Principles for Stormwater Wetlands Management in the City of Calgary

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KEY STAKEHOLDERS

Alberta Environment - Regional Services

Alberta Environment - Water Administration, Bow Region

Alberta Environment - Water Management Division

Alberta Infrastructure

Alberta Transportation - Planning

Bow River Basin Council/River Valleys Committee

Calgary Airport Authority

Calgary Field Naturalists' Society

Canadian Wildlife Service - Environment Canada

Carma Developers Ltd. - Urban Development Institute

City of Calgary - Corporate Properties

City of Calgary - Development & Building Approvals

City of Calgary - Environmental Management

City of Calgary - Land Use & Mobility

City of Calgary - Law

City of Calgary - Parks Planning and Design Services

City of Calgary - Parks Resource Management

City of Calgary - Planning & Transportation Policy

City of Calgary - Roads

City of Calgary - Urban Development

City of Calgary - Utilities and Environment Protection

City of Calgary – Water Services

Ducks Unlimited Canada

Enviro Consult - Urban Development Institute

Fish and Wildlife - Wildlife Management Branch

Fisheries and Oceans Canada

Hopewell - Urban Development Institute

Municipal District of Foothills

Municipal District of Rocky View No. 44

National Association of Industrial & Office Properties

Parks Foundation, Calgary

River Valleys Committee

Sustainable Resource Development - Public Lands

University of Calgary Student - Calgary Wetlands Committee

Urban Development Institute

ACRONYMS

Organizations / Legislative Terms/ Policy Documents

AENV	Alberta Environment
AEP	Alberta Environmental Protection (renamed Alberta Environment in 1999)
BIA	Biophysical Impact Assessment
CCC	Construction Completion Certificate
CRC	Cooperative Research Center
ER	Environmental Reserve
E&SCP	Erosion and Sediment Control Plan
FAC	Final Acceptance Certificate
LEC	Lilley Environment Consulting
UDI	Urban Development Institute
US EPA	United States Environmental Protection Agency

Technical Terms

ASP	Area Structure Plan
BMP	Best Management Practices
GIS	Geographic Information System
GPT	Gross Pollutant Trap
HWL	High Water Level
NWL	Normal Water Level
PUL	Public Utility Lot
RAP	Restricted Activity Period
TSS	Total Suspended Solids

GLOSSARY

Bathymetry - The study of underwater depth, of the third dimension of lake. A bathymetric map or chart usually shows floor relief or terrain as contour lines of aquatic habitats.

Biodiversity - The number and variety of organisms found within a specified geographic region. It also includes the variability among living organisms, including the variability within and among species and within and among ecosystems.

Cattails - Wetland plants belonging to the family Typhaceae, e.g., Typha.

Constructed Stormwater Wetland - A wetland that has been designed and constructed specifically for stormwater management purposes, and, if properly designed, provide some ecological value and amenity.

Corm - A short, vertical, swollen underground plant stem that serves as a storage organ used by some plants to survive winter or other adverse conditions such as summer drought and heat.

Engineered Natural Stormwater Wetland - A natural wetland that has been deemed appropriate for stormwater management purposes and has been modified with forebays, control structures or other engineered components to increase stormwater storage and treatment capability. The design of these wetlands should balance ecological, amenity and stormwater management objectives

Eutrophication - Waters rich in mineral and organic nutrients that promote a proliferation of plant life (especially algae), which reduces the dissolved oxygen content and often causes the extinction of other organisms.

Hydraulic efficiency - A term used to describe the optimal flow hydrodynamics within a wetland. Where perfect “plug flow” conditions exist, the hydraulic efficiency is equal to one (1), and water moves through the wetland, together as one body maximizing the full available wetland detention storage and flow area. This increases contact with vegetation and provides a higher removal efficiency of sediment and pollutants. In practice, true plug flow conditions in wetlands do not exist, and the hydraulic efficiency of wetlands is generally less than one. Hydraulic efficiency decreases to zero (0) as conditions degrade due to short circuiting, re-circulation and dead storage areas (stagnation)

Impervious surface - A surface that has been covered by any material that impedes the infiltration of water into the ground increasing the amount of surface runoff e.g., road pavement, buildings, concrete, asphalt, rooftops and severely compacted areas of soil.

Microorganisms - Organism that are microscopic (usually too small to be seen by the naked human eye), including most commonly bacteria, fungi and viruses.

Natural Wetland - A wetland that has not been altered by humans

Peat - Partially decayed vegetation matter that accumulates in peat lands. Peat consists most often of remains of peat mosses, e.g., Sphagnum mosses.

Protected Wetland - Natural wetlands deemed significant under current planning policy that are not recommended for use as stormwater management facilities and are protected under local and provincial legislation.

Retrofit Stormwater Wetland - An existing Constructed Stormwater Wetland or Engineered Natural Stormwater Wetland amended to meet improved or multiple ecological, amenity and stormwater management objectives.

Rhizome - A characteristically horizontal stem of a plant that is usually found underground, often sending out roots and shoots from its nodes.

Riparian - Riparian areas are those areas where the plants and soils are strongly influenced by the presence of water. They are transitional lands between aquatic ecosystems (wetlands, rivers, streams or lakes) and terrestrial ecosystems. Also called 'buffers'.

Run-off - Water movement when the soil is infiltrated to full capacity and excess water, from rain, snowmelt or other sources flows over the land.

Sedge - Any of the numerous plants in the sedge family Cyperaceae, e.g., Carex, Eleocharis and Eriophorum.

Stormwater Wetlands - Wetlands that have been specifically designed for stormwater management purposes. They can be categorized as either Engineered Natural Stormwater Wetlands or Constructed Stormwater Wetlands.

Total Nitrogen - A measure of the nitrogen concentration in a solution, as the sum of total Kjeldahl nitrogen and nitrate-nitrite.

Total Phosphorus - A measure of the phosphorus concentration in a solution, as the sum of soluble reactive phosphorus and organic phosphorus.

Total Suspended Solids - The portion of dissolved solids that are retained by a 2.0 µm filter.

Treatment train - A combination of structural and/or non-structural features in sequence that enhances the removal of sediment and pollutants in run-off. These structures may include vegetative buffer strips, grass swales, gross pollutant traps (GPT's), infiltration basins or other low impact development (LID) facilities.

Tuber - Various types of modified plant structures that are enlarged to store nutrients. They are used by plants to overwinter and re-grow the next year and as a means of asexual reproduction.

Watershed - Area drained by a stream or other body of water. The limits of a given watershed area are the heights of land separating it from neighbouring drainage systems. The amount of water reaching the river, reservoir or lake from its watershed area depends on the size of the area, the amount of

precipitation, and losses through evaporation, infiltration and surface ponding, Also called 'Catchment'.

Weed - A plant that is considered a nuisance. A weed is an unwanted plants in human-made settings, such as gardens, lawns or agricultural areas, but also in parks, woods and other natural areas. More specifically, the term is often used to describe native or non-native plants that grow and reproduce aggressively.

Wetland - A wetland is land where the water table is at, near or above the surface or which is saturated for a long enough period to promote such features as wet-altered soils and water tolerant vegetation. Wetlands include organic wetlands or "peat lands" and mineral wetlands or mineral soil areas that are influenced by excess water but produce little or no peat.

1. INTRODUCTION

The City of Calgary (the City) contains about 8,000 wetlands. Of these, only about 20 are used specifically for stormwater management. There are generally two categories of wetlands that need to be defined in relation to stormwater management: (i) natural wetlands (including protected) and (ii) Stormwater Wetlands (including Engineered Natural Stormwater Wetlands and Constructed Stormwater Wetlands).

Natural wetlands are wetlands that have not been altered by humans. In urbanizing watersheds, natural wetlands will inevitably be impacted due to changes in the hydrological regime and water quality associated with urban development, even if there is no intention to use them for stormwater management (Azous and Horner, 1997). Protected wetlands are natural wetlands deemed significant under current planning policy. They are not recommended for use as stormwater management facilities and are protected under local and provincial legislation (COC 2004a). With increasing population growth in the City, natural wetlands are being put under increasing pressures to be used for the management of stormwater.

Stormwater Wetlands are wetlands that have been specifically designed for stormwater management. They can be categorized as either Engineered Natural Stormwater Wetlands or Constructed Stormwater Wetlands. Engineered Natural Stormwater Wetlands are natural wetlands that have been deemed appropriate for stormwater management purposes and have been modified with forebays, control structures or other engineered components to increase stormwater storage and treatment capability.

These wetlands inevitably forego some natural ecological and amenity value in lieu of providing stormwater management benefits. The magnitude of impact to the natural wetland depends on how it is incorporated within the overall stormwater management system. Constructed Stormwater Wetlands are those wetlands that have been designed and constructed specifically for stormwater management purposes, and, if properly designed, provide some ecological value and amenity.

The main objective of natural wetland management is the conservation of the natural ecological function of the wetland system. For the case of protected wetlands, which are not recommended for stormwater management, ecological function and habitat can be theoretically maintained by emulating pre-development hydrological and water quality conditions, and incorporating sufficient natural buffers to separate the wetland from developed areas. Alternatively, the objectives for design and management of Engineered Natural and Constructed Stormwater Wetlands (or Stormwater Wetlands in general) will vary from site to site, depending on the needs of the community and regulatory requirements. Design and management objectives for these wetlands therefore need to address a balance between ecological function and habitat, amenity value and stormwater management requirements (Figure A).

Determining the appropriate balance between ecological, amenity and stormwater management objectives will depend not only on stakeholder involvement but also on the physical constraints of the site. Technical challenges include balancing ecological integrity with urban stormwater issues, such as high sediment loads, high nutrient loads

(resulting in eutrophic conditions), and accommodating increased flows and runoff volumes. Operationally, challenges include ensuring (i) Stormwater Wetlands remain easily maintainable, (ii) procedures are in place and executed to maintain and protect wetland function as defined in the design intent and (iii) appropriate parties assume the responsibility to perform the required operational procedures.

The City currently has no tool to determine an appropriate balance between ecological, amenity and stormwater management objectives. The difficulty in determining an appropriate balance is apparent in the competing philosophies found within the two City departments (Parks and Water Services), which are largely responsible for the approval and management of Stormwater Wetlands. The City strives to balance Parks' objectives to design Stormwater Wetlands as sustainable ecological systems with amenity value, and Water Services' requirements to use Stormwater Wetlands for stormwater management.

Little guidance is currently available on the design, construction and maintenance of natural wetlands amended to Engineered Natural Stormwater Wetlands. The Calgary Wetland Conservation Plan (COC 2004a) states that the design of these wetlands should focus on long-term sustainability and balance, ecological and stormwater management objectives.

