Baseline Habitat Evaluation and Evaluation of the Impacts of City Activities

Prepared for:

City of Corvallis, Oregon

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STREAM BASELINE ANALYSIS

The analysis uses as its template the "Matrix of Pathways and Indicators" developed by NMFS. This enables the use of the same techniques NMFS used as a framework for the major habitat categories. Further breakdown into specific elements will follow, along with conditions for establishing degraded, at risk, and properly functioning conditions, and the pathways for arriving at those conditions. The conditions for the analysis—the habitat elements, impacts, and pathways—are those established earlier in this document.

Assessment of Corvallis Streams

Dixon Creek (From CSMP 2000)

Dixon Creek originates in the hills to the northwest of Corvallis. Most of its length lies within the City, where it is an important feature of many residential backyards. It also runs through several school properties and parks before reaching commercial property at 9th Street and Reiman Avenue and shortly thereafter the Willamette River. The Dixon Creek watershed contains 2,712 acres. The largest land use is low-density residential, which covers more than one-third of the watershed. In addition, medium-density residential, Oregon State University (OSU) forestland (McDonald State Forest), and vacant parcels each cover about 400 acres.

If the watershed is developed to full build-out according to the City of Corvallis' Comprehensive Plan (1998), the vacant land may be largely converted into low- and high-density residential use. Other changes may include a decrease in medium-density residential and an increase in commercial land use. Overall, the number of impervious acres is estimated to increase by 13%, from 897 acres to 1,017 acres.

Habitat evaluations were made using both the Streamwalk conducted by Watershed Applications and field analyses conducted by SHAPIRO.

<u>Temperature</u>

The City is evaluating temperature at four permanent monitoring sites in Dixon Creek. Thermistors at the sites record the water temperature hourly.

<u>Sediment/Turbidity</u>

The high levels of fine sediment found throughout the Dixon Creek watershed likely are a function of the local geology and urbanization. In the vicinity of Dixon Creek, the Willamette valley floor is composed nearly entirely of silty-loam soils (USDA 1975). Therefore, high levels of fine and suspended sediments are likely natural features of the stream. Stream incision and bank erosion likely have added to the natural loads of fine and suspended sediments. Nutrient inputs from urban landscaping and fertilizing likely have increased the amount of algae in the stream and contributed to higher turbidity levels.

Chemical and Nutrient Contamination

The U.S. Geological Survey assessed Dixon Creek during its sampling in the mid-1990s. The chemicals found in it placed it in the non-agricultural category. These included Carbaryl (Sevin), used for both home and landscape applications; Dichlobenil (Casoron) and Tebuthiuron, used to control broadleaf weeds and under asphalt and railway rights-of-way (ROW); Diazinon, whose use is similar to Carbaryl; and Prometon, which is used in urban landscaping, ROW, and industrial applications, and by homeowners. Dixon Creek also exceeded standards for temperature, fecal coliform, and *Escherichia coli* bacteria. It appeared to have no excessive nutrients. It is likely, too, that this stream carried the "usual" urban runoff components of metals and petroleum products.

Physical Barriers

A partial barrier exists at the confluence of Dixon Creek and the Willamette River. The box culvert under Highway 20 has been modified to promote fish passage by creating deeper, slower flows through a portion of the culvert. However, because the culvert is perched and falls onto riprap, access to the culvert's fishway may be restricted to times when the water level in the Willamette is near the culvert outfall.

Flat-bottomed box culverts located at 3rd Street, 4th Street, Buchanan Avenue, Kings Boulevard, 29th Street, and Walnut Boulevard may pose additional passage problems during high and low flows. Dace were observed in the stream up to 29th Street, indicating that all of these box culverts are likely passable during some flow conditions.

Substrate

Exposed clay layers, silt, and riprap are the most common substrates in Dixon Creek. The high levels of silt and lack of gravel likely are a function of the local geology. No rock outcroppings or colluvial debris slides occur in the watershed to serve as a source of coarse stream sediments. Moreover, the silt loam soils that dominate this area of the Willamette valley (USDA 1975) are likely the dominant streambed material in the small wetland channels that historically appeared in the Corvallis area. The prevalence of exposed substrate probably is the result of urbanization along Dixon Creek. Channelization and changes to the creek's hydrograph have led to increased downcutting of the streambed and the exposure of clay layers formerly covered by the more erodible silt soils. The large quantities of riprap in the channel result from the frequent bank stabilization efforts needed to protect the highly erodible streambanks.

Large Woody Debris (LWD)

The small amount of LWD in Dixon Creek does not contribute significantly to stream complexity or aquatic refuge. Most pieces of wood in the creek are small-diameter deciduous logs that decay rapidly and have little potential to create significant instream cover. The highest concentrations of LWD are in the small headwater streams of Dixon Creek where fish presence is unlikely, as is downstream transport of the LWD. Recruitment potential is limited by the reduced size of the riparian zones and channel incision.

Pool Frequency

Long, trench-like scour pools with long, glide-like tail-outs are the dominant habitat types in reaches of Dixon Creek that could potentially support salmonids. However, pool frequency does not meet the 184 (or 96 pools per mile) standard established by NMFS. The long pool lengths preclude sufficient numbers of pools from occurring in any 1-mile (1.6 kilometer) length of stream.

Pool Quality

Pool quality in Dixon Creek is low. Deep scour or trench pools are abundant in Dixon Creek; however, they lack structures such as LWD and undercut banks that provide cover for fish. Reduction of pool depth because of sediment deposition is not a concern in Dixon Creek. The channelized nature of the stream ensures that all deposited sediments are washed out of the system during high flow events.

Off-Channel Habitat

Channel entrenchment in the lower reaches of Dixon Creek precludes the formation of off-channel habitat. No off-channel habitat exists in stream reaches that may potentially be in the mainstem of Dixon Creek or the lower portions of the tributary streams.

