The Scope of Integrated Stormwater Management

Chapter Three

3.1 Overview and Context

An integrated approach recognizes that land use changes outside a stream corridor result in changes within the corridor. The impact of land development in changing both stormwater quantity and quality can trigger progressive loss of biodiversity and abundance of aquatic species within the corridor.

Connecting the Natural and Built Environments

Integrated, or watershed-based, stormwater management recognizes the relationships between the natural environment and the built environment, and manages them as integrated components of the same watershed. These relationships are illustrated in Figure 3-1. Traditional drainage practices concentrated on peak flow rates and overlooked the importance of volume management. Integrated solutions manage both volume and flow rates.

Integration Means Tackling both Stormwater Quantity and Quality

Integrated stormwater management includes attention to both stormwater quality and quantity. Water quality impairments correlate with increased watershed percent imperviousness, as well as with increased population density. Rainfall washes fine sediment from hard surfaces into piped systems that discharge into receiving waters. As an area develops, the total volume of sediment loading increases.

The majority of trace metals and hydrocarbons, for example, are associated with suspended sediment. Hence, it is common sense that reducing stormwater volume will also reduce sediment loading and reduce aquatic pollution. When stormwater is infiltrated through soil, many sediment-bound contaminants are removed by filtration. Similarly, constructed wetlands can also act as settling ponds to remove and treat suspended sediments in runoff. Other stormwater treatment technologies are available commercially and may become important as development intensifies.

Programs that increase public awareness of common non-point source pollutants in the home and business will also contribute to reduced pollutant loads. Other more rigorous source control programs (e.g. bylaws) may also become necessary as land use intensifies.

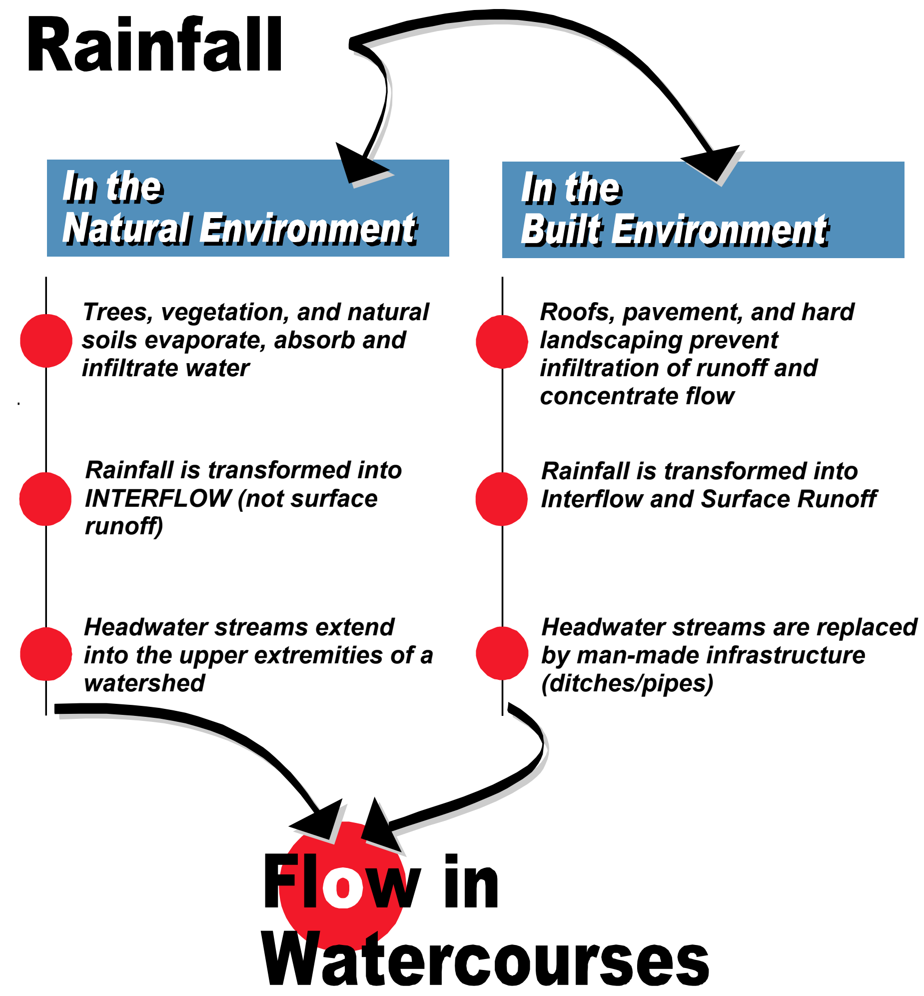

Figure 3-1

Blending Policy, Science and Site Design

Integrated stormwater management blends policy, science and site design through an integrated approach. Key steps are:

- **Policy** –
  Identify goals, objectives, locations and guidelines for both land use development and stormwater management. Organize priorities and financial and administrative support.

