

Developing and Implementing an Integrated Stormwater Management Plan (ISMP)



Chapter Nine

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9.1 Overview of ISMPs

The focus of Part B was on developing integrated solutions at the site level, where the source of stream degradation and flooding problems can be eliminated. The purpose of this chapter is to:

- Show how these site level solutions fit in to a larger watershed context, and are complemented by a range of other watershed protection and flood risk management tools.
- Provide a framework for developing an ISMP. This framework is adapted from a range of BC case study experiences.

In general, an ISMP process must address the following fundamental question:

- How can the ecological values of stream corridors and receiving waters be protected and/or enhanced, and drainage-related problems prevented, while at the same time facilitating land development and/or redevelopment?

Objectives of an ISMP

The objectives of an ISMP will be watershed-specific, but will generally encompass the following:

- **Drainage Objectives** - Alleviate existing and/or potential drainage, erosion, and flooding concerns.
- **Stream Protection Objectives** - Protect and/or restore stream health, including riparian and aquatic habitat.
- **Water Quality Objectives** - Remediate existing and/or potential water quality problems.

The ISMP focus is on the integration of stormwater management and land use planning. An ISMP is an integral component of a local government's land development and growth management strategy because upstream activities (land use change) have downstream consequences (flood risk and environmental risk).

Elements of the ISMP Process

This chapter presents a process for developing an ISMP for a watershed and its constituent drainage catchments. Through this process, watershed stakeholders collectively answer the questions listed below and illustrated as Figure 9-1:

- **“What do we have?”** - understanding the watershed issues
- **“What do we want?”** - setting achievable performance targets
- **“How do we get there?”** - developing an ISMP implementation program

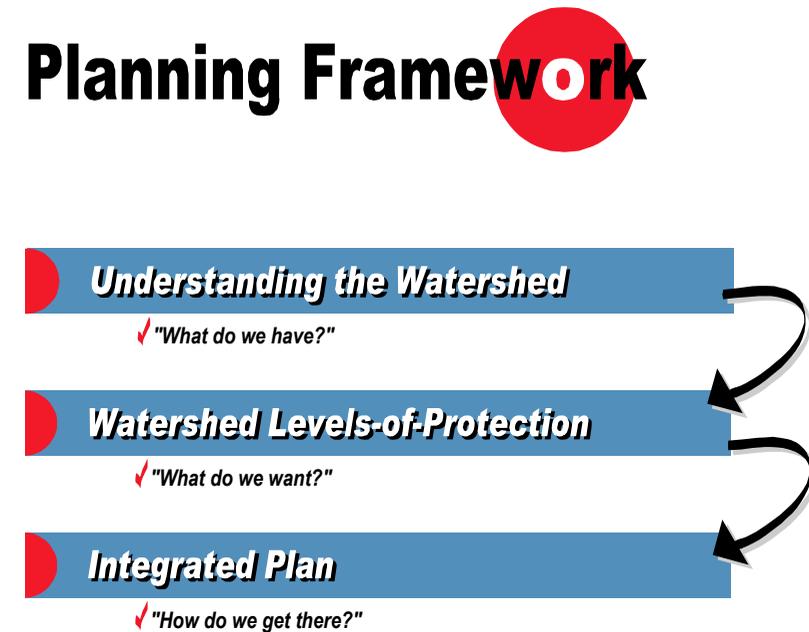


Figure 9-1

Layered Approach to Developing an ISMP

Figure 9-2 conceptualizes the building blocks that are the essence of an integrated approach to stormwater management. It was originally developed to guide an ISMP process for the City of Kelowna.

Figure 9-2 also illustrates how the bridge is built between environmental goals (as defined by community expectations and legislative initiatives) and a stormwater management and stream stewardship strategy (as defined by an ISMP). This involves a layered approach:

- ❑ **First Layer** – Identify the stormwater-related objectives for a watershed (e.g. protection of aquatic resources, protection of life and property, protection of water quality). These objectives define what the ISMP is striving to achieve.
- ❑ **Second Layer** – Develop strategies to achieve the watershed objectives. This includes setting performance targets to guide selection of site design solutions.
- ❑ **Third Layer** – Implement appropriate site design solutions (e.g. source controls) for achieving performance targets that suit local objectives and conditions.

To select appropriate stormwater management strategies and site design solutions, it is first necessary to identify the resources to be protected, the threats to those resources, and the alternative management strategies for resource protection. The foundation for this approach is found in the At-Risk Methodology presented in Chapter 5.

ISMP Technical Products

An ISMP includes three core deliverables or ‘technical products’ – an inventory, component plans, and an implementation program - as shown in the table part of Figure 9-2. These technical products were introduced in Chapter 4.

The distribution of effort among the three products should be balanced. Often effort is concentrated on the inventory phase, and not enough effort is invested in the elements of an implementation program. The best plan, without a sound implementation program, can result in watershed conditions getting worse with time rather than better.

The remainder of this chapter presents the process for developing and implementing an ISMP for either a watershed or its component drainage catchments.

Political Commitment to the ISMP Process

If site level solutions are to successfully fit into a larger watershed context, political will and commitment are essential inputs at two critical points in the ISMP development process:

- ❑ **Launching the ISMP Process** – Unless there is a political buy-in to do things differently, the process will not be effective.
- ❑ **Implementing the ISMP Action Plan** - Political will is crucial if there is to be a move from planning to action.

Integrated solutions transcend technical analyses. This chapter discusses how to secure political support and commitment to first develop and then implement an ISMP. Looking ahead, Chapter 11 elaborates on the ingredients for building consensus and creating change.

Community Expectations and Legislative Initiatives

Community expectations and legislative initiatives provide the driving force for political action to launch the ISMP process. Community expectations are reflected in both an Official Community Plan and a Liquid Waste Management Plan. This is the first building block as shown in Figure 9-2.

ISMP Building Blocks

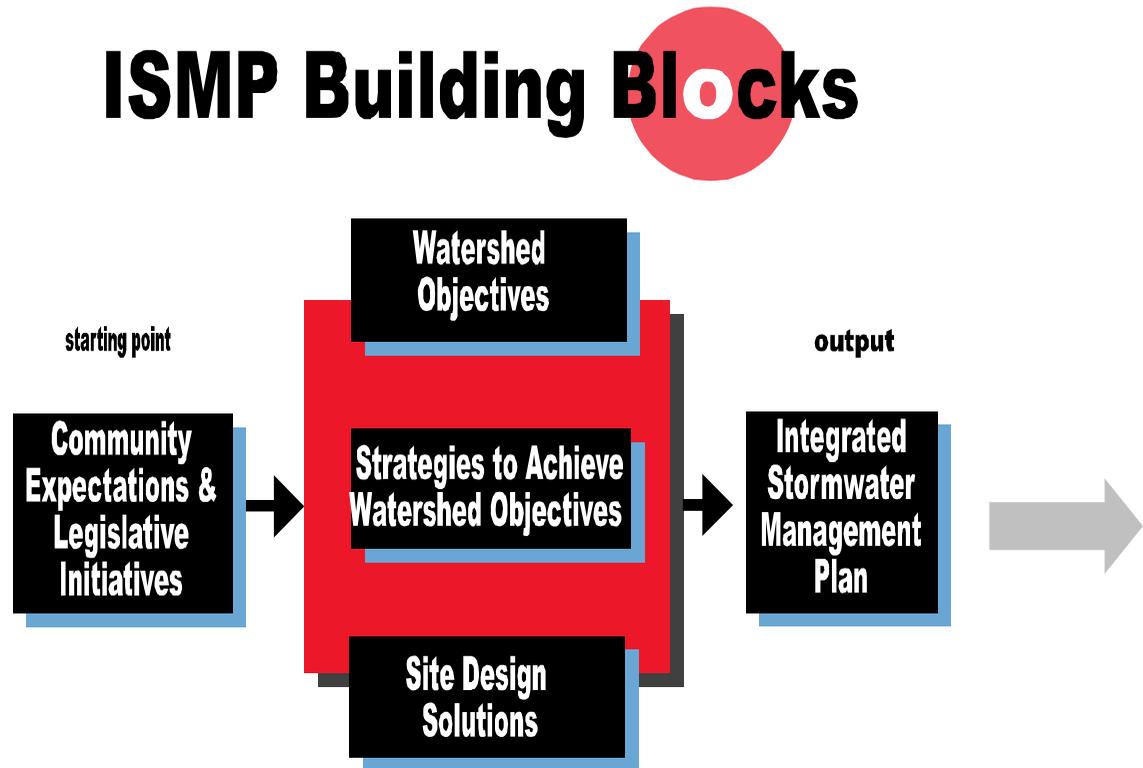


Figure 9-2

ISMP DELIVERABLE	SCOPE OF DELIVERABLE
An inventory of the physical and biological systems	<ul style="list-style-type: none"> • streams, rivers, and drainage systems • wetlands, ponds and lakes • infiltration areas and aquifers • land use information • flooding and erosion problem areas • water quality problems
Component plans to protect key resources, resolve identified problems, and accommodate development	<ul style="list-style-type: none"> • plan for integrating appropriate source controls with land development, including a description of any required regulatory changes • plan for improvements to drainage systems and stream reaches • plan for ongoing data collection and monitoring • cost estimates for all planned actions
An implementation program	<ul style="list-style-type: none"> • administration • projects, phasing and budgets • financing mechanisms • community education • maintenance activities, standards and schedules • performance monitoring

Case Study Example: GVRD Template for ISMPs

The Greater Vancouver Regional District (GVRD) has developed a *Terms of Reference Template for Integrated Stormwater Management Planning* (2002) to provide a standardized process that includes all of the key stormwater components. These are listed in Table 9-1, and are categorized in terms of three disciplines – engineering, planning and environmental. The work effort is organized as four phases:

- ❑ Information Gathering (15 tasks)
- ❑ Analysis (9 tasks)
- ❑ Alternatives (6 tasks)
- ❑ ISMP (5 tasks)

A municipality can decide which components are applicable, and establish the level of effort required based on risk and local conditions. Not all of the components may be relevant for a given watershed or drainage catchment.