Refugia

Dixon Creek was likely a braided wetland channel surrounded by gallery forests before settlement by Euro-Americans. Land conversion and urbanization have dramatically changed the nature of the stream and its riparian areas. While a small amount of remnant aquatic refugia may exist in the headwater streams, none was observed during the survey. The natural wetland channels have been converted to a single entrenched channel. Gallery forests and riparian wetlands have been replaced with residential developments. Riparian buffers are narrow and have been overrun by invasive species such as Himalayan blackberry (*Rubus discolor*) and bedstraw (*Galium* sp.).

Width-To-Depth Ratio

Width-to-depth ratio is estimated to be approximately 8, which meets the NMFS criteria for PFC. However, because the channel is entrenched and revetments often prevent the stream from widening, this indicator may not be appropriate for use in evaluating stream health. The low width-to-depth ratio is more a function of degradation caused by urbanization than preservation of natural habitat conditions. Habitat features usually associated with low width-to-depth ratios, such as lower stream temperatures and instream cover, are not characteristic of the conditions in Dixon Creek.

Streambank Condition

The condition of streambanks in Dixon Creek is variable. The stream is undercutting root masses of living trees and bank erosion is common in the upper watershed. In areas where root masses are being undercut, future bank erosion is likely as the trees fall and expose unstabilized soils. Large portions of the streambanks have been armored with riprap, gabions, and log bulkheads. As more impervious surface is added to the watershed, bank erosion and undercutting likely will increase.

Floodplain Connectivity

Channel incision has severed much of the natural hydrologic link between the floodplain and the stream channel. Incision depth in the mainstem of Dixon Creek averages approximately 2.5 meters (8.2 feet). High flows that once regularly exceeded the streambanks and inundated the floodplain are now confined to the entrenched channel. Over-bank flooding now occurs only during extreme runoff events. Wetland riparian areas that once bordered the creek have become perched and drained as the water table has deepened.

Peak and Base Flows

Peak and base flows undoubtedly have been altered by the loss of riparian wetlands, channel incision, and land conversion and the addition of large amounts of impervious surface to the watershed. The loss of floodplain wetlands caused by channel incision has decreased the watershed's capacity to store water and likely has resulted in decreased base flows. Channel incision has increased the conveyance in the watershed and has contributed to sharper peaks in the stream hydrograph. The addition of large amounts of impervious surface, coupled with stormwater conveyance systems, creates a pathway by which precipitation is collected and quickly piped to the stream rather than percolating into the groundwater or slowly trickling into the stream. This rapid transformation of precipitation to runoff creates unnaturally high, sharp spikes in the hydrograph of Dixon Creek.

Road Density and Location

Road density in the urban environment of Dixon Creek is very high. A significant portion of the watershed is covered with impervious surface. Roads closely parallel the stream in many places and numerous road crossings fragment the aquatic and riparian habitat.

Disturbance History

More than 60% of the Dixon Creek watershed has been developed for commercial or residential purposes. Very little late successional or old growth forest remains in the area. Because of the permanent nature of urban development, no significant improvements to this indicator are expected.

Riparian Reserves

Approximately 80% of the riparian area in the watershed is developed. Riparian vegetation in the developed areas is confined to the land at or below the top-of-bank. At least 33 road crossings dissect Dixon Creek. These crossings reduce the connectivity and create a discontinuous series of isolated riparian areas.

References

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CORVALLIS ESA RIPARIAN MAPPING SUMMARY

All comments apply only to the area within the 400-foot- (122-meter-) wide riparian corridor.

Dixon Creek

- The mainstem (south of Walnut Avenue) is almost completely residential.
- The majority of the mainstem, although residential, includes a narrow strip of deciduous forest canopy that shades the channel.
- Street crossings that dissect the riparian zone are common on the mainstem.
- Tributaries (north of Walnut Avenue) generally are either in strips of deciduous forest bordered by unmaintained herbaceous vegetation or in continuous deciduous forest.
- Street crossings north of Walnut Avenue are uncommon or nonexistent.
- Some first-order tributaries are in herbaceous vegetation.

Oak Creek

- Most of the stream is bordered by a narrow strip of forest canopy.
- The lower 0.8 kilometer (0.5 mile) (downstream from 35th Street) includes commercial/industrial and residential development; road crossings are common.
- Upstream from 35th Street, the forested area varies from very narrow to the full width of the riparian area, averaging one-third to one-half of the corridor width.
- Agricultural lands make up most of the remainder of the corridor above 35th Street.
- Above 35th Street, road crossings occur every 0.4 to 0.8 kilometers (0.25 to 0.5 mile).

Mary's River

- The riparian buffer along the Mary's River consists mostly of deciduous forest that extends the full 61 meter (200 feet) on each side of the stream.
- The forest strip is contiguous on both sides of the stream, for the full length of the stream within the UGB.
- A small amount of agricultural land is located on the outer edges of the corridor just downstream from the point where the Mary's River flows into the UGB.

Squaw Creek

- Six major or complex road crossings fragment the system.
- Scattered but generally small pockets of commercial/industrial and residential development impinge on the corridor in several places.
- A forested strip is adjacent to nearly all of the stream, including the mainstem, north fork, and south fork; it averages about one-third the total width of the corridor.
- South of Philomath Avenue, the remainder includes residential, commercial/industrial, and infrastructure developments
- North of Philomath Avenue, the remainder consists mostly of agricultural lands.

