Article 29

Feature article from Watershed Protection Techniques. 2(2): 329-337

Crafting Better Urban Watershed Protection Plans

A dynamic local watershed management plan is arguably the best and most comprehensive tool to protect urban streams, lakes, and estuaries from the cumulative impact of land development. In practice, however, few such plans have actually realized this goal. Rather, most watershed plans are little more than a onetime report that is quickly consigned to the bookshelf to languish in obscurity, never to be read or implemented. This article examines why local watershed plans often fail to live up to their promise, and is organized into two parts. The first part outlines 11 frequently cited reasons cited for poor outcomes in local watershed plans, drawn from a critical analysis of several dozen past watershed monitoring, modeling, and management efforts, as well as the experience of a number of watershed planning practitioners.

The second part of the article proposes a 12-point protocol to prepare more effective watershed management plans that avoid these common problems. The core of the protocol is a simple method to classify and manage urbanizing watersheds, based on measurements of current or projected impervious cover. The method emphasizes the importance of impervious cover management at both the site and watershed scale through limits on the amount of new impervious cover that can be created. The protocol explicitly links the cumulative impact of future growth to zoning and application of urban best management practices at the subwatershed level. Other elements of the local watershed plan protocol emphasize subwatershed scales, regular management cycles, resource-based monitoring, integrated resource mapping, local program audits and subwatershed-specific development criteria. Together, these elements should improve the effectiveness of local watershed protection plans as a management tool to prevent cumulative impacts.

A Critique of Local Watershed Plans: 11 Reasons Why Watershed Plans End Up on the Shelf

Everyone seems to agree that the watershed is the most appropriate geographic unit to protect urban water resources. Indeed, the 1990s will undoubtedly be remembered as the decade in which the watershed approach became a dominant paradigm for local environmental management. Despite this welcome trend, it is reasonable to ask whether local watershed plans have actually worked to protect streams from degradation from the cumulative impact of land development.

At the outset, it is important to distinguish between the watershed *study* and the watershed *management plan.* The former is a *technical analysis* to identify water quality problems in a watershed and define their sources, and may also explore possible options to remedy them. The watershed management plan, on the other hand, is a much more comprehensive *management process* that should ultimately lead to the implementation of measures that collectively protect the watershed from the impacts of future development (i.e., land use, site planning, riparian management, and stormwater practices) and establish a baseline to gage the effectiveness of that implementation.

Over the last year, staff at the Center have interviewed a wide cross-section of environmental planners, municipal officials, consultants, watershed scientists and others about the effectiveness of local watershed management plans. The consensus was that most had failed to adequately protect their watersheds. Failure, as defined here, is the inability of a plan to meaningfully prevent or reduce cumulative impacts at the watershed scale in the long run. In this sense, an effective watershed protection plan is one that produces the desired long-term outcome of protecting streams (or other water resources) from degradation.

When asked about the wide gulf between watershed planning and implementation, our admittedly unscientific sample cited one or more of the following reasons for poor watershed plan outcomes:

Reason No. 1: Plan was conducted at too great a scale.

Scale was considered the *critical* factor in preparing effective local watershed plans. Quite simply, when watershed plans were conducted on too large a scale (50 or more square miles), the focus of the plan became too fuzzy. Too many different subwatersheds had to be considered, and important differences in stream quality and development patterns could not be isolated. Land use changes were too complex to forecast. The critical link between individual land use decisions or restoration projects and the watershed plan was broken. While the number of stakeholders involved in the plan proliferated, actual responsibility for implementing the plan diminished. Costs for both monitoring and watershed analysis skyrocketed. A bewildering number of non-urban water quality sources, issues and problems complicated the picture. In short, the watershed planning process was too big to be effective. Only by "decomposing" it into smaller, more manageable watershed units, was it possible to produce a meaningful plan.

Reason No. 2: Plan was a one-time study rather than a long-term and continuous management commitment.

A common complaint concerned the fact that the local government did not fully commit its resources and authority to a long-term watershed management process. Instead, the plan was conceived as a short-term study that would produce the requisite answers in a year or two. As a result, the watershed management effort was quickly transformed from a process into a report, and within a few years, the report and its recommendations were forgotten amid competing priorities.

