The Washington Water

RESOURCE

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Contents

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Message from the Director

Although the field of urban water resources management includes far more than "stormwater runoff," the last several months have displayed the degree to which that historic focus of the Center continues to be of substantial regional interest. Most recently, the proposed listing of Puget Sound salmon species under the Endangered Species Act (ESA) has given rise to substantially increased attention to this issue at both state and local agencies. Proposals for spending many millions of dollars, plus the prospect of new regulations that would indirectly cost the public many millions more, are being articulated in the name of stormwater management and stream rehabilitation almost weekly. The pace of such activity will surely be increasing in the months ahead.

Yet there are no assurances that even the best intentioned efforts will return urbanized streams to biologically healthy, salmon-bearing waterways. A recent conference, *Salmon in the City*, was held in Mount Vernon in late May to explore this uncertainty. Although planned before the ESA listings were announced, the conference was remarkably timely in its thematic focus and was attended by nearly 300 scientists, engineers, citizens, and politicians from around Washington state and the Pacific Northwest region. Two papers from that conference are reprinted later in this edition of the *Newsletter*, but the overriding issue was summarized by Jennifer Belcher, State Lands Commissioner, quoted in the Seattle Post-Intelligencer (5/22/98) after the meeting:

> "Belcher told a conference here this week that trying to accommodate the influx of new residents is inconsistent with preserving salmon and other natural resources, and must be slowed…Belcher said that counties should resist the state's Growth Management Act's mandates that they plan to accommodate rapid population growth. If the law blocks them, she added, they should change the state law…'If we aren't willing to step on a few toes,' she said, 'we ought to stop pretending we're going to save salmon.'"

Unfortunately, population increases do not always respond to governmental edict, and even "no more growth" does not repair the damage that has been done already to the region's aquatic resources. The failures to date are not simply a lack of will, or a lack of money; they also reflect a lack of knowledge in how to act most effectively. In response to the regional needs and this long-standing uncertainty, the Center is moving forward on two new efforts in conjunction with our three-year project on urban stream rehabilitation (see the Fall 1997 *Newsletter*). The first is a compilation of stream rehabilitation projects, which we are preparing in conjunction with agen-

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cies throughout the region this summer. We believe that there is a tremendous base of empirical information that can help guide the kinds of projects that can be successful in accomplishing certain goals in particular watershed settings. Graduate students Stephen Kropp and Marit Larson will be conducting this effort, through which we hope to compile and add to the inventories already existing from various agencies. We are particularly interested in those projects where pre- and post-construction data are available (or can be collected), because post-construction *effectiveness* of such projects is rarely documented to the same extent as the pre-construction promises. Agencies who are interested in having their projects included on this inventory are encouraged to call the Center (206-543-7923).

The second such effort this summer is being conducted jointly with the City of Bellevue, King County, Snohomish County, and others interested in coordinated stream monitoring. We have begun working with these agencies to evaluate the relative utility of the various monitoring protocols now in use throughout the region. In particular, we plan to help analyze some replicate studies of stream evaluation techniques (*e.g.*, same stream, different protocols; or same protocols, different observers). Our goal is to help determine useful and cost-effective monitoring strategies for the variety of purposes for which these efforts are being used.

❖ *Derek Booth*

Needs of Salmon in the City: Habitat in the Urban Landscape

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King County Department of Natural Resources
Presented at *Salmon in the City*, Mt. Vernon, WA, May 20, 1998

Introduction

Aquatic habitats critical to salmonids are the outcome of physical, chemical and biological processes acting across various scales of space and time. The environmental conditions that result from these processes provide the habitat requirements for a variety of species and life history stages of salmonids and other stream dwellers. Whether in pristine watersheds or in those most heavily urbanized, the basic requirements for survival of salmonids are the same. Salmonids are temperate and subarctic (and rarely, arctic) zone fishes, well adapted to the cold, clear, waters of Pacific Northwest rivers and streams.

