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

As of last month, the Center is now an organizational unit with formal, multi-year financial support from the University of Washington. This represents a major change of our standing here; it could only have happened with the commitments that have been made and kept over the last seven years by our agency supporters in many of the cities and counties across the state.

The University support comes from both the College of Engineering, which is the administrative "home" of the Center (within the Department of Civil Engineering), and the College of Forest Resources through our affiliate there, the Center for Streamside Studies. This multi-college sponsorship allows us to tap the interdisciplinary resources of the University more effectively, and it alleviates all of the nagging concerns about the long-term viability of a center that heretofore has operated only on year-to-year contributions from external supporters. It should also enable us to turn our attention more fully to issues of regional and extra-regional importance across the entire spectrum of "urban water resources," and not just those related to the historic emphasis of the Center on stormwater runoff and management. An increased level of interest in our work across a much broader spectrum of water-resource faculty, particularly in the Civil Engineering department, bodes well for such an expansion of efforts and for better integration of related topics through education and research.

Without belaboring what is now obvious, the recent listing of Puget Sound salmon species under the Endangered Species Act provides us all with both an opportunity and an admonition. The admonition is that, despite millions of dollars and the effort of hundreds of scientists and engineers and planners over the last years and decades, we have failed to halt the long-recognized decline of these fish, indicators of the overall health of our aquatic ecosystems. The opportunity is that the incentives to work more effectively towards their protection have never been greater. Yet, not *every* solution is clear—we do not yet know how to mitigate fully the consequences of urban development on stream channels, for example, or even *if* we can rehabilitate fish habitat without making wholesale changes to the post-urban watershed first. In helping to answer these kinds of questions the University has a genuine role to play, and I believe that we are in a good position to assist agencies with authority and obligation to improve these conditions.

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.

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New Report Explains the Biological Monitoring of Stream Health

The most direct and effective indicator of the health of a water body is the condition of its living systems. For this reason, biological monitoring is used to track the health of living systems. Biological monitoring aims to detect change in those systems— specifically, change caused by humans. Tracking, evaluating, and communicating biological condition and the effects of interference by human activities lie at the heart of biological monitoring. During a century of evolution, through changing human impacts on water and its associated resources, biological monitoring programs have taken a variety of approaches. This began with the development of a multimetric index of biological condition in 1981. Called the index of biological integrity (IBI), this index is now well documented as effective for assessing ecological condition in a variety of management settings, with many taxa, and in diverse geographic regions. The IBI evaluates ecological condition in terms of a system's ability to support healthy living systems —in terms of the biota's ability to sustain itself —ultimately the most relevant endpoint for sustaining human society.

In much the way investors track the health of the economy with economic indexes, the index of biological integrity integrates measurements of many biological attributes (metrics) to assess the condition of a place. Metrics are chosen on the basis of whether they reflect specific and predictable responses of organisms to human activities. Ideal metrics should be relatively easy to measure and interpret. They should increase or decrease as human influence increases. They should be sensitive to a range of biological stresses, not narrowly indicative of commodity production or threatened or endangered status. Most important, biological attributes chosen as metrics must be able to discriminate human-caused changes from the background "noise" of natural variability. Human impact is the focus of biological monitoring.

Five activities are central to making multimetric biological indexes effective:

1. Classifying environments to define homogeneous sets within or across ecoregions (e.g., streams, lakes, or wetlands; large or small streams, warm-water or cold-water lakes; high- or low-gradient streams).
2. Selecting measurable attributes that provide reliable and relevant signals about the biological effects of human activities.
3. Developing sampling protocols and designs that ensure that those biological attributes are measured accurately and precisely.
4. Devising analytical procedures to extract and understand relevant patterns in those data.
5. Communicating the results to citizens and policymakers so that all concerned communities can contribute to environmental policy.

A new report (Karr and Chu, 1997; see below) describes the state of running waters in the United States and the value of multimetric biological indexes in assessing and communicating their condition. The extent to which

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better decisions are made—decisions that actually maintain or restore aquatic systems (as opposed to the bureaucratic status quo)—will be a measure of these indexes' success.

The report sets out a number of premises and debunks a number of myths in the assessment literature. It reviews trends in aquatic resource condition and how and why multimetric indexes work. It is aimed at people concerned about streams: an agency scientist trying to decide whether and how to use fish or invertebrates in monitoring work, a researcher designing a study to detect human effects, or a state agency responding to EPA's mandate to develop biocriteria. This is a handbook for those working to protect the nation's waters.

This report is available through the Center's publication distribution service as number E14. Its reference is: James R. Karr and E. W. Chu, 1997, Biological Monitoring and Assessment: Using Multimetric Indexes Effectively: EPA 235-R97-001, University of Washington, 149 p. ❖

Landslides in Puget Sound

The winter nearly past has not produced large rainstorms, and the flooding and landsliding that accompanies such events, in the fashion that were brought to the region last year. Yet such processes will be with us forever. Despite the relative calm in which we seem to be closing out the winter of 1997-98, a review of some of the determining factors on landsliding in the region nevertheless seems warranted. *Washington Geology*, the (free) quarterly publications of the Division of Geology and Earth Resources, Washington State Department of Natural Resources, recently published an excellent article titled, "Puget Sound Bluffs: The Where, Why, and When of Landslides Following the Holiday 1996/97 Storms" (vol. 25, no. 1, p. 17-31). It shows numerous examples of last winter's landsliding, describes the general mechanisms by which landslides occur, and outlines some of the basic strategies that can be used to reduce the risk of future landslide hazard.

The definition of a "landslide" can vary somewhat with the application, but one characteristic is fundamental: landslides are in a class of geologic processes where the material moves under its own weight, *not* because it is being transported by some flowing medium like water. Our concern is with the strength of the earth material, and with the forces that are endeavoring to pull that material downhill. Where the strength exceeds the downslope stresses, the material will be stable. As either the strength declines or the downslope stress increases, however, the risk of sliding will increase.

What determines the level of risk at any given location? Three sets of factors are important; they are all interrelated, but they are worth considering individually. They are:

1. Topography and surface water: Where is the ground steep, and where do surface-water drainage patterns tend to concentrate the flow of runoff? With only this information, we can find good expression of high-risk areas. Researchers here at the University of Washington, notably David Montgomery in Geological Sciences, have successfully identified many of the regions of greatest historic landslide activity just by digital models that incorporate only these two factors. The reason is intuitive—steep slopes produce greater downslope stresses, and a greater drainage area increases the likelihood that water, which buoys up a potential slide mass and so reduces its strength, will be abundant.
2. Human activity is very important but harder to predict. In a survey done by King County after the major storm in January 1990, over 80 percent of the slides that occurred had an identifiable human agent as the cause or the trigger, typically the ill-advised diversion of surface runoff or the oversteepening of slopes. It is what commonly turns a "potentially hazardous site" into an "active slide," and so we should learn to get better at avoiding these actions. They are not, however, terribly easy to predict.
3. Geology and groundwater are in many ways the most fundamental and yet the most difficult factors to evaluate. Their variability is the reason that not *every* steep hillslope fails at the same time, and why landslides continue to occur at "unexpected" locations and often with the most severe consequences for human development. The strength of the hillslope materials, the availability of groundwater, and the slope response during major rainstorms are all determined by the tremendous variety of geologic materials that we find across the Puget Sound region.

Landslides are not capricious in either time or space, but what controls their occurrence *is* rather complex. We can do a reasonable job of identifying generically hazardous areas with nothing more than topographic information, but "generic" hazard identification is no

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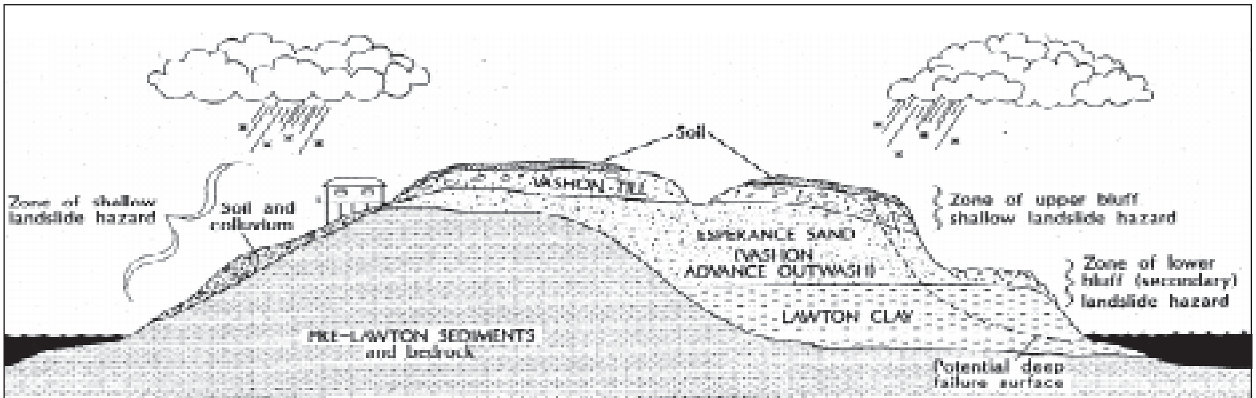
longer sufficient in highly developed, or rapidly developing, areas. Much better predictive success is possible, but it will require significant improvement in the quality and the detail of geologic information on the sediments that form the slopes of the Puget Sound region.

A one-day seminar on "Landslides in the Puget Sound Region," sponsored by the Seattle section of the American Society of Civil Engineers, the University of Washington Department of Civil Engineering, and the U. S. Geological Survey, will be held on April 4, 1998, on the University of Washington campus. More information is available from Christine Larkin at 206-728-2674, or *clarkin@geoengineers.com*.

A free subscription to *Washington Geology* is available upon request to the Division of Geology and Earth Resources, P.O. Box 47007, Olympia, WA 98504-7007; phone 360-902-1450; email *judy.henderson@wadnr.gov*. ❖



This is an idealized cross section of the characteristic stratigraphy in the Seattle area that is responsible for landsliding. The Esperance sand and Lawton clay are unit names restricted to the Seattle area, but similar sequences are present elsewhere in the Puget Lowland (figure from *Washington Geology, 25(1):25;* adapted from Tubbs, 1974, *Landslides in Seattle*: Washington Division of Geology and Earth Resources Circular 52).

Optimizing the Maintenance of Formal and Informal Water-Quality Facilities at the Urban Fringe—Recent Work and Upcoming Research

The long-standing attention to improving the water quality of storm runoff has traditionally focused on the types of facilities that can successfully remove pollutants. Significant effort has been invested in determining the optimal design of such facilities, their anticipated performance, and their net cost. Under the influence of this collective but largely uncritical emphasis on the *design* of structural controls, municipalities across the country now require such facilities as an ordinary part of new development.

Unfortunately, such an emphasis has failed to acknowledge some of the primary determinants of water quality, particularly at the urban fringe. These determinants include (1) the sediment and other pollutant loadings associated with land clearing and construction which typically bypass most structural facilities; (2) the *maintenance* of "formal" water-quality facilities, such as biofiltration swales and wet ponds, that must occur in perpetuity after these carefully designed structures are actually constructed; and (3) the improvement (or degradation) to water quality that is contributed by "informal" water-quality facilities, such as road ditches, that are in fact the single most common element of the constructed drainage system across vast tracts of rural and suburban America.

Attention to these components of land development and stormwater management have attracted little attention to date. They are mundane, they appear trivial, and they are as obvious as the roads we drive down every day. Yet in many landscapes the net consequences of construction-related erosion, facility maintenance, and road-ditch design are by far the most important determinants of downstream water quality. The historic attention on facility *design* is laudable but almost irrelevant; if our interest is in genuine improvement in water quality, we must attend to the elements of the

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stormwater system, and of the operation of that system, that are most pervasive and most important.

The Center is embarking on a new research project to address these issues. We plan to investigate three specific elements:

1. What is the most appropriate maintenance for water-quality facilities (both formal and informal), particularly those emphasizing the use of vegetation to provide filtration and uptake?
2. What is the net watershed contribution of construction-site erosion? How important is this problem to the long-term loading of sediment and associated pollutants to downstream systems?
3. How should road ditches be designed to maximize their contribution to water quality (or to minimize their *degradation* of water quality), given their relationship to the stream-channel network and the external constraints imposed by gradient, soils, and available space?

Vegetation maintenance for water-quality facilities has been the focus of an internship funded by contributions from local stormwater management agencies into the Center for Urban Water Resources Management, in acknowledgment that vegetation maintenance of bioswales, wetponds, and roadside ditches is a very high research priority for addressing practical agency needs. As a preliminary effort, a literature search was conducted of databases to compile the existing information on different management practices and their effects on the pollutant removal capabilities of these facilities. Personal contacts were made with both locally and nationally recognized professionals on a variety of aspects of current management practices including the frequency of mowing, types of equipment used, miles of ditches mowed, number of sites maintained, and the cost of maintenance per mile and per facility. The results of this work were outlined in the Summer 1997 Newsletter, and the report is now available through the Center's publication distribution service (Publication G11).

The results of these surveys have documented a general and significant *lack* of data on the mowing practices or the vegetation types that provide that greatest impact on the quality of the water leaving these facilities. A significant amount of research has been undertaken on the design aspects of bioswales and wetponds, but none of them have attempted to establish the effects of various types of vegetation maintenance or mowing practices on the efficiency of the structures. Current BMP's ("Best Management Practices") provided by design manuals for vegetation maintenance and mowing have been established through general observation and on the plausible assumption that higher grass densities remove more pollutants. Depending on the pollutant of concern, however, some research results actually appear to conflict with these assumptions. In addition, the current vegetation management practices are being implemented only to the extent that agency budgets will allow. Those practices are commonly not in line with design standards, primarily in the lack of removal of the clippings after mowing.

Based on this review, several member agencies of the Center have already committed substantial additional funding for additional work, particularly field experiments to evaluate the effectiveness, and the cost-benefit values, of different maintenance practices for wetponds and bioswales. Determinants on vegetation establishment and growth are already under investigation here with a related $38,000 project (1996-1998), "Maintenance of Failed Biofiltration Swales," but the explicit linkages between vegetation and water-quality improvement is not yet clear. This will be a major emphasis under this upcoming work.

Construction-site erosion has been long-recognized as a major source of fine sediment, but previous studies have almost exclusively sought to characterize the very high concentrations of sediment that emerge from small, bare sites during storms. What is lacking, however, is any systematic *watershed-scale* assessment of this sediment source, and the degree to which it may exceed or greatly exceed other such sources in urban or urbanizing basins, such as landsliding or channel-bank erosion. This element is being investigated (1) through evaluation of the influence of fine sediment on stream function, through our 3-year EPA "Waters and Watersheds" grant project ("Urban Stream Rehabilitation in the Pacific Northwest," described in the Fall 1997 Newsletter) and (2) by a case study of an urban sediment budget that will be conducted on the 59-square-mile Issaquah Creek watershed in western Washington, funded by King County and the City of Issaquah for 1998-1999.

The design of road ditches is normally considered a purely hydraulic problem. Yet road ditches are the most common of water-quality "facilities," and their maintenance can be the greatest single expense for a

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stormwater-management agency. Agency managers are very concerned that such an investment be repaid with the greatest potential improvement in not only the ditches' primary function (conveyance) but also a potentially significant ancillary effect, namely water quality improvement. We intend to investigate this issue through a careful analysis of how the road ditch network intersects with, and interrelates to, the natural channel network. Different points in the channel network will have different degrees of sensitivity, particularly those channel types and locations that (1) are more or less able to transport fine sediment, (2) do or do not lead to receiving waters that are sensitive to high nutrient inputs (*e.g.*, phosphorus-limited lakes, common here in the Pacific Northwest), or (3) may be dominated by the flow contribution from the road-ditch system. These questions lie at the intersection of geomorphology, land use, and aquatic biology. The program here is well-positioned to draw on expertise from each of these fields of inquiry.

Expected Products and Schedule

Identification of potential field-monitoring sites will begin this spring and some prototype maintenance alternatives initiated in summer 1998, with field monitoring during the winter of 1998-1999. We are hoping for additional financial resources, however, to allow a greater scope of both sites and of overall thematic focus. Should those additional resources become available, the study will be extended an additional year and the intended products will be (1) clear and unequivocal maintenance procedures for local stormwater agencies, delineating costs and benefits for alternate vegetation management practices in water-quality facilities; (2) an equivalent set of procedures for both maintenance and design of road ditches, acknowledging not only their hydraulic role but also their hydrologic setting and water-quality functions; and (3) one or more journal articles that establish the context for stormwater facilities in watershed water quality improvements. We believe that both avenues of communication—locally accessible "manuals" and nationally disseminated articles—are critical to effective communication and long-term beneficial outcomes. ❖

Conducting Watershed Management Training

The University of Washington has been selected by the U. S. Environmental Protection Agency's Office of Water to assemble a team to conduct watershed training in the Pacific Northwest. That team includes a set of regionally and nationally known scholars and practitioners covering the full range of watershed management from both scientific and social perspectives, with the participation of two multi-disciplinary research centers dedicated to stream and watershed issues. The outcome of this project will be the first of what is anticipated to be annual courses in watershed assessment, rehabilitation, and management, conducted on behalf of EPA for regional agency staff and other professionals in the field. This workshop is noteworthy for several reasons:

- It is part of EPA's "Watershed Academy," a nationwide program to improve the management of watersheds through improved dissemination of technical and scientific information. The Watershed Academy was a featured element of the President's initiative on the Clean Water Act during the State of the Union address this last January.
- The Endangered Species Act listing of several salmonid species is likely to have major impacts on many human activities in the affected watersheds (*e.g.*, forestry, urban development, agricultural practices, and fishing policies). This workshop will be a timely and valuable contribution to the discussion of these issues.
- This project is the first fully cooperative effort of the Center for Urban Water Resources Management, here in the College of Engineering, and the Center for Streamside Studies in the College of Forest Resources and the College of Ocean and Fisheries Sciences. The technical lead for this project is being provided by the two directors, Derek Booth and Susan Bolton.
- Financial support by EPA ensures that the net cost per participant for the week-long workshop will be very low.

Although final logistics are still to be negotiated with EPA, we expect that the initial workshop will be held in Seattle in mid- to late-September 1998. The following elements are anticipated for the workshop, based on EPA's requirements and preliminary outline:

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1. Benefits and challenges of working at the watershed level.
2. Watershed ecology, emphasizing the relationships between biotic and abiotic components and processes.
3. Effects of disturbance (natural and human) on watershed components and processes. Although we will introduce the full range of natural and human disturbances, the initial workshop will look specifically at landslides, floods, forestry, urbanization, and agriculture.
4. Role of watershed analysis and planning in mitigating or minimizing watershed disturbance.
5. Activities and measures that can restore or sustain watershed functions and processes.
6. Social and organizational elements of watershed management.

In addition, two days of field trips are anticipated. One will review the wide range of development, management activities, and human and natural disturbances that are represented in the greater Seattle area, and the other will focus specifically on stream restoration projects in order to demonstrate what works and what doesn't.

We have assembled the following instructional team for this workshop:

- Drs. Susan Bolton (hydrology; forestry-related issues) and Derek Booth (stream channels, urban-related issues, local government institutional issues) as co-lead instructors.
- Drs. James Karr (ecology and fisheries), Clare Ryan (social sciences), and David Montgomery (watershed processes), also from the University of Washington faculty.
- Martha Bean and Alice Shorett, national consultants who address organizational issues and public participation in a variety of public-private settings.

We also intend to involve personnel from local watershed groups, one or more basin stewards from the surrounding watersheds, tribal representatives, and other active citizens and environmental professionals in the various case-study segments of the course curriculum and field visits. ❖

Workshop on Urban Stormwater Management by The Center for Watershed Protection

The Center for Watershed Protection, founded in 1992, works with local, state, and federal governmental agencies, environmental consulting firms, watershed organizations, and the general public to provide objective and scientifically sound information on effective techniques to protect and restore urban watersheds. The Center also acts as a technical resource for local and state governments around the country to develop more effective urban stormwater and watershed protection programs.

The Center is offering a workshop in urban stormwater here in Seattle from April 27 to May 1, 1998. It is designed to provide in-depth training to design engineers, regulatory officials and others interested in stormwater management. It provides a comprehensive curriculum to prepare seminar participants in the subject areas of watershed hydrology, water quality assessment, stormwater best management practices, water quality monitoring and operation and maintenance. It is planned to cover all aspects of stormwater management, from theory to practice, emphasizing practical aspects through example calculations and case studies. The registration cost is $795.

This course was designed for professionals currently involved in, or about to begin, designing or permitting stormwater best management practices. The intended audience are government officials, planners, health officials, hydrogeologists, engineers, water suppliers, industry representatives, consultants, developers, and others involved in land planning regulatory review, and water resource management and protection.

The instructors include Tom Schueler, co-founder and Executive Director of the Center for Watershed Protection; Scott Horsley, partner in the environmental services firm of Horsley & Witten, Inc.; Whitney Brown and Richard Claytor, Center for Watershed Protection; and Tom Sexton, Director of Engineering at Horsley & Witten, Inc.

More information on the Center for Watershed Protection is available on its web page, *http://www.pipeline.com/~mrrunoff/*; their address is The Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043. ❖

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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Recent Research Findings

The functions of riparian buffers in urban watersheds

Jennifer Leavitt, MS candidate, Department of Civil Engineering

The riparian zone provides numerous functions for the streams in undisturbed watersheds of the Pacific Northwest. Most generally, the vegetation in this zone influences the water quality, hydrology, and biology of the streams. This study has investigated how the riparian buffer interacts with the stream to moderate temperature, reduce sediment and nutrient loads, attenuate peak flows, and maintain the biological integrity of the stream. By first evaluating how these functions are provided by riparian areas in undisturbed watersheds, we can then consider whether a riparian buffer can provide the same functions in urban watersheds.

Urban watersheds have many unique characteristics, resulting in altered water quality, hydrology, and biology of the associated streams. To address this problem, government agencies enforce riparian buffer widths in an attempt to minimize the impacts of development on the stream. In urban watersheds, however, the buffer may not be an effective method to reduce the degradation of urban streams due to the increased volume of stormwater, which is often channeled through the buffer without any interaction. The buffer is bypassed and therefore is not effective at reducing peak flows or the sediment and nutrients carried by the stormwater.

An evaluation of the effectiveness of a riparian buffer in moderating stream temperatures was done using data collected in two watersheds, Rock and Richardson creeks, in the Portland (Oregon) metropolitan area. Portland Metro, the regional government there, is interested in the condition of these watersheds because they both lie within the urban growth boundary, and so the amount of development in these watersheds is expected to double over the next 50 years. The establishment of riparian buffers is one methods of regulation that will be implemented in these watersheds to protect the streams from urbanization. In an attempt to evaluate one aspect of the effectiveness of this method, temperature attenuation was examined in each of the watersheds. The percent of the riparian buffer that was intact upstream of multiple sampling sites was correlated with the maximum, minimum, and daily fluctuation observed throughout the summer of 1997. All three measures of temperature tended to increase as the percent of intact buffer decreased. This supports the hypothesis that certain conditions of the stream are related to the condition of the riparian buffer; however, other stream conditions exist that are almost surely not protected by the buffer at all.

Soil amendment use in urban lawn soils

Tracy Chollak, MSCE graduate, Department of Civil Engineering

The hydrologic effects of urbanization are far-reaching. Among the most obvious changes are the increase peak flow from minor- to intermediate-sized storms and decreased baseflow. The role of turf areas is fre-

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quently overlooked as a major contributor to these changes. Lawns within the Puget Sound lowlands, however, are generally shallow-rooted sod mats overlaying a glacial till subsoil. In addition to generating stormwater runoff with high concentrations of fertilizers and pesticides, the traditional lawn's low water-holding capacity necessitates frequent watering.

The soil's permeability and water-holding capacity can both be greatly improved by increasing the organic content of a soil through incorporation of a well degraded compost. This will tend to delay and often reduce the peak stormwater runoff rate and also decrease irrigation water requirements. Amending soils will also enhance the lawn's long-term aesthetics while reducing fertilizer and pesticide requirements.

Although the benefits of increasing a soil's organic content have been established, traditional lawn installation procedures continue in new developments. As a means to promote the use of soil amendments, a "Handbook for Soil Amendment use in Puget Sound Landscapes" has been developed through the work on this project, previous studies here at the Center, and technical staff at the City of Redmond. The handbook includes information on the factors to be considered when amending a site, the recommended procedure to be followed, and the comparative costs of following these suggested guidelines over traditional lawn installation procedures.

The impact of warming on the long term primary production dynamics of a subalpine lake

Professor Michael Brett, Department of Civil Engineering

There is considerable concern that human activities are transforming the global climate, and that anthropogenically driven global warming may alter biological processes. Monitoring of primary production (PPr) has been conducted since 1959 at subalpine Castle Lake, California, at weekly intervals during the summer period and at least 10 depths/date. During this time, the region surrounding Castle Lake has shown a warming trend, with an increase in mean annual temperature of approximately 1.1 °C ($r^2 = 0.26$). There is also substantial variation between warm and cold years at this site with the warmest 9 years (upper 25%) being 1.8 °C warmer than the coldest 9 years (lower 25%). While we do not believe that these data allow us to claim global warming has actually impacted Castle Lake, this very extensive data set (ca. 12,000 observations) does allow us to measure the impact of short term climatic warming on the biological processes of Castle Lake. Since our data set monitors CO_2 uptake by primary producers, it also allows us to make inferences about biological buffering of global change. Since 1959 mean annual PPr has nearly doubled at Castle Lake. The warmest 9 years have an average 60% higher mean annual PPr than the coldest years. This difference does not vary notably during the summer, but the increased PPr mainly occurs in the epilimnion of Castle Lake. These data suggest the biota of lakes may be quite sensitive to climate change, and that lakes may respond to increased temperatures by taking up more atmospheric CO_2. ❖

1998 Professional Engineering Practice Liaison (PEPL) Courses

April 22 and 23
Design and Retrofit of Culverts in the Northwest for Fish Passage

June 9 and 10
Infiltration Facilities for Stormwater Quality Control

August 6-8
Quaternary and Engineering Geology of the Central and Southern Puget Sound Lowland

September 8 and 9
Construction Site Erosion and Pollution Control

September 15, 17, 22, 24, 29
Effective Writing for Technical Professionals

October 20-22
Designing and Implementing Stream Habitat Modifications for Salmon and Trout

October 27 and 28
Stormwater Treatment: Chemical, Biological and Engineering Principles

November 4 and 5
Geology and Geomorphology of Stream Channels

November 18-20
Hydrologic Modeling and Design of Retention/Detention Facilities

December 15 - 17
Wetlands Ecology, Protection and Restoration

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New 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 order form on page 11.

Quality Indices 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)

This study, summarized in the Winter 1997 issue of the Newsletter, was designed to assess the impact of urbanization and development on small lowland streams. A sub-set of 22 small, Puget Lowland stream watersheds was chosen to represent a range of development levels from relatively undeveloped (reference) to highly urbanized. The attributes of the stream catchments were established using standard watershed analysis methods (aerial photos, basin plans, and field-surveys). Impervious surface coverage, riparian integrity (quantity and quality), instream (salmonid) habitat, chemical water-quality constituents, and aquatic biota were analyzed on watershed and stream-segment scales. Discharge was continuously monitored by local agencies on 10 of the study streams. Chemical water-quality monitoring (baseflow and storm event) was also performed. Macroinvertebrate sampling was performed in 31 reaches. Extensive assessment of instream physical habitat were made on 120 stream-segments, each representing local physiographic and land-use conditions from the headwaters to the mouth of the stream. Current and historic salmonid abundance data was obtained from local governmental, private, and tribal sources.

Management implications of this multi-year study suggest that efforts should emphasize the preservation of high-quality stream systems through the use of land-use controls, riparian buffers, and protection of critical habitat. Enhancement and mitigation efforts should be focused on watersheds where ecological function is impaired but not lost. Downstream changes to both the form and function of stream systems appear to be inevitable, unless limits on the extent of urban development itself are instituted.

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 (E14; see accompanying article)

Current Status of Vegetation Management in Roadside Ditches and Stormwater Management Facilities: Implications for Stormwater Quality by Daniel Schultz. Report of the Center for Urban Water Resources Management, February 1998, 15 p.

Price = $4.00 (G11; see accompanying article on the maintenance of formal and informal water-quality facilities) ❖

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