APPENDIX F
INFILL DEVELOPMENT AND WATERSHED REHABILITATION PLAN

The development of an *Infill Development* or *Subwatershed Rehabilitation Plan* (terms used interchangeably in this appendix) is the preferred approach in addressing stormwater quality and quantity concerns associated with infill development.

A plan is particularly important for larger infill sites (> 5 ha); in municipalities where significant growth is expected from infill development; and for effective use of off-site systems (OSS) stormwater management practices because:

- a wider range of SWMPs may be applied within the infill site for larger sites and off-site systems;
- the potential impact on the receiving environment will likely be more significant; and
- the opportunity for restoring existing environmental problems within the tributary area are more feasible.

Chapter 5 outlines some options that may be considered for small infill development (< 5 ha) where anticipated infill development is not sufficient to warrant the preparation of an Infill Development/Subwatershed Rehabilitation Plan.

The intent of this appendix is to provide direction/general steps in developing an Infill Development/Subwatershed Rehabilitation Plan. Many of these steps are similar to those outlined for environmental planning studies (Chapter 2) and retrofit studies (Appendix G). The major difference from environmental planning studies is that infill developments occur in built-up areas and impacts on the receiving water may already be occurring.

Figure F.1 illustrates a hypothetical site which will be used to assist in defining the steps that need to be undertaken. This large infill site is assumed to be located within a developed area serviced by storm sewers which discharge to a small stream which is a tributary of a larger stream.

Major Steps in Developing an Infill Development/Subwatershed Plan

There are three major steps in developing an Infill Development/Subwatershed Plan:

Step 1: Develop Environmental Goals, Objectives and Targets

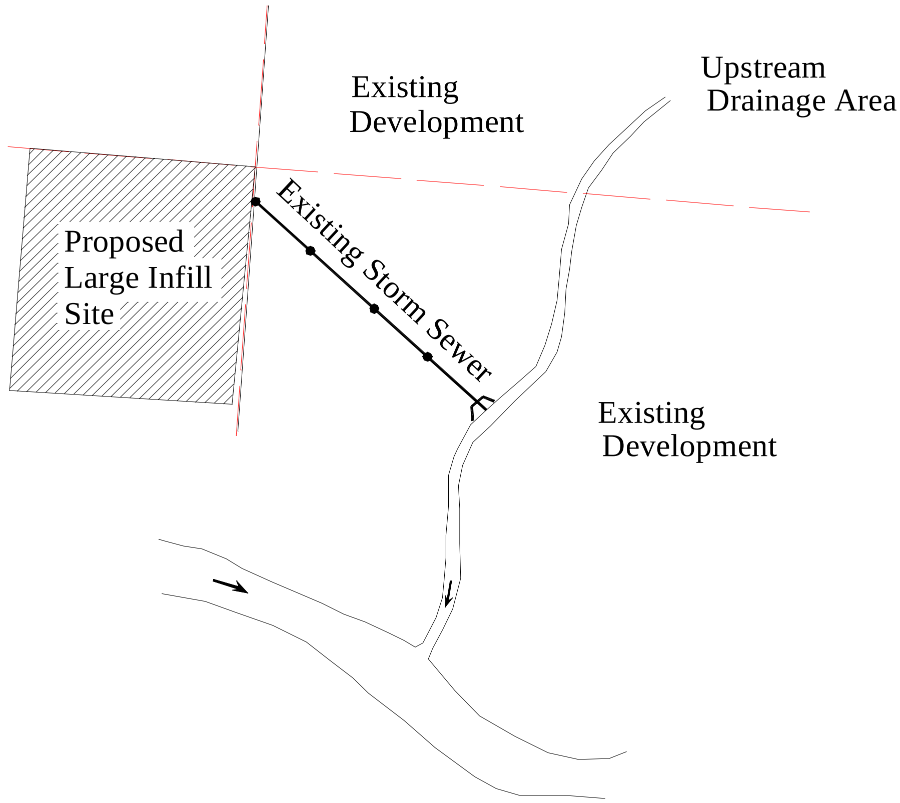
Step 2: Undertake Technical Studies

Step 3: Identify and Select Preferred SWMP

Step 1: Develop Environmental Goals, Objectives and Targets

The environmental goals, objectives and targets may either be available from previous studies or would need to be developed as part of the Plan once the technical studies have been completed. Chapter 2 and Appendix G provide direction for developing environmental goals, objectives and targets.