*Legend of Codes for ISMP Components

E1	=	Engineering item
P	=	Planning item
E2	=	Environmental item
S	=	Stakeholder/Public Process
I	=	Integration of all disciplines



Table 9-1: ISMP Components (from GVRD Template)

		ISMP Component	Code*
Information Gathering	1	Establish Framework	I
	2	Mapping/Information Gathering	I
	△	Stakeholder/Public Notification & Consultation	S
	3	Hydrometric Data Collection	E1
	4	Drainage System Inventory	E1
	5	Hydrogeology/Geotechnical Assessment	E1
	6	Land Use Information	P
	7	Agricultural Lands	P
	8	Recreation Opportunities & Public Access	P
	9	Biophysical Inventory	E2
	10	Riparian Corridor Assessment	E2
	11	Wildlife Assessment	E2
	12	Benthic Community Sampling	E2
	13	Water Quality Analysis	E2
	14	Baseplan Mapping	I
15	Existing Stormwater Program	I	
Analysis	16	Hydrological Analysis (Tool 1)	E1
	17	Hydraulic Analysis (Tool 2)	E1
	18	Channel Erosion	E1
	19	Agricultural-Upland/Lowland Analysis	E1
	20	Natural Hazard Assessment	E1
	21	Land Use Sensitivity Analysis	P
	22	Recreation & Public Access Analysis	P
	23	Environmental Parameters	E2
	24	Ecological Health Analysis (Tool 3)	E2
Alternatives	25	Flood/Erosion Management Alternatives	E1
	26	Land Use Alternatives	P
	27	Stormwater Management Alternatives	E2
	28	Water Quality Alternatives	E2
	29	Evaluate Alternatives	I
	30	Stormwater Program	I
ISMP	△	Stakeholder/Public Consultation	S
	31	ISMP	I
	32	Implementation Strategy	I
	33	Integrate with Other Municipal Master Plans	I
	34	Develop Adaptive Management Program	I
	35	Draft/Final Report	I
△	Stakeholder/Public Consultation	S	

9.2 Process for Developing and Implementing an ISMP

Figure 9-3 illustrates a seven-step process for developing and implementing an ISMP. The objective is to reach the target condition over time. This process is based on a proven approach to decision making for complex issues. This process underpinned the four ISMP case studies introduced in Table 1-1.

The first six steps ultimately lead to implementation of integrated solutions for a watershed. These steps are described in Sections 9.3 to 9.8. Overcoming barriers in order to get from Step #5 to Step #6 is described in the context of moving from planning to action.

In Step #7, the ISMP process is revisited in a greater level of detail to validate and refine the integrated solutions. Step #7 will involve successive cycles of adaptive management over time. This step is discussed in Section 9.9.

Case Study Example: Brunette Basin Plan and the Stoney Creek ISMP

The Stoney Creek ISMP established a British Columbia precedent for application of all steps in the seven-step process to move from planning at the watershed scale to action at the site level. This was a pilot project that was completed in 1999 as part of the GVRD's Brunette Basin Plan (reference: Table 1-1). Success at each level has been accomplished through a working session process that resulted in a shared vision of what is achievable, both in the short-term and over the long-term.

Develop a Shared Watershed Vision

The Brunette River is an inter-municipal waterway that is managed by the Greater Vancouver Region District. It receives runoff from five cities: Vancouver, Burnaby, New Westminster, Coquitlam, and Port Moody.

The Brunette River Basin Plan was developed through an inter-municipal pilot process for consensus-based watershed planning in the Greater Vancouver Region. All five municipalities agreed to the vision, goals and objectives for catchments within the Basin. To

determine how to achieve the shared watershed vision, the Stoney Creek catchment was selected as a pilot program for ISMP development.

Selecting an At-Risk Drainage Catchment

Stoney Creek was selected for three reasons: it has the highest value aquatic resources; these resources are at risk due to pending residential development in the Burnaby Mountain headwaters; plus it has an active and proactive streamkeeper group. The Stoney Creek pilot program was also directed by an inter-municipal and inter-agency Steering Committee.

The purpose of the pilot program was to test the principles of a watershed-based approach to integrating stormwater and riparian corridor management. The Stoney Creek process resulted in a philosophy and hydrologic criteria for watershed protection and restoration over a 50-year timeline. By consulting the streamkeeper group and applying their expert knowledge, an aquatic habitat rating was established for each creek reach. The critical reaches drove selection of the plan elements for stormwater management.

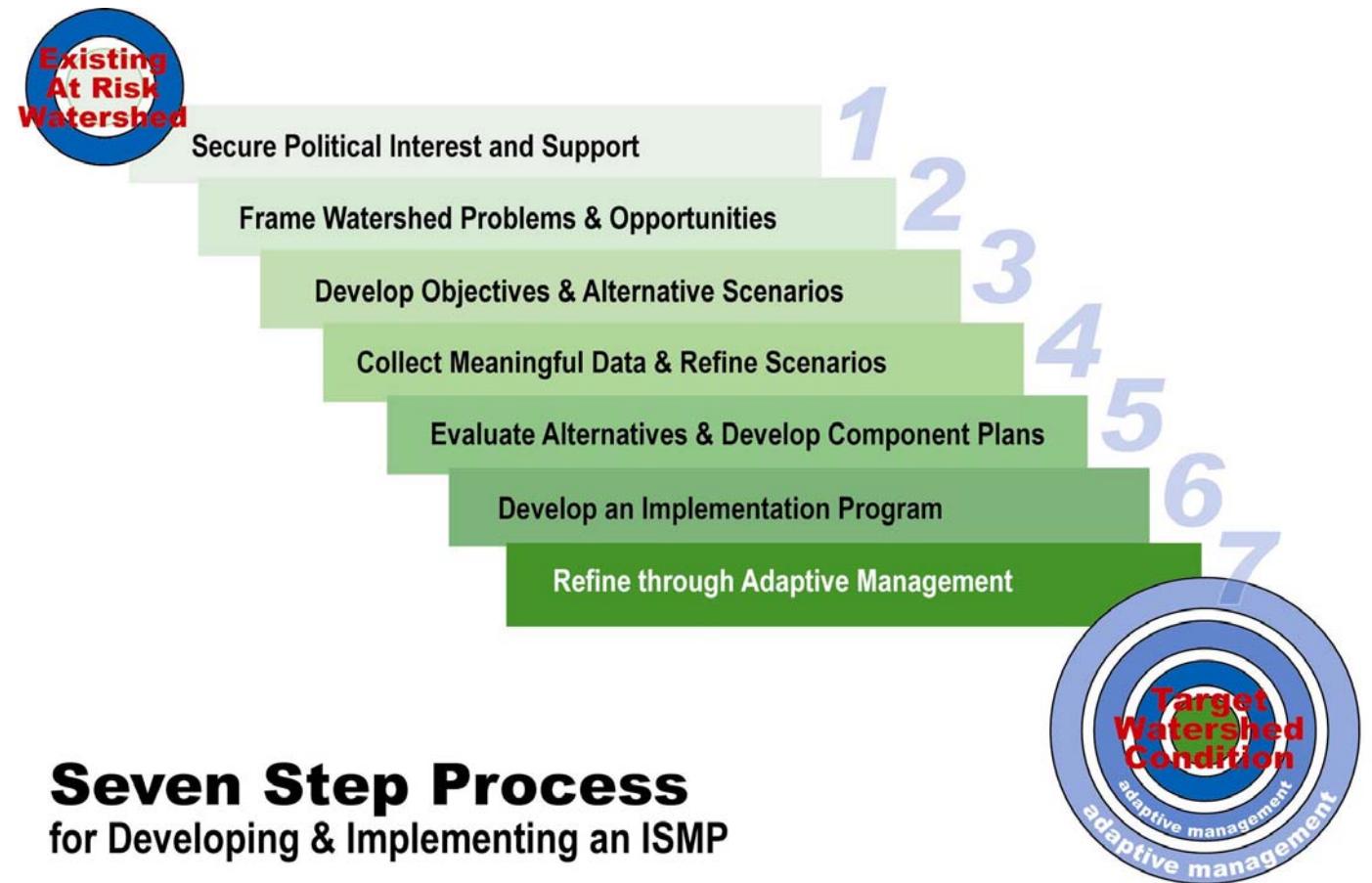
Protect the Natural Water Balance at the Site Level

A high-density urban community for 10,000 people is being built at the top of Burnaby Mountain, the headwaters of Stoney Creek, over a 20-year period. Hence, this is where early action has been focused to blend policy, science and site design. The resulting *Burnaby Mountain Watercourse and Stormwater Management Plan* (2002) is a pilot project for stormwater volume reduction at the source. The Plan has been developed under the umbrella of an inter-agency advisory committee. The Plan:

- translates the Stoney Creek vision and hydrologic criteria into performance targets and design criteria that are being applied at the neighbourhood level
- translates the performance targets and criteria into specific stormwater management and site design practices

The performance of the Burnaby Mountain stormwater management system will be monitored as development proceeds. In this way, stormwater management and site design practices can be improved for future development within the Brunette Basin, and elsewhere.

