

11.0 MONITORING PROGRAM

11.1 EAST SIDE LANDS – MONITORING PROGRAM HISTORY AND CONTEXT

Monitoring within the East Side Lands was initiated in 2005 to support subwatershed planning for 5 subwatersheds: Hopewell Creek, Chilligo Creek, Randall Drain, Breslau Drain and Freeport Creek. The monitoring program has been periodically updated to reflect anticipated timing of urban area expansions. The last update to the monitoring program was in 2013.

The short-term objective of the monitoring program was to characterize the natural systems within the subwatersheds and establish baseline conditions upon which additional survey information could build as part of a subwatershed study. Monitoring has continued at a moderate level of effort for subwatersheds with near to medium term development pressure (i.e. Freeport Creek, Randall and Breslau Drains). For subwatersheds with longer-term or will experience development pressure in a limited area, monitoring efforts have been reduced in recent years (Hopewell Creek, Chilligo).

Through subwatershed studies, monitoring activities are updated both in terms of objectives and scope. The following sections provide the recommended monitoring program for the Randall and Breslau Drains.

11.2 MONITORING APPROACH – RANDALL AND BRESLAU SUBWATERSHEDS

The overarching goal of the Randall and Breslau Drain Subwatershed Study Monitoring program is to assess and protect the form and function of the natural heritage system within the subwatersheds including groundwater, surface water and natural heritage features (woodlands, wetlands, aquatic features and wildlife).

Two general objectives have been identified for developing an approach to fulfill this goal. The monitoring program should:

- Assess the efficacy of recommended mitigation measures in protecting the natural heritage system within the subwatersheds; and
- Identify opportunities for adaptive management at appropriate temporal and geographic scales based on land use changes and pressures within the system(s).

A two-tiered approach to monitoring the Randall and Breslau Drain Subwatersheds is recommended to effectively meet the monitoring objectives identified above. Consisting of System-Scale and Site-Scale monitoring programs, this two-tiered approach allows each monitoring program to achieve specific objectives relevant to potential site or system impacts associated with land use change. Each program focuses monitoring activities where adaptive management opportunities exist at each scale. Details on the recommended monitoring stages and components is outlined in **Table 11-1** and discussed in the sections below.

Table 11-1: Randall and Breslau Drain Subwatershed Monitoring Program Overview

Monitoring Stage / Phase		Monitoring Parameter(s)	Location(s)	Frequency	Timeframe / Reporting	Responsibility
System-Scale Monitoring		Surface Water Flows	Randall Drain - upstream and downstream of urban area expansion Breslau Drain - no flow monitoring recommended	Continuous (Randall Drain)	<p>Timeframe - system-scale monitoring was initiated in 2005 and will continue with modifications per this monitoring program and based on periodic review. Monitoring will continue until such time as development within the subwatersheds has ceased and potential for impacts to the natural heritage system is minimized to the satisfaction of the agencies.</p> <p>Reporting - data should be compiled on a 5 year frequency.</p>	GRCA / RMOW
		Surface Water Quality	Upstream and downstream of urban expansion area(s) for Randall and Breslau Drain. Water Quality will be collected at flow monitoring stations where available.	Grab samples 16/yr Continuous for conductivity and temperature		
		Benthic Macroinvertebrate	Upstream and downstream of urban expansion area(s) for Randall and Breslau Drain.	Annual (spring or fall sampling period for Breslau Dr, fall sampling for Randall Dr, as appropriate for site based on existing information)		
		Fish Community	Upstream and downstream of urban expansion area(s) for Randall and Breslau Drain.	One sampling event every 3 years		
Site-Scale (Development) Monitoring	Pre-Construction	Surface Water Quality	If watercourse located on or immediately adjacent to property, monitoring to be completed upstream and downstream of property limits	Grab samples 16/yr Continuous for conductivity and temperature	<p>Timeframe - To be proposed and approved in consultation with the GRCA and the Region, as appropriate. Monitoring plans should be developed as early as possible in the planning stages of a development. A 2-year pre-construction monitoring period is generally required.</p> <p>Reporting - a summary report and data tables in .xls or other appropriate database format as prescribed by the agencies is required to be submitted to the City and GRCA at the preliminary design stage.</p>	Developer
		Groundwater levels and quantity	Gradients and quality - upstream and downstream of site with focus on relevant stratigraphic units. Where groundwater supported features are present, shallow groundwater monitoring focused on monitoring inputs to features	Site gradients - seasonal Quality - annual Feature(s) - monthly from snowmelt to freeze-up		
		Quantitative Photo Monitoring	Within immediately adjacent natural features	Annually in June		
		Site-Specific Wildlife Monitoring	Within buffers and / or immediately adjacent natural features or at mitigation or compensation habitats / structures. Site-Specific Wildlife Monitoring may be identified through an EIS and additional detailed survey information (e.g. Species at Risk)	As appropriate for the species / feature of concern. To be determined through an EIS, permit and / or monitoring plan, as appropriate.		