Habitat

Salmon—at least the anadromous ones—must live in and migrate through three quite distinct aquatic environments: freshwater, estuarine, and marine. Within those large environments, however, salmon are apt to be found in particular local environments at particular times during their life history. These local environments possess the combinations of physical, chemical and biological conditions to which salmon have become adapted over the many thousands of years they have occupied the Pacific Northwest. Thus, habitat can be thought of as the set of environmental conditions, variable in space and time, that salmon require for survival; more simply, as those places where salmon are "apt to be found." When considering habitat requirements, it is necessary to keep in mind some important characteristics of salmonid ecosystems (Spence et al., 1996):

- Watersheds and streams differ in a variety of physical, chemical and biological characteristics.

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- Salmonid populations are locally adapted to these conditions and their natural fluctuations.
- Specific habitat requirements differ among species and life history stages, and change with the season.
- Aquatic ecosystems are dynamic, undergoing periodic cycles of disturbance and recovery.

Everest et al. (1985) noted that while it is certainly the case that each species of salmonid differs in its specific habitat requirements, all species share some basic habitat needs. In rivers, all salmonids require cool, flowing water free of pollutants and high in dissolved oxygen; gravel substrates low in fine sediment for reproduction; unimpeded access to and from spawning and rearing areas; sufficient refuge and escape cover; and sufficient invertebrate organisms for food. Bjornn and Reiser (1991) provide a detailed review of freshwater habitat requirements from a variety of field observations and laboratory studies. Pearcy (1992), in his review of ocean ecology of salmonids, discusses estuarine habitat requirements that are functionally similar to those in freshwater: areas of cold, well-oxygenated water; refuge for resting and escape from predators; sufficient food resources; and, unique to estuaries, mixing zones of reduced salinity necessary for making the physiological transition from fresh to salt waters. In the ocean environment, most of the same characteristics are necessary for salmon survival as well, and the various species may migrate great distances to reach areas of the Pacific where these conditions are found.

Table 1 outlines some of the important features of freshwater habitat for salmonids. Within this basic framework are five classes of features that determine the suitability of aquatic habitats for salmonids.

This generally simple view of habitat belies the true nature of the complex and dynamic nature of ecosystems. We tend to describe habitat based on that which is most visible and observable, and we commonly ascribe a stability and uniformity to it that does not, in fact, exist. We must keep in mind that habitat is the product of the interactions among the features in Table 1 and is therefore far more complex than this simple assortment suggests. These features vary over a season, some over decades, and others over centuries. Flow, for example, falls to its lowest in the late summer when streamflow may be intermittent or absent all together in small streams. Runoff during late winter, however, may crest the streambanks and be 20, 30 or 40 times the summer flow. Even at the this short time scale, the habitat structure of the system is very different to the species and life stages dwelling there. Habitat structure also varies from place to place across the river landscape. As one travels from headwaters to estuary, flow increases, sediment distribution and bedform change, flood-tolerant species come to dominate the riparian zone, and temperature patterns are altered. Large woody debris, so critical to sediment storage and pool formation in upper and mid-river reaches, tends to function more as refuge or as substrate in the lower reaches, often partially buried in the fine sediments of the river bottom or encrusted with barnacles on estuarine mudflats.

Habitat is the outcome of various processes, each with its own characteristic rates, magnitudes, spatial and temporal scale (Spence et al. 1996), and can be usefully characterized as the relationship among process, structure and function within ecosystems. At large spatial and long temporal scales, the dominant processes that shaped PNW landscapes were tectonic and glacial. These processes established the landscape framework upon which further processes occur. Over periods of decades to centuries, large floods, mass wasting and fires have been the dominant processes shaping riverine ecosystems. These disturbances have caused abrupt changes in habitat conditions: large floods reconfigure the channel, often causing channel migration and abandonment, redistribution of bars and pools, and thus the destruction

Table 1. Important Components of Freshwater Habitat for Salmonids

PHYSICAL	CHEMICAL	BIOLOGICAL
Flow Regime	Water Quality	Interactions Among Species and Life Histories
• Depth, velocity, seasonality	• Dissolved oxygen	• Competition
Habitat Structure	• Anions and cations	• Predation
• Substrate material, size and distribution	• pH	• Biological modification
• Channel morphology	• Dissolved nutrients	• Redd building
• Channel slope, width, depth	• Pollutants	Energy Supply
• Bedforms: pools, riffles	• Turbidity	• Riparian inputs
• Large woody debris		• Carcass loading
• Cover		• Instream inputs/ macroinvertebrates
• Escape, feeding, resting		
• Riparian structure		
• Stand composition, age		
• Temperature		

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of existing habitats and the formation of new ones. Changes in the structure may persist for decades or centuries, affecting the relative suitability of these habitats for various salmonid species. This natural disturbance and recovery regime, however, has directed the evolution of life history characteristics and strategies for salmonids

At the watershed scale, the major physical processes that affect the attributes of habitat are hydrology, sediment transport, energy transfer, nutrient cycling, and delivery of large woody debris. Hydrology is the primary "forcing" process at this scale and determines the quantity and timing of streamflow (flow regime) which in turn directly influences sediment transport, channel configuration and habitat availability. Moreover, flow indirectly controls nutrient cycling and energy transfer by affecting the movement of litter, emergence of aquatic insects and the distribution of temperature in the stream environment. The delivery of large woody debris to stream systems illustrates the relationship among process, structure, and function quite well. The age and composition of the forest stand (structure) influences the rate of delivery into the stream (process) and also the longevity and interaction of the woody debris with water and sediment (function). The wood, in turn, influences both flow and sediment transport in such a way that pools and riffles are formed, and habitat diversity for salmonids is modified.

An important biological process for Northwest rivers is the migration and spawning of anadromous salmon in our rivers. In the process of spawning, salmon turn over considerable portions of the gravel bed, thus modifying habitat structure to aid survival of their offspring. This activity may also benefit the survival of species that spawn later because fine material is flushed from the stream bed. More importantly, because of our recent glacial history and the presence of our dense coniferous forests, nutrients in our rivers are in short supply. Salmon are a crucial link between oceanic processes and riverine process and structure. Nutrients flushed to the oceans perhaps centuries before are returned in the form of salmon carcasses to nourish bear, mink, elk and deer, and the diversity of aquatic insects that will be food for the next generation of salmon. In fact, recent research has demonstrated that overwintering salmon and trout have significantly higher growth rates in streams where anadromous salmon spawn and die. Some of these nutrients find their way into vegetation within the riparian zone and are taken up by vegetation as diverse as western hemlock and the most appropriately named salmonberry.

The interaction of these processes, at time scales from 1-10,000 years and at landscape scales from reach to region, have produced habitats of unique structure and function suited to a unique family of fishes. The conservation of salmon will ultimately depend upon maintaining and restoring the integrity of these processes at their natural rates and magnitudes or providing structural and functional surrogates for them where ecosystem integrity has been lost.

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Are Wild Salmon Runs Sustainable in Rehabilitated Urban Streams?

Derek B. Booth

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Presented at *Salmon in the City*, Mt. Vernon, WA, May 21, 1998

Introduction

Urban development imposes a variety of watershed changes that profoundly affect runoff processes and the downstream surface-water aquatic system. Attention is generally given to *channel changes*: the stream channel itself is the object of interest and also, typically, the focus of any subsequent restoration or rehabilitation efforts. Yet that stream channel, commonly draining many square kilometers, is the product of its upland watershed. The net effect of *upland changes*, occurring across the land surface of the contributing headwater catchments, is at least as important in determining overall stream function, degradation, and rehabilitation potential. The widespread failure to recognize these watershed interconnections, or the acknowledgment of those interconnections but the unwillingness to let that understanding guide choices for realistic rehabilitation goals or strategies, explains much of the present sorry state of salmonid habitat in the urban and urbanizing streams of the Pacific Northwest.

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Towards a Watershed-Level, Process-Based Approach

Despite the inescapable connection between the stream channel and its contributing watershed, stream-channel rehabilitation has traditionally been conducted in near-isolation from the surrounding landscape: channels have a particular set of desired physical features (the channel *structure*) which are presumed to correlate precisely with the desired channel *functions:* if that structure is "deficient," it must be "fixed." A voluminous literature of channel-assessment techniques has been developed over the last two decades, determining any "deficiencies" in a given stream environment by comparison to some predetermined standard of acceptable channel structure. The implicit (but fundamental) assumption is normally made that the desired physical and biological *functions* always follow from the correct physical structure. This assumption is made regardless of whether that structure was achieved as the outcome of intact upland processes operating across the contributing watershed or as a consequence of site-specific application of earthmoving equipment and replanted vegetation.

As rehabilitation efforts have been applied to more profoundly disturbed areas, however, unintended consequences of this approach have become manifest. Unrealistic promises are made, large sums of limited resources are spent on projects that achieve their immediate structural objectives (and these only briefly) but which subsequently fail to meet biological goals, multiple projects with less ambitious individual goals but potentially greater aggregate benefit are ignored, and the overall quality and health of a region's waters decline in a seemingly inexorable downward spiral. The underlying reason is simple—severing the behavior of a stream network from its geomorphic context eliminates our ability to understand how the channel currently functions, how channel form and channel functions relate to each other, and how those functions may change following human intervention. Many of the critical changes underlying the loss of physical and biological functions are occurring on the *land surface* of headwater catchments; their effects will never be reversed by thinking only of the observed degradation in a downstream channel.

In addition to these physical and biological issues, there are social realities. The general public often values a "derelict but natural" landscape as a reminder of the large natural landscape beyond the urban fringe. However, people will begin to "care for" these landscapes by cleaning out woody debris and other desirable elements or by fashioning homemade retaining walls to stabilize eroding banks. In other words, while people generally *like* the idea of a stream nearby, they more likely want its appearance to fit into their neighborhood landscape—to look more manicured than scruffy. When public agencies attempt to restore degraded channels they either complete the manicuring process, with smoothed banks having little if any rehabilitation value, or they build more biologically functional measures that seem unkempt, scruffy, and even more derelict to the nearby homeowner than the original degraded site.

Thus any approach to stream rehabilitation, and the rebuilding of salmonid habitat in urban settings, must acknowledge both the complex dependencies of channel response on watershed land use *and* the social environment in which rehabilitation actions must be taken. Rehabilitation approaches will be most successful if they tackle the most important tasks out of those that are possible to address at all. In nearly all cases the single greatest change is one of *hydrology*—the disruption (and generally the augmentation) of flows rolling off the surface of the watershed and entering the channel. Time and again, however, the willingness of governmental agencies or individual property owners to accept either the cost or the change in development patterns (or both) necessary to materially improve this condition has been insufficient. Until this political and economic reality changes, any other rehabilitation measures are likely to provide modest, incremental improvements at best; the most ambitious goals of returning self-sustaining salmon runs to urban streams will be wholly beyond reach.

If such "hydrologic rehabilitation" is not an option, other measures that yield measurable (though incomplete) benefits must be sought. These include reducing sediment loads from hillslope sources and reestablishing "stability" of the overall channel grade, as the first steps to recover a stable form. But recognize that such restabilization is not equivalent to the dynamic stability of natural systems, and it has not occurred by the dynamic balance of flows, sediment, and bed resistance. Instead it arises simply from the imposition of rigid structures. This may be necessary and appropriate in the urban environment, but the resulting channel form will not necessarily look "just like natural," and from a biologic point of view it certainly will not perform that way, either.

So what *should* be a set of worthy yet realistic goals for urban streams? Every community, every researcher, and probably every individual can and should have their own list; the following is simply one suggestion:

1. Address causes, not symptoms—The most effective rehabilitation efforts must emphasize first the fundamental determining processes, such as hydrology, in disturbed watersheds. Only then can they target recreation of the structural in-channel features consistent with renewed processes, and *finally* reestablished biological activity. Taking this sequence out-of-order is very unlikely to produce biologically meaningful results (although it may support other valid community goals).

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2. Fix past errors—Urban channels should not be toxic or lethal to temporary aquatic residents, and they should pose no significant barriers to migration into more hospitable areas farther upstream. Similarly, stream rehabilitation should not make matters worse.
3. Maintain stable channel grade—Catastrophic channel failure, with attendant destruction of not only habitat quality but also aesthetic values and channel-bank stability, is most commonly associated with rapid channel incision. There is no adequate "cure" once this has occurred.
4. Minimize sediment sources—Geomorphically, this task should be secondary to that of minimizing flow increases, because increased overland flow is the greatest single source of increased sediment delivery, and because increased in-channel flow is the greatest single source of channel erosion (and thus new in-channel sediment). Yet minimizing sediment is generally a far more tractable task than that of minimizing flows, and techniques are more readily and cheaply available to achieve relative success. Even the best results, however, will not produce a channel with a pre-development sediment flux.
5. Engage the public—Urban channels, particularly in the Pacific Northwest, are one of the most visible and nearby manifestations of the natural environment. An interest to care for that environment, and a willingness to support the broader ecosystem, should arise from how those channels are managed and rehabilitated.
6. Enhance biological activity—Regardless of whether self-sustaining wild salmon will ever repopulate the urban streams of the Pacific Northwest, *any* level of fish use, and the biological activity that surrounds that use, supports both ecological and community goals. It is not hypocritical to have to constantly restock "boutique" salmon runs in urban streams, because it brings direct aesthetic and educational values to the community. It is less credible, however, to imply that such measures are but a temporary step on the way to long-term biotic integrity. Without clear articulation of what is plausible, limited resources may be spent on what can *never* be achieved while more attainable objectives languish forever. ❖

Status of Projects at the Center

- ➤ Hydrogeologic Pathways, Duwamish Corridor (see Fall 1996 Newsletter; final report anticipated this summer)
- ➤ Maintenance of Failed Biofiltration Swales (see Spring 1997 Newsletter; final report anticipated this summer)
- ➤ Puget Lowland Urban Corridor Geology and Geologic Hazards (see Spring 1997 Newsletter and related article, Winter 1998 Newsletter)
- ➤ Environmental Benchmarks in Citizen-Based Watershed Planning (see Summer 1997 Newsletter; final report anticipated this summer)
- ➤ Aquatic-System Monitoring, Urban Planned Developments on the Bear Creek Plateau (see Fall 1997 Newsletter)
- ➤ Urban Stream Rehabilitation in the Pacific Northwest (see Winter 1998 Newsletter)

RESEARCH NOTE

The Effects of Subsampling on the Performance of Macroinvertebrate Biomonitoring

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Biological monitoring is an invaluable component of all aquatic resource protection and rehabilitation efforts. If used correctly, biomonitoring provides scientists with crucial information about the condition, or "health," of the biological communities that inhabit rivers and streams, and therefore the overall condition of an aquatic system. Much of the strength and utility of these approaches lies in the integration of multiple measures of biological condition (metrics), which reliably reflect human-induced changes in stream condition (Karr and Chu 1998). By examining many aspects of the sample biota, multimetric indexes summarize biological responses to human influence, which in turn can be used to evaluate the biological condition of a site.

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Macroinvertebrate-based multimetric indexes have come a long way since their initial development, yet their full potential has yet to be realized. Although substantial time and effort have been dedicated to testing and evaluating the applicability of different indexes and individual metrics (Ohio EPA 1988, Barbour et al. 1992, DeShon 1995, Kerans and Karr 1994, Fore et al. 1996, Karr and Chu 1998), their utility has been limited by disagreements over preferred methods of collecting and analyzing field samples.

The focus of this study was to determine the management consequences of deciding how many actual organisms should be evaluated in a macroinvertebrate-based stream assessment, independent of the original sample size. Some argue that the proper way to analyze macroinvertebrate samples is to count and identify all the organisms collected, thus maximizing the information extracted from the sampling efforts (Ohio EPA 1988, Courtemanch 1996, Karr 1998). Others believe that such "whole-sample" processing is too time-consuming for the amount of information returned, and therefore suggest *subsampling* the field samples to as few as 100 organisms to yield adequate information with significantly less expended effort (Resh and Jackson 1993, Barbour and Gerritsen 1996, Vinson and Hawkins 1996, Barbour et al. in press). As of 1996, 44 states were using macroinvertebrate-based bioassessments in their water resource management programs (Davis et al. 1996). Greater than 30 of these states reported using subsampling methods, typically counting only 100 organisms. Are they producing analyses of questionable quality and reliability?

The primary goal of this study was to investigate the effects of subsampling on the value of multimetric indexes and to determine whether subsampling methods yield consistent, accurate, and reliable information. Subsampling does reduce the quality of information provided by macroinvertebrate biomonitoring programs, but the key unanswered question remains how significant the effect is and, therefore, whether the results of subsampling are reliable enough to be used for management decisions.

The approach used for this study was straightforward. Multiple computer-generated subsamples drawn from actual macroinvertebrate samples were used to compute the minimum differences (in biological measures) that could be detected between streams, and thus the maximum number of classes of stream quality that could be distinguished, using the benthic index of biological integrity (B-IBI). The results led to the conclusion that the common practice of subsampling benthic samples to as few as 100 organisms introduces considerable variability among different replicates from the same population, which in turn introduces serious uncertainties about the reliability of any single measurement. Moreover, the magnitude of this variability changes significantly among different metrics and different sites, adding to the uncertainty associated with each individual assessment. As a result, the discriminatory power of the B-IBI is drastically reduced as subsample size declines.

As an example, counting all of the organisms collected from a high quality creek (*e.g.* the set of approximately 1200 organisms collected from a sample at King County's Rock Creek) generates a B-IBI score accurate enough to discriminate nearly 6 possible classes of stream condition. In contrast, the uncertainty associated with subsampling this same population by using only 100 organisms reduces B-IBI's discriminatory capabilities to only 2 classes of stream condition (*e.g.*, "good" and "bad"). Yet most water resource decisions require discrimination beyond just two classes of stream quality. Indeed, two classes of stream condition can be discriminated with casual field observations alone; counting invertebrates is not even needed to make such a coarse evaluation.

Managers must be certain that they know the quality and limitations of their data before using those data to make water resource decisions. Since a single 100-organism assessment may only be able to differentiate two classes of stream condition, better methods will normally be necessary. For example, suppose a high quality, protected stream is being monitored to ensure that nearby recreation does not damage the stream. What if the monitoring data show that the site is still healthy when in fact subtle (but significant) degradation has begun? The potential for irreparable (yet perhaps avoidable) damage to the stream is high, not to mention the resources wasted on the ineffective monitoring efforts. Similarly, what if monitoring data indicate that a stream's condition is deteriorating when in fact it is not? The resultant unnecessary regulatory action might cost hundreds of thousands of dollars, most of which would be passed on to consumers or citizens (Rankin 1995).

Successful biological monitoring requires researchers and managers first to define the quality of information that is required and then to ensure that the data meet those demands. Fiscal constraints should not compromise the analytical quality of the biological information. Because the potential for (and cost associated with) ill-informed decisions is normally high, the consequences of poor decision-making almost always outweigh the savings associated with a subsampling procedure. As the quality of our nation's waters and aquatic ecosystems continues to decline, and more and more miles of biologically healthy streams are irreparably damaged by human activity, we cannot afford to act on the basis of inadequate information.

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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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Recent Research Findings

Spatial Prediction of Phosphorus and Algal Biomass in Cobble/Gravel-bed Rivers During Summer Conditions

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Department of Civil Engineering

Nutrient enrichment produces nuisance levels of periphytic algae in streams. This work represents the development of a model to characterize the accrual of periphytic algal biomass in riverine systems during low-flow summer conditions. Nuisance levels result in adverse impacts to the beneficial uses, water quality, and habitat structure of stream ecosystems. This modeling effort expands existing periphyton models to more accurately describe nutrient availability and periphyton biomass accrual in cobble/gravel-bed rivers. Existing models employ a plug-flow, single-compartment approach to describe nutrient concentration longitudinally in the water. However, regeneration of algal nutrients contained in particulate organic matter (POM) is an important source affecting downstream nutrient concentration and periphyton growth. The decomposition of POM trapped or moving along the stream bottom, as well as dead, floating algal mats help explain the pattern of periphytic algal biomass observed in rivers with biomass in excess of nuisance levels. Thus a three-compartment (i.e., surface, water column, benthic) model was developed which allows materials in the surface compartment to move at different rates than materials in the water column, and allows stationary and bedload transport in the benthic layer. This three-compartment model provided a better description of the spatial and temporal dynamics governing the quantity of limiting nutrient available for periphyton growth and biomass accrual.

Model output showed that periphytic algae probably act as a temporary trap, preventing loss of nutrient to downstream transport. Decay of algal POM provided a “time-release” mechanism for nutrient regeneration to the water column. In addition, reduction of soluble reactive phosphorus (SRP) loading to a river controlled the distance at which algae would reach maximum and nuisance levels. However, reaches nearest the nutrient discharge source would still develop very high levels of biomass despite nutrient reduction. This suggests management decisions to control nuisance conditions (i.e., nutrient load reduction) must consider biomass development within a reach as well as the longitudinal distance that exceeds nuisance biomass levels.

By including a more comprehensive estimate of available nutrient concentration, a more realistic prediction of periphytic biomass can be achieved. In addition, the model defined research work needed to refine the model and manage periphyton responses to changes in phosphorus loading. Sensitivity testing on selected model variables revealed specific areas where process research would improve model formulation.

Little Soos Creek Microbial Source Tracking

Naomi Checkowitz, M.S.E. Candidate
Department of Civil Engineering

The Little Soos Creek Microbial Source Tracking Survey was designed to help characterize the sources of fecal coliform bacterial contamination in Little Soos Creek located in southeast King County, Washington. The study was conducted for King County Water and Land Re-

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1998 Professional Engineering Practice Liaison (PEPL) Courses

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, 19, 20
Hydrologic Modeling and Design of Retention/Detention Facilities

December 15 and 16
Wetlands Ecology, Protection and Restoration

Spring 1999 (Originally scheduled August 6, 7, 8, 1998)
Quaternary and Engineering Geology of the Central and Southern Puget Sound Lowland

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SPATIAL PREDICTION (from page 9)

sources Division. The study makes use of an innovative method for tracking microorganisms in the environment, Microbial Source Tracking (MST). It is based on the ability to identify and match microorganisms with their sources, human or other animal, by comparing genetic patterns. This was done by comparing DNA patterns of fecal coliform bacteria isolated from the stream to DNA patterns of fecal bacteria isolated from potential sources known to exist in the watershed.

The goal of the MST survey of Little Soos Creek was to help determine the contribution to contamination of the stream by two primary potential sources, which could then support implementation of specific source controls. The anticipated sources were (1) livestock on hobby farms and ranches adjacent to the stream and (2) on-site septic systems close to the stream in highly permeable soils. Other animal sources were also evaluated as potential secondary contributors. The evaluation was made by sampling water from the stream and potential source fecal material found in the watershed from September 1993 through March 1995. These samples were then processed to establish collections of bacterial cultures, referred to as isolates, representative of the Escherichia coli (E. coli) population in each sample. Of 1639 E. coli isolates, 589 were from water, 227 from septage, and 823 from animals. Genetic fingerprinting using ribosomal RNA typing was performed on each E. coli isolate. These DNA patterns, or ribotypes, were then used to effectively match specific strains of E. coli from a contaminated site in the stream to its source.

The primary sources of contamination were determined to be cows, dogs, and horses. The greatest proportion of water-to-source ribotype matches were found to be water-to-cow and water-to-horse. However, the greatest proportion of water isolates belonging to strains associated with these matched ribotypes were water-to-cow and water-to-dog. This suggests that cows and dogs were the greatest contributors overall to the identified portion of the stream fecal coliform contamination.

Although septage was identified as a contributor to the contamination problem, it is not indicated as a major source. However, even low levels of contribution by septage suggest the potential for Little Soos Creek to harbor a number of human viral, bacterial, and parasitic pathogens associated with human sources. For this reason, further investigation of the contribution by septic systems and of human exposure (particularly children) to the stream may be warranted. It is possible that a portion of the unidentified water isolates is attributable to septage. Additional sampling of septic tanks in the watershed and vicinity or use of ribotype information from regional studies may provide additional water-to-septage matches. ❖

"Working at a Watershed Level"

A one-week course in the basics of watershed management

As described in the last edition of the *Newsletter*, The Center for Urban Water Resources Management and the Center for Streamside Studies have been selected by the U. S. Environmental Protection Agency's Office of Water to conduct watershed training in the Pacific Northwest. We are beginning with the first West-Coast offering of the foundation course of the *Watershed Academy*, the training program of the U. S. Environmental Protection Agency being developed as part of the nationwide "Clean Water Initiative" begun on the 25th anniversary of the Clean Water Act. A Federal interagency group (USEPA, US Forest Service, Bureau of Land Management, US Fish and Wildlife) has established the overall curriculum; the University of Washington instructional team was selected after a nationwide competition.

This course provides a basic but very broad foundation of scientific and social principles proven useful in guiding watershed-level activities. The six training units move through a discussion of how watersheds work, how change occurs in watersheds, methods to assess watershed conditions and plan for management, watershed management practices, and the all-encompassing social and cultural context for watershed management.

The course is structured for a range of attendees:

1. Entry-level staff with little watershed science background or with a strong background in one or several aspects of watershed management but who lack breadth of knowledge and experience across scientific and social disciplines integral to the watershed approach;
2. Experienced technical staff, who may seek a broader perspective than their narrow specialty or who may desire a comprehensive refresher of watershed approach principles;
3. Managers who cannot afford the time for in-depth technical training yet must direct and evaluate activities that require a sound watershed approach; and
4. Informed citizens involved in working with their own watershed.

Out of this course, attendees can expect to obtain a comprehensive overview of the scientific and social elements of watershed management, together with a set of resources that will enable them to pursue any particular technical subject in greater depth. The emphasis will be balanced between technical information on physical and biological watershed processes, social and economic realities of watershed activities, and practical examples and experiences of what is and is not successful.

Continued on page 11

WORKING (from page 10)

Primary Instructors

Dr. Susan Bolton—Associate Professor of Forestry and Director of the Center for Streamside Studies, University of Washington. Dr. Bolton has a background in ecology, hydrology and engineering. She has studied and worked in interdisciplinary environments for 20 years. Her research has focused on various aspects of the impact of land-use on hydrologic systems, including stream temperature, water quality, snow accumulation, fish habitat and channel migration. She also teaches several courses that deal with ecological impacts of human management activities on the landscape.

Dr. Derek Booth—Director of the Center for Urban Water Resources Management, University of Washington. Dr. Booth spent eight years as senior technical staff (and one year as program manager) in King County's "Basin Planning Program," a multi-disciplinary watershed assessment and rehabilitation team. As director of the University's urban water center, his research focuses on the effects of land-use change on aquatic systems, primarily from a physical geomorphological perspective.

Dr. Clare Ryan—Assistant Professor of Forest Management. Dr. Ryan has a combination of science and policy experience. She has worked for the Washington Department of Ecology and the USEPA on technical and policy issues. Much of this work has involved collaborative planning/problem solving process facilitation and participation in community relations and education.

Dr. Jim Karr— Professor of Fisheries, Public Affairs, Zoology, and Environmental Health. Dr. Karr is a leader in developing biotic methods for assessing the health of streams and watersheds. His work has been instrumental, both regionally and nationally, in informing society about the ecological risks associated with human actions.

Dr. David Montgomery— Associate Professor of Geology. Dr. Montgomery is interested in physical processes that affect watersheds and how these processes in turn affect the ecological functioning of the watershed. As a geologist, his primary research interests concern landscape-forming processes and their interactions with other natural systems. Montgomery leads a research program that seeks to develop models of the physical environment necessary for understanding landscape development and ecological response to disturbance.

Martha Bean—Ms. Bean is a Northwest consultant, most recently with Triangle Associates, who has focused on watershed-related issues, providing public involvement, facilitation, planning, and mediation services to public agencies, businesses, and communities for the past decade.

Logistics

The course will be held September 21-25. 1998. Each day will begin and end at the University of Washington campus in Seattle, although two days will also involve field trips to watersheds and stream-restoration sites in the surrounding region. Because of the commitment of the U. S. Environmental Protection Agency to this local-level watershed training, the course fee is only $200 for the entire 5 days and covers all classroom materials, field trip transportation, and lunches. Registration will be limited to 50 attendees and is being handled by Engineering Professional Programs at the University of Washington. Formal registration will begin next month, but we anticipate the course to fill rapidly. Center subscribers can contact EPP now (206-543-5539), however, to ensure a registration slot. ❖

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The Washington Water RESOURCE

The quarterly report of the Center for Urban Water Resources Management

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