting stands of sedges and buttercups toward its downstream end. The clay streambanks show minimal erosion near Knollbrook Place. Canopy coverage is of moderate quality due to the discontinuity of the stands and the relatively young native trees in the riparian area.

Modeling Results: Modeling shows flooding occurs in this reach due to backwater effects from the downstream channel configuration during the 10-year storm event. The bridge at Knollbrook Place appears to be undersized as well. Velocities are below the 4-fps criteria for the 2-year storm event due to the low gradient of the streambed.

35th Street to Country Club Place (West Branch)

Public Comments: "Wetland between Country Club and Research Way—will it be preserved?"

City Staff Reports: The February 1996 storm caused high water along Country Club Drive from 49th Street to Martin Street. The duck population at Starker Arts Park pond may be the source of bacteria pollution. Pet waste may also be a problem along the bike path that runs parallel to the creek.

Field Observations: At present, the 500-foot riparian area downstream of Country Club Place is a wet woodland and may be a jurisdictional wetland. It appears that the area was formerly a pasture or hay meadow. Drainage ditches from the golf course run down steep slopes until they run under Country Club Drive where the slope flattens out. Gradient transitions from steep to flat are often the cause of flooding problems. Drainage from the golf course is a potential pollutant source. Waterfowl in the Starker Arts Park pond are another pollution source. The 100-foot-long earthen ditch leading from the pond outlet to Squaw Creek could be converted into a bioswale to provide water treatment.

Modeling Results: The model shows the channel from 35th Street to Research Way is undersized for the 10-year storm event, although the flooding is restricted to wooded areas and does not threaten developed property. The drainage ditches from the golf course were not modeled. Parts of the stormwater collection system serving Research Way are undersized due to backwater conditions from Squaw Creek that reduce pipe capacity to below the 10-year design storm. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

Country Club Place to Technology Loop (West Branch)

Public Comments: No public comments on this reach.

City Staff Reports: The riparian corridor is narrow at several locations with poor or nonexistent canopy cover. Adjacent areas that may be wetlands are mowed. Runoff from the ball field parking lot enters the creek with no water quality protection.

Field Observations: The channel is not incised and the floodplain is unconstrained upstream of Country Club Place. The persistent wetness of this area indicates the presence of wetlands. Mowing practices in this reach restrict wildlife habitat potential. The channel appears stable throughout this reach, although the stream lacks the structural diversity for good habitat. The 1,100-foot section of stream that runs by the ball fields at Sunset Park offers an opportunity for riparian improvement/restoration. There is a wide buffer area between the creek and the multi-unit housing complex on the right bank downstream of Technology Loop. The 600 feet of straightened channel affords the opportunity to enhance this area as a model for both habitat and aesthetic improvements.

Modeling Results: Modeling shows that 10-year storm event flows exceed the channel capacity and flood the overbank area at the ball fields in Sunset Park. The culverts downstream at Country Club Place are surcharged. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

Technology Loop to 53rd Street (West Branch)

Public Comments: "Do new parking lots such as Bi-Mart treat runoff?"

"Ditches have been deepened and weren't revegetated following widening of the bike lane—lots of erosion."

City Staff Reports: This reach has a narrow stream corridor with poor to nonexistent canopy. Adjacent wetland areas are mowed. Parking lot runoff from adjacent developed properties enters the creek with no water quality treatment. Culverts on Philomath Boulevard and 53rd Street present fish passage obstacles.

Field Observations: The stream channel is not incised through most of this reach. Canopy coverage is only fair, consisting of thick stands of small deciduous trees along most of the stream reach. The Bi-Mart/Safeway shopping complex is situated immediately next to the stream. The complex's large parking lot drains into inlets along the parking area periphery that are equipped with inverted elbows to remove oil and trash. The pipes drain into the stream through pipes equipped with flap gates.

Modeling Results: Manholes along the Technology Loop pipe system surcharge during the 10-year storm event, with the potential for flooding at the upstream end near 53rd Street, which may necessitate replacing the downstream pipes. Neither the public nor the City has reported surcharging in this area. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

53rd Street to Headwaters (West Branch)

Public Comments: Residents along Philomath Boulevard are interested in riparian enhancement opportunities upstream of 53rd Street.

"Concerned about stream widening out over large area and cutting new channels."