Table 11-1: Randall and Breslau Drain Subwatershed Monitoring Program Overview

Monitoring Stage / Phase		Monitoring Parameter(s)	Location(s)	Frequency	Timeframe / Reporting	Responsibility
	During-Construction	All Pre-Construction monitoring	As outlined above		<p>Timeframe - To be proposed and approved at the time of detailed design submission / in advance of grading.</p> <p>Reporting - annual reports and data tables in .xls or other appropriate database format as prescribed by the agencies are to be prepared and submitted to the City of Cambridge / Township of Woolwich, GRCA and RMOW, as appropriate, during active construction from the start of grading to substantial completion (90% build-out).</p>	Developer
		Quantitative Photo Monitoring	Within ecological buffers (in addition to pre-construction monitoring)	Annually in June; monitoring is initiated as buffers are established		
		ESC measures & SWM System Performance	All ESC mitigation measures (per construction monitoring requirements) and at outlets of temporary and permanent facilities, as appropriate	Monthly (minimum) – and event-based		
	Post-Construction	All Pre-Construction monitoring	As outlined above		<p>Timeframe - To be proposed and approved at the time of detailed design submission.</p> <p>Reporting - annual reports are to be prepared and submitted to the City of Cambridge / Township of Woolwich, GRCA and RMOW, as appropriate, for a period of three years from substantial completion (90% build-out) provided that performance of systems / mitigation measures has been confirmed. If adaptive management strategies have been triggered, monitoring must continue until 2 years of monitoring demonstrate the mitigation measure has successfully addressed the concern.</p>	Developer
		Quantitative Photo Monitoring	Per Pre- and During-Construction Monitoring Requirements.	Annually in June		
		SWM system(s) performance (at-source, conveyance and end-of-pipe facilities)	End-of-pipe facility outlets and LID systems, as appropriate	Monthly and Event-based, as appropriate		
Post-Development Monitoring		SWM system(s) performance (at-source, conveyance and end-of-pipe facilities)	End-of-pipe facility outlets and LID systems, as appropriate	Per Environmental Compliance Approval conditions	Initiated at the time SWM facility / facilities are assumed by the municipality. Carried out per Environmental Compliance Approvals.	Municipality

11.3 SYSTEM-SCALE MONITORING

Building on baseline information collected through existing monitoring activities and this subwatershed study, system-scale monitoring will continue to develop a comprehensive understanding of the natural systems within the Randall and Breslau Drain subwatersheds. System-Scale Monitoring will be the responsibility of GRCA and the Region. The objectives of the system-scale monitoring program are to:

- Provide ongoing assessment of the overall and long-term health of the natural features and functions at the subwatershed scale
- Assess the efficacy of the natural heritage system and associated setbacks at mitigating impacts to natural features and functions in an urbanizing landscape
- Monitor for system-scale impacts associated with urbanization to inform future subwatershed studies within the East Side Lands (i.e. adaptive management at a system scale)

The system-scale monitoring program will focus on maintaining long-term monitoring sites within and outside the urban expansion area to assess conditions upstream and downstream and / or before and after development. Results of the system-scale monitoring program should be documented on a 5-year cycle comparing conditions with the baseline established in the Subwatershed Study.