Design criteria for the design of Constructed Stormwater Wetlands are already provided in the City's Stormwater Management and Design Manual (hereinafter referred to as the Design Manual); however, balancing the design and management intent of Constructed Stormwater Wetlands with the ecological, amenity and stormwater objectives is not directly addressed.

The aim of this document is to address the current deficiencies discussed above and to provide guidance that will balance the design and management of all Stormwater Wetlands within the City, while addressing Parks and Water Services objectives and management responsibilities.

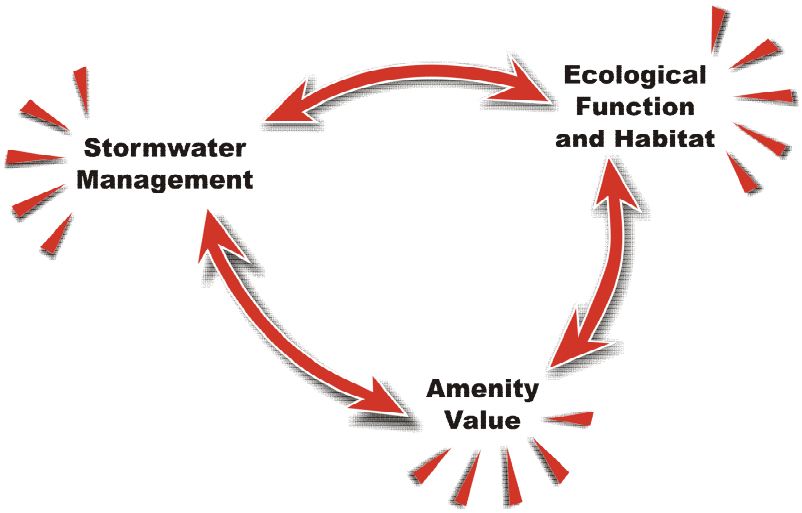


Figure A Balancing the Ecological, Amenity and Stormwater Management Objectives

1.1 Document Purpose & Objectives

The purpose of this document is to provide City staff, developers and other stakeholders a tool to assist in the planning, design and management of Stormwater Wetlands, while considering competing ecological, amenity and stormwater management objectives.

To achieve this purpose, the four main objectives are:

- To provide a tool to guide the planning, design and management of Stormwater Wetlands as well as the approval processes for the City, the developer and other stakeholders;
- To supplement gaps in current planning, design and management information for Stormwater Wetlands with special focus on Engineered Natural Stormwater Wetlands and balancing ecological, amenity and treatment requirements;
- To provide a set of procedures that summarize the management (operation and maintenance) roles and responsibilities of Parks and Water Services for Stormwater Wetlands in the City, including general cost estimates and scheduling information for various operation and maintenance activities for budgeting purposes; and
- To ensure significant issues with current Stormwater Wetland planning, design and management in the City are addressed based on a review of the available information and field studies.

Until such time that a detailed design manual specific to Stormwater Wetlands is developed, it is recommended that this document be used along with other existing City documents pertaining to stormwater wetland design and management (Section 1.3).

1.2 Supporting Studies

Additional activities undertaken to meet the purpose and objectives of this document included:

- A desktop assessment and update of the City's Wetland Inventory;
- Wetland Field assessments (WorleyParsons and Aquality 2009); and
- A City staff Stormwater Wetland workshop, questionnaires and interviews (minutes from the wetland workshop and questionnaires can be found in Appendix 1).

The desktop assessment involved bringing together all of the previous wetlands information held by the City and combining it into a single manageable database that could be shared centrally between departments. The information combined included a Water Services spreadsheet inventory of all of the City's current stormwater ponds, and stormwater wetlands, including all of the pond/wetland locations, sizes, year built etc., and a Parks Geographic Information System (GIS) of all of the natural wetlands currently defined in the City including their location, size and classification according to the Steward and Kantrud Classification Method (1971) etc.

The Wetland Field Assessments (WorleyParsons and Aquality 2009) were undertaken to provide a 'snapshot understanding' of the current status of the City's wetlands. The scope of work for the assessments included the analysis of six wetlands: one natural wetland, two modified

(engineered) wetlands, and three Constructed Stormwater Wetlands, thought to be representative of the variety of wetlands located within the City. For each wetland a site visit was undertaken to collect water and sediment samples, measure in situ water quality parameters, take photographs, make field observations on flora and fauna status, and in the case of the Constructed and Engineered Natural Wetlands, report on any observed design, operation and maintenance issues. Wetlands were also classified using the Stewart and Kantrud Wetland Classification System (1971). Though it was not possible to provide a thorough assessment of the health, function and treatment efficiency of each wetland, or draw definitive conclusions based on the one site visit, the field assessments provided valuable insight into some of the current design, operational and maintenance issues prevalent among the City's wetlands.

A workshop, questionnaires and interviews were also conducted during the writing of this document with City staff to gain a better understanding of the current design and approval processes followed by the City for wetland applications, and understand the current roles and responsibilities of the various City staff and departments (Appendix 1). Additional staff provided valuable input as to their perceptions of the current design, operational and maintenance issues affecting the City's Stormwater Wetlands.

Consideration was given during the writing of this document to the numerous planning, design, construction, operational and maintenance issues and concerns gleaned from each of the above tasks. What has transpired through addressing the objectives of this document, and undertaking these tasks is a document unique to the City, providing guidance to City staff, developers and other stakeholders as to how Stormwater Wetlands should be designed and managed to enable these wetlands to exist as sustainable features in the urban landscape.

1.3 Supporting Documents and References

The City and related organizations have produced several documents related to the planning, design and management of Stormwater Wetlands in Calgary. These documents include:

- Support documents which are pertinent to these guidelines; and
- Important references, which provide useful information for planning, designing and managing Stormwater Wetlands.

The intent of this document is not to supersede Stormwater Wetlands design and planning information currently available in published City documents. This document is meant to provide a summary of the existing information provided in these other documents and fill the gaps where information is not available or where best practice has changed. They are also meant to provide general guidance and recommendations rather than a prescription for design.

Supporting documents and their general association to this document are described in Table A.

Table A Direct Supporting Documents for Stormwater Wetland Design and Management

Author	Publication Date	Document	Summary and Relation to These Guidelines
City of Calgary	May 2004	Calgary Wetland Conservation Plan	Wetlands Policy and procedures for identifying wetlands and their significance to ensure their conservation and/or mitigation. This document is referenced to support discussions on wetland policy including design and operations objectives.
City of Calgary, Parks Department	March 2003	The City of Calgary Open Space Plan	A single, comprehensive and integrated source of policy on open space within the City of Calgary. This document is also referenced to support discussions on wetland policy including design and operations objectives.
City of Calgary, Wastewater & Drainage	December 2000	Stormwater Management and Design Manual	This document provides detailed design information pertaining to Constructed Stormwater Wetland design and management as well as the associated approval process. The manual is referenced extensively through this document, especially when discussing detailed design, construction or maintenance requirements
City of Calgary Wetland Task Force	June 2004	Constructed Wetlands for Water Quality Improvement A Design Primer for the Development Industry	Research results on constructed wetlands for water quality improvement from the Elbow valley. Constructed Wetland Project. This document is referenced in support discussions on Stormwater Wetland design.

Other important references, which provide useful information on Stormwater Wetland planning, design, approvals, construction and management are summarized in Appendix 2.

2. STORMWATER WETLAND DESIGN AND DEVELOPMENT APPROVAL PROCESSES

The design and approval process for Stormwater Wetlands in the City is presented below. The design process focuses on actions that should be undertaken by developers and their consultants during the various planning, design, construction and operation phases to ensure they meet the requirements of the City and other regulatory stakeholders. The approval process focuses on the roles and responsibilities of the City as the approving authority for Stormwater Wetlands. Figure B summarizes both processes in terms of the following five Stormwater Wetland development phases:

- Preliminary Planning and Design Intent;
- Conceptual Planning and Design;
- Detailed Design;
- Construction Planning; and
- Operation and Maintenance (three year post-Construction Completion Certificate -CCC).

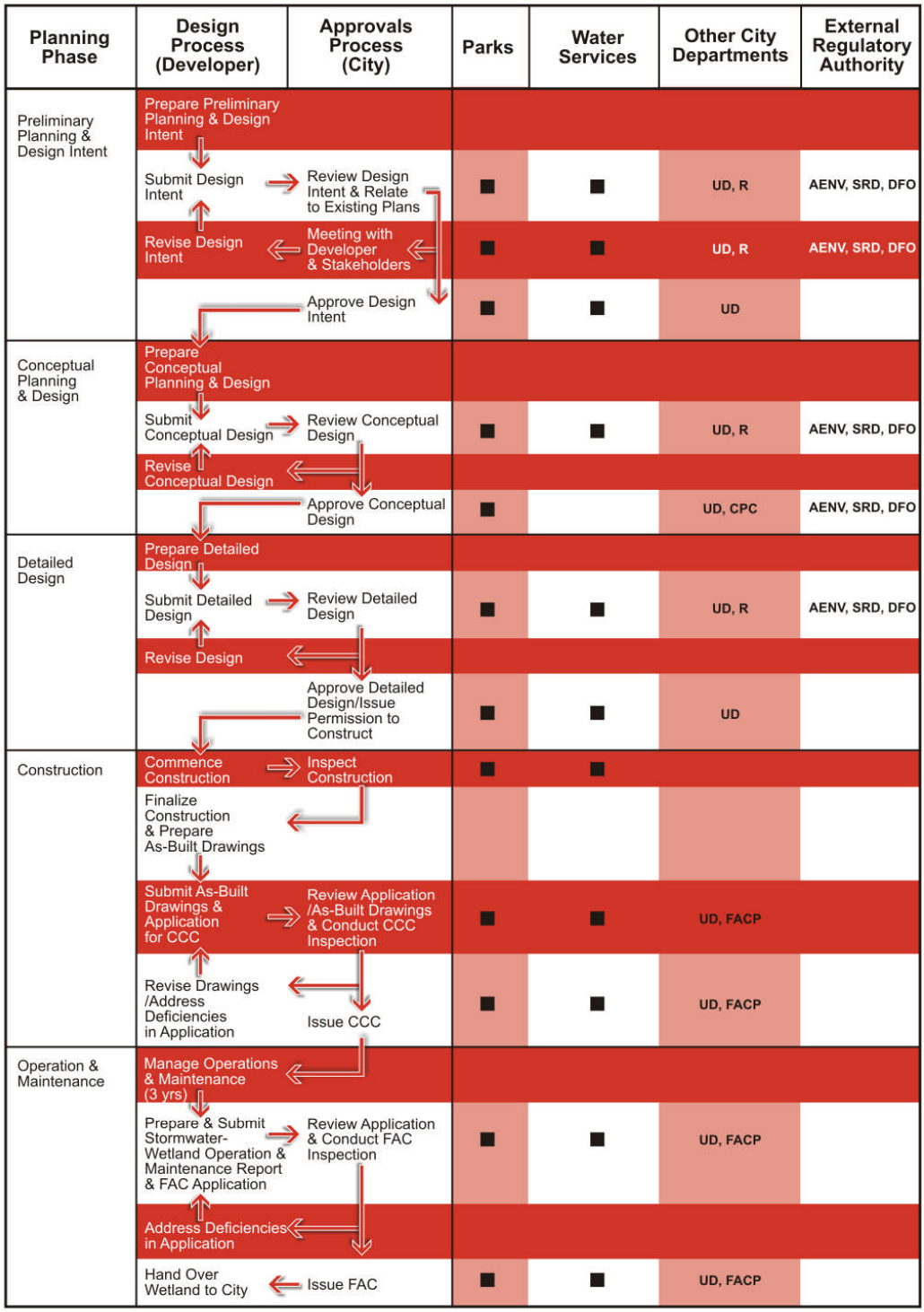
Information concerning Stormwater Wetland design and approval processes is also provided in the City's Design Manual, Development Guidelines and Standard Specifications: Landscape Construction (2008) and the Calgary Wetland Conservation Plan (2004a).