Step	Description and Scope
1	Secure Political Interest and Support <ul style="list-style-type: none"> ❑ Inter-departmental & inter-agency steering committee ❑ Political and public support ❑ Stakeholder focus groups
2	Frame the Watershed Problems and Opportunities <ul style="list-style-type: none"> ❑ Assemble existing information ❑ Identify and prioritize problems (knowledge-based approach)
3	Develop Objectives and Alternative Scenarios <ul style="list-style-type: none"> ❑ Establish desired levels of environmental protection and other objectives ❑ Set appropriate performance targets ❑ Model alternative scenarios for achieving targets
4	Collect Meaningful Data and Refine Scenarios <ul style="list-style-type: none"> ❑ Collect data needed to: <ul style="list-style-type: none"> ▪ refine scenario models ▪ evaluate effectiveness and affordability ▪ e.g. hydrometric data, soils data
5	Evaluate Alternatives & Develop ISMP Component Plans <ul style="list-style-type: none"> ❑ Land Development Action Plan ❑ Habitat Enhancement Plan ❑ Flood Risk Mitigation Plan
6	Develop an Implementation Program <ul style="list-style-type: none"> ❑ Finance and implement ISMP actions
7	Refine Through Adaptive Management <ul style="list-style-type: none"> ❑ Define adaptive management rules, roles and responsibilities ❑ Constantly improve integrated solutions



Seven Step Process
for Developing & Implementing an ISMP

Figure 9-3

9.3 Step #1: Secure Political Interest and Support

An ISMP process starts with a high-level political commitment to protecting property, water quality and aquatic habitat. This policy commitment is made through an over-arching OCP and/or LWMP. Step #1 in the actual ISMP process is to convert high-level policy statements into concrete action so that there will be a flow of funding for the ISMP process.

To accomplish this objective requires a different level of political support, especially when there are multiple watersheds and the financial commitment is multi-year. Without political support for funding, there will be no ISMP process. Once funding is assured, however, a key to a successful outcome is that there be a commitment by all stakeholders to make the ISMP process work.

Framework for ISMP Process

Before elected officials can be expected to commit to a long-term investment in an ISMP process for multiple watersheds, local government managers must be able to provide a clear and convincing case that answers four questions:

- ❑ Why do it?
- ❑ What will it cost?
- ❑ What are the benefits?
- ❑ Why should this take priority over other community needs?

These questions are best addressed through front-end development of an over-arching or framework document that:

- ❑ Defines a drainage planning philosophy
- ❑ Formulates a set of supporting policy statements
- ❑ Establishes design criteria to achieve the policies

This approach provides elected officials with an informed basis for making the decision to fund and proceed with the first ISMP (Step #2). The purpose of the over-arching document is to demonstrate to elected officials that there has been stakeholder input, that stakeholders have endorsed the process, and that stakeholder input is reflected in the policy content.

Case Study Example: City of Chilliwack Surface Water Management Manual

The City of Chilliwack has developed a *Policy and Design Criteria Manual for Surface Water Management* (2002) that serves two purposes:

- ❑ **At the Watershed Scale** - Provides a comprehensive framework that will guide the development of individual ISMPs over a multi-year period.
- ❑ **At the Neighbourhood and Site Scales** - Provides land developers with specific direction in undertaking the stormwater component of sustainable urban design.

The Manual was developed and vetted through an inter-departmental and inter-agency process that also included community participation. It took nine months to complete, and culminated with an interactive session with Chilliwack City Council.

The Manual presents key information that elected officials, City staff, and land developers need in order to understand and implement the City's approach to stormwater management. The Manual includes a five-year Action Plan for removing barriers and undertaking ISMPs.

Case Study Example: Regional District of Nanaimo Action Plan

Chapters 4 and 5 described how the stormwater component of the Regional District of Nanaimo's (RDN) Liquid Waste Management Plan was developed through a roundtable process. This resulted in a five-year Action Plan for gradual phase-in of stormwater management.

At the end of the five-year period, the RDN will have developed a clear understanding of appropriate stormwater management approaches that are customized to the local environment and are acceptable the development community.

The objective of the RDN is to take small steps that build community and political support for undertaking ISMPs. It is proposed that a pilot ISMP be completed in year four.

Time-Frame for Launching an ISMP Process

The RDN timeframe is consistent with the experience of Chilliwack and other communities. It typically takes 3 to 5 years of sustained effort for local government to generate the momentum needed to launch a new program. In part, this reflects the budget cycle. When a need is first identified, it may take a year or two to obtain initial funding. There are often delays in funding subsequent steps in the process.

Communicating Relevant Information to Elected Officials

Securing political approval and commitment to proceed to Step#2 requires that the need for action be communicated in clear and concise terms. Presented below is an example of a single page synopsis of the supporting rationale for a Resolution by Council to adopt an Action Plan that will guide City of Chilliwack staff for the next five-year period.

Case Study Example: City of Chilliwack Staff Report

- ❑ **Manage the Complete Spectrum of Rainfall Events** – The City’s approach to stormwater management is evolving, from a reactive approach that only dealt with the consequences of extreme events, to one that is proactive in managing all 170 rainfall events that occur in a year. The objective is to control runoff volume so that watersheds behave as though they have less than 10% impervious area.

Reducing runoff volume at the source – where the rain falls - is the key to protecting property, habitat and water quality.

- ❑ **Five-Year Action Plan for Integration of Stormwater Management and Land Use Planning** – In 2000, Council accepted a Process Flowchart and Timeline for moving forward with master drainage planning. The Manual is a milestone in that process. It identifies and organizes the actions required over the next five years to achieve the City’s stormwater management objectives.

Implementation of regulatory change should proceed on a phased-in basis, with ISMPs providing a mechanism to study, test and adapt proposed regulations to suit the range of needs and conditions in Chilliwack.

- ❑ **Submission Requirements for Land Development Projects** – To provide clarity and conciseness regarding the City’s expectations and requirements for subdivision design, the Manual defines the technical information that land developers must submit to the City in order to obtain development approvals. The Manual also includes Design Guidelines that illustrate how to comply with performance targets for stormwater source control, detention and conveyance.

Having a comprehensive checklist will help proponents think through the drainage details of project implementation, and will ensure consistency in the way information is presented for review and evaluation by the City.

Leadership and Inter-Departmental Commitment

Leadership is established through the formation of a Steering Committee that has inter-departmental representation. Also, there must be a champion within local government (refer to Chapter 11) to provide the energy and organizational drive needed to move the ISMP process through the various steps.

The integration of disciplines and departmental objectives must be the beginning and foundation of any ISMP. Only then should each discipline focus on its specific analytical skills and tools.

The objective is to benefit from the synergies that result from brainstorming and the sharing of interdisciplinary perspectives. Thus, it is important to create an atmosphere that is conducive to free thinking and open discussion.

Too often the reverse is used where disciplines work independently, and at best integration becomes merely a lateral process or something added at the end to appease stakeholders.

Stakeholder Involvement

Because of the implications for land use planning and aquatic habitat, senior government agencies and other affected stakeholders need to be represented in the ISMP development process. Chapter 11 elaborates on how to involve stakeholders in a Focus Group so that they can contribute to development of integrated solutions.

Looking ahead to Chapter 11, the stakeholder involvement process is described as the second track in a ‘Two-Track Approach’ because technical analysis feeds into working sessions with the Steering Committee and Focus Group.

9.4 Step #2: Frame the Watershed Problems and Opportunities

Step #2 is critical. This involves application of an interdisciplinary roundtable process (refer back to Chapter 5) to identify and rank the problems and opportunities in a watershed. Sufficient time must be invested at this stage to ensure that there is a clear understanding of the problems to be solved. This understanding will then guide the rest of the ISMP process.

All too often, technical people go directly to Step #4 (Collect Data) without first asking what they are trying to accomplish, and why. As a result, they solve the wrong problem, and then wonder why elected officials and/or the public takes issue with the proposed solution.

Applying a Knowledge-Based Approach

It is important to identify where problems are in relation to areas where future land use change is likely (new development or re-development), because land use change can:

- ❑ create or exacerbate stormwater-related problems (e.g. degrade aquatic resources or increase flooding risk)
- ❑ present opportunities to restore stream health, improve water quality, or reduce drainage-related problems through the application of source controls

The knowledge-based approach described in Chapter 5 should be applied to determine what the existing and/or potential problems and issues are in a watershed, and the level of concern related to these problems and issues.

Existing knowledge and information about a watershed should be adequate to determine where in the watershed there are general indicators of existing or potential problems, such as:

- ❑ flood hazards
- ❑ stream channel erosion
- ❑ aquatic habitat degradation
- ❑ water quality deterioration

The roundtable approach relies on the knowledge of local residents and key experts (from the planning, ecology and engineering disciplines), combined with a local government's existing information on land use, aquatic resources and drainage systems.

Making Use of Available Information

Available information can and should be used to provide a better understanding of the watershed. The following information is useful in helping to define the watershed issues and frame the problems:

- ❑ **Watershed Base Map** - the first building block
- ❑ **Watershed Issues Summary** - where and what are the identified problems
- ❑ **Sensitive Ecosystem Inventory** - what is to be protected
- ❑ **Land Use Map** - what are the existing and future generators of runoff
- ❑ **Drainage System Inventory** - how the conveyance system functions
- ❑ **Concurrent Rainfall and Streamflow Data** - how the watershed responds to rainfall
- ❑ **Soils and Groundwater Maps** – where might infiltration be feasible

The foregoing are the core deliverables resulting from Step #2. This set of graphics provides a picture of the watershed. Visual presentation helps develop a common understanding among ISMP participants. Section 9.5 explains why this is so.

