Chapter 1

Environmental Report

Draft Sustainable Development Study – R-1 Zone: Environmental Report

Sustainable Development Study R-1 ■ City of Woodinville ■ September 2007

Sustainable Development Study – R-1 Zone: Environmental Report

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January and February 2007/Steward & Associates
Revised August 2007/Jones & Stokes
Revised September 2007/Jones & Stokes

This document should be cited as:
Jones & Stokes and City of Woodinville Community Development Department. 2007. Sustainable Development Study – R-1 Zone: Environmental Report. August. (J&S.) Bellevue, WA. Prepared for City of Woodinville.

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Executive Summary

This report was first commissioned by the City of Woodinville (City) in June 2006, and later revised on the basis of new data collected through July 2007. The report is intended to help the City evaluate environmental conditions that could affect zoning densities and development standards in its current Residential-1 (R-1) zone (Figure 1-1). 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 several reports included in the Sustainability Study for the R-1 zone. The other parts include neighborhood character, transportation, capital facilities, buildable lands and housing, and potential code amendments.

The City's R-1 zone, where the minimum size for new parcels is 1 acre, encompasses approximately 33% 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.

Recent Court and Board decisions may indicate that what have been called "minimum urban densities" are not invariably required in all urban areas. Among the factors considered when determining appropriate residential densities are 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, the percentage of overall land in the City where lesser densities may be permitted, and whether, overall, the City's planning record indicates that it is and will continue to meet its obligations under the Growth Management Act (GMA).

This environmental report evaluates whether there are critical areas—including wetlands, fish and wildlife habitat conservation areas, geologically hazardous areas, and critical aquifer recharge areas—in or adjacent to the current R-1 zone that meet the *Litowitz* test and if so, how they could be affected by different zoning densities. Concurrently, this report evaluates how the function of critical areas may be impacted by development occurring outside of those critical areas, and whether low density may help to minimize such impacts. This report also addresses options for the City to 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. This report recognizes that, consistent with the GMA, any future density developments would be required to protect critical areas through the provisions of the Critical Areas Ordinance

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

(Woodinville Municipal Code [WMC] 21.24) and the Stormwater Manual (WMC 14.09), e.g., protective buffers, detention, and discharge to safe locations. However, this report also finds that even for limited areas where density greater than R-1 might be considered, protection of critical areas cannot be confidently secured at an R-4 (or greater) density. Although in principle the ecological and hydrologic impacts of greater density can be minimized via measures such as low-impact development (LID), such measures have not been found to fully compensate for the associated impacts, except under fairly unusual conditions. Moreover, there is currently no regulatory process in place to designate appropriate minimization measures, let alone to ensure that such measures would be appropriately and fully implemented.

In summary, four critical areas are identified as meeting the *Litowitz* test. These include Cold Creek Springs, Lake Leota, Cottage Lake, and a Snohomish County wetland complex just north of the R-1 zone. These aquatic resources are all highly dependent on properly functioning headwater hydrologic systems to maintain water quantity and quality. These surface waters, in turn, service ecosystems that meet the *Litowitz* criteria. Cold Creek Springs is critical to maintenance of lower Cold Creek, downstream of the R-1 zone as habitat for a federally threatened population of Chinook salmon. Maintaining the viability of Cold Creek Springs via maintenance of the headwater hydrologic system is identified as a near-term goal in the federally approved recovery plan for the Chinook salmon. Lake Leota is regionally significant as the only lake in Woodinville, and is at high risk of water quality impairment caused by development pressures. Cottage Lake is under a Total Maximum Daily Load (TMDL) limitation imposed by the Washington Department of Ecology, which identifies stormwater contributions from Daniels Creek as a major source of nutrient inputs that have degraded water quality in the lake (Washington Department of Ecology 2007). The Snohomish County wetland complex is also vulnerable to water quality and quantity issues that would likely result from higher intensity development in the R-1 zone.

See Tables 1-1, 1-2, and 1-3 for summaries of recommendations and technical findings.

Overall Conclusions

Based on environmental factors, the conclusions of this study differ for different areas of the current R-1 zone, primarily because of complex patterns of surface water drainage and groundwater flow and the special needs to protect Lake Leota, Cottage Lake, Cold Creek, and the Snohomish County wetlands complex that cannot be accomplished by the standard requirements of the City's Critical Areas Ordinance. The areas include six drainage basins shown in Figure 1-2: Lake Leota Basin, the School Basin, the 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 have been used to determine a broader planning level analysis that identifies how different zoning densities could affect 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 WMC Critical Areas Ordinance, Chapter 21.24, this study determines that maintenance of low density is an important and valuable tool in the effort to maintain or improve conditions in vulnerable critical areas. Other tools are also available, including providing sewerage for new development, retention or increase in effective forest cover, and implementation of LID measures that are sufficiently stringent to maintain existing volumes of precipitation infiltration to groundwater. If such measures were developed, adopted, and effectively and stringently implemented, higher density (not to exceed R-4) development might be accommodated within the R-1 zone without significantly increased impairment of the Cold Creek Springs, Lake Leota, Cottage Lake, and Snohomish County wetland complex critical areas. However, there are several reasons why this outcome is unlikely:

- Sewerage alters local hydrology in complex ways and is likely to result in at least local reductions in infiltration to groundwater.
- Reestablishment of forest and forest soils is a process that takes decades and therefore has limited potential to mitigate development impacts that happen in a space of months or years.
- LID ordinances have rarely been found adequate to fully compensate for the hydrologic and ecological impacts of development. Such ordinances are difficult to properly implement and effectively enforce, and they rely on technology-intensive solutions that are likely to receive inadequate or inappropriate maintenance over the long term (see Perteet's detailed discussion of low impact development in Appendix 1D.1).

For these reasons the conclusion is reached that long-term protection of the high-value critical areas named above is best served by retention of R-1 zoning in the basins serving those critical areas.

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

Area	Conclusions	Technical Findings
Lake Leota Basin[1]	▪ R-1 zoning provides substantial, long-term environmental benefits not solely achieved by requirements of the Critical Areas Ordinance. ▪ Lake Leota is a significant resource as the only lake in Woodinville. Absent special protection measures, the lake is at imminent risk of water quality degradation sufficiently severe to violate state water quality criteria. ▪ In lots adjoining Lake Leota and its marginal wetlands, increased density would yield a net environmental benefit if accompanied by the conversion of these lots from septic to sewer service (see options under technical findings, at right). ▪ Require LID as part of stormwater regulations throughout basin.	▪ Lake Leota meets *Litowitz* criteria. Further impairment of water quality inputs would likely result in violation of state water quality criteria for nutrients. ▪ Lake Leota is at risk of eutrophication; which would worsen with increased development density. ▪ Lake Leota is growing shallower, becoming more polluted. ▪ Trends in lake conditions and urbanization in its watershed pose long-term risks to the lake, Cold Creek, and the Bear Creek system. ▪ Goal: minimize stormwater runoff to the lake. ▪ Wastewater management should be modified to reduce nutrient inputs by either repairing or replacing existing poorly functioning septic systems. This could be achieved by (i) modification of existing septic systems to avoid overflows to the lake; (ii) replacing existing systems with specialized single-home treatment systems; or (iii) installation of sewers and conveyance to a central treatment facility. ▪ Limited Steep Slopes – per mapping. ▪ Wetlands are located around Lake Leota and would likely be rated as having moderate habitat values. Some wetlands to the north of the lake drain via surface flow and subsurface pipes and discharge into a large forested wetland present within a largely undeveloped lakeside property. ▪ Wildlife – no protected species documented; many birds and mammals exist in an urban setting; proposed corridor system yields multiple benefits to wildlife, hydrology, and human environment.
School Basin	▪ R-1 zoning benefits Cold Creek in the same manner as in Lake Leota basin; maintaining low density in this part of R-1 Zone is as important as in Lake Leota Basin. ▪ Protection of critical areas requires adopting LID to maximize infiltration of stormwater, minimizing loss of forest cover, providing sewerage for new development and educational measures to discourage use of pesticides and fertilizers.	▪ Surface water from basin drains to Cold Creek; provides relatively small contribution to Cold Creek flows. ▪ Groundwater from a portion of the basin flows directly to Cold Creek Springs. ▪ 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. ▪ Wetlands (north) – At least two wetlands in the northern part of the basin are connected to each other by a series of narrow surface channels, which convey water to the north into Snohomish County. Surface waters from these wetlands are routed through a stormwater pond, and into the southern arm of a large National Wetland Inventory-mapped wetland located just north of the Woodinville city limits in Snohomish County. This wetland complex

Area	Conclusions	Technical Findings
		in Snohomish County north of the Woodinville city limit is large in scope, is mapped as having multiple wetland classes, and thus is likely complex in function and of some regional significance both to water quality and to local wildlife populations given its urbanized setting. The Snohomish County wetland complex would likely be rated Category I under the Department of Ecology rating system. ▪ Wetlands (south) – Six wetlands are probably at least seasonally connected with Cold Creek. These six wetlands provide water quality treatment and retention of the largely untreated stormwater that runs off of local streets, homes, and landscaping within the School Basin. ▪ Wildlife – no protected species documented, many birds and mammals exist in an urban setting; proposed corridor system yields multiple benefits to wildlife, hydrology, and human environment.
Daniels Creek Basin	▪ R-1 zoning provides benefits to Daniels Creek and to Cottage Lake, similar to the Leota basin. Development in the Daniels Creek basin has significantly impaired water quality in Cottage Lake. ▪ LID, sewerage for new development, etc., would provide benefits as in Lake Leota and School basins.	▪ Surface water from area represents a small part of Daniels Creek basin; groundwater from area feeds the Cold Creek Springs, but only a small fraction of precipitation infiltrates to groundwater in the R-1 zone due to relatively impervious glacial till soils. ▪ Cottage Lake attenuates impact of Daniels Creek on rest of Bear Creek system. However, Cottage Lake is recognized as a water-quality-limited water body due to excessive nutrient concentrations primarily due to stormwater inputs. Daniels Creek is one of the principal sources of that contamination and further urbanization of the Daniels Creek Basin would likely worsen the problem. ▪ Limited steep slopes, per mapping. ▪ Wildlife – no protected species documented; many birds and mammals exist in an urban setting; proposed corridor system yields multiple benefits to wildlife, hydrology, and human environment.
Upper Woodin Creek Basin	▪ R-1 zoning provides some protection to geologic hazards, minor benefits to Woodin Creek. ▪ Stormwater management is necessary to protect geologic hazard areas; fuse-welded tightlines (e.g., high-density polyethylene [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 Woodin Creek, but infiltration should be prohibited within 50 feet from top of slope, and within 50 to 500 feet should be 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. ▪ Native Growth Protection Easements (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 feet from top of slope, and within 50 to 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.

Area	Conclusions	Technical Findings
		▪ Wildlife – no protected species documented; many birds and mammals exist in an urban setting; proposed corridor system yields multiple benefits to wildlife, hydrology, and human environment.
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 feet from top of slope, and within 50 to 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. 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 likely would 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. The proposed corridor system yields multiple benefits to wildlife, hydrology, and human environment.
Golf Course Basin	▪ R-1 zoning provides some protection from 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. ▪ LID, especially in headwaters of basin, could provide significant benefits to Golf Course creek; infiltration should be prohibited within 50 feet from top of slope, and within 50 to 500 feet should be thoroughly reviewed and supported by geotechnical reports and approved by the City.	▪ 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 discharges. ▪ Wildlife – no protected species documented; many birds and mammals exist in an urban setting; proposed corridor system yields multiple benefits to wildlife, hydrology, and human environment.

[1] 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.