The City's Parks and Water Services departments administer the majority of the development approvals process for Stormwater Wetlands and are primarily responsible for the operations and maintenance of Stormwater Wetlands within the City. Several other departments are also involved during the development approvals process. A table detailing the five Stormwater Wetland phases is provided in Appendix 3, describing in detail the roles and responsibilities of the various City departments and the requirements and actions involved.

2.1 Preliminary Planning and Design Intent

The first and most critical step in the design process is preliminary planning which focuses on determining the design intent for the Stormwater Wetland. Due to the variability and complexity of Stormwater Wetlands, design intent should be determined on a case-by-case basis, and focus on determining an appropriate balance between ecological objectives, amenity objectives and stormwater management objectives based on site constraints and stakeholder input. Preliminary planning for Engineered Natural Stormwater Wetlands is especially important due to potential complexities of the existing natural system. The design intent should be determined before conceptual design and planning commences.

The City's role in preliminary planning in terms of the approval process is focused on reviewing, providing input and approving the design intent and objectives (Figure B, Appendix 3). The vision for the Stormwater Wetland should be provided to the City as an informal or formal communication. A meeting should be held following this communication to discuss tentative project objectives and Biophysical Impact Assessment (BIA) scope (Section 3.2.1), if required. A BIA is required if the proposed Stormwater Wetland has the potential to impact sensitive environmental features (e.g., natural wetland) associated with



UD = Urban Development, R = Roads, AENV = Alberta Environment, SRD = Sustainable Resource Development, DFO = Department of Fisheries & Oceans, CPC = Calgary Planning Commission, CCC = Construction Completion Certificate.

Figure B Relative Progression of Design and Approvals Processes

the development site. A BIA may have already been performed for the larger development area. In this case, the City should review the existing BIA information and determine if additional work is required. Following completion of the BIA, a formal design intent document should be developed and submitted by the developer. The design intent document may be submitted on its own or (if required) with other supporting information, such as a BIA.

As shown in Appendix 3, the Stormwater Wetland design intent information should be reviewed concurrently by Parks and Water Services and, if required, by other pertinent City departments. During the review process, Parks and Water Services should determine if the developer has provided adequate information to satisfy City and other stakeholder requirements or if additional information is required. In the event that additional information is required or the design intent does not meet the requirements of the City, additional information may be requested from the developer. An additional formal meeting or workshop with stakeholders to further define the design objectives may also be required during this phase.

Formal City checklists and procedures do not exist for this phase of the Stormwater Wetland development.

2.2 Conceptual Planning and Design

A conceptual design should be prepared following acceptance of the design intent and objectives by the City as shown in Figure B and Appendix 3. Conceptual planning and design should address and expand on these objectives to determine the concepts (e.g., size, vegetation, landscaping, layout and zones, inlets/outlets, operating philosophy, etc.) of the Stormwater Wetland. Information submitted should include a Wetland Report and Wetland Landscape Plans, which include sufficient information to address known issues and provide the City with a sufficient level of confidence that adequate planning and design has been undertaken, and water quantity and quality performance objectives outlined in current regional watershed management plans within the City e.g., the Nose Creek, Elbow and Bow River Basin watersheds have been considered. The conceptual design must also comply with all applicable statutory requirements and previously prepared Master/Staged Master Drainage Plans applicable to the proposed development area.

The review and approval process for Stormwater Wetlands at the conceptual planning and design phase requires the cooperation and input of various City departments (Appendix 3). The conceptual planning approval process is composed of a “submit, review and revise” feedback loop (Figure B). A more detailed discussion on the planning process and legislation triggering separate approvals by Federal and Provincial authorities can be found in Chapter 2 of the City’s Design Manual.

Following resolution of the review and revision process, a report recommending approval (or refusal) along with recommended Conditions for Approval is prepared by Parks (Corporate Planning Advisory Group) and presented to the Calgary Planning Commission for review. The Calgary Planning Commission has authority to remove or amend any condition during this process. The City provides a Letter of Authorization to the developer accompanying the final Conditions of Consent approved by the Commission. At this time, the Development

Approvals department assigns each Stormwater Wetland a Stormwater Wetland Identification Code.

The Checklists for Master Drainage Plans, Staged Master Drainage Plans and Pond Reports outline some of the information required for a Stormwater Wetland Report (Appendix 4). Requirements for the Stormwater Wetland Landscape Plans are outlined in the Development Guidelines and Standard Specifications: Landscape Construction (COC 2008).

2.3 Detailed Design

Detailed design and planning should commence following acceptance of the conceptual planning and design by the City via the Letter of Authorization (Figure B, Appendix 3). Detailed planning and design focuses on refining the conceptual design and development of a set of detailed design drawings that specify how the wetland will be constructed. Detailed landscape and construction drawings include material specifications and prescribe dimensions and details for all of the wetland components. In addition, a Wetland Operating and Maintenance Plan (Draft) should be developed and submitted for review.

The detailed planning process involves another "submit, review and revise" feedback loop as shown in Figure B. Detailed design drawings and specifications are circulated internally by the Urban Development department to the Parks, Water Services (Development and Approval, and Infrastructure Delivery Divisions), Roads departments to ensure compliance with applicable statutory requirements including those presented in the City's Design Manual and Standard Specifications Landscape Construction Manual (2008). The design must also be reviewed to confirm the specific design objectives defined during the preliminary planning and design intent stage have been addressed. Once all of the Conditions of Consent set by the Calgary Planning Commission have been satisfied, Permission to Construct is provided by Urban Development giving the developer authority to commence construction. These permits are not released until confirmation is also given by Urban Development that all other necessary external approvals, such as those required by Alberta Environment, are in place. The Development Approvals department proposes a construction start date and enters the Stormwater Wetland information into the City's pond/wetland inventory database (reviewed and updated during guideline development). This database refers to the database currently owned and maintained by Water Services that contains information about stormwater ponds and Stormwater Wetlands only. Parks currently does not have access to this database.

Formal City checklists do not exist for this phase of Stormwater Wetland development.

2.4 Construction Planning

Construction of the Stormwater Wetland can begin once an Approval to Construct is granted by the City (Appendix 3). Construction activities have the potential to cause significant disturbance to existing wetland habitats and downstream environments, and therefore careful consideration should be taken during construction to ensure impacts are minimized. Note that detailed design plans should also provide detailed information pertaining to construction activities.

Prior to commencing construction the developer and their nominated contractors

must submit a Contractor Environmental Acknowledgement Form (Appendix 4), acknowledging they are aware of the City's environmental policies associated with construction activities. The City's environmental policy addresses erosion and sediment control during the construction phase of a Stormwater Wetland and predicates the offsite disposal or reuse of excavated soils, in particular wetland and riparian soils.

Once construction is completed, the proponent requests a CCC from Urban Development. At this point, the developer must submit digital as-built drawings to Water Services (Development Approvals Division) and the final version of the Wetland Operating and Maintenance Plan for review and approval. CCC inspections are conducted separately by Parks and Water Services to support issuance of the CCC. The CCC is issued once all City concerns have been addressed.

As described in Appendix 3 and provided in Appendix 4, formal checklists that should be completed during construction design phase and to receive the CCC include:

- Park's Construction Inspection Checklist and CCC Report;
- Water Services' Wet Pond/Wetland Inspection Check Sheet; and
- Water Services' Pond As-Built Requirements for CCC.

Upon receiving the CCC, a three-year operation and maintenance period commences for the developer.

2.5 Operation and Maintenance

All Stormwater Wetlands must be operated and maintained by the developer for a period of three years following issuance of the CCC. During this time, the developer is responsible for addressing any issues that arise, maintaining and operating the wetland, monitoring wetland performance, and general up-keep of the surrounding areas. At the end of the three-year maintenance period, the City may issue a Final Acceptance Certificate (FAC) if requested by the developer. FAC inspections are currently conducted separately by Parks and Water Services to support issuance of the FAC. Coordinated inspections will reduce time, resource requirements and issues in the long term for both departments.

Checklists that should be completed for the FAC (Appendix 4) include:

- Park's Final Acceptance Inspection Checklist and Report;
- Water Services Wet Pond/Wetland Inspection Check Sheet; and
- Water Services' Pond Requirements for FAC.

Following issuance of both FACs by Parks and Water Services, the wetland becomes the City's asset, and the responsibility for operations, maintenance and liability are transferred from the developer to the City. The Development Approvals department updates the City's pond/wetland inventory database with the change of ownership status, and the Stormwater Operations Engineer initiates the process for corresponding utility and monitoring equipment transfers.

Parks and Water Services departments operate and maintain the Stormwater Wetland and surrounding area following issuance of the FAC. In general:

- Parks (Resource Management and Natural Areas Management divisions)

maintains and operates all areas above the High Water Level (HWL) or, in certain cases, below the HWL, if manicured lands exist in that area or vegetation has been planted, which requires maintenance. Land designated as Environmental Reserve or Municipal Reserve also becomes the responsibility of Parks; and

- Water Services maintains and operates all areas below HWL that are not manicured or contain vegetation requiring maintenance.

3. STORMWATER WETLAND PLANNING AND DESIGN CONSIDERATIONS

For Stormwater Wetlands to become sustainable components of an urban landscape, planning and design considerations must be given to ecological and amenity as well as stormwater management objectives. The City's Design Manual, which is currently under review, provides a summary of the minimum design requirements for Constructed Stormwater Wetlands to ensure stormwater management objectives are met. Several of the principles presented within the Design Manual are also applicable to Engineered Natural Stormwater Wetlands in terms of stormwater management. The Design Manual and the other available City publications addressing design of Stormwater Wetlands (Table A) provide limited planning and design information for balancing stormwater objectives with those of ecological function and habitat, and amenity value.