City Staff Reports: A DEQ hazardous clean-up site was located along the stream, and has been recently closed out. Benton County has purchased the property for development.

Field Observations: The stream and floodplain in the area approximately 500 feet upstream of 53rd Street consist of a wide, continuous riparian corridor of ash and hawthorn trees with considerable channel-spanning, downed woody debris (mostly smaller material). The channel in this reach is not incised nor is there significant bed or bank erosion. Although the canopy cover is good and riparian and instream habitat value is of good quality, this reach has potential for additional restoration.

Modeling Results: This reach was modeled up to West Hills Road. Modeling indicated that about one-half mile of channel upstream of 53rd Street is undersized for the 10-year storm event. The flooding does not impact any existing developed areas. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

Confluence with West Branch to Philomath Boulevard (North Branch)

Public Comments: "Vernal pond used by water fowl, frogs, herons, etc.—totally cool spot!"

"Ashbrook School removed sediment fence prior to revegetating the construction area and it is a constant, chronic source of sediment input directly into the creek."

"ODOT site committed to re-establishing a healthier reach of stream."

City Staff Reports: There is no protection between the maintenance area on ODOT property and the stream channel. The area floods frequently, covering the bike path, but this is natural for this flat area.

Field Observations: The ODOT maintenance facility has a large, graveled equipment yard abutting the creek near the bike path. The yard contains several potential pollutant sources, including tanks of paint, de-icer, and piles of gravel, with inadequate cover or containment. Leaks from truck and heavy equipment using the yard are also a concern. Vegetation along the yard edges may provide some filtration between the yard and the stream.

Modeling Results: Modeling shows that the channel is undersized for 700 feet downstream of Philomath Boulevard along the ODOT facility during the 10-year storm event. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

Philomath Boulevard to West Hills Road (North Branch)

Public Comments: "Highway 34 build up has increased flooding."

City Staff Reports: Multiple culverts under the highway may be an obstacle for fish passage. The stream corridor near Philomath Boulevard does not have a canopy and is mowed to the stream channel. Highway runoff discharges directly into the creek without treatment. The canopy upstream of the highway is good but the channel is very narrow. ODOT property is managed to protect the riparian habitat adjacent to the creek.

Field Observations: No field observation performed for this reach.

Modeling Results: Modeling shows the channel at the intersection of Western and Philomath Boulevards is undersized for the 10-year storm event due to its flat slope. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

West Hills Road to 53rd Street (North Branch)

Public Comments: No public comments on this reach.

City Staff Reports: Canopy cover is good in most places, although farming activities crowd the stream corridor.

Field Observations: No field observation performed for this reach.

Modeling Results: Hydraulic facilities within this reach are adequately sized for the design storms for existing and future build-out conditions. Stream velocities in this reach are below the 4-feet-per-second criteria for the 2-year storm event.

53rd Street to Headwaters (North Branch)

Public Comments: No public comments on this reach.

City Staff Reports: Flooding closed the roads at 53rd Street and Reservoir Road due to the February 1996 storm. A large pipe running along 53rd Street from the north needs to be investigated, as the County does not appear to have detailed records of it. Multiple culverts under 53rd Street, railroad tracks, and the Reservoir Road area may be a barrier for fish passage. The riparian corridor parallel to 53rd Street is narrow with average canopy value, and drainage in this area is not clearly defined. Runoff from agricultural properties is a source of pollutants (nutrients and bacteria from manure) during high runoff events. The Benton County Fairground parking lot drains directly into the creek with no treatment or buffer. The fairgrounds are a potential source of manure that could enter the creek during high runoff events. The industrial area on Reservoir Road does not have a stormwater runoff plan to help prevent pollutants from entering the creek.

Field Observations: A large amount of undeveloped land is located upstream of 53rd Street. Some of this land is publicly owned as part of Bald Hill Park. Several large ponds are present in the system behind the sawmill on Reservoir Road. These ponds are not believed to be hydraulically connected to Squaw Creek and were not directly observed.

Modeling Results: Except for the industrial area, most of this reach is outside of the city limits. Hydraulic capacity and velocities were not directly modeled for this reach of the stream, although runoff contributions from this area were included in the downstream modeling.

