APPENDIX D

WATER BALANCE FOR PROTECTION OF NATURAL FEATURES

Contents

D1. Introduction

The following guidelines set out the requirements for maintaining hydrologic function of natural features that have been recommended for protection through an Official Plan designation, Subwatershed Study, Master Environmental Servicing Plan, Environmental Impact Study, or another similar study, and/or in consultation with the conservation authority and municipality. They outline the general requirements for a water balance for natural features, which may be scoped down in consultation with the conservation authority and municipality, depending on the sensitivity of the features, degree of anticipated impacts, and the current planning stage.

1.1 Guiding Principles

The objective of protecting a natural feature's specific water balance is to ensure that the changes anticipated post development do not exceed the feature's capacity to respond and adapt, allowing for its long-term perpetuation and sustainability, while minimizing the resources/interventions needed to manage and maintain it. This is really an assessment of risk. The desire is to maintain the physical and biological complexity of the system and not move to a more simplified system.

The information that is collected as part of the process to determine protection will assist in scoping the work required to determine the existing hydrologic regime of the feature. This information, in concert with information on the form and type of development that is being proposed, will be used in the more detailed analysis.

It is important that the proponent's consulting team meet with staff from the conservation authority (CA) early in the process to detail the works required as part of the water balance evaluation. Factors that will be considered when looking at field investigations, instrumentation, and modeling include but are not limited to, the following:

- The extent that the feature is supported by ground water and the extent that is surface water;
- The extent of the catchment (surface or ground water) that is going to be modified by the proposal;
- The nature of the feature's vegetation and habitat characteristics and their ecological amplitude or range of conditions that they are suited to;
- The extent to which it has been agreed that the feature can be modified through the development process (e.g. headwater features where the functions are to be replicated through modifications).

Instrumentation and the type of modeling required will be based on the above (i.e. information may or may not be available) and discussed with the CA. The CA will assess the results to determine if the information/results are correct and will determine the degree of error/risk associated with the analysis.

1.2 Wetland Hydrology

Wetlands can naturally control peak floods by retaining water and allowing slow release of water to receiving bodies (e.g. lakes, streams, aquifers). The hydroperiod is the seasonal pattern of water level fluctuation (Mitsch and Gooselink, 2007; Wright et al. 2006; Azous and Horner, 2001; Reinelt et al., 1998). It is the result of inflow and outflow, surface contours of the landscape, substrate and groundwater conditions. Wetlands vary in their susceptibility to changes in hydroperiod. Shallow wetlands may experience greater impacts to decreases in water depth (i.e. reduction in water volume) than deeper wetlands since even minor reductions in water depth may reduce the extent of flooding around the fringe of shallow wetlands. Swamps may experience greater changes over the long term if flood frequency and duration are altered since these features depend on a period of dry soils to replenish the oxygen supply that will sustain the community during inundation. Under natural conditions, groundwater dominated wetlands experience little fluctuation in water levels due to seasonal variation in climate. However increases in imperviousness may increase runoff and impact recharge rates thereby increasing surface water inputs and decreasing the availability of groundwater to the wetland, respectively (Wright et al. 2006).

When they qualify as wetland, due to their size and dependence on climate, vernal pools are likely the most sensitive wetland in terms of annual climatic variation. Obligate species in vernal pools are accustomed to the hydrologic regime of their specific pools. Changes to hydrology may create habitats unsuitable for inhabitants and may result in habitats more suitable for predators previously not found, thereby changing the composition and dynamics of the system.

Vegetation tolerance to fluctuations in water depth, duration and frequency varies (Baldwin et al. 2001). As water depth increases community composition transitions to more aquatic vegetation (floating or submergent species) or no vegetation at all. An increase in the duration of inundation depletes nutrients and oxygen stored in the soil and prevents recharge of these nutrients. Studies show that the frequency by which a wetland is inundated influences plant richness. Increases in inundation can translate to decreases in plant richness (Azous and Horner, 2000). Managing water balance with the intent to maintain the hydroperiod of wetlands is the first step in ensuring the long-term health and survivability of these features and those species that depend on them.

1.3 Woodland Hydrology

There is usually a decreasing gradation in soil moisture from wetlands to woodlands. However, maintaining soil moisture in woodlands is important, particularly for those with moisture regimes from moist-fresh (according to Lee, et al. 1998). Drier upland communities may be less sensitive to surface water changes than, for example, wetlands. However, water is important to these upland habitats as well. In woodlands, shallow aquifers may interact with root zones. The species composition in upland communities is in response to the hydrology of that given area. Vegetation adapts to the specific hydrology and local conditions of their community. Generally, sugar maple, white ash, and white elm are common in fresh to moist areas, whereas red oaks and red and white pines are more prevalent in areas of dry regimes. Changes in hydrology can dry out or saturate soils, changing the amount of oxygen available to roots. Moisture also plays a key role in decomposition of organic material, which affects the composition of soils within the community.