APPENDIX A. DIXON CREEK STREAM SURVEYS

Dixon Creek Reach 1

Incision: 3 meters (9.9 feet)
Width: 3 meters (9.9 feet)
Bankfull Width: 5.5 meters (18.1 feet)
Substrate: silt, clay, and riprap
Gradient: near 0%

Reach 1 of Dixon Creek is marginal salmonid habitat. With the exception of one 5-meter- (16.4-foot-) long riffle, the entire reach is composed of slack water, slough-like habitat. The six pieces of LWD located in the reach would provide little shelter for fish during high flows. Off-channel habitat is absent in the reach and the clay, silt, and riprap substrate does not provide suitable salmonid spawning habitat or adequate habitat for many of the aquatic invertebrate species on which salmonids typically feed. At the time of the survey, turbidity in the reach was high and visibility was limited to approximately 0.4 meter (1.3 feet). The lack of adequate instream structure, substrate, food, and flow, and poor water, greatly limit salmonid use of the habitat in Reach 1 of Dixon Creek.

Reach 1 functions primarily as a conveyance system for flows generated farther up the watershed. The absence of off-channel habitat and the depth of incision preclude any flood storage potential in the reach. Streambanks appeared to be stable, except for a few small areas of active erosion.

The riparian area consists of a narrow strip of vegetation confined by residential developments on the south bank and the City's sewage treatment plant on the north bank. Grasses, small herbaceous plants, and Himalayan blackberries (*Rubus discolor*) were the dominant understory vegetation. The overstory shaded approximately 70% of the active stream channel and was composed of black cottonwood (*Populus balsamifera*), Oregon ash (*Fraxinus latifolia*), and big-leaf maple (*Acer macrophyllum*).

Dixon Creek Reach 2 (downstream from Highway 99)

Incision: 3meters (9.8 feet)
Width:3 meters (9.8 feet)
Bankfull Width: 6 meters (19.7 feet)
Substrate: silt and clay
Gradient: 1%

Habitat in Reach 2 is dominated by slow-moving glides and pools. The substrate is composed of deposited silt and exposed clay layers. Riprap and highly embedded gravel also are present in significant quantities. Very little instream cover is present in the reach, the result of no LWD or other sheltering structures. The lack of instream cover, dominance of slack water habitat, and poor substrate quality combine to make the aquatic habitat unsuitable for salmonid use.

Reach 2 functions primarily as a conveyance system for runoff generated in the upper watershed. The incised channel has little storage capacity and contains no high-quality fish habitat. Streambanks in the reach appear stable; large portions have been stabilized. Only one small area of stream bank erosion was identified near the middle of the reach.

The riparian area within the reach is constrained by the City's wastewater treatment plant on the north bank and residential development on the south bank. The width of the riparian buffer varies between 10 and 15 meters (23.8 and 49.2 feet) on either bank. Near Highway 99, no riparian overstory exists. The streambanks recently have been armored with riprap, covered with matting, and replanted with herbaceous vegetation. Planting trees in this area would improve channel shading.

Dixon Creek Reach 3

Incision: 3 meters (9.8 feet)
Width: 3 meters (9.8 feet)
Bankfull Width: 5 meters (16.4 feet)
Substrate: silt, clay, and riprap
Gradient: 1%

Habitat in Reach 3 is typical of the highly modified and contained urban environment common throughout most of Dixon Creek. Shallow glide habitat, approximately 0.3 meter (1.0 foot) deep, dominates the reach. A few riffles and pools are present and usually are associated with riprap stream substrates. Instream cover is limited by the lack of woody debris or other structures within the channel. Silt and clays dominate the substrate, although riprap also is common throughout the reach. The lack of cover and suitable substrates and poor water quality likely preclude salmonids from using Reach 3.

Reach 3, like most of Dixon Creek, has been straightened and its banks have been modified to prevent erosion. The banks on the outside of the 90-degree turns in the channel have been stabilized with gabions. A low terrace located on the north and east banks of the creek functions as a small floodplain and absorbs some of the energy of high-flow events. The width of this terrace varies between 3 and 10 meters (9.8 and 32.8 feet).

The riparian area is very narrow along most of the reach. Confined by adjacent development, the riparian overstory is limited to a single row of trees consisting of red alder (*Alnus rubra*), Oregon ash, cottonwood, and willow (*Salix* sp.). Recent plantings in the reach aimed at stabilizing streambanks and providing overhead cover have sustained damage from nutria.

Dixon Creek Reach 4 (27th Street to 29th Street)

Incision: 2.5 meters (8.2 feet)
Width: 1.5 meters (4.9 feet)
Bankfull Width: 4 meters (13.1 feet)
Substrate: silt, clay and riprap
Gradient: 1%

The aquatic habitat in Reach 4 consists of long trench pools and glides separated by a few short riffles. Pool habitat is generally of poor quality as it lacks both the depth and structure that provide cover for fish. Very little gravel is present in this reach and the substrate is composed of deposits of silt, organic sediments, an exposed clay layer, and riprap from bank stabilization projects. The few riffles of the reach are all associated with accumulation of riprap. No suitable salmonid spawning gravels are present in the reach and rearing habitat appears to be limited by the lack of cover. Dace (*Rhinichthys cataractae*), however, were observed in several places in Reach 4, suggesting that some salmonids may be present in the reach during a portion of the year.

Reach 4 functions primarily as a conveyance system for runoff generated in the upper portions of the Dixon Creek watershed. The stream course in Reach 4 has been channelized and is confined by residential development. No room is available for the construction or natural development of low terraces or a functioning floodplain. Residential yards and structures are present at or near the top-of-bank throughout the reach. A large portion of both streambanks has been armored with riprap or concrete debris. A treated-log bulkhead has been placed at the 90-degree bend just downstream from 29th Street. This stacked-log revetment is being undercut by the stream and the lower bank behind the structure is eroding. Other small areas of bank erosion in the reach usually are associated with revetment failures.