All available information should be assembled at this stage to help frame the problems, but further investment in data collection should not be made at this stage. Once watershed objectives and catchment-specific performance targets are established (see Step #3), the investment in data collection can be directed where it will be most useful and effective. Data collection is discussed in depth in Step #4.

Broad-Brush Ranking of Issues

In Step #2, the approach is broad-brush. The objective is to create understanding and an intuitive feel for conditions in the watershed. This will then guide follow-up investigations that achieve greater levels of detail where it is required.

An outcome of Step #2 should be a preliminary ranking of watershed issues. This ranking would reflect a generalized assessment of questions such as: Is flooding the dominant concern? Or is it aquatic habitat degradation? Is water quality a real or perceived problem? Where can existing and/or potential problems be turned into opportunities?

Case Study Examples: Creating a Picture of Stream Habitat Conditions

The evolving science of stormwater management has broadened the traditional engineering approach to one that integrates flooding and aquatic habitat concerns. Whereas flooding and erosion problems are normally obvious to all, habitat concerns can be subtle in nature. Hence, assessing aquatic habitat at an overview level is a key part of framing the problems in a watershed. This helps to focus subsequent effort.

The Bear Creek and Stoney Creek case studies introduced in Table 1-1 resulted in development of a five-task process for creating a reach-by-reach picture of aquatic habitat conditions. This process applies the knowledge-based approach described in Chapter 5, and goes to another layer of detail in assessing conditions reach-by-reach. The desired outcome is a mapping tool that serves two purposes - planning and communication.

- ❑ **Task #1 - Develop an Ecosystem Overview:** Review all existing biophysical information for stream corridors.
- ❑ **Task #2 – Identify and Fill Critical Data Gaps:** Fill any critical information gaps with a reconnaissance inspection of specific locations or reaches.
- ❑ **Task #3 – Create a Planning Tool:** Prepare an overview map of the stream that identifies spawning and rearing habitat and highlights aquatic habitat concerns related to readily apparent sedimentation and erosion, barriers to fish movement and point sources of pollution.
- ❑ **Task #4 - Prioritize Ecosystem Values:** Convene a workshop for individuals with practical, hands-on experience in the watershed to refine the stream map and build consensus on stream corridor and/or aquatic habitat values and threats.
- ❑ **Task #5 - Integrate Ecosystem Values:** Analyze and integrate the habitat and fisheries constraints with the engineering requirements and a land use map that breaks the stream into reaches for stormwater planning.

Task #4 is pivotal as it provides the foundation for the habitat component of an ISMP. To build local government commitment and secure financial support for habitat protection and/or enhancement initiatives, it is first necessary to demonstrate what is to be protected, and why.

9.5 Step #3: Develop Objectives and Alternative Scenarios

Step #3 involves further application of the interdisciplinary roundtable process to:

- ❑ determine which problems and/or opportunities are priorities for action
- ❑ establish objectives for dealing with these priority problems/opportunities
- ❑ develop alternative scenarios for achieving the objectives

Developing a common understanding among participants in the ISMP process is key to developing a shared vision of what is desirable, practical and achievable.

Developing a Shared Vision

People typically learn best in one of three ways: either by seeing, by hearing or by doing. Hence, it is important to use a variety of communication techniques to ensure clarity of understanding. Looking ahead, Chapter 11 elaborates on this topic. In general, a common understanding is achieved in a workshop setting by:

- ❑ illustrating concepts through the use of graphics
- ❑ guiding individuals to blend concepts with their own experience

The graphic presented on Figure 9-4 translates scientific findings on the impacts of land use change into a decision making tool for stormwater goals and objectives. It illustrates the consequences for stream corridor ecology of various attitudes towards stormwater management.

Figure 9-4 was at the heart of the stakeholder visioning process for all four ISMP case studies introduced in Table 1-1. Participants were provided with clear visual choices regarding a desired ISMP outcome.

To reach consensus on a shared vision of what is desirable and achievable for watershed protection, ISMP participants need a picture of what a stream corridor could and/or should look like. Figure 9-4 fulfils this need. The visioning process boils down to whether or not a stream corridor will have a functioning aquatic ecosystem.

ALTERNATIVE VISIONS FOR THE LONG-TERM ENVIRONMENTAL HEALTH OF STREAM CORRIDORS

Conceptual Framework for Selection of ISMP Level

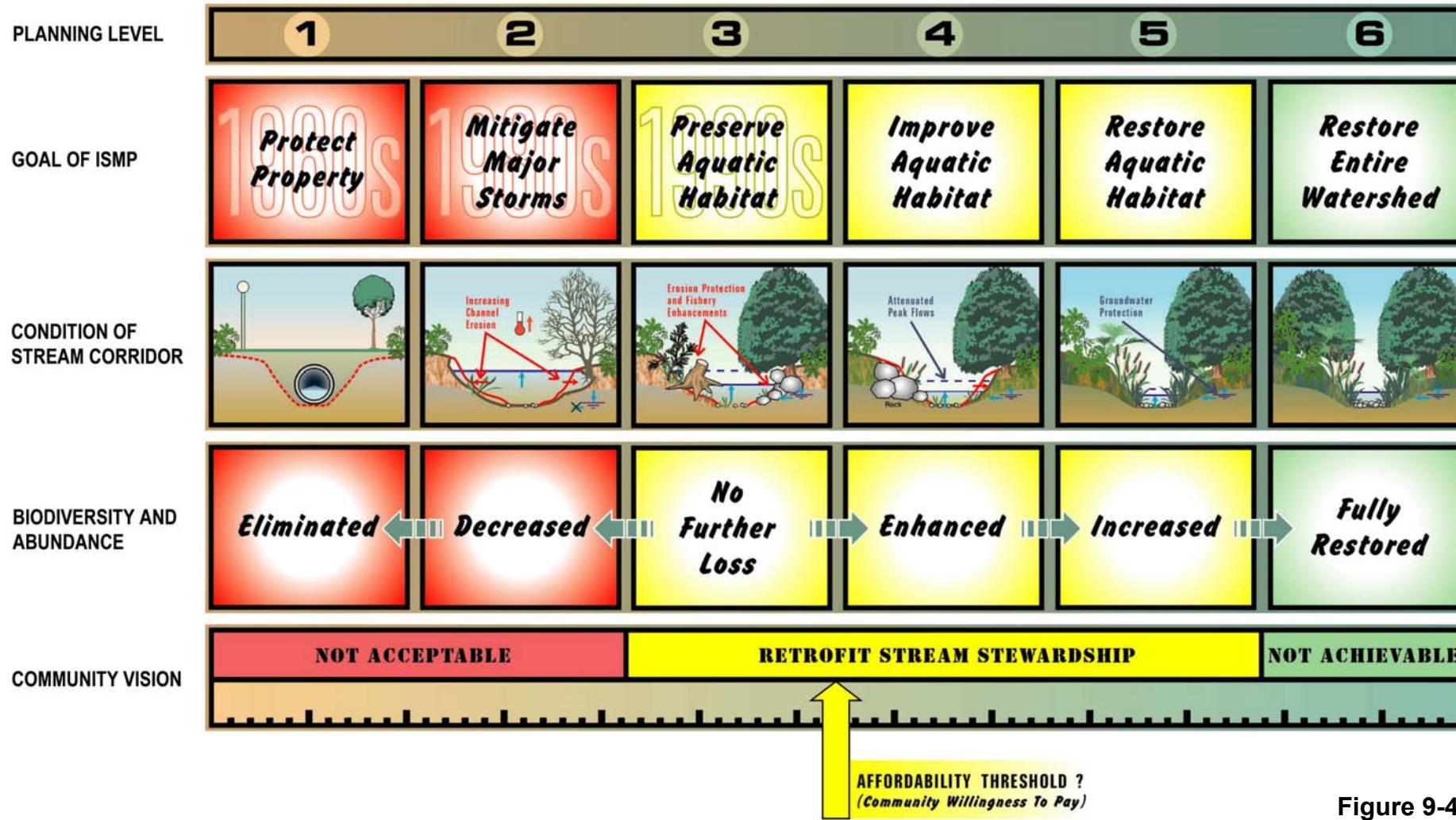


Figure 9-4

Identify Alternatives and Make Choices

Figure 9-4 captures the evolution of drainage planning philosophy over the decades for watersheds that include some prior development. It provides a framework for defining strategic objectives and identifying management practices for achieving those objectives.

Figure 9-4 provides a starting point for an interdisciplinary roundtable to make choices and agree on a guiding philosophy for integrated stormwater management for specific watersheds. It can also be employed to assess whether technical solutions are environmentally and politically acceptable. The choices can be considered to lie on a spectrum of:

(Allow to) Worsen ←-----"Hold the Line" -----→
Improve

The process of determining an appropriate shared vision balances what is desired (or ideal) with what is technically feasible, affordable and politically palatable.

Integration of Aquatic Habitat Condition Assessment

The results of the five-task aquatic habitat condition assessment in Step #2 provide both a frame of reference and a starting point for scenario development in Step #3. The reach-by-reach picture enables ISMP participants to ask two questions:

- Where are we now?
- Where do we wish to be in future?

In general, priority effort should generally be directed where the best habitat is threatened by pending or potential land use change.

Starting Point for an Action Plan

For developed watersheds, Level 3 (from Figure 9-4) would be the likely starting point for an action plan, with the objective of moving from left to right over time (i.e. to improve conditions).