Woodlands can be affected by development through changes to hydrology. Typically, pre-development surface drainage to woodlands may be diverted away to storm sewers, or these stormwater sewers may direct concentrated flow into woodlands where they previously did not exist. These changes can cause increases or decreases in soil moisture or water table levels that can cause detrimental community shifts over time. An example of this is Altona Forest in Pickering, which has experienced drying of forest communities following the development of surrounding lands and diversion of surface water drainage (Behera and Graham, 2004). Managing the water balance with the intent to maintain the functions of the hydrology of woodlands following development will also help to ensure that the woodland is more resilient to the many stressors it will have to endure in urban and urbanizing contexts.

1.4 Watercourse Hydrology

Variability in intensity, timing, and duration of precipitation and in the effects of terrain, soil texture, and evaporation on the hydrologic cycle collectively form the local and regional flow pattern. The timing, or predictability, of flow events is of paramount ecological importance because the life cycles of many aquatic or riparian organisms are timed to either avoid or exploit flows of variable magnitudes (Poff et al. 1997). For example, the natural timing of high or low streamflows is a trigger for the initiation of life cycle processes, such as spawning, egg hatching, rearing, movement onto floodplains for feeding or reproduction, or migration upstream or downstream.

In addition, most permanently flowing streams derive their baseflow from groundwater, interflow or wetland contributions. Groundwater discharge to streams may be more significant in some reaches than others. Areas of strong groundwater discharge often provide critical refuge or spawning habitat for some coldwater fish species. Protecting these groundwater contributions is paramount for these species, but groundwater discharge also provides thermal stability for many other species. It is important to manage the water balance with the intent to maintain/replicate these groundwater contributions through the development process via.

Urbanization can impact the natural flow regime by altering the hydrologic components. Runoff tends to increase, and evapotranspiration and infiltration tend to decrease, causing the flow regimes of streams to become more flashy (see rate of change of flow in glossary), which stresses aquatic systems. Managing the water balance after development occurs is critical to continued functionality for watercourses.

Headwater drainage features (HDFs) are zero or first-order streams, swales and wetlands, which may not flow or sustain water year-round. Because of their small size and temporary nature, HDFs provide the greatest opportunity for interaction between aquatic and terrestrial ecosystems. These features are also considered to be important sources of food, sediment, water, nutrients and organic material to downstream reaches (TRCA and CVC, 2007). Because they are temporary, HDFs have unique hydroperiods, different from perennial streams, but important in maintaining downstream aquatic integrity. Headwater drainage features also provide important habitat for amphibians (TRCA 2010) and other taxa that rely on temporary waters. Up to 90% of a river's flow can be derived from catchment headwaters (Saunders et al. 2002).

Alterations to the hydroperiods of HDFs can change the hydrology of downstream ecosystems and impact the supply of organic and inorganic materials that are important to aquatic communities. Naturally variable flow regimes create and maintain the dynamics of in-channel and floodplain conditions and habitats that are critical to aquatic life (Poff et al. 1997). The timing, duration, magnitude, frequency, and rate of change of flow are all critical components of flow (Poff et al. 1997; Saunders et al. 2002; Richter et al. 1997). Together these components constitute the flow regime or hydrological regime of an area. The critical components for aquatic communities, including water temperature, dissolved oxygen concentrations, suspended sediment loads, nutrient availability, and physical habitat structure, all vary with hydrological regime (Richter et al. 1997). As such, aquatic communities are vulnerable to changes in the flow regime. Poff et al. (1997) suggest that flow regime is the 'master variable' limiting the distribution and abundance of riverine species.

D2. Definitions

2.1 Wetland

As a result of Ontario Regulation 97/04 (Generic Regulation), "wetlands" became areas that can be regulated under Section 28(1) of the *Conservation Authorities Act*. A wetland is defined as land that:

a. *is seasonally or permanently covered by shallow water or has a water table close to or at its surface,*

b. *directly contributes to the hydrologic function of a watershed through a connection with a surface watercourse,*

c. *has hydric soils, the formation of which has been caused by the presence of abundant water, and*

d. *has vegetation dominated by hydrophytic plants or water tolerant plants, the dominance of which has been favoured by the presence of abundant water, but does not include periodically soaked or wet land that is used for agricultural purposes and no longer exhibits a wetland characteristic referred to in clause (c) or (d).*

Under the Provincial Policy Statement (2005), wetland refers to:

Lands that are seasonally or permanently covered by shallow water, as well as lands where the water table is close to or at the surface. In either case the presence of abundant water has caused the formation of hydric soils and has favoured the dominance of either hydrophytic plants or water tolerant plants. The four major types of wetlands are swamps, marshes, bogs and fens. Periodically soaked or wet lands being used for agricultural purposes, which no longer exhibit wetland characteristics, are not considered to be wetlands for the purposes of this definition.