The riparian vegetation in Reach 4 is limited to the ground at or below the top-of-bank. A single row of cottonwoods and red alders along portions of the channel provides shade to approximately half of the channel. Other areas of the channel have no canopy closure and are exposed to direct sunlight during most hours of the day. Understory vegetation is dominated by Himalayan blackberry and herbaceous plants.

West Fork Dixon Creek Reach 1 (Hoover School to Walnut Blvd.)

Incision: 2.5 meters (8.2 feet)
Width: 2 meters (6.6 feet)
Bankfull Width: 4.0 meters (13.1 feet)
Substrate: silt and fine sediment
Gradient: 2%

This deeply incised channel provides very marginal fish habitat. A lack of cover results from the scarcity of deep scour pools and instream structures such as LWD and rootwads. The substrate is

composed of silt and fine sediments that are not suitable for salmonid spawning and do not provide habitat for many of the aquatic invertebrates typically consumed by salmonids.

The primary hydrologic function of this reach of Dixon Creek is to convey stormwater generated by the large amount of impervious surface higher up the watershed. The numerous stormwater outfalls both within and upstream from the reach generate frequent and unnaturally high peaks in the hydrograph of Dixon Creek. These frequent high flow events are responsible for bank erosion and increased incision in the reach. The reach was identified as a chronic sediment source by a Corvallis Storm Water Management Plan (2000).

The width and health of the riparian zone in this reach of Dixon Creek are variable. Hoover School, residential developments, a church, and Walnut Boulevard border the north bank of the creek. Development on the south bank is less common and a stream buffer is present downstream from Hoover School. Overstory vegetation, including Oregon ash, white oak (*Quercus alba*), and red alder, shade approximately 80% of the stream channel. Bedstraw (*Galium* sp.) and dense thickets of Himalayan blackberry dominate the understory.

West Fork Dixon Creek Reach 2 (20 meters [65.6 feet] upstream from Acacia Drive to 30 meters [98.4 feet] upstream from Ponderosa Avenue)

Incision: 1.5 meters (4.9 feet)
Width: 2 to 2.5 meters (6.6 to 8.2 feet)
Bankfull Width: 3 meters (9.8 feet)
Substrate: Heterogeneous mix of silt, gravel, riprap, and bedrock
Gradient: 4-6%

The channel in Reach 2 of the west fork of Dixon Creek is narrow and incised, composed of pool and riffle habitat. Live root masses create terrace-like waterfalls in the stream channel. As the stream flows over the root masses, it erodes the downstream substrate, creating waterfalls and plunge pools. Some pools in the reach appear to be suitable trout habitat; however, the frequent cascades may limit access to it. Patches of gravel, bedrock, riprap, and silt are present in the reach. Some gravel may be suitable spawning substrate for trout.

The sinuous stream channel appears to be downcutting and becoming more incised. The stream is undercutting trees adjacent to the channel. Channel incising likely is exacerbated by the stormwater runoff from the impervious surface in the watershed. Several 10.7- to 15.2-centimeter (4- to 6-inch) drain pipes from local residences empty directly into the stream.

The riparian area along the channel consists of a thin strip of trees near or below the top-of-bank. Overstory tree species include Oregon ash, red alder, big-leaf maple, and white oak. In some cases, riparian vegetation has been cleared to the edge of the bank and replaced with landscaping and lawns. The encroachment of development has led to decreased vegetative shading of the stream channel. Overstory vegetation provides shade to approximately 60% of the channel.

West Fork Dixon Creek Tributary (along Romancier Drive)

Incision: 0.3 meters (1.0 foot)
Width: 0.75 meters (2.5 feet)
Bankfull Width: 1.5 meters (5.0 feet)
Substrate: silt and organics
Gradient: 4%

The west fork tributary to Dixon Creek flows through a several-hundred-foot-long culvert as it passes under Walnut Boulevard. and part of a residential development. The moderate gradient and length of the culvert combine to make it an impassible barrier to migrating salmonids. The upstream end of the culvert has a debris grate at its opening. The stream does not appear to contain suitable fish habitat. The shallow channel possesses few significant pools and likely dries up during the summer months. The substrate is composed nearly exclusively of silt and organic sediments and would be suitable spawning habitat.

The channel becomes more incised approximately 70 meters (229.7 feet) upstream from the culvert inlet. Incision increases from 0.5 meter (1.6 feet) or less to an average depth of 1.0 meter (3.3 feet). Where the incision is less, flat riparian wetlands may provide water storage during periods of high runoff. Drain pipes from residences located on the east side of the stream empty directly into the creek. Presumably, these pipes are used to convey stormwater from roofs or driveways. These additions of stormwater may pose a threat to the functioning of the small stream channel. By increasing flow during periods of heavy precipitation, they may increase the amount of bank downcutting in the channel. A detention system would help alleviate these risks.

Middle Forks Dixon Creek

Incision: 0-1.5 meters (0-4.9 feet)
Width: 1 meters (3.3 feet)
Bankfull Width: highly variable
Substrate: silt and organics
Gradient: 2-5%

The middle forks of Dixon Creek flow through a sloping wetland between the two Arrowood Circle stream crossings. These channels are low-energy streams, with little or no channel incision. The westernmost stream channel is the largest. From the northern Arrowood Circle stream crossing, it flows along the western edge of a residential subdivision. Much of its right bank is closely bordered by landscaped yards. In one instance, a resident has attempted to prevent the channel from overflowing into his/her yard by lining the streambanks with sand bags; however, no significant impacts to the stream are evident. At the downstream end of the accessible stream habitat, the channel becomes more incised with step-like cascades and small plunge pools. The eastern channel averages approximately 0.6 meter (2.0 feet) in width and is usually incised less than 0.5 meter (1.6 feet). Stream flows become subsurface in places and likely are present only seasonally.