Monitoring stations established through the East Sides Lands monitoring program and the subwatershed study will be integrated into the system-scale monitoring program, as appropriate. Monitoring site selection may be subject to securement of landowner permissions to access private property. Components of the system-scale monitoring program are discussed below.

11.3.1 SURFACE WATER & HYDROLOGIC MONITORING

SURFACE WATER FLOW

Surface water flow conditions should be monitored continuously within Randall Drain upstream and downstream of urban expansion area(s). Existing monitoring stations will be integrated as appropriate based on the objectives of the system-scale monitoring so that data can be compared between existing and future monitoring. Monitoring design will be completed by the Region and GRCA.

No surface flow monitoring is recommended for Breslau Drain.

SURFACE WATER QUALITY

Surface water quality grab samples should be collected upstream and downstream of urban expansion area(s) in both Randall and Breslau Drains. A total of 16 grab samples per year should be collected per monitoring station during ice-free conditions and include samples during

periods of low flow, base flow and post significant rainfall events to obtain a cross-section of water quality conditions. Continuous monitoring of conductivity and temperature are recommended for Randall and Breslau Drain.

Existing monitoring stations will be integrated as appropriate based on the objectives of the system-scale monitoring so that data can be compared between existing and future monitoring. Monitoring design will be completed by the Region and GRCA.

To ensure that the results collected for the baseline conditions are complete and consistent, and that potential trends may be established, sampling parameters for system-scale monitoring shall remain unchanged from the existing monitoring program. **Table 11-2** below lists the parameters which are currently sampled and which shall continue to be sampled during future monitoring of Breslau Drain and Randall Drain

Table 11-2: Water Quality Parameters and Sampling Procedures

Parameter	Procedure
Total Ammonia as N	Grab
Total Dissolved Solids	Grab
Total Kjeldahl Nitrogen (TKN)	Grab
Orthophosphate (P)	Grab
Total Phosphorus	Grab
Total Suspended Solids	Grab
Dissolved Sulphate (SO ₄)	Grab
Dissolved Chloride (Cl)	Grab
Nitrite (N)	Grab
Nitrate (N)	Grab
Nitrate + Nitrite	Grab
Temperature	Field
pH	Field
Conductivity	Field
Dissolved Oxygen (DO)	Field

11.3.2 BIOLOGICAL MONITORING

Biological monitoring can include aquatic and terrestrial systems. At the system-scale, biological monitoring density and frequency are reduced, providing ‘snap shots’ of the system over prescribed time periods. Trends and metrics can be used to assess form and function over time, providing an ongoing assessment of long term health and identifying potential impacts to the system associated with urbanization to inform future subwatershed studies. Within the Randall and Breslau Drain Subwatersheds and within and adjacent to urban expansion areas, biological monitoring will focus on aquatic systems that have been historically monitored.

Representative sites will be selected that provide a cross section of the features and functions present in the natural heritage system. Sites will be selected within and outside of development areas such that baseline conditions outside of areas potentially impacted by development can be compared against conditions observed within development areas. Aquatic sites should be

selected that allow for both benthic macro-invertebrate and fish community sampling to occur in the same location. Terrestrial monitoring is not at this time included in the system-scale monitoring. Biological monitoring components are described below.

BENTHIC MACRO-INVERTEBRATES

Benthic macro-invertebrates are good water quality indicators. Composition of the benthic community is generally reflective of system quality over time and serves as a key metric for long-term system health monitoring and assessment. The assessment of impacts to the benthic community is best accomplished at the system-scale as impacts to these communities is often difficult to attribute to site-scale changes. This difficulty may be associated with the cumulative impact of changes over time or due to lag-time between the impact occurring and it being reflected in the community. As a result there are limited opportunities to implement adaptive management strategies at a site-scale to mitigate these impacts. Impacts at a broader geographic and temporal scale provide the opportunity to assess the overall impact of urbanization and land-use changes and the efficacy of mitigation measures established to protect aquatic systems (buffers, stormwater management, etc.).