For an undeveloped watershed, the starting point would likely be Level 5, with the objective of 'holding the line' to preserve and protect existing habitat values in the short term, with restoration of aquatic habitat over the long term.

Case Study Example: Scenarios for Stoney Creek ISMP

Based on Figure 9-4, the alternative watershed visions listed below were defined for Stoney Creek:

- **SCENARIO A - Status Quo Strategy for Stream Management (Level 2)**
Maintain the status quo for local government decision making around development practices. Existing regulations and procedures would continue, and habitat values would continue their present downward trend.
- **SCENARIO B - Hold the Line and Accommodate Growth Strategy for Stream Management (Level 3)**
Sustain existing environmental conditions as development and re-development proceeds, with associated additional program requirements and financial costs.
- **SCENARIO C - Enhance Aquatic Conditions and Accommodate Growth Strategy for Stream Management (Level 4)**
Enhance existing aquatic environmental conditions, but at substantial additional cost for regional facilities and increased requirements for on-site facilities to manage stormwater from new development and redevelopment.

The application of these scenarios to make decisions is discussed next. These scenarios provided the basis for Resolutions by all three City Councils that embraced Scenario B as the 20-year vision, and Scenario C as the 50-year vision.

Case Study Example: Evaluate Scenarios and Make Choices

Table 9-2 is the Stoney Creek example of how to apply a decision making matrix for evaluating alternative scenarios. The decision criteria are the management objectives. To decide which level of environmental protection is preferred, the decision maker must determine how well each scenario achieves each objective and balance the trade-offs and conflicts.

With the matrix, each criterion can be considered for each scenario and the results can be visualized, compared and recorded. In a workshop setting, roundtable participants can evaluate and discuss each alternative and select a preferred approach.

Because data are often limited, and in view of the complexities of dealing with natural systems, each decision maker has to rely in part on his/her own informed, professional judgement to evaluate the alternatives.

Adding the Dimension of Time

Change takes time. What is not achievable in the next five years may be quite achievable over fifty years. Integration of stormwater management with land use planning involves a timeline. General time-related objectives can be defined as follows:

- ❑ **20-Year Vision (Preservation)** – Develop policies and implement demonstration projects that show how to succeed in achieving stream preservation (i.e. ‘hold the line’), thereby building support for the 50-year vision to improve watershed and stream conditions.
- ❑ **50-Year Vision (Improvement)** – Continue to implement changes in land use and regulation that mitigate changes in hydrology at the source (i.e. improve conditions), thereby enabling watershed protection/restoration and lasting stream improvement.

Ongoing monitoring and assessment of progress towards a long-term vision will improve the understanding of how to blend policy, science and site design to achieve the shared vision for property, water quality and habitat protection. Building on initial successes, local governments may well decide to advance the schedule and strive for improvement within the 20-year horizon.

Table 9-2 Decision Criteria to Select Strategies for Stream Management

OBJECTIVES OR DECISION CRITERIA		IMPORTANCE?❶	HOW WELL DOES EACH SCENARIO ACHIEVE EACH OBJECTIVE?❷		
			SCENARIO A (LEVEL 2)	SCENARIO B (LEVEL 3)	SCENARIO C (LEVEL 4)
As Established by the Brunette Basin Task Group			STATUS QUO, CONTINUED DECLINES IN FISH	HOLD THE LINE, SUSTAIN TROUT AND HATCHERY SALMON	ENHANCE HABITAT, SUSTAIN WILD SALMON
1.	Protect or enhance biodiversity	very important	low	medium	high
2.	Protect or enhance aquatic habitat*	very important	low	medium	high
3.	Protect or enhance terrestrial habitat	moderate importance	low	medium	high
4.	Enhance recreation opportunities	moderate importance	low	medium	high
5.	Minimize health and safety impacts	very important	high	high	high
6.	Minimize total costs	very important	high (no change in existing costs)	medium (increased costs)	low (high cost)
7.	Minimize property damage	very important	medium	high	high
8.	Increase scientific and management understanding	least important	medium	high	high
9.	Increase opportunity for public learning	least important	medium	high	high

❶ Three judgmental choices are provided for rating each objective: very important, moderate importance, and least important.
❷ Three judgmental choices are provided for rating each scenario: low, medium and high.

Using Performance Targets to Quantify Watershed Objectives

Performance targets provide a quantifiable way of measuring success in protecting (or restoring) a watershed, and for identifying what needs to be done to achieve a given environmental protection objective.

- ❑ Desired protection objectives for significant stream reaches should be translated into performance targets for the catchments draining into those reaches. For example, to maintain or restore the health of a stream reach, an appropriate performance target would be to limit the volume of runoff from land uses in the drainage catchment to 10% or less of total rainfall volume.
- ❑ For catchments upstream of drainage ‘hot spots’ (e.g. chronic flooding locations), a more appropriate performance target may be to reduce peak runoff rates from large rainfall events (e.g. 5-year storms).
- ❑ Other performance targets relating to the preservation/restoration of significant natural features (e.g. riparian forests, wetlands), measurement of stream health (e.g. B-IBI), protection/improvement of water quality, or instream enhancements (e.g. for habitat or fish passage) should also be established.

A key principle is to establish performance targets that relate directly to the watershed objectives. Refer back to Chapter 6 for further guidance on setting performance targets.

The selected targets should also be monitored over time to ensure that the ISMP is achieving the desired results. Refer to Section 9.9 for more detail on this topic.

Setting Performance Targets

To establish realistic performance targets for a given watershed, an ISMP must answer questions such as those introduced in Chapter 6 and reiterated below:

- ❑ What is the existing level of annual runoff volume? What percentage of total annual rainfall volume does it represent? What is the existing Mean Annual Flood (MAF)?
- ❑ What are acceptable levels of runoff volume and rate in terms of flood risk and environmental risk? What are the consequences of increased or decreased flows related to land development? Are these consequences acceptable?

- ❑ What actions are needed to avoid flooding or environmental consequences?
- ❑ How can the necessary actions be staged over time?
- ❑ Are the targets to maintain 10% runoff volume and maintain the natural MAF necessary or achievable over time? If not, what levels are?

Modeling Alternative Scenarios

Scenario modeling can be used to assess a range of performance targets, and evaluate options for achieving these targets.

Scenario modeling involves consideration of the complete spectrum of rainfall events that typically occur in a year. (Refer back to Chapter 6 for further details regarding the three tiers.) An integrated approach to managing these events comprises three components:

- ❑ retain the small events (Tier A) at the source,
- ❑ detain the large events (Tier B) in detention facilities
- ❑ safely convey the extreme events (Tier C)

Relationship of Rainfall Spectrum to Watershed Objectives

The balance between the above three components depends on the watershed objectives.

- ❑ Stream protection/restoration objectives would likely govern scenarios that emphasize source control (e.g. infiltration, rainwater re-use), along with other possible options, such as riparian corridor protection.
- ❑ Flood management objectives would likely govern scenarios that place more emphasis on detention and conveyance.

The key is to determine which scenario or blend of scenarios has the best ‘fit’ to address a range of watershed objectives.

A key aspect of scenario development will be to consider what can be done at the site level to retain the small events, given constraints such as soil conditions, hydrogeology, topography and land use. Further data collection may be required to assess the feasibility of achieving performance targets (see Step #4).

Modeling Hierarchy

A computer model is a decision support tool. A model can help evaluate alternative scenarios, but it does not make decisions. Sometimes there is a tendency to over-emphasize the value of modeling. The reliability of model output depends on the quality of the input data, and especially on the judgement of the modeler in making critical assumptions.

A fundamental principle is that the level and/or detail of modeling should reflect the information needed by decision makers to make an informed decision. The modeler must always take a step back and ask three key questions:

1. Why is the model being built?
2. How will the model be applied?
3. What problems will the model help us solve?

Figure 9-5 illustrates the four main levels (or applications) of drainage modeling. Moving down the pyramid reflects an increasing level of detail, and hence investment of resources.

At this stage of the ISMP process, modeling should be at a strategic (i.e. conceptual or overview) level to provide basic information to support the decision making process.

Modeling tools take on added importance once the focus shifts to the functional planning and design of proposed stormwater management facilities. More data is required at this level of modeling.

Data Requirements for Strategic Level Scenario Modeling

Continuous rainfall data (in time increments of one hour or less) is the key data requirement for scenario modeling. Ideally, site-specific rainfall data should be used, but even data from a location with similar rainfall characteristics can be used at this stage.

At this strategic level of modeling, the other model inputs (e.g. regarding land use and soil conditions) should be estimated based on the best available information (assembled in Step #2). Where there is high degree of uncertainty regarding certain parameters, a range of assumptions may be tested, and data collection efforts can then be targeted to refine these assumptions (see Step #4).

The appropriate type of modeling will depend on the characteristics of the scenarios being modeled, as discussed on the following page.