Figure F.1: Hypothetical Example for Proposed Large Infill Site



Step 2: Undertake Technical Assessments

A variety of field/technical studies may be required in order to define existing environmental conditions; assess opportunities and constraints; and assist in identifying SWMPs which are suitable based on site conditions as well as the defined environmental goals, objectives and targets.

The general types of component studies may include:

- aquatic;
- surface water quantity and quality;
- groundwater;
- geomorphologic;
- terrestrial; and
- infrastructure.

A brief overview of key points to be considered for component studies are provided below:

Aquatic
Aquatic communities (particularly fish species) are typically used as an indicator of environmental health. Section 1.3 of this manual discusses the impact of stormwater runoff on stream ecosystems. The four factors identified (i.e., changes in hydrology, changes in urban stream morphology, changes in stream water quality and changes in stream habitat and ecology) all generally impact existing aquatic communities.

Table F.1 lists one approach for defining the hydrologic, morphologic, water quality and habitat requirements for a range of different aquatic communities. This table may be used to assist in defining aquatic objectives for the target species and defining required standards to meet an aquatic objective. The integrated set of standards that are required may, in turn, be compared to actual physical and biological conditions in order to identify the performance standard(s) which are limiting.

Other considerations such as the identification of physical barriers together with benthic invertebrate work may well be required to completely address aquatic goals and objectives.

Surface Water Quantity and Quality
For surface water quantity there are three general conditions that need to be considered, including:

- low flows (baseflow);
- frequent flows (generally associated with erosion); and
- high (flooding) or infrequent flows.

Baseflow within the stream generally needs to be determined since lack of baseflow impacts aquatic communities and may also indirectly impact water quality conditions. Frequent flows and high flows are generally derived via a modelling exercise (see geomorphologic sub-section). For high flows, a hydrologic/hydraulic assessment may be required in order to determine the impact on downstream areas and, therefore, the requirement for flow controls for the proposed site.

The approach for undertaking water quality assessments is changing. Whereas past efforts focussed on collecting wet weather samples at a number of sites, present efforts are considering:

- replacing wet weather sampling with comprehensive water quality sampling programs with streamlined quality sampling programs together with programs focussing on biologic indicators (biomap, benthic invertebrate); and

- monitoring dry weather conditions as well as wet weather conditions as urban streams typically have short periods (1 - 3 hours out of 72 hours on average) when wet weather flows govern and contaminant levels during dry weather have been found to be higher than initially thought.

Table F.1: Biophysical Performance Standards for Aquatic Ecosystem Objectives

Aquatic Performance Standard	AQUATIC ECOSYSTEM OBJECTIVE			
	R Brook Trout	R Brook Trout R Brown Trout	R Pike R Darters R Sunfish	R Longnose Dace R Brown Bullhead R Brook Stickleback
HYDROLOGY • baseflow	• minimum 30% of average annual daily flow	• minimum 10-20% of average annual daily flow	• minimum 5% of average annual daily flow or sufficient to maintain isolated pools	• minimum to maintain isolated pools, may be < 5% of average annual daily flow
• bankfull frequency	• 1-2 times per year	• 1-2 times per year	• as required to protect downstream aquatic communities	• as required to protect downstream aquatic communities
CHANNEL MORPHOLOGY	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features	• dynamically stable channels with 'natural' features
• average pool area as % of total surface area at low flow	• > 12%	• > 4%	• > 4%	• > 4%
• average riffle area as % of total surface area at low flow	• > 12%	• > 10%	• generally > 5%	• may be < 5%
• average minimum summer pool depth	• 0.5 m	• 0.3 m	• 0.2 m	• 0.2 m
• bankfull width-to-depth ratio	• generally < 10	• generally 5-10	• generally 5-10	• no requirement

Table F.1: Biophysical Performance Standards for Aquatic Ecosystem Objectives (cont'd)