Under the Oak Ridges Moraine Conservation Plan (2002) and the Greenbelt Plan (2005), wetland is defined as:

Land such as swamp, marsh, bog or fen (not including land that is being used for agricultural purposes and no longer exhibits wetland characteristics) that:

a. *Is seasonally or permanently covered by shallow water or has the water table close to or at the surface;*

b. *Has hydric soils and vegetation dominated by hydrophytic or water-tolerant plants; and*

c. *Has been further identified, by the Ministry of Natural Resources or by any other person, according to evaluation procedures established by the Ministry of Natural Resources, as amended from time to time.*

A feature that meets any of the above applicable definitions would qualify as a wetland for the purposes of this guideline.

2.2 Woodland

A woodland is defined by the Provincial Policy Statement (2005) as:

Treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as erosion prevention, hydrological and nutrient cycling, provision of clean air and long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products. Woodlands include treed areas, woodlots or forested areas and vary in their level of significance at the local, regional and provincial levels.

The Oak Ridges Moraine Conservation Plan (2002) defines a woodland as:

A treed area, woodlot or forested area, other than a cultivated fruit or nut orchard or a plantation established for the purpose of producing Christmas trees

The Greenbelt Plan (2005) defines a woodland as:

Treed areas that provide environmental and economic benefits to both the private landowner and the general public, such as erosion prevention, hydrological and nutrient cycling, provision of clean air and the long-term storage of carbon, provision of wildlife habitat, outdoor recreational opportunities, and the sustainable harvest of a wide range of woodland products. Woods include treed areas, woodlots or forested areas.

A feature that meets any of the above applicable definitions, or any definition used by a municipality in their Official Plan, would qualify as a woodland for the purposes of this guideline. **Note that swamps are considered to be wetlands and not woodlands for the purposes of this guideline**.

2.3 Watercourse

The 1998 amendments to the *Conservation Authorities Act*, and subsequent approval of individual Section 28(1) Regulations by the Minister of Natural Resources in May 2006, gave all Conservation Authorities the legal right to apply a consistent definition of watercourse, which is:

An identifiable depression in the ground in which a flow of water regularly or continuously occurs.

Headwater drainage features, which are ephemeral or intermittent streams or swales, could qualify as a watercourse under this definition and may also require a water balance to protect hydrological function.

2.4 Negative Impacts

According to the Provincial Policy Statement (2005), negative impact means:

a. degradation to the quality and quantity of water, sensitive surface water features and sensitive ground water features, and their related hydrologic functions, due to single, multiple or successive development or site alteration activities;

b. in regard to fish habitat, the harmful alteration, disruption or destruction of fish habitat, except where, in conjunction with local authorities, it has been authorized under the Fisheries Act; and

c. in regard to other natural heritage features and areas, degradation that threatens the health and integrity of the natural features or ecological functions for which an area is identified due to single, multiple or successive development or site alteration activities.

D3. Water Balance Requirements for Wetlands (Including Vernal Pools)

These guidelines set out the steps for undertaking a water balance when a development is proposed that may affect a wetland that has been identified for protection through the planning or regulatory process within the CA's jurisdiction. Vernal pools that support amphibians may also require a water balance analysis if there is a likelihood that the proposed development will impact the features and their functions.

Overall Objective: Maintain quantity of surface water and groundwater contributions that ensures the pre-development hydroperiod (seasonal pattern of water level fluctuation) of the wetland is protected. The proposed development does not cause changes to the hydroperiod that negatively impact the hydrological functions of the feature. In areas identified as degraded, the objective may be to enhance water balance of the feature.

Vernal pools may be small inclusions in larger woodland polygons, which may not be specifically targeted through a woodland water balance. Since hydrology may be an important factor that allows sensitive amphibian species to inhabit vernal pools, a wetland water balance should be undertaken where deemed necessary for these features. For vernal pools that are identified as being ecologically important, please consult the CA and municipality prior to undertaking an evaluation to determine appropriate requirements.

MNR must also be contacted if species at risk are known to use the vernal pool or any other wetland feature. Wildlife Scientific Collectors Authorizations (WSCAs) and Endangered Species Act (ESA) permits are required for any surveys or studies to investigate for the presence of species at risk.

Consult with CA and municipal staff to establish the terms of reference (TOR) and scope of work.

The following is a general outline of the process and requirements for undertaking a water balance for wetlands.

Step 1 – Determining the Need for a Water Balance

- Identify existing and proposed land uses.
- Delineate the area contributing (both surface and ground water catchments) to the wetland, and determine if the proposal may affect the catchment or wetland directly.
- If the change in catchment size, the amount and form of the development and the sensitivity of the wetland are such that an impact is likely, a water balance will be required. Consult with Conservation Authority and municipal staff to establish the terms of reference (TOR) and scope of work. The following steps outline the general requirements.

Step 2 – Establishing Baseline Conditions

- Using a digital elevation model or detailed topographical information, determine the topographical contours on the site and catchment for the feature to the finest resolution possible (e.g. 0.25 m or less).
- Delineate the bathymetry of the wetland by with a series of water depth measurements referenced to a known elevation.
- Collect baseline data on wetland water levels using staff gauges, data logger (continuous basis) and/or mini-piezometer(s), as necessary, for a minimum of 3 years. The number and arrangement of instrumentation and methods of equipment installation (to manage potential impacts) should be determined in consultation with the Conservation Authority.
- To supplement mini-piezometer data, measure depths of organic layers and depths to mottles and gley using a soil core or auger in order to ascertain vertical water level fluctuations. High water marks may also be observed and measured.
- For multiple developments within the same wetland catchment, a comprehensive, coordinated water balance analysis should be undertaken, with Conservation Authority and municipal staff to assist in facilitating discussion and development of TOR.
- All monitoring should stay in place throughout the development process in order to establish multiple years of data pre and post development for the monitoring plan (see Step 6).

Step 3 – Developing the Existing Conditions Water Budget Model

- Conduct a soils analysis and/or borehole drilling program within the catchment to determine the proportion of precipitation that will characterize the components of the water budget (i.e. runoff vs. infiltration).

- Determination of soil characteristics and permeability estimates should be performed using field testing methods:
  - visual examination and description of shallow surficial soil and changes in lithology with depth;
  - hydraulic testing for permeability such as percolation tests at a selection of sites within the wetland catchment area. Distinct soils would require separate tests;
  - the Guelph Permeameter and double ring infiltrometer are two approved methods for percolation testing.
  - Although grain size distribution analysis assists in identifying the soil constituents (clay, silt, sand, gravel) and soil type, it alone does not allow estimates of permeability for tills that predominately occur within the area.
- Check with the Conservation Authority regarding the location of existing rain gauges to obtain precipitation data. Additional rain gauges may or may not be required.
- Using the information gathered through Step 2 and the soils analysis, determine the quantity and flow paths of water to the wetland(s), and describe the proportion of flows that reach the wetland(s) via surface water and groundwater from the subject site. Ensure that each subcatchment is appropriately identified and characterized.
- Include inflow and outflow information for the wetland in order to ascertain the type of wetland being assessed (i.e. palustrine, isolated, riverine or lacustrine), and how this affects the wetland's hydrology.
- Develop an Existing Conditions Water Budget using an approved continuous model, such as PRMS, HSPF, QUALHYMO, or SWMM, to be calibrated with measured data where available and technically appropriate. A groundwater model is not a requirement for the wetland water budget at this time (although the applicant is free to propose to use a groundwater model in addition to a surface water model). The understanding of groundwater/surface water interactions should inform the selection and set up of the surface water models described above.
- Run long-term analysis based on nearest available climate data, e.g. precipitation, temperature, etc. as a minimum, using the period between 1991 and 2008, which is considered to be representative. Using a 30-year climate record or greater is preferred.
- Using the long-term climate record, determine if the measured data represent a wet or dry year, and run the model under varying scenarios.
- Daily water balance analysis should be used to generate weekly results. Consult with the Conservation Authority and municipality to determine if an alternate resolution is more appropriate.
- It may be necessary to submit the Existing Conditions Water Budget Model, existing conditions/inventory data and calculations to the Conservation Authority and municipality for review and approval prior to proceeding to Step 4.

Step 4 – Comparing Pre-development and Post-development

- In consultation with the Conservation Authority and appropriate agencies, establish water balance goals and targets for the wetland's hydroperiod (including extent, duration, depth and timing) maintaining consistency with targets and objectives determined through subwatershed plans, watershed plans, or other relevant studies

- Conduct a water budget analysis to determine how the proposed changes in landuse within the wetland catchment will affect the water budget. Conduct a daily water balance analysis and generate results on a weekly basis.
- A comparison of pre- development and post-development groundwater conditions can be completed in a number of ways. For example, dewatering calculations (when appropriate) or a comparison of pre-development and post-development groundwater recharge rates. The approach should be discussed with the Conservation Authority, including how the groundwater and surface water assessment results will be incorporated.
- Based on the modeled analysis, quantify changes in infiltration, runoff, and evapotranspiration, as well as changes in the distribution of flow paths, and surface water and groundwater levels on a weekly basis to determine if the development will result in changes to the wetland hydroperiod.
- Generate maps, tables and graphs illustrating these changes. Plot the pre-development and post-development hydroperiods on graphs, and delineate the area of flooding on a seasonal/monthly basis on maps.

Step 5 – Applying Mitigation

- Please note that the Conservation Authority prefers that clean roof water be utilized to make-up the wetland water balance and that treated stormwater should be redirected to nearby creeks.
- Apply mitigation measures to manage the water balance with the intent to maintain the pre-development hydroperiod of the wetland according to the Overall Objective.
- If the pre-development runoff and/or infiltration cannot be achieved through the proposed mitigation measures, an analysis of the anticipated negative impacts will need to be completed in order to determine if the Overall Objective is adhered to. If negative impacts are anticipated, additional mitigation measures will be required.

Step 6 – Reporting and Monitoring

- Synthesize the information gathered through the above steps into a water balance report and submit to the Conservation Authority and municipality for review. Provide a comparison table showing the differences between the pre-development conditions, post-development condition, and the post-development with mitigation condition for all components of the water budget and for each subcatchment. Appendices containing models and calculations shall be provided.
- Consult with the Conservation Authority and municipality to determine if monitoring is required. If monitoring is required, the report should discuss proposed post-development monitoring of all baseline parameters to determine the effectiveness of mitigation measures and to assess the level and extent of negative impacts, if any. A Terms of Reference for the monitoring plan should be included in the water balance report. For significant features, the requirement for a monitoring plan can be anticipated.

- A 3-year post-development monitoring plan should be developed, however more may be required depending on the scope and scale of the development (i.e. timing and duration of build-out). A post-development monitoring report should be submitted to the Conservation Authority and municipality at the end of the monitoring period.
- Generally, the purpose of this monitoring will be to monitor changes to the hydrology of the natural features and identify whether remediation measures to tweak the hydrology should be employed. These remediation measures need to be considered early on in the planning phases in order to ensure feasibility, and identified through discussion with the Conservation Authority and municipality. A Contingency Plan (for short-term impacts) and an Adaptive Management Plan (for the long-term) should be developed in these instances to identify steps to be taken if it is identified that there is a negative impact on the feature. Mitigation considered in previous steps should be designed to account for opportunities to refine the hydrology.

D4. Water Balance Requirements for Woodlands

These guidelines set out the steps for undertaking a water balance when a development is proposed that may affect a woodland that has been identified for protection through the planning process within the Conservation Authority's jurisdiction. These guidelines only apply to woodlands with moist-fresh moisture regimes according to Lee et al. (1998), and/or when the water table is less than 3 m below ground in spring (Schenk and Jackson, 2002, Crow 2005). They are meant to apply to more sensitive core, mature habitats and not to plantations, successional, corridors, or marginal habitats.

Overall Objective: Manage the water balance with the intent to maintain volume, timing and spatial distribution of surface water and groundwater contributions that ensures that hydrological changes do not cause a negative impact on the form and/or function of the woodland. In areas identified as degraded, the objective may be to enhance water balance of the feature.

The following is a general outline of the process and requirements for undertaking a water balance for woodlands:

Step 1 – Determining the Need for a Water Balance

- Identify existing and proposed land uses.
- Delineate the area contributing (both surface and ground water catchments) to the woodland, and determine if the proposal may affect the catchment or woodland directly.
- If the change in catchment size, the amount and form of the development and the sensitivity of the woodland are such that an impact is likely, a water balance will be required. Consult with Conservation Authority and municipal staff to establish the terms of reference (TOR) and scope of work. The following steps outline the general requirements.

Step 2 – Developing the Existing Conditions Water Budget Model

- Using a digital elevation model or detailed topographical information, determine the topographical contours on the site and for the feature using the finest resolution possible.
- Conduct a soils analysis and/or borehole drilling program within the catchment to determine the proportion of precipitation that will characterize the components of the water budget (i.e. runoff vs. infiltration).
- Check with the Conservation Authority regarding the location of existing gauges to obtain precipitation data. Additional rain gauges may or may not be required. For multiple developments within the same woodland catchment, a comprehensive, coordinated water balance analysis should be undertaken, with Conservation Authority and municipal staff to assist in facilitating discussion and development of TOR.
- Determine the quantity and flow paths of water to the woodland(s), and describe the proportion of flows that reach the woodland(s) via surface water and groundwater from the subject site. Ensure that each subcatchment is appropriately identified and characterized.
- Develop an Existing Conditions Water Budget using an approved continuous model, such as PRMS, HSPF, QUALHYMO, or SWMM. A groundwater model is not a requirement for the water budget at this time (although the applicant is free to propose to use a groundwater model in addition to a surface water model). The understanding of groundwater/surface water interactions should inform the selection and set up of the surface water models described above.
- Run long-term analysis based on nearest available climate data, e.g. precipitation, temperature, etc., as a minimum, using the period between 1991 and 2008, which is considered to be representative. Using a 30-year climate record or greater is preferred.
- Using the long-term climate record, determine if the measured data represent a wet or dry year, and run the model under varying scenarios.
- Daily water balance analysis should be used to generate monthly results. Consult with the Conservation Authority and municipality to determine if an alternate resolution is more appropriate.
- It may be necessary to submit the Existing Conditions Water Budget Model to the Conservation Authority and municipality for review and approval prior to proceeding to Step 4.

Step 3 – Comparing Pre-development and Post-development

- In consultation with the Conservation Authority and appropriate agencies, establish water balance goals and targets consistent with subwatershed plans, watershed plans, and other relevant studies.
- Conduct a water balance analysis to determine how the proposed changes in landuse within the woodland catchment will affect the water budget. A daily water balance analysis should be undertaken to generate monthly results.
- A comparison of pre- development and post-development groundwater conditions can be completed in a number of ways. For example, dewatering calculations (when appropriate) or a comparison of pre-development and post-development groundwater

recharge rates. The approach should be discussed with the Conservation Authority, including how the groundwater and surface water assessment results will be incorporated.

- Based on the modeled analysis, quantify changes in infiltration, runoff, and evapotranspiration, as well as changes in the distribution of flow paths, and surface and groundwater levels. Provide the information on a monthly basis to determine if the development will result in changes to the woodland hydrology. Provide maps, tables and graphs as necessary.

Step 4 – Applying Mitigation

- Apply mitigation measures to manage the water balance with the intent to maintain the pre-development hydrology of the woodland according to the Overall Objective.
- If the pre-development runoff and/or infiltration cannot be achieved through the proposed mitigation measures, an analysis of the anticipated negative impacts will need to be completed in order to determine if the Overall Objective is adhered to. If negative impacts are anticipated, additional mitigation measures will be required.
- Please note that the Conservation Authority prefers to utilize clean roof water to augment the woodland water balance and to redirect treated stormwater away to nearby creeks.

Step 5 – Reporting and Monitoring

- Synthesize the information gathered through the above steps into a water balance report and submit to the Conservation Authority and municipality for review. Provide a comparison table showing the differences between the pre-development conditions, post-development condition, and the post-development with mitigation condition for all components of the water budget and for each subcatchment. Appendices containing models and calculations shall be provided.
- Consult with the Conservation Authority and municipality to determine if monitoring is required. If monitoring is required, the report should discuss proposed post-development monitoring of all baseline parameters to determine the effectiveness of mitigation measures and to assess the level and extent of negative impacts, if any. A Terms of Reference for the monitoring plan should be included in the water balance report.
- A minimum 3-year post-development monitoring plan should be developed, however more may be required depending on the scope and scale of the development (i.e. timing and duration of build-out). A post-development monitoring report should be submitted to the Conservation Authority and municipality at the end of the monitoring period.
- Generally, the purpose of this monitoring will be to monitor changes to the hydrology of the natural features and identify whether remediation measures to tweak the hydrology should be employed. These remediation measures need to be considered early on in the planning phases in order to ensure feasibility, and identified through discussion with the Conservation Authority and municipality. A Contingency Plan (for short-term impacts) and an Adaptive Management Plan (for the long-term) should be developed in these instances to identify steps to be taken if it is identified that there

is a negative impact on the feature. Mitigation considered in previous steps should be designed to account for opportunities to refine the hydrology.

D5. Water Balance Requirements for Watercourses (Including Headwater Drainage Features)

These guidelines set out the steps for undertaking a water balance when a development is proposed that may affect a watercourse and/or headwater drainage feature that has been identified for protection through the planning or regulatory process in the Conservation Authority's jurisdiction.

NOTE: For headwater drainage features, please refer to the Evaluation, Classification and Management of Headwater Drainage Features (HDF): Interim Guidelines March 2009, and ensure that the requirements for meeting management recommendations of the interim headwater guidelines are met, prior to proceeding with the water balance analysis, as necessary.

The requirements listed below are expected for all watercourses and HDFs, unless otherwise determined in consultation with the appropriate agencies. Please obtain further guidance from the Ministry of Natural Resources (MNR) regarding the locations of watercourses being managed for species at risk under the Endangered Species Act.

Overall Objective: Manage the water balance with the intent to maintain quantity of surface water and groundwater contributions with respect to duration, frequency, magnitude, and flow. In areas identified as degraded, the objective may be to enhance water balance of the feature.

Fish community, management zone mapping, and targets are defined by the Fisheries Management Plan (FMP) at the watershed scale, but may be further refined based on more recent information. In cases where an FMP does not exist, the proponent should consult with the Conservation Authority for further information and appropriate targets.

The following is an outline of the process for undertaking a water balance for watercourses:

Step 1 – Determining the Need for a Water Balance

- Identify existing and proposed land uses.
- Delineate the area contributing (both surface and ground water catchments) to the watercourse on the subject property, and determine if the proposal may affect the catchment or watercourse directly.
- If the change in catchment size, the amount and form of development, and the sensitivity of the watercourse are such that an impact is likely, a water balance will be required.
- Consult with Conservation Authority and municipal staff to establish the terms of reference (TOR) and scope of work. The following steps outline the general requirements.

Step 2 – Establishing Baseline Conditions

- Determine stream classification based on relevant Fisheries Management Plan including community classification, targets, and management objectives.
- MNR must also be contacted if species at risk are known to occupy the watercourse. Scientific Collectors Authorizations and Endangered Species Act (ESA) permits are required for any surveys or studies to investigate for the presence of species at risk.
- Identify groundwater discharge/seepage, tile drain outlets, culverts, and other relevant features that could affect drainage to the watercourse, if any, on maps for submission.
- Collect continuous baseline data (data loggers) on hydraulic gradients using mini-piezometers for 3 full years to identify vertical hydraulic gradients.
- Collect baseline data on stream flows on a continuous basis (data loggers), for at least one full year or check with the Conservation Authority for stream gauge data. Instrumentation should be placed in the watercourse at the upstream limit of the proposed development site, and another should be placed at the downstream limit of the site in order to assess and quantify whether the watercourse is a losing or gaining stream.
- It is recommended that the proponent consult with the Conservation Authority as it may have some of the above information.
- Contact the Conservation Authority for agreement on the Terms of Reference for study design, location and number of instrumentation required and to manage impacts associated with equipment installation.
- All monitoring should stay in place throughout the development process in order to establish multiple years of data for the monitoring plan (see Step 6).

Step 3 – Developing the Existing Conditions Water Budget Model

- Conduct a soils analysis and/or borehole drilling program to determine the proportion of precipitation that will characterize the components of the water budget (i.e. runoff vs. infiltration).
- Check with the Conservation Authority regarding the location of existing gauges to obtain precipitation data. Additional rain gauges may or may not be required.
- Using the information gathered through Step 2 and the soils analysis, determine the quantity and flow paths of water to the watercourse, and describe the proportion of flows that reach the watercourse via surface water and groundwater from the subject site. Ensure that each subcatchment is appropriately identified and characterized.
- Develop an Existing Conditions Water Budget using an approved continuous model, such as PRMS, HSPF, QUALHYMO, or SWMM, to be calibrated with measured data where available. A groundwater model is not a requirement for the water budget at this time (although the applicant is free to propose to use a groundwater model in addition to a surface water model). The understanding of groundwater/surface water interactions should inform the selection and set up of the surface water models described above.

- Run long-term analysis based on nearest available climate data, e.g. precipitation, temperature, etc., as a minimum, using the period between 1991 and 2008, which is considered to be representative. Using a 30-year climate record or greater is preferred.
- Using the long-term climate record, determine if the measured data represent a wet or dry year, and run the model under varying scenarios.
- Daily water balance analysis should be used to generate weekly results. Consult with the Conservation Authority and municipality to determine if an alternate resolution is more appropriate.
- It may be necessary to submit the Existing Conditions Water Budget Model to the Conservation Authority and municipality for review and approval prior to proceeding to Step 4.

Step 4 – Comparing Pre-development and Post-development

- In consultation with the Conservation Authority and appropriate agencies, establish water balance goals and targets consistent with subwatershed plans, watershed plans, fisheries management plans, and other relevant studies.
- Conduct a water budget analysis to determine how the proposed changes in landuse within the watercourse(s) catchment will affect the water balance.
- A comparison of pre- development and post-development groundwater conditions can be completed in a number of ways. For example, dewatering calculations (when appropriate) or a comparison of pre-development and post-development groundwater recharge rates. The approach should be discussed with the Conservation Authority, including how the groundwater and surface water assessment results will be incorporated.
- Based on the modeled analysis, quantify changes in infiltration, runoff, and evapotranspiration, as well as changes in the distribution of flow paths, particularly groundwater discharge/upwellings cumulatively and on a weekly basis.
- Generate maps, tables and graphs illustrating these changes. Plot the pre-development and post-development hydrograph.

Step 5 – Applying Mitigation

- Apply mitigation measures to manage the water balance with the intent to maintain the pre-development hydrology of the watercourse or HDF according to the Overall Objective.
- If the pre-development runoff and/or infiltration cannot be achieved through the proposed mitigation measures, an analysis of the anticipated negative impacts will need to be completed in order to determine if the Overall Objective is adhered to. If negative impacts are anticipated, additional mitigation measures will be required.

Step 6 – Reporting and Monitoring

- Synthesize the information gathered through the above steps into a water balance report and submit to the Conservation Authority and municipality for review. Provide a comparison table showing the differences between the pre-development conditions, post-development condition, and the post-development with mitigation condition for all components of the water budget and for each subcatchment. Appendices containing models and calculations shall be provided.

- Consult with the Conservation Authority and municipality to determine if monitoring is required. If monitoring is required, the report should discuss proposed post-development monitoring of all baseline parameters to determine the effectiveness of mitigation measures and to assess the level and extent of negative impacts, if any. A Terms of Reference for the monitoring plan should be included in the water balance report.
- A minimum 3-year post-development monitoring plan should be developed, however more may be required depending on the scope and scale of the development (i.e. timing and duration of build-out). A post-development monitoring report should be submitted to the Conservation Authority and municipality at the end of the monitoring period.
- Generally, the purpose of this monitoring will be to monitor changes to the hydrology of the natural features and identify whether remediation measures to tweak the hydrology should be employed. These remediation measures need to be considered early on in the planning phases in order to ensure feasibility, and identified through discussion with the Conservation Authority and municipality. A Contingency Plan (for short-term impacts) and an Adaptive Management Plan (for the long-term) should be developed in these instances to identify steps to be taken if it is identified that there is a negative impact on the feature. Mitigation considered in previous steps should be designed to account for opportunities to refine the hydrology.

D6. Glossary

Bog – a wetland ecosystem characterized by high acidity, low nutrient levels, and accumulation of peat and mosses, chiefly Sphagnum. The water table is at or near the surface in spring, and slightly below during the remainder of the year. The bog surface is often raised, or if flat or level with the surrounding wetlands, it is virtually isolated from mineral soil waters. Peat is usually formed in situ under closed drainage and oxygen saturation is very low. In Ontario, defined by a lack of vascular plant diversity.

Catchment – the groundwater and/or surface water drainage area from which a woodland, wetland or watercourse derives its water.

Duration– the period of time associated with a specific water level condition

Extent – the lateral distance inundated by water

Fen – characterized by surface layers of poorly to moderately decomposed peat, often with well-decomposed peat near the base. The waters and peats are less acid than in bogs, and often are relatively nutrient rich and minerotrophic since they receive water through groundwater discharge from adjacent uplands. May occur in rich non-peat based systems. Fens are characterized in Ontario by the presence of fen-indicator plant species.

Frequency– how often a water level above a given magnitude recurs over some specific time interval; inversely related to magnitude

Gley – A blue-grey colour in soil due to the reduction of iron. Formed in a process characterized by low oxygen conditions due to permanent water logging. The depth to gley in soils of different types is a diagnostic indication of the moisture regime.

Groundwater - Water that occurs below the earth's surface. It originates as precipitation, runoff, and snowmelt, which infiltrates vertically downward into the ground via gravity to the water table.

Hydraulic gradient – a measure of the change in groundwater head over a given distance. Maximum flow will normally be in the direction of the maximum fall in head per unit of vertical distance.

Hydric soils – a soil that is saturated, flooded or ponded long enough during the growing season to develop anaerobic conditions.

Hydrologic cycle – The continuous movement of water from the oceans to the atmosphere (by evaporation), from the atmosphere to the land by condensation and precipitation, and from the land back to the sea (via groundwater and stream flow.

Hydrologic Function – means the functions of the hydrological cycle that include the occurrence, circulation, distribution and chemical and physical properties of water on the surface of the land, in the soil and underlying rocks, and in the atmosphere, and water's interaction with the environment including its relation to living things.

Hydrology – A science dealing with the properties, distribution, and circulation of water on the land surface and in the soil, underlying rocks, and atmosphere.

Hydroperiod – the seasonal pattern of water level fluctuation. This approximates the hydrologic signature of each wetland type (Mitsch and Gooselink, 2007; Wright et al. 2006; Azous and Horner, 2001; Reinelt et al., 1998). Four attributes are important for this pattern, including extent, duration, depth and timing of inundation.

Interflow - The lateral movement of water in the unsaturated zone during and immediately after a precipitation event. The water moving as interflow discharges directly into a stream or lake, but is considered to be a component of the groundwater system.

Isolated wetland – wetlands that have no surface inflow or outflow, such as kettle wetlands. Inflows occur mainly as sheet flow and outflows occur mainly through infiltration.

Lacustrine wetland – wetlands that are situated on and/or are influenced by lakes.

Magnitude– the amount of water moving past a fixed location per unit time

Mottles – spots or blotches of different colours or shades of colours interspersed with the dominant colour, usually the result of alternating aerobic and anaerobic soil conditions. Caused by the oxidation of iron within the soil, it is indicative of poor drainage and seasonal water logging. The depth to mottles in soils of different types is a diagnostic indication of the moisture regime.

Marsh – marshes are wet areas periodically inundated with standing or slowly moving water, and/or inundated areas characterized by robust emergents or anchored floating plants and submergents.

Moisture regime – The available moisture supply for plant growth estimated in relative or absolute terms; classifications for moisture regimes come from the integration of several factors, including soil texture and drainage, and depth to mottles and gley.

Palustrine wetland – wetlands with no or intermittent inflows and either intermittent or permanent outflows.

Rate of change– how quickly flow changes from one magnitude to another (i.e. flashiness).

Riverine wetland – wetlands that are situated on and are influenced by rivers. Usually defined as wetland units with permanent inflows and outflows.

Surface water - Water-related features on the earth's surface, including headwaters, rivers, stream channels, inland lakes

Swamp – swamps are wetlands with 25% cover or more of trees or shrubs. Standing to gently flowing waters occur seasonally or persist for long periods on the surface. Many swamps are characteristically flooded in spring, with dry relict pools apparent later in the season.

Timing– the regularity with which a flow or water level of a certain magnitude occurs

Vernal pools – temporary pools of water that are usually devoid of fish, and thus allow the safe development of natal amphibian and insect species.

Water budget – the mathematical expression of the water balance.

Water balance – the accounting of inflow and outflow of water in a system according to the components of the hydrologic cycle.

Water table - The zone where the pore spaces are fully saturated.

D7. References

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