7.2.6 Watershed Summary

Squaw Creek has several reaches where flows overtop the channel banks during large storms. The sections with the most flooding impacts are the reaches between Brooklane Drive and 35th Street, where the sharply meandering channel and flat slopes reduce the stream's hydraulic capacity. In other areas, the flooding does not impact developed property, such as along 35th Street to Country Club Place, and 53rd Street to the headwater.

Fish passage is a concern at several locations within Squaw Creek. Under normal flow conditions, fish passage between Marys River and Squaw Creek is prevented by a 4-foot-high vertical wall in the channel near Brooklane Drive. Along the West Branch, the culverts beneath Philomath Boulevard and 53rd Street present a fish obstacle. City staff also identified potential problems with the culverts under the intersection of Western and Philomath Boulevards.

Pipe systems along Research Way and Technology Loop surcharge under the 10-year design storm. Backwater effects from Squaw Creek influence the capacity of both systems.

Squaw Creek contains a number of potential stream restoration or enhancement opportunities. Many of these opportunities are centered on the wooded wetlands that are common along the relatively flat stretches of Squaw Creek. Opportunities such as those in Sunset Park are especially noteworthy because they occur in publicly owned areas.

7.3 WATERSHED MANAGEMENT OPTIONS

Recommendations for the Squaw Creek watershed are shown in Table 7-3. The short-term program recommendations are shown in Table 7-4. They include restoring riparian habitat along several reaches, working with property owners of large parcels on water quality issues, and coordinating with ODOT in several locations.

The long-term program includes recommendations dealing with flooding in the lower reaches of the stream and a large riparian enhancement project at Sunset Park ball fields. Long-term projects are shown in Table 7-5.

Flooding along Squaw Creek near Knollbrook has been a longtime concern of residents. Information gathered during a City flood mitigation study in 1999 was incorporated into the current work. Simply widening the channel at this point was dismissed due to the close proximity of houses. An analysis of the detention required upstream to reduce the peak flows to prevent flooding showed that approximately 87 acre-feet of storage are needed. The available space is much less than what would be required and most of the available land is designated wetlands, which would cause wetland permitting challenges. Thus, a strategy of preserving existing upstream floodplain storage, flood-proofing homes, and providing an overflow channel downstream was selected.

Table 7-3. Squaw Creek Options

Reach	Abridged observations	Recommended activity	Priority
Marys River to Reed Place	1) Marys River floods over Brooklane Drive under high-flow conditions.	a. Develop citywide requirements along with cooperate with Benton County and Marys River Watershed Council to improve upland stormwater management practices for reducing flows during larger storm events.	Ongoing
		b. City should establish floodplain policies, which include flood proofing, or purchase of properties in this area.	Long-term
	2) Erosion and subsidence problems, along with loss of wildlife species.	a. Develop citywide measures for preventing additional runoff volume or excessive velocities into the stream.	Ongoing
		b. Stabilize streambank and restore riparian habitat value. May require City purchase of adjacent lands.	Long-term
	3) Large areas filled with Himalayan Blackberry, an invasive, non-native plant. Poor canopy coverage and riprapped channel.	a. Restore habitat value by improving vegetative and native tree plantings along stream.	Short-term
	4) Concrete structure near Brooklane Drive bridge is a fish passage issue.	a. Develop and construct alternative to existing structure to remove fish barrier.	Short-term

Table 7-3. Squaw Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
Reed Place to 35th Street	1) Channel erosion at several locations is creating more incised and wider channel.	a. Develop citywide measures for preventing additional runoff volume or excessive velocities into the stream.	Ongoing
		b. Stabilize streambank and provide for stream meander.	Long-term
	2) Sediment and debris collecting near Knollbrook Place bridge are reducing hydraulic capacity. Modeling shows the bridge is undersized.	a. Remove excessive accumulations of material from culvert.	Short-term
		b. Develop citywide measures for reducing erosion from construction sites.	Ongoing
		c. Work with the school district to re-establish floodplain downstream of 35th Street and stabilize slopes at upstream eroded streambank locations.	Long-term
	3) Flooding in this reach of Squaw Creek due to back water effects and downstream constrictions.	a. Provide or require floodproofing of homes in this area.	Long-term
		b. Implement floodplain policies, which include flood proofing or purchase of properties in this area.	Ongoing
	4) Canopy cover is poor or lacking in some areas of this reach. Properties are mowed down to edge of low-flow channel.	a. Develop citywide requirements for improving stream and riparian habitat.	Ongoing
		b. Work with property owners to modify landscaping practices. Plant trees along south bank to provide shading. Use tree and shrub plantings to create riparian fringe along stream.	Short-term
	5) Large storms cause flooding near Knollbrook Place. Field studies show the channel capacity is limited due to tight meanders and large amounts of woody debris above normal water levels. Hydraulic modeling shows flooding near Knollbrook Place.	a. Create overflow channel for high flows along north side of channel.	Long-term

