The Washington Water RESOURCE

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Message from the Director

Most noteworthy of the last three months was the Annual Review of the Center's research, held October 16th on the University of Washington campus. Nearly 100 people attended to hear reports ranging from stream monitoring and rehabilitation to groundwater modeling. We continue to enjoy strong support from the University and an ever-growing range and inventory of research projects; we are also in a very good position to consider prospective graduate students over the next several months for the upcoming academic year.

As befits the time of year, Center subscription renewals for 1999 will be sent out in January. I certainly hope you continue to participate, but only if you are finding some direct or indirect benefit from our work here. Subscriptions cover the cost of the newsletter and help support many of the ongoing, cooperative functions of the Center as well. Thanks to the support from the colleges of Engineering and Forest Resources, however, we can continue to maintain the same subscription rates that have been in effect since the Center began in 1990. I also remind you that all are welcome to add additional recipients of the newsletter to your subscription without charge, because our interests are all best served through the broadest distribution of information.

As part of our desire to broaden interaction among urban water-resource managers, we have been working with several local agencies to identify and evaluate various protocols to assess stream habitat conditions in western Washington. We are interested in integrating those findings into a set of recommendations for use by public agencies in developing and executing their stream-monitoring programs. The particular focus is on the *urban* environment, recognizing that most monitoring protocols currently in widespread use have had their origins in the forestlands of western Washington and Oregon. Those protocols are useful for many applications, but the immediate needs of resource-management agencies here in the Puget Sound region have not been entirely served by existing alternatives. A more complete report should be ready by the next issue of the Newsletter.

Finally, I want to repeat the announcement from last issue of the initiation of the Center's web page, <http://weber.u.washington.edu/~cuwrm>. It provides us with a very convenient way to distribute certain types of information and data (for example, see the accompanying article on last August's stream-temperature survey), and it provides a useful introduction to prospective subscribers. Yet the ready availability of information over the web does not supercede the normal consideration due to the agencies and researchers who have collected the data made available through this medium (from the Center's, or any one else's, electronic distribution source). Referencing and acknowledging the sources of data is an absolute minimum in any transfer of information, and direct permission from the people involved prior to use of data in any public presentation or publication is always appropriate and usually mandatory. The proper balance between open communication and propri-

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The Washington Water Resource is the quarterly publication of the Center for Urban Water Resources Management at the Department of Civil Engineering, University of Washington, Box 352700, Seattle, WA 98195.

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MESSAGE FROM THE DIRECTOR (from page 1)

etary information will always be difficult at the margins; for an organization such as ours, we will try to err on the side of free communication. As an ever-widening circle of researchers contribute to our efforts, however, we will need your continued conscientiousness in order to maintain that approach.

Derek Booth ❖

Regional, Synchronous Field Determination of Summertime Stream Temperatures in Western Washington: 600 Sites in 120 Minutes

The Center for Urban Water Resources Management, in cooperation with the Center for Streamside Studies and local stormwater agencies, tribes, and citizen groups, coordinated a regional, one-day intensive stream-temperature monitoring survey on August 19, 1998. Our intention was to characterize the range, distribution, and determinants of summertime high temperatures in fish-bearing (and tributary to fish-bearing) lowland stream systems in the Puget Sound lowlands. Cold-water fisheries can be strongly affected by elevated summertime stream temperatures, but the causes for and the magnitude of these conditions is relatively well understood only in the abstract. Their quantification in any given watershed is confounded by the vagaries of groundwater and surface-water inflows and the complex interplay of stream orientation and sun angle, canopy cover, and air temperature. Individual temperature measurements can give insight into the specific conditions for a particular stream, but they do not provide the context to evaluate unusual natural or human-induced temperature conditions at any given site.

To provide this context, over 100 individuals, representing approximately 20 different agencies and community groups, collected over 600 temperature measurements across the south-central Puget Lowland in the two-hour period from 3:00 to 5:00 PM on August 19th. Sites were arrayed to provide coverage of both scattered individual sites and whole stream systems on a watershed-wide basis, with drainage areas ranging from 100 km^2 on down to the limits of perennial flow. Reflecting our interest in quantifying human influences, we targeted watersheds with primarily urban and suburban land uses but included some rural and forested basins as controls. About a dozen sites with continuous recording temperature gauges already installed were also covered to provide a temporal context for these "snapshot" data. Our intention is to provide a systematic, regional data set available to all scientists, planners, and managers to improve our understanding of the magnitude of high-temperature problems in developing parts of the region, and to guide strategies for their correction.