- **Science** –
  Build a science-based understanding of the link between urban development impacts, stream degradation, and other policy objectives. This understanding leads to realistic performance targets and design criteria for each watershed catchment.

- **Site Design** –
  Identify site design practices that support the policy objectives and meet the performance targets. Once identified, these site design practices must be allowed and supported at the policy level. Changes to development standards and regulations are also needed to enable better site design practices.

Policy, science and site design are blended through a participatory and interactive process where technical products are developed and presented at a series of working sessions with stakeholders. The objective is to reach consensus on a shared vision that is practical and achievable, and that will be supported by the community. Community support is the key to moving from planning to action. Chapter 11 elaborates on this topic.

3.2 The Transition from Traditional to Integrated Stormwater Management

Evolution of the Integrated Approach

Stormwater management has evolved over the decades, and continues to evolve. The following comparison captures the key elements of the transition from a traditional, 1980s approach, to an integrated approach in the 2000s. The integrated approach still incorporates the traditional scope of engineering work, but builds on it to achieve environmental as well as drainage objectives, as the following table demonstrates:

TRADITIONAL is defined as:		INTEGRATED is defined as:
✓ Drainage Systems	⇨	✓ Ecosystems
✓ Reactive (Solve Problems)	⇨	✓ Proactive (Prevent Problems)
✓ Engineer-driven	⇨	✓ Interdisciplinary Team-driven
✓ Protect Property	⇨	✓ Protect Property and Resources
✓ Pipe and Convey	⇨	✓ Mimic Natural Processes
✓ Bureaucratic Decisions	⇨	✓ Consensus-based Decisions
✓ Local Government Ownership	⇨	✓ Partnerships with Others
✓ Narrow Scope of Work (drainage focus only)	⇨	✓ Holistic Scope of Work (stormwater integrated with land use)

An integrated approach to stormwater planning is inter-departmental, interdisciplinary and inter-agency. It also involves community representatives in the planning process. These elements and their significance are explained in later chapters in Part C.

Change in Approach: from Reactive to Proactive

Integrated stormwater solutions ensure protection of both property and ecosystems. Past drainage practices only dealt with the consequences of land development. An integrated approach also attempts to eliminate the source of problems.

Figure 3-2 illustrates what is involved in moving from an 'end-of-pipe' approach that solves problems after the fact, to one that is proactive in preventing problems from occurring.

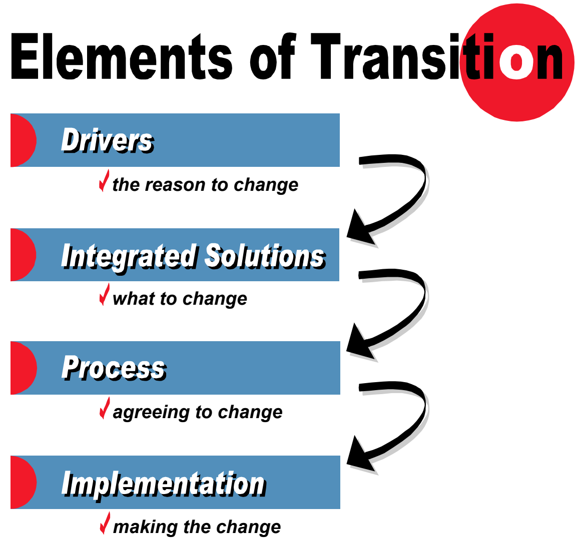

Figure 3-2

Volume Reduction is the Key to Property and Environmental Protection

To avoid aquatic habitat and water quality impacts and protect property, it is necessary to ***decrease the volume of runoff that flows to streams***, thereby creating a situation that mimics or approximates a naturally vegetated watershed. Past stormwater management practices did not accomplish this because they focused only on the conveyance and/or detention of the extreme storms.

Extreme storms occur rarely. Because the small, frequently occurring rainfall events represent the bulk of total rainfall, the key to ***runoff volume reduction*** is to capture those events at the source. If they can be captured and restored to their natural hydrologic pathways (through infiltration and re-use within a development site), then the majority of the total annual rainfall will be managed in a manner approximating a natural system.