In many North American jurisdictions, design of Stormwater Wetlands only considers Constructed Stormwater Wetlands; natural wetlands in the urban setting are most often thought of in terms of protection and conservation in relation to stormwater. The United States Environmental Protection Agency (US EPA) went so far as to develop a document titled "Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices" (US EPA 1996). This document focused on characterizing and protecting pre-disturbance wetland attributes in the urban landscape. In addition, most published guidelines and policies addressing Stormwater Wetlands generally refer to Constructed Stormwater Wetlands; natural wetlands are often not considered for this purpose. The City's Design Manual, for example, relates specifically to the design of Constructed Stormwater Wetlands; however, through the adoption of the Calgary Wetland Conservation Plan in 2004, the City has set about to change this view by recognizing the contribution that amended natural wetlands (i.e., Engineered Natural Stormwater Wetland) may play in managing the quality and quantity of stormwater run-off.

The planning and design considerations provided below are intended to supplement design information provided in the City's current publications while ensuring design objectives are addressed early in the planning process. Where the information presented for wetland planning and design deviates from the information presented in the City's current publications, a note has been added.

Stormwater Wetland design considerations are discussed below in terms of the first three project phases introduced in Section 2:

- Preliminary Planning and Design Intent;
- Conceptual Planning and Design; and
- Detailed Design.

In addition, a short section has been provided discussing the viability of amending a natural wetland to an Engineered Natural Stormwater Wetland.

3.1 When can a natural wetland be used for stormwater management and when is a wetland protected?

As defined in the Calgary Wetland Conservation Plan (COC 2004a), the City's

goal is to ensure a "No Net Loss" of Calgary's wetlands within areas of future development. Therefore, one of the most important questions that must be answered before a natural wetland is used for stormwater management purposes is, 'When can a natural wetland be used for stormwater management and when is a wetland protected?'.

As already noted in Section 1, there are two general categories for wetlands in the City that need to be addressed in terms of stormwater management: (i) natural (including protected) wetlands and (ii) Stormwater Wetlands (including Engineered Natural Stormwater Wetlands and Constructed Stormwater Wetlands). Wetlands that automatically qualify as "protected" wetlands are not recommended for stormwater management. These include all naturally occurring wetlands that have been identified under the Stewart and Kantrud Wetland Classification System (1971) as seasonal, semi-permanent, permanent or alkali ponds (i.e., Classes III, IV, V or VI, respectively). An overview of the Stewart and Kantrud Wetland Classification System can be found in Appendix I of the Calgary Wetland Conservation Plan (2004a). Wetlands with these classifications are either owned by the Government of Alberta and protected under the Water Act (1996) or Public Lands Act (1980) or have been identified as Environmental Reserve Areas by the City and are protected under the Municipal Government Act (1994).

Wetlands deemed to be "Environmentally Significant" by the City can also be protected under the Calgary Wetland Conservation Plan (2004a), regardless of their classification under the Stewart and Kantrud Wetland Classification System (1971), and are not recommended for stormwater management. Methods for determining wetland environmental significance are provided in Appendix F of the City's Open Space Plan (2003) and Appendix 2 of the Calgary Wetland Conservation Plan (2004a). These methods provide criteria for measuring the degree of environmental significance based on characteristics such as rare plant habitat, significant waterfowl habitat or wildlife corridor, contribution to hydrologic function and flood control, and recreation, education, or urban design potential. An environmental significance assessment is completed by Parks early in the development planning process to determine if a wetland located in an area of a proposed development is Environmentally Significant.

Natural wetlands classified under the Stewart and Kantrud Wetland Classification System (1971) as ephemeral and temporary wetlands (i.e., Classes I and II, respectively) are not deemed Environmentally Significant, and are eligible for stormwater management purposes and could be modified and used as Engineered Natural Stormwater Wetlands. The Wetland Evaluation and Development Assessment found in the City's Open Space Plan (2003). Appendix F summarizes general recommendations for using natural wetlands for stormwater management.

For cases where significant impacts from development cannot be avoided, wetlands determined to be Protected Wetlands under the Stewart and Kantrud Wetland Classification System (i.e., Classes III, IV, V and VI) may still potentially be used as Engineered Natural Stormwater Wetlands. Compensation may be required under these circumstances. The City is currently developing a compensation tool to offset wetland disturbance and loss of habitat.

3.2 Preliminary Planning and Design Intent

The preliminary planning stage should focus on developing the design intent and objectives that will guide the design and management of each Stormwater Wetland. Early identification of multiple-use priorities is a critical step in the Stormwater Wetland design process and for the planning of future operation and maintenance requirements (Wong et al., 1999). Due to the variability and complexity of design criteria required for Stormwater Wetlands, approval of a Stormwater Wetland is required at the planning stage as stated in the City's Design Manual. The design intent should be defined based on input from stakeholders and a multi-disciplinary design team and should provide a balance between ecological function and habitat, amenity value and stormwater management requirements.

Information pertaining to Stormwater Wetland preliminary planning and design intent are provided in several City documents, including:

- Stormwater Management and Design Manual (COC 2000);
- Calgary Wetland Conservation Plan (COC 2004a);
- Open Space Plan (COC 2003);
- Constructed Wetlands for Water Quality Improvement: A Design Primer for the Development Industry (COC 2004b); and
- Development Guidelines and Standard Specifications: Landscape Construction (COC 2008).

Additional municipal and provincial acts and policies pertaining to Stormwater Wetland design and management are listed in Appendix 2.

3.2.1 Biophysical Impact Assessment

Prior to incorporating natural wetlands (and other environmentally sensitive features) into an urban landscape, a detailed BIA must be performed in consultation with Parks and Water Services. The purpose of the BIA in relation to stormwater management is to determine baseline characteristics and sensitive/key components of the biophysical system and examine potential impacts of proposed stormwater management schemes. If the wetland is being considered for amendment to an Engineered Natural Stormwater Wetland or is currently being used for stormwater treatment and needs to be enhanced through retrofit applications, special assessment consideration should be given. For example, key wetland characteristics that should be conserved to maintain ecological and amenity attributes, which could potentially be impacted by stormwater, should be focused on in the BIA. The scope and requirements of the BIA should be developed in consultation with Parks and Water Services. The BIA should be submitted with the preliminary planning and design intent prior to conceptual planning (e.g., Master Drainage Planning). The design intent and objectives should be developed based on information provided in the BIA.

"Protecting Natural Wetlands: A Guide to Stormwater Best Management Practices" (US EPA 1996) and "Guidelines for the Approval and Design of Natural and Constructed Treatment Wetlands for Water Quality Improvement" (AENV 2000) provide overviews of wetland components that should be characterized pre-disturbance to protect against unwanted stormwater-related impacts. An assessment of baseline conditions of wetland components is important to help

understand potential effects of stormwater and determine acceptable levels of impact (or treatment capacity).

In general, the BIA should address:

- Delineation of the differing wetland habitats (perpendicular from the open water to the surrounding upland);
- Assessment of the vegetation communities (biodiversity, production, density, general health, sensitive species, presence of pathogens or pests);
- Assessment of wildlife biodiversity and sensitive species (birds, mammals, reptiles, invertebrates, micro-organisms);
- Characterization of the physical setting of the wetland (size, water depth, surrounding slope, catchment characteristics);
- Characterization of the wetland watershed (size, topography, geology);
- Characterization of water quality and sediment quality; and
- Wetland hydrology (surface water, groundwater, water levels, hydrological regime and overall water balance).

Additional information pertaining to BIAs is provided in the Design Manual.

3.2.2 Stormwater Wetland Design Objectives

The key goal for preliminary planning is to balance realistic stormwater management objectives with ecological and amenity objectives based on the intended end-uses of the Stormwater Wetland and, if applicable, natural or pre-disturbance site characteristics. The design intent of a Stormwater Wetland is discussed below in terms of stormwater management, ecological and amenity objectives.

Stormwater Performance Objectives

Land use changes within an urban watershed result in changes to stormwater quantity (run-off volume, peak flow magnitude and distribution) and quality. Urban watersheds are characterized by increases in impervious surfaces, which include roads, sidewalks, parking lots and buildings, compared to natural land uses. Increased imperviousness leads to increased water quantities (run-off volumes and flows) and water quality deterioration due to higher pollutant loads.

Both Engineered Natural Stormwater Wetlands and Constructed Stormwater Wetlands should have pre-determined performance objectives for water quantity and quality. The criteria should be determined on a case-by-case basis according to the attributes of the contributing watershed as well as consideration of ecological and amenity objectives to ensure impacts are limited to pre-defined levels. In some instances, a stand-alone Stormwater Wetland may not be able to meet the level of service requirements provided in the Design Manual. In instances where it is determined that only partial treatment of stormwater is possible (in relation to the level of service requirements) in the Stormwater Wetland, additional stormwater management measures, such as source controls, ponds, etc., may have to be implemented in a treatment train approach. A treatment train stormwater approach uses two or more stormwater facilities in succession.

Stormwater Quantity

The Design Manual provides prescriptive water quantity level of service criteria for the design of stand-alone Constructed Stormwater Wetlands; the minimum active storage volume must be able to retain a 100-year return period storm and detain it for a period of 24 hours with a maximum active depth of 1 m. Release rates from the wetland must also be equal to or less than pre-development run-off rates up to those associated with the 100-year return period. Pre-development release rates are usually required to mitigate impacts on other downstream water bodies, such as lakes or rivers, and the potential for flooding.

Stormwater quantity performance criteria selected for Engineered Natural Stormwater Wetlands, Constructed Stormwater Wetlands in a treatment train and retrofit Stormwater Wetland projects may be equivalent to or less conservative than the level of service requirements prescribed for stand-alone Constructed Wetlands in the Design Manual due to the need to address ecological and amenity objectives defined by stakeholders. Stormwater quantity objectives for these wetland systems should be determined using baseline information collected during the BIA (if applicable). Additional stormwater management facilities (using a treatment train approach) may be required to meet City level of service requirements. The stormwater quantity performance criteria for Engineered Natural Stormwater Wetlands, Constructed Stormwater Wetlands in a treatment train and retrofit wetland projects should therefore be defined on a case-by-case basis in consultation with the wetland design team and stakeholders.

Minimum criteria that should be specified in relation to stormwater quantity objectives during the preliminary planning and design intent phase include:

- Maximum inflows (e.g., equal to or less than two year post-development flows) to reduce soil erosion, damage to vegetation, etc. (see Section 3.3.2., Inlet Zone);
- Maximum outflows (e.g., equal to or less than 100-year pre-development flows when combined with other stormwater components, if applicable);
- Maximum Normal Water Level (NWL) and High Water Level (HWL) with associated storage volumes i.e., permanent depth and active storage depths (e.g., equal to maximum pre-development depths, or an acceptable alternative based on site specific information); and
- Retention times (e.g., minimum detention of 24 hours and maximum detention time of 96 hours).