Modeling Hierarchy

Policy Evaluation
Strategic Decisions
Master Plans

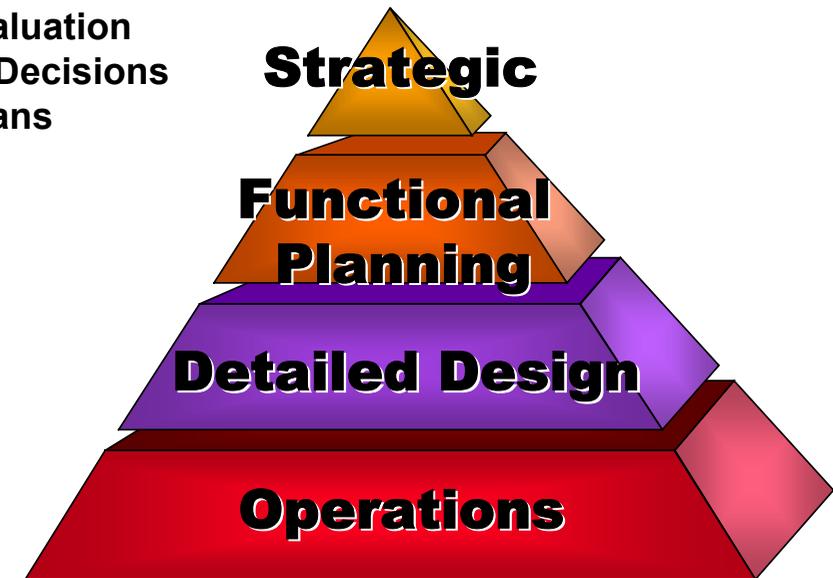


Figure 9-5

Types of Modeling: Single Event versus Continuous Simulation

There are two types of modeling: ‘single event’ and ‘continuous simulation’. Single event typically means a storm duration up to 24 hours. Continuous simulation typically covers a year or a multi-year period, with time-steps up to 1 hour. Their respective applications are summarized as follows:

- ❑ **Single Event Modeling** – acceptable for most applications of Tier C flood risk management
- ❑ **Continuous Simulation Modeling** – required for Tier A rainfall capture, Tier B runoff control, and some applications of Tier C flood risk management

For both types of modeling, measured rainfall data (rather than artificial ‘design storms’) should be used as input data. Refer back to Chapter 6 for further discussion on the three rainfall tiers.

Continuous Simulation for Source Control (Tier A) and Detention (Tier B)

The distinction between Tier A and Tier B modeling is that Tier A requires volume-based thinking, whereas Tier B involves flow-based thinking. Conventional modeling packages are flow-based, and thus most appropriate for modeling detention (Tier B) and conveyance (Tier C) scenarios.

Models may be hydrologic (i.e. simulate runoff response), hydraulic (i.e. perform flow routing functions), or both. A selection of flow-based models is provided below for reference purposes. The appropriate model type depends on the scenario being modeled.

Model Name	Does it have Continuous Simulation Capabilities?	Is it a Hydrologic and/or Hydraulic Model?
HEC-1	No	Hydrologic
HEC-RAS	No	Hydraulic
HYDSYS	No	Both
OTTHYMO	No	Hydrologic
QUALHYMO	Yes	Hydrologic
HSPF	Yes	Hydrologic
SWMM	Yes	Both
MOUSE	Yes	Both

Note that the level of effort and amount data required to apply these models is highly variable. Some of these models require a high level effort, which may not be suitable for scenario modeling applications at the strategic level. The GVRD ISMP Template provides further details on these models.

Because Tier A simulation is volume-based, it is described as Water Balance modeling (refer back to Chapter 7 for further details). Since the focus of stormwater source control is on runoff volume reduction, Water Balance Modeling is most appropriate for source control scenarios. The Water Balance Model (WBM) is an example application (refer back to Chapter 7 for details).

Source Control Scenario Modeling

Whereas the use of conveyance and detention are relatively well understood stormwater management strategies, the use of source control is less well-known. Discussion among ISMP participants is likely to focus on whether source controls are effective or practical in the context of watershed-specific conditions.

Generating source control scenarios through Water Balance modeling can be a critical tool in informing this discussion (refer back to both Chapters 7 and 8).

Model scenarios can provide guidance for selecting source control options to achieve catchment-specific performance targets. Further data collection should focus on collecting the information needed to determine whether these options are achievable (see Step #4). For example, if infiltration is identified as an option for achieving performance targets in a particular drainage catchment, a key information need would be to determine soil conditions in that catchment.

Flood Management Scenario Modeling

The primary purpose of modeling for flood management purposes (i.e. Tier C) is to assess the conveyance capacity of drainage facilities installed at stream crossings. The level of preciseness in quantifying design flows is not critical because rated capacity is not the governing consideration.

Physical adequacy normally governs the acceptability of a drainage installation (refer back to Chapter 6). Hence, the real purpose in comparing design flows to rated capacities is to provide a relative measure of the degree of risk. This comparison helps elected officials make decisions to invest in drainage facility upgrades and/or replacement.

For certain flood management scenarios, continuous simulation modeling would be more appropriate. For example, continuous simulation would be needed to provide an idea of the extent and duration of flooding over an extended period of time under different detention and/or flow conveyance scenarios.

9.6 Step #4: Collect Meaningful Data and Refine Scenarios

Step #4 is to collect the additional data that may be needed to evaluate the effectiveness, feasibility and affordability of implementing the scenarios identified in Step #3 for meeting watershed objectives.

This step may involve collecting site-specific data to refine the assumptions of the scenario models generated in Step #3 (e.g. site-specific data on soils or drainage system components).

Be Strategic When Investing in Data Collection

The level and/or detail of data collection should reflect the information needed by the decision maker to make an informed decision. This principle is framed by these three questions:

- ❑ Why do we need the data?
- ❑ How will the data be applied?
- ❑ What problems will the data help us solve?

The impacts of changes in land use are generally understood. At this point, the investment in data collection needs to be strategic. We know that restoring the natural Water Balance and hydrology is required to address the source of stormwater-related problems. Data collection should focus on improving understanding of how to do so in the context of local conditions.

Before investing in data collection, there needs to be a clear understanding of the methodology to ensure that data collection is done right. Consistency and rigour are important to allow the data to be used as a baseline for comparison with future data.

Concurrent Rainfall and Streamflow Data

Having reliable rainfall and streamflow data is the key to a performance-based approach to ISMP development, implementation and effectiveness monitoring.

The minimum requirements are a streamflow station at the drainage outlet of watersheds or catchments of concern, and a strategically located rainfall station.

Concurrent and continuous records of rainfall and streamflow data provide a picture of the characteristic rainfall-runoff response of a neighbourhood, a drainage catchment or a watershed. Having a picture creates understanding. Understanding is required for two conditions in particular:

- ❑ ‘rainfall-runoff response’ during wet weather periods
- ❑ ‘runoff decline’ during dry weather periods

The latter is key to baseflow analysis. Baseflow availability is likely to be the limiting factor for fish survival in small streams during dry weather periods.

Rainfall and streamflow data play a key role in an adaptive management program (see Step #7 and also refer back to Chapter 6). Monitoring the change in rainfall-runoff response as land development progresses in a catchment will indicate the effectiveness of site design solutions.

Concurrent rainfall and streamflow data is also needed to calibrate and verify computer models. This is key to refining the scenarios developed in Step #3.

Streamflow Data from Undeveloped Catchments

Monitoring streamflow in undeveloped catchments (i.e. under natural conditions) provides valuable information because it defines the target hydrograph. The key objective for the design and operation of stormwater systems is to replicate this target hydrograph as closely as possible in catchments where development is occurring.

Streamflow data from undeveloped catchments also provide the best basis for establishing release rates for detention facilities (refer back to Chapter 6). Monitoring also provides a baseline for evaluating any future changes in hydrology due to development in these catchments.

Data on Soils and Groundwater

Soil and groundwater conditions govern the feasibility and affordability of using infiltration facilities to meet catchment-specific performance targets for runoff volume or rate reduction.

If not already available, soils information should be collected in catchments where infiltration is identified as an option for achieving stream protection and/or flood management objectives. This will enable a more detailed assessment of what is actually achievable in these catchments.

It is also important to collect basic groundwater information to identify areas where the groundwater table is very high, since infiltration is not likely feasible in these areas.

Refer back to Chapters 6 for details regarding the importance of soils information in setting catchment-specific performance targets. Refer back to Chapter 7 for details on the relationship between soils and infiltration performance.

Data on Drainage Facilities

Scenario modeling may identify flood management concerns relating to certain drainage system components. Data collection should then focus on characterizing these critical drainage system components and evaluating the effectiveness of improvement options.

For example, if the conveyance capacity of a particular culvert installation is identified as a high risk flooding location, data collection may focus on determining the effectiveness of options for improving physical and/or hydraulic acceptability of that culvert.

Data on Fish and their Habitats

Where watershed objectives focus on the protection and/or restoration of fish and their habitats, there may be a need to collect additional data to define the value of these resources and evaluate options for their protection or restoration.

For example, if restoration of a critical stream reach is established as an objective, detailed surveys of this reach would likely be required to evaluate restoration options.

Water Quality Data

If surface water or groundwater pollution is identified as a key issue in a catchment, there may be a need to collect water quality data in order to provide a better understanding of the types and sources of pollution. This would become important for evaluating options to manage the sources of water quality problems.

For example, high nutrient loading in watercourses may indicate the need to manage runoff quality from upstream agricultural areas.

Monitoring turbidity (and correlating with TSS) can provide a good indicator of changes in water quality and watercourse erosion rates over time. This can play an important role in evaluating the effectiveness of integrated solutions that are implemented in a watershed (refer back to Chapter 6).

Also, performance targets can be established based on total suspended solids (TSS) loading, using natural loading rates as a baseline. Note that TSS targets are closely related to runoff volume targets (increase in runoff volume is the primary cause of watercourse erosion).