Reason No. 3: Lack of local ownership in the watershed management process.

A related problem was the tendency for many communities to hand off responsibility to a consultant or their own technical staff. Many local planners and officials perceive watershed management as a daunting and complex technical challenge, and are all too happy to shift the responsibility to someone who knows better. Consequently, the task was assigned to a single project manager, who in turn assigned it to a technical consultant. While this approach helps complete the technical study in a timely fashion, it generally doesn't generate the kind of internal consensus and support needed to champion the watershed management process. An overreliance on technical consultants often means that few local staff have much ownership or understanding of the plan, and, consequently, have little stake in the outcome of the watershed management process.

Reason No. 4: Plan skirted real issues about land use change in the watershed.

For many, a key flaw in their watershed plan was a failure to accurately measure land use, or project how it would change in response to the prevailing zoning or comprehensive plan. Detailed analysis of current or future land use or impervious cover was either not scoped in the plan, not budgeted, or simply unavailable. In a surprising number of cases, consideration of alternative land use densities or locations was not part of the study. Few watershed plans actually attempted to directly measure or forecast cumulative impacts based on impervious cover, and therefore could not directly test whether the watershed plan would actually mitigate or prevent cumulative impacts.

Reason No. 5: Budget for watershed plan was poor or unrealistic.

Numerous watershed plans were hamstrung by the fact that the original scope of work was far too broad and ambitious to be completed with available resources. By the time extensive watershed mapping and baseline monitoring tasks were completed, the project budget was all but exhausted. Few resources remained to begin the watershed management process, much less to develop the funding and consensus to adopt and implement it. In many cases, monitoring merely confirmed what was already known, or produced reams of data of little value to managers. By contrast, many watershed budgets scrimped on the considerable staff resources needed to develop and implement the plan. The recurring budget shortfalls suggest that watershed monitoring may be overemphasized (and budgeted) at the expense of the watershed management process. The potentially high cost of monitoring and mapping elements are seldom fully appreciated by watershed managers.

Reason No. 6: Plan focused on the tools of watershed analysis rather than their outcomes.

Many consultants and planners were overly-fascinated with the many tools of watershed analysis, such as geographic information systems (GIS), computer simulation modeling, intensive stormwater monitoring and the like. As a result, many of these studies were more about demonstrating the intrinsic value or legitimacy of one these tools, than about the specific watershed management outcome. Quite simply, a fancy GIS map, a finely calibrated model, or an extensive monitoring baseline will never serve as a watershed plan. This is not meant to imply that any of these tools were not helpful for local watershed management, just that they are only tools, and rather expensive ones at that. Once again, a watershed plan should be focused on tangible outcomes with respect to land use and practices. The tools of watershed analysis are a means toward that end, but should never be confused with the end product.

Reason No. 7: Document was too long or complex.

Many local watershed plan documents were uncharitably described as Watershed Environmental Impact Statements. Running into several hundred pages, or even several volumes, many watershed plans were too long and complex to induce anyone to read them. The thickness may have been needed to justify the many dollars that were invested in their production, but ended up obscuring the real findings and issues, and intimidating the lay reader. Frequently, decision-makers could not even find, much less understand, the specific watershed management recommendations they were supposed to implement.

Reason No. 8: Plan failed to critically assess adequacy of existing local programs.

Few plans seriously considered the complex management process of how to get the proposed management measures implemented across the watershed over the next several decades. In particular, little attention was paid to critically evaluating the management capability of existing local government to handle future watershed development decisions, whether it be funding, organization, staffing, enabling ordinances, regulations or the development review process. The central question of whether the objectives of the watershed plan could be successfully integrated into each of the hundreds of individual development decisions that were expected to occur in the future in the watershed was not adequately addressed.

Reason No. 9: Plan recommendations were too general.