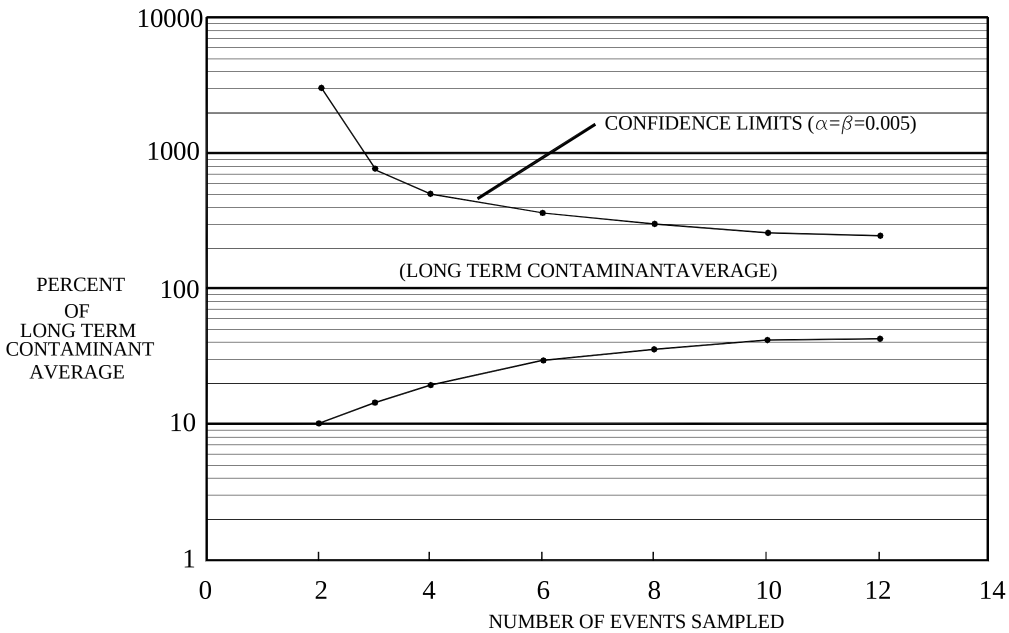
Aquatic Performance Standard	AQUATIC ECOSYSTEM OBJECTIVE			
	R Brook Trout	R Brook Trout R Brown Trout	R Pike R Darters R Sunfish	R Longnose Dace R Brown Bullhead R Brook Stickleback
IN-STREAM COVER	• minimum total in-stream cover 30-40% by surface area • woody debris presents up to 10% of surface area • minimum 15% of surface area with overhead cover • minimum 5% of surface area with overhead cover	• minimum 10% of stream area during low flow • 10-20% of bottom of pool/backwater habitats covered by logs, vegetation, woody debris and boulder • cover at stream margins critical for juvenile fish	• minimum 5% of stream area during low flow • 10% of bottom of pools/ breakwaters covered by logs, vegetation, woody debris and boulder	• minimum 5% of stream area during low flow • 5% of bottom of pools/ backwaters covered by logs, vegetation, woody debris and boulder
SUBSTRATE	• well-sorted riffle zones • maximum 25% fines in spawning substrates • maximum 30% fines in riffle zones • upwelling conditions required • minimum 50% of riffles composed of cobble, rubble, small boulder	• D5O in pools generally < 80 mm • fines in riffle zones moderate to low (< 50%)	• D5O in pools generally < 40 mm • more fines in riffle zones, generally > 50%	• no requirement

Table F.1: Biophysical Performance Standards for Aquatic Ecosystem Objectives (cont'd)

Aquatic Performance Standard	AQUATIC ECOSYSTEM OBJECTIVE			
	R Brook Trout	R Brook Trout R Brown Trout	R Pike R Darters R Sunfish	R Longnose Dace R Brown Bullhead R Brook Stickleback
RIPARIAN HABITAT				
• shaded during 1000-1400 hr	• minimum 35%	• minimum 0% • maximum 50-75%	• minimum 0% • maximum 75%	• minimum 0% • maximum 100%
• woody debris	• important component of in-stream cover and roughness	• important for roughness and refuge during peak flows	• woody debris less important	• less important
WATER QUALITY				
• maximum annual water temperature	22°C	30°C	31-35°C	31-35°C
• average annual total suspended solids (ppm)	< 20	< 150	< 200	< 400
• dissolved oxygen (ppm)	> 5	> 3-4	> 2	< 2
• spills	none	none	none	none
BARRIERS	• remove as feasible	• removal as feasible	• minimize as feasible	• minimize as feasible

Furthermore, in cases where wet weather sampling is being undertaken, at least eight events are being sampled in order to reasonably define the chemical constituents over a variety of rainfall conditions (see Figure F.2).