Sources of Data

Data can typically be obtained by contacting the federal and provincial agencies listed below:

- ❑ Rainfall – from the Atmospheric Environment Service (Environment Canada)
- ❑ Streamflow – either from the Water Survey of Canada (Environment Canada) or the provincial Ministry of Water, Land and Air Protection (MWALP)
- ❑ Species and Habitats of Concern – either from Fisheries and Oceans Canada or the Environmental Stewardship Division of MWALP
- ❑ Water Quality - from the Environmental Protection Division of MWALP

9.7 Step #5: Evaluate Alternatives and Develop Component Plans

Once watershed objectives have been established, alternative scenarios for achieving those objectives have been generated, and the data needed to evaluate the effectiveness of these scenarios has been collected, the next step is to evaluate the alternatives and make decisions.

These decisions will provide the basis for developing plans for habitat enhancement, flood risk mitigation and relevant land development actions. These are all related components of an ISMP, as shown in Figure 9-6. These component plans are described in this section.

The fourth component is a financial and implementation program (see Step #6), which is essential for moving from planning to action.

Habitat Enhancement Plan

The Habitat Enhancement Plan should identify:

- ❑ key wetlands or sensitive ecosystem areas needing protection
- ❑ riparian setback objectives
- ❑ schematic alignment for creek relocations, with corresponding riparian restoration and land requirements
- ❑ streamside and instream complexing features to be incorporated
- ❑ location and description of barriers to fish passage, and prescriptions to remove barriers where advisable

A companion report would provide cost estimates, land acquisition costs, logical phasing and logistics of the planned habitat improvements. It should outline a monitoring and maintenance program that addresses jurisdiction and ownership of stream corridors, and requirements for agency approvals.

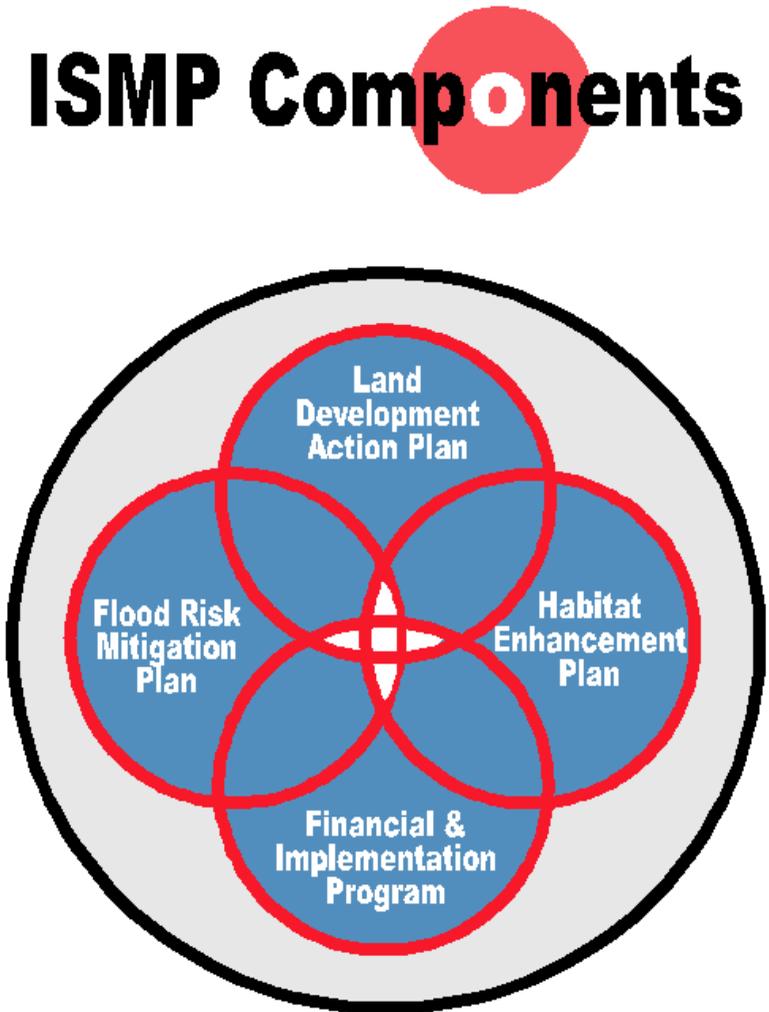


Figure 9-6

Flood Risk Mitigation Plan

The Flood Risk Mitigation Plan should identify:

- ❑ required stormwater storage facilities
- ❑ proposed split between storage budgets in community detention facilities and private developments
- ❑ type and distribution of stormwater infiltration and storage facilities
- ❑ flow paths for major events
- ❑ piped sections, or high-flow pipe diversion works
- ❑ conceptual cross-sections of major stream diversions

A companion report would provide a description of the elements and cost estimates for land acquisition and capital works, suitable for use in development cost charge (DCC) bylaws and capital works plans.

Land Development Action Plan

A Land Development Action Plan should illustrate the relationship between the proposed habitat enhancement and flood mitigation works and existing and proposed land use in the watershed. Recommended changes to land use designations should be highlighted for consideration in Neighbourhood Plans and the Official Community Plan.

Location and routing of flood control works, stream relocations and riparian leave strips should be developed within a strategy for land acquisition or regulatory protection. The Land Development Action Plan should show the location of required lands and outline a strategy to achieve their protection over the long-term.

The Land Development Action Plan should also identify the distribution of stormwater source control use in the watershed. Some source controls may be targeted to only part of the watershed (e.g. infiltration only in certain soil conditions). Other source controls may vary in application by zoning (e.g. green roofs only on commercial or multiple family buildings).

Adding the Dimension of Time

Changes take time. What is not achievable over the next five years may be quite achievable over a twenty-year or fifty-year timeline. Action plans to integrate stormwater management with land use planning should be framed in terms of long-term visions and time-related objectives (e.g. what do we want to achieve over the next 5, 20 and 50 years). Refer back to Section 9.5 for further discussion of planning horizons.

9.8 Step #6: Develop an Implementation Program

Step #6 is essential for moving from planning to action, yet many planning processes never get to this step. Without an implementation program and financial plan, watershed objectives will not be achieved.

Financial Plan and Implementation Program

The purpose of an ISMP is to identify the risks, what needs to be done to manage the risks, who should be responsible, and lay out a general timeline for implementation.

The Financial Plan and Implementation Program should therefore outline how the land acquisition and capital financing of the elements can be achieved. Tools might include negotiations during zoning changes, land exchange, density bonuses, adjustment of existing DCCs or other means. Strategies will be specific to the properties in question.

In addition to capital financing, the regulatory framework is another component of implementation to be used in balance with public awareness and capital works programs.

There are many questions related to regulatory change that must be resolved, including:

- ❑ What is the role of various regulatory tools (e.g. zoning negotiations, development permits for protection of the natural environment, ecosystems and biodiversity, tree protection bylaws, watercourse protection bylaws, engineering standards and specifications)?
- ❑ How can regulatory tools work together, without overlap or excessive red tape?

Chapter 11 provides guidance regarding the types of regulatory changes that may be needed to achieve stormwater management objectives.

Recommended Bylaw Approach

A key objective of the ISMP process is to create a recommended bylaw approach. This would define the bylaw that each stormwater source control or policy is to be implemented through, and the relationship between bylaws. The product would be a point form outline of each proposed bylaw change. The outline should be relatively specific, and should address:

- ❑ Enabling legislation
- ❑ Principles behind the bylaw change
- ❑ Key bylaw requirements
- ❑ Key definitions needed
- ❑ Key illustrations or engineering details needed
- ❑ Key filter and exemption clauses
- ❑ Key application information requirements
- ❑ Enforcement options

This product should provide clear direction for subsequent work by separate assignment to write and provide legal review of the actual bylaw changes. Land use regulation should reflect a pragmatic approach that is based on these guiding principles:

- ❑ **Principle #1** - Recognize the body of existing local bylaws, and identify how they can be adapted to suit new objectives.
- ❑ **Principle #2** - Create the simplest possible regulatory system. Watch out for overlap or conflicting bylaws. Try to reduce the number of permits required.
- ❑ **Principle #3** - Understand that bylaws will only succeed if the solid majority of the public supports them.

The last principle underscores the importance of public awareness programs that provide the public and the development community with the information they need in order to decide whether to support new regulations.

9.9 Step #7: Refine Through Adaptive Management

Step #7 is key to resolving stakeholder uncertainty associated with changes in standard practice. This objective is achieved through an adaptive management framework as illustrated by Figure 9-7. This will be ongoing through time.

Monitoring and evaluating the performance of demonstration projects will provide confidence in new approaches. It will also provide the basis for optimizing stormwater system design to reduce costs while still achieving defined goals for protecting downstream property, aquatic habitat and receiving water quality (refer back to Chapter 6).

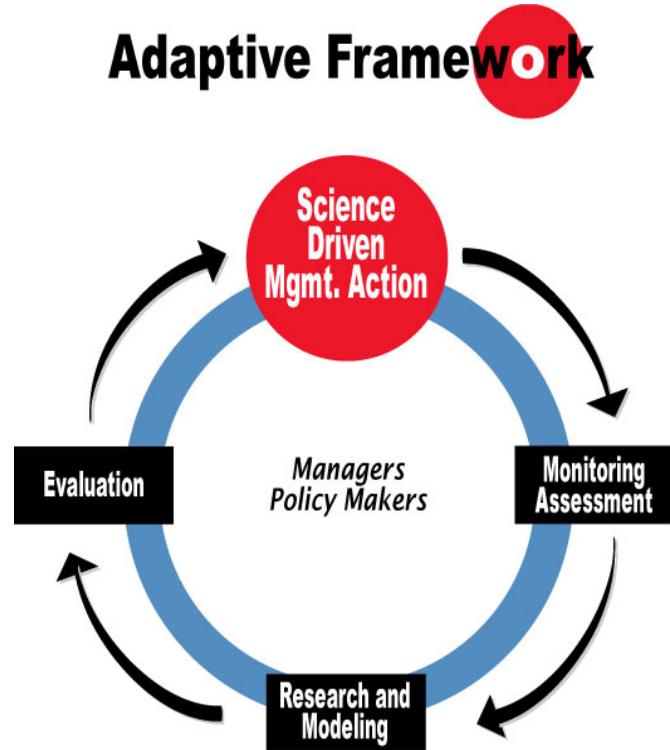


Figure 9-7

Defining the Rules of Adaptive Management

An ISMP implementation plan must define:

- ❑ **Early Actions** - the integrated stormwater management solutions to be implemented in priority (at-risk) catchments
- ❑ **Rules of Adaptive Management** – a clear set of rules that define monitoring requirements and consequences to allow for improving integrated solutions over time

Build and Maintain Trust

In order to build and maintain trust between local governments, landowners, developers and senior government agencies, the following questions must be answered at the plan development stage:

- ❑ What needs to be monitored?
- ❑ How will monitoring results:
 - a) define better stormwater management and development practices?
 - b) lead to changes in development standards and regulations?