A particular criticism by many respondents was the fact that most watershed plans were too general. One individual noted that the plan recommendations could have been written in a couple of hours by a group of reasonable people *before* the study ever began. A quick survey of recent plans supports this contention. The familiar litany of general watershed recommendations is surprisingly similar. For example, one plan recommended improved erosion and sediment control for new development, but never considered how to pay for more inspectors. The need for greater agency coordination was highlighted in another, but no actual mechanism was proposed to achieve it. A third plan recommended wider use of stormwater practices, but remained conspicuously silent on how they were to be selected, designed or maintained. A long-term watershed monitoring program was proposed in another, but no agency was assigned to implement it. The need for a stream buffer network was also identified, but the required ordinance or performance criteria was omitted. Restoration projects were identified in yet another study, but were not ranked in priority order, much less included in the local capital budget.

The key point of this litany is that we already know in advance generally what we need to do protect watersheds from development, but we lack either the management tools or the community consensus to get it done. Therefore, plan recommendations need to be as specific as possible, including the *authority, budget and timetable to make it happen.* The term "watershed management" implies that responsibilities are assigned, resources are allocated, and timetables are adhered to for each specific recommendation. Yet, it is the rare plan that considers these essential management tasks.

Reason No. 10: Plan had no regulatory meaning.

Perhaps the greatest reason cited for consigning watershed plans to the shelf was that no one was required to pull it down and use it as a routine part of the land development process. Consultants, planners, and local officials are exceptionally busy and generally do not read watershed plans as a leisure activity. Therefore, unless land development is required to conform to the specific criteria and maps outlined in the watershed plan, few people have a compelling reason to even open it.

Reason No. 11: Key stakeholders are not involved in developing the management plan.

A good urban watershed management plan creates meaningful change in how and where land is developed. Changes of this nature will always be controversial. The purpose of the watershed management process is to allow stakeholders a legitimate and early opportunity to participate in the development of the plan. Stakeholder involvement provides the foundation to obtain the feedback, consensus, and support needed in the implementation. Yet it is often the case that most local watershed plans only ask for feedback at the end of the study, if at all. Important stakeholders, such as developers, environmentalists, property owners, non-governmental organizations, and local, state, and federal agencies, are often not included. Each of these parties will be affected by in some way by the subwatershed plan, and if they are not satisfied with their opportunity to participate in it, they will likely turn their considerable energies to defeating it. If stakeholders are not provided a meaningful role in the watershed management process, needless controversy will inevitably result.

Twelve Elements of an Effective Local Subwatershed Management Plan

It is evident from the foregoing discussion that many first-generation watershed studies have failed to deliver on their promise of protecting urban watersheds from degradation. When the reasons for the poor outcomes are analyzed, however, the limited effectiveness of plans is not so surprising. There seems to be no underlying framework or protocol that supports the local watershed management process. Is it possible to develop such a protocol? In order to promote dialogue on the subject, the Center has drafted an initial outline of the possible elements of a local watershed protocol (see Table 1). It is drawn from a variety of sources—practical experience of watershed practitioners from around the country, a number of recently completed subwatershed studies (Grand Traverse County, 1995; MNCCPC, 1995; Johnson Creek Corridor Committee, 1995), and watershed planning documents and protocols (Clements *et al.*, 1996; Arnold and Gibbons, 1996; USEPA, 1991 and 1995). The 12 elements of the protocol are enumerated below.

No. 1: Create a Watershed Management Institution

A key milestone in any subwatershed plan is the creation of a formal or informal authority that is invested with primary responsibility for implementing and then updating the plan after it is developed. Communities may elect to create a single authority at the watershed level, or a series of smaller authorities at the subwatershed level. At any rate, the plan should set forth the structure of any interagency or multi-jurisdictional partnerships needed, and where possible, explore funding mechanisms to support for the required management activities needed over the entire subwatershed cycle. As Clements *et al.* (1996) notes, a single agency champion must take responsibility for leading the watershed institution-building process. In many cases, the stakeholder involvement process (see No. 11) helps to determine the membership and structure of the institution. The watershed institution is the only reliable way to provide continuous, long term management commitment needed to implement the plan.