Table 7-3. Squaw Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
35th Street to Country Club Place	1) Potential waterfowl pollution at Starker Arts Park Pond.	a. Convert the 100-foot long earthen ditch at pond outlet into a vegetated bioswale to provide filtration.	Short-term
	2) Several small drainage ditches may carry potential pollution from golf course into Squaw Creek.	a. Provide vegetative filtration to dechannelize lower ends of ditches. This would allow water to spread out into wooded wetland area.	Long-term
		b. Work with golf course to develop a chemical use minimization plan to reduce potential for fertilizer, herbicide and pesticide pollution.	Short-term
	3) Research Way pipe system has backwater problems, restricting capacity. No flooding complaints have been received.	a. Replace undersized pipes.	Long-term
	4) Model shows undersized channel from 35th Street to Research Way, approximately 1400 feet. Flooding appears restricted to wooded wetland area.	a. Preserve undeveloped area near channel. Reconnect channel to floodplain. Preserve and enhance vegetative buffer.	Long-term
Country Club Place to Technology Loop (West Branch)	5) Flooding has occurred along Country Club Drive from 49th Street to Martin Street during larger storm events.	a. Develop citywide measures for preventing additional runoff volume or excessive velocities into the stream.	Ongoing
	1) The riparian corridor is narrow at several locations with poor canopy cover. Mowing practices in this reach limit riparian habitat value.	a. Develop citywide requirements for improving stream and riparian habitat.	Ongoing
		b. Work with property owners to modify landscaping practices to improve habitat.	Short-term
	2) The runoff from the parking lots is minimally treated and presents risk to stream water quality.	a. Develop citywide water quality requirements for parking lot runoff.	Ongoing

Table 7-3. Squaw Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
	3) Habitat is poor because straightened channel lacks canopy cover, woody debris, and is mowed to streambanks. Sunset Park is public land offering excellent opportunity to implement stream corridor rehabilitation project. Model shows flooding of channel at Sunset Park.	a. Regrade streambank to lower angle, reconnect stream to floodplain, and provide for stream meander. Design and construct stream and riparian enhancements as part of project.	Long-term
Technology Loop to 53rd Street (West Branch)	1) Concern over parking lot runoff from Bi-Mart/ Safeway shopping complex.	a. Work with shopping complex owners to identify additional on-site measures to protect stream water quality.	Short-term
	2) This reach has a narrow riparian corridor with poor canopy cover. Adjacent wetland areas are mowed.	a. Develop citywide requirements for improving stream and riparian habitat.	Ongoing
		b. Work with property owners to modify landscaping practices.	Short-term
	3) Culverts at Philomath Boulevard and 53rd Street may be a fish passage issue.	a. Investigate to see if culverts meet new ODOT/ODFW standards for fish passage.	Short-term
	4) Model shows undersized pipes in the Technology Loop collection system due to backwater from high flows in Squaw Creek. No complaints have been reported.	a. Replace undersized pipes along Technology Loop beginning at 53rd Street.	Long-term
53rd Street to Headwaters (West Branch)	1) The stream is getting wider and cutting new channels. Modeling shows 2500 feet of undersized channel upstream of 53rd Street.	a. Develop citywide measures for preventing additional runoff volume or excessive velocities into the stream.	Ongoing
		b. Preserve undeveloped area near channel. Improve overbank area to provide flow and storage capability while improving riparian zone.	Long-term
	2) Canopy cover and riparian area are of good quality. Landowners in area have indicated interest in working with City to restore habitat.	a. Develop citywide requirements to protect existing natural resources, including the stream and buffer areas.	Ongoing
		b. Implement stream stewardship program.	Ongoing