Strategies to Reduce Runoff Volume and Flow Rate

Integrated solutions reduce the volume and the rate of surface runoff from the built environment by a combination of three strategies:

- Minimize creation of impervious area, e.g. by using pervious surfaces, narrower roads, skinny buildings, etc.
- Install hydraulic disconnects that return local runoff from impervious surfaces back into the ground or re-use it within the development site.
- Store runoff and release it slowly. Ideally this storage would discharge to an infiltration device prior to discharge to a watercourse.

In summary, integrated stormwater management recognizes that flood control, protection of aquatic habitat and improvement of water quality are all complementary objectives. They all have the same starting point – increased impervious area leads to increases in runoff.

The Evolving Role of Governments in Integrated Stormwater Management

The goal in BC is to develop integrated stormwater solutions that will ensure protection of life, property, aquatic habitat and water quality. Achieving this goal requires alignment of the roles and responsibilities of the different levels of government.

Local government has responsibility for land use decisions. Local government is also responsible for protection of property. Because of the direct relationship between land use development and stormwater impacts, local government must play a primary role in aquatic habitat protection and restoration related to stormwater management.

Recent changes to the *Local Government Act* have expanded the mandate for municipalities and regional districts to manage runoff and impervious area.

In view of the expanding role of local governments in stormwater management, a key objective of the Guidebook is to provide a pragmatic, integrated and science-based approach to stormwater planning. This will enable local governments and landowners to make long-term land use and development decisions with more confidence.

Providing Economy and Certainty During a Period of Transition

During this period of transition from traditional drainage practice to integrated stormwater management, there is uncertainty as to what roles various levels of government and the private sector should play in stormwater management, and who pays.

Part C of the document suggests partnerships among various levels of government. Senior governments recognize the importance of being proactive in developing strong and lasting partnerships with local governments.

The Guidebook presents an adaptive methodology for moving from planning to action. This methodology focuses the limited financial and staff resources of governments on implementing early action where it is needed most. It explains how to select conservative strategies to guide early action. It also provides a framework for reducing the costs of these strategies through ongoing monitoring and evaluation.

3.3 Plan at Four Scales – Regional, Watershed, Neighbourhood and Site

What the Cell is to the Body, the Site is to the Region

Just as the health of the human body is dependent on the health of the individual cells in it, so too is the health of the suburban region dependent on the health of the individual site – this is an over-arching theme.

A guiding principle is to plan at four scales to ensure that solutions are both integrated and cascading. The scales are the region, watershed, neighbourhood and site, as shown in the adjacent table.

Cascading Hierarchy for Integrated Solutions

The objectives for stormwater management are referenced to, and defined by, the cascading hierarchy shown to the right. Each successive level provides more specific details as to what is to be accomplished, and how to achieve a shared community vision for the region and/or watershed.

The planning scales are not mutually dependent. However, they work best when undertaken together. In the context of this Guidebook, watershed-based planning means that resource, land use, and community design decisions are made with an eye towards their potential impact on the watershed or drainage catchment. Therefore, what happens at the scale of the individual parcel and street affects what happens at the watershed scale.

Planning Scale	Description of Initiative	Opportunity for Implementing Stormwater Management
Regional	Regional Growth Strategy	Provide local government with enabling tools
Regional	Stormwater Component of Liquid Waste Management Plans (LWMPs)	Prioritize limited resources on key environmental stewardship issues
Regional	Official Community Plan (OCP)	Define over-arching community goals and objectives
Watershed	Watershed-Based Land Use Planning Process	Develop a stewardship-based 'watershed vision' that reflects OCP
Watershed	Integrated Stormwater Management Plan (ISMP)	Protect property, aquatic habitat and water quality
Neighbourhood	Neighbourhood Community Plan (NCP), or Local Area Plan (LAP)	Establish performance targets for subdivisions and site design
Site	Subdivision and Single Lot Development Plans	Implement performance targets for site design

3.4 Integrated Stormwater Management Planning

The evolving science of stormwater management has broadened the traditional engineering approach to one that integrates hydrologic and environmental concerns, and that is also proactive in managing risk. Hence, the term *Integrated Stormwater Management Plan* (ISMP) is gaining widespread acceptance in BC because it addresses two categories of risk management:

- Flood Risk – to protect life and property
- Environmental Risk – to protect habitat and property

Producing a Shared Vision

To address stormwater issues, it is critical that key stakeholders have a shared vision of the science and the appropriate solutions for the watershed under consideration. Stakeholders must understand that land use change alters the natural Water Balance, that the result is more surface runoff, and that the increase in both volume and flow rates has consequences.

The purpose of an ISMP is to create a clear picture of a desired outcome that will facilitate a broad understanding of integrated solutions – why they are needed, what they are, and how they can be practically and affordably accomplished. An ISMP implementation program will organize a transition from existing to revised standards that achieve the desired outcome.

An Action Plan with Four Components

Figure 3-3 illustrates how a process produces a shared vision that results in an action plan with four component plans. Chapter 10 elaborates on the concepts presented in this section.

The effectiveness of flood risk and environmental risk management depends on a ***Land Development Action Plan*** that integrates decisions about land use and on-site stormwater best management practices to protect and/or restore the natural Water Balance.

The purpose of a ***Flood Risk Mitigation Plan*** is to protect life and property. This is achieved by containing and conveying the floodflows that result from the extremely large rainstorms that rarely occur. This component has historically been called a Master Drainage Plan.

The purpose of a ***Habitat Enhancement Plan*** is to address environmental risk (to aquatic habitat and water quality). This means protecting stream corridor ecosystems from being progressively degraded by the erosion and sedimentation that result from the small rainfall events that occur all the time. This is achieved through a combination of retention (rainfall capture at the source) and detention (runoff control) strategies. This combination also indirectly addresses risks to water quality.

The purpose of a ***Financial and Implementation Plan*** is to provide cost sharing and control, funding and organization of the stakeholders to ensure effective implementation, monitoring, operating and maintenance.

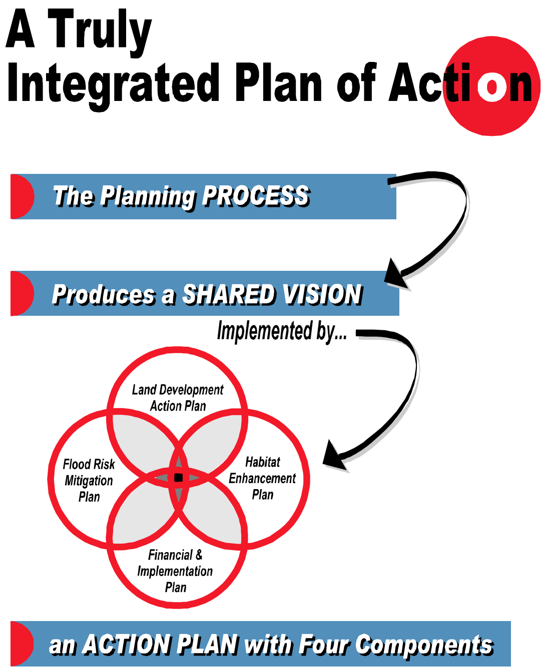

Figure 3-3

3.5 The Relationship between Stormwater and Land Use

As introduced in Chapter 2, the impacts of increasing impervious area on stream flows and fish habitat are cumulative. Changes in land use designations and zoning should consider how much change to effective impervious area is encouraged by the proposed land use.

Table 3-1 shows a typical, generalized relationship between imperviousness and land use, without mitigation by best management practices (BMPs). This illustrates how the area per dwelling unit decreases with density. For example, the impervious area per dwelling unit for a high-density multi-family development is about 1/8 of the per unit area for a 1960s suburban residential development.

Table 3-1 Presumed Relationship between Impervious Area and Land Use [1]

Land Use	Density (units / acre)	TIA (percent)	EIA (percent)	Land/1000 Dwellings (acres)	EIA / 1000 Dwellings (acres)
Rural Residential	0.5	10	4	2000	80
Estate Residential	1	20	10	1000	100
1960s Suburban	4	35	24	250	60
1990s Suburban*	5	55	45	200	90
Low Multi-family	8	60	48	125	60
High Multi-family** (underground parking)	50	60	48	20	10
Commercial/Industrial	n/a	90	86	n/a	n/a

[1] Extracted from Dinicola, 1989, Jackson and Booth, 1997

TIA = total impervious area and EIA = effective impervious area (i.e. directly connected to drainage system)
Refer to Chapter 6 for additional explanation regarding TIA versus EIA

* Source: Como Creek watershed, City of Coquitlam – airphoto interpretation
** Source: Burnaby Mountain Community, City of Burnaby – neighbourhood plan

Ten Principles

An improved understanding of the relationship between stormwater management and land use is important to make the case for closer integration of OCP and ISMP processes, and to break down barriers between planners and engineers. Table 3-2 identifies ten principles that help define the relationship between stormwater management and land use.

Looking ahead to Chapters 6 through 8, understanding the relationship between stormwater and land use is also important in deciding when, where and how stormwater management performance targets should be applied.

Table 3-2: Ten Principles that Define the Relationship between Stormwater Management and Land Use

1. 10% impervious area is a critical threshold - Stormwater impacts increase dramatically when land use creates over 10% impervious area in a watershed or drainage catchment.
2. Residential development has the greatest overall impact - Residential development often has the greatest cumulative impact on stormwater management because it covers the greatest land area.
3. Greater population = greater impact - The higher the population accommodated in a watershed or sub-watershed, the higher the likely water quantity and water quality impacts.
4. Same population, greater density = less impact - The greater the density of residential land use in a watershed for a given population, and the more remaining vegetated green space, the lower the likely stormwater impact.
5. Rule of thumb is to maintain catchment effective impervious area (EIA) below 10% - Generally, stormwater best management practices (BMPs) to manage flows should be triggered for all developments that involve more than 10% total impervious area. The objective of the BMPs would be to reduce the effective impervious area, and to meet designated targets for rainfall capture and runoff control.
6. BMPs are needed for residential densities exceed 1 unit per hectare - Most residential developments of densities greater than 1 unit per hectare will exceed the 10% impervious area trigger.
7. Industrial/commercial = greatest impervious area - Medium density commercial and industrial developments have high impervious area that needs to be mitigated. However, these developments often represent a small portion of the watershed when compared to other land uses (e.g. residential).
8. Large structures in forestry/agricultural areas may require mitigating BMPs - Very low density land uses such as agriculture or forestry will often have impervious area less than 10%, but can still have a major impact on watershed hydrology due to the consequences of clearing and ditching. In addition, local sites such as greenhouses or temporary industrial operations may trigger the need for specific stormwater management measures. At the same time, drainage from upland urban areas may have flooding impacts on agricultural lowland uses if not mitigated.
9. The impacts of impervious area are cumulative – An existing development that is not creating a problem may contribute to a future problem as adjacent development infills. For this reason, all development with >10% EIA should implement stormwater management, except in isolated cases where there is no likelihood of the total impervious area in a drainage catchment exceeding 10% (e.g. in completely rural areas).
10. Compact communities are most compatible with stormwater objectives - The most favorable land use pattern for minimum stormwater impacts is compact, dense, pedestrian-oriented development with effective stormwater BMPs, and with the majority of the watershed in vegetation and absorbent soils.

3.6 A Guide to Part B

Often it is the small or tributary drainage catchments that are heavily impacted by land use change. Since development activities can quickly transform a large portion of these at-risk catchments, it is important that integrated stormwater management programs be put in place quickly. Priority action in at-risk catchments has several advantages:

- Demonstrates that local government is taking immediate action
- Focuses attention on the types of stormwater problems that will have to be addressed in other areas
- Serves as a demonstration project for testing the effectiveness (and affordability) of stormwater management policies and techniques

Looking ahead, Chapter 4 describes two tools that can be used by local government to bring about policy changes that will result in integrated solutions.

Chapter 5 describes an approach for setting priorities for early action. This is called the *At-Risk Methodology* (ARM). This methodology relies on a roundtable process that brings together people with knowledge about future land use changes, high-value ecological resources, and locations that have chronic drainage problems. The Regional District of Nanaimo is the case study example.

Chapters 6 through 8 then lead the reader through a step-by-step discussion on the selection and application of achievable performance targets. Each chapter is a building block in a systematic process for translating performance targets into design criteria that can be implemented at the site level to achieve watershed objectives. The City of Chilliwack and the Greater Vancouver Regional District (GVRD) are the case study examples.

- Chapter 6 explains how science-based performance targets have been set for the City of Chilliwack, and shows how these targets have been translated into design criteria.
- Chapter 7 then demonstrates how Chilliwack has integrated performance targets with stormwater management policies.
- Finally, Chapter 8 illustrates how Chilliwack has incorporated performance targets into a set of *Design Guidelines for Stormwater Systems* that developers can understand and apply at the site level.

Case Studies

The targets, criteria, policies and guidelines are incorporated in the City of Chilliwack's *Policy and Design Criteria Manual for Surface Water Management.* This Manual has been developed as a case study application of the Guidebook content.

The GVRD case study (also presented in Chapter 8) evaluates a broad range of stormwater source control options that can be applied to achieve performance targets.