For example, defining the extent, depth and duration of active storage used in an Engineered Natural Stormwater Wetland should be determined on a case-by-case basis to achieve a balance between preserving ecological function whist achieving stormwater quantity control.

It is essential that natural wetting and drying cycles be preserved as closely as possible to minimize impacts on the ecological function of a natural wetland. Peak inflows and runoff volumes to Stormwater Wetlands should also be controlled (in terms of velocity, magnitude and volume) to reduce impacts and ensure that incoming waters can be retained as required.

Stormwater Quality

The general water quality parameters that are impacted by urban development include suspended sediment, dissolved oxygen, nutrients (phosphorus and nitrogen), metals, pesticides and herbicides, hydrocarbons and temperature.

The current water quality treatment level of service requirement only addresses suspended sediment in the form of Total Suspended Solids (TSS). The Design Manual states that a minimum of 80% TSS (superseded by Alberta Environment's requirement of 85%) removal of particle sizes > 75 µm is required. This water quality level of service requirement can be accomplished using a stand-alone Stormwater Wetland or the Stormwater Wetland may be part of a treatment train approach. Other recommended stormwater quality performance criteria for parameters of concern include total phosphorus (45% reduction in load) and total nitrogen (45% reduction in load) (Stormwater Committee, 1999).

Where possible, it is recommended that Stormwater Wetlands be designed to address the TSS level of service requirement and total nitrogen and total phosphorous performance objectives provided above. Treatment capability of Stormwater Wetlands may be limited, depending on the desired ecological and amenity objectives. Limited treatment capability will most likely be associated with natural or previously constructed facilities that are slated for amendment to Engineered Natural Stormwater Wetlands or retrofit stormwater wetland projects. Therefore, the stormwater quality performance criteria should also be defined on a case-by-case basis in consultation with all members of the design team, having considered all wetland assessment information, stakeholder input and other applicable water quantity and quality performance objectives outlined in current regional watershed management plans within the City, e.g., the Nose Creek, Elbow and Bow River Basin watershed.

In almost all cases, the incorporation of pre-treatment facilities (e.g., source controls, trash racks and sedimentation forebays) upstream of the main wetland area will be required to meet City water quality requirements.

Ecological Objectives

Ecological objectives should be developed by the design team having considered stakeholder input and wetland assessment information. Ecological objectives should strive to establish (for Constructed Stormwater Wetlands) or preserve (for Engineered Natural Stormwater Wetlands) ecological function and habitat while considering amenity value and stormwater management design objectives. At a minimum, ecological objectives should focus on establishing an effective biotic wetland community to maximize water treatment effectiveness. Alternatively, ecological objectives may be developed to preserve a large portion of a natural wetland slated for amendment to an Engineered Natural Stormwater Wetland.

Specifically, in reference to Engineered Natural Stormwater Wetlands, one must consider that natural wetlands are integral parts of a watershed; their position in the landscape is influenced by and influences the characteristics of a watershed. Natural wetlands can function as nutrient sinks, temporary water storage areas, groundwater recharge areas and critical wildlife habitat. Natural and limited anthropogenic (human-induced) activities within a watershed influence the functions of these wetlands. When these activities remain

relatively constant and human induced impacts are minimal, the functions of natural wetlands tend to exist in dynamic equilibrium with the surrounding conditions; however, changes due to urban development within a watershed can result in dramatic changes in the functions of natural wetlands.

Mitsch and Gosselink (1986) concluded that hydrologic conditions are extremely important for the maintenance of a wetland's structure and function, although simple cause-and-effect relationships are difficult to establish. Each wetland type exhibits unique hydrologic characteristics that are fundamental in the stability of the system. Changes in the natural hydrology of a wetland can therefore affect many of the functions of a wetland. When volumes of stormwater runoff to a wetland increase, or when a wetland is impounded to treat stormwater runoff, changes to the biotic and abiotic characteristics can occur. Actions that upset the established balance found in the biological community, such as changes in volume of runoff, or water quality, lead to significant changes in the functions of a wetland. For example, increasing the volume of stormwater runoff that enters a wetland can stress indigenous vegetation and allow more flood-tolerant species of vegetation (e.g., Typha) to take over a wetland. Therefore, a balance between ecological objectives and stormwater management objectives should be established based on the site-specific conditions.

Modifying existing processes can also result in changes in wetland soil characteristics. For example, changes in the textural characteristics of an Engineered Natural Stormwater Wetland soil can result from changes in the amount, type and/or particle size of sediments that enter a wetland in stormwater. The modification of soil textural characteristics can then result in changes in the drainage characteristics of the wetland. In addition, the chemical quality of stormwater can alter the chemical characteristics of the Engineered Natural Stormwater Wetland soil if the stormwater is not adequately treated prior to its discharge to the wetland. Suspended organic and inorganic particles tend to adsorb pollutants, such as heavy metals, nutrients, hydrocarbons and bacteria (Stockdale 1991). If the suspended particles are deposited in the wetland, the pollutants can become incorporated into the soils. Over a period of time, pollutants that have accumulated in the soil can appear throughout the wetland environment via chemical transformations, vegetative uptake and re-suspension.

Defining ecological objectives should also focus on identifying certain flora/fauna for protection, based on wetland assessment data. Similarly, certain species may be identified as requiring deterrents to keep them away from a wetland to ensure the health and safety to both other special flora/fauna communities and in some instances the general public. All of these considerations need to be addressed in this process.

A summary of potential ecological objective topics that may be considered include:

- Fauna (including invertebrates, fish, amphibians, reptiles, birds, and mammals) diversity and productivity;
- Flora (floating, rooted, emergent, submerged, herbaceous, and woody) diversity and productivity;
- Habitat productivity and availability;
- Soil composition and quality;
- Water quality; and

- Hydrologic regime.

Some issues that may arise during development of ecological objectives include ensuring sufficient undisturbed area is conserved to maximize habitat for a species or providing an additional area for expansion of a population that might become affected. Design modifications to the location and configuration of a wetland may also be considered. Where species have been identified and an area has been set aside, interpretive information signage could be provided to make users of the wetlands aware of the importance of the preserved area and that it is provided to protect that species.

Amenity Objectives

The amenity benefits of natural wetlands have long been recognized. Like natural wetlands, Stormwater Wetlands provide excellent opportunities for recreational and educational activities, including bird watching, photography, cycling, walking, jogging, picnicking, and arts and crafts. Melding certain recreational activities (e.g., swimming) with Stormwater Wetlands can be problematic from a health and safety perspective due to the potential poor water quality in a stormwater-receiving wetland. In addition, some recreational pursuits can negatively impact wetlands.

Amenity objectives should be determined at the design intent stage in conjunction with ecological and stormwater management objectives. Amenity objectives focused on recreational and educational uses and aesthetic considerations should ultimately be determined by stakeholders and local physical constraints associated with the site.

Public access to Stormwater Wetlands can come at a cost, as appreciation may lead to

Table B Summary of Potential Impacts to Stormwater Wetlands from Recreational/Educational Use

Impact	Activity Responsible
Disturbance to wildlife	Movement of people or pets; lightning may deter use by nocturnal animals; man-made noise; animal mortality due to vehicles; release of unwanted animals; and theft of plants or plant parts.
Habitat loss	Space allocated to visitor amenities, such as visitor centre or kiosk; parking; trails; interpretive billboards; and openings to allow views where buffers from visitors are preferable.
Overuse by visitors	Trampling; vandalism; trash accumulation.

greater demand than the wetland can tolerate. Overall, the public is more likely to enjoy a wetland that is attractive than one that appears heavily impacted. Numerous activities can impact the attractiveness of wetlands as outlined in Table B. Proper management of and design for these activities, when possible, will reduce their impact on Stormwater Wetlands.

3.3 Conceptual Planning and Design

The following sections provide guidance for Stormwater Wetland (including wetland retrofit projects) conceptual planning and design. A summary of relevant information currently available from City documents is also provided. The conceptual design should outline general concepts of the design for review and acceptance by the City (and other stakeholders) before detailed design is undertaken. Stormwater Wetland conceptual design should be guided by the design intent and objectives determined during the preliminary planning phase and address ecological, amenity and stormwater management objectives.

Conceptual planning and design information for Stormwater Wetlands is currently available in City publications including: the Design Manual, Constructed Wetlands for Water Quality Improvement (2004b) and Development Guidelines and Standard Specifications: Landscape Construction (2008). The Design Manual provides detailed guidance on the conceptual (and detailed) design requirements specifically for Constructed Wetlands. Conceptual design items addressed include Stormwater Wetland layout, storage, land area and pre-treatment requirements. In some instances, these requirements are applicable to Engineered Natural and retrofit Stormwater Wetland projects as described below.

3.3.1 Water Quantity and Quality Level of Service

The conceptual design should be governed by the approved design intent and objectives of the Stormwater Wetland determined in the preliminary planning phase. The design intent should outline what portion of the level of service requirements (Section 3.2.2) will be addressed by the Stormwater Wetland and what additional facilities are required (if any) to meet any remaining deficiencies in stormwater management level of service requirements.

Stormwater modelling should be undertaken to support the conceptual design and demonstrate that stormwater quantity and quality performance criteria can be achieved. Due to the unique nature of wetlands, alternate modelling approaches and software from those discussed in the Design Manual and used for ponds and storm sewer systems may be required. Deviations from standard modelling approaches and software presented in the Design Manual should be discussed and approved by Water Services prior to commencement of the conceptual design.

3.3.2 Stormwater Wetland Layout

Numerous combinations of wetland types and layouts can be implemented for stormwater management (Wong et al. 1999, COC 2000, AENV 2000, Ontario Ministry of the Environment 2003, COC 2004b). For example, Stormwater Wetlands may be designed as off-line facilities as part of a hybrid or treatment train stormwater management system, whereby lower intensity storms (e.g., two year

or five year return periods) are diverted off-line and other end-of-pipe Best Management Practices (BMPs) are implemented to ensure water quantity and quality level of service requirements are met. In other designs, a Stormwater Wetland may be the stand-alone end-of-pipe facility for an urban area.

Stormwater Wetland layout should also be guided by the design intent for the Stormwater Wetland and physical constraints of the site. The layout of a Stormwater Wetland, whether Constructed, Engineered Natural or a wetland retrofit, in general, should incorporate a minimum of three zones to ensure the wetland functions as intended. The zone design approach allows the flexibility to isolate and protect existing natural wetland habitats and promote stormwater treatment effectiveness. The general recommended layout is provided in Figure C. The recommended minimum wetland zones include: (i) an inlet zone, (ii) wetland zone, and (iii) outlet zone. Additional Stormwater Wetland design zones or sub-zones should be determined on a case-by-case basis to incorporate site features, support innovation and incorporate new research and technologies.