Table 7-3. Squaw Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
Confluence with West Branch to Philomath Boulevard (North Branch)	1) Construction site erosion complaints have been recorded in this reach.	a. Develop citywide requirements for erosion control.	Ongoing
	2) ODOT is re-establishing a natural area located near their facility.	a. Coordinate with ODOT efforts, consider extending the restored natural area further downstream along bike trail.	Long-term
	3) No protection between ODOT maintenance area and stream.	a. Encourage ODOT to implement a stormwater pollution prevention plan (cover materials, limit runoff, etc.).	Short-term
		b. Widen vegetated buffer between ODOT site and stream.	Short-term
		c. Require implementation of citywide BMPs for all vehicle maintenance areas to reduce potential for water quality pollution.	Ongoing
	4) Modeling shows 700 feet of undersized channel downstream of Philomath Boulevard at ODOT facility. City staff notes that area floods frequently.	a. Increase channel capacity to prevent flooding and pollution from ODOT site. Coordinate with ODOT natural area.	Long-term
Philomath Boulevard to West Hills Road (North Branch)	1) Multiple culverts under highway may be barrier to fish passage.	a. Investigate to see if culverts meet new ODOT/ODFW standards for fish passage.	Short-term
	2) Stream corridor near highway has no canopy and is mowed to stream channel.	a. Work with ODOT to modify landscaping practices.	Short-term
	3) Modeling indicates undersized channel at intersection of Western and Philomath Boulevards.	a. Work with ODOT to ensure that culverts are well maintained (sediment removal). Replace culverts with larger ones if required as part of fish passage analysis.	Short-term
West Hills Road to 53rd Street (North Branch)	1) Farming activities crowd the stream corridor.	a. Work with County to require wide streamside buffers.	Short-term

Table 7-3. Squaw Creek Options (continued)

Reach	Abridged observations	Recommended activity	Priority
53rd Street to Headwaters (North Branch)	1) Intersection of 53rd Street and Reservoir Road is prone to flooding.	a. Work with Benton County and developers to protect existing upstream ponds and establish detention facilities.	Short-term
		b. Develop City and Countywide measures for preventing additional runoff volume or excessive velocities into the stream.	Ongoing
	2) Fish passage may be an issue at the 53rd Street and Reservoir Road culverts.	a. Investigate to see if culverts meet new ODOT/ODFW standards for fish passage.	Short-term
	3) Potential pollution from fairground parking lot and animal pens.	a. Route runoff through a vegetated swale that is regularly maintained.	Long-term
		b. Require roof and/or berm around animal pens to keep manure out of runoff.	Short-term
		c. Develop citywide requirements for treatment of parking lot runoff.	Ongoing
		d. Work with Benton County on requirements for treatment of runoff from animal storage facilities.	Ongoing
	4) Runoff from agricultural areas with livestock is a problem during storm events.	a. Establish riparian buffer and fence off stream to keep livestock out.	Short-term
		b. Develop citywide requirements for treatment of runoff from private animal storage facilities.	Ongoing
	5) Reservoir Road industrial area (sawmill) does not have a stormwater plan for preventing pollution.	a. Work with property owners to identify specific problems and potential solutions to protect water quality.	Long-term

Table 7-4. Squaw Creek Short-Term Program

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
Marys River to Reed Place	3) Restore habitat value by improving vegetative and native tree plantings along stream.	45,000	2,300	
	4) Develop and construct alternative to existing structure to remove fish barrier.	100,000	5,000	
Reed Place to 35th Street	2) Remove excessive accumulations of material from culvert at Knollbrook Place.	NA	300	
	4) Work with property owners to modify landscaping practices. Plant trees along south bank to provide shading. Use tree and shrub plantings to create riparian fringe along stream.	1,000	NA	Orange line
35th Street to Country Club Place	1) Convert the 100-foot long earthen ditch at pond outlet into a vegetated bioswale to provide filtration.	1,600	300	
	2) Work with golf course to develop a chemical use minimization plan to reduce potential for fertilizer, herbicide and pesticide pollution.	400	NA	
Country Club Place to Technology Loop (West Branch)	1) Work with property owners to modify landscaping practices and improve habitat.	200	NA	
Technology Loop to 53rd Street (West Branch)	1) Work with shopping complex owners to identify additional on-site measures to protect water quality in stream.	400	NA	
	2) Work with property owners to modify landscaping practices. Plant trees along south bank to provide shading. Use tree and shrub plantings to create riparian fringe along stream.	1,800	NA	Orange line
	3) Investigate to see if culverts at Philomath Boulevard and 53rd Street meet new ODOT/ODFW standards for fish passage.	400	NA	
Confluence with West Branch to Philomath Boulevard (North Branch)	3) Encourage ODOT to implement a storm-water pollution prevention plan (cover materials, limit runoff, etc.).	NA	NA	
	3) Widen vegetated buffer between ODOT site and stream.	1,800	NA	