Both streams offer good flood-storage potential. The lack of incision and the wide, flat wetland areas adjacent to the streams allow floodwaters to easily top the banks and disperse across the floodplain. By dissipating their floodwaters energy and slowing their movement downstream, these wetland channels help prevent downstream erosion and stabilize the hydrograph of Dixon Creek.

The habitat in both middle fork channels is unsuitable for fish. Very few pools were observed in the stream and flowing water likely is seasonal. The substrate is composed entirely of silt and other fine sediments and therefore, not suitable for spawning.

Riparian zones along both streams show impacts from development. The riparian areas on the left bank of the western channel and the right bank of the eastern channel have been converted to residential yards. In places, these yards extend to edge of the creek. Where residential development has not encroached into the riparian area, flat wetlands border the stream. Despite these disturbances, the canopy over the stream shades approximately 85% of the wetted channel. Overstory vegetation consists of Oregon ash, red alder, white oak, and Douglas fir (*Pseudotsuga menziesii*). Understory vegetation consists of Himalayan blackberry, nootka rose (*Rosa nutkana*), Indian plum (*Oemleria cerasiformis*), and hawthorn (*Crataegus* sp.).

East Fork Dixon Creek

Incision: < 1.0 meters (3.2 feet)
Width: 1.0 meters (3.2 feet) (when flowing)
Bankfull Width: 2.0 meters (6.6 feet)
Substrate: silt and fine sediments

This stream should not be considered fish habitat because it is dry for much of the year. The well-drained soils near the stream allow water to percolate during the dry periods of the year.

The stream channel varies in incision depth. In Timber Hill Park, the channel is incised approximately 1.5 meters (4.9 feet). Approximately 152.4 meters (500 feet) upstream from the 29th Street crossing, incision decreases to less than 0.5 meter (1.6 feet). Because most of the banks and streambed are composed of alluvial soils, the stream is highly susceptible to bank erosion and channel entrenchment. Development projects in the upper portions of this small stream pose a serious risk to its functioning. Undetained stormwater inputs into the creek likely will result in high levels of bank erosion and increased channel incision.

Riparian vegetation is restricted to the floodplain and low terraces of the creek. Canopy closure is approximately 65% in the lower portions of the creek but decreases further upstream where the stream flows through open grassland habitat. Commonly occurring riparian species include Oregon ash, red alder, Himalayan blackberry, and Indian plum.

Watershed: DIXON CREEK

Date: November 1997

Location: West Tributary to North Fork

Observations: The small segment of creek most directly affected consists of approximately 300 feet of channel immediately upstream from Arrowood Circle just north of Sitka Place. The channel traverses set-aside open space (a community commons) within a suburban residential development in this headwaters area of the creek. Ownership is unknown. The channel is in a broad draw, has a generally very steep gradient, is 0.6 to 0.9 meter (2.0 to 3.0 feet) wide and 0.3 to 0.5 meter (12 to 18) inches deep, and is intermittent.

The stream nearly disappears as a discrete watercourse in the upper part of the draw, especially where the gradient flattens locally. Downstream, the channel becomes increasingly steep and more and more deeply entrenched as the road (Arrowood Circle) is approached. This results in exceptionally steep (>1:1) and essentially bare side slopes which are several feet high. The terrain at this lower end of the reach is man-made and surface soils appear to consist largely of sterile subsoils. The slopes at the lower end are therefore subject to chronic surface water erosion and are too steep and sterile to support ground-covering vegetation (without an intensive planting effort). The lower parts of the convex side slopes are too steep to support vegetation.

According to Patricia Benner (Benner 1984), this area has incised and headcut to a considerable degree over the last several very wet winters and all appearances suggest that this is in fact the case. Channel degradation no doubt occurred because future channel adjustments accompanying alteration of the catchment's hydrology were not considered and planned for during site development. The trajectory (although not the rate) of channel adjustment in this area was perfectly predictable before development. That is, discharging more water than the amount to which it was previously adjusted into a high gradient-channel that traverses erodible material will result in channel degradation.

A local property owner has lined the channel with angular rubble rock, apparently as a response to channel incision. Rock along the bank is now becoming stranded as the streambed degrades. The rock in the channel bed can only exacerbate a tendency for future lateral channel adjustments (i.e., widening). If left alone, this segment of the creek will continue to be a chronic sediment source and, increasingly, an eyesore in this landscaped commons. This little stream unfortunately serves as an unequivocal and highly visible model of inappropriate channel management in the urban setting, especially in valuable open space.

Recommendations: Relatively minor channel bank regrading over most of the reach, an intensive replanting effort, and the installation of appropriately placed, naturalistic grade control structures (otherwise known as channel-spanning sills, weirs, or "check dams") would prevent further channel degradation and soil erosion in this area. Based on the experience of a soil scientist who visited the site, large boulder sills tend to be simpler to build and more trouble-free than log sills in this type of setting. The very steep, deeply entrenched banks on the lowermost

stream segment would need a low retaining wall structure integrated into the channel reconstruction. This probably could be either in the form of a hand-stacked stone treatment or a more naturalistic boulder-strewn bank.

All plantable surfaces should be amended with organic matter to improve the soil's tilth and productivity. Attractive native species, many of which are used as landscape ornamentals (e.g., vine maple (*Acer circinatum*), kinnickinnik (*Arctostaphylos uva-ursi*), and Oregon grape (*Berberis aquifolium*), can be planted in such a way as to preserve the view of the creek channel for the neighbors. Mowing requirements would be reduced and people strolling the adjacent asphalt path would gain aesthetic and sensory benefits from the many small, noisy "waterfalls" now forming the watercourse.