It is recommended that benthic macro-invertebrate monitoring stations be established upstream and downstream of urban expansion area(s) for Randall and Breslau Drain. Sampling stations established as part of the existing East Side Lands monitoring program should be used to ensure consistency and comparability in data across all monitoring years. Sampling station selection will be determined by GRCA.

Benthic sampling should be conducted annually in the spring (Breslau Drain) or fall (Randall Drain) at all stations for the period of development within the urban area expansion. Monitoring effort beyond active development may be reduced to a level of one event every three years, as appropriate for long-term system monitoring.

FISH COMMUNITY

Fish community sampling should continue to monitor the health and function of the aquatic systems in Randall and Breslau Drain. One sampling event every 3 years is appropriate for long-term monitoring of these communities.

It is recommended that fish community sampling stations be consistent with sampling stations established as part of the East Side Lands monitoring program for comparability of data across all monitoring year. Sampling station selection will be determined by GRCA.

Fish community and benthic invertebrate surveys should occur at / near the same survey location, however, benthic surveys must be conducted either before electrofishing the site or at least two weeks afterwards to avoid impacts to results.

11.4 SITE-SCALE DEVELOPMENT MONITORING

Site-scale development monitoring (herein referred to as development monitoring) will include pre-, during- and post-construction monitoring with a focus on confirming implementation and function of mitigation measures and potential impacts that can be mitigated through adaptive

management at a site-scale. Development monitoring is the primarily responsibility, in terms of financing and completion, of the development proponent (the developer). The objectives of site-scale monitoring programs are to:

- Confirm conditions within or immediately adjacent to development areas compared to baseline conditions reported in this subwatershed study for parameters where baseline updates are required.
- Confirm implementation and proper functioning of stormwater, erosion and sediment control and ecological mitigation measures recommended through this subwatershed study (e.g. buffers, setbacks, linkages / corridors).
- Monitor features within and immediately adjacent to development areas for potential impacts associated with development and support system-scale monitoring through during- and post-construction periods.
- Enhance existing, or implement additional mitigation measures where, through monitoring, development impacts are identified (i.e. adaptive management).

Development monitoring requirements will be reviewed and applied on a site-by-site basis as applicable. A detailed monitoring plan will be submitted by the developer in accordance with **Table 11-1** and this report for approval by the GRCA, Region and / or the local Municipality, as appropriate. The detailed monitoring plan will describe how the developer has met the requirements outlined in this study, including site locations.

11.4.1 PRE-CONSTRUCTION MONITORING

It is recommended that appropriate agencies (GRCA, Region of Waterloo, local Municipality) be consulted prior to initiation and throughout pre-construction monitoring. Results of pre-construction monitoring should be provided in advance of or, at a minimum, as part of the preliminary design process. A single report documenting pre-construction conditions would be sufficient for review and informing during- and post-construction monitoring requirements.

GROUNDWATER

Pre-construction groundwater monitoring will focus on the shallow aquifer, but will also include relevant stratigraphic units to assess potential impacts associated with site development. Where possible, existing shallow monitoring wells and mini-piezometers should be utilized for comparison against existing data.

Feature-based groundwater monitoring should also be included on sites where groundwater supported features (wetlands, watercourses) occur on or immediately adjacent to the site to refine the understanding of contributions of the site to these features (pre-development) and monitor during- and post-condition water balance associated with these features.

Monitoring is recommended for two years prior to construction (baseline) and will consist of the following components:

- Groundwater level monitoring seasonally in spring, summer and fall.

- Groundwater quality sampling on an annual basis for both laboratory and field parameters.
- Feature-based groundwater level monitoring monthly from snowmelt to freeze-up.

Field tested parameters should include temperature, pH, electrical conductivity (EC) and dissolved oxygen (DO). Laboratory tested parameters should include major anions and cations (including nitrogen species and chloride), total dissolved solids (TDS), and phosphorus (as total phosphorus and soluble reactive phosphorus). Duplicate samples shall be taken for QA/QC purposes.