Table 7-4. Squaw Creek Short-Term Program (continued)

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
Philomath Boulevard to West Hills Road (North Branch)	1) Investigate to see if culverts at Philomath Boulevard meet new ODOT/ODFW standards for fish passage.	400	NA	
	2) Work with ODOT to modify landscaping practices.	200	NA	Orange line
	3) Work with ODOT on sediment removal	200	NA	
West Hills Road to 53rd Street (North Branch)	1) Work with County to require wide streamside buffers.	200	NA	
53rd Street to Headwaters (North Branch)	1) Work with Benton County and developers to protect existing upstream ponds and establish detention facilities.	400	NA	
	2) Investigate to see if culverts meet new ODOT/ODFW standards for fish passage.	400	NA	
	3) Require controls to keep animal manure out of runoff.	400	NA	
	4) Establish riparian buffer and fence stream to keep livestock out.	NA	NA	
Total		**154,800**	**7,900**	

[1] Project types are in the Figure 7-3 map legend.

Table 7-5. Squaw Creek Long-Term Program

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
Marys River to Reed Place.	1) Establish floodplain policies (purchase or flood proofing of homes with problems).	112,500	NA	
	2) Stabilize streambank and restore riparian habitat value. May require City purchase of adjacent lands.	21,000	1,100	
Reed Place to 35th Street	1) Stabilize streambank and provide for stream meander.	160,000	8,000	Yellow line
	2) Work with school to re-establish floodplain downstream of 35th Street and stabilize banks.	1,600	80	
	3) Provide or require floodproofing of homes in this area.	112,500	NA	
	5) Create overflow channel for high flows along north side of channel.	480,000	24,000	Yellow line
35th Street to Country Club Place	2) Provide vegetative filtration to dechannel-ize lower ends of ditches from golf course. This would allow water to spread out into wooded wetland area.	20,000	1,000	
	3) Replace undersized pipes along Research Way.	65,000	NA	Red line
	4) Reconnect channel to floodplain from 35th Street to Research Way. Work to preserve vegetative buffer.	280,000	14,000	
Country Club Place to Technology Loop (West Branch)	3) Design and construct stream and riparian enhancement project, including reconnection of channel to floodplain at Sunset Park.	300,000	15,000	
Technology Loop to 53rd Street (West Branch)	4) Replace undersized pipes along Technology Loop beginning at 53rd Street. Install structural stormwater treatment facilities at discharge to creek.	102,000	NA	Red line
53rd Street to Headwaters (West Branch)	1) Improve overbank area to provide flow and storage capabilities while enhancing riparian zone.	500,000	25,000	
Confluence with West Branch to Philomath Boulevard (North Branch)	1) Coordinate with ODOT efforts, consider extending the restored natural area further downstream along bike trail.	800	NA	
	4) Increase channel capacity. Coordinate with ODOT natural area.	140,000	7,000	Yellow line

Table 7-5. Squaw Creek Long-Term Program (continued)

Reach	Recommended activity	Capital cost ($)	Annual O&M ($)	Project type[1]
53rd Street to Headwaters (North Branch)	3) Route runoff from fairgrounds through a vegetated swale that is regularly maintained.	2,600	130	✣
	5) Work with property owners to identify specific problems and potential solutions to protect water quality.	600	NA	✣
Total		**2,298,600**	**95,310**	

[1]Project types are in the Figure 7-4 map legend.

Figure 7-3 Short Term Project Locations

(see Table 7-4 for project descriptions)

LEGEND

- Pipes/Bridges
- Channels
- Basin Boundary
- Bank Stabilization
- Canopy Revegetation
- Channel Improvement
- Replace Pipe/Bridge
- Fish Passage
- Buffer/Riparian Habitat
- Floodplain Reconnection
- Water Quality BMP
- Flood BMP
- Maintenance
- Monitor
- Multi-Use Facility

N

Feet 600 0 600 1200 1800 2400 Feet

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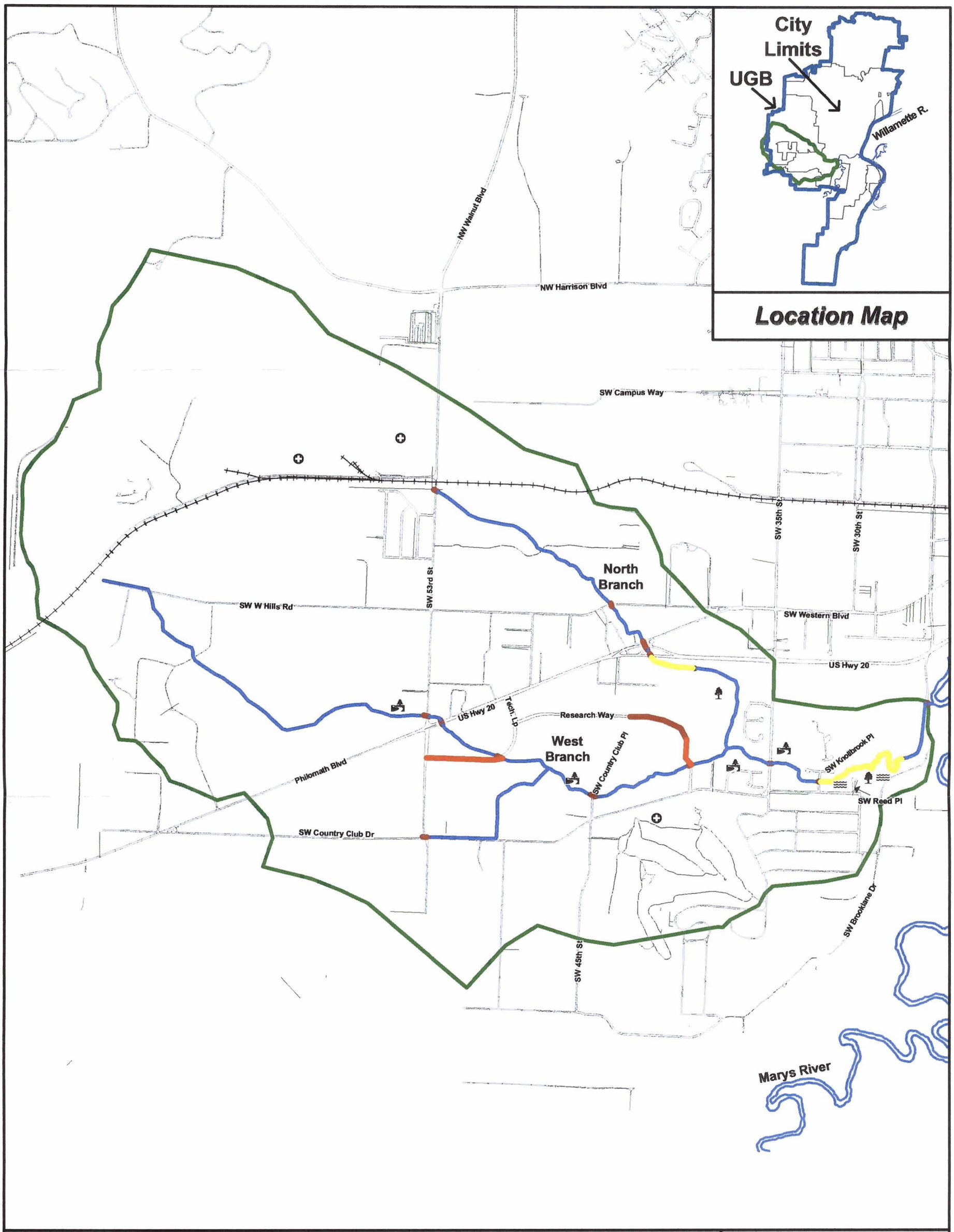

Figure 7-4 Long Term Project Locations

(see Table 7-5 for project descriptions)

LEGEND

- Pipes/Bridges
- Channels
- Basin Boundary
- Bank Stabilization
- Canopy Revegetation
- Channel Improvement
- Replace Pipe/Bridge
- Fish Passage
- Buffer/Riparian Habitat
- Floodplain Reconnection
- Water Quality BMP
- Flood BMP
- Maintenance
- Monitor
- Multi-Use Facility

N

Feet 600 0 600 1200 1800 2400 Feet

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