Stewardship Opportunities: The project scale is small enough that community volunteers could complete most, and potentially all, of this project. In-water work during the summer months would not be an issue. Small mobile landscape equipment, such as Bobcats, potentially can be operated by volunteers and can access the site easily without damage to property. Rock sills and retaining walls can be constructed with supervised untrained manual labor and, of course, volunteers could accomplish all of the soil amendment and planting tasks. After a careful design is provided, the cost for equipment and supplies, including large stock plantings, is likely to be quite small (provisionally estimated at less than $7,500).

Location: North Fork Dixon Creek, existing pond (Hidden Pond) immediately upstream from Walnut Boulevard

Observations: Pond infilling with sediment; concrete outlet structure beginning to fail; potential source of thermal pollution (because of the large surface area of standing water and shallow depth) and chemical pollution (because of contamination by waterfowl excrement) to mainstem Dixon Creek; controlled water surface limits flood storage potential.

Recommendations: Remove the pond and outlet structure and re-create a naturalistic low-flow channel through the area. This would create a large in-line flood storage facility with considerable freeboard. The area also would sequester sediments (from continuing construction and/or poor management practices upstream) on the constructed floodplain. This could reduce sediment supply (and therefore channel-filling deposition) in the low-gradient, flood-prone area of Dixon Creek downstream. As an added measure, a sediment forebay and engineered channel clean-out area potentially could be installed on the upstream side of Walnut Boulevard. Because of the Walnut Boulevard culvert and very limited fish potential upstream fish would not appear to be an issue

Location: Timberhill at Creek Tributary to Dixon Creek, Timber Hill Park immediately upstream from Walnut Boulevard

Observations: The park appears under-utilized at present; grass turf extends to channel margin; a major park usage appears to be dog-walking, resulting in potential animal waste discharge to creek (no intervening buffer); moderate in-channel condition and poor riparian zone condition.

Recommendations: Regrade and replant the parkside (left side) of the creek to create a functional buffer; possible opportunity to retrofit (with extensive excavation) for meaningful flood storage, benefiting the flood-prone portion of Dixon Creek downstream. A sediment forebay and engineered channel cleanout potentially could be installed on the upstream side of Walnut Boulevard in conjunction with this work. Because of the Walnut Boulevard culvert and very limited fish potential upstream fish would not appear to be an issue.

Location: Near Walnut Place

Observations: A residential structure (possibly a deck) has been placed over the channel just downstream from the Walnut Place crossing. This represents undesirable infrastructure encroachment on the floodway and poses a hazard during floods. (Blackberry thickets obscured the view of this structure.)

Location: Substation and Hoover School to Northwest Baptist Church site

Observations: Stream is deeply to moderately entrenched and moderately confined by infrastructure, with significant areas of riparian open space. Cover is mainly either a rank-growth of grasses or mowed lawn, with substantial areas of blackberry. The channel is deeply incised near the Hoover School and substation, with many mature alder trees rooted low along the channel. The steepest banks here (1:1) are experiencing some erosion, exacerbated by the low-rooted trees, which act as hard points and concentrate scour locally. A sewer crossing in this vicinity has been uncovered by channel incision. The concrete cap over the pipe has been partly removed, leaving the pipe exposed.

Extensive and broad channel-marginal flood benches in the vicinity of the Northwest Baptist Church suggest recent incision into an area of former alluviation. This area is maintained and mowed for recreational use. Overhead cover, mainly alder, is good.

Overall instream and riparian habitat quality is low throughout this entire reach. The overall trajectory of channel-change in the area is stream degradation (channel incision and widening). This is evidenced by exhumed rooted tree trunks in the active channel, suspended outfalls, laterally undercut tree roots, bank failures, and toppling trees. This reach is now a chronic sediment source for Dixon Creek.

Recommendations: Regrade and replant streambanks and install naturalistic and fish-passable channel grade-control structures. A large area (more than 5 acres) of open space, which likely is used only seasonally, in the vicinity of the Baptist Church site affords an opportunity to retrofit for significant flood storage in this area. A passive flood storage facility could be designed which would enhance natural features and recreational use of the area during the non-flood season. Constraint: Private ownership.

Toppling trees present potential debris-jam and bank-erosion sites since the trees are likely to fall during a flood. To eliminate this hazard, the trees at risk can be removed, leaving the rooted stumps in place. The exposed sewerline upstream should be stabilized by recapping and installing grade-control structures and channel-marginal treatments to prevent further channel incision or widening.

Location: Northwest Baptist Church to 29th Street

Observations: The stream is channelized, deeply to moderately entrenched, and highly confined by mostly residential development. Banks along the lower reach appear generally stable, with extensive blackberry and ivy (*Hedera helix*) cover. Narrow flood benches marginal to the low-flow channel are common. Overhead cover (mainly alder) is good, although overall instream and riparian habitat quality is low. Substrate is largely gravel and soft bedrock, with silt-floored backwater pools. This area shows evidence of beaver activity in this area.

Recommendations: Closely spaced mature alders form a significant channel pinch point not far upstream from 29th Street. To eliminate this hazard, the lower bank trees can be selectively removed, leaving the rooted stumps in place.

Location: 29th Street to 27th Street

Observations: The stream is channelized, deeply entrenched, and highly confined by residential development. Significant sections of the lower bank have been revetted with stacked demolition debris (broken-up concrete pieces). Non-protected banks appear generally stable because of cohesive bank materials, although significant bare upper-bank areas are subject to chronic but apparently low levels of erosion by scour or surface wash. Overhead canopy coverage is moderate, although some of these trees are rooted along the low-flow channel, creating a potential conveyance issue. Overall instream and riparian habitat quality is low. Substrate is largely gravel and bedrock. Fish passage is hampered at the 29th Street box culverts.