Inlet Zone

To control inflows to Stormwater Wetlands and prevent sediment from entering the sensitive vegetation areas of the wetland zone, an inlet zone is recommended at the upstream end of the Stormwater Wetland. The main feature of this zone is a sediment forebay. Additionally, the inlet zone may be equipped with a flow control structure (e.g., a high flow by-pass), to regulate incoming flows or volumes to meet ecological or stormwater treatment objectives.

The provision of a sediment forebay will minimize sediment removal necessary within the wetland zones, thereby reducing impacts to

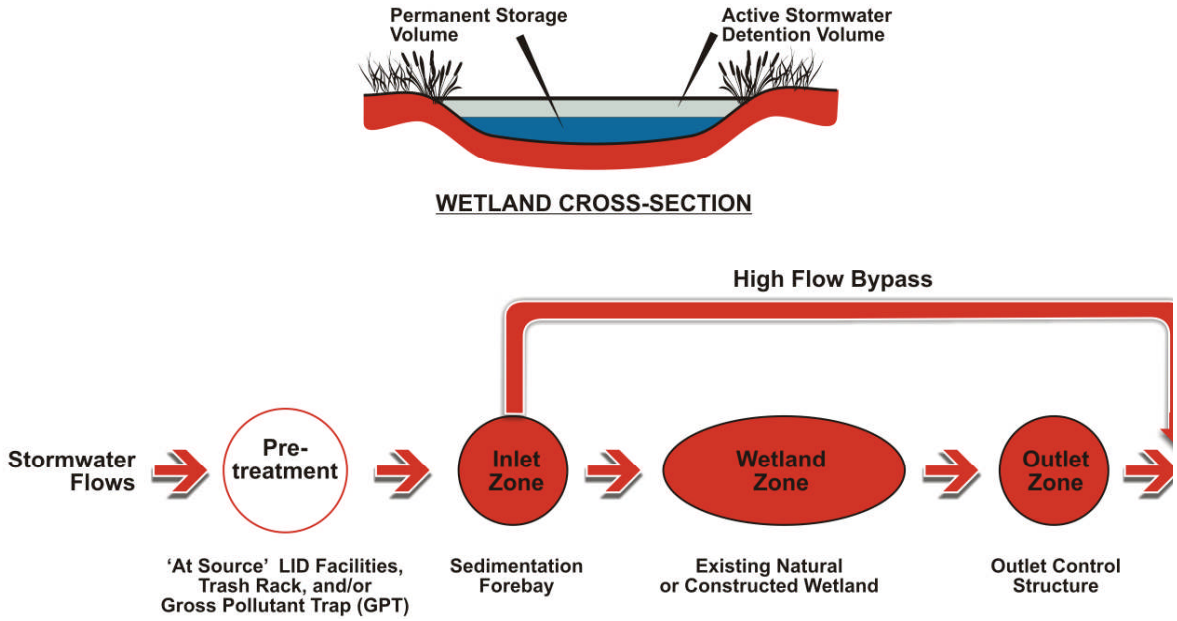


Figure C General Layout of a Constructed or Engineered Natural Wetland

biological components within the wetland zone. The sediment forebay or equivalent sediment removal facility should be provided upstream and separated from the rest of the Stormwater Wetland to simplify maintenance (vegetation in the wetland area restricts sediment removal) and protect the vegetated wetland system. The Design Manual states that the forebay should be capable of removing 80% of the suspended solids load for particles greater than 75 µm. Requirements outlined in the Design Manual state that the length to width ratio should be no less than 2:1, area should be about 10% of the overall wetland area and the depth should be 1.5-2.0 m to minimize the potential for scour and re-suspension. An additional recommendation is that the forebay should be designed to store about 10% of the treatment volume (Schueler 1992). The Design Manual provides a detailed a methodology for forebay design. Alternatively, other methods of forebay design may be used as long as they are supported by a defensible methodology with associated calculations.

To ease maintenance scheduling requirements, the sediment removal facility should also be sized to accommodate the amassed sediment for a minimum period of five years without affecting treatment capability. The sedimentation forebay should include a maintenance pipe to allow the drawdown of the forebay for sediment removal and other maintenance.

Flow control structures, such as a high flow bypass, may be used to ensure uncontrolled flows do not enter the Stormwater Wetland. If required, a high flow bypass routes flows greater than a specified design flow (and/or volume) downstream to other stormwater management facilities. A high flow bypass should be designed to prevent flows and/or volumes greater than those produced from a pre-defined storm event (as defined in the design intent and objectives) from entering the Stormwater Wetland. In most cases, flows and/or volumes associated with storms greater than a five year, 24-hour return period storm should be routed downstream via a high flow bypass. The chosen bypass design storm should be based on the design intent and local constraints of the site and may, therefore be designed to accommodate more conservative or less conservative flows and volumes. In general, the design flows and volumes that can be accepted by an Engineered Natural Stormwater Wetland will be lower than those proposed for a Constructed Stormwater Wetland due to the pre-defined characteristics and sensitivity of an existing natural system. Acceptable design flows for Engineered Natural Stormwater Wetlands should be determined using information from the BIA combined with appropriate hydrologic analysis (e.g., modelling).

Wetland Zone

The wetland zone, consisting of open water and vegetated areas within the wetland, is where the majority of biological and chemical treatment processes will occur, as well as additional physical processes. This zone may consist of any combination of shallow marsh areas, pond-wetland complexes, extended detention or meadow areas, pocket wetland features and aquatic terraces. The wetland zone also provides the temporary detention storage required to satisfy all or a portion of the stormwater management quantity and release rate level of service.

The wetland zone contains the majority of wetland habitat. For projects incorporating existing wetland areas, such as Engineered

Natural Stormwater Wetlands, this area will include the natural wetland. Thus, the importance of pre-treatment upstream is crucial to maintaining wetland habitat and function.

The wetland zone should consist of varying densities and species of wetland vegetation in shallow, deep and ephemeral zones. With such an importance on the appropriate selection and placement of wetland vegetation, the services of a specialist experienced in wetland botany or horticulture should be sought during the design process.

Flow control features may also be incorporated into this zone of the Stormwater Wetland to ensure inflows from the inlet zone are at or below recommended velocities using sheet flow or flow spreading concepts (e.g., islands or a vegetated berm). At a minimum, incoming flows should be dispersed evenly to minimize disturbance, ensure flows are distributed evenly over the wetland zone cross-section and achieve maximum contact with wetland vegetation. Where natural wetlands are to be used or incorporated into this zone, care must be taken to maintain existing flow paths and ensure flows into the zone are controlled so impacts do not exceed those outlined in the design intent.

Again, the overall design of the wetland zone should be guided by the design intent and objectives. Conceptual design layout for this area should be determined on a case-by-case basis. Minimum design requirements are provided in the Design Manual; however, the final design will depend on other stormwater facilities, if any, incorporated into the overall stormwater management system design.

Outlet Zone

The outlet zone of the wetland should include an outlet pond area and an outlet control structure designed to control Stormwater Wetland storage and water level requirements and ensure discharge from the wetland is controlled to meet specified release rates.

An outlet pond area should be provided to minimize clogging of the outlet. General design recommendations for the outlet pond are similar to those recommended for a forebay: a depth of 1.2-2.0 m with a volume equal to about 10% of the treatment storage volume (Schueler 1992).

The outlet control structure should be designed to provide control of water levels (maximum levels and regression), storage and detention time as specified in the design intent. Outlet control structures recommended in the Design Manual include weir walls, reverse slope pipe and orifices; however, contrary to this common practice, single weirs, orifices and culverts are not recommended for the control of wetland water level due to their inability to promote a range of fluctuations required for proper wetland function (Wong et al. 1999).

Water entering a wetland tends to have a range of detention times due to the highly variable nature of flows entering a wetland and natural water level control mechanisms. Recent research has shown that the outlet design has an effect on the range of detention times within a wetland. The smaller the range of detention times, the greater treatment efficiency associated with the system. A properly design riser outlet consisting of multiple outlet holes provides the smallest range of detention times and therefore the greatest treatment efficiency (Wong et al. 1999). In addition, when designing for wetland water level fluctuations riser outlets

incorporating small holes, multiple orifice/weir outlets and siphon outlets provide the best solution for mimicking a natural hydrologic regime (Wong et al. 1999).

Computer modelling as recommended in the Design Manual (or an alternative approved by Water Services) should be used to determine the conceptual design requirements of the outlet structure.

3.3.3 Stormwater Water Quantity and Water Quality Considerations

Stormwater Wetlands should be designed to capture, detain and treat stormwater in accordance with the design intent and design objectives determined during preliminary planning. Determining the conceptual design characteristics of Stormwater Wetland, to a large extent, should focus on achieving hydrologic objectives and hydraulic efficiency objectives while optimizing biochemical treatment processes using vegetation. The overall water balance should also be assessed to ensure the wetland is viable. Designing for hydrologic considerations and hydraulic efficiency of a wetland, while considering biotic requirements and the water balance of the system, promotes the necessary physical, biological and chemical processes required for treatment of stormwater (Persson et al. 1999).

Designing for Stormwater Quantity

Hydrological considerations should be governed by site constraints and the design intent and objectives to determine the most effective use of wetland volume and most effective inflow and out flow rates for stormwater management purposes. Stormwater Wetland hydrologic variables are controlled by site constraints, level controls, grading and inlet/outlet facilities. General recommendations are provided below for wetland volumes and water levels. Inflow and outflow recommendations are discussed in Section 3.2.2.

As specified in the Design Manual, the majority of the wetland at the NWL should have a depth less than 0.5 m with an average of about 0.3 m. In general, deeper areas should be limited to less than 25% of the wetland zone, since these areas do not sustain emergent vegetation. This criterion will differ for pond-wetland hybrid systems. Stormwater Wetlands should be designed to have fluctuating water levels, like most natural wetlands, to support a diverse wetland ecosystem. The Design Manual states that the maximum recommended water level fluctuation for Stormwater Wetlands is 1.0 m. This value should only be exceeded infrequently during extreme runoff events. The maximum water level fluctuation is defined as the difference between the NWL and HWL. The volume associated with the maximum water level fluctuation is termed active storage volume. Permanent storage volume is defined as the storage from the bottom of the wetland to the NWL (Figure C).

Maximum recommended water level fluctuations for Engineered Natural Stormwater Wetlands should, if possible, be defined during preliminary planning based on site-specific information gathered during the BIA. Maximum water level fluctuations for Engineered Natural Stormwater should be selected to ensure that all design objectives (e.g., stormwater, ecological and amenity) are satisfied including conservation of natural wetland features identified in the design intent.