Figure F.2: Comparison of Sample Contaminant Averages to Long-Term Contaminant Average



Groundwater

Key tasks to be undertaken include defining basic geologic conditions, identifying recharge/discharge areas and determining the relative importance of the site with respect to protecting groundwater supply; and determining a water budget for the proposed infill site under present and proposed conditions. With respect to the last point, the water budget assessment presented in Section 3.2 may be useful.

Geomorphologic

Section 3.4 together with Appendices B through D provide information with respect to erosion and geomorphologic assessments. Several key points that must be considered when undertaking these assessments are outlined below.

Typically, a stream will take a considerable time (25 to 60 years) to respond to land use change. Therefore, depending upon the relative timing between the proposed infill site and previous development, the stream may still be enlarging or have already enlarged to its ultimate cross-sectional shape.

Stream channels enlarge at a different rate depending upon the total basin imperviousness value. Therefore, the stream will respond to a different degree depending upon the relative size of the proposed infill site to the total catchment area and the relative level of development (or percent imperviousness) within the basin.

A majority of urban streams have been altered over time. Alteration may have taken the form of the physical relocation of a stream, construction of a roadway across the stream or modification of the connectivity between the low flow channel and the floodplain. As a result of the alterations as well as the ongoing cross-sectional changes that are occurring, urban streams typically are subject to excessive erosion rates and have lost many of the attributes that are necessary to provide habitat for sensitive aquatic species. If improving aquatic conditions, protecting public property or restoring recreational/environmental opportunities along the stream corridor are goals as set out in the study, then restoration of the stream will likely be needed.

Terrestrial

Terrestrial resource assessments typically include wetlands, woodlots, landforms and specially designated natural areas. An approach for undertaking terrestrial assessments within an existing developed area is not covered in this appendix. Assessment of the proposed infill site will be necessary to ensure that the above noted resources are protected.

Infrastructure

An assessment of the existing storm sewer system from the proposed infill site to the receiving stream may be required depending upon capacity constraints, the proposed release rate of flows from the infill site and the potential for basement flooding in areas within the sewershed. Accommodation of major system flow (Section 4.7.2) must also be accounted for.

Step 3: Identify and Select Preferred SWMP(s)

Once the environmental goals, objectives and targets have been confirmed and the technical studies completed, the preferred SWMP can be identified and selected. Generally, a combination of practices will be required to address the overall environmental targets. Table 1.3 summarizes different SWMPs and their suitability with respect to different environmental criteria (e.g., water quality, erosion, water quantity). This table should be used in conjunction with Table 4.1 which summarizes physical criteria that need to be considered when evaluating each type of SWMP.

As discussed in Chapter 5, on-site stormwater management is generally the preferred option in addressing cumulative stormwater impacts; however, in certain situations it may be ineffective or impractical because of physical constraints. In these cases, an off-site system (OSS) SWMP may be considered at another location within the same subwatershed and could be financed through a financial contribution from the project proponent based on formulas developed by local municipalities. OSS are most effective within the context of an Infill Development/ Subwatershed Rehabilitation Plan.

Besides off-site SWMPs, municipalities may also be able to use funds for watershed management and restoration works. For example, the technical assessment may find that some stream reaches lack suitable habitat for a target aquatic community and are experiencing ongoing erosion problems as the channel continues to enlarge. Furthermore, construction of erosion control measures on site will result in no net increase in erosion potential but will not restore the degraded habitat conditions or prevent ongoing erosion from existing development.

In this case, construction of an in-stream works to improve habitat conditions and curtail ongoing erosion processes could be considered rather than the construction of on-site stormwater erosion control measures. However, before this approach can be used, there must be concurrence from the appropriate agencies and the private sector. Furthermore, all existing policies, guidelines and acts must be reviewed.