A stacked log/timber pile revetment of creosote-treated logs is along the outside bend approximately 100 feet downstream from 29th Street. (Creosote-treated logs are not considered appropriate for the small waterway environment.)

Recommendations: The timber pile revetment structure is being undercut by high stream flows and should be watched for future instability. Alternatively, the structure could be preemptively replaced to provide a more durable, environmentally appropriate structure associated with upper bank riparian revegetation.

Location: 27th Street to Elmwood Drive

Observations: The stream is channelized, deeply entrenched, and highly confined by residential development. Extensive lengths of channel-confining bank revetments are present, especially

along the right bank. These include high walls of stacked timbers, salvaged concrete pieces, or stone. Unprotected banks appear generally stable because of cohesive bank materials and dense vegetation (mainly weedy blackberry and ivy). Overhead canopy cover is generally good. Overall instream and riparian habitat quality is low. Substrate is sand, gravel, and soft bedrock. Fish passage is hampered at the 27th Street box culverts.

The breached remnant of a concrete low-head dam was identified approximately 100 feet downstream from the 27th Street crossing. This caused accelerated bank erosion. The dam was removed by the City in 1998.

Location: Elmwood Drive to Circle Boulevard

Observations: The stream is channelized, moderately to deeply entrenched, and moderately confined by residential development. Banks are largely unprotected by revetments, although a few homemade lower bank treatments are present. Streambank angles vary from very steep to relatively low, with the banks appearing to be generally stable because of cohesive composition and extensive vegetation cover (mainly blackberry and ivy). Some of the grass-covered flood benches present forming significant undercut banks. Overhead canopy cover is moderately good, considering the small channel size, although overall instream and riparian habitat quality is low. Substrate is silt, sand, and gravel. Extensive gravel bars are present in the upper part of this reach. The Elmwood Drive box culverts were partially clogged with sediment deposits in November 1997.

Recommendations: A small concrete stop log structure just upstream from Circle Boulevard creates a pinch point for a potential debris jam. Damming the creek here is inappropriate and removing this structure will relieve this hazard.

Location: Circle Boulevard to Kings Boulevard (Jefferson Elementary School)

Observations: The stream is moderately entrenched with no confinement by developed infrastructure along the right (south) bank; a parking area closely encroaches on the north bank. The school property along the right bank appears to be under-utilized, consisting of the maintained playground most distant from the school buildings and a large, infrequently-mowed vacant area to the west of this. Relatively recent enhancement plantings have supplemented mature alders on the right bank, resulting in canopy coverage of the channel which should impove over time. Low flood benches with undercut banks are extensive along this reach, producing overhead cover and somewhat improved aquatic habitat compared to many other reaches. Overall instream and riparian habitat conditions must still be considered degraded. The prevalence of these low flood benches creates a narrow, two-stage flood cross-section, mimicking a natural floodplain where overbank areas absorb much of the energy of high stream flows. Substrate is silt, sand, and gravel. Channel bank and beds appear essentially stable. The Circle Boulevard twin box culverts were partially blocked by sand and gravel deposits in November 1997.

Recommendations: This large area of under-utilized, publicly owned open space immediately adjacent to the stream provides a potentially valuable opportunity to create a relatively large, passive flood-storage facility. This can be a true multi-objective urban stream rehabilitation project, with habitat, recreational, and visual improvements readily integrated into the flood alleviation design. The standard prescription would be to excavate a large area adjacent to the channel to greatly enlarge functional floodplain area.

Stewardship Opportunities: Enhancement work here affords obvious educational/volunteer opportunities.

Location: Kings Boulevard to Beca Avenue

Observations: This area was enhanced for improved drainage in 1997. The streambanks were regraded to enlarge the flood conveyance cross section and bypass pipes ere installed at road crossings. Upper bank planting of native riparian trees will eventually provide overhead cover, improving the thermal regime of the creek.

Recommendations: The left (north) bank just downstream from Kings Boulevard began failing (caused mainly by mass wasting processes, not fluvial erosion) in the winter of the 1997-98. This area was at the upstream end of (and primarily upstream from) the previously described streambank work. Watershed Applications analyzed the site and recommended a planted log cribwall treatment along this section of bank. This was installed by the City in the fall of 1998.

Location: Beca Avenue to Buchanan Avenue

Observations: Moderate entrenchment and moderate to low confinement by residential development. Banks through most of the reach are stable, although recent flooding has caused substantial areas to erode. Bank cover angle varies from near-vertical (at failures) to quite shallow; bank cover varies from bare to grass to extensive areas of blackberry thicket. Glide and backwater pool habitat predominate (forced by riffles comprised of rubble and demolition debris or soft bedrock knickpoints). Substrate is primarily silt and sand. Overhead canopy cover is generally good, with this provided largely by ornamental plants and conifers. Overall instream and riparian habitat quality is low. Yard-debris dumping along the channel margin is common.

Recommendations: A large area of apparently under-utilized streamside property on the left (east) bank upstream from Buchanan Avenue could potentially be used to create an off-channel flood storage site. Constraint: Probable private ownership.

The left bank just downstream from the junction of 15th Street and Lincoln Avenue is eroded. Grass extends to the channel edge, with no native riparian buffer. A low, dry, stone retaining wall could be constructed along the bank toe. The upper bank could be regraded and planted with native riparian vegetation. Minor boulder grade controls could be installed to support the dry stone wall revetment.