Water level fluctuations above the NWL should be of limited duration and designed to address the requirements of the chosen wetland plant communities or, for Engineered Natural Stormwater Wetlands, be determined based on the requirements of the natural wetland vegetation.

As discussed, storage within the wetland zone includes both permanent storage and active storage. A minimum permanent storage requirement for Stormwater Wetlands is not specified in City's Design Manual. In most instances, permanent storage in the wetland zone should be between 10-15% of the total wetland zone storage to take advantage of a longer detention time promoted by a permanent pool without compromising the hydrologic regime of the wetland (Wong et al. 1999). Permanent storage for an Engineered Natural Stormwater Wetland should be determined on a case-by-case basis.

Note that a minimum amount of active storage is required to meet the City's level of service requirements for stormwater quantity (detention and release rate). Depending on the design intent and objectives of the Stormwater Wetland, the site characteristics and hydrologic characteristics of the catchment, additional storage may be required to address the City's level of service requirements.

Design for Stormwater Quality

The physical, chemical and biological treatment processes that occur within a Stormwater Wetland rely on the efficient flow of water through the system (Jenkins 2005). Therefore, the treatment capability of a Stormwater Wetland, largely, depends on effective detention volume and hydraulic efficiency of the wetland. Short-circuiting within a wetland, due to zones of re-circulation and stagnation, reduce the effective treatment volume. The reduced treatment volume can be referred to as the effective detention volume. Hydraulic efficiency represents the hydrodynamic performance of a wetland taking into consideration flow distribution and re-circulation and provides a good measure of effective detention volume of a wetland.

Hydrodynamic performance can be evaluated using a hydraulic efficiency concept where perfect "plug flow" is assumed to have the highest hydraulic efficiency, equal to one (Persson et al. 1999). In wetland systems; however, water does not stay together as a single plug flow as it moves through the system (Jenkins 2005) and therefore wetland hydraulic efficiencies are less than one. Hydraulic efficiency decreases to zero as conditions degrade due to short circuiting, re-circulation and stagnation. Hydraulic efficiency for Stormwater Wetlands should be between 0.5-0.7 (Figure D). Persson et al. (1999) provide a complete discussion for estimating the hydrodynamic performance of wetlands using hydraulic efficiency.

In addition to ensuring good hydraulic performance, sufficient detention time must also be provided to meet necessary treatment requirements determined in the design intent and objectives.

The following recommendations and Figure D summarize important design concepts for achieving an acceptable level of hydraulic efficiency:

- Designs involving length-to-width ratios of 3:1 or less with point inflow and outflow will not promote good hydraulic efficiency (Wong et al. 1999) unless steps are taken to distribute inflow

across the width of the wetland zone over the entire length of the wetland;

- Although length-to-width ratios of 8:1 or greater provide an acceptable level of hydraulic efficiency, care should be taken: to ensure that flow velocity associated with narrower cross sections does not exceed 0.05 m/s and to minimize the potential for flow path obstruction due to accumulating debris.
- Baffles and channels can be used to increase the hydraulic efficiency. However, care should be taken to ensure flows do not become isolated from other parts of the wetland zone (Wong et al. 1999);
- Flows should be distributed (especially at the inlet) using islands, weirs, distributed/multiple inlets, vegetated berms and aquatic benches installed perpendicular to flow and/or uniform cross-sectional bathymetry (Persson et al. 1999);
- Vegetation layout within a wetland can be the most important variable in improving hydraulic efficiency. Fringe-only planting should be avoided as it reduces hydraulic efficiency (Jenkins 2005). Vegetation should be planted in bands perpendicular to flow or evenly throughout the wetland zone. Special care should be given to water level control and the matching of vegetation; and
- A single outlet point is the preferred design approach; however, the most appropriate type of outlet should be selected to ensure hydrologic considerations are addressed (Section 3.2.2.).

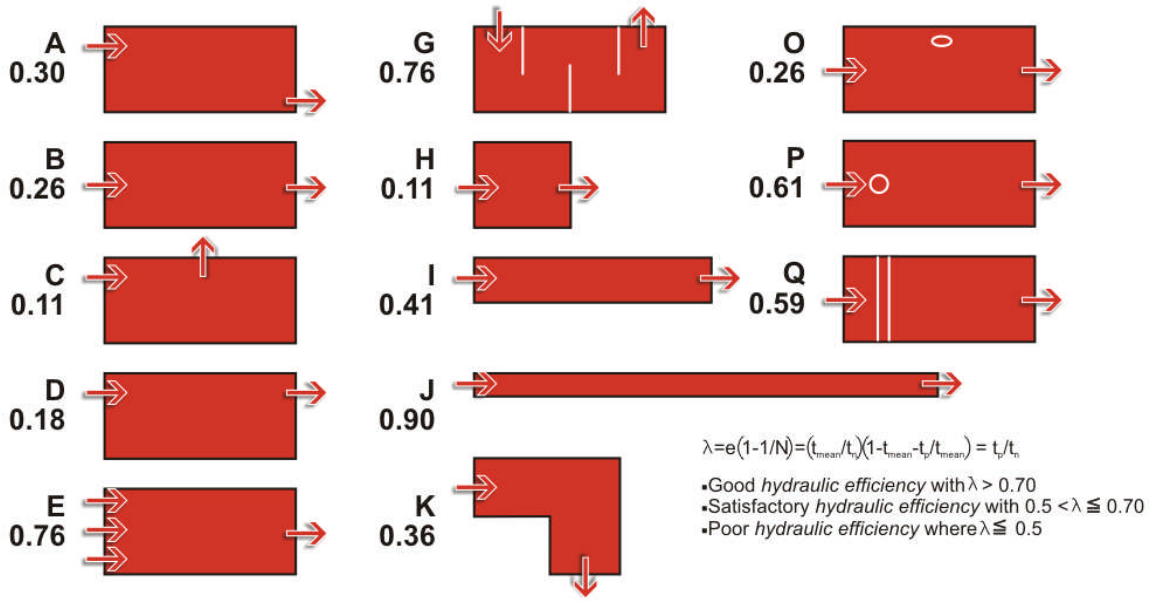


Figure D Hydraulic Efficiency of Various Wetland Zone Designs (Persson et al. 1999)

The City's Design Manual states that the minimum length-to-width ratio for the wetland zone is 1:1, with a preferred ratio of 3:1 or greater; however, based on hydraulic efficiency concept, length-to-width ratios of 1:1 should be avoided (Persson et al. 1999).

Careful consideration should be taken when trying to achieve hydraulic efficiency in an Engineered Natural Stormwater Wetland. Undertaking in-wetland modifications can cause harmful alteration of habitat and, therefore, in-wetland work should be carefully weighed against other options such as expanding the wetland or creating additional wetland zones upstream of the natural area. Consideration also needs to be given to maintaining established flow paths that existed in the natural wetland before modification. Any modifications to the natural flow path may negatively impact the wetland vegetation and its function.

Treatment efficiency is also largely dependent on catchment characteristics, which include surficial materials and sediments properties, pollutant loads within stormwater, and provision of upstream pre-treatment. These factors should also be considered when designing Stormwater Wetlands for water quality improvement. The type, location and density of wetland vegetation are also fundamental to the treatment efficiency of a wetland. Wetland vegetation is responsible for the filtration, biological and chemical processes occurring in a wetland. Additional information on wetland vegetation is provided in Section 3.2.4.

The treatment capability of Stormwater Wetlands should be supported by computer modelling. To date there are limited software programs with the ability to simulate treatment capability within wetlands; hence, the benefit of using the tank-reactors approach combined with hydraulic efficiency concept. Two-dimensional depth averaged models should only be used to provide information to support the conceptual design of wetlands provided careful attention is placed on modelling the diffusion process (Somes et al. 1996). The City is currently investigating the use of MUSIC (CRC 2005), an Australian based software program, for this purpose. Modelling approaches that are not described in the Design Manual require approval from Water Services.

Water Balance and Wetland Area

Stormwater Wetlands must be supplied with sufficient water quantities, whether surface water or groundwater, to support wetland function. Generic criteria provided in the Design Manual state that a minimum drainage area of 4 ha must drain to a Stormwater Wetland with a preference for 10 ha or larger. A review of available literature also states that the area of a Stormwater Wetland should fall between 1-5% of the contributing drainage area (LEC 2000). Specifying design criteria based on a minimum drainage requirement or percentage of drainage basin is not recommended however because of the dynamic nature and limited understanding of wetland systems.

As an alternative to sizing wetlands using these generic guidelines, it is recommended that both wetland area/minimum drainage areas be assessed to ensure that sufficient run-off exists to maintain a permanent pool. Assessment should include a water balance study for the wetland using information from the BIA and additional hydrologic assessment as well as continuous model simulation. Water balance variables that should be incorporated into the analysis include inflows and outflows,

precipitation, evapotranspiration and groundwater gains/losses (where possible).

As stated in the Design Manual, a geotechnical study must be performed to determine soil and groundwater characteristics. In most cases, a Constructed Stormwater Wetland should be constructed using a natural low permeability material (permeability coefficient less than 1 x 10-6 cm/s) to prevent water loss.

Engineered Natural Stormwater Wetlands may have a low permeability bottom resulting in insignificant groundwater losses or gains (i.e., it is surface water supplied), or they may have a higher permeable bottom that is associated with significant groundwater losses and/or gains. Due to the natural variability associated with Engineered Natural Stormwater Wetlands, extra emphasis should be put on the groundwater and soil portion of the geotechnical assessment. Alternatively, additional groundwater assessment could be performed in a separate document and supplement the BIA. Proper characterization of wetland-groundwater interaction should be used for determining wetland water balance and contamination concerns as well as the most appropriate modifications for amending a natural wetland to an Engineered Natural Stormwater Wetland.

3.3.4 General Vegetation and Landscape Considerations

Ecological objectives developed during the preliminary planning phase should guide the conceptual design of biotic components of the wetland system. Biotic components that should be addressed at the concept stage include the general locations and characteristics of wetland and upland vegetation while considering ecological, amenity and stormwater objectives.

General wetland vegetation types, species lists and planting locations should be determined in coordination with wetland layout, water levels and bathymetry and water quality requirements. For example, the wetland outlet structure may be designed to manipulate water levels to support specific plant species.

The biotic community is already established in Engineered Natural Stormwater Wetlands; however, this community may change in response to altered hydrologic or water quality regimes associated with stormwater influxes. In these cases, optimal growing and reproduction conditions for desired individual plant species need to be determined while considering treatment requirements and the new hydrologic regime.