Table 1-2. Litowitz Criteria Evaluation

Sensitive Resource	Area of concern	Why it is important	Litowitz Criteria			Determination
			Large in scope	Complex in structure and function	High Rank Order	
Lake Leota	Entire lake watershed Especially the immediate vicinity	Woodinville's only lake May be 303(d) qualified for fecal coliform, and could be qualified for nutrients.	Large at the within-City scale	Responsive to hydrology at the basin scale and to multiple stressors; therefore complex.	Largest lake within the City	Qualifies under criteria because failure to protect will likely result in exceeding state water quality criteria with resulting harm of lake beneficial uses.
Cold Creek Springs	Areas of groundwater recharge upgradient of springs, including School and a small part of the Leota and Daniels basins	Plays a recognized critical role in both protection and recovery of federally protected Chinook salmon in the north Lake Washington watershed.	Large at the within-County scale	Springs are an exceptionally complex hydrologic phenomenon, almost unique in the region.	Recognized importance to threatened Chinook populations in the Puget Sound region	Qualifies under criteria because failure to protect may materially impair adopted, federally approved measures to recover Chinook salmon in the North Lake Washington populations.
Cottage Lake	Tributary basin: Daniels Creek	TMDL for nutrients due to contributions from Daniels and Cottage Lake Creeks places a state-mandated limit on stormwater discharges to the creek.	Large at the within-County scale	Nutrient dynamics of basin and lake represent a complex system on which fish & other aquatic life depends.	Protection is mandated by State Lake water quality important to downstream population of threatened Chinook salmon	Qualifies under criteria because failure to protect will result in exceedances of state water quality criteria with resulting harm of lake and downstream beneficial uses.
Snohomish County Wetland Complex	North School basin, which drains to the wetland complex	Generally wetlands are vulnerable to amount and quality of water delivered to them. Also, the Snohomish County complex provides a variety of habitat types, and the source wetlands are functioning well.	Large at the within-County scale	Preliminary function analysis indicates wetland has several functional types, is therefore exceptionally complex. Source wetlands in School Basin also highly functional.	Source wetlands are high rank order in Woodinville. Snohomish wetland complex would likely be rated Category I under the Department of Ecology rating system	Qualifies because the wetland is large and ecologically diverse.

Table 1-3. Summary of Recommendations

		Recommendation				
		R1 zoning: To preserve environmental resources not fully protected by existing regulation	LID: To minimize impacts of new development and redevelopment	Sewerage: To minimize impacts of any new development at R-4 or higher	Creating Forest: To offset impacts of new development and redevelopment, and to alleviate existing stormwater problems	Additional measures to reduce potential for stormwater to destabilize steep slopes
Drainage Basin	Golf Course Basin	Not needed	Recommended with exception (stormwater infiltration can create instability on steep slopes)	Recommended	Recommended	Recommended
	Hillside Drainages	Not needed	Recommended with exception (stormwater infiltration can create instability on steep slopes)	Recommended	Recommended	Recommended
	Woodin Creek Basin	Not needed	Recommended with exception (stormwater infiltration can create instability on steep slopes)	Recommended	Recommended	Recommended
	Lake Leota Basin	Recommended	Recommended highly: Existing Lake Leota problems partly caused by stormwater	Recommend additional measures, retrofit to homes around Lake Leota, to eliminate septic overflows to lake	Recommended	Not required
	School Basin	Recommended	Recommended	Recommended	Recommended	Not required
	Daniels Creek Basin	Recommended	Recommended highly: Existing Cottage Lake problems mainly caused by stormwater.	Recommended	Recommended	Not required

Jones & Stokes Associates – July 31, 2007

1 Introduction

This report was commissioned by the City of Woodinville (City) in June 2006, originally published in January 2007, and substantially revised in August 2007 on the basis of new data collected up through July. The report evaluates potential impacts on critical areas from different zoning densities in the City's Residential-1 (R-1) zone (see Figure 1-1) 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 Growth Management Act (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 several reports included in the analysis of Sustainability Study. The other parts include neighborhood character, transportation, capital facilities, buildable lands and housing, and potential code amendments.

The R-1 zone is the largest contiguous residential area in the City, encompassing about 33% of the City's total geographic area. "R-1" refers the minimum size of 1 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 pers. comm.). Woodinville, incorporated in 1993, inherited 1-acre zoning in this area from King County. Most homes in the zone are 20 to 30 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 are 20 feet wide with no shoulders or 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 R-1 zone, sewer service would be unusually expensive due to topographic constraints, distance from existing sewer mains, and the need for pump stations (see Appendix D, *Capital Facilities and Utilities in the R-1 Area,* of the overall R-1 review report). 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.

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

- A series of wetlands in north School Basin that supply headwater flow to a large wetland complex in Snohomish County.
- 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.
- Parts of the Little Bear Creek watershed, which is another salmon-bearing tributary to the Sammamish River.
- Part of the watershed of Daniels Creek, which is a principal source of pollutants to Cottage Lake, which is listed by the State of Washington as water quality limited due to high nutrients.
- Aquifer recharge areas, some of which are designated as highly susceptible to pollution.

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 Land Use-1 (LU-1) in Woodinville's Comprehensive Plan in the Land Use Element). This tree canopy helps protect all of the critical areas mentioned above, contributes to the functioning hydrologic system in multiple basins, 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 Ordinance in March 2007, interim zoning currently applies in the R-1 zone, removing the provision of Woodinville Municipal Code (WMC) 21.04.080(1)(a) that allowed an R-1 zoned property only when sewer and adequate public facilities are not available. The purpose of the interim zoning 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 GMA and the City's goals, policies, and legal requirements.

1.1 Regulatory Basis: Growth Management and Urban Densities

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

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

> 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 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]

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

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[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).

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 promotes "a variety of residential densities and housing types, and encourage[s] preservation of existing housing stock" (Revised Code of Washington [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 preliminary 2007 buildable land analysis shows that the City has sufficient capacity under its current zoning to accommodate up to approximately 2,005 new housing units, more than are needed to meet its 2022 population allocation. (See Appendix E for more information on the City's buildable lands analysis.)

1.2 Refined Goals of This Report

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 Citizens Advisory Panel (CAP). As part of developing the work program in 2006, and revising the work program in 2007 (most recently April 9, 2007, the City Council considered and approved a schedule and scope of work on the Sustainable Development Report. During discussions of the work program, goals were

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[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).

evaluated for their achievability and appropriateness at a planning level analysis. The study goals are summarized as follows:

- Inventorying critical areas that are in the current R-1 zone or may be influenced by development in the R-1 zone (without conducting detailed surveys).
- 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.
- Developing recommendations to the City based on 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 2 of this report, together with Appendices A, B, C, E, and F, addresses the first three of these goals. A planning level reconnaissance inventory of critical areas within the R-1 zone was conducted. The information can be used as a guide for future land use applications; a more specific level of detail is required of all development proposals. Chapter 2 also includes a detailed review of those critical areas in or adjacent to the R-1 zone that meet the *Litowitz* criteria. 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. The feasibility and appropriate expectations for a wide range of LID techniques were reviewed under different zoning densities. Also reviewed were special considerations for LID techniques to minimize impacts on specific critical areas within the R-1 zone.

Chapter 3 concludes with 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.

2 Critical Area Review

2.1 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, lakes, and their riparian areas); wetlands; geologically hazardous areas; and critical aquifer recharge areas. The other type of critical area that is identified in the GMA, frequently flooded areas, is not found in the R-1 zone. This inventory discusses each of the applicable critical areas and hydrologic systems in the study area.

2.1.1 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-1, groundwater from most of the R-1 zone (i.e., basins other than Lake Leota, School and Daniels Creek) flows to the southwest, away from Cold Creek (see Figure 1-4). The Lake Leota basin is part of the headwaters of Cold Creek. The lake's outlet stream, which directly connects to Cold Creek, and on some maps is named Cold Creek, flows only when the lake is high. 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 no surface connection with Lake Leota. The lake is growing shallower, however, through a natural process of eutrophication, which has been 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 stream and its riparian corridor extend from the corner of 152nd Avenue NE and NE 195th Street southeast to the far western end of Lake Leota (Figure 1-3 and 1-5). Surface water flows through this channel during the winter rainy season (no water was obvious in any observable stretch in August 2006) 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 1980s, 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 is referred to 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, a salmon-bearing stream west of the R-1 zone. 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 NGPEs 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 (Crawford pers. comm.). Outside of upper Woodin Creek, there are only a few other such easements in the R-1 zone, in some cases associated with wetlands.

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[8] WMC 21.06.406 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.

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 feet tall and 15 to 19 inches in diameter at breast height (dbh). There is typically 40 to 75% canopy closure in the denser forested tracts. An inexhaustive field review 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.

Although not currently designated as FWHCAs, wildlife corridors are also an important habitat feature within the R-1 Area. Wildlife corridors have not been designated; however Wildlife Habitat Connectivity Emphasis Areas have been identified within the R-1 Area and are shown on Figure 1-5. In general, the landscape within the R-1 area appears relatively permeable to wildlife, meaning that wildlife can move through the area with relative ease. The abundant trees and large lot sizes along with protected areas provide for a relatively high level of habitat connectivity on a landscape scale. Riparian zones with vegetated buffers and patches of wildlife habitat within the R-1 area provide for connectivity at the planning area scale also.

As mentioned above, several areas meeting the criteria of Fish and Wildlife Habitat Conservation Areas per WMC 21.24.410 have been identified in the R-1 Area. These areas can be categorized in two ways in terms of their contribution to wildlife habitat connectivity in the R-1 Area: as habitat patches and as connective corridors.

Areas containing relatively large blocks of contiguous habitat include areas of Westside lowland conifer/hardwood forest in the northwest corner of the R-1 area and the NGPE Area associated with Woodin Creek. A third large patch of forested wetland habitat is located to the north of the northeast corner of the R-1 Area in Snohomish County.

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.

Potential connective corridors between the large patches of habitat have also been identified. Potential corridor areas incorporate existing habitat features including wetlands and streams with their associated buffers; additional areas are mapped as Westside lowland conifer/hardwood forest, and additional NPGE areas. Where these features are discontinuous across the landscape, relatively high areas of tree canopy coverage, as determined through aerial photograph interpretation, were included to provide connectivity. Together, the patches of habitat and areas of potential connectivity between them have been identified as a Wildlife Habitat Connectivity Emphasis Area, shown on Figure 1-5. The Wildlife Habitat Connectivity Emphasis Area also extends outside of the R-1 Area to show potential linkages with neighboring jurisdictions. It is not the intention of this analysis that the entire area identified as Wildlife Habitat Connectivity Emphasis Area be protected as a wildlife corridor, but that wildlife habitat connectivity be considered and maintained in these areas as part of future development plans for individual parcels. Potential regulatory approaches to wildlife habitat management are described in Appendix E of this Environmental Report.

2.1.2 Wetlands

Information on wetlands contained within this report is a synthesis of work conducted by Cooke Scientific in 2006 and subsequent work conducted by Jones & Stokes (J&S) in 2007. Technical memoranda describing the methods, findings, and conclusions were prepared by both J&S and Cooke Scientific and are attached to this report as Appendix C-1 and Appendix C-2 respectively. Information from these memos is summarized in this report.

Appendix C-2 provides a map of wetlands in the R-1 zone that had previously been identified with corrections and additions developed as a part of the work by Cooke Scientific. 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. Cooke Scientific 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, Cooke Scientific examined a large wetland in the northwestern part of the R-1 area (identified as BBC127 in Appendix C-2).

In February 2007 J&S conducted an independent wetland reconnaissance survey within the portion of the City currently zoned R-1 to build on the information contained within the Cooke Scientific report. The purpose of this reconnaissance survey was to identify wetland areas based on a visual inspection from public roadways and signed private roadways to help the City more fully determine the extent and general nature of the wetland resources within the R-1 area. J&S conducted additional reconnaissance surveys in May and June 2007, to provide additional details about the identified wetland resources within the School Basin, specifically, to determine the degree to which the wetlands previously identified within the School Basin are interconnected with each other and to the portion of Cold Creek to the northeast of Lake Leota.

Neither Cooke Scientific nor J&S calculated formal rating scores on these wetlands using the Washington Department of Ecology's latest rating system (WDOE 2004). Cooke Scientific did describe the vegetation community observed for each wetland studied and made estimates of the likely ratings the wetlands would have received. Details are in Appendix C-2.

In summary, the R-1 area appears to contain a concentration of wetlands, particularly in the School Basin and around Lake Leota. Wetlands in the R-1 zone are generally considered to be either Category II or III wetlands. Some wetlands in the School Basin are hydrologically connected, elevating their importance as an interconnected system, even though taken separately they would not be of exceptional significance or functionally irreplaceable. There is a wetland complex in Snohomish County north of the School Basin that is large in scope, is mapped as having multiple wetland classes, and thus is likely complex in function and of some regional significance both to water quality and to local wildlife populations given its urbanized setting. This is likely a Category I wetland. At least two wetlands located in the School Basin are connected to each other by a series of narrow surface channels, which convey water to the north, out of the School Basin and into Snohomish County. Surface waters from these wetlands are routed through a stormwater pond, and into the southern arm the large, complex wetland.

