Attachment A Environmental Report

Sustainable Development Project R-1 Area: Environmental Report
(Steward & Associates and City of Woodinville)

CITY OF WOODINVILLE
SUSTAINABLE DEVELOPMENT PROJECT
R-1 AREA

ENVIRONMENTAL REPORT

January 2007

Revised February 2007

Steward & Associates

With revisions by the City of Woodinville

Executive Summary v
Overall Conclusions vi

I. Introduction 12
Regulatory Basis: Growth Management and Urban Densities 14
Refined Goals of This Report 16

II. Critical Area Review 18
Inventory 18
Fish and Wildlife Habitat Conservation Areas 18
Wetlands 23
Geologic Hazards 24
Critical Aquifer Recharge Areas 24
Litowitz Test 26
Cold Creek 27
Lake Leota 28
Implications for Development Densities 30
Lake Leota 30
School Basin 31

III. Conclusions 33
Lake Leota Basin 33
Other Considerations 33
School Basin 35
Daniels Creek Basin 35
Upper Woodin Creek Basin 35
Hillside Drainages 36
Golf Course Basin 37

IV. References 38

Tables

Table ES-1. Summary of Environmental Conclusions and Technical Findings viii

Figures

Figure ES-1. Woodinville Drainage Areas vii
Figure I-1. R-1 Zoning 13
Figure II-1. Groundwater Contour Map of Woodinville R-1 Area 20
Figure II-2. Woodinville Slopes and Storm Drainage 22
Figure II-3. Moderate & High Critical Aquifer Recharge Areas (CARAs) 25

Appendices

A. Hydrogeologic Analysis for City of Woodinville Sustainable Development Program, Golder Associates

B. Lake Leota Analysis for City of Woodinville Sustainable Development Program, C. Michael Falter

C. Wetland Evaluation for City of Woodinville Sustainable Development Program

   C-1. Woodinville Additional Wetland Reconnaissance Survey, Jones & Stokes

   C-2. Woodinville Wetland Survey, Cooke Scientific

   C-3. Citizen Advisory Panel Supplied Map

D. Low-Impact Development Analysis for City of Woodinville Sustainable Development Program, Perteet Inc.

Executive Summary

This report was commissioned by the City of Woodinville in June 2006 to help the City evaluate environmental conditions that could potentially affect zoning densities and development standards in its R-1 zone. The Growth Management Act (GMA) (RCW 36.70A.070(2)) calls for ensuring "the vitality and character of established residential neighborhoods" and past Central Puget Sound Growth Management Hearings Board (Board) decisions have explicitly authorized lower urban densities when they provide added or necessary protection for critical areas that are large in scope, complex in structure and function, and of a high rank order. (These criteria are known as the "*Litowitz* test," following the name of the plaintiff in the case where they were first identified[1].) This environmental report is one of four reports included in the analysis of Sustainability Study. The other three parts include neighborhood character, transportation, and capital facilities.

The city's R-1 zone, where the minimum size for new parcels is one acre, encompasses approximately 30% of the City's area and is located in the City's northeast corner. Under current codes, the R-1 zone density can be increased to R-4 only upon approval of a rezone. R-1 to R-4 in Woodinville's Comprehensive Plan is considered Low Density.

Viewed in the abstract, R-1 zoning has been inconsistent with past decisions by the Board regarding minimum urban densities, but recent Court and Board decisions indicate that such densities are not necessarily required in all urban areas as an absolute rule. The following are relevant contextual factors when determining densities and are specifically discussed in the neighborhood character report:

- The percentage of the overall land in the City where lesser densities may be permitted; and
- Whether the City is meeting its assigned growth target, the City's overall average density, what density and designations are applied to undeveloped/unplatted areas of the City, and whether, overall, the City's planning record indicates that it is meeting its obligations under the Growth Management Act (GMA).

One of the purposes of this environmental report is to evaluate whether there are any critical areas—including wetlands, fish and wildlife habitat conservation areas, geologically hazardous areas, and critical aquifer recharge areas—in or adjacent to the R-1 zone that meet the *Litowitz* test and if so, how they likely would be affected by different zoning densities. This report also advises the City on how it can best meet its overall environmental goals in this zone under a variety of densities, from R-1 to R-4. It is important to note that this study evaluates environmental issues at a planning level. At any future density, developments would be required to protect critical areas through the provisions of the Critical Areas Ordinance (WMC 21.24) and the Stormwater Manual (WMC 14.09), e.g., protective buffers, detention and discharge to safe locations.

In summary, we identify two critical areas in the R-1 zone that meet the *Litowitz* test: Cold Creek and Lake Leota. These two critical areas are linked via the Lake Leota drainage basin, which is the primary headwaters for Cold Creek. The outlet stream of Lake Leota is, in fact, Cold Creek, but for the majority of time the lake does not flow out through this stream, but instead infiltrates into groundwater, which reaches Cold Creek through seeps and springs to the east of the R-1 zone. Cold Creek's unusual reliance on groundwater is why it provides a steady flow of cold, clean water to the

[1] *Litowitz v. Federal Way*, CPSGMHB Case No. 96-3-005 (July 22, 1996).

Bear Creek system downstream. Bear Creek is the largest producer of naturally spawned salmon for a stream its size in western Washington, and Cold Creek plays a very important role in that.

Maintaining R-1 zoning within the 505-acre basin that drains to Lake Leota would help protect the lake from increasing phosphorus inputs from stormwater, which is crucial for the lake's future water quality. The Lake Leota basin comprises approximately 40% of the entire R-1 zone (see Figure ES-1 for a map of drainage basins in the R-1 zone). See Table ES-1 for a more detailed summary of our recommendations and technical findings.

Overall Conclusions

Based on environmental factors, the conclusions of this study differ for different areas of the R-1 zone, primarily because of complex patterns of surface water drainage and groundwater flow and the special needs to protect Leota Basin and Cold Creek that cannot be accomplished by the standard requirements of the city's Critical Areas Ordinance. The areas include six approximate drainage basins identified in Figure II-2: Lake Leota Basin; the School Basin; the small part of the R-1 zone that drains to Daniels Creek; the upper Woodin Creek Basin; the Hillside Drainages along the slopes of the northwest section of the zone; and the Golf Course Basin in the far northwest corner of the zone. The data collected for this study has been used to determine a broader planning level analysis that identifies whether or not different zoning densities could improve the protection of important critical areas in the city. Taking into account that individual developments are required to protect on-site critical areas such as streams, wetlands, steep slopes, aquifer recharge areas, and others by complying with the Woodinville Municipal Code, Critical Areas Ordinance, Chapter 21.24, the conclusions of this study determined that Lake Leota and Cold Creek required additional protection through decreased densities.

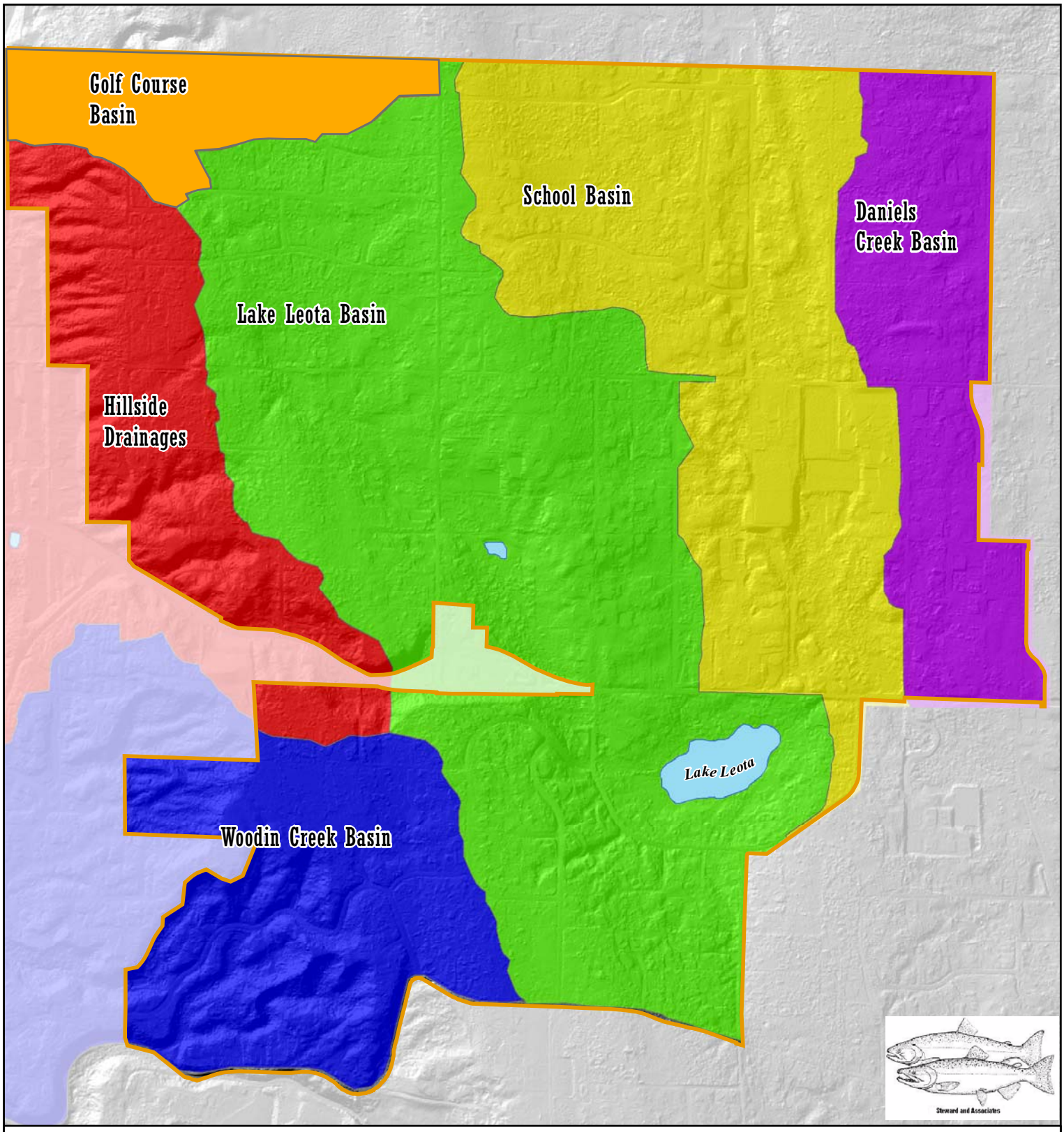


Figure ES-1. Woodinville Drainage Areas

Drainage areas

- Hillside Drainages
- School Basin
- Daniels Creek Basin
- Woodin Creek Basin
- Lake Leota Basin
- Golf Course Basin
- R-1 boundary
- Waterbodies

0 0.5 Miles

N W E S

1:13,500

Table ES-1. Summary of Environmental Conclusions and Technical Findings

Area	Conclusions	Technical Findings
Lake Leota Basin*	• *R-1 zoning provides substantial, long-term environmental benefits not solely achieved by requirements of the Critical Areas Ordinance* • Even if increased density is necessary to provide sewer service, there would be a net environmental benefit directly surrounding the lake • Require Low-Impact Development (LID) as part of stormwater regulations throughout basin. LID performs best at lower densities.	• Lake Leota and Cold Creek meet Litowitz criteria; lake is part of Cold Creek headwaters which flows to Bear Creek, high spawning tributary in Western Washington • Lake is at risk of accelerating eutrophication; which would worsen with increased development density • Lake is growing shallower, becoming more polluted • Trends pose long-term risks to Cold Creek, Bear Creek system • Goal: minimize eroded sediments from stormwater entering lake • Reducing net nutrient inputs by replacing septic systems directly adjacent/around lake with sewer would probably be positive even if accompanied by other impacts on water quality from increased density • Septic systems should be upgraded to increase nutrient removal • Limited Steep Slopes –per mapping • Wildlife – no protected species documented, many birds and mammals exist in an urban setting.
School Basin	• *R-1 zoning* benefits Cold Creek, but *with minimal effect on its most important attributes; maintaining low density in this part of R-1 Zone is not as important as in Lake Leota Basin* • *R-4 could have negative impact without LID* • Emphasis in this area is requiring LID through stormwater performance standards for new development. This provides greatest benefit at lower densities but, ironically, they may be more important at higher densities, where the potential impacts to downstream resources would be greater without such extra effort.	• Surface water from basin drains to Cold Creek; provides relatively small contribution to Cold Creek flows • Groundwater drains west, bypassing Cold Creek • Stormwater impacts have little effect on contribution of cold, steady summer flows downstream • Cold Creek remains important system to protect in its own right, supporting five salmon species • Limited Steep Slopes –per mapping • Wildlife – no protected species documented, many birds and mammals exist in an urban setting.