No. 2: Subwatershed Scale

The subwatershed is probably the best unit to develop an effective management plan. Subwatersheds are defined as having drainage areas of two to 15 square mile in size. In most cases, the influence of impervious cover on hydrology, water quality and biodiversity is most strongly felt at the subwatershed scale. Due to their size, many subwatersheds are entirely contained within the same political jurisdiction which helps to establish a clear and direct regulatory authority. Depending on their size, a typical municipality or county might have 10 to 50 subwatersheds to manage.

Another practical advantage for choosing subwatersheds as the primary management unit is that they can be mapped at a resolution that is meaningful to a planner or the public. (e.g., the entire subwatershed can easily fit on a standard 24 by 36 inch quad sheet at 1 inch:2000' scale, or equivalent to a U.S. Geological Survey quadrangle or National Wetlands Inventory map). This choice makes it easier to relate individual development or restoration projects to the overall subwatershed plan and to initially locate many (but not all) of the larger environmental features on the map (larger wetlands, the stream buffer network, steep slopes, etc.)

A last practical advantage of the subwatershed scale is that it is small enough to perform required monitoring, mapping and other tasks of the watershed study in a relatively brief time frame (perhaps six to 12 months). It is generally possible to complete the watershed management plan within a year's time, while still providing sufficient time for criteria development, agency coordination and stakeholder involvement. The fact that each subwatershed management plan can be done in such a short time-frame enables local governments develop multiple subwatershed management plans in a regular and coordinated cycle.

No. 3: Subwatershed Management Cycle

Clements *et al.* (1996) has advanced the concept of the subwatershed management cycle for local planning. In brief, each subwatershed plan in a locality is prepared under a defined management cycle that last five to seven years. Preparation of individual subwatershed plans are sequenced according to a staggered schedule, with a few started each year in a rotation so that all local subwatershed plans are completed within five to seven years (See Figure 1).

Table 1: Twelve Elements of an Effective Subwatershed Management Plan

No.	Subwatershed Management Planning Element
1.	Create watershed management institution
2.	Conduct at the subwatershed scale
3.	Commit to a continuous watershed management cycle
4.	Accurately measure and forecast land use
5.	Shift the location and density of future development
6.	Produce integrated resource map for subwatershed
7.	Devise specific criteria to guide subwatershed development
8.	Emphasize strategic resource-based monitoring
9.	Audit effectiveness of local watershed protection programs
10.	Incorporate priorities from larger watershed management units
11.	Actively engage stakeholders and include public early and often
12.	Promote intra- and inter-agency coordination

The actual management plan for an individual subwatershed is expected to take no longer than 12 months to complete. To provide continuous management, however, each subwatershed plan is revisited and updated at the beginning of each new cycle. In particular, strategic monitoring data and changes in impervious cover are collected in each to assess the effectiveness of the subwatershed plan. Another benefit of the subwatershed management cycle is that it helps local authorities to balance their workload, and provides a defined schedule for management and assessment activities.

From a practical standpoint, some communities may want to schedule some management or monitoring tasks at the onset of the subwatershed management cycle. Examples include strategic indicator monitoring to identify sensitive streams and measurement of impervious cover in all subwatersheds to identify growth areas. If these tasks are completed early, managers can more easily target which subwatersheds should be addressed on a priority basis. In addition, communities may want to phase the rotation of their subwatershed cycle so that the first four include representative examples of sensitive, impacted, non-supporting, and restoration streams. Specific subwatershed criteria developed in these first four subwatersheds can then be applied on an interim basis to subwatersheds of the same classification until such time as all subwatershed plans are completed.

Figure 1: Subwatershed Management Cycle

	First Management Cycle										Second Management Cycle									
	Year 1		Year 2		Year 3		Year 4		Year 5		Year 6		Year 7		Year 8		Year 9		Year 10	
Subwatershed 1	C	W	S	M	I						C	S	R	I						
Subwatershed 2	C	W	S	M	I						C	S	R	I						
Subwatershed 3	C	W	S	M	I						C	S	R	I						
Subwatershed 4	C	W	S	M	I						C	S	R	I						
Subwatershed 5	C			Mi	S	W	M	I			C				S	R	I			
Subwatershed 6	C			Mi	S	W	M	I			C				S	R	I			
Subwatershed 7	C			Mi	S	W	M	I			C				S	R	I			
Subwatershed 8	C			Mi	S	W	M	I			C				S	R	I			
Subwatershed 9	C			Mi			S	W	M	I	C							S	R	I
Subwatershed 10	C			Mi			S	W	M	I	C							S	R	I
Subwatershed 11	C			Mi			S	W	M	I	C							S	R	I
Subwatershed 12	C			Mi			S	W	M	I	C							S	R	I

Subwatershed Management Phases

- **S** Strategic Monitoring
- **C** Measure Impervious Cover
- **W** Begin Subwatershed Study
- **M** Adopt Stream Management Plan
- **Mi** Adopt Interim Stream Management Plan
- **I** Implementation
- **R** Revise Subwatershed Management Plan

No. 4: Measuring Land Use Change

Impervious cover is perhaps the best indicator of development activity, and is of great use for both classifying urban streams and managing subwatersheds (Arnold and Gibbons, 1996; Schueler, 1995). Each subwatershed can be classified into one of three functional categories, based on current or future estimates of percent impervious cover:

	Impervious cover
Sensitive streams	0 to 10%
Impacted streams	11 to 25%
Non-supporting streams	26 to 100%

This simple classification scheme emphasizes the key role of impervious cover in influencing the future quality of urban streams, based on a range of hydrological, habitat, water quality and ecological studies conducted over broad geographic regions (Schueler 1995). A series of research studies demonstrated that a relatively low percentage of impervious cover (10 to 15%) can induce adverse and irreversible changes in the quality of streams. Similarly, many streams become non-supporting once watershed impervious cover exceeds 25% (Table 2). The scheme provides a simple but powerful method to predict the future quality of streams, based on measurable land use change.

Therefore, the accurate measurement of impervious cover will be an important element in any subwatershed plan. The study plan should clearly describe the techniques that will be used to estimate both current and future land use, and the method to convert land use data into estimates of impervious cover. In many cases, *current* land use and impervious cover can be directly estimated from low altitude areal photography, at reasonable cost. Estimating *future* impervious cover, however, is much more problematic. To begin with, the two techniques used to estimate future land use change—*zoning buildout* and the *rate of growth adjustment*—are often imprecise and can give conflicting estimates. For example, zoning buildout analysis assumes that all development shown on a zoning map will ultimately be constructed, and then multiplies each zoned acre by average impervious cover for that particular zone. Zoning, however, reflects a locality's long-term dreams about economic growth. Consequently, much of the development shown on the maps will never be built because of economic conditions or the lack of roads, sewers and water to serve it. Thus, zoning buildout analysis can overestimate impervious cover, at least for the first several decades.

The second technique, known as *rate of growth adjustment*, also has problems. Typically, future impervious cover is derived by simply multiplying current impervious cover by a projected rate of population or economic growth. The rate of growth adjustment is based on local forecasting models, most of which extend only 15 or 20 years in the future. Growth rates may be wildly inaccurate if demographic or economic assumptions in the model prove to be either optimistic or pessimistic. It is therefore good practice to choose a mid-range estimate that falls between the short-run rate of growth adjustment technique and the more long-run zoning buildout technique.

Both techniques rely on general land use/impervious cover ratios that indicate the percent impervious cover associated with a particular zoning category. An original source for these estimates was a study in the Washington metropolitan area performed by NVPDC (1978). Subsequent reanalysis has indicated that these ratios do not always include collector and arterial streets, or highways that can sharply increase impervious cover. Therefore, communities may wish to derive their own local land use/impervious cover ratios during the low altitude aerial photography phase to estimate current impervious cover. Random sampling and analysis of "blocks" from existing zoning categories should be satisfactory.