Cooke Scientific Wetland Review

In general, all of the wetlands Cooke Scientific observed have been substantially degraded by past alterations and impacts from surrounding development and appear to be Category II or III wetlands. Category I wetlands were not found in the study area, and none 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 (*Rana catesbeiana*) 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. Cooke Scientific reviewed those delineations (Shapiro and Associates 1999; Pentec Environmental 2000) and found them still to be generally accurate. Appendix C-2 provides more detail from the further review of these two areas, which comprise two of the three largest extensions of the Lake Leota shoreline wetland system. Cooke Scientific did not have access to the third large wetland area, along the lake's seasonal outlet stream.

Cooke Scientific investigated the wetland at the toe of the slope in the northwestern portion of the R-1 zone (identified as BBC127 in Appendix C-2) from the uphill and downhill edges. Its toe-of-slope boundaries could not be determined because of a very dense thicket of blackberries that ran along both the upslope and downslope edges. The east-to-west portion of the wetland was verified. 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*).

J&S Wetland Review

In February 2007, J&S conducted an independent wetland reconnaissance within the study area. The purpose of that work was to build on previous October 2006 reconnaissance work by Cooke Scientific and to identify wetland areas based on a visual inspection from public roadways and signed private roadways. The efforts were intended to help the City more fully determine the extent and general nature of the wetland resources within the R-1 zone of the Sustainable Development Study. J&S's efforts in May/June 2007 built upon the previous reconnaissance, providing additional details about the identified wetland resources specifically within the School Basin. The latest findings are based on greater access to private property (39 properties), the assistance of local property owners in describing surface water flows and subsurface stormwater pipe connections, and a map of citizen-identified possible wetland areas and surface flow directions provided to the City by the Citizen's Advisory Panel (CAP).

On May 25 and June 8, 2007, J&S conducted additional wetland reconnaissance within the School Basin, as depicted on Figure 1-6 (See Appendix C-1). In addition to determining the degree to which the wetlands previously identified within the School Basin are interconnected with each other and to the portion of Cold Creek to the northeast of Lake Leota, J&S also confirmed the presence/absence of "possible wetlands" and the approximate extent of previously identified "potential wetlands" and sought to field verify surface drainages/"potential streams" in the School Basin. These "potential streams" had been indicated within the City's geographic information system (GIS) data layers based on light detection and ranging (LIDAR) interpretation, but had not been field-verified.

Verification of surface water connections and flow directions was based on visual evidence of surface flow, either flowing water or indications of water flow such as the existence of a defined bed and bank, slope or channel erosion, and/or topographic slopes and culverts.

Identification of "possible" and "potential" wetland areas was based on visual evidence of hydrophytic vegetation, as outlined in Corps of Engineers Wetland Delineation Manual (1987 Manual) (Environmental Laboratory 1987) and Washington State Wetlands Identification and Delineation Manual (Ecology 1997). Wetland functions and associated classification was based on the Washington State Wetlands Rating System for Western Washington (Hruby 2004) and the City of Woodinville's Critical Areas Development Standards (Chapter 21.24.320). Areas that might be wetlands but for which visual reconnaissance was limited were also identified, as were areas of possible wetlands based upon information provided by citizens. J&S numbered the wetlands reviewed as Wetlands 1 through Wetland 11, and they are shown on Figure 1-6. "Potential streams" and/or subsurface stormwater pipes are not numbered.

J&S was able to confirm that Wetlands 1 and 2 located along the southern end of 162nd Avenue NE are connected to each other and that Wetland 3 is not connected to any other wetland or to the stormwater system. Stormwater from many of the properties along 162nd Avenue NE is routed directly into Wetland 2 at its northwestern corner via subsurface stormwater pipes (see Figure 1-6). Surface water then moves from Wetland 2 south into Wetland 1 via a 12-inch diameter culvert beneath NE 187th Street, and then from the outlet of Wetland 1, southeast across NE Woodinville-Duvall Road via an 18-inch culvert. Surface water flows daylight briefly and then moves through a developed residential property via subsurface pipes and discharges to the west into a large forested wetland present within a largely undeveloped lakeside property. Flows from Wetlands 1 and 2 thus directly connect into Lake Leota via this lakeshore wetland.

The School Basin can be divided into two areas based on the connections between the wetlands: 1) the area north of NE 195th Street and the elementary school, roughly between 164th Avenue NE and 166th Avenue NE, and 2) the area west of the "street of dreams" roughly east of 161st Avenue NE.

For the area west of the "street of dreams," most of the surface runoff and wetland discharge is routed through stormwater ponds and pipes, rather than through surface water channels/"potential streams." J&S was able to confirm that Wetland 4 receives stormwater routed from a stormwater detention pond located along 161st Avenue NE. The stormwater is then routed out of the wetland and into the large detention pond associated with the 'street of dreams' properties. Wetland 5 receives surface water from its surrounding residential area and a small surface channel coming into it from the west. Water moves through the wetland to the southeast and flows into a stormwater pipe from which it is routed into the "street of dreams" detention pond. Water from that detention pond flows south of the pond and into the northwestern corner of the residential property located at the end of 165th Avenue NE. From there the water is piped beneath this partially forested property into the western lobe of Wetland 8.

North of the elementary school, surface waters from the properties along both sides of 164th Avenue NE are routed south into a detention pond and then into Wetland 7 (water from the west side of the street) or directly into Wetland 7 (water from the east side of the street). Wetlands 6 and 7 are thus hydrologically connected to each other. Water from Wetland 7 appears to move out of the southeastern corner of the wetland into the large "potential wetland area" at the corner of NE 195th Street and 166th Avenue NE before flowing into a 24-inch culvert, which pipes water under the elementary school field and into the northern end of Wetland 8.

J&S could not field verify a surface water connection linking the School Basin wetlands and surface water flows directly to Cold Creek due to lack of permission by landowners to enter property. At this time, J&S is unable to verify the configuration, extent, and outlet of Wetland 8 and whether or not it directly connects (either seasonally, or perennially) with Cold Creek north of Woodinville-Duvall Road. However, J&S can confirm that the large, forested Wetland 8 does receive surface waters from Wetlands 4, 5, 6, 7, and 11 largely via subsurface stormwater pipes which enter the wetland from along its eastern and northern edges. Based on the topography of the wetland visible from the school property, the wetland does appear to slope to the south and east and thus it is reasonable to conclude there may well be a surface channel outlet from the southeastern end of the wetland. It is also possible that additional water enters Wetland 8 from properties to its east (which J&S did not have access to) and/or that any drainage out of Wetland 8 flows through subsurface stormwater pipes across or through those properties.

J&S also confirmed that at least two wetlands located on the properties surrounding NE 200th Court and along NE 203rd Place (area of Wetland 10) are connected to each other by a series of narrow surface channels, which convey water to the north, out of the School Basin and into Snohomish County. Surface waters from these wetlands are routed through a stormwater pond, and into the southern arm of a large National Wetland Inventory-mapped wetland located just north of the Woodinville city limits in Snohomish County (see Figure 1-6). This wetland complex in Snohomish County north of the Woodinville city limit is large in scope, is mapped as having multiple wetland classes, and thus is likely complex in function and of some regional significance both to water quality and to local wildlife populations given its urbanized setting.

The data collected by J&S and previously by Cooke Scientific indicate that the wetlands present within the R-1 area are typical forested and scrub-shrub wetlands (Cowardin et al. 1979), either depressional, riverine flow-through (associated with Cold Creek), or lacustrine fringe (surrounding Lake Leota) (Hruby 2004). The wetlands are dominated by typical wetland trees and shrubs, which are commonly found throughout western Washington, particularly within urban areas in which much of the original forests and wetlands were cleared for residential and commercial development. These types of wetlands are generally seasonally saturated to ponded and provide a variety of wildlife habitat functions, particularly for birds and small mammals, as well as water quality improvement and hydrologic (stormwater retention) functions typical of depressional wetlands within urbanized areas.

Taken separately, none of the mapped wetlands identified within the School Basin appears to be of exceptional local significance, or of irreplaceable ecological functions. However, their

interconnection with Lake Leota (Wetlands 1 and 2) and with each other does elevate their local significance. This is particularly true for the six wetlands that are likely at least seasonally connected with Cold Creek. These six wetlands provide water quality treatment and retention of the largely untreated stormwater that runs off of local streets, homes, and landscaping within the School Basin.

By intercepting, slowing, and treating this storm water, the School Basin wetlands essentially buffer/prevent this untreated stormwater from reaching the upper portions of Cold Creek and affecting its water quality. Because of their hydrologic connections, these wetlands cumulatively appear to perform a systemic function of water quality treatment within the School Basin and possibly also for the upper portions of Cold Creek. This function is likely provided mainly during the higher flow, winter months and extending into the spring and early summer as the wetlands fill, hold water within their soils and vegetation, and slowly release it as they seasonally dry out.

During the lower-flow summer months of July, August, and September, wetlands typically absorb most of the seasonal stormwater that they receive. Unless there is an as-yet-unknown stormwater pipe connection between Wetland 8 and the upper portion of Cold Creek, and/or a significant low area and positive gradient from the southern end of Wetland 8 to Cold Creek, it is unlikely that any surface water is conveyed to Cold Creek during the summer months.

Cold Creek's contribution of cold, high-quality groundwater to the Bear Creek system is of greatest local significance during the summer months. However, the water quality treatment and attenuation of stormwater flows by the School Basin wetlands is also likely of importance (albeit arguably of lower significance) to the greater Bear Creek basin because little other water quality or stormwater retention currently occurs within the School Basin.

2.1.3 Water Resources

Surface Water

Surface water within the City was studied to determine the relative contribution of each drainage basin to cold, clear water in the Sammamish River watershed. Cold, clear water is important for properly functioning salmonid habitat.

A total of six subbasins were identified within the R-1 Area, shown on Figure 1-2 and Figure 1-3. The Hillside and Golf Course drainages drain to the west to Little Bear Creek. These drainages represent a relatively small portion of the entire Little Bear Creek watershed. The Woodin Creek basin drains west and southwest to the Sammamish River. Approximately 40% of the Woodin Creek basin is within the R-1 Area, with the remainder outside. The Lake Leota basin drains generally southeastward into Lake Leota and is considered part of the larger Cottage Lake Creek drainage that spans the Snohomish-King County line. The Lake Leota basin comprises the largest proportion of the R-1 Area. The School basin is also part of the Cottage Lake Creek

drainage, but does not discharge into Lake Leota. Rather, it is likely that it discharges to Cold Creek; however, the precise hydrologic connectivity is not known, as described above under Wetlands. A portion of the area mapped as the School basin drains to a large wetland complex to the north of the R-1 Area. This wetland may drain to the south within the mapped School basin in the R-1 Area, which it appears to do based on topography; however this condition has not been confirmed. The Daniels Creek basin is located on the eastern edge of Woodinville and is also part of the Cottage Lake Creek drainage. Daniels Creek flows into Cottage Lake.

Monthly mean stream temperatures for six different streams within or near Woodinville are shown in Figure 1-7. Figure 1-7 also shows the temperature ranges for properly functioning streams, streams considered at risk for proper functioning, and streams that would be considered to be not properly functioning based on National Oceanic and Atmospheric Administration (NOAA) Fisheries matrices of pathways and indicators for assessing and documenting baseline conditions for salmonids.

All of the streams show seasonal fluctuations in temperature, but some show more variance in temperature cycling than others. Of the six streams examined, five are considered at risk of proper functioning or not properly functioning during the summer due to thermal loading. This generally occurred from May through October. Only Cold Creek, downstream of Cold Creek springs, showed summer temperatures that stayed within the properly functioning range for all salmonid life history stages. The low variance associated with seasonal temperature cycles is indicative of a primary groundwater source for Cold Creek.