Location: Buchanan Avenue to 11th Street (Corvallis High School)

Observations: The stream is channelized, moderately entrenched, and moderately confined by school infrastructure. Banks are largely unrevetted, although a dumped rock riprap treatment is located at the bend just downstream from the Buchanan Avenue bridge. Localized bank failures are common and there is a partially slumped bank on the right channel margin about 61 meters (200 feet) downstream from Buchanan Avenue. Downstream from this, an old outfall structure forms a hard point, with a small area of bank erosion immediately downstream. Tension cracks are common along the right bank just upstream from 11th Street. Bank vegetation is mainly weedy grasses; canopy cover is almost non-existent. Stream habitat in this low-gradient reach consists mainly of glide habitat formed by a backwater condition generated well downstream from 11th Street (see below). Fine-grained substrate predominates. Instream habitat and riparian zone conditions are uniformly poor. A large deposit of sediment was observed under the Buchanan Avenue bridge in 1997.

Recommendations: Multi-objective rehabilitation project for bank stabilization, improved conveyance and bank storage, improved stream habitat, enhanced amenity value, and educational opportunities. This can be accomplished by regrading and replanting streambanks, creating a stable channel margin, and creating a two-stage channel cross section (by the excavation of low, channel-margin flood benches) in the long but relatively wide reach between opposing school buildings. Additional work could include adding a curb to the parking lot on the right bank and directing storm runoff through a stepped grassy swale instead of through the pipe now discharging directly to the creek. Enhancement work here affords obvious educational/volunteer opportunities.

Location: 11th Street to 10th Street

Observations: The stream is channelized, moderately entrenched, and highly confined by residential development. Banks are largely non-revetted but appear relatively stable because of cohesive bank materials and blackberry and ivy vegetation cover. Overhead canopy coverage is good, with a large component supplied by non-native horticultural species (especially English laurel [*Pranus laurocerasus*]). Overall instream and riparian habitat quality is low. Substrate is largely silt. A 30.5-centimeter (12-inch) diameter steel pipe and rubble cover forms a low weir with a 0.5-meter (1.5-foot) drop about 38.2 meters (125 feet) downstream from 11th Avenue. This creates the long backwater extending upstream through the Corvallis High School reach. This weir/ramp also creates a long plunge pool below the structure. Sediment and vegetation-covered dumped riprap treatments up- and downstream from the 10th Street bridge restrict conveyance in this area.

Location: 10th Street to 9th Street

Observations: The stream is channelized, deeply entrenched, and highly confined by both residential and commercial development. Banks are largely covered with a rank growth of non-

native grasses or (especially) with dense blackberry thickets. Although banks appear to be mainly stable (because of cohesive bank materials and vegetative cover), the dense blackberry cover may be hiding bank failures: streambanks appear to be quite steep in these areas. Some of the turf-covered banks also appear to be deeply undercut and may be prone to localized failure. The left (outside) bank of the tight bend below 10th Street is revetted with dumped demolition debris and has an associated scour pool; the right (outside) bank of the tight bend upstream from 9th Street is turf-covered and is progressively failing as localized sloughs. Overhead canopy coverage is very poor and overall instream and riparian habitat quality is low. Substrate is unknown (most of the channel was inaccessible on the survey date) but is suspected to be dominated fine sediment accumulations because of low channel gradient: grade control at the 9th Street crossing creates a long backwater up through this reach.

Location: 9th Street to Reiman Avenue

Observations: The stream is channelized, deeply entrenched, and highly confined by commercial development. The left bank is covered by a rank growth of non-native herbaceous weeds which appear to be periodically treated by cutting or herbicides. The slope angle here is about 2:1; the right bank is very steep (1:1) and covered with a similar but thin growth which appears to reflect poor soil conditions (gravelly silty clay). This oversteepened right bank has a few slump failures. Overhead canopy coverage is nil and overall instream and riparian habitat quality is extremely poor. Native herbaceous wetland species such as rushes and sedges (e.g. *Scirpus* sp.) grow along the channel bottom, along with reed canarygrass (*Phalaris arundinacea*) and other weedy graminoids. The streambed consists mainly of gravel and rubble with vegetation-stabilized fine sediment deposits along the margins.

Recommendations: Regrade banks to lower angles (requiring widening of the easement and some removal of asphalt) or create low stone breast walls to allow lower angle plantable surfaces within the existing easement. Amend soils and replant banks (especially the south bank) with native riparian vegetation, including fast-growing species such as alders. Capture/treat parking lot runoff if feasible.

Location: Reiman Avenue to railroad tracks (end of survey)

Observations: The stream likely is channelized but has begun to reinstate a sinuous alignment. The channel is deeply entrenched, however, and some relatively extensive bank failures have occurred here. Significant bank erosion is evident on the right bank just downstream from the Reiman Avenue crossing. This is both exacerbated by and evidenced by a poured concrete spillway draining a facility pad, which is now deeply undercut. The property is undeveloped so is mostly unconfined by infrastructure (especially on the right bank downstream from the light industrial facility (with the drain) near Reiman Avenue. The streambed varies from sand and gravel to coarse rubble, with shallow glide/pool habitat and intervening rubble riffles. Banks are steep but are widely separated, providing for a narrow but low functional floodplain of both depositional and streamcut surfaces. Bank cover is largely non-native grasses with minor blackberry thickets and some native woody vegetation.

Recommendations: Variably regrade banks to lower angles to create plantable surfaces along the channel margin. Amend soils and replant banks (especially the south bank) with native riparian vegetation, including fast-growing species such as alders. Special emphasis should be given to preserving as much existing woody vegetation on the site as possible, including the large specimen oak at the top of the bank near the railroad tracks. Naturalistic grade control structures may be required, but these can also provide instream habitat and visual interest. This project, in a site yet to be developed, could serve as a model for the preemptive rehabilitation of urban infill sites.

References

Benner, (Patricia) 1984. "Oak Creek: Management of the basin." Oregon State University, Corvallis, Ore. URL http://osu.orst.edu/dept/oakcreek/ (visited June 2001).