No. 5: Change Current Zoning in Subwatersheds

A subwatershed plan is essentially a test whether existing zoning can maintain or support aquatic resources in the future. The relationships between impervious cover and stream quality noted earlier provide a quantitative framework to make this assessment. The entire process, known as subwatershed-based zoning, is outlined in Table 3. In short, a jurisdiction analyzes its inventory of subwatersheds, and classifies streams based on current and future impervious cover. If future growth is expected to downgrade a stream's classification, the current zoning of the subwatershed may need to be decreased to maintain stream quality. Additional growth may be shifted to other subwatersheds, which have additional room under the impervious "cap," given their stream classification.

Subwatershed-based zoning has many important benefits. First, it is an excellent framework to track cumulative development impacts over time in a series of subwatersheds. The reliance on impervious cover also acknowledges the primacy of land use control as the first defense to protect watersheds. Subwatershed-based zoning explicitly recognizes that the potential quality of a stream is determined, to a great extent, by impervious cover, and therefore, stream protection tools need to be adapted to different subwatersheds. Subwatershed zoning is ideally suited to growth management, as it provides a framework to direct growth to subwatersheds that have the needed infrastructure to support it. New development is shifted to where it has occurred in the past, concentrating growth and avoiding sprawl.

Table 3: Process for Watershed Based Zoning

1. Comprehensive stream inventory
2. Verify impervious cover/stream quality relationships
3. Measure current levels of impervious cover
4. Project future levels of impervious cover
5. Designate subwatersheds, based on stream quality categories
6. Modify master plan/zoning to meet subwatershed impervious cover targets
7. Incorporate management priorities from larger watersheds/basins
8. Adopt specific stream protection strategies for each subwatershed
9. Long-term monitoring cycle to assess stream status

Table 2: Stream Characteristics Based on Impervious Cover

Stream Variable	Sensitive	Impacted	Non-Supporting
Channel stability	Stable	Unstable	Highly unstable
Water quality	Good to excellent	Fair to good	Fair to poor
Biodiversity	Good to excellent	Fair to good	Poor

Table 4: Subwatershed Development Criteria

Example 1: Sensitive Streams (0 to 10% impervious cover)*	
Goal:	Maintain predevelopment biodiversity
Land Use:	Watershed and site impervious cover limits
Practices:	Maintain predevelopment hydrology and recharge Emphasis on ED and infiltration Restrictions on wet ponds “Country drainage”
Buffers:	Widest stream buffers, protection sensitive areas
Monitoring:	Biological, including single species (e.g., trout)
Other tools:	Land acquisition, clearing limits, extra ESC control
Example 2: Impacted Streams (11 to 25% impervious cover)	
Goal:	Limit degradation of stream habitat and quality
Land Use:	Upper limit on sub-watershed impervious
Practices:	All emphasize pollutant removal/channel protection
Buffers:	Standard three zone, variable width stream buffers
Monitoring:	Biological and physical indicators
Other tools:	Regional pond systems, low input lawn care, site planning techniques
Example 3: Non-supporting Streams (26% or greater impervious cover)	
Goal:	Minimize downstream pollutant loads/prevent floods
Land Use:	No watershed cap, redevelopment encouraged
Practices:	Maximize removal of phosphorus/metals/toxins No restrictions on ponds and wetlands
Buffers:	Greenway for recreation/flood protection
Monitoring:	water quality trends and loads
Other tools:	Pollution prevention, illicit connections, “hotspot” management,
Example 4:Restorable Stream** (non-supporting or impacted stream)	
Goal:	Restore stream biodiversity to impacted or sensitive levels
Land Use:	Limited watershed redevelopment with full BMPs, some infill
Practices:	Subwatershed restoration w/ stormwater retrofit ponds and wetland creation
Buffers:	Acquisition or easements on stream corridors, riparian reforestation
Monitoring:	Biological monitoring, citizen monitoring.
Other tools:	Pollution prevention, “hotspot” management, watershed awareness, fish barrier removal, flood-plain wetland creation.

* Impervious cover limits are approximate.