SURFACE WATER QUALITY

Surface water quality grab samples should be collected from receiver streams / features upstream and downstream of the development site to assess baseline (pre-construction) conditions for 2 years prior to construction. A total of 16 grab samples should be collected per year per monitoring station during ice-free conditions and include seasonal representation and samples during periods of low flow, base flow and post significant rainfall events to obtain a cross-section of water quality conditions. Existing monitoring stations should be used where appropriate / possible so that data can be compared with existing monitoring information. Parameters monitored should include, at a minimum, those where exceedances were identified through the subwatershed study including TSS, chloride, nitrate / nitrite and total Phosphorous.

QUANTITATIVE PHOTO MONITORING – ADJACENT NATURAL AREAS

Quantitative monitoring will provide information on the implementation and vegetation performance, condition and quality within the buffers during- and post-construction. To facilitate this assessment, quantitative plots should be established and monitoring be initiated in adjacent natural areas to confirm baseline conditions prior to construction.

A technique described by Van Horn and Van Horn (1996), known as 'quantitative photo monitoring', will be used to sample permanent monitoring plots. Permanently marked transects will be established in natural heritage features (woodlands, wetlands, riparian areas) immediately adjacent to development. Sites should be selected with consideration for where monitoring within buffers will occur.

Quadrats will be established along the transect (at 1 m, 3 m, 5 m, and 8 m) and inventoried for plant species (presence / absence and frequency of occurrence) and photographed. Additional measurements and observations will be made (e.g. dominant trees, shrubs and/or herbaceous plants between the photo and reference points, the depth and location of any standing water, general notes on community health and site disturbance). Inventoried plant species will be characterized by their *Coefficient of Conservatism* and *Coefficient of Wetness*. Quantitative photo monitoring will be undertaken once annually in June during pre-construction monitoring.

11.4.2 DURING-CONSTRUCTION MONITORING

The During-construction phase of monitoring begins with the initiation of grading or other significant site-alteration and continues until 90% stabilization of the catchment area (e.g. lots are constructed, sodded or stabilized if being left un-developed). During-construction monitoring continues pre-construction monitoring activities and also focuses on confirming the proper implementation and effectiveness of mitigation measures established on the site during the construction process. Some monitoring components will be triggered as mitigation measures are installed / established during construction. Note that the monitoring requirements described in this report are in addition to standard construction inspection requirements (i.e. inspection of erosion and sediment control measures). Construction inspection requirements will be identified and approved through the detailed design process.

During-construction monitoring activities and outcomes will be reported annually. Each annual report will summarize observations / analysis of results, impacts or deficiencies identified, how deficiencies were addressed and conclusions. Reports are to be circulated to the regulatory agencies, including GRCA, the Region and the City or Township, as appropriate.

SURFACE WATER QUALITY

Grab samples, as described in the pre-construction monitoring should be continued during construction. In addition to these, the developer will be responsible for obtaining samples from temporary sediment and ultimate stormwater management facilities to ensure that the pond performance levels are attained (as specified in Chapter 7 requirements of the City of Cambridge SWM Policies, 2011). The minimum performance target of SWM ponds should be 80% total suspended solid removal as per the 2003 MOE Manual. Minimum sample collection monthly with increased frequency for frequent or significant storm events.

GROUNDWATER

Groundwater monitoring as described in the pre-construction monitoring should be continued during construction to monitor groundwater levels and quality as development occurs and identify any potential impacts associated with the construction. Specific consideration should be given to supporting natural heritage features that rely on groundwater contributions.

QUANTITATIVE PHOTO MONITORING – BUFFERS & ADJACENT NATURAL AREAS

Quantitative photo monitoring of permanent plots within adjacent natural heritage features will continue as described in pre-construction monitoring above. Quantitative plots will be added to buffer areas in accordance with the methods listed in the pre-construction section and monitoring will initiate as buffers are established. Monitoring within buffers may be initiated at different times across the site based on construction phasing / staging.

Quantitative photo monitoring within buffers should focus on assessing establishment, function and effectiveness of the buffers in protecting adjacent natural heritage features (e.g. invasive species abundance, species diversity, etc.). This will include considering changes to plots over

time within features and in their associated buffers. Quantitative photo monitoring will be undertaken once annually in June.

11.4.3 POST-CONSTRUCTION MONITORING

Post-construction monitoring continues pre- and during-construction monitoring and focuses on confirming ongoing function and effectiveness of mitigation measures recommended through this subwatershed study and implemented during construction. This period ensures they are functioning as designed and achieve required control-targets, prior to assumption of the facilities by the appropriate municipality. The post-construction monitoring period is defined as three-years after 90% of the catchment area is stabilized (e.g. lots are built, sodded or stabilized if they are to remain un-developed).

Post-construction monitoring activities and outcomes will be reported annually. Each annual report will summarize observations / analysis of results, impacts or deficiencies identified, how deficiencies were addressed and conclusions. Reports are to be circulated to the regulatory agencies, including GRCA, the Region and the City or Township, as appropriate. If adaptive management strategies have been triggered, monitoring must continue until 2 years of monitoring demonstrate the mitigation measure has successfully addressed the concern.

SURFACE WATER QUALITY

Grab samples, as described in the pre-construction monitoring should be continued during construction. The developer will additionally be responsible for monitoring influent and effluent samples from stormwater management facilities to ensure that the pond performance levels are attained (as specified in Chapter 7 requirements of the City of Cambridge SWM Policies, 2011). The minimum performance target of SWM ponds should be 80% total suspended solid removal as per the 2003 MOE Manual.

Post construction monitoring also applies to source and conveyance controls implemented on individual, commercial, and industrial properties as well as end-of-pipe controls. Monitoring requirements for LID source and conveyance controls should be in accordance with the LID Planning and Design Manual (TRCA / CVC, 2011) and the CVC Stormwater Management and LID Monitoring and Performance Assessment Guide (CVC 2015).

Sampling will be conducted monthly and for storm events.

GROUNDWATER

Groundwater monitoring as described in the pre-construction monitoring should be continued post-construction to monitor groundwater levels and quality to confirm there are no impacts associated with the development. Specific consideration should be given to supporting natural heritage features that rely on groundwater contributions.

QUANTITATIVE PHOTO MONITORING – BUFFERS & ADJACENT NATURAL AREAS

Quantitative photo monitoring of permanent plots within adjacent natural heritage features will continue as described in pre-construction and during-construction monitoring above. Quantitative photo monitoring during the post-construction period should focus on the effectiveness of buffer implementation (establishment, vegetation performance, species diversity and quality). If it is determined that buffers are not performing as intended (i.e. dumping, invasive species and / or non-native dominance, etc.) recommendations for changes to the buffers (e.g. debris removal, invasive species control, barrier plantings, re-seeding / planting with native species) is to be made as part of annual reported and implemented as appropriate.

11.4.4 POST-DEVELOPMENT MONITORING

Ongoing post-development monitoring of facility performance will be the responsibility of the municipality upon assumption of the facilities and will be undertaken in accordance with Environmental Compliance Approvals conditions. It is anticipated that municipal monitoring would include end-of-pipe facilities only; at-source and conveyance systems on private property would not be the responsibility of the municipality. Consideration for post-development monitoring requirements of systems on private property should be reviewed through subdivision or site-plan agreements, as appropriate. Any post-development monitoring identified for systems on private property should be detailed and include scope and duration.

11.4.5 SITE-SPECIFIC VEGETATION AND WILDLIFE MONITORING

There is no site-scale vegetation or wildlife monitoring required consistently for all development sites. Site-specific vegetation or wildlife monitoring may be triggered where there is a risk of impact to a significant species or feature (e.g. Barn Swallow, species at risk bats, significant habitat for species of concern or species at risk, groundwater seeps) that necessitates more detailed monitoring. If based on site-specific conditions targeted vegetation or wildlife monitoring is required, it will be identified through an EIS and monitoring requirements confirmed through a detailed monitoring plan or based on permit or registration conditions (for Species at Risk). It is important that any requests for additional monitoring meet the test of having opportunities to adapt mitigation measures to affect the impact being observed.