Although our sample date missed the hottest days of 1998, the maximum air temperature on August 19 was exactly the average for the month of August (24°C), and our sample interval (3–5 PM) was within 1°C of the maximum water temperature of that day. Thus, the results we report are representative of "normal" but not "extreme" summertime conditions.

To test the replicability of the data, temperatures were taken at the same site by different volunteers at different times during the sampling period. Reported stream temperatures at these replicate sites tended to differ by about 1°C, suggesting some limitations in the precision of these data. Volunteers also characterized the shade cover at the reach, and the flow conditions both in the reach and at the sampling point. These qualitative categories (e.g., "open sun," "partial trees," and "full shade") also tended to vary, reminding us that monitoring programs that rely on multiple individuals will not always yield fully consistent results.

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REGIONAL SYNCHRONOUS FIELD *(from page 2)*

Some of the different potential determinants of stream temperature are explored by Figures 1a and 1b. At each site, observers characterized flow conditions (Figure 1a) and riparian canopy conditions (Figure 1b) by choosing one of four descriptive words for each of these attributes. Each curve on these two graphs shows the cumulative percent of sites with progressively warmer temperatures in each category. Both differences in flow condition and differences in riparian canopy may account for one to four degrees difference between sites, although the change from "partial" vegetation to no vegetation ("open sun") is particularly marked. Note on Figure 1b that over half of the stream channels in open sun exceeded the Washington State water-quality standard for temperature (16 degrees), despite the fact that August 19th was not an exceptionally hot day. In contrast, only the warmest 15% of streams in full shade exceeded this value.

The bar-and-whisker plot (Figure 2) offers additional interpretation of the reach-scale data. By discriminating the results into two different classes of flow, "free" and "stagnant," the interaction of flow and riparian conditions is displayed. In particular, full sun on stagnant flow produces a marked response in stream temperature that significantly exceeds the simple addition of each individual factor.

Figure 3 plots the temperature range of the most clearly "urban" and "rural" streams in our survey. The urban channels all have more than 75 percent of their watersheds covered by urban development; all are located in the cities of Seattle and Bellevue. The rural channels all lie beyond the suburban fringe; they lack any urban development in their watersheds and have at most 5% impervious-area coverage. Although typical urban effects, such as canopy removal and loss of baseflow, clearly affect stream temperature (Figures 1 and 2), generic "urbanization" does not display any discernable influence.

The full data set is posted on the Center's web page and is available for downloading as an Excel spreadsheet. We invite subscribers to the Center and other readers of this Newsletter to explore the information contained in this data set, and to share with us any results of your analyses. ❖

Figure 1a

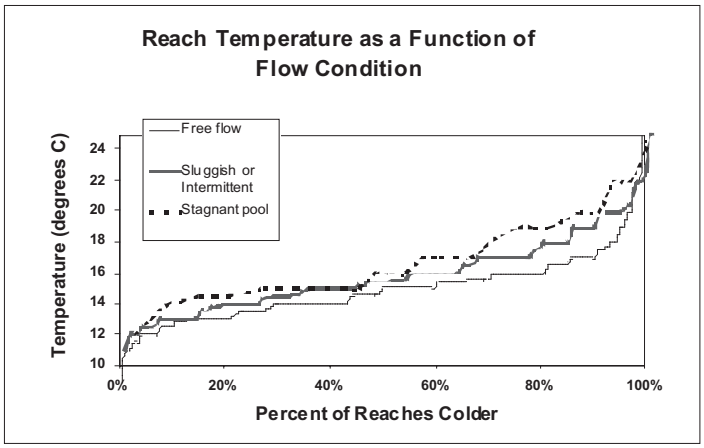


Figure 2

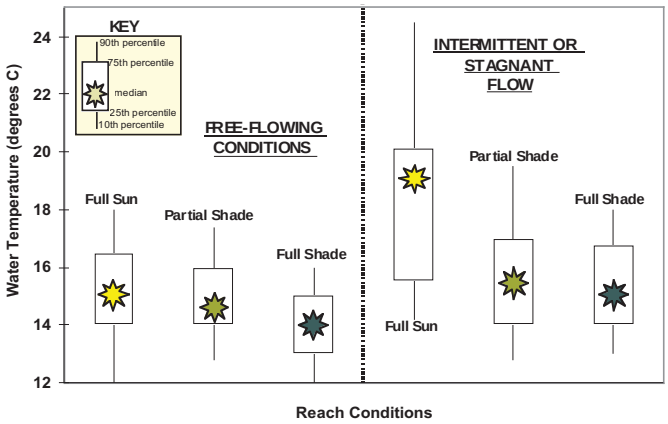


Figure 1b

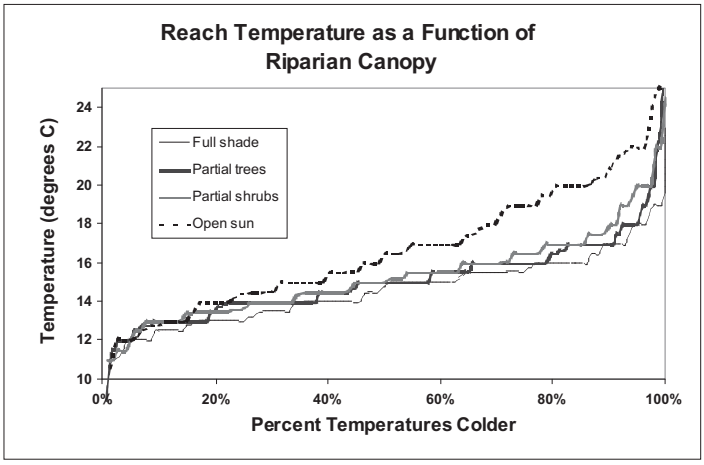
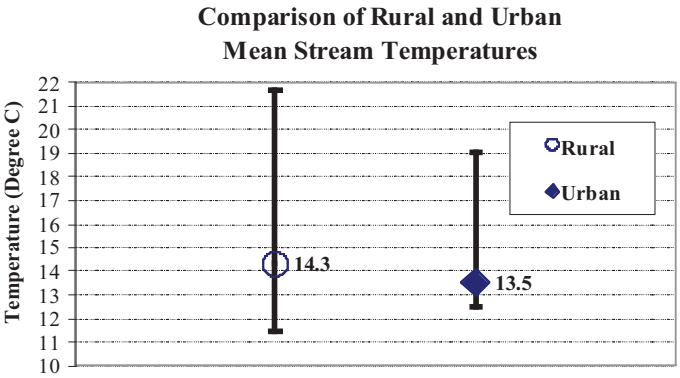


Figure 3



The Stream Rehabilitation Project Information System

The *Stream Rehabilitation Project Information System* is a database compiled during the summer of 1998 that contains information on close to 400 instream and riparian corridor rehabilitation projects in the Puget Sound Basin. The work was conducted by Stephen J. Kropp, a graduate research assistant working for the Center. In compiling the information, an emphasis was placed on identifying appropriate projects within King, Pierce, and Snohomish counties. Selected projects in Kitsap, Thurston, Mason, Skagit, and Whatcom counties are also included. The database is written in Access 97 and provides full support for user queries by location, agency, project type, project size, date, and other parameters.

The following types of projects were included in the inventory:

- channel construction
- bed excavation
- instream flow control (energy dissipaters, dams, weirs and other devices to control water velocity)
- grade control
- bank stabilization
- large-scale streamside re-vegetation
- berm setback
- large woody debris installation
- channel width adjustment or construction of meander bends
- backwater habitat connection
- gravel replacement
- fish passage (culvert removal or upgrade, fish ladders, etc.)
- livestock fencing

Detention ponds, bypass pipelines, or other flood control projects were not included in the inventory. Neither were drainage improvement projects (i.e. local flood control projects that channelize runoff), simple conservation easements or property acquisitions, or wetland projects. Projects located in forested catchments were also eliminated from the inventory. In general, priority was given to obtaining information on larger instream rehabilitation projects, where the length of stream or riparian corridor that was altered by the rehabilitation exceeded 100 meters. Fish passage projects were an exception to this rule.

Priority was given to obtaining the following information for each project:

- location of site
- project objectives
- what was done (techniques)
- date construction started and completed
- responsible agency
- project contact
- length of stream affected
- availability of pre- and post-construction monitoring data

Detailed locations (street addresses or intersections, township and range information, etc.) are provided for about 80% of the projects. Relatively detailed descriptions are included for most (89%) of the projects. The lead agency was identified for 92% of the projects, although the project manager is known for only 40% of the projects.

Pre- and post-construction monitoring data are known to be available for only 44 of the projects identified in this inventory. Only 18 projects are known to have been evaluated using any sort of biological and/or habitat suitability data. Several contacts verified that in most cases, city, county and state agencies and grantees do not appropriate funds for project monitoring or evaluation. It would thus appear that the impacts of a large majority of the projects identified in this inventory on aquatic biota have not been evaluated, despite the rapid pace at which such projects are being designed and constructed.

Projects included in the inventory at the present time are characterized by project type and basin in Table 1. More continue to be added to the list, but we are not the only ones who have recognized the potential value of such a compilation. A number of other related efforts, in addition to the Center's Urban Stream Rehabilitation Project that supported this work, are underway to inventory and to evaluate selected projects in the region, including:

1. Washington State Department of Fish and Wildlife *Watershed Recovery Inventory Project*, initiated to develop an inventory of watershed restoration projects and salmonid habitat information needed to respond effectively to the challenges and opportunities presented by the potential salmonid listings under the federal ESA. The inventory identified 971 "watershed restoration projects" statewide. Approximately 600 of these projects are located in the Puget Sound Basin. Only about 60 projects were identified in King, Pierce, and Snohomish Counties, suggesting that the Center's work may be able to significantly augment this WDFW effort. Investigator: Leni Oman.
2. Washington State Department of Transportation Capital Budget Coordinating Committee *Habitat Mitigation and Restoration Partnership Program*, an effort intended to improve the outcomes of aquatic habitat projects by sharing information about other similar projects that have been completed. A stream restoration project inventory for the Snohomish and Cedar/Sammamish Basins contains information on additional projects in these basins and was produced as a precursor to this study. Investigators: Leni Oman, Joel Gjuka, Ed Molash, Heather Roughgarden.
3. Northwest Indian Fisheries Commission, *Salmon and Steelhead Habitat Inventory and Assessment Project*, principal goals of which include providing information necessary to develop basin specific protection and restoration strategies, and a means to prioritize restoration projects that are most cost effective at restoring basin production. Investigators: Randy McIntosh, Tom Ostrom, Osa Odum, Jennifer Cutler, Ted Labbe, and Byron Rot.

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STREAM REHABILITATION *(from page 4)*

4. Nooksack Salmon Enhancement Association *Project Monitoring Program*, intended to assess the impacts of stream rehabilitation projects completed by the Association. Investigator: Margaret Neuman.

The database is soon to be posted under "RESEARCH" on the Center's web page. We anticipate maintaining the database over the next several years, particularly if it sees active use and application—so we welcome any response or comments from users. ❖

Project Type	Channel Construction	Bed Excavation	Instream Flow Control	Bank Stabilization	Berm Setback	Re-Vegetation	LWD Installation	Width Adjustment	Backwater Habitat	Grade Control	Gravel Replacement	Habitat Rocks	Fencing	Fish Passage	TOTAL
Basin															
Bear Creek	1			8		14	5					1	2	7	**28**
Coal Creek						1	2		1						**3**
Cottage Lake Creek			1	1		8	1						1	1	**9**
Des Moines Creek				2		1	1								**2**
Deschutes River		1		2		1	2		2		1	1		2	**6 ***
Duwamish River	1					1	1				1			1	**1 ***
East Lake Sammamish			1	5	1	2	5			1				2	**18**
East Lake Washington	1					2	1								**6**
Evans Creek				1		2	2						2	1	**9**
Green River	1						1								**2 ****
Issaquah Creek	3	1		6		8	7		1				1	2	**25**
Juanita Creek				2		1	1			1		1			**3**
Kelsey Creek						1				1				1	**3**
Little Bear				1		1				1				1	**2**
Longfellow Creek	2			3		1	1			1				3	**7**
Lower Cedar River	7	3	1	7	1	14	8		3		1	1	1	3	**42**
Lyon Creek															**1**
May Creek						2	1						1		**4**
Mill Creek				1			1			1	1				**1**
Nisqually River	1			1										2	**4 ***
Nooksack River	1					1	1		1					1	**9 ***
North Lake Washington															**3**
Other	6	5	4	32		42	11		3		9		31	36	**115**
Puyallup/White				1		5	5				1	1	2	1	**12**
Sammamish River	3		2	4	2	10	4			1	1			4	**23**
Skagit River			1	5		8				3	2	2	5	2	**19 ***
Skykomish River															**1 ***
Snohomish River							5							1	**1 ***
Soos Creek	4		1	1		6	6		1			1	2	5	**14**
Stillaguamish River	1					4	1			1			1	3	**7 ***
Swamp Creek				3		4	3			1					**5**
Thornton Creek	3			1		4			3			1		2	**15**
Tibbetts Creek		1		1		1	1	1		1					**3**
Tolt River														1	**2**
West Lake Sammamish			1			1					1	1			**2**
West Lake Washington															**1**
Total Project Type	**35**	**11**	**12**	**88**	**4**	**146**	**77**	**1**	**15**	**13**	**19**	**10**	**49**	**82**	

* Represents only a fraction of the work done in these basins.

** Does not include Soos, Newaukum, Mill, or Springbrook Creek.

Recent Publications Available through the Center

To order these or any other publications, or to receive a complete listing of available titles, contact the Center's publication distribution service using the enclosed order form.

Biological Monitoring and Assessment: Using Multimetric Indexes Effectively
by James R. Karr and E. W. Chu., EPA 235-R97-001, University of Washington, 149 p. 1997.
Price = $22.50 (Publication E14)

Environmental Limitations to Vegetation Establishment and Growth in Vegetated Stormwater Biofilters
by Greg Mazer. Report of the Center for Urban Water Resources Management, July 1998, 138 p.
Price = $22.00 (Publication G12)

Quality Indicies for Urbanization Effects in Puget Sound Lowland Streams
by Chris W. May, E.B. Welch, R.R. Horner. J.R. Karr, and B.W. Mar, Water Resources Series Technical Report No. 154, 1997, 229 p.
Price = $35.00 (K20)

Guidelines for Landscaping with Compost-Amended Soils
by Tracy Chollak and Paul Rosenfeld: report prepared for the City of Redmond, 1998. Publication K21; on Center's web page with no charge to download. ❖

Professional Engineering Practice Liaison (PEPL) Program

The PEPL (Professional Engineering Practice Liaison) Program, in cooperation with the Center for Urban Water Resources Management, offers a continuing education program in urban water resources management.

As part of the benefits extended to supporters of the Center for Urban Water Resources Management, member organizations submitting five or more registrations for the same course may deduct $30 per registration for a 1-day course, $35 for 1.5-day, $45 for a 2-day course, $50 for a 2.5-day course, and $60 for a 3-day course.

For further information on the *Urban Surface Water Management Continuing Education Program* or on any of the courses on the next page, please contact:

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Environmental Limitations to Vegetation Establishment and Growth in Vegetated Stormwater Biofilters

To address the problem of degraded urban water quality, both federal and local governmental agencies throughout the country have required construction of low cost, in-pipe or end-of-pipe stormwater filtration facilities. One such facility increasingly employed in the Puget Sound region is the biofiltration swale (also called bioswale or biofilter). Bioswales are open channels possessing a dense cover of grasses and other herbaceous plants through which runoff is directed during storm events. Above-ground plant parts (stems, leaves, and stolons) retard flow and thereby encourage particulates and their associated pollutants to settle. The pollutants are then incorporated into the soil where they may be immobilized and/or decomposed. Despite some experimental evidence to the contrary, herbaceous cover is commonly considered to predict treatment efficiency.

Greg Mazer, a graduate research assistant at the Center for Urban Horticulture, finished a major investigation of bioswale vegetation this last spring to determine the relative importance of the various factors influencing vegetation establishment and growth. Three of these swales were regraded, retrofitted with new soil, and hydroseeded in September 1996. A nested two-factorial greenhouse experiment tested the response of four turfgrass species, commonly seeded in bioswales, to four moisture regimes (three inundation schedules plus a control). Preliminary results were presented in the Spring 1997 issue of this Newsletter.

Of the three retrofitted bioswales, only one (SAY7) accrued an abundance of vegetation deemed adequate for effective biofiltration. Vegetation and organic litter biomass there was comparable to that of the three other evaluated swales that also supported high herbaceous cover (at Discovery Elementary School, Pine Lake Park, and the Center for Urban Horticulture), although these swales were seeded 3–9 years ago. Virtually no hydroseeded grasses established at the two other retrofitted swales (SAY8 & SAY9) due to particularly long inundation durations after seeding, a consequence of the local soils and hydrologic regime. However, some volunteer wetland plant species grew in less erosive and shallower areas of these sites.

The proportion of time that each swale was inundated at or above 2.5 cm depth proved to be the variable that was most closely correlated with plant and organic litter biomass (r^2 = -0.92). For those plots that experienced summer drought, vegetation biomass was strongly dependent on adequate soil depth (r^2 = 0.74). Field monitoring revealed other factors that locally limit bioswale vegetation growth, such as springtime base flow velocity and excessive shading by trees. In contrast, bioswale biomass was *not* well correlated with certain hydraulic variables, such as the rate at which runoff is introduced over the surface of the swale, that *are* important in determining sedimentation potential and thus pollutant removal. As a result, the condition of swale vegetation may not reflect a facility's actual pollutant-removal effectiveness.

In the greenhouse experiment, the "wet" treatment (long-term inundation of seeds) produced equally poor germination amongst all grass species. For each of the other three moisture treatments, *Festuca arundinacea* (Tall Fescue) accrued significantly more biomass, and *Agrostis alba* var. *stolonifera* produced significantly more leaf blades, in comparison to the other species. These greenhouse results were consistent with field observations in retrofitted swale SAY7, where Tall Fescue established more quickly than the other seeded species while *Agrostis alba* var. *stolonifera* achieved nearly equivalent abundance within one year. Both field observations and greenhouse experiments clearly demonstrate that persistent inundation severely limits germination and establishment of those grasses typically seeded in biofiltration swales.

Continued on page 7

ENVIRONMENTAL LIMITATIONS (from page 6)

Several shortcomings of current bioswale design and construction are evident from this study. First, the factor that most critically determines vegetation success (inundation during germination) is not acknowledged by present design or construction guidelines. Second, current design guidelines permit flows at overly high rates that can overwhelm the vegetation or circumvent filtration via channeled flow. Finally, factors that contribute to eventual success but that vary widely on a site-by-site basis can only be addressed by careful evaluation and construction, but most bioswales are constructed without incentives to install high-quality stormwater runoff facilities that are suited to the requirements of individual site characteristics.

The results of this study suggest that bioswale design standards should be modified to restrict the permitted inflow discharges to much lower maximum values than at present, and that implementation guidelines should ensure that proper moisture conditions for germination are achieved. Given the multiple challenges to constructing and maintaining functionally satisfactory biofiltration swales, however, construction of alternative stormwater facilities with less critical requirements should be investigated. Carefully designed constructed wetlands, for example, may provide conditions conducive to sediment deposition more readily, offer more effective immobilization and/or greater biological uptake of contaminants, and concurrently create refuge for native flora and fauna.

This report is available as Publication G12 of the Center for Urban Water Resources Management. ❖

Current Projects at the Center

- Stream Temperature Survey: See article in this issue of the Newsletter.
- Rehabilitation-Project Database: See article in this issue of the Newsletter.
- LANDSAT Land Cover Interpretation: Erik Botsford and Kristina Hill, Graduate Research Assistant and Professor in the Department of Landscape Architecture, have developed a preliminary land-cover classification method for the LANDSAT images over the urbanizing parts of the central Puget Lowland. Error-checking begins this month, with the results to be published in the next issue of the Newsletter.
- Urban Stream Rehabilitation in the Pacific Northwest (see description in the Summer 1998 issue of the Newsletter)
- Puget Lowland Urban Corridor Geology and Geologic Hazards (see description in the Summer 1998 issue of the Newsletter)
- Road-ditch and water-quality BMP maintenance (see Winter 1998 Newsletter)
- Issaquah Creek sediment budget (see description in the Fall 1997 issue of the Newsletter)
- UPD monitoring (see description in the Fall 1997 issue of the Newsletter)
- Boeing Creek Reestablishment: (see description in the Spring 1997 issue of the Newsletter; channel was resurveyed in early September and showed almost complete stability since November 1997)
- Watershed Academy (see Winter 1998 Newsletter): This joint offering of the Center for Streamside Studies and the Center for Urban Water Resources Management was conducted September 21–25, 1998 on the University of Washington campus and was attended by 50 individuals. The sponsoring agency, USEPA, was quite pleased with the results and intends to have us offer this program on an annual basis. ❖

Professional Engineering Practice Liaison (PEPL) Courses

January 12 and 13, 1999
Storm and Surface Water Monitoring

February 10 and 11, 1999
New Technologies and Concepts in Stormwater Treatment

February 17 and 18, 1999
How to Successfully Use Value Engineering in Capital Projects

February 25 and March 2, 4, 9 & 11, 1999
Effective Writing for Technical Professionals

March 17 and 18, 1999
Groundwater Monitoring for Water Purveyors

March 25 and 26, 1999
Alternative On-Site Stormwater Management Techniques

April 7 and 8, 1999
Stormwater Treatment by Media Filtration

April 15, 16 and 17, 1999
Quaternary and Engineering Geology of the Central and Southern Puget Sound Lowland

May 12 and 13, 1999
Design and Retrofit of Culverts in the Northwest for Fish Passage

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