Table ES-1. Summary of Environmental Conclusions and Technical Findings

Area	Conclusions	Technical Findings
Daniels Creek Basin	• *R-1 zoning provides minor benefits to Daniels Creek, minimal benefits to Bear Creek system* • LID would provide some benefit, but lower priority than elsewhere	• Surface water from area is small part of Daniels Creek basin; groundwater drains to west • Cottage Lake attenuates impact of Daniels Creek Basin on rest of Bear Creek system • Limited Steep Slopes –per mapping • Wildlife – no protected species documented, many birds and mammals exist in an urban setting.
Upper Woodin Creek Basin	• *R-1 zoning provides some protection to geologic hazards, minor benefits to Woodin Creek* • Stormwater management is key to protecting geologic hazard areas; fuse-welded tightlines (e.g. HDPE pipe) for discharge of storm water • Infiltration near slopes would threaten geologic hazard areas • Sewer service is needed for densities greater than R-1, to prevent slope instabilities and groundwater contamination • LID would provide some downstream benefit to Woodin Creek, but infiltration should be prohibited within 50' from top of slope, and within 50-500 feet should be thoroughly reviewed and supported by geotechnical reports and approved by the city.	• Woodin Creek probably does not meet Litowitz criteria, especially above fish blockages • R-1 area is relatively small part of basin • NGPEs provide valuable protection that remains regardless of zoning • Geologic hazards are common and significant • HDPE fuse-welded tightlines and tanks or vaults, not ponds, should be adequate to protect slopes from adjacent stormwater • Groundwater surcharge from increased infiltration or denser septic discharges would pose risk to geologic hazards; infiltration should be prohibited within 50' from top of slope, and within 50-500 feet should be thoroughly reviewed and supported by geotechnical reports and approved by the city. • Large underdeveloped parcel has geologic hazards and wetland, is headwaters of North Tributary • Wildlife – no protected species documented, many birds and mammals exist in an urban setting.

Table ES-1. Summary of Environmental Conclusions and Technical Findings

Area	Conclusions	Technical Findings
Hillside Drainages	• *R-1 zoning provides some protection to geologic hazards, minor benefits to Little Bear Creek;* • Stormwater management is key to protecting geologic hazard areas; fuse-welded tightlines (e.g. HDPE pipe) for discharge of stormwater; • Infiltration near slopes would threaten geologic hazard areas; • Sewer service is needed for densities greater than R-1, to prevent slope instabilities and groundwater contamination. • LID would provide some downstream benefit to Little Bear Creek, but infiltration should be prohibited within 50' from top of slope, and within 50-500 feet should be thoroughly reviewed and supported by geotechnical reports and approved by the city. • Other forms of LID still encouraged.	• Hillside Drainages are relatively small part of Little Bear Creek basin flows • HDPE tightlines would be adequate to protect slopes from adjacent stormwater • Groundwater or perched water surcharge from increased infiltration or denser septic discharges would pose risk to geologic hazards • Along the northwestern portion of the basin, a large undeveloped forested hillslope runs north-south, connecting to a large vegetated area in the adjacent golf course to the north and an industrial area below. Although there are no documented protected species (threatened, endangered) in this area, the area provides a place for urban species to forage, nest, drink and move into adjacent open areas. Pileated woodpeckers are a "State Candidate" species without specific or designated protection, and are not expected to be impacted by future development. The industrial area and highway, limit the ability to support wildlife species that are not tolerant of substantial human disturbance.
Golf Course Basin	• *R-1 zoning provides some protection to geologic hazards, minor benefits to Little Bear Creek, helps minimize erosion in Golf Course Creek;* • Stormwater management is key to protecting geologic hazard areas; fuse-welded tightlines (e.g. HDPE pipe) for discharge of stormwater; • Infiltration near slopes would threaten geologic hazard areas; • Sewer service is needed for densities greater than R-1, to prevent slope instabilities and groundwater contamination;	• Golf Course Basin is relatively small part of Little Bear Creek basin flows. • HDPE tightlines would be adequate to protect slopes from adjacent stormwater. • Groundwater or perched water surcharge from increased infiltration or denser septic discharges would pose risk to geologic hazards. • Golf Course creek may be perennial, provides important source of water for wildlife in area. • Golf Course creek carries high sediment load from eroding ravine, which could be exacerbated by development in headwaters area without stormwater management focused on minimizing erosive

Table ES-1. Summary of Environmental Conclusions and Technical Findings

Area	Conclusions	Technical Findings
	• LID, especially in headwaters of basin, could provide significant benefits to Golf Course creek; infiltration should be prohibited within 50' from top of slope, and within 50-500 feet should be thoroughly reviewed and supported by geotechnical reports and approved by the city.	discharges.

*While zoning densities and development regulations are crucial to the long-term health of Lake Leota, there are additional actions that could provide both short-term and long-term benefits to the lake. These include constructing new stormwater management facilities and channel improvements to reduce erosion into the lake, as well as providing education and technical assistance to property owners—especially lakeside property owners—regarding best management practices for landscaping, septic system maintenance, and other issues.

I. Introduction

This report, commissioned by the City of Woodinville in June 2006, evaluates potential impacts on critical areas from different zoning densities in the City's R-1 zone (see Figure I-1) and provides recommendations to protect the functions and values of those areas. It also provides general recommendations concerning how the City can best meet its overall environmental goals in this zone under a variety of potential densities, from R-1 to R-4. The GMA (36.70A.070(2)) calls for ensuring "the vitality and character of established residential neighborhoods" and past Central Puget Sound Growth Management Hearings Board (Board) decisions have explicitly authorized lower urban densities when they provide added or necessary protection for critical areas that are large in scope, complex in structure and function, and of a high rank order. (These criteria are known as the "*Litowitz* test," following the name of the plaintiff in the case where they were first identified[2].) This environmental report is one of four reports included in the analysis of Sustainability Study. The other three parts include neighborhood character, transportation, and capital facilities.

At 1,258 acres, the R-1 zone is the largest contiguous residential area in the City, encompassing 30% of the City's total geographic area. Based on current zoning, it represents about 11% of the future residential development capacity in the City (B. Wuotila, City of Woodinville, personal communication). "R-1" refers the minimum size of one acre for new parcels in the zone. Past subdivision has created some smaller parcels than this; the median existing parcel size in the zone is 0.9 acre (Wuotila, personal communication). The City inherited one-acre zoning in this area from King County, when Woodinville incorporated in 1993. Most homes in the zone are twenty to thirty years old and were built under King County regulations. According to the City's 2002 Comprehensive Plan, 89% of the housing stock in the R-1 zone is ranked as either "good" or "very good." Most roads in the R-1 zone have narrower widths of 20 feet, no shoulders, and no sidewalks. All homes in the zone are served by septic systems. The zone is within the Woodinville Water District. In the eastern part of the study area, sewer service would be more expensive given topographic constraints, distance from existing sewer mains, and need for pump stations, which is generally more costly. (See Attachment D of the overall R-1 review report, "Capital Facilities and Utilities in the R-1 Area.") Under WMC 21.04.080(1)(a), development can proceed in the R-1 zone at densities up to R-4 (four units per acre) if adequate infrastructure can be provided. Change from the R-1 zone classification to R-4 would require a rezone.

The R-1 zone contains the following critical areas:

- Lake Leota, the largest lake in the City and part of the headwaters of Cold Creek, an important tributary to Bear Creek, a large producer of naturally spawned salmon for a stream its size in Western Washington;
- Steep slopes and other geologic hazards, which run along much of the zone's western border;
- Probably more wetlands than any other part of the City, although no Category I wetlands or wetlands with high habitat value;
- The headwaters of Woodin Creek, a salmon-bearing tributary to the Sammamish River;
- Aquifer recharge areas, some of which are designated as highly susceptible to pollution.

---

[2] *Litowitz v. Federal Way*, CPSGMHB Case No. 96-3-005 (July 22, 1996).

City of Woodinville

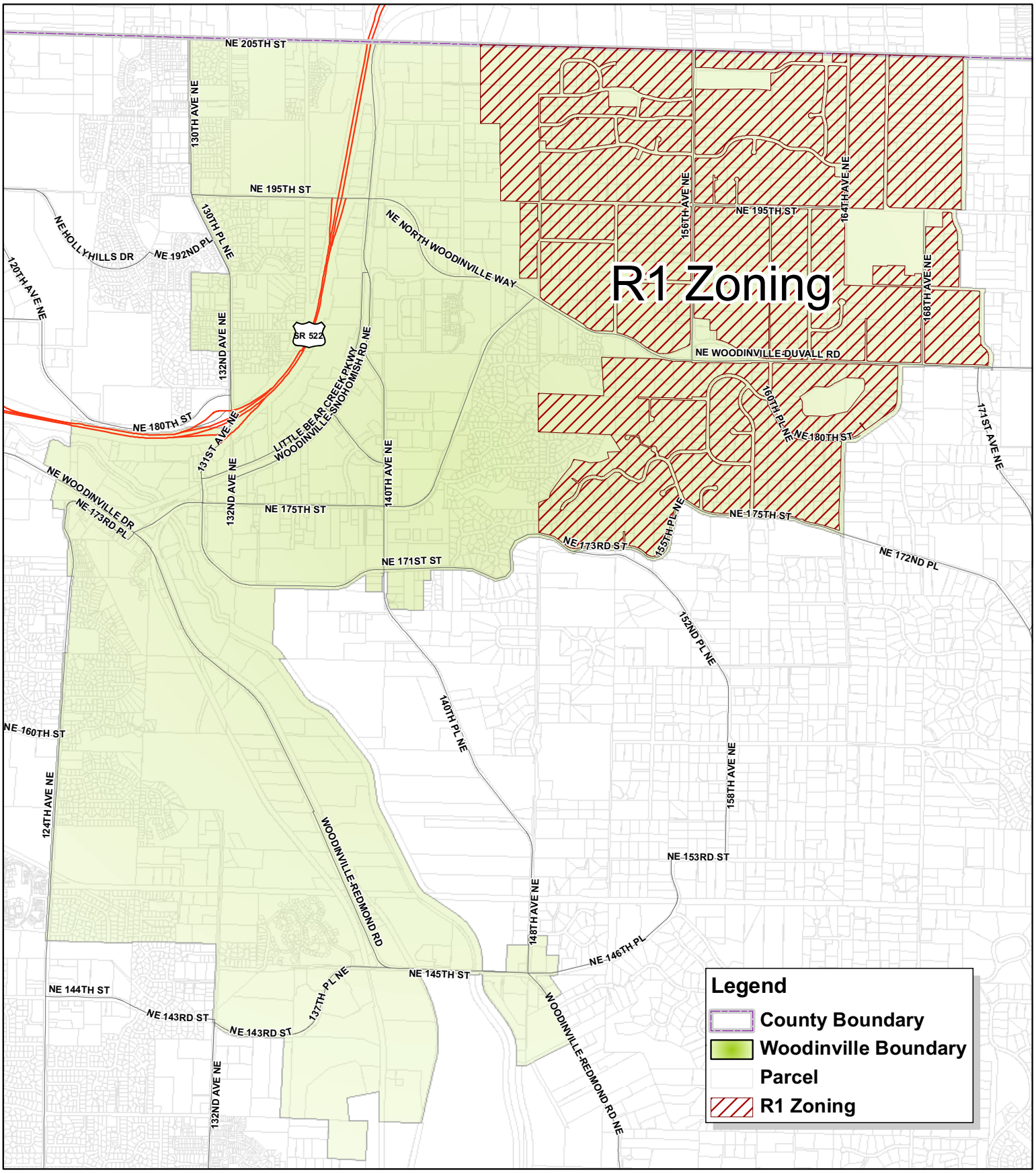
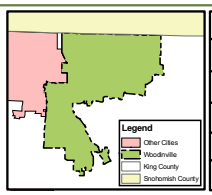


Figure I-1. R-1 Zoning

1 inch equals 2,200 feet

File Name: R1 Zoning Letter.mxd



NO	DESIGN/REVISION	DATE	BY
1	Final	01/17/07	AU
2			
3			
4			
5			

City of Woodinville
17301 - 133rd Ave NE
Woodinville, WA 98072
www.woodinville.wa.us
425-489-2700

Disclaimer

Any use of or reliance upon the information contained in this document is at the user's sole risk. The City of Woodinville does not warrant the accuracy, currency, completeness or quality of said information. The City expressly disclaims any warranty of merchantability or fitness for any particular purpose with respect to such information. The City further disclaims all responsibility or liability for any damage, injury or loss resulting therefrom.

The R-1 zone also contains the most mature and dense tree canopy in a City that prides itself on its "Northwest woodland character" (for example, see goal LU-1 in Woodinville's Comprehensive Plan in the Land Use Element). This tree canopy helps protect all of the critical areas mentioned above, and also provides habitat for birds and other wildlife that are an important part of the quality of life in the R-1 neighborhoods and the City as a whole.

By City Ordinances 419, 424, and 427, there is currently a moratorium on most new building and land use permits in the R-1 zone, with the exception of some construction related to existing structures, public facilities, accessory living quarters, and vested development (see Attachment E of overall R-1 review). This moratorium was first adopted on March 20, 2006 and has been extended through March 20, 2007. The purpose of the moratorium is to provide time for this environmental report to be completed, as well as for the City to perform other studies and actions that are part of its Sustainable Development project, which are necessary to ensure that development proceeds in the R-1 zone in a manner consistent with the Growth Management Act and the City's goals, policies, and legal requirements.

Regulatory Basis: Growth Management and Urban Densities

In 1995, the Central Puget Sound Growth Management Hearings Board established a "general rule" of four net dwelling units per acre as a minimum density for urban areas under the Growth Management Act.[3] Calling this standard a "bright line," the Board stated:

> Any residential pattern at that density, or higher, is clearly compact urban development and satisfies the low end of the range required by the Act. Any larger urban lots will be subject to increased scrutiny by the Board to determine if the number, locations, configurations and rationale for such lot sizes complies with the goals and requirements of the Act, and the jurisdiction's ability to meet its obligations to accept any allocated share of County-wide population. Any new residential land use pattern within a UGA [Urban Growth Area] that is less dense is not a compact urban development pattern, constitutes urban sprawl, and is prohibited.

The next year, the Central Board identified the criteria it would use to determine whether environmental factors could justify a lower density in urban areas:

> The Board holds that when environmentally sensitive systems are large in scope (e.g. a watershed or drainage sub-basin), their structure and functions are complex and their rank order value is high, a local government may also choose to afford a higher level of protection by means of land use plan designations lower than 4 du [dwelling units]/acre.

These criteria have come to be known as "the *Litowitz* test," following the name of the plaintiff in the case. The criteria have not changed, nor have they been substantially clarified, under subsequent Growth Board decisions. This leaves many important details somewhat ambiguous. Watersheds and drainage sub-basins can be identified across a wide range of sizes, from a large river system like the Columbia River to an individual wetland or small stream. To some degree, the structure and functions of nearly all natural systems are complex. The meaning of "rank order value" is also unclear and depends on scale. A particular stream or wetland, for example, could rank of high importance within a small jurisdiction or small drainage basin but of much less importance when

[3] *Bremerton v. Kitsap County*, CPSGMHB Case No. 95-3-0039c (October 9, 1995).

considered at larger geographic scales. Nevertheless, it is clear that critical areas that are not of high relative value within the larger natural systems in the surrounding vicinity or within an individual jurisdiction would be unlikely to pass the *Litowitz* test.

In a later case, *Fuhriman v. Bothell*[4], the Board acknowledged "a possible expansion of *Litowitz* analysis," where lower densities might be allowed to protect critical areas that do not, strictly speaking, meet the *Litowitz* test. It noted that critical areas that are linked hydrologically could have "unique geologic or topographical features that would also require the additional level of protection of lower densities in those limited geologically hazardous landscapes." Such areas might, for example, provide sources of cool water for streams and rivers, wildlife habitat, and other ecological functions.[5] The Board has never explicitly addressed whether it would support reduced densities solely to reduce the public safety threat of geologic hazards, which generally can be addressed through other means (e.g., setbacks, vegetation retention, appropriate stormwater management, and site-specific conditions on development).

Complicating this legal context further, in 2005 the Washington State Supreme Court found that the Growth Boards do not have the legal authority to set "bright line" rules that are not contained within the GMA.[6] In March 2006, a King County Superior Court judge found that this Supreme Court ruling voided a Central Board decision against the City of Normandy Park, where much of the existing zoning is well below four units per acre.[7] Judge Bruce Hilyer found that, both under the Supreme Court case and under his own independent reading of the GMA, Growth Boards do not have the authority to impose "bright line" rules of their own construction, heightened scrutiny tests, or uniform minimum residential densities. Judge Hilyer emphasized that, under the GMA, deference must be given to a local government's decision regarding appropriate urban densities, based on local circumstances.

The Superior Court case is currently on appeal. Thus, it is not absolutely certain what criteria might be applied to judge the validity of Woodinville's R-1 zoning, should it be challenged to the Central Board or the courts. It is worth noting, however, that the GMA provides for a "broad range of discretion" in local planning. The Act's housing goal explicitly promotes "a variety of residential densities and housing types, and encourage[s] preservation of existing housing stock" (RCW 36.70A.020(4)). The Act also calls for housing elements in local Comprehensive Plans that ensure "the vitality and character of established residential neighborhoods" (RCW 36.70A.070(2)).

Under the King County population allocation process performed under the GMA, the City of Woodinville is required to provide up to 1,869 new housing units by the year 2022. In an extensive public process, the City strategically evaluated where and how it could locate its population growth with the goal of preserving its woodland community character. The City did this through creation of a Central Business District zone for the downtown, which allows a base density of 36 units per acre, up to a maximum of 48 units per acre. With development standards that encourage high density housing and transit oriented design, the City's buildable land analysis shows that the City has sufficient capacity under its current zoning to accommodate up to 1,947 new housing units, 78 more

---

[4] *Fuhriman v. Bothell*, known as "Fuhriman II," CPSGMHB Case No. 05-3-0025c (August 29, 2005).

[5] This decision drew on *Kaleas v. Normandy Park*, CPSGMHB 05-3-0007c (July 19, 2005).

[6] *Viking Properties v. Holm, et al*, 155 Wn.2d 112, 118 P.3d 322 (2005).

[7] *City of Normandy Park v. Central Puget Sound Growth Management Hearings Board et al*, King County No. 05-2-27090-0 KNT (March 30, 2006).

than are needed to meet its 2022 population allocation. (See Attachment B for more information on the City's land capacity analysis.)

Refined Goals of This Report

At a minimum, this report evaluates and applies the *Litowitz* test and takes into account refined goals expressed by the City Council, City staff, the Planning Commission and the Citizen Advisory Panel (CAP). The following refined goals were evaluated for their achievability and appropriateness at a planning level analysis. During a City Council meeting, staff explained that completing a detailed "survey" of all wetlands and steep slopes could costs in the millions of dollars and would not provide proportionate benefit. The council determined that the level of analysis being proposed by staff was adequate to defend a planning level of analysis. Parentheses indicate the council's acceptance

- Inventorying critical areas that are in the R-1 zone or may be influenced by development in the R-1 zone (without conducting detailed surveys or identifying all wetlands);
- Identifying those critical areas that are "large in scope, complex in structure and function, and of a high rank order;"
- Evaluating how those critical areas may be impacted by different potential development densities in the R-1 zone, and the degree to which those impacts could be mitigated;
- Evaluating sustainable and low-impact approaches to development in the R-1 zone that could, under different potential densities, provide the greatest environmental benefits to residents of the R-1 zone, the City of Woodinville, and the ecosystems of which they are a part, at a reasonable public and private cost; and
- Developing recommendations to the City based upon environmental issues for appropriate development densities and regulations in the R-1 zone, to help the City meet its legal responsibilities and the full range of goals for the R-1 zone.

Chapter II of this report, together with Appendices A, B, and C, addresses the first three of these goals. A comprehensive inventory of all critical areas within the R-1 zone was not possible to the level of detail required of all development proposals. Chapter II also includes a detailed review of those critical areas in or adjacent to the R-1 zone that, in our judgment, meet the *Litowitz* test. The current status of these critical areas and potential threats to their functions and values from future development at different zoning densities were evaluated. This provides the technical basis for further discussion of recommended actions later in the report.

Appendix D addresses the fourth goal listed above for the report. It reviews different techniques and approaches to site and building designs, construction materials, and stormwater management that can reduce the environmental impacts of new development and redevelopment. This report collectively defines these techniques and approaches as "low-impact development" or "LID." Different zoning densities with different environmental constraints provide different capacities for LID, affecting the degree of benefit that LID techniques can provide, individually and collectively. We reviewed the feasibility and appropriate expectations for a wide range of LID techniques under different zoning densities. We also review special considerations for LID techniques to minimize impacts on specific critical areas within the R-1 zone.

Chapter III concludes with our recommendations, which are organized by drainage basin within the R-1 zone.

Public involvement opportunities have been numerous and are listed in the Executive Summary of the overall R-1 Sustainable Development Review report.

II. Critical Area Review

Inventory

Four different types of critical areas are found in or adjacent to the R-1 zone: fish and wildlife habitat conservation areas (which include streams); wetlands; geologically hazardous areas; and critical aquifer recharge areas. The other type of critical area that is identified in the Growth Management Act, frequently flooded areas, is not found in the zone. Our inventory discusses each of the other four types of critical areas in turn.

Fish and Wildlife Habitat Conservation Areas

The most important fish and wildlife habitat conservation area (FWHCA) in or adjacent to the R-1 zone is Cold Creek, a tributary to Cottage Lake Creek within the Bear Creek basin, which is predominantly to the east of the R-1 area. While Cold Creek's functions and values are affected by conditions in the R-1 zone, just how much they are affected is less clear. As discussed in Appendix A, groundwater from most of the R-1 zone appears to flow to the west, away from Cold Creek (see Figure II-1). The Lake Leota basin is part of the headwaters of Cold Creek, but the lake's outlet stream (which directly connects to Cold Creek, and on some maps is named Cold Creek) flows only intermittently, when the lake is high. Cold Creek is primarily fed by groundwater from a large receiving area to the north, as well as by groundwater discharge from Lake Leota, as discussed in Appendix A. Cold Creek's steady flow of cold water is most important to the Bear Creek system in the summer and early fall, when Cold Creek currently has little if any surface connection with Lake Leota. The lake is growing shallower, however, through a natural process of eutrophication, which has been dramatically accelerated by development within its drainage area. The implications of this change for Cold Creek are discussed later in this chapter. Appendix B describes the status and trends for the lake in detail.

There are three inlets to Lake Leota, from the south, north and west. The inlets from the north and south are essentially stormwater channels. They carry significant volumes of water and sediment during storms, but otherwise appear to be dry most of the year. The City has not mapped these inlets as intermittent streams, but based on their substrate and channel characteristics, they could potentially be mapped as such. The City has mapped the inlet to the west as a Type 4 (non-fish-bearing, intermittent) stream. This stream is called "Cold Creek" on at least one City map. The riparian corridor originates at the corner of 152nd Avenue NE and NE 195th Street and proceeds in a southeasterly direction before entering Lake Leota at its far western end (see Figure II-2). There is evidence that water flows through this corridor during the winter rainy season (no water was obvious in any stretch we could observe in August) to at least the area north of NE Woodinville-Duvall Road. Downstream of the road, the creek appears to have been dry for many seasons. There were no recent scour marks, algae layers, or any other indication that water had flown through this area in the recent past. The channel on the lot adjacent to the lake did show some patches of gravel habitat, but the channel was dry in August. The resident of the lot (Verna Zander) did not know if water flowed in the channel in the past few years. Prior to the 1980's, she reported it had flowed quite regularly for the entire year.

Woodin Creek, a Type 2 (fish-bearing, perennial) tributary to the Sammamish River, also has its headwaters at least partly within the R-1 zone. The mainstem of the creek originates near NE 177th Drive, in the southwest corner of the R-1 zone. The drainage basin for this upper reach of Woodin

Creek extends further into the R-1 zone, including a substantial Native Growth Protection Area[8] that is established on either side of NE 177th Drive. Headwaters for the creek also include a larger area of unincorporated rural lands outside of the City boundary as well as an R-6 zone within the City that comprises most of the headwaters area for the two forks of Woodin Creek's North Tributary. No fish are found in the portions of Woodin Creek within the R-1 zone, due to substantial blockages downstream (Adolfson Associates 2004). Pileated woodpeckers, Pacific chorus frogs, and many other wildlife species are found in forested headwater areas (Adolfson Associates 2004). One of the largest developable parcels in the R-1 zone is part of the headwaters for the North Tributary.

Small, at least seasonal streams appear to be located at the base of some of the ravines along the northwest edge of the R-1 area. The largest of these streams, which may be perennial, is located in the far northwest corner of the R-1 zone, at the base of a particularly steep ravine that extends into the Wellington Hills Golf Course in Snohomish County. While this stream is unnamed, for purposes of this report we refer to it as "Golf Course Creek." This creek and the other streams along the northwest slope of the R-1 zone are piped under the industrial area to the west before entering Little Bear Creek. Golf Course Creek appears to be a significant source of water for wildlife in the vicinity. The other streams provide some localized habitat value within the ravines and presumably have some effect on flows and water quality in Little Bear Creek, but this effect is likely minor and not greatly impacted by development in the R-1 zone. While Golf Course Creek is the largest of all these streams, it likely also has only minor effects on flow and water quality in Little Bear Creek. However, small landslides or heavy erosion in the steep ravine in which Golf Course Creek is located could be a significant source of fine sediments in lower Little Bear Creek.

The City has designated Native Growth Protection Easements as FWHCAs, in recognition of their habitat value. By far the largest concentration of these easements in the R-1 zone is in the headwater drainage area for Woodin Creek discussed above. These easements cannot be developed, even if the underlying zoning is changed (D. Crawford, City of Woodinville, personal communication). Outside of upper Woodin Creek, there are only a few other such easements in the R-1 zone, in some cases associated with wetlands.

The R-1 zone contains the most extensive and mature tree canopy in Woodinville, a City that prides itself on its northwest woodland character. Forested areas in the R-1 zone include a mixture of coniferous and deciduous, young to middle-aged, second- to third-growth trees. Common species include western red cedar (*Thuja plicata)*, western hemlock (*Tsuga heterophylla*), big-leaf maple (*Acer macrophyllum*), red alder (*Alnus rubra*), Douglas fir (*Pseudotsuga menziesii*), and bitter cherry (*Prunus emarginata*). Most appear to be approximately 60' to 70' tall and 15-19 inches in diameter at breast height (dbh). There is typically 40 to 75 percent canopy closure in the denser forested tracts. Our field review, although not exhaustive, noted 13 "heritage trees" (identified mostly by girth) dispersed across the north central portion of the R-1 zone. The density of homes and narrow streets made a determination of tree height difficult.

---

[8] WMC 21.06.406 Native growth protection area (NPGA). Native growth protection area (NPGA): an area where native vegetation is preserved for the purpose of preventing harm to property and the environment, including, but not limited to, controlling surface water runoff and erosion, maintaining slope stability, buffering and protecting plants and animal habitat.

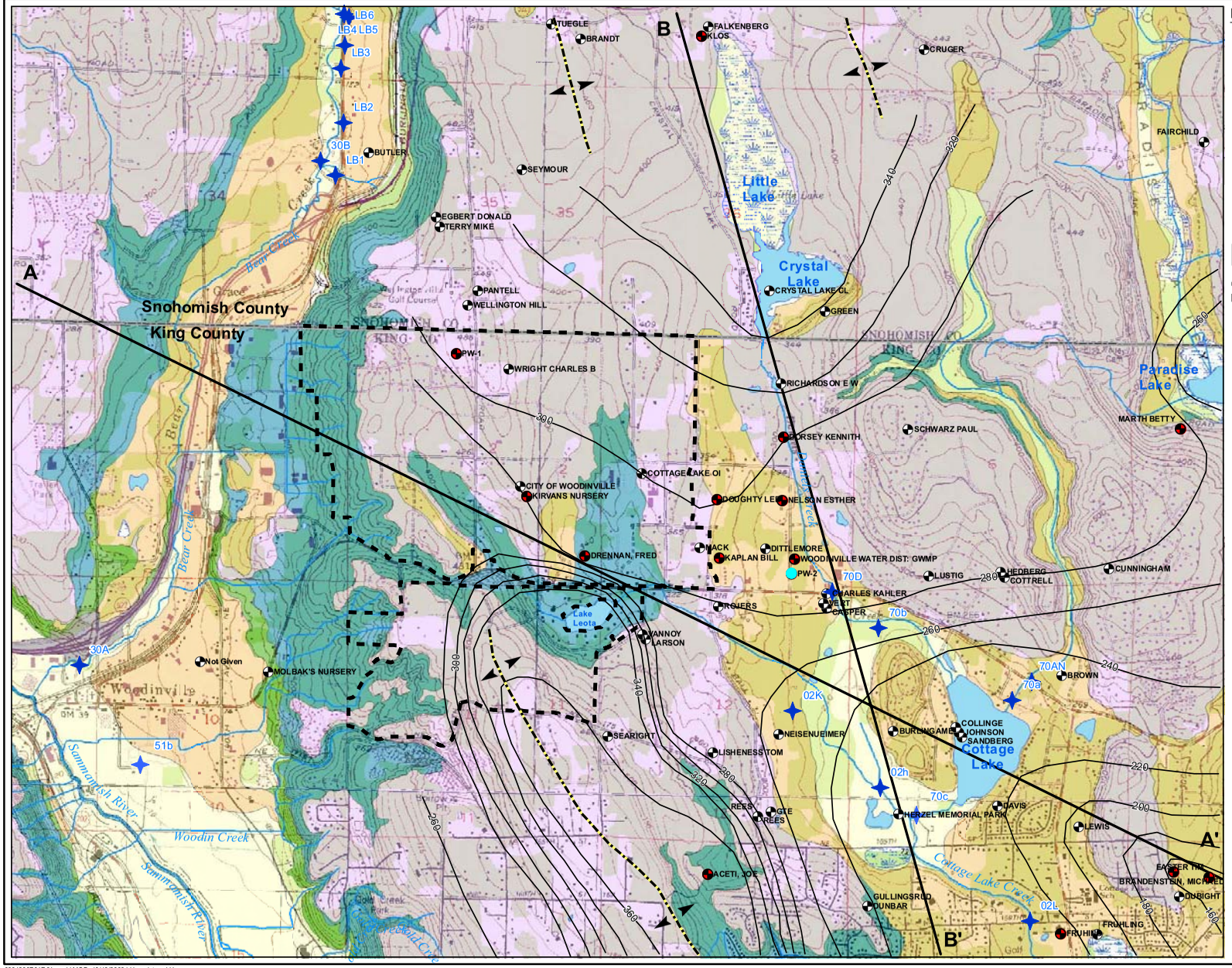


FIG. II-1

GROUNDWATER CONTOUR MAP OF WOODINVILLE R-1 AREA

SA/WOODINVILLE HYDROGEO SVCS/WA

0631230F04R01.mxd | MOD: 10/19/2006 | Unregistered User

Golder Associates

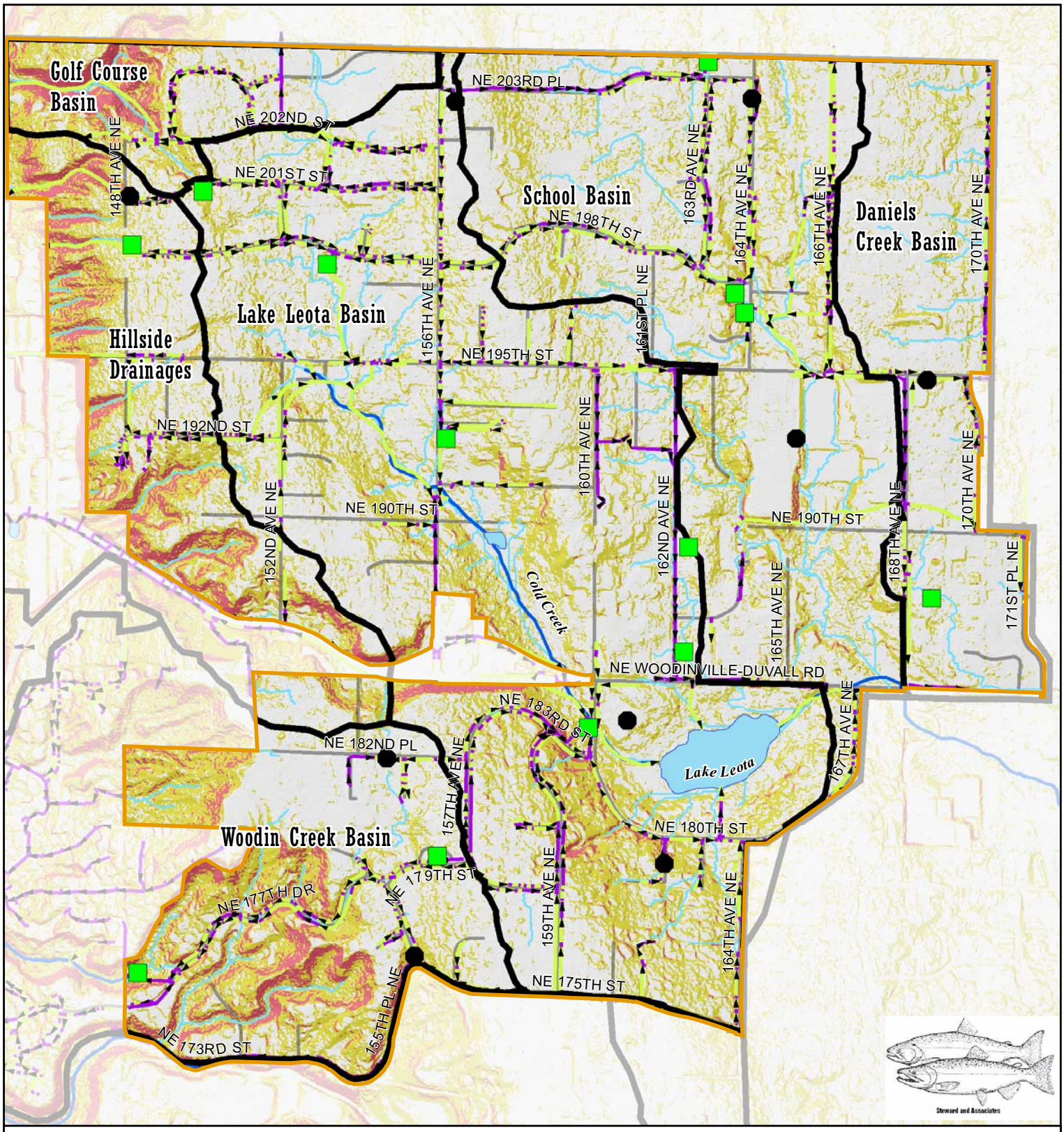


Figure II-2. Woodinville Slopes and Storm Drainage

R-1 Boundary

Slope information

- 0 -15
- 15.1 - 40
- >40.1

- Stormwater pond
- Stormwater tank
- Known streams
- Potential streams
- Waterbodies
- City streets
- Stormwater pipes
- Open channel
- Drainage area

Data for locations of stormwater pipes, ponds, tanks, known streams, open channels and drainage areas are from the City of Woodinville. The locations of potential streams are based on use of LiDAR data. These locations have not been field tested and do not necessarily represent the actual locations of intermittent or perennial flow. This method of identifying potential streams does not account for groundwater seepage.

0 0.5 Miles

N W E S

1:13,500

The most significant tract of undeveloped forest in the R-1 zone is found along the slopes of the northwestern edge of the zone, including the western portion of the Wood Trails Preliminary Plat and Rezone site and extending north of the City into the Wellington Hills Golf Course. This approximately 75-acre parcel is generally covered with second- to third-growth trees, as described in the preceding paragraph. There is some downed wood, but snags are uncommon (City of Woodinville 2006). The size and character of the site, adjacent to a noisy industrial area and highway, limit its ability to support wildlife species that are not tolerant of substantial human disturbance. Mule deer (*Odoceoileus hemionus*) and coyote (*Canis latrans*) traverse the site in a north-south direction. Pileated woodpeckers (*Dryocopus pileatus*) have been observed on the site, and may possibly nest there (City of Woodinville 2006). Pileated woodpeckers are a "State Candidate" species, but without specific or designated protections issued by the Washington Department of Fish and Wildlife.

Wetlands

Appendix C provides a map of wetlands in the R-1 zone, that were identified with corrections and additions developed as a part of this study. This study focused on wetlands that were part of the area draining to Lake Leota, particularly those that have a direct hydrologic connection to the lake, at least seasonally. We also examined some of the larger wetlands in the vicinity of Leota Junior High School, where the City's maps generally show the greatest concentration of wetlands in the R-1 area. Lastly, we examined a large wetland in the northwestern part of the R-1 area (identified as BBC127 in Appendix C).

While we did not calculate formal rating scores on these wetlands using the Washington Department of Ecology's latest rating system (WDOE 2004), we did describe the vegetation community observed for each wetland studied and we made estimates of the likely ratings the wetlands would have received. Details are in Appendix C. In general, all of the wetlands we observed have been substantially degraded by past alterations and impacts from surrounding development. We found no Category I wetlands and none that were likely of great significance to fisheries resources downstream. No wetland in the R-1 zone has high habitat values, based on the Washington Department of Ecology's rating system (Hruby 2004); most have low habitat scores, but some around Lake Leota would likely be rated as having moderate habitat values (scores between 20 and 28 in Ecology's system). Wetlands in the Lake Leota basin are still important for protecting the lake's water quality, both through filtration of pollutants and detention of stormwater to reduce erosion downstream.

Lake Leota is surrounded by a narrow band of wetland vegetation, which expands further in the vicinity of the lake's three inlets and one outlet and in other localized areas, particularly along the southwestern edge of the lake. Dominant plants observed in this band are: Douglas spirea (*Spirea douglasii*), willows (*Salix sitchensis, Salix lucida, and Salix scouleriana),* Nootka rose (*Rosa nutkana*), Soft rush (*Juncus effusus*), Yellow flag iris (*Iris pseudacorus*), reed canarygrass (*Phalaris arundinaceae*), marsh cinquefoil (*Potentilla palustris*) Slough sedge (*Carex obnupta*), sawbeak sedge (*Carex stipata*), creeping buttercup (*Ranunculus repens),* Common horsetail (*Equisetum arvense),* giant horsetail *(Equisetum telmateia), redtop (Agrostis gigantea*). It is common to see western red cedar (*Thuja plicata*), red alder (*Alnus rubra*), black cottonwood (*Populus trichocarpa),* and Oregon ash (*Fraxinus latifolia*) near the shoreline. Bullfrogs appeared to be plentiful in the adjacent shallow water.

A portion of the wetland area along the lake's southwestern edge, as well as some of the riparian wetlands along the seasonal tributary to the lake from the northwest, have been delineated within the past decade. We have reviewed those delineations (Shapiro and Associates 1999; Pentec Environmental 2000) and found them still to be generally accurate. Appendix C provides more detail

from our further review of these two areas, which comprise two of the three largest extensions of the Lake Leota shoreline wetland system. We did not have access to the third large wetland area, along the lake's seasonal outlet stream.

We investigated the wetland at the toe of the slope in the northwestern portion of the R-1 zone (identified as BBC127 in Appendix C) from the uphill and downhill edges. We could not determine its toe-of slope boundaries because of a very dense thicket of blackberries that ran along both the upslope and downslope edges. We did verify the east-to-west portion of the wetland. This portion of the wetland is located within a steep-walled ravine and there is a stream in the bottom of the ravine. The vegetation in this corridor consists of devil's club (*Oplopanax horridus*), skunk cabbage (*Lysichiton americanum*), Cooley hedgenettle (*Stachys cooleyea*), piggy-back plant (*Tolmeia menziesii*), lady fern (*Athyrium filix-femina*), with an overstory of salmonberry (*Rubus spectabilis*), red alder (*Alnus rubra*), vine maple (*Acer circinatum*), and paper birch (*Betula paperifera*).

Geologic Hazards

The primary geologic hazards in and adjacent to the R-1 zone occur along the slopes of the zone's western edge, which extend into adjacent land use zones. Currently, City maps designate much of the slopes north of the intersection of NE North Woodinville Way and NE Woodinville-Duvall Road as an erosion hazard area, based on soil and slope conditions. They also indicate scattered steep slopes in the R-1 zone that would qualify as potential landslide hazards. More recent data, however, indicate that landslide hazards due to steep slopes may be more prevalent than this in the area north of NE North Woodinville Way, and that both erosion and landslide hazards likely extend along the slopes from NE North Woodinville Way south to the City limits. As discussed in more detail in Appendix A, these more recent data sources include an updated regional geology map developed through the University of Washington, topographical maps based on LIDAR, and citizen comments, with some brief visual confirmation we have made in the field. These data are further corroborated by geologic analysis performed for the Wood Trails/Montevallo FEIS (Nelson Geotechnical Associates 2006).

Groundwater seepage occurs in many locations along the slopes and ravines of the areas just described. While much of the R-1 zone and lands immediately to its north likely serve as sources for this groundwater, the most important sources are likely relatively close to the slopes, particularly where soils are porous. Activities that alter the hydrologic regime in these areas, such as increased infiltration or inappropriate storm water management practices, can cause changes to the hydrogeologic conditions that could destabilize slopes and enhance erosion.

Critical Aquifer Recharge Areas

The City has identified part of the area north of Lake Leota and Woodinville-Duvall Road as an area of high susceptibility to groundwater contamination, apparently based on earlier King County analysis (Wuotila, personal communication). However, the more recent University of Washington analysis identifies a considerably larger, V-shaped area with its base in the vicinity of Lake Leota as having porous glacial outwash geology (see Figure II-1 and II-3). This geology extends in a narrow band approximately along NE Woodinville Way until it reaches the western slopes of the R-1 zone, where glacial outwash geology is also characteristic. The southwestern edge of the "V" of porous geology and most of the porous geology in the Woodin Creek basin is also characterized by "somewhat excessively drained soils," based on maps from the Natural Resource Conservation Service (see Figure II-2). Where excessively drained soils overlie glacial outwash geology, aquifer recharge areas have a particularly high susceptibility to groundwater contamination.

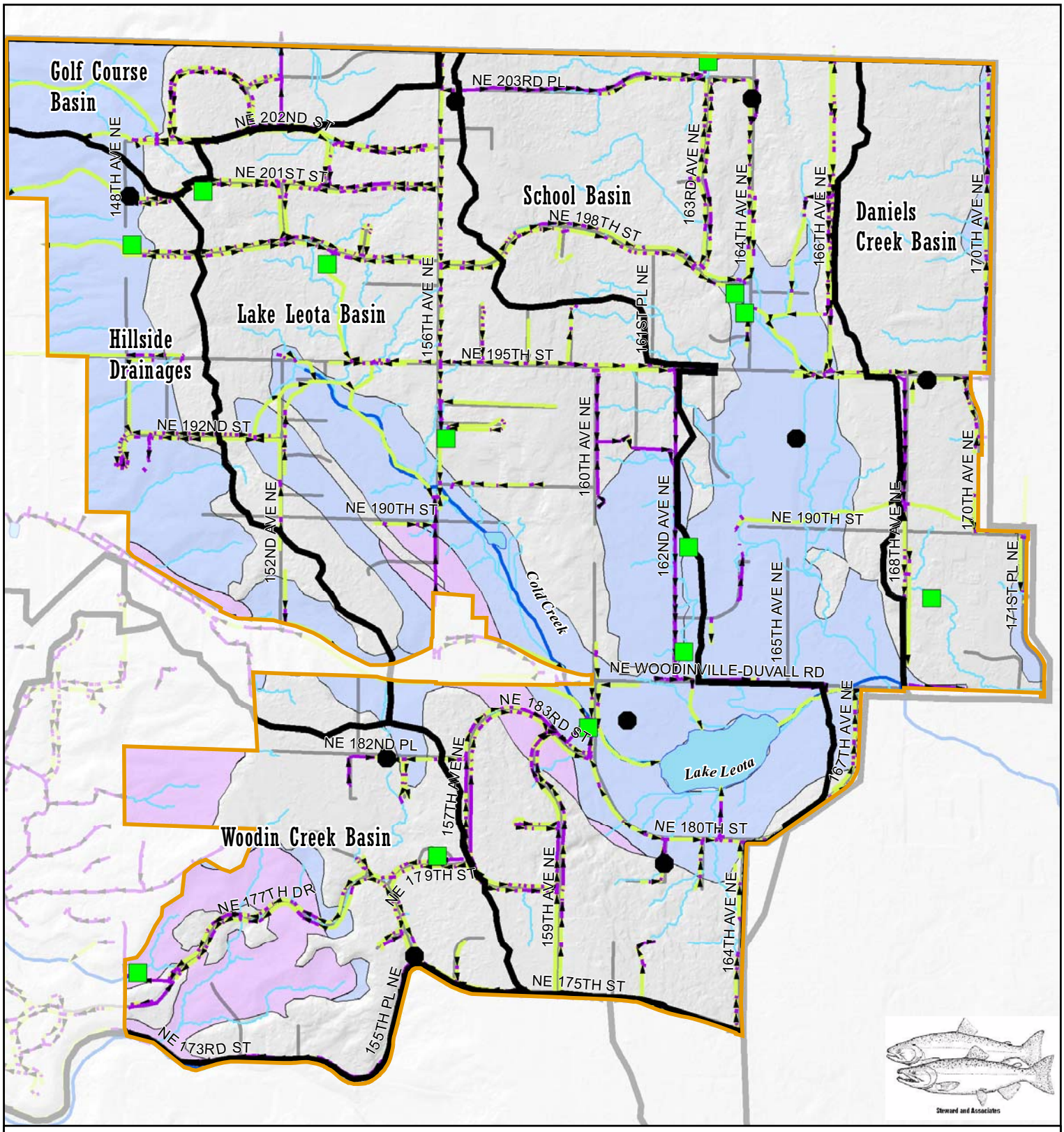


Figure II-3. Moderate & High Critical Aquifer Recharge Areas (CARAs)

CARAs

- Moderate
- High

- Stormwater pond
- Stormwater tank
- Known streams
- Potential streams
- Waterbodies
- City streets
- Stormwater pipes
- Open channel
- Drainage area

CARAs are identified wherever the underlying geology is glacial outwash, which is much more permeable then the glacial till found under the remainder of the R-1 zone. In CARAs with "High" susceptibility to contamination, this geology is overlain by "somewhat excessively drained" soils; CARAs with "Moderate" susceptibility to contamination are overlain by "moderately well drained" soils. Data is from Appendix A to this report.

0 0.5 Miles

N W E S

1:13,500

Much of the rest of the "V" area with glacial outwash geology is also likely at least moderately susceptible to contamination. Because the entire R-1 zone is residential, the primary concern for aquifer contamination in this area would be from on-site sewage treatment systems. If such systems are properly maintained, the risk of groundwater contamination at current densities is relatively low. The risk could increase significantly, however, with denser development if it is not served by sewers. Groundwater from most of the R-1 zone flows to the southwest, toward the potentially geologically hazardous areas discussed above. Under normal conditions, this groundwater ultimately seeps out in ravines or serves as the source for streams with headwaters in these areas. As just discussed, however, activities that alter the hydrologic regime near these geologically hazardous areas could destabilize slopes and enhance erosion. That would be particularly true in areas with permeable soils or permeable underlying geology.

Litowitz Test

This section evaluates critical areas in the R-1 zone relative to the three *Litowitz* test criteria: whether they are large in scope, complex in structure and function, and of a high rank order. We also evaluate whether lower density zoning would substantially aid efforts to protect the functions and values of such areas.

The *Litowitz* criteria have generally been applied to wetlands, streams, and other fish and wildlife habitat conservation areas, because the importance of these critical areas often relates to their connections with larger systems. The criterion for complexity, however, has also considered whether such larger systems have included other types of critical areas, such as geologically hazardous areas, frequently flooded areas and critical aquifer recharge areas.

Based on the analysis in the last section, we believe there are two critical areas in or affected by the R-1 zone that meet the *Litowitz* criteria: Cold Creek and Lake Leota. Other critical areas were ruled out for the following reasons:

- No wetlands in the R-1 zone are of a high rank order; few, if any, could be argued to be large in scope or unusually complex in structure and function.

- No stream within the R-1 zone beside Cold Creek is of a high rank order. Woodin Creek, while arguably large in scope (at least within the City's jurisdiction) and complex in structure and function, does not support fish in the R-1 zone and supports very few spawning salmon downstream. Juvenile salmonids have been observed in the Woodin Creek's lowest reach, but these have likely been either salmon spawned elsewhere or cutthroat trout, which are common in urban streams and are, in fact, an important predator of salmon. We therefore do not believe that Woodin Creek is of a high rank order.

- Increased density in the R-1 zone would likely have only small impacts on all affected streams beside Cold Creek. These impacts could be further minimized by appropriate stormwater management and mitigation. The portions of the R-1 zone that drain to these other streams (including Little Bear Creek, Woodin Creek, and Daniels Creek—an upper tributary of the Bear Creek system) are small relative to their overall basins. Moreover, existing NGPEs in the upper basin of Woodin Creek would significantly reduce potential downstream impacts.

- Protection of geologically hazardous areas in and adjacent to the R-1 zone depends primarily on proper development practices and stormwater management, not maintenance of R-1 zoning. For example, conveying storm water via fuse welded HDPE pipe down steep slopes to a safe discharge point or detaining storm water in a detention vault or tank rather than a pond.

- To the extent that critical aquifer recharge areas within the R-1 zone are threatened by contamination, the greatest current threat is from inadequate or poorly maintained septic systems. This threat would increase with more dense development on septic systems, but would decrease or be eliminated by development accompanied by sewers serving new and existing development.

Our evaluation of Cold Creek and Lake Leota against the *Litowitz* criteria follows.

Cold Creek

Large In Scope

The Bear Creek watershed, which covers approximately 50 square miles and includes 100 miles of stream habitat and over 30 different tributary systems (King County et al. 1989; Kerwin 2001), is certainly large in terms of its physical size and scope.

Cold Creek is one of the tributary systems within the Bear Creek watershed that also warrants a "large in scope" description. The outlet of Lake Leota is a seasonal contributor of surface flow to the perennially flowing, spring-fed portion of Cold Creek further downstream. Cold Creek is an integral part of the Bear Creek watershed in that it provides cold, clean water to Cottage Lake Creek and to subsequent reaches downstream in mainstem Bear Creek. The Bear Creek watershed is one of the largest producers of naturally spawned salmon for a stream its size in western Washington, primarily because of its large runs of sockeye and Chinook salmon (King County et al. 1989; Kerwin 2001). Conditions that allow the Bear Creek watershed to produce salmonids at a rate greater than other streams its size directly relate to quantity and quality of instream habitat, which is driven in part by the groundwater spring sources provided by Cold Creek. Water quality problems in the Bear Creek Basin include elevated water temperatures (Kerwin 2001). Temperatures in Cold Creek are consistently 5-7°C colder than other streams in the Bear Creek watershed due to its groundwater spring influence, allowing it to serve as a thermal refuge for salmonids (King County 2001a; Kerwin 2001). Although Cold Creek might present a small fraction of the total tributary flow to the Bear Creek Basin, its ability to provide a steady source of cold water to the system in the critical summer and fall months underscores its important influence on instream habitat and salmon production in the Bear Creek Basin and the Greater Lake Washington Watershed.

Complex in Structure and Function

Bear Creek supports populations of Chinook, sockeye, coho, and kokanee salmon, as well as steelhead and cutthroat trout (King County 2001a). Bear Creek is known to contain the largest freshwater mussel population in King County and also contains freshwater sponges, river otters, crayfish, and a good representation of aquatic insects (Kerwin 2001). The diversity and number of aquatic resources in the Bear Creek basin distinguish it as one of the top six natural resource basins in King County in the Waterways 2000 program.

Cold Creek flows through mixed-forested wetlands that include diverse instream structure and complex morphology. The stream contains pool and riffle habitat in its upper reaches with glide and riffle habitat very common in the lower gradient reaches further downstream. A diversity of cold-water macroinvertebrate fauna and salmonids, including cutthroat trout, coho salmon, and even Chinook salmon are present in the stream (King County 2001b). A field visit to Cold Creek in the summer of 2006 by project personnel noted the presence of a wide range of substrate types, including sand, pebble, and cobble. In addition, an abundance of large-woody debris was apparent in the riparian area, providing excellent wildlife habitat for many amphibian, small mammal, and bird species.

The Cold Creek watershed remains relatively undeveloped (King County 2004). Approximately 38% of the watershed is comprised of undeveloped forest, grassland, and scrub/shrub areas. The remaining 60% of the watershed is developed, but over 50% of that area is defined as low intensity development. Moreover, groundwater sources for Cold Creek extend further north, into an area that is almost completely zoned rural (the only exception being the Lake Leota area). Minimal development in the Cold Creek watershed has resulted in high quality biological conditions relative to other developed and developing watersheds in the Greater Lake Washington Watershed. This finding is corroborated by the results of macroinvertebrate sampling in 2002, 2003, and 2005 in the Greater Lake Washington Watershed (King County 2004; King County 2005).

The Cold Creek Natural Area, comprised of nearly 250 acres in the Bear Creek basin, is a very complex stream and wetland system located northeast of the City of Redmond, east of the City of Woodinville, and just south of the Snohomish County line (King County 2001a). The Natural Area contains high quality peat bog wetland habitat as well as reaches of Cold Creek, Daniels Creek and Cottage Lake Creek. Increased structural complexity provided by different vegetation types within the wetland and riparian habitats associated with Cold Creek optimizes potential breeding areas, escape, cover, and food production for the greatest number of species (Hruby et al. 2004).

High Rank Order

Cold Creek is of a high rank order both because of its ecological importance, discussed above, and because actions by the City of Woodinville will be a primary determinant of its future quality. In comparison, approximately 80% of the Little Bear Creek Basin is in Snohomish County and the stream only enters the City of Woodinville just prior to its confluence with the Sammamish River. As such, much of what the City can do to improve Little Bear Creek water quality and habitat pales in comparison to what needs to be done further upstream in the watershed. In contrast, much of what the City of Woodinville decides to do in relation to development in the R-1 zone will play a direct role in determining future water and habitat quality of Cold Creek.

The Bear Creek watershed and Cold Creek in particular rank high among other streams within the Lake Washington Watershed. Bear Creek is one of only two "Tier 1" streams (receiving the highest priority for salmon conservation) in WRIA 8, the other being the lower Cedar River (WRIA 8 2005). Cold Creek was specifically identified in the WRIA 8 Chinook Salmon Conservation Plan (2005) as a stream in need of protection due to its ability to reduce water temperatures in the Cottage Lake Creek/Bear Creek watershed. The WRIA 8 Plan (2005) also recommends that "growth within Woodinville should be managed to minimize impacts" to Cold Creek, further strengthening its importance and ranking related to other streams in the City and other streams in the larger watershed.

Lake Leota

Large in Scope

At 10.4 to 12.3 acres (depending on water level), Lake Leota is the largest lake within the City of Woodinville. Its 505-acre watershed comprises 40% of the R-1 zone and is almost completely contained within it (see Figure II-2). Considered within the City's jurisdictional area, the lake is clearly large in scope. At a regional level, the size and importance of the lake should be considered in the context of its being at the headwaters of Cold Creek. Seepage from the lake contributes to the cool summer water temperatures that are the primary basis for Cold Creek's importance within the Bear Creek system. The lake therefore plays an important role in the 50-square-mile Bear Creek system, which clearly is large in scope.

Complex in Structure and Function

Lake Leota's advance towards eutrophy (high productivity, characterized in part by large and extended algae blooms) is evident by in-lake conditions in late summer/early fall measured in recent years. The lake's eutrophic status has evolved through the complex interaction of multiple factors:

1) Septic and landscaping seepage of nutrients, which has entered shallow peaty soils over glacial gravels of high hydraulic conductivity;

2) Storm runoff of sediments and nutrients *via* surface channels to the lake;

3) Lake shallowing by sediments delivered to the lake *via* surface runoff;

4) Lake shallowing by organic production from algae production, high production of near-shore submergent plants including the exotic Eurasian watermilfoil and/or its hybrid, and high production of near-shore emergent plants, such as the exotic white water lily as well as native yellow water lilies and cattails.

These environmental factors, which increase with greater urban development, have combined to increase nutrient supply to water column algae and rooted plant production, as sediments increasingly interact with well-lit, warm productive surface waters. Entrainment of nutrients from these shallow sediments is becoming an increasingly important nutrient source. Algae blooms, fed by high nutrient levels, are becoming more common.

The shallow band of near-shore rooted plants is now encroaching on open waters in the central lake basin. These plants will continue to make this band wider and more shallow around the lake until wetland conditions predominate across the lake. Continued external loading of sediments and nutrients will eventually transition the wetland to a wet meadow. At that point, lake outflow will be largely *via* a warmer *surface* channel with reduced groundwater seepage outflow from a lakebed sealed with deeper sediments. Cold Creek will have lost part of its cold, clear, high quality water source through the low flow summer/fall months, replaced with warm water that will reduce its capacity to benefit the entire Bear Creek system downstream.

Lake Leota appears to be moving into or is already in a phase when phosphorus (the nutrient that controls the lake's productivity) will regenerate on a self-sustaining basis, recycling nutrients stored in lake sediments. Under those conditions, even maintaining present levels of nutrient loading would likely lead to accelerating eutrophication. In time, a shallower, more eutrophic lake will discharge warmer water downstream to the Cold Creek system.

Heavy metals are also accumulating in lake sediments, well beyond regional background concentrations. Some metals, such as lead and nickel, are now much higher than "consensus" concentrations accepted to cause adverse environmental effects in at least 50% of bottom invertebrate fauna. Accelerating eutrophication will increase the time period each year when bottom sediments become anaerobic (oxygen-starved). This has the chemical effect of increasing the mobilization of these heavy metals from sediments into the water column and uptake by plant and animal communities both in Lake Leota and downstream in the Cold Creek system.

In short, Lake Leota is both complex in structure and function itself and in relation to Cold Creek. If current trends in Lake Leota continue, Cold Creek will become a warmer, lower flow stream in summer/fall, with higher heavy metals concentrations, significantly reducing its value to the entire Bear Creek system. The lake itself will also become a much less attractive amenity for surrounding property owners and the Leota neighborhood.

High Rank Order

For all of the reasons discussed above, concerning both Cold Creek and Lake Leota, the lake clearly is of a high rank order, both within the City and in a regional context.

Implications for Development Densities

Lake Leota

There are a wide variety of actions, or combinations of actions, that could be taken to protect Lake Leota, as discussed in more detail in Chapter III of this report. These include low-impact development (LID) standards for appropriate development in the lake basin, providing sewer service to properties around the lake, controlling the lake outlet, dredging, an aggressive education program regarding best management practices for lakeside property owners and others within the basin, and stormwater and channel improvements upstream of the lake to reduce erosion and high flows. No one action will be sufficient to protect the lake, given the complex factors affecting its water quality, trophic status, and metals accumulation. Under any scenario, one factor that must be addressed for long-term success is to reduce sediment, nutrient, and heavy metal inputs into the lake from stormwater. Zoning density will play a significant role in determining the City's and the community's ability to accomplish this.

Increases in density will almost certainly increase runoff from impervious surfaces and therefore erosive pressures on stream channels. Stormwater management requirements on new development can mitigate this to a degree. But engineered stormwater facilities are short of 100% effective at removing nutrients (such as phosphorus) from stormwater (see Appendix D of this environmental report).

To an extent, stormwater impacts from increased density could be mitigated by requiring LID standards, provided that some developments were exempt from these requirements. But, as discussed in more detail in Appendix D, the potential benefits of low impact development techniques decrease with increased density, particularly above R-2 (two units per acre). Increased density necessarily removes tree cover and soils that the LID techniques rely on for successful stormwater control. Increased density also will impact groundwater quality unless it is served by sewers. Yet in the eastern part of the study area, sewer service would be more expensive given topographic constraints, distance from existing sewer mains, and need for pump stations, which is generally more costly In addition, LID techniques such as infiltration of storm water may not be advisable along steep slopes unless setback appropriately (see also Appendix A of this environmental report for the Golder Inc. "Preliminary Assessment of Hillside Drainages Infiltration").

In short, maintenance of R-1 zoning in the area that drains to Lake Leota—and even removing the possibility of rezones to R-4 with adequate infrastructure—would be a helpful and potentially necessary component of a strategy to maintain the lake's water quality and its supportive role in the regionally unique Cold Creek system. R-4 zoning most likely would lead to a significant increase in phosphorus inputs to the lake from stormwater, which would place a greater burden on other strategies to reduce other phosphorus inputs and on lake management strategies to respond to the results. In the worst case, the increased phosphorus inputs from stormwater would push the lake into a self-sustaining cycle of increased eutrophication, which would threaten serious damage to Bear Creek salmon runs in the long-term or require expensive and ongoing management interventions to avoid.

There is one potential exception to these concerns over increased density in the Lake Leota Basin. As discussed in Appendix C, if sewer service were provided just to the properties around the lake (between NE Woodinville-Duvall Road and NE 180th Street and 160th Avenue NE and 167th Avenue NE), this would likely provide substantial benefits to lake water quality. Even optimally maintained septic systems release a substantial amount of phosphorus in their effluent, which the soils around the lake are poorly suited to remove. Effluent from septic systems further from the lake generally either flows away from the lake or loses more of its phosphorus as it passes through intervening soils before reaching the lake. The benefit to Lake Leota's water quality from connecting properties around the lake to a sewer system would likely be large enough to outweigh the likely increases in phosphorus from stormwater that would result from denser development there, assuming increases in density would be necessary to support the sewer service. However, the gain from sewer service would not outweigh the likely increases in phosphorus from stormwater if substantially more of the Lake Leota basin would need to become more dense to support the service.

An option to sewering near-lake residences would be conversion of existing near-lake septic systems to enhanced septic systems capable of greater nutrient removal. The most common form of these "super septics" is an elevated mound system, in which standard septic tanks discharge effluent to a drain field on an artificially created mound of layered absorbent soils. The built-up drain field distributes liquid effluent on these high quality absorbent materials and is structured to provide ideal porosity, which minimizes clogging yet provides high rates of selective nutrient removal before effluent reaches native soils. Elevated, artificial drain fields have been proven effective where native soils are either too porous or too readily clogged; in either case, the septic system will eventually fail to trap nutrients without this modification.

In the case of Lake Leota, near-lake septic systems probably fail more because of clogging, given the high clay and peat content of soils with anaerobic characteristics. This situation is probably worsened by the likelihood that many drainfields are very close to, or even in, shallow groundwater flows moving to the lake. In this situation, perched drainfields are particularly effective. Nutrient removal efficiency of such perched systems is easily monitored by sampling of groundwater flows downslope of the drainfields via shallow standpipes. Loss of drainfield function can then be surgically remedied by adjustment of fill in individual mounds. As with any septic system, the distance between drainfields and surface water should be maximized; in some situations, leachate could be pumped from the septic tank to drainfields constructed further upslope. Also as with standard septic drainfields, perched drainfields may be landscaped with non-woody plant cover.

School Basin

There is also a part of the R-1 zone that drains directly to Cold Creek (the surface outlet channel from Lake Leota). This 286-acre basin, which includes Wellington Elementary and Leota Junior High Schools (leading us to call it the "School Basin" in this report), has a substantially different relationship to Cold Creek compared to the Lake Leota basin. Based on our current understanding of groundwater flows, groundwater from almost all of the School Basin flows to the west, away from Cold Creek (see Figure II-1), even though its surface water flows to the creek. So the School Basin has little effect on Cold Creek's cold, steady flow in the important summer and early fall months. The basin also has no clearly defined channel through which its surface water flows into Cold Creek, at least as we were able to determine in relatively brief field visits. Much of the stormwater from the School Basin is piped, although there are open channels in parts of the basin (see Figure II-2).

Higher density in the School Basin could potentially have some negative impacts on habitat quality and channel stability in Cold Creek downstream, given the sort of stormwater impacts discussed above for Lake Leota. But Cold Creek is a predominantly groundwater fed stream, with a remarkably

steady flow pattern (see Figure 7 in Appendix A), based on a contributing area considerably larger than the School Basin. Higher stormwater volumes and peak flows from the School Basin would therefore likely have relatively small impacts on habitat quality and channel stability in Cold Creek. From the perspective of the larger Bear Creek system, these are, in any case, less important features of Cold Creek than its steady flow of cold water, which would be largely unaffected by increased density in the School Basin. Higher stormwater flows from the School Basin would also not impact water quality in Cold Creek nearly as much as would higher stormflows from the Lake Leota basin, which would be warmer and carry higher loadings of nutrients and metals. Even in a worst case scenario, including R-4 zoning with no LID and no new public infrastructure to manage increases in stormwater, impacts to Cold Creek's steady flow of cold water would be minimal.

There is, therefore, a much weaker argument on strictly environmental grounds for maintaining R-1 zoning in the School Basin than in the Lake Leota basin. Stormwater management in the School Basin would be important to reduce impacts on downstream habitat quality and channel stability, but with appropriate stormwater management, densities up to R-4 would probably not cause substantial harm to downstream resources. LID, even with its more limited effectiveness at higher densities, would be a valuable component of stormwater management in this area.

III. Conclusions

Based on environmental factors, the conclusions of this study differ for different areas of the R-1 zone, primarily because of complex patterns of surface water drainage and groundwater flow and the special needs to protect Leota Basin and Cold Creek that cannot be accomplished by the standard requirements of the city's critical areas ordinance. The areas include six approximate drainage basins identified in Figure II-2: Lake Leota Basin; the School Basin; the small part of the R-1 zone that drains to Daniels Creek; the upper Woodin Creek Basin; the Hillside Drainages along the slopes of the northwest section of the zone; and the Golf Course Basin in the far northwest corner of the zone. The data collected for this study has been used to determine a broader planning level analysis that identifies whether or not different zoning densities could improve the protection of important critical areas in the city. Taking into account that individual developments are required to protect on-site critical areas such as streams, wetlands, steep slopes, aquifer recharge areas, and others by complying with the Woodinville Municipal Code, Critical Areas Ordinance, Chapter 21.24, the conclusions of this study determined that Lake Leota and the Cold Creek required additional protection through decreased densities.

Lake Leota Basin

Maintenance of R-1 zoning in the Lake Leota Basin, ideally without allowing rezones to R-4 that are conditioned on adequate infrastructure, should provide substantial, long-term benefits to both Lake Leota and Cold Creek by minimizing erosion and other pollutants from stormwater entering Lake Leota. With this in mind, applicable low-impact development (LID) performance standards are encouraged in this area. LID techniques and performance standards are discussed in detail in Appendix D of this environmental report.

Other Considerations

In addition to R-1 zoning, improving stormwater and channel improvements upstream of the lake could address some of the long-term pressures of eutrophication of Lake Leota. These could include new stormwater ponds and treatment facilities to serve existing development, and channel stabilization and riparian improvements where erosion is currently occurring during high flows. A separate study and environmental inventory would be needed to identify these actions, and there necessary funding source.

The separate study could come in the form of a grant from the Washington Department of Ecology to develop a management plan for Lake Leota, which could review all potential actions to protect the lake and help prioritize them most cost-effectively. Sometimes management plans are funded at least in part by management districts, which involve annual pro-rated assessments on properties that potentially impact the resource, depending on the degree of impact.

However, the City need not wait for a lake management plan to take or continue other actions that would benefit the lake such as,

- Continue the current rule against boat engines on the lake. If allowed, propwash from powerboats could disturb the bottom of the shallow lake, which would increase entrainment of nutrients, sediments, and metals into the water column.

- Initiate education and technical assistance to property owners in the basin, particularly those along the lakeshore, regarding best management practices that can benefit the lake. These include:

  - Regular maintenance of septic systems, including upgrading drain fields to enhance nutrient retention;
  - Minimizing the use of fertilizer, particularly phosphorus-rich, artificial fertilizers used on lakeside lawns;
  - Management of aquatic plants (all harvested material should be removed from the lake, to avoid releasing nutrients and metals taken up by the plants back into the lake);
  - Other landscaping issues, including maximizing native vegetation and minimizing lawns near the lakeshore to enhance nutrient retention;
  - Stopping all irrigation pumping from the lake, with or without a permit, to maximize water retention and volume in the lake, thereby maximizing groundwater seepage to Cold Creek;
  - Limiting the size of docks on the lake and designing them to increase the amount of light reaching the water, which will improve the diversity of plant and animal communities near the shoreline; and
  - Avoiding the use of laundry detergents that contain phosphorus, particularly for lakeside property owners.

- Work with King County and lakeside residents to improve monitoring of Lake Leota to better understand its status and trends and to help prioritize management actions. This could include, in order of increasing cost:
  - Monitoring oxygen levels in the lake's water column (particularly in deeper water) to evaluate oxygen deficits each summer and fall (the cost for this would be very low);
  - Monitoring days of anoxic sediments and the extent of the lake bottom that is anaerobic at the peak of summer/fall algae blooms each year, which would aid in evaluating the lake's trophic state;
  - Updating Lake Leota's bottom contour map to permit more accurate measures of the lake's volume;
  - Monitoring lake sediments for metals concentrations on a periodic basis; and
  - Monitoring surface channel inflows to establish water, sediment, nutrient and metals budgets for the lake.

A lake management plan could also help the City and the community further evaluate the potential benefits of:

- Connecting lakeside homes to sewer service – would reduce nutrient input by replacing septic systems with sewer directly around the lake and could create a positive net benefit to water quality even if the R-1 density was amended to R-4. However, modifying existing septic systems to provide extra nutrient removal could potentially provide similar benefits without increasing density.
- Dredging lake sediments – would require state and potentially federal permits.

- Controlling the lake's outlet – is potentially the simplest way to increase the lake's depth, which would enhance seepage to the Cold Creek system, and reduce eutrophication, thus, improving both in-lake and downstream water quality. This action would require state and federal permits.

School Basin

Maintaining the R-1 density in this part of the R-1 Zone is not as important as in the Lake Leota Basin because the surface water flows are only a small portion of the overall flows to Cold Creek. In addition, groundwater from this basin flows to the west and not to Cold Creek or Lake Leota. The emphasis in this area is requiring LID through stormwater performance standards for new development, which would minimize stormwater impacts to Cold Creek. In this case, LID techniques are valuable no matter what zoning density is designated for this basin. They provide the greatest benefit at lower densities but, ironically, they may be more important at higher densities, where the potential impacts to downstream resources would be greater without such extra effort.

In addition, improvements in the City's identification of stream channels and wetlands are also probably more important in this basin than in any other in the R-1 zone. In this study, stream channels in this basin were cursorily identified and need to be further defined. Figure II-2 identifies potential streams based on LIDAR analysis, but they are approximate and need to be further verified. There were also a number of wetlands in this basin that were identified in this study and will need to be accurately located on the City's maps, as shown in Appendix C of this environmental report.

Daniels Creek Basin

The northeastern edge of the R-1 zone drains to Daniels Creek, as shown on Figure II-2. While LID and lower densities essentially always benefit downstream resources, they are less important here, given the considerably larger area that drains to Daniels Creek, all of which is zoned rural outside of Woodinville. Daniels Creek, moreover, flows into Cottage Lake, which attenuates stormwater impacts downstream. The lake's outlet stream, Cottage Lake Creek, is fed in the summer and early fall by the lake's warm upper layer of water, whose temperature is controlled primarily by air temperatures and solar radiation. Changes to the temperature of Daniels Creek therefore have essentially no effect on water temperature downstream of Cottage Lake. (Cottage Lake Creek depends on Cold Creek, which joins it less than ¼-mile downstream of the lake, to provide hospitable temperatures for salmon during the summer and early fall.)

Upper Woodin Creek Basin

LID and lower densities are more valuable here than in Daniels Creek, but not dramatically so, given the relatively small portion of the Woodin Creek basin within the R-1 zone, as well as the substantial Native Growth Protection Easements already in place on either side of NE 177th Drive. These easements provide valuable protection to the upper mainstem of Woodin Creek and, to a lesser extent, the North Tributary. This protection would remain regardless of changes in zoning density. The NGPEs also provide valuable protection for the landslide and erosion hazard areas within and below the easement areas.

Although at this time none of the upper Woodin Creek Basin is currently identified by the City as an erosion hazard area, this study does include these areas as erosion and landslide hazards based on geologic instabilities as well as steep slopes. With this study's review of LIDAR, the latest geologic maps available from the University of Washington, and field reconnaissance, the City's maps will be updated to include this most recent information after completion of the Sustainable Development

Study. Geologic hazards in this area will limit the appropriateness of infiltration as a LID strategy near the steep slope part of the basin. Proper setbacks and stormwater management should address most issues, even at densities higher than R-1, although development of any particular site should receive its own, site-specific geotechnical evaluation. More detailed information is available in Appendix A of this environmental report.

In general, with the latest geotechnical information (see Appendix A of this environmental report), infiltration should be prohibited within 50' from top of slope, and within 50-500 feet should be thoroughly reviewed and supported by geotechnical reports and approved by the city. In addition, any development including single family building permits should be required to convey storm drainage over steep slopes to a safe location using appropriately sized HDPE (high density polyethylene) pipe[9] or similar fuse welded pipe. The pipe is typically installed above-ground and supported with metal collars with pins or some form of anchor to secure the tightline in-place. Above ground installation is preferred as it provides ready access to the pipeline if problems develop and makes for easy detection of leakage should it occur. If aesthetics or other issues are a concern, the pipeline may be buried. Burying the pipeline within a shallow trench will require additional measures such as trench breakers to minimize erosion and piping of the backfill. Some type of energy dissipater structure is necessary at the end of the tightline. Such structures could include a concrete vault with weirs and baffles or grouted or rip rapped open channels. Discharge from the tightline system could be tied into an existing storm water system if one is located in the vicinity, or some form of infiltration facility.

Development not served by sewers would raise similar concerns about effects on slope stability due to infiltration of sewage through on-site systems. R-1 zoning would minimize potential impacts to steep slopes, provided that drainfields are set back at least 50 feet based on geotechnical reports.

There is one large, developable parcel in the north part of this basin where the opportunity for LID is greatest. The 19.8-acre property, which drains to the North Tributary, includes steep slopes, a substantial wetland, and forest that provides valuable wildlife habitat. Whether or not this parcel remains in R-1 zoning, when it is ultimately developed the City should work with the property owner to maximize the potential environmental benefits from this site.

Hillside Drainages

This basin in the R-1 zone is comprised of a collection of many smaller, but steeply incised drainages located in the northwestern edge of the zone. All of the drainages ultimately feed to Little Bear Creek, in many cases passing through an extensive system of underground stormwater pipes after leaving the R-1 zone.

Geologic hazards along the slopes are the primary concern. More detailed information is available in Appendix A of this environmental report (in particular sub-appendix C of the Golder Inc. Hydrologic Study titled "Preliminary Assessment of Hillside Drainages Infiltration"). We would again recommend an update to the City's map of geologic hazards using LIDAR, the latest geologic maps available from the University of Washington, and field reconnaissance.

---

[9] Fuse welded HDPE pipe has a smooth interior wall and a continuous welded seam between pipe sections. This method is preferred over bell and& spigot pipes because it decreases the potential of leakage at pipe joints and the pipe itself can withstand most tree falls or other impacts.

All recommendations concerning slope stability, geologic hazards, and infiltration for the upper Woodin Creek Basin would also apply to the Hillside Drainages. See the discussion in the Woodin Creek Basin.

Golf Course Basin

As with the Hillside Drainages, all recommendations concerning slope stability, geologic hazards, and infiltration for the upper Woodin Creek Basin would also apply to the Golf Course Basin. See the discussion in the Woodin Creek Basin.

Golf Course Creek appears to provide a locally important steady source of water for wildlife in the vicinity. Citizen testimony and LIDAR analysis suggest that Golf Course Creek may be perennial. The steep ravine in which Golf Course Creek is located appears to be highly erodable with significant potential for slumps or at least small landslides, which could be significant localized sources of fine sediment in lower Little Bear Creek. Stormwater management in the part of Golf Course Creek's headwaters that is within the R-1 zone should therefore protect against discharges that would cerate additional erosion or further impact downstream systems that are already partially blocked and possibly undersized.

IV. References

Adolfson Associates. 2004. Woodin Creek Basin Habitat Assessment Final Report. Prepared for City of Woodinville. September 2004. Seattle.

City of Woodinville. 2006. Wood Trails & Montevallo Subdivisions: Final Environmental Impact Statement. October 2006. Woodinville.

Hruby, T. 2004. Washington State wetland rating system for western Washington – Revised. Washington State Department of Ecology Publication #04-06-025.

Kerwin, J., 2001. Salmon and Steelhead Habitat Limiting Factors Report for the Cedar – Sammamish Basin (Water Resource Inventory Area 8). Washington Conservation Commission. Olympia, WA.

King County Surface Water Management, Snohomish County Surface Water Management, and the City of Redmond Public Works. March 1989. Bear Creek Basin Current and Future Conditions Analysis. Final Report.

King County. July 1990. Water and Land Resources Division, Bear Creek Basin Plan.

King County Department of Construction and Facilities Management. Fall 2001a. Cold

Creek Natural Area Site Management Plan. Prepared for King County Department of Parks and Recreation. 26 pp.

King County. May 2001b. Known Freshwater Distribution of Salmon and Trout – WRIA 8. Accessed at: http://dnr.metrokc.gov/Wrias/8/fish-maps/distmap.htm

King County. August 2004. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds Year 2002 Data Analysis. Final Report submitted by EVS Environmental Consultants. Web access: http://dnr.metrokc.gov/wlr/waterres/streamsdata/reports/benthic- macroinvertebrate-reports.htm

King County. March 31, 2005. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds Year 2003 Data Analysis. Final Report submitted by EVS Environmental Consultants. Web access: http://dnr.metrokc.gov/wlr/waterres/streamsdata/reports/benthic- macroinvertebrate-reports.htm

King County. 2006. Benthic Macroinvertebrate Study of the Greater Lake Washington and Green-Duwamish River Watersheds. Final 2002 and 2003 reports accessible at: http://dnr.metrokc.gov/wlr/waterres/streamsdata/reports/benthic- macroinvertebrate-reports.htm

Nelson Geotechnical Associates. 2006. Geotechnical Engineering Evaluation Wood Trails Woodinville, Washington. Prepared for the City of Woodinville. Woodinville.

Hruby, T. 2004. Washington State wetland rating system for western Washington – Revised. Washington State Department of Ecology. Publication # 04-06-025. Olympia, Washington.

WRIA 8 Chinook Salmon Conservation Plan, Volume I. July 2005. Final Report.