** Potential candidate for restoration based on completion of subwatershed restoration inventory.

No. 6: Integrated Resource Map

Another key product of a subwatershed study is an integrated resource map. The map shows the public and the development community the location of catchments, steep slopes, floodplains, stream buffers, wetlands, forest conservation areas, parks, open space, existing development, future zoning, stormwater practices or watershed restoration projects, and strategic monitoring stations—all on a single sheet. As noted earlier, the small size of most subwatersheds allows them to be portrayed on a standard sheet at a reasonable mapping scale (e.g., 1" to 2000' or 1" to 1000' or even finer). While this scale is not fine enough to reveal the entire stream network, all development parcels or every environmental feature, it helps planners, citizens, and developers all visualize the spatial implementation of the subwatershed plan.

No. 7: Subwatershed Development Criteria

An important outcome of any subwatershed management plan is the adoption of specific development criteria that are consistent with its stream classification. These criteria are not intended to be another layer of rules and regulations, but to make better sense of existing ones. The performance criteria outline what is typically expected at each development site. Thus, they may include site or subwatershed impervious cover limits; performance criteria to select, design and locate stormwater practices; criteria for the width and management of the stream buffer; and appropriate stream protection tools. Several examples of subwatershed development criteria are outlined in Table 4 for each of three stream categories (plus a restoration category). Once adopted in the plan, all new development in the subwatershed must conform to the expanded criteria. Consultants must then routinely refer to the subwatershed plan during land development to determine applicable site requirements. This helps ensure an eternal readership for the plan. Both the integrated resource map and subwatershed development criteria provide a greater degree of certainty to the development process, which is often desirable in land transactions.

No. 8: Strategic Resource-Based Monitoring

The objective of monitoring is to provide timely feedback on how the aquatic resource is responding to the management practices outlined in the plan. Given the high cost of monitoring, communities need to be very strategic about what, when and where they intend to sample. For this reason, many have chosen to focus on environmental indicators of change, such as physical parameters, biological diversity and habitat quality. Once the baseline is established, these lower cost stream indicators are then sampled on a five to seven year rotation (according to the local subwatershed management cycle). To ensure that the sampling is consistent and can be repeated in the next cycle, the subwatershed management plan should document the rationale for selecting stream indicators, establish the location of all long-term stream monitoring stations or reaches, and document the sampling technique and frequency used to measure each indicator. Such information ensures that future monitoring in the cycle will be fully compatible with the baseline data.

An often neglected component of subwatershed monitoring is the measurement of various indicators of management performance. Examples include the growth of impervious cover, surveys of public attitudes or behavior, number of stormwater practices installed or maintained, rates of permit compliance stream miles in buffer, waivers granted, or restoration projects constructed (Claytor and Brown, 1996). These programmatic indicators can measure progress made toward plan implementation, and provide an excellent basis to assess the plan after the first management cycle.

No. 9: Audit of Local Programs

A subwatershed management plan should include a critical assessment of existing local capability to implement the plan during each stage of the development cycle. This "audit" should examine whether existing local tools exist or are adequate to implement the plan. The scope of the audit might include an analysis of local master plans, ordinances, development review process, performance criteria, program funding and staffing levels. The audit should identify key deficiencies that need to be remedied. Where possible, the audit should utilize actual and quantitative measures of local program efforts (such as waivers, inspections, maintenance, rezoning applications, plan review workloads, permit backlogs).

No. 10: Consistency with Larger Watershed Management Units

Each subwatershed is nested within many larger watersheds, sub-basins and basins. As an example, Sligo Creek *subwatershed* lies within the Anacostia *watershed*, which in turn, lies with the Potomac River *sub-basin*, which is but a part of the Chesapeake Bay *basin.* It is obvious that subwatershed management plans must be developed within the context of the larger watershed management units in which it is located. The first and most simple step is to identify each of the larger watershed management units. Next, key water quality management objectives from these units should be incorporated into the subwatershed plan. Some of regional objectives that often transcend the subwatershed are fish passage, nutrient or toxic reduction targets, water supply, flood protection and wastewater effluent limits. Early coordination with state and federal agencies can ensure these objectives are fully integrated into the subwatershed plan.