The general physical features of a wetland, determined at the conceptual design stage, have a significant influence on wetland fauna diversity and abundance (LEC 2000). For example, waterfowl populations can be enhanced by incorporating islands and open water areas. Alternatively, banks and surrounding areas may be graded and planted to discourage waterfowl use.

Upland areas around the Stormwater Wetland should be naturalized, based on the City's Development Guidelines and Standard Specifications: Landscape Construction (2008), to provide additional habitat for fauna and amenity value. Upland and riparian areas may undergo infrequent flooding under some design scenarios, which should be accounted for in the design. The minimum buffer strip associated with upland areas is 8 m with greater than 16 m being preferred for wildlife purposes (Schueler 1992). Final buffer strip widths need to be determined on a site-by-site basis. It should be noted that planting

strategies should be undertaken to deter direct access of people to the wetland (LEC 2000).

3.3.5 General Amenity Considerations

A Stormwater Wetland may provide amenity and attract public interest for passive use and enjoyment. At the conceptual design phase all pathways, viewing areas and amenities necessary to support the recreational uses identified in the design intent phase should be clearly labelled on a conceptual layout of the site. General educational and signage concepts should also be identified.

Recreational Considerations

Due to the significant vegetation, certain activities at Stormwater Wetlands should be prohibited, including non-motorized boating activities, e.g., swimming, kayaking, canoeing, paddle boating, rafting and model boating. These activities need not be addressed at conceptual design unless they have been specifically indentified during the design intent phase. Activities including photography, bird watching, bicycle riding, jogging, walking, picnicking, on-leash dog walking and arts and crafts need to be addressed during conceptual design. Conceptual design for these activities will likely include pathways, parks and buildings. Proper signage is required to identify allowed activities within the wetland or in the proximity of the wetland. Restricting public access to a stormwater wetland must be determined at the Area Structure Plan (ASP) stage, e.g., due to the location of the stormwater wetland on private land or the presence of uncommon or rare plants and animals.

Aesthetic Considerations

Wetlands are beautiful and diverse environments, which are home to a broad array of plants and animals. The natural beauty and diversity of wetlands make them ideal educational tools to enlighten humans about the value of nature and its inhabitants. Moreover, wetlands provide scenic beauty and can increase property values and increase the desirability of living in specific neighbourhoods home to wetlands. Conceptual design should address viewscapes, access considerations, boardwalks and viewing areas.

3.3.6 General Operation and Maintenance Considerations

Construction and maintenance considerations must be considered at the conceptual design stage to ensure adequate area and access is available for these purposes. Maintenance planning must focus on the areas of the wetland that will require access and the type of machinery required to do so. Provisions for access into the forebay and wetland zones will be required to periodically remove sediment build-up and perform routine maintenance Additional considerations for the appropriate design of maintenance access is included in Section 4.4.

3.4 Detailed Design

The detailed design concepts presented below are not intended to provide ‘how to’ detail design prescriptions for Stormwater Wetlands. Rather they are intended to provide guidance for detailed design with a focus on recommended design principles and BMPs that should be considered for Stormwater Wetlands (including retrofit Stormwater Wetland

projects). They are not site-specific and consideration should always be given on a case-by-case basis as to what the predominant issues are. Detailed design information for Stormwater Wetlands is presented in the Design Manual, Constructed Wetlands for Water Quality Improvement (COC 2004b), Development Guidelines and Standard Specifications: Landscape Construction (COC 2008). In some instances, the information provided in these documents is applicable to Engineered Natural and retrofit Stormwater Wetland projects.

3.4.1 Detailed Design Drawings

Detailed design will be based on information presented in the conceptual design stage. Refinement of the conceptual design is undertaken at this point and should be supported by additional design and analysis, as required.

Detailed landscape and civil engineering design drawings, specifications and reporting information must be prepared for approval and eventual construction. Design details that should be included in the detailed design drawings for Stormwater Wetland should address landscaping, vegetation planting, amenity considerations, general grading, all civil works (buildings, roads and pathways), hydraulic structures (manholes, inlets, outlets, flow bypasses and minor system and drainage piping), electrical and mechanical systems and other designed components. All details related to the Stormwater Wetland and the surrounding areas should be reviewed and finalized by the wetland design team to ensure the design intent and objectives are addressed.

3.4.2 Detailed Design Considerations for Vegetation and Landscaping

The biotic concepts presented at the conceptual design stage, including upland and wetland vegetation, should be developed further into detailed landscaping and planting plans (including drawings and specifications) at the detailed design stage. These plans must be developed by qualified professional wetland specialists, horticulturists and engineers and submitted to the City. The requirements of these plans are outlined in the City's Development Guidelines and Standard Specifications: Landscape Construction (2008). Plants native to Calgary should be used where possible as described in Appendix E of the Design Manual. A vegetation management plan for inclusion should also be developed at this stage so that the selection of plant species and strategies for suppressing and controlling noxious weeds are documented.

Several methods exist for establishing vegetation in and around Stormwater Wetlands: direct seeding, seedlings plating, transplanting harvested material and transplanting wetland sediment seedbanks. The recommended strategy for vegetating wetlands is to use nursery-grown seedlings for the planting of broad areas. Direct seeding and transplanting harvested materials can be used where opportunities arise. Sandbank material from wetland sediment is best suited to rehabilitating of degraded wetlands or where species selection is less critical. In general, planting density should achieve coverage of about 80% vegetation meaning plants should occupy 80% of each square meter of vegetated wetland zone (Wong et al. 1999). This recommended percent coverage conflicts with

the Design Manual, which states that planting density need not be high as natural succession will ultimately make up the vegetation. The 80% coverage value reduces the risk of weed invasion and is consistent with Schueler's (1992) recommendation of planting a diverse species selection within one year after construction to avoid dominance of volunteer species, including cattails and Phragmites, which flourish in disturbed conditions.

Specific plant species selected for detail design should be guided by the general plant communities provided during conceptual design. The approach should focus on balancing between selecting plant species for particular wetland depth ranges, to enhance particular treatment processes and to promote ecological diversity. The hydrologic regime will influence the wetland vegetation zones present within the system, determining which species will dominate (Wong et al. 1999).

Seeds can be collected from emergent plant species or from the seedbank of natural or other constructed wetlands in close proximity to the wetland designated to receive stormwater runoff. Some plants produce large quantities of seeds, e.g., cattails, while others produce smaller quantities, e.g., bulrushes. These seeds can be broadcast using rotary seeders or by hand and then being lightly harrowed into the surface soil layer. Alternatively, seeds can be acquired from the seedbank of a nearby wetland by removing the top 10-20 cm of topsoil and then distributing this soil in strips or over the entire surface of the new wetland. Maintaining an adequate moisture regime, i.e. saturated but not flooded, is important for the successful establishment of emergent vegetation communities in the wetland designated to receive stormwater runoff.

There are three potential problems associated with the establishment of an emergent vegetation community using seeds: (i) it takes considerably more time to establish a dense vegetation community, (ii) it is unknown which seeds will germinate following the application of seedbank material from a nearby wetland, i.e., undesirable plants may germinate in greater numbers than desirable plant species, and (iii) low vegetation cover or bare soils may result in some areas due to the germination of seeds of upland plant species, which may die following the establishment of higher water levels. The use of seeds vs. seedlings is advantageous in large-scale wetland construction projects since costs are lower for seeding; however, the establishment of a desirable vegetation community may take several years and, as mentioned, there is a higher chance of weed invasion.

Bare-root seedlings can be grown from field-collected or nursery brood stocks in flats containing potting soil. Once established (i.e., 20-50 cm tall), these seedlings can be removed from the potting soil, their roots washed with water to remove all potting soil, wrapped in moist paper towels, and then transported to the wetland designated to receive stormwater runoff for planting. These seedlings are easily planted in shallow individual holes prepared with a shovel, trowel or spike. The survival rate of planted seedling is significantly higher than for field germination of seeds. Generally, up to 80% of planted seedlings survive from a healthy plant stock and maintenance of an adequate soil moisture regime. This technique also facilitates the establishment of a high-density plant community, which may be of importance where minimal start-up time is of the essence. Potted plants in soil establish similarly successfully. This approach may be most applicable to

woody plants with slower growth rates; however, this approach carries an initially higher cost and may be unattractive in larger-scale construction projects.

Plants can also be field-harvested, which is advantageous in areas with abundant wetlands in the vicinity of the wetland designated to receive stormwater runoff. Plants are removed from a nearby wetland using a shovel, backhoe or dragline and then spread out in an open area. They are then separated by hand into plantable sizes. Due the rhizomatous growth habit of many wetland plants species (e.g., sedges and cattails) it is more difficult to plant field-harvested plants; however, it is advantageous to plant field-harvested plants, since these plants store their growth reserves in below-ground structures (e.g., corms, rhizomes or tubers) which are transplanted along with the plants. In addition, if these plants are already established (e.g., in a natural wetland designated to become an Engineered Natural Stormwater Wetland), they would already be adapted to local environmental conditions. Transplanting field-harvested plants also facilitates the establishment of other plant wetland plant species, which may be adhered to the soil attached to the transplanted plants. This increases the biodiversity of the vegetation community in the wetland designated to receive stormwater runoff and may be desirable.

The successful establishment of a continuous and healthy emergent vegetation community depends on various factors: (i) climate, (ii) soil preparation, (iii) soil moisture and (iv) plant density.

Most plants in northern Stormwater Wetlands are perennial and re-grow from belowground stored reserves. In some cases, re-growth is timed to coincide with precipitation events or specific soil moisture conditions rather than day-length or temperature. Understanding the requirements of individual plant species prior to planting ensures a higher success rate in the establishment of emergent vegetation cover in a wetland designated to receive stormwater runoff. The optimal time to establish plants in a Stormwater Wetland is spring or early summer. At this time, available light increases continually and competition from other plants or pathogens is minimal. In addition, the time period prior to senescence or death of aboveground plant tissues later in the year is maximized and provides sufficient time for plant development and the attainment of adequate plant density.

Soils for the wetland should also be determined at the detailed design stage. One of the major elements required to ensure growth is selecting a suitable substratum for growth (Wong et al. 1999). Soils are important for establishing vegetation as well as to support other wetland processes. If available, Water Environment Federation / American Society of Civil Engineers (WEF/ASCE 1998) recommend using soils displace from other wetlands after ensuring the soil is not contaminated. In the likely circumstance that wetland soil is not available, a 20-30 cm layer of topsoil or peat can be used for plant establishment (LEC 2000). Topsoil and peat should also be tested for potential contaminants. Wetland plants require suitable top soils for their establishment and growth, whereby a mixture of sand, silt and clays are optimal. These soils provide adequate texture and organic matter to retain moisture, allow the diffusion of oxygen and carbon dioxide and retain nutrients for plant growth. During the construction of a Stormwater Wetland, it is important to ensure that wetlