The Washington Water RESOURCE

The quarterly report of the Center for Urban Water Resources Management

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Contents

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Message from the Director

Several new projects, some potentially broadened activities, and one lost opportunity have marked the last three months. New projects are being initiated in the monitoring of very large-scale developments and the effectiveness of their (regionally unprecedented) levels of aquatic system protection and stormwater management. We are also beginning a preliminary investigation into the sources of stream sediment in the Issaquah Creek watershed, with potential applications both to the supply of fine sediment and associated phosphorus into Lake Sammamish and to the long-term deposition of coarse sediment in the channel of Issaquah Creek. A closer liaison with the Center for Streamside Studies, jointly managed by the colleges of Forestry and Oceanography, has continued to proceed more slowly than anticipated in the last issue of the Newsletter, but the likelihood of a closer and more constructive relationship between our two research centers is still very high. Our Center is also being encouraged to look more closely at the interrelationship of water supply with other elements of urban water resource management, particularly those elements that have been more of the historic focus of work here.

On a less positive note, although the Center was successful in having a $297,000 grant proposal accepted by the Water Environment Research Foundation, the University of Washington was unable to come to a satisfactory agreement with the Foundation over contract terms. As a result, that project has evaporated. Although the loss of this work is unfortunate because it complemented several of our other projects so well, it has scarcely slowed the ongoing research in several programs at the university on how to characterize the condition of aquatic systems, in both natural and disturbed environments.

The remainder of this Newsletter is given over to monitoring protocols, the status of our evaluation of urban stream rehabilitation efforts, and the research results of several recently completed projects. Subscription renewals will be sent out soon; I hope you remain on our list!

Derek Booth ❖

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.

Evaluation of Urban Stream Channels: The Rapid Stream Assessment Technique (RSAT)

One of the major continuing challenges facing researchers and water-resource managers alike is how to characterize the "health" or the "quality" of a stream. Historic reliance on chemical measures are gradually giving way to a much broader and more comprehensive assessment of stream conditions, using physical and biological (as well as chemical) measures. In the Pacific Northwest, as in many other parts of the country, biological indicators are becoming particularly prominent in the mix of evaluation techniques. Professor James Karr and his students, here at the University of Washington, have been at the forefront of these efforts for characterizing aquatic systems.

For a variety of reasons, many agencies nationwide are trying to develop multi-parameter measures of stream conditions. One of the most complete and field-tested has been the Rapid Stream Assessment Technique, developed by John Galli and other staff of the Metropolitan Washington (DC) Council of Governments (Galli and others, 1996). The RSAT systematically focuses on conditions reflecting aquatic-system response to watershed urbanization. It groups those responses into six categories, presumed to adequately evaluate the conditions of the stream system at the time of measurement on a reach-by-reach basis. The six categories are:

1. Channel stability;
2. Channel scouring and sediment deposition;
3. Physical instream habitat;
4. Water quality;
5. Riparian habitat conditions; and
6. Biological conditions.

Within each of these categories, specific parameters are measured at approximately 400-foot intervals. The raw values are assigned point scores, based on the anticipated and observed range of values of each parameter. Expressed as such, these parameters can be used as "environmental indicators" and have been subsequently used in a variety of technical and public policy settings.

The RSAT measures the following parameters under each of the six categories of stream condition:

1. Channel Stability

- Bank material type
- Bank instability (severity, and length affected)
- Bank landsliding and erosion
- Recent tree falls
- Exposed sewer lines
- Perched culverts or other indicators of instability

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2. Channel Scouring and Sediment Deposition
   - Sediment embeddedness
   - Point bars—number and stability
   - Sediment deposits and sandy streak marks
3. Physical Instream Habitat
   - Baseflow discharge
   - Riffle particle size distribution
   - Riffle/pool ratio
   - Pool size, depth, and quality
4. Water Quality
   - Water temperature
   - pH
   - Dissolved oxygen
   - Turbidity
   - Total dissolved solids
   - Substrate fouling
   - Water color
   - Water odor
5. Riparian Habitat Conditions
   - Canopy coverage
   - Vegetation type
   - Buffer width
6. Biological Conditions
   - Number of individuals
   - Number of taxa
   - Presence/dominance of mayflies, stoneflies, caddisflies
   - Presence/dominance of worms, snails, midges
   - Presence of other specified taxa

The primary purpose of this method is *evaluation*—what is the present condition of the stream system?—which in turn can be used to guide rehabilitation priorities by identifying areas of greatest need, and to track progress (or decline) in the face of both project implementation and continued urbanization. Yet the indicators can also be used to predict future condition by seeking correlation between these "aquatic system responses," measured by the RSAT, and selected "determining factors." Galli and others (1996) examined the correlation between the RSAT scores and two significant determining factors, watershed imperviousness and observed number of storm drain outfalls entering the reach in question. They found significant correlation between both of these determinants and the overall RSAT score of aquatic system conditions; they also found strong correlation between imperviousness and (1) measures of total dissolved solids and substrate fouling (both water quality elements) and (2) their index of biological community health. Knowing projected land-use changes, therefore, would allow a rapid prediction of future stream-channel health. If the components of the RSAT score are adequately communicated to and accepted by the public, this then becomes a powerful tool for both land-use decision-making and prioritization of stream rehabilitation projects.

Reference

Galli, J., 1996. Rapid Stream Assessment Technique (RSAT) field methods. Metropolitan Washington Council of Governments, Department of Environmental Programs, Washington, DC, 36 pp.

More information on the RSAT can be obtained from John Galli, 1-202-962-3348, email *jgalli@mwcog.org*, at the Metropolitan Washington Council of Governments.

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Status of Projects at the Center

- ➤ Maintenance of Failed Biofiltration Swales (see Spring 1997 Newsletter)
- ➤ Eastgate Water-Quality Pond Performance (see Summer 1997 Newsletter)
- ➤ Puget Lowland Urban Corridor Geology and Geologic Hazards (see Spring 1997 Newsletter)
- ➤ Hydrogeologic Pathways, Duwamish Corridor (see Fall 1996 Newsletter)
- ➤ Urban Stream Rehabilitation in the Pacific Northwest (see article, this Newsletter)
- ➤ Environmental Benchmarks in Citizen-Based Watershed Planning (see Summer 1996 Newsletter)
- ➤ Lakemont Boulevard Construction Oversight (accompanying articles, this Newsletter).

Urban Stream Rehabilitation in the Pacific Northwest: Physical, Biological, and Social Considerations

Last spring, the Center for Urban Water Resources Management was awarded a three-year grant from the joint National Science Foundation/ U. S. Environmental Protection Agency interdisciplinary program, "Waters and Watersheds." The project was developed by four faculty from the University of Washington: Derek Booth and Stephen Burges (Civil Engineering), Sally Schauman, (Landscape Architecture), and James Karr (Departments of Fisheries, Public Affairs, and Zoology). In addition, several graduate students in departments across campus—Chris Konrad and Marit Larson (Civil Engineering); Sarah Morley (Fisheries); Stephen Kropp (Marine Affairs); and Sandra Salisbury, Karen Billica, and Cory Parker (Landscape Architecture)—have begun working on various aspects of this project, together with what we hope to be the active and ongoing participation of water-resource agencies across the region. A summary of that three-year project was included in the Summer 1996 Newsletter.

Since the beginning of the project in April 1997, we have accomplished several tasks:

1. Site selection for examining process, environmental changes, and cultural context of stream degradation.

We have selected eighteen sites that span a gradient from low to high urbanization. Since highly urban streams exhibit cumulative changes in most every physical and biological condition, our sites emphasize the lower end of this spectrum, where degradation can be seen incrementally, in an effort to define critical causal mechanisms that initiate degradation. Physical, biological, and social conditions have been characterized for all sites, but there are four areas of special emphasis for evaluating processes of stream degradation: benthic macroinvertebrates, channel form, bed sediment, and the surrounding cultural landscape.

2. Evaluation of visual preferences for rehabilitation design and human behaviors exhibited toward urban riparian areas and rehabilitation designs.

One masters' thesis has already been completed on the preliminary evaluation of visual preferences for typical restoration techniques, and an initial scoping study of observed behaviors towards urban riparian systems has been made. We expect that the list of these behaviors will provide us with an initial set of terms that describe human interactions with urban streams.

3. Assessment of project costs and outcomes.

Although this topic is a primary focus only in subsequent project years, some efforts are beginning. We are compiling the available data on biological and physical characteristics of stream channels, before and after construction of stream-rehabilitation projects, in order to start quantifying benefits and to identify where additional targeted monitoring in 1998-1999 will be most beneficial. We also are starting the process of contacting agencies throughout the region who are planning or have already undertaken stream rehabilitation projects, in hope that we can use the broad range of experience here to better evaluate what can be accomplished in stream rehabilitation, and through what means. In subsequent years of the project, we look to apply an improved understanding of degradation processes to the very tangible problems of minimizing urban consequences on natural stream systems, long-term, with only limited available resources with which to accomplish this work. ❖

Porous Asphalt Road Shoulders: Effect of Road Sanding Operations and Their Projected Life Span

Background

This last year, Matthew St. John, a graduate research assistant working with Professor Richard Horner, investigated the effects of road-sanding operations on the permeability of porous asphalt on behalf of the King County Department of Transportation. Previously, a one-year monitoring study of road shoulder runoff quality and quantity cosponsored by the King County Roads and Engineering Division and the Washington State Department of Transportation demonstrated that porous asphalt road shoulders do have the capacity to significantly reduce the volume of road runoff and to decrease road runoff pollutant loads (St. John 1997). Because the results of this previous study were promising, the King County Department of Transportation is now considering a program to pave shoulders with porous asphalt. However, porous asphalt pavements are relatively new and have not been widely used, and so there is limited data on their long-term performance, durability, and life span.

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POROUS ASPHALT (from page 4)

One of the primary concerns with porous asphalt pavements is that they will clog with fine-grained particles. In fact, Schueler (1987) specifically cautioned against use of porous pavement systems that are expected to receive particulate pollutants such as those associated with road sanding. In King County, road sanding operations are routinely performed during periods of snow and ice in order to maintain the public roadway system. Therefore, the King County Department of Transportation was particularly interested in determining the long-term effect of road sanding operations on porous asphalt road shoulders with respect to clogging in order to better understand their long-term performance and to project the life span of porous asphalt shoulders.

The partial-depth porous asphalt pavement overlay consists of an open-graded coarse aggregate held together by asphalt cement, forming a coherent mass which allows water to penetrate and flow through the pavement to the underlying soil layer (U.S. EPA 1980, Washington Department of Ecology 1992, Oregon Department of Transportation 1994, Hossain and Scofield 1991). In addition to permitting water to flow through the pavement, the voids in the porous pavement provide temporary storage of storm water. Pollutant concentrations are decreased due to removal mechanisms associated with infiltration, including settling, filtration, adsorption, ion exchange, and biological decomposition.

Study Objectives

The goal of this research was to investigate the effect of road sanding operations on the hydrology of a porous asphalt road shoulder test section in Redmond, Washington. The intention was to apply sufficient sand, as called for in routine winter maintenance and in additional applications for study purposes, to cause an appreciable change in the hydrology of the porous asphalt shoulder test section. The study objectives were:

1. To determine the preliminary hydrologic characteristics (infiltration rate and runoff coefficient) associated with the porous asphalt road shoulder test section.
2. To determine the sand load that is applied to King County roads during typical road sanding operations, and to determine the cumulative sand load that is applied during a typical winter.
3. To simulate cumulative road sanding operations in order to determine the number of years of typical sanding operations that will elapse before porous asphalt road shoulders clog, as demonstrated by a measurable decrease in the infiltration rate and increase of the runoff coefficient.
4. To evaluate the benefit of sweeping porous asphalt road shoulders with mechanical sweep trucks following road sanding operations in order to reduce clogging.
5. To make projections regarding the life span of porous asphalt road shoulders.

Existing Information on the Durability of Porous Asphalt Pavements

Although there are reports that open-graded-type asphalt pavements have been available since the late 1940s, these materials have not been widely used or tested. Table 1 presents the initial and, where available, the long-term in-situ infiltration rates for a variety of porous asphalt installations.

Table 1: In-Situ Infiltration Rates for a Variety of Porous Pavement Installations

Installation Description	Initial Infiltration Rate	Long-Term Infiltration Rate (Time elapsed and rate)
Porous pavement system in parking lots in Austin, Texas[1]	1765 in/hr	None reported
Porous pavement section on Arizona highway[2]	77 in/hr	After 4 yrs. — 40 in/hr
17 porous asphalt test sections on motorways, interurban, and urban roads[3]	335 in/hr	After 4 yrs. — 210 in/hr
Concrete block permeable pavement in a parking lot[4]	None reported	After 9 yrs. — 39 in/hr
Permeable pavement surfacings of roadways in residential and industrial areas[5]	1840 in/hr	After 4 yrs. — 850 in/hr

[1]Goforth *et al.* 1983; [2]Hossain and Scofield 1991; [3]Isenring *et al.* 1990; [4]Pratt *et al.* 1995; [5]Balades *et al.* 1995

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POROUS ASPHALT (from page 5)

There are a number of *potential* structural problems associated with porous asphalt pavements. Due to the relatively high void volume, there can be rutting and distortion under heavy loads. In addition, porous asphalts are susceptible to structural distress when the bitumen-aggregate bond is weakened due to contact with water. Finally, the surface pores are exposed to air and sunlight, increasing the potential for photo-oxidative degradation, which can result in cracking and raveling. However, none of the studies reviewed for this work reported *any* signs of significant structural deterioration.

Though a few studies have reported some rutting of porous asphalts, any rutting reported has been within acceptable limits, and the structural durability of porous asphalt pavements does not appear to present any significant long-term problems. The average rut depth on a porous asphalt pavement section on an urban highway in Arizona was 0.20 inches after four years of use (Hossain *et al.* 1991). By contrast, the average rut depth on the conventional asphalt pavement section on the same highway was 0.10 inches within the same time period. Oregon Department of Transportation (1994) found some rutting but emphasized that porous pavements have largely shown considerable resistance to rutting. This same conclusion was reached by Goforth *et al.* (1983), who found no signs of rutting on a porous asphalt parking system in Texas. Finally, *none* of these studies reported signs of other types of structural distress including cracking, scuffing, abrasion, or distortion (Hossain *et al.* 1991, Goforth *et al.* 1983, Van der Zwan *et al.* 1990, Ruiz *et al.* 1990).

Experimental Design

The porous asphalt shoulder test site is located on the south shoulder of the NE Woodinville-Duvall Road north of Redmond, Washington, and is described in more detail elsewhere (St. John 1997). Two porous asphalt road shoulder test sections (each 2.4 meters [8 ft] wide by 14.6 meters [48 ft] in length, with a 6-meter [20-ft] buffer between them) were investigated for this study. The soil underlying the porous asphalt test sections is gravel-sand fill material with a seasonal high water table 1.22 meters (4 ft) below the surface. The test sections consisted of a porous asphalt mix, similar to that developed by the Arizona DOT, with the AR-4000 binder. The porous asphalt mix was applied and lightly compacted to a depth of approximately 8.9 cm (3.5 inches).

Slot drains were installed at the base of the shoulder test sections to collect surface runoff. The slot drain (Dura Channel System) is a plastic U-shaped channel 15 cm (6 inches) wide at the top and supports a plastic grate through which the stormwater enters the drain. A 10-cm (4-inch) diameter PVC pipe was attached to the outlet of the slot drain and directed the runoff into a 170 L (45 gallon) collection container.

The experimental protocol was to apply a known quantity of sand to the porous asphalt shoulder test section, simulate a rainstorm of known size and intensity, and collect the total volume of surface runoff. This sequence of events was repeated until there was an indication that the porous asphalt test section was clogging, as determined by an increase in the runoff coefficient (ratio of runoff collected to rainfall applied) and a decrease in the infiltration rate.

Local climatological records for King County (NOAA National Climate Data Center) were reviewed for 1988 to 1997 to estimate the typical number of passes by sander trucks at the Woodinville-Duvall Road site during winter months. During the past 10 years in King County, there were, on average, 31 days per year when the temperature dropped below 32°F for part of the day, 14 days per year when the temperature was below 32°F and there was precipitation, and 6 days per year when there was snow on the ground. Based on these figures it was estimated that there are *typically* 6 sanding operations per year. For this study, sand was applied to the porous asphalt test section at loads equaling one to two sanding operations at a time.

Results and Discussion

Eight sanding experiments were conducted between May and June 1997. A total sand load of approximately 600 lbs (5.76 ft^3) was applied to the porous asphalt shoulder test section in increments of 50 to 100 lbs (0.48 to 0.96 ft^3). This cumulative sand load application equals two years of typical sanding operations. Prior to the sanding experiments the porous asphalt shoulder test sections were in place for two years, during which time approximately 660 lbs (6.4 ft^3) of sand had already been applied to the roadway during routine sanding operations.

Porous Asphalt Shoulder Infiltration Rate

There was a measurable, and significant, change in the porous asphalt shoulder in-situ infiltration rate since the shoulder test section was constructed and following the sanding experiments (Table 2 on page 7).

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Table 2: Average In-Situ Infiltration Rates of Porous Asphalt Shoulder Over Time

Time Since Construction	Average Infiltration Rate (± 1 std. Deviation) (inches/hour)
11 Months	1750 ± 177
20 Months (Prior to sanding experiment)	57 ± 140
48 Months (Following sanding experiment)	1.4 ± 4.1

Despite the measurable decrease in the infiltration rates, the runoff coefficient remained constant and there was no change in the volume of runoff from the porous asphalt shoulder test section. It appears that though there was a decrease in the *average* infiltration rate, the decrease was not sufficient to reduce the fraction of rainfall that was infiltrated through the pavement.

Considerable variation in the infiltration rates was measured from one location to another within the porous asphalt test section. These variations can be attributed to several factors: the inhomogeneity of porous asphalt mixes, tire scour on the surface of the porous asphalt pavements which tends to be concentrated in the region of the shoulder close the road, and the migration of sediments on the surface of the shoulder causing patchy surface clogging. In particular, the infiltration rates tended to be lower in the region of the porous asphalt shoulder closest to the roadway compared to the region furthest from the roadway. This implies that runoff may not infiltrate in the region of the shoulder closest to the roadway but can still do so in the region farther from the active roadway, where the infiltration rate is higher. These results have an important implication on the projected time until porous asphalt shoulders become completely clogged. The infiltration rates in the region of the shoulder farther from the roadway may remain higher than the inflow rate for many years, thereby maintaining a condition of reduced runoff despite measurable clogging elsewhere on the shoulder.

After two years of operation the porous asphalt road shoulders showed no signs of structural instability. There was no indication of cracking, disintegration, or rutting. Yet the surface conditions of the porous asphalt did change since the pavement was installed. For approximately one year the surface of the porous asphalt maintained a matrix of pores at the surface, similar in appearance to popcorn bonded together. After nearly two years, however, some of the surface pores had become filled-in with sediment, and the surface structure appeared somewhat abraded. In three core samples, extracted from the porous asphalt shoulder test section after the sanding experiments were completed, sediment particles were visibly embedded in the surface pores but only within the upper one centimeter of the sections. This observation concurs with studies on clogging of porous asphalt surfacings on roadways in France (Balades *et al*. 1995), where the clogged area was limited to the first two centimeters of the surface structure. There was no indication that the interstices of the porous asphalt were being clogged with sediment, although small localized pockets of sediment, some as large as 1 mm in diameter, had collected.

Several experiments were conducted to test the efficacy of sweeping the porous asphalt shoulders following road sanding operations in order to reduce clogging. The results indicate that the *mechanical* sweep truck does reduce the runoff coefficient of the porous asphalt shoulder test section somewhat, but there was no measured decrease in the runoff coefficient following the *vacuum* sweep.

Based on the results of this study and review of the literature on porous asphalt pavements, it is possible to make projections of the life span of porous asphalt road shoulders. Review of the literature indicates that porous asphalt pavements have maintained their structural durability for at least 10 years, the longest duration that a porous pavement has been monitored. Exposure to loads is likely to be the primary cause of structural deterioration. However, porous asphalt pavements on road shoulders are not expected to receive heavy traffic loads. Therefore, based on structural durability alone, the life span of a porous asphalt shoulder should lie between 12 and 20 years, typical to that of conventional asphalt pavements on residential roads.

The life span of porous asphalt road shoulders with respect to clogging is somewhat uncertain. The results of the sanding experiments indicate that though the infiltration rates do decline as a result of road sanding operations, they remain high enough to receive the inflow from the adjacent road for at least 4 years. Based on the current trends, the *average* infiltration rate might decline to a rate below the inflow rates within 5 to 7 years, at which time the porous asphalt shoulder may be func-

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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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What do you think?

The PEPL program is developing a short course on protocols and methods for sampling of monitoring wells and would like to know if a course of this nature would be of interest to you or your agency.

Reply to: Phil Cohen, City of Redmond
phone: (425) 556-2808
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<pcohen@ci.redmond.wa.us>

POROUS ASPHALT (from page 7)

tionally clogged. The heterogeneity of the infiltration rates within the shoulder, however, indicates that the region of the shoulder farther from the road will maintain infiltration rates that are higher than the rates in the region of the shoulder close to the road. The infiltration rates farther from the road may remain high enough to receive the inflow to the shoulder for as much as 15 years. Although the runoff coefficient will increase somewhat over time, the porous asphalt is unlikely to become fully clogged for at least 10 years.

Conclusions

1. There were no signs of structural instability (cracking, disintegration, or rutting) of the porous asphalt shoulder test sections after two years of operation.
2. There was a significant change in the in-situ infiltration rates of the porous asphalt shoulder since construction of the shoulder test sections and as a result of the sanding experiments.
3. The runoff coefficient of the porous asphalt shoulder did not increase despite the significant decrease in the infiltration rates, because the *average* infiltration rate of the porous asphalt was sufficient to receive the inflow rate.
4. Based on current trends, the *average* infiltration rate *may* decline to a rate below the inflow rates within 5 to 7 years, at which time the porous asphalt shoulder may be functionally clogged. However, due to the heterogeneity of the infiltration rates within the road shoulder, the region of the shoulder farthest from the road may maintain infiltration rates high enough to receive the inflow rates for up to 15 years.
5. Based on the results of this study and a review of the relevant literature, the projected life span of porous asphalt road shoulders is determined to be approximately 10 years.
6. Sweeping the porous asphalt shoulders with mechanical or vacuum sweep trucks appears to decrease the porous asphalt runoff coefficient somewhat, if it becomes elevated by partial clogging.

Recommendations

Based on the results of this study and others (St. John and Horner 1997), it is recommended that porous asphalt road shoulders be installed in suitable locations on county roads. The results of this study indicate that the runoff reduction benefits associated with porous asphalt road shoulders will not be diminished due to routine road sanding operations at least over 4 years and probably over 10 years. Therefore, it is projected that the life span of porous asphalt road shoulders, installed at suitable locations, is approximately 10 years. Mechanical or vacuum sweeping should be employed as a routine maintenance practice on porous asphalt road shoulders in order to help maintain low porous asphalt runoff coefficients, although further study of the effects of routine sweeping would benefit the analysis of the long-term performance of porous asphalt shoulders.

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1997–1998 Professional Engineering Practice Liaison (PEPL) Courses

December 11 and 12, 1997
Stormwater Treatment by Media Filtration

January 12, 14, 21, 26 and 28, 1998
Effective Writing for Technical Professionals

January 14 and 15, 1998
Fundamentals of Urban Surface Water Management

February 18 or
February 21, 1998
Effective Project Negotiation Skills

March 4 and 5, 1998
Achieving Real Success as a Project Manager

March 24, 1998
Risk Allocation in Design/Build (D/B) and General Contractor/Construction Manager (GC/CM) Projects

March 25 and 26, 1998
Biofiltration for Stormwater Runoff Quality Enhancement

April 15 and 16, 1998
Design and Retrofit of Culverts in the Northwest for Fish Passage

June 10 and 11, 1998
Construction Site Erosion and Pollution Control

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Water Quality Management and Erosion Control on a Construction Site

As part of an ongoing, multi-year contract with the City of Bellevue to review designs, permits, and monitoring results for the construction of Lakemont Boulevard at the south end of Lake Sammamish, professors Brian Mar and Richard Horner and graduate research assistants Owen Reese and Sherri Peterson have been monitoring construction activity this year. A brief summary of the project was given in the last Newsletter.

The part of the overall project under the direction of Owen Reese is now complete. His study examined the water quality monitoring program and erosion control best management practices (BMPs) used on the Lakemont Boulevard construction project, focusing on the 1997 summer construction period of May 1 through October 1. The intensive water quality monitoring and BMP programs used on the project were evaluated for their effectiveness in reducing project loads for total phosphorus (TP) and total suspended sediment (TSS). TP had been determined to be the pollutant of greater concern to Lake Sammamish, and thus it was the primary pollutant addressed in this study.

Prior to the start of construction, a maximum acceptable export of phosphorus into Lake Sammamish had been determined through modeling of lake conditions. On this basis, a reduction of 75 percent in the anticipated *uncontrolled* export of sediment was set as a project objective; a reduction of 90 percent of that uncontrolled export was established as a desirable and potentially achievable goal. During the summer construction period, the project succeeded in meeting the target of 90 percent reduction in projected uncontrolled TP loads. This corresponded to a TP load, from the project during the summer, of between 17 and 42 pounds. This range in the estimated project TP load, despite intensive monitoring efforts, was due to the difficulty in separating the project's contribution from background conditions and from other sources farther upstream.

Although the project objectives were met, there were still considerable problems with lack of BMP implementation and maintenance, and poor monitoring data on storm-condition water quality. The following actions would help avoid these problems in the future:

1) Avoid design situations where constructing a particular BMP facility would impede the construction of the overall project. In such conflicts, the project needs will always supersede the erosion-control plan at the expense of water quality protection.
2) Provide incentives for the client and the contractor to comply with erosion control plans by making water quality and BMP inspection results public.
3) Improve the institutional linkage between the monitoring of BMPs and remedial activities.
4) Trigger storm response monitoring based on rainfall *intensity* rather than cumulative rainfall totals.
5) Replace the traditional, but highly non-representative, sampling of storm conditions using grab samples with low-cost composite samplers.

The Center is working with a number of jurisdictions, both in and outside of the Lake Sammamish watershed, to improve the monitoring of erosion-control facilities and to increase the level of expertise in erosion-control designers and inspectors. A new series of training courses in this area is anticipated beginning in the spring of 1998, and will be announced in the next edition of the Newsletter. ❖

Stormwater Sampling Methods For Low Flow Streams

Work at the Center continues on the development of low-cost sampling devices that sacrifice a modest degree of precision in taking truly flow-weighted samples for a dramatic reduction in cost. Previous work here has shown that only in the most unusual of cases is the high cost of continuous automatic samplers justified by the need for high-precision data in making management decisions. Conversely, the more traditional "low-cost" sampling methodology, episodic grab samples triggered either by the timing of regular site visits or by the occurrence of a particular threshold storm event, produce extremely unreliable results because of the rapid change in water-quality parameters during the course of a single storm.

Sherri Peterson, a graduate research assistant working with Dr. Brian Mar, has continued work on the design, development and testing of a stormwater sampling device (Instream Needle Composite Sampler) for use in low-flow streams (see also Center publication E13). This device provides a low-cost alternative to current practices. The Instream Needle Composite Sampler collects a continuous composite sample, which can be

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STORMWATER SAMPLING (from page 10)

easily transferred to a laboratory bottle for analysis. These data can be used for a variety of purposes. In the present study, they have been used to evaluate the effectiveness of best management practices (BMPs) on construction sites to determine whether they are providing adequate protection to nearby waters.

Performance of the sampler was evaluated in a laboratory flume and in several small streams crossed by the Lakemont Boulevard construction project in Bellevue, Washington (see associated article, this Newsletter). Samples collected in the streams were compared to grab samples collected during the same storm events. Total Suspended Sediment (TSS) and Total Phosphorus (TP) concentrations from the composite samples were within a factor of two of the grab samples, and their values are probably more representative of the periods covered than those determined by the grab samples. Development of this technology is continuing; prototype designs are being deployed at a number of sites around the region with the intention of establishing a robust design and clear understanding of the quality and limitations of the data collected over the next year or so. ❖

Subscription Renewals

Center subscription renewals for 1998 will be sent out in January. Should you continue to participate? We hope so, but only if you are finding some direct or indirect benefit from our work here—an expanded newsletter, ready access to a growing list of recent publications, training discounts, and broadened access to research opportunities and research results. Subscriptions cover the cost of the newsletter and help support many of the ongoing, cooperative functions of the Center as well. We continue to repeat our invitation for you to add additional recipients of the newsletter to your subscription without charge, and we are happy to report that all subscription rates will remain unchanged.

Thank you for your support, be it new or long-standing. Please feel free to contact the Center Director (Derek Booth at the University of Washington) or the Chair of the Center's Advisory Board (Joan Lee at Snohomish County Surface Water Management) with your questions, comments, or concerns. ❖

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