It is interesting to note that an increasing number of state governments are adopting a "basin management approach" (BMA) to systematically manage water resources at the scale of the watershed, sub-basin and basins (EPA, 1995; Clements *et al*., 1996). The BMA approach has many similar characteristics to the subwatershed management cycle, and offers an opportunity for greater consistency among watershed management units.

No. 11: Early Stakeholder and Public Involvement

To obtain consensus and support needed for future implementation, it is very important to have a representative group of subwatershed "stakeholders" to guide the development of the plan. A stakeholders is defined as any agency, organization, or individual that is involved in or affected by the decisions made in the subwatershed plan. The ideal group of stakeholders might include interested citizens, developers, environmentalists, consultants, planners and property owners. In addition, many local agencies may have a strong interest (e.g., parks, public works, transportation and planning agencies) and state, regional or even federal water resource agencies may also wish to be represented.

By virtue of their small scale and great number, most subwatersheds will have a manageable number of stakeholders to guide plan development. Early and frequent stakeholder involvement is essential to develop consensus in what could otherwise be a controversial process. The roles of stakeholders should be well-defined, meaningful, and wide-ranging—sharing data and mapping, setting priorities, establishing goals, developing subwatershed development criteria, measuring success, reviewing and even approving the plan. In some communities, the stakeholder group may ultimately evolve into a permanent watershed management committee or task force.

In a real sense, every current and future resident is a stakeholder, although most are unaware of their everyday role in protecting the subwatershed. A key goal of the subwatershed plan, then, is to increase watershed awareness among the public and more actively engage them in protection efforts. A targeted outreach and education program is often the best means to achieve this goal. In this respect, community attitude surveys are often indispensable in scoping critical watershed issues.

No. 12: Intra- and Inter-Governmental Coordination

It is almost a ritual to invite a broad spectrum of local, state and federal agencies to participate in watershed plans, which necessarily involves a lot of coordination meetings. Such coordination is absolutely essential when the watershed in question extends over more than one political jurisdiction. The problem is how to get such a diverse group to do more than just attend meetings. To get an interagency group to share resources and data, develop and endorse the plan, and become true partners in the long-term management process requires strong skills in the art of bureaucratic navigation. One instrument that can help steer the process are political agreements to legitimize the watershed management partnership. In most cases, the first agreement is simply to participate in the process, with few binding obligations or financial commitments. Subsequent agreements may become more formal and detailed over time, reflecting the growing trust and consensus among the participants.

Some subwatershed plans may require less extensive interagency partnerships, since they are entirely contained within a single local jurisdiction. For these subwatersheds, bureaucratic navigation can be confined to local agency coordination, i.e., reaching consensus among the many conflicting units of local government (planning, development review, public works, parks, resource management, transportation, and economic development to name but a few). Each of these units of local government plays a key role in either the formulation or implementation of the subwatershed plan, and needs to be represented in the stakeholder process. Several local governments have organized local interagency workgroups to address overarching issues, using independent facilitators to guide the group toward consensus.

Subwatershed Planning and the Real World

While it is easy to outline what should be done in subwatershed planning, it is obviously much harder to actually make it happen. After all, what community isn't subject to tight budgets, strong development interests, and a planning horizon that extends to the next local election? When local political will is lacking, is the subwatershed management planning protocol described here just a pipe dream? (or for that matter, any watershed approach).

The answer is a somewhat guarded no. The proposed subwatershed protocol represents a new way of thinking about local watersheds that emphasizes practical management tasks. As such, it is not expected to cost more than traditional watershed studies (and possibly less, given that the monitoring effort is often less intensive). In addition, the protocol is oriented to actively engage both stakeholders and the general public to build consensus for the long-term management process. Thus, even if the results of the first management cycle are less than desired, it is possible to improve the plan during the next cycle. If local political currents run strongly against land use controls, the protocol clearly shows the likely long-term changes in stream quality (and provides guidance on how the changes can best be managed).

If watershed planning is ever to become an effective tool to protect streams in the real world, it will be because they incorporate the practical management details that lead to better implementation. The 12 management elements outlined here represent an initial exploration into this new territory.

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