The adaptive management framework presented in Chapter 6 provides a starting point for establishing a set of rules that answer the above questions. This must be a collaborative process, so that the rules are understood and supported by all stakeholders.

Desired Outcomes

A clearly understood and widely supported set of adaptive management rules will:

- ❑ Enable landowners and developers to make long-term land use and investment decisions with more confidence.
- ❑ Provide senior government agencies with regulatory certainty as new approaches are tested and refined.
- ❑ Ensure that the investments of local governments (both staff and financial resources) will lead to constant improvement.

Adaptive Management Roles and Responsibilities

An implementation plan must clearly define who is responsible for monitoring what, and establish regular intervals (e.g. every year) for working sessions to review monitoring results. These working sessions are critical to the ongoing process of change, because this is where decisions will be made regarding what to change and how these changes will be made.

Local governments may need to take the lead in implementing and monitoring the initial demonstration projects (e.g. on public works projects). Local government leadership is important for demonstrating to developers, landowners and senior government regulators that proposed actions at the site level are both effective and affordable. This will build support for regulatory changes that enable or require these site level actions.

Stewardship groups also have a role to play in monitoring the catchment and watershed scale effectiveness of new land development practices.

Types of Monitoring

The following types of monitoring should all be included in a comprehensive adaptive management program.

- ❑ **Effectiveness Monitoring** – Determines the extent to which the completed actions have achieved the management objectives (for example, monitor the volume and frequency of overflow from an on-site facility and compare with the performance targets).
- ❑ **Compliance Monitoring** – Identifies whether or not the implementing parties have completed the actions they agreed to complete in the planning phase (for example, confirm that developers are incorporating properly sized on-site storage and infiltration facilities).
- ❑ **Validation Monitoring** – Measures the extent to which completion of the objectives (actions) has been successful at achieving the goal (for example, monitor annual watershed runoff volume and compare with the performance target established for runoff volume reduction).

Effectiveness monitoring is the key to learning from experience and constantly improving land development and stormwater management practices.

The Role of Effectiveness Monitoring

Chapter 6 included a discussion on performance monitoring in the section about optimization of stormwater system design. Chapter 6 also introduced the need for performance monitoring at different scales. This section elaborates on that discussion.

Proper assessment of the effectiveness of site design practices in a watershed context requires monitoring at three scales:

- ❑ **Site Level - Monitor Volume and Frequency of Overflow from Individual Facilities**
The performance of individual rainfall capture and runoff control facilities must be monitored to determine if targets for runoff volume reduction and rate control are being met.
- ❑ **Neighbourhood Level - Monitor the Change in Rainfall-Runoff Response from Development Areas**
It is important to monitor flow at the drainage outlet (e.g. outfall to a stream) of a development area serving an integrated network of rainfall capture and runoff control facilities. This will enable an assessment of how well this integrated system achieves the performance target for volume reduction.
- ❑ **Catchment Level - Monitor Early Warning Indicators of Stream Health**
It is important to determine how well actions at the site level are maintaining or restoring a healthy catchment. This can be accomplished by monitoring the following indicators:
 - Water Balance - streamflow at the downstream end of the catchment
 - Water quality - turbidity and total suspended solids (TSS)
 - Biophysical - Benthic Index of Biological Integrity (B-IBI)

Managing Drainage from an Ecological Perspective

This section elaborates on indicators that can be used to provide a warning system regarding the impacts of human actions on the environmental health of stream corridors so that corrective action can be taken when they are required.

The governing consideration is that indicators accurately represent the environmental state of both the surface drainage function and the ecological function of the receiving waters.

Elements of an Integrated Program for Monitoring Stream Health

In recent years stormwater managers have recognized the need for a stream health monitoring program that is sensitive to changes in hydrology and habitat. The need arose because traditional chemical and physical monitoring did not produce the type of information needed to understand the overall environmental health of a stream corridor and manage drainage from an ecological perspective.

A comprehensive approach combines simplified chemical and physical monitoring with annual monitoring of physical changes to habitat and a biological index of benthic organisms.

An *Integrated Monitoring Program* would comprise ambient biological monitoring, continuous rainfall and streamflow recording, some chemical and habitat measurements, and possible microbiological monitoring to allow the identification of fecal coliform sources.

Description of Ambient Monitoring

A baseline ambient monitoring program would comprise Benthic Index of Biological Integrity (B-IBI) scores at selected sites, plus concurrent field measurements of conductivity and temperature, plus physical measurements of stream and habitat elements.

For chemical parameters, conductivity has the best correlation with urban impacts. Also, it can be measured inexpensively in the field. TSS and zinc also have good correlation, but provide little additional information over that provided by conductivity alone.

9.10 Synopsis of the Seven-Step Process for ISMP Development and Implementation

Table 9-3 provides a synopsis of the seven-step process. For each step the scope, desired outcome, and deliverables are summarized. The overall aim of this process is to achieve healthier urban watersheds over time.

Build the Vision, Create a Legacy

A shared long-term vision is needed to focus the effort that will create a legacy. This vision provides a context for all planning, data collection, sensitivity analyses, capital expenditures and regulatory changes. Prioritizing goals and actions (ideally through consensus) provides a road map for moving towards a target condition by identifying:

- ❑ the interconnected nature of goals, values and expectations
- ❑ risks and opportunities
- ❑ what needs to be done to manage the risks and achieve the opportunities
- ❑ who should be responsible
- ❑ a general timeline for implementation

This framework addresses the goal of identifying options to change the way that land is developed and re-developed, so that people, property and natural systems can be better protected and over time, infrastructure can be managed more efficiently and watersheds can become healthier.

Table 9-3 Synopsis of the Seven-Step Process for ISMP Development and Implementation

Step	Scope	Outcome	Deliverable
1	Secure Political Interest and Support	<input type="checkbox"/> Define a guiding philosophy <input type="checkbox"/> Formulate supporting policies <input type="checkbox"/> Establish design criteria to achieve policies	<input type="checkbox"/> Document 1 - Policy and Design Criteria Manual
2	Frame the Watershed Problems and Opportunities (Apply the Knowledge-Based Approach) <ul style="list-style-type: none"> <input type="checkbox"/> Land Use Working Session <input type="checkbox"/> Drainage Working Session <input type="checkbox"/> Ecology Working Session <input type="checkbox"/> Interdisciplinary Roundtable Session 	<input type="checkbox"/> Identify resources to be protected <input type="checkbox"/> Establish an order of priority for plan development at the sub-watershed scale	<input type="checkbox"/> Document 2 – Understanding the Watershed <ul style="list-style-type: none"> • Watershed Base Map • Watershed Issues Summary • Sensitive Ecosystem Inventory • Land Use Map • Drainage System Inventory • Soils and Groundwater Map
3	Develop Objectives and Alternative Scenarios <ul style="list-style-type: none"> <input type="checkbox"/> Flood Management Scenario Modeling <input type="checkbox"/> Source Control Scenario Modeling 	<input type="checkbox"/> Identify inadequate drainage facilities <input type="checkbox"/> Establish a customized performance target for each sub-watershed	<input type="checkbox"/> Document 3 – Results of Flood Management Scenario Modeling <input type="checkbox"/> Document 4 – Results of Source Control Scenario Modeling
4	Collect Meaningful Data and Refine Scenarios <ul style="list-style-type: none"> <input type="checkbox"/> Concurrent Rainfall and Streamflow Data <input type="checkbox"/> Data on Soils and Groundwater <input type="checkbox"/> Water Quality Data <input type="checkbox"/> Data on Fish and Their Habitats 	<input type="checkbox"/> Identify gaps <input type="checkbox"/> Supplement existing programs	<input type="checkbox"/> Document 5 – Data Collection Framework
5	Evaluate Alternatives and Develop Component Plans	<input type="checkbox"/> Make decisions	<input type="checkbox"/> Document 6 – Flood Risk Mitigation Plan <input type="checkbox"/> Document 7 – Habitat Enhancement Plan <input type="checkbox"/> Document 8 – Land Development Action Plan
6	Develop an Implementation Program	<input type="checkbox"/> Consolidate supporting documents <input type="checkbox"/> Develop financial plan <input type="checkbox"/> Create a recommended bylaw approach	<input type="checkbox"/> Document 9 - Implementation Report
7	Refine Through Adaptive Management	<input type="checkbox"/> Establish rules of adaptive management <input type="checkbox"/> Implement comprehensive monitoring program	<input type="checkbox"/> Document 10 - Performance Evaluation Plan