Groundwater provides temperature buffering to surface waters, providing cool water in summer and relatively warm water in the winter. Cold Creek provides this function when groundwater expresses as surface water in the vicinity of Cold Creek Springs. Once expressed as surface water, however, water in Cold Creek is subject to temperature variations associated with surface water, as well as mixing with other surface flows. Data collected from two stream gages, one immediately below Cold Creek Springs and one approximately 0.5 mile downstream from Cold Creek Springs show temperature fluctuations becoming more pronounced as water flows downstream. This occurs because of the effects of ambient warming, energy input from the sun, and mixing with Cottage Creek. Even with increased temperature variance, water temperatures at the downstream Cold Creek gauging station still fall within properly functioning conditions, with on exception during summer of 2006.

Groundwater

The surficial geology of the Woodinville area is predominantly Vashon till (Qvt). In the Bear Creek drainage and the area surrounding Lake Leota, the Vashon advance outwash (Qva) deposits have been exposed through erosion of Qvt. Other stratigraphic units that occur in the area include Quarternary alluvium (Qal), Vashon recessional outwash (Qvr), and pre-Fraser undifferentiated sediments (Qpf). Surficial geology is shown on Figure 1-4.

There are two aquifers in the Woodinville area, one is shallow and unconfined and is located in the sediments of the Qvr. The second is deeper and semi-confined and is located within the sediments of the Qva. The Vashon till is generally not considered to be an aquifer but it is saturated and capable of transmitting groundwater. The Qva aquifer is located between 20 to 100 feet below ground surface, and daylights along the Little Bear Creek, Paradise Valley, and Evans Creek drainages. The Qva aquifer is an important source of groundwater.

No detailed groundwater flow mapping has been conducted previously in the R-1 Area. The only source of existing information on ground water is the well logs that were completed when wells were drilled. In order to provide a more accurate analysis, a more detailed inventory of wells was conducted. Based on information in the Washington Department of Ecology Well Log database, and King County's parcel database, a total of 176 properties were identified east of 156th Avenue NE as potentially having wells. The CAP identified an additional four properties known to have wells.

Of the 176 potential wells, Golder Associates was able to verify that 112 existed. Of these, 16 wells were visited and data was collected on well elevation and water level. Property owners provided elevation and water level information for two additional wells. This data was mapped and used along with well logs to create two geological cross sections for this analysis. One of these cross sections includes Lake Leota. The water levels on the cross section show that Lake Leota is "perched" above the water table within the Qva aquifer.

The direction of groundwater flow can be determined using water level elevations measured in wells. Water levels are plotted on a map and contours are drawn to show lines of constant elevation. Groundwater flows from higher to lower elevation. The direction of ground water flow is influenced by the geometry of topographic highs and lows, and the presence of streams and lakes. Streams and lakes can be areas of groundwater discharge or areas of groundwater recharge, depending on the elevation of the stream or lake relative to groundwater.

Based on past analysis (Golder 2000) groundwater in the Woodinville region generally follows the local topography. An important regional groundwater divide exists along an approximately north-south alignment trending through Clearview, Maltby, and Crystal Lake, to the north of the R-1 Area. Groundwater on the east side of the divide discharges toward Paradise Creek and the Snohomish/Snoqualmie River Basin, while groundwater on the west side of the divide discharges toward Little Bear Creek. The divide crosses into King County south of Crystal Lake and trends toward Lake Leota. This divide is shown on Figure 1-4. Within the R-1 area, groundwater on the west side of this divide flows south-southwest toward the Hillside Drainages and groundwater on the east side of this divide flows south-southeast toward the Cottage Lake and Cold Creek Springs.

Based upon regional groundwater flow and estimated groundwater recharge rates, Golder Associates estimated that portions of the R-1 area on the east side of the groundwater divide, i.e., part of the School and Daniels Creek basins, may contribute up to 0.5 cubic feet per second (cfs)

of annualized recharge to the flow from Cold Creek Springs, representing as much as 12% of the total flow from the springs.

Flow and temperature data from Cold Creek and Lake Leota were examined further. There is no obvious continually flowing surface water connection between Lake Leota and Cold Creek Springs. Sub-surface drains and piping have been reported but could not be verified during this investigation.

Flow from the Cold Creek Springs is nearly constant at 4 cfs throughout the year. The temperature in Cold Creek Springs also remains relatively constant throughout the year, varying by less than 3° Centigrade (C), compared to a temperature fluctuation of about 15°C throughout the year in Lake Leota. This flow and temperature data suggests that Lake Leota is fed by a relatively deep groundwater that is constant in temperature and flow rate. If shallow infiltration from Lake Leota or other surface water was making a significant contribution to Cold Creek Springs, a higher degree of flow and temperature fluctuation would be expected.

2.1.4 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 pers. comm.). 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 1-4 and 1-8). 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 1-8). Where excessively drained soils overlie glacial outwash geology, aquifer recharge areas have a particularly high susceptibility to groundwater contamination.

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.

2.1.5 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-1, 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.

Based on review of the background information, the existing Woodinville landslide hazards ordinance captures the majority of the potential landslide hazards within the city limits. However, review of the available information, field reconnaissance, and subsurface exploration suggests that the west-facing slopes located in the R-1 area (the Hillside Drainages and the Upper Woodin Creek Basin) should be classified as Landslide Hazard Areas. Geologic conditions prone to unstable slope conditions are rather localized in nature.

Several areas within the city limits exhibit geomorphic characteristics indicative of older landslides. These older landslide deposits have remained relatively stable under the present climatic conditions. However, these deposits may become destabilized if significant alteration occurs that affects the equilibrium of the slope.

Potential geologic hazards exist in association with earthquake faults in the R-1 area. A U.S. Geological Survey study of these faults is nearing completion. Because the results of that study are not yet available, this report does not consider seismic hazards. When the study results are available, they may present further evidence relevant to the question of whether low density is appropriate in the R-1 zone.

2.2 *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.

The *Litowitz* criteria are here best applied at the landscape scale because the analysis has revealed substantial environmental functions in the R-1 zone that cannot be adequately protected simply by designation of critical areas. Specifically, ecological functions at the landscape scale are critical to protection of critical areas associated with surface water resources and wildlife habitat.

2.2.1 Surface Water Resources: Science Review

Surface water resources associated with critical areas include wetlands, lakes, streams, and their associated riparian areas. The ecological condition of surface water resources is highly dependent on water quality and quantity, which are generally derived from outside of the critical area and then delivered to the critical area via surface and groundwater flow. Ultimately, the source of these waters is precipitation, which in Woodinville is almost all received in the form of rain. Inappropriate management of incident precipitation has been widely recognized as causing reduced ecological function with regard to numerous environmental indicators, which can be broadly separated into indicators related to water flow and indicators related to water quality.

With regard to flow, urbanization results in reduced infiltration. Thus less precipitation enters the groundwater reserve, and more is directed into surface water channels.

Reduction in groundwater recharge normally causes a reduction in water table elevation, reducing water supply for dependent aquatic resources including lakes, streams and wetlands. This reduction is most apparent during the dry summer months when, in the absence of groundwater influx, wetlands and streams may dry up entirely, with obvious negative consequences for fish, amphibians, and vegetation in those areas.

The redirection of water into surface channels also has adverse impacts. Peak flows increase substantially; thus stream channels must accommodate greatly increased flow volumes and flow velocities. These conditions cause erosion of stream bed and banks. Often such erosion causes the channel to downcut, resulting in the drying up of riparian wetlands. The altered channel usually experiences impaired fish habitat quality. The provisions of the critical areas ordinance

do not provide a mechanism to address this habitat degradation because (1) the ordinance cannot affect the amount of water delivered to the stream, and (2) the ordinance cannot mandate habitat restoration actions. Thus the impacts of urbanization on stream channels are normally not effectively addressed solely by protection of critical areas.

With regard to water quality, the effects of urbanization on surface and ground water quality commonly include the introduction of toxics, changes in fundamental water quality parameters, and changes in water temperature.

The introduction of toxics is ultimately caused primarily by the increased use of agricultural chemicals and motor vehicles in the watershed. Suburban homeowners commonly use chemicals such as pesticides and fertilizers at far higher per-acre loading rates than do commercial farmers. Streams throughout western King and Snohomish counties show pesticide concentrations high enough to be a concern with regard to endangered salmonid populations. Similarly, motor vehicles are a source of both petrochemical toxins and metals (primarily derived from brake linings). Although existing regulations for treatment of road runoff are intended to reduce pollution from this source, both the National Marine Fisheries Service (NMFS) and the U.S. Fish and Wildlife Service (USFWS) have indicated that they do not regard existing regulations as adequately protective of endangered salmonid populations. Runoff from the R-1 zone, though it does not enter salmon-bearing streams within the R-1 zone, does eventually enter such streams further downstream in the Bear Creek watershed and has the potential to degrade water quality in those areas.

Fundamental water quality parameters altered by urbanization include dissolved oxygen concentration, nutrient concentrations, biochemical oxygen demand, and turbidity. Complex ecological factors mediate the changes in dissolved oxygen, nutrients, and biochemical oxygen demand, but generally they reflect increased nutrient inputs in the form of phosphorus from eroded rocks, chemical fertilizers, and organic matter (typically in the form of sewage from septic systems or sewerage overflows, along with contributions from pet and livestock feces), as well as increased aquatic plant activity due to loss of forest canopy and increased water surface exposure to sunlight. Turbidity increases are commonly identified with the loss of forest cover and increase in grassy, weedy, and bare ground cover types, all of which are more vulnerable to erosion. Although turbidity effects are commonly damped downstream of an activity and are a minor consideration in groundwater contamination, increases in nutrient concentration can be conveyed downstream to impair water quality in both surface and ground waters. One of the principal symptoms of excessive nutrient levels is eutrophication, which occurs when human-caused nutrient inputs drive a sharp increase in biological activity (usually involving undesirable organisms such as algae and bacteria) in a lake. Eutrophication is a developing problem in Lake Leota.

Water temperature changes occur both because of the loss of riparian forest cover, and because of the flow changes discussed above. Existing critical areas protections are adequate to minimize the risk that loss of forest cover will occur in riparian areas. Flow changes, however, are a more significant concern. Groundwater enters surface waters at the temperature of the groundwater,

which is approximately equal to the average annual temperature – about 47°Fahrenheit (F) in the R-1 zone. Consequently, even a small groundwater influx can substantially reduce peak temperatures in a receiving water, while a large groundwater influx can be a major factor in overall salmonid productivity in a stream. This occurs in Cold Creek, as discussed below.

In conclusion, critical areas are not fully protected by regulations that only govern management of the critical area. The condition of aquatic critical areas (streams, lakes, wetlands, and riparian areas) is strongly influenced by conditions throughout the watershed. Watershed changes associated with urbanization result in substantial adverse impacts to the quality and quantity of water delivered to surface water resources. These impacts are normally accepted as a consequence of urbanization. However, they may not be accepted if they impact resources that warrant protection under the *Litowitz* criteria of large scope, complexity, and high rank order.

2.2.2 Surface Water Resources: Applicability to the R-1 Zone

Surface water resources in the R-1 zone include wetlands, Lake Leota, Woodin Creek, Daniels Creek, and Cold Creek. Summary conclusions about the applicability of the *Litowitz* criteria to these resources are presented in Table 1-2. The rationale for those conclusions is detailed here.

As discussed in the preceding inventory, there are no wetlands in the R-1 zone having a high rank order. Few, if any, are large in scope or unusually complex in structure and function. However, there is a series of wetlands in the northern School Basin that drain to a large, structurally complex wetland just to the north in Snohomish County. That wetland would likely be rated Category I under the Department of Ecology rating system due to its complexity and size, and is therefore a high rank order resource. The supporting wetlands in northern School Basin provide functional support to that wetland complex by delivering headwater flows of clean water. Further study of that wetland would be required to ascertain the quantitative importance of the School Basin wetland for maintenance of the larger wetland. However, it is reasonably certain that a reduction in the flow or quality of water delivered to the large wetland would not have a beneficial effect. Effects of urbanization on wetlands commonly include introduction of sediments, non-native weeds, and toxic chemicals that may be incorporated in wetland soils and sediments. All of these are adverse effects that would be minimized by reducing urbanization in the north School Basin.

Woodin Creek, while it occupies a large part of the City's jurisdiction and is complex in structure and function, does not support any special status fish in the R-1 zone and supports very few spawning salmon downstream. Juvenile salmonids have been observed in Woodin Creek's lowest reach, but these have likely been either salmon spawned elsewhere or cutthroat trout, which are common in urban streams. Also, a significant fraction of the Woodin Creek headwaters has been protected in NGPEs, helping to ameliorate the watershed-scale impacts of urbanization.

In the case of Daniels Creek, the situation is more complex. Precipitation incident in the Daniels Creek watershed enters both groundwater and surface water flows. The surface water flows enter Daniels Creek and are conveyed to Cottage Lake. Because Cottage Lake is a naturally warm water body, those cool water flows do not benefit salmon, which are found downstream of Cottage Lake. Cottage Lake is a water quality limited lake, which is operating under a Department of Ecology TMDL restriction due to phosphorus inputs from stormwater, which are causing eutrophication in the lake (Washington Department of Ecology 2007). Therefore urbanization in the Daniels Creek Basin has a high risk of increasing stormwater yield and phosphorus discharges to Daniels Creek, exacerbating existing water quality problems in Cottage Lake. Because of its water quality limited status, and the high potential for urbanization in the Daniels Creek basin to exacerbate the water quality problems in Cottage Lake, the lake is a resource that meets the *Litowitz* criteria. Due to its size and importance within the Bear Creek watershed, it is large within the context of northern King County. Due to the fact that it is a lake, experiences water quality problems, and is responsive to multiple stressors, it is complex in structure and function. Finally, primarily because activities in its watershed must manage to minimize water quality impacts consistent with an adopted TMDL plan, it has a high rank order.

Groundwater flows from the Daniels Creek basin are directed towards Cold Creek Springs, and represent a portion of the springs' discharge. The great majority of that groundwater is not derived from within the R-1 zone, though. Soils in the Daniels Creek basin are derived from glacial till and are relatively impervious. Thus a minimal amount of precipitation infiltrates to ground water, and the ground water flows within the Daniels Creek basin are actually derived from groundwater that enters the basin from the north, in Snohomish County. Thus, as long as wells are not installed, human activity has relatively little potential to alter groundwater flows in the Daniels Creek basin.

Cold Creek and Lake Leota, which are considered together because Lake Leota is in-line within the Cold Creek system, have also been determined to meet the *Litowitz* criteria. The Bear Creek watershed covers approximately 50 square miles and includes 100 miles of stream habitat and more than 30 different tributary systems (King County et al. 1989; Kerwin 2001). Cold Creek, a major tributary to the Bear Creek system, is also large in scope. Cold Creek 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 9 to 12.5°F (5 to 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 provides a fraction of the total tributary flow to the Bear Creek Basin, its capacity to provide a steady source of cold water to the system during the warm, low flow summer and fall

periods underscores its importance for instream habitat and salmon production in the Bear Creek Basin and the Greater Lake Washington Watershed. Recent groundwater investigations (Appendix A-1) indicate that groundwater flows originating in the R-1 zone (specifically, in portions of the Lake Leota, School, and Daniels Creek Basins that are east of the groundwater divide shown in Figure 1-4) represent up to 12% of the total discharge volume at Cold Creek springs, and that loss of this groundwater input would result in up to a 1°F (0.5°C) increase in water temperature in Cold Creek. Since cold stream temperatures are an essential component of salmon habitat and the Bear Creek system is already limited by excessively high summer water temperatures (Kerwin 2001), such a temperature change would represent a highly significant adverse water quality impact in Cold Creek, with measurably adverse effects on Chinook salmon, a federally threatened species.

Lake Leota is fed by Cold Creek and groundwater influx, and discharges to Cold Creek via a surface water outlet during high flows. At 10.4 to 12.3 acres (depending on water level), Lake Leota is the only 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 Figures 1-2 and 1-3). Considered within the City's jurisdictional area, the lake is clearly large in scope.

Bear Creek supports populations of Chinook, sockeye, and coho 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 Steward & Associates 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 more than 50% of that area is defined as low intensity development. Groundwater sources for Cold Creek extend further north, into an area that is primarily zoned rural. 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).

As noted previously, Lake Leota is developing signs of eutrophication, such as late summer and fall algal blooms. The lake's eutrophic status has developed through the complex interaction of multiple factors:

1. Septic and fertilizer seepage delivering nutrients, which have entered shallow peaty soils over glacial gravels of high hydraulic conductivity.
2. Sediments and nutrients running off from storms to the lake via surface channels.
3. Lake infilling by sediments delivered via surface runoff.
4. Lake shallowing due to excess organic matter production from algae, near-shore submergent plants (including the invasive Eurasian watermilfoil and/or its hybrid), and near-shore emergent plants (including white and yellow water lilies, and cattails).

The shallow band of near-shore rooted plants is now encroaching on open waters in the central lake basin. These plants will continue their encroachment until wetland conditions predominate across the lake. Continued loading of sediments and nutrients will eventually transform the wetland to a wet meadow.

Heavy metals, likely delivered via atmospheric deposition, septic seepage, and influent streams, are accumulating in lake sediments. These metals are present at concentrations exceeding regional background concentrations. Some metals, such as lead and nickel, are present at concentrations exceeding levels known 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.

Cold Creek is of a high rank order because of its ecological role as a cool water salmon refugium in the Bear Creek watershed, which is one of the most important smaller watersheds in King County due to its high productivity of the threatened Chinook salmon (more than 90% of the Chinook salmon in the north Lake Washington area originate in the Bear Creek system [Shared Strategy 2007]). Bear Creek and Cottage Creek, which both receive cold water from Cold Creek, have been identified in the Puget Sound Chinook recovery plan as two of the "areas of highest

abundance and most consistent use by Chinook for spawning and rearing," and the recovery plan identifies protection of the Bear Creek watershed as a core strategy for protection of Chinook salmon in the Lake Washington watershed (Shared Strategy 2007). The recovery plan includes specific actions in the Bear Creek watershed to be accomplished in the next 10 years. These actions specifically include:

> Headwater wetlands and Cold Creek groundwater springs will be protected through regulations, incentives, and acquisitions. Undeveloped, forested properties throughout the Bear/Cold Cottage Creek basin are targeted for protection….Regulations, incentives and educational outreach will be used to protect forest cover, soil infiltrative capacity, riparian vegetation, floodplain connectivity, instream channel complexity, water quality and instream flow (Shared Strategy 2007).

Actions by the City will be a primary determinant of future water quality and quantity in Cold Creek. Absent special protections to reduce the hydrologic and water quality impacts of urbanization, future development of the R-1 zone would be expected to result in reduced flow of cool, clean water from Cold Creek Springs during the late summer low flow period, and would also be expected to result in higher winter peak flows and reduced water quality due to the influx of toxins that are at best incompletely removed by stormwater treatment facilities. As such, 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 Water Resource Inventory Area (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.

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

2.2.3 Wildlife Habitat

No special status wildlife species are known to use the R-1 zone. Largely for that reason, wildlife habitat in the area is not assigned high rank order and thus wildlife habitat per se does not justify low density based on the *Litowitz* criteria. However, protection of wildlife habitat does constitute a substantial benefit of low density development that warrants consideration as an ancillary benefit from density management to protect more significant resources.

The proposed wildlife corridor system would support an increase in forest cover in the R-1 zone. This benefits desirable wildlife species (in the R-1 zone, primarily native birds and mammals) by providing a larger area of suitable habitat and by providing connections between areas of suitable habitat. This allows wildlife species to more readily disperse across the landscape, which in turn allows maintenance of larger and more stable breeding populations, especially for rarer species that require a large area of habitat in order to support enough individuals for a sustainable population. The proposed wildlife corridor system would also support surface water resources and the human environment. Surface water resources would benefit from the increased forest cover, which would provide hydrologic benefits of increased infiltration and reduced runoff, as discussed above. The goal of increased forest cover in the Cottage Creek-Bear Creek system, as a means of protecting the cold water flow from Cold Creek springs, is specifically identified as a near-term goal in the Chinook salmon recovery plan (Shared Strategy 2007). Moreover, the human environment would benefit from the amenity value and the natural divisions between neighborhoods created by the forest corridors.

2.3 Implications for Development Densities

2.3.1 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 3 of this report. These LID standards for appropriate development in the lake basin, retrofits, and modifications to alleviate problems experienced by existing septic systems, providing sewer service for new development in the lake basin, 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 objective.

Increases in density would 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, particularly if those requirements place a strong emphasis on LID techniques that maximize infiltration and minimize runoff. However, LID techniques have limited efficiency, and engineered stormwater facilities are only partly effective at removing nutrients (such as phosphorus) from stormwater (see Appendix D-1 of this environmental report). Higher-density development would be expected to result in increased discharges and impaired quality of the discharged waters.

To an extent, stormwater impacts from increased density could be mitigated by requiring LID standards. As discussed in more detail in Appendix D-1, the potential benefits of LID techniques decrease with increased density, particularly above R-2 (two units per acre). Increased density will impact groundwater quality unless it is served by sewers. LID techniques such as infiltration of storm water may not be advisable along steep slopes unless set back appropriately (see also Appendix A of this environmental report for the Golder Inc. "Preliminary Assessment of Hillside Drainages Infiltration"). Finally, LID techniques are subject to problems in design and maintenance. Optimum design requires a level of expertise rarely encountered among developers or among permitting staff charged with LID ordinance implementation. Maintenance is required to keep LID systems functioning properly, but such maintenance is often neglected. Thus, there is a substantially higher failure risk associated with LID approaches than with low density approaches. Even with adoption of all these measures—stormwater infiltration, LID techniques, and sewerage for new development—new development is still expected to result in water quality impairment due to incomplete effectiveness of these measures, loss of forest cover, an unauthorized but nonetheless predictable incidence of noncompliance, and the occasional loss of critical areas that occurs as a result of the reasonable use exception.

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. Conversely, R-4 zoning most likely would lead to a significant increase in phosphorus inputs to the lake from stormwater, a reduction in groundwater recharge, and increased flow variability that would amplify seasonal variations in lake level and contribute to erosion and channel destabilization upstream of the lake. In the worst case, the increased phosphorus inputs from stormwater would push the lake into a self-sustaining cycle of increased eutrophication, which would result in routine exceedance of state water quality standards in the lake 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 B, 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 outweigh the expected increases in nutrients 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 nutrients from stormwater if substantially more of the Lake Leota basin would need to become denser to support the service.

It is also possible to replace the existing septic systems with alternative single-family treatment technologies that would not discharge nutrients to groundwater; although such a solution would be costly, it could be implemented with no associated increase in density. The most common such alternative technology 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 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.

2.3.2 School Basin

Groundwater flows originating in the School Basin feed the Cold Creek Springs. It is thought that surface water discharges from the basin convey waters to Cold Creek via surface connection, at least during the winter months, but this has not been proven. Much of the stormwater from the School Basin is piped, although there are open channels in parts of the basin (see Figure 1-6).

Higher density in the School Basin could impair habitat quality and channel stability in Cold Creek downstream, given the sort of stormwater impacts discussed above for Lake Leota. Higher density in School Basin, if accompanied by higher stormwater runoff and reduced infiltration, would reduce groundwater supply to Cold Creek Springs. This would substantially impair the quality of a high rank order resource that meets the *Litowitz* criteria, as discussed above. However, there is less likelihood that peak flow increases and water quality impairments could be conveyed to Cold Creek, because a substantial acreage of wetlands in the lower School Creek basin provides floodwater detention and filtration functions. Sufficiently high development intensities could overwhelm those functions, although stringent sewerage and LID requirements would likely be sufficient to prevent that outcome at R-4 densities. As noted above for the Leota Basin, reliance on LID techniques may not fully offset potential impacts of higher densities.

Additionally, higher density development in north School Basin would increase surface water flow and therefore, pollutants to wetlands that could impair function in the receiving wetlands and the major Snohomish County wetland complex downstream. The Snohomish County wetland is a complex wetland system that would likely be considered a Category I under Department of Ecology standards. This wetland is a peat land. Peat wetlands are particularly sensitive to altered hydrology.

2.3.3 Daniels Creek

Groundwater and surface water flows originating in the Daniels Creek Basin feed Cottage Lake. Higher density in the Daniels Creek Basin would result in increased stormwater discharges to Cottage Lake. Such stormwater inputs have been identified in the Cottage Lake TMDL (Washington Department of Ecology 2007) as a primary cause of excessive nutrient loading in the lake. Such a stormwater runoff increase would substantially impair the quality of a high rank order resource that meets the *Litowitz* criteria, as discussed previously. As discussed for Lake Leota above, stormwater treatment and LID technologies alone would not be adequate to mitigate those impacts, though they could be adequate to improve water quality in the lake if implemented in the absence of any density increases.

3 Conclusions

The conclusions of this study vary for different portions 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, Cold Creek, Cottage Lake, and the Snohomish County wetland complex that cannot be accomplished by the standard requirements of the City's critical areas ordinance. The areas include six approximate drainage basins identified in Figures 1-2 and 1-3: 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 have been used in a broader planning level analysis that identifies whether alternative 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, and aquifer recharge areas complying with WMC Critical Areas Ordinance, Chapter 21.24, this study has determined that Cold Creek, Lake Leota, Cottage Lake, and wetlands north of School Basin require additional protection that can be met via several congruent strategies that include low development densities, LID performance standards, forest preservation, and sewerage.

3.1 Lake Leota Basin

Maintenance of R-1 zoning in the Lake Leota Basin would be expected to approximately maintain current conditions for Lake Leota by minimizing erosion and other pollutants from stormwater entering Lake Leota. Positive benefits to water flow and quality in these waters could be achieved by the requirement of appropriate LID performance standards in this area, modification of septic tank treatment systems around the lake, and implementation of the recommended system of wildlife corridors. LID techniques and performance standards are discussed in detail in Appendix D of this environmental report.

3.1.1 Other Considerations

Improving stormwater detention and treatment, 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 detention and treatment facilities to serve existing development, stormwater infiltration to serve new 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 specific actions.

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. That report 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:
  - Maintaining septic systems on a regular basis, including upgrading drain fields to enhance nutrient retention.
  - Replacing septic systems with alternative single-family technologies that do not discharge to groundwater.
  - Minimizing the use of fertilizer, particularly phosphorus-rich, artificial fertilizers used on lakeside lawns.
  - Managing 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).
  - Maximizing native vegetation and minimizing lawns near the lakeshore to enhance nutrient retention, as well as addressing other landscaping issues.
  - Stopping all irrigation pumping from the lake, with or without a permit, to maximize water retention and volume in the lake.
  - 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.
  - 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 bathymetric (bottom topography) map to permit more accurate measures of the lake's volume.
- Monitoring lake sediments for metals concentrations on a periodic basis.
- 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, which 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, which would require state and potentially federal permits.
- Controlling the lake's outlet, potentially the simplest way to increase the lake's depth, which might enhance flows to the Cold Creek system and would reduce eutrophication, thus, improving in-lake water quality. This action would require state and federal permits.

3.2 School Basin

Groundwater flows originating in the portion of School Basin east of the groundwater divide are critical to maintaining flow and water quality at Cold Creek springs, while groundwater flows from west of the divide influence water quality in Lake Leota. Therefore the same measures intended to preserve groundwater flow and quality in the Lake Leota basin also apply to the School basin. These include requiring appropriate LID performance standards in this area, and implementation of the recommended system of wildlife corridors. LID techniques and performance standards are discussed in detail in Appendix D of this environmental report.

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. Flow paths and seasonality of surface water connections between School Basin and Cold Creek have not yet been confirmed, as described in Appendix C-1 of this report.

Wetlands in the north School Basin provide flows to a regionally significant large wetland complex in adjacent Snohomish County. Further study would help to clarify the magnitude of influence this wetland connection has on hydrology and habitat in the larger wetland complex.

3.3 Daniels Creek Basin

The northeastern edge of the R-1 zone drains to Daniels Creek, as shown on Figure 1-3. LID and lower densities are also important to protect resources in this basin, because Daniels Creek flows into Cottage Lake, a water quality limited lake which is operating under a Washington Department of Ecology (2007) TMDL restriction due to phosphorus inputs from stormwater, which are causing eutrophication in the lake. Therefore urbanization in the Daniels Creek Basin has a high risk of increasing stormwater yield and phosphorus discharges to Daniels Creek, exacerbating existing water quality problems in Cottage Lake. 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 0.25 mile downstream of the lake, to provide hospitable temperatures for salmon during the summer and early fall.)

3.4 Upper Woodin Creek Basin

LID and lower densities are valuable here, but not as much as in the Lake Leota, School, and Daniels Creek basins, 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 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 applicability of infiltration as a LID strategy near steep slopes in 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-1 of this environmental report.

In general, with the latest geotechnical information (see Appendix A-1 of this environmental report), infiltration should be prohibited within 50 feet from top of slope, and within 50 to 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 dissipator 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 stormwater 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 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.

3.5 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-1 of this environmental report (in particular sub-Appendix C of the Golder Inc. Hydrologic Study titled “Preliminary Assessment of Hillside Drainages Infiltration”).

[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.

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.

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.

3.6 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 create additional erosion or further impact downstream systems that are already partially blocked and possibly undersized.

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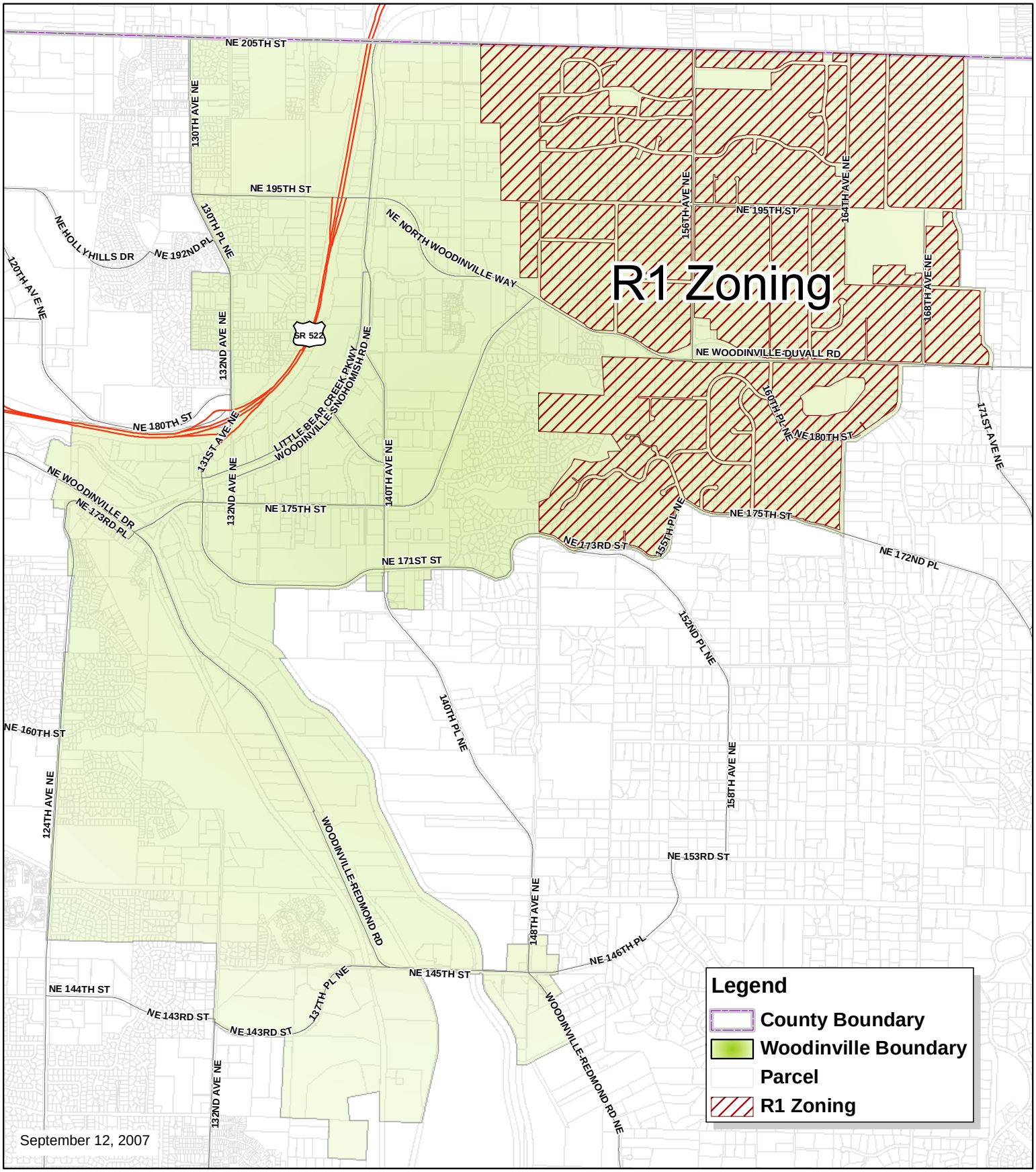

Figure 1-1. R-1 Zoning

1 inch equals 2,200 feet

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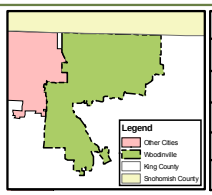

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1	Final	01/17/07	AU
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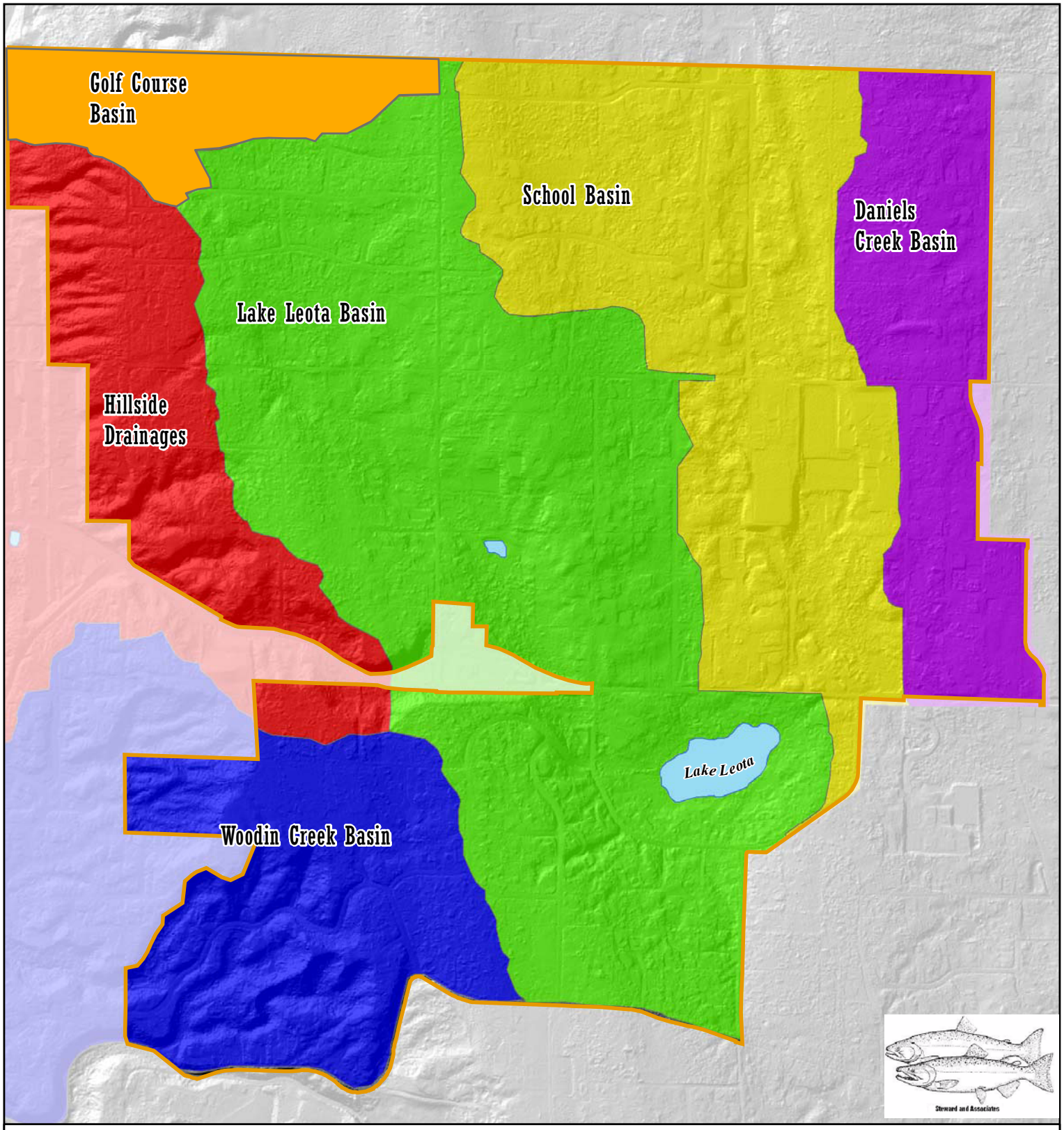

Figure 1-2. Woodinville Drainage Areas

September 12, 2007

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

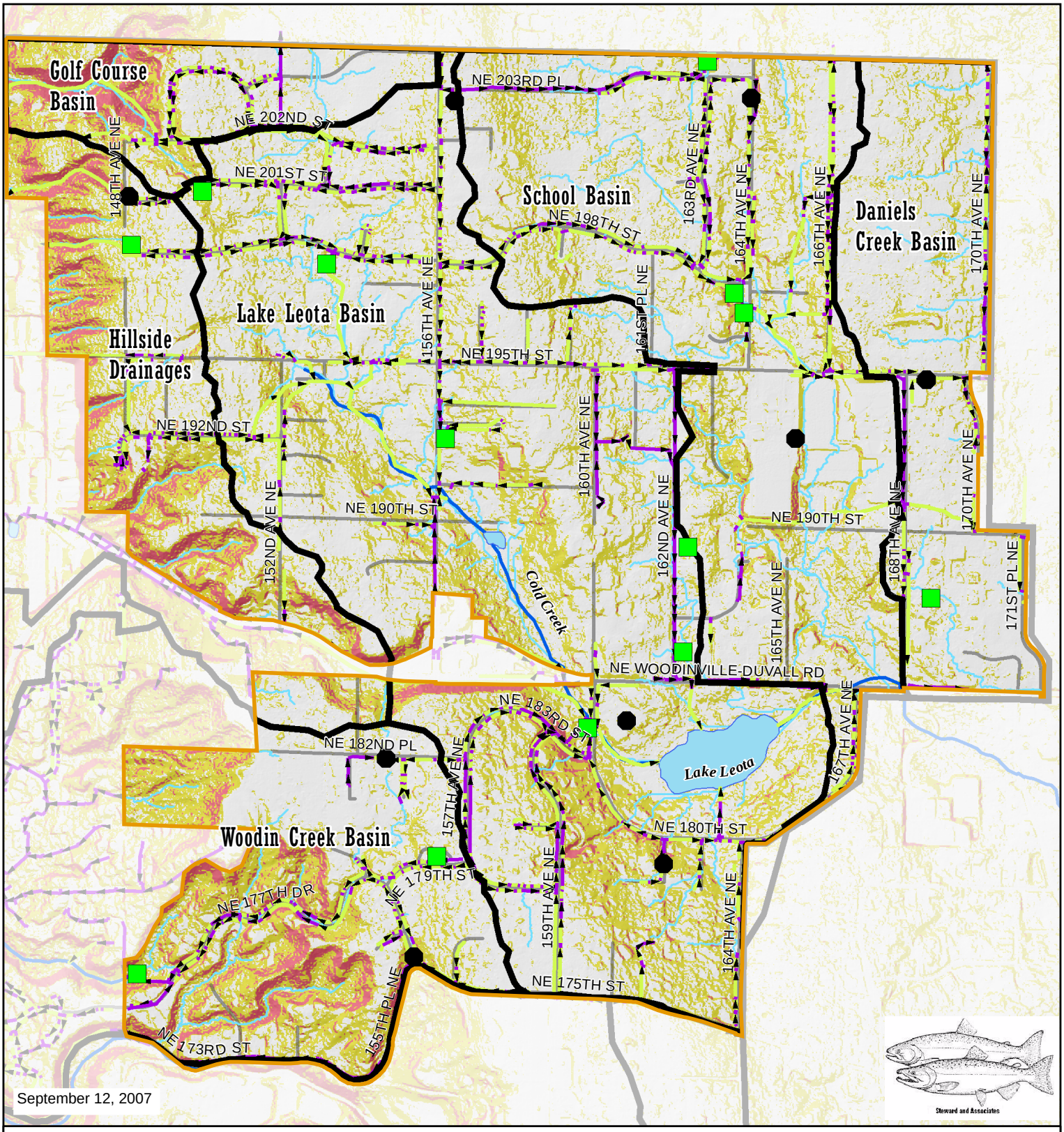

Figure 1-3. Woodinville Slopes and Storm Drainage

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

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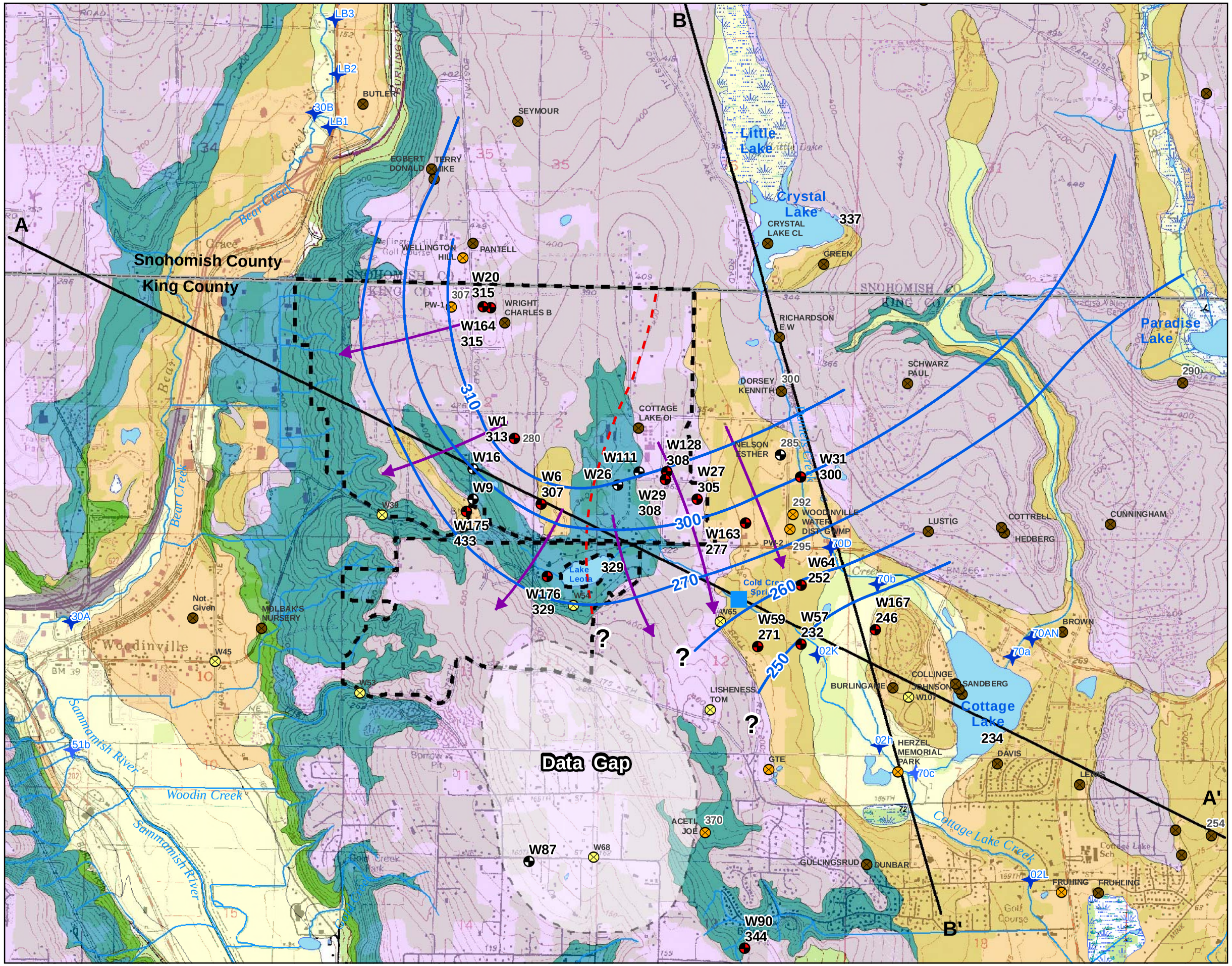

FIG. **1-4**

GEOLOGY AND WELLS R-1 AREA

SA/WOODINVILLE HYDROGEO SVCS/WA

September 12, 2007

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Golder Associates

City of Woodinville

Sustainable Development Project

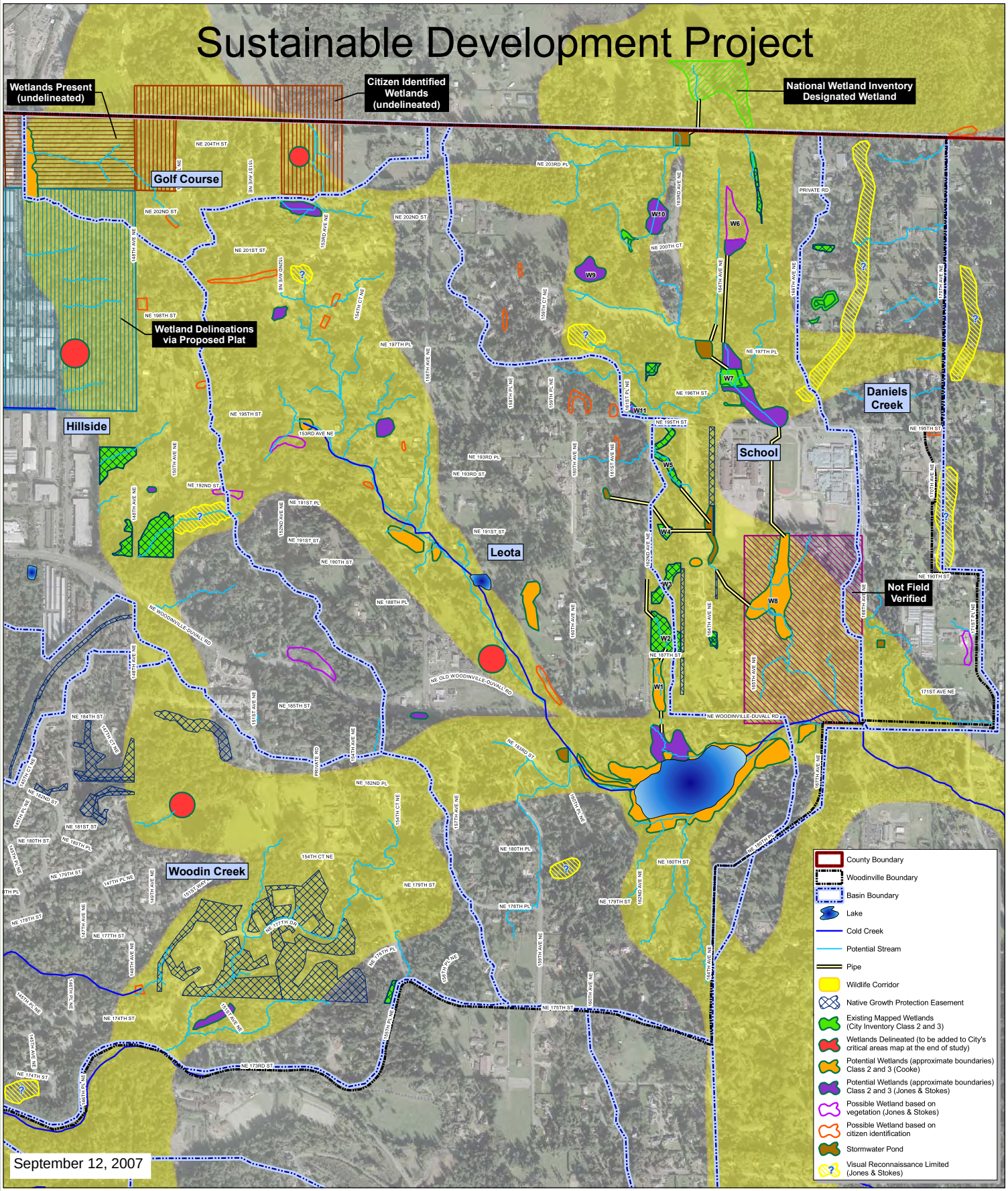

Figure 1-5. Wildlife Habitat Connectivity Emphasis Area

0 500 1,000
Feet

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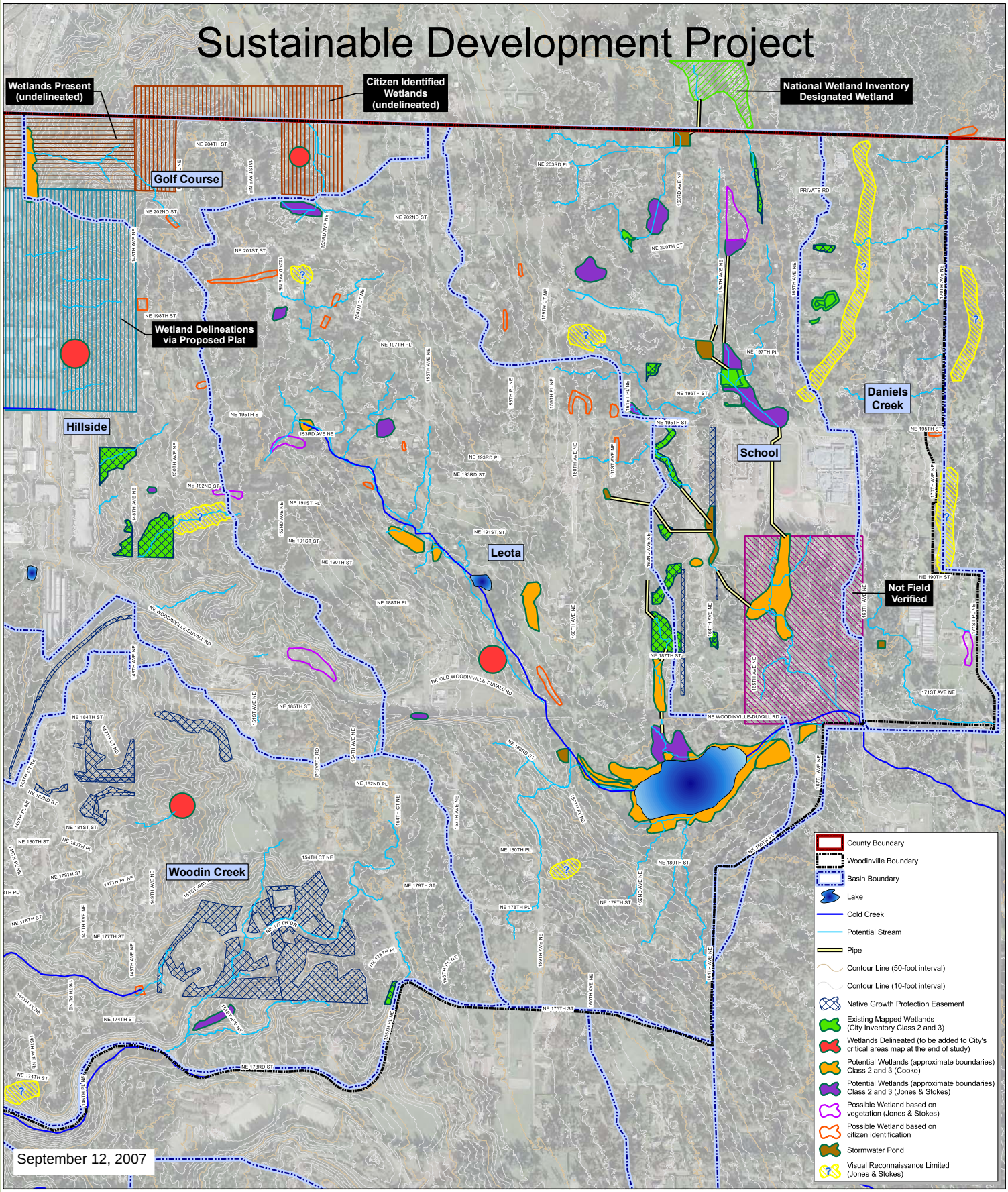

Compilation of Wetlands Reconnaissance and Inventories

Figure 1-6

0 500 1,000
Feet

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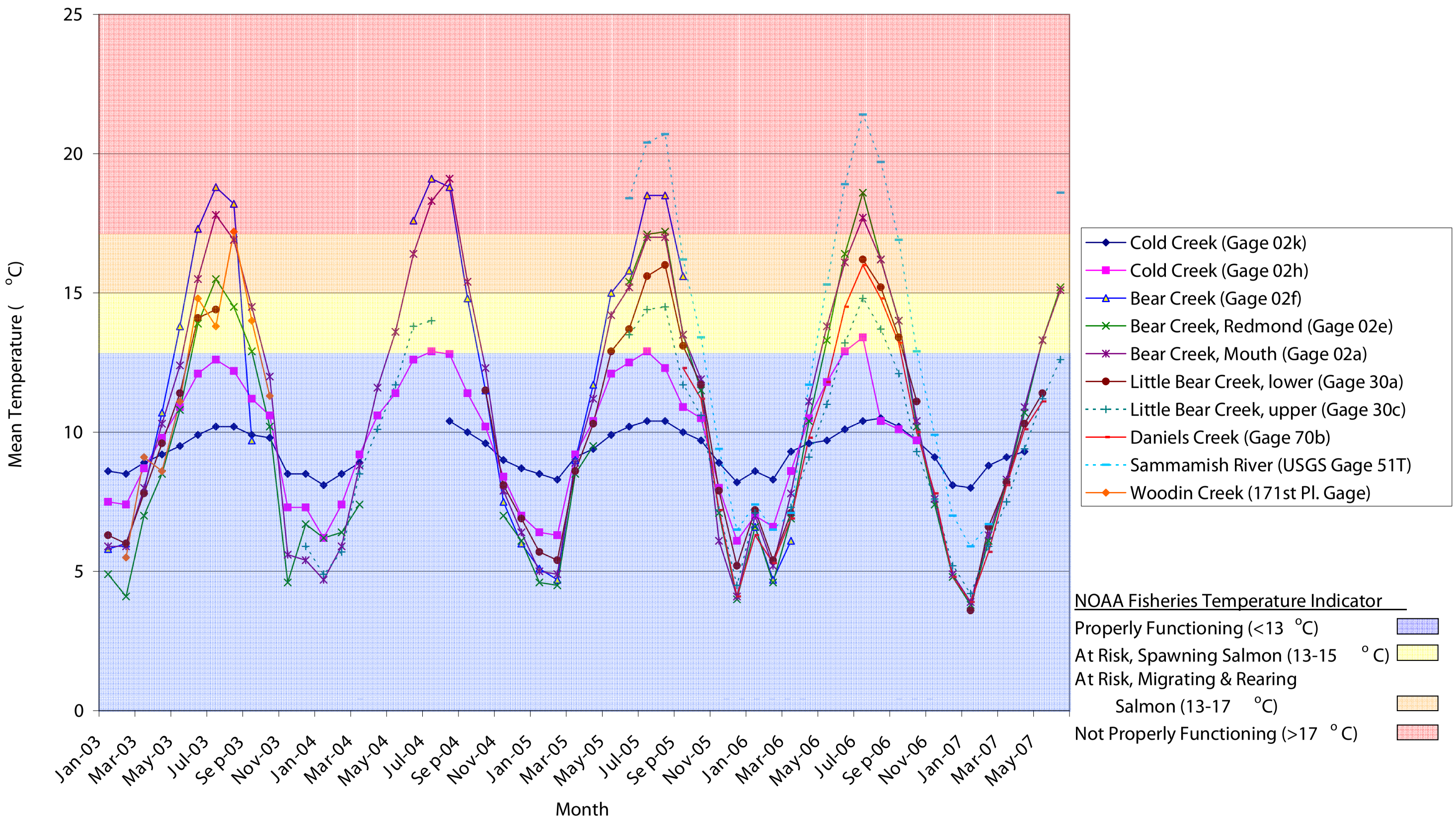
Fig. 1-7 —Monthly Mean Stream Temperatures



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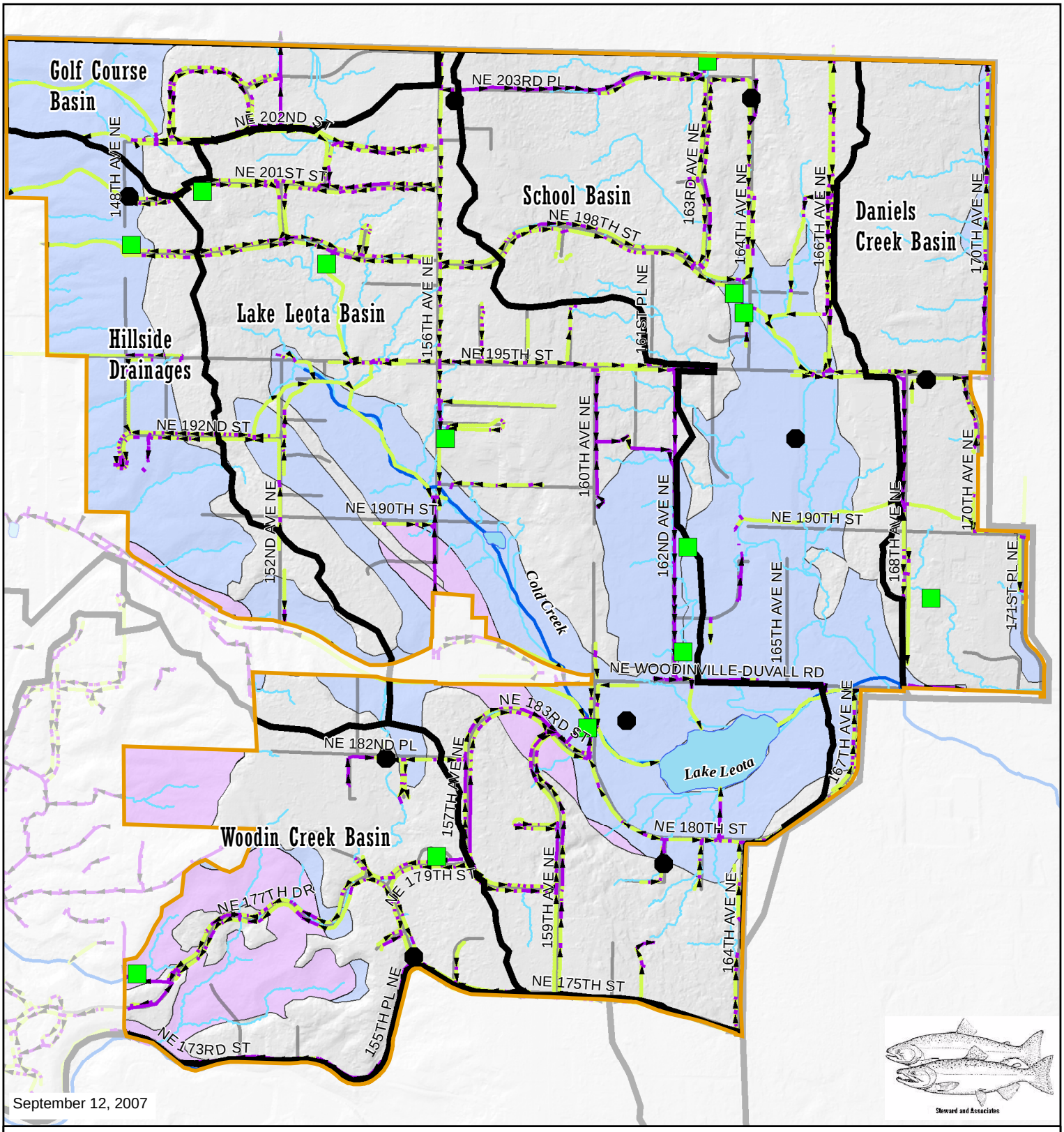

Figure 1-8. Moderate & High Critical Aquifer Recharge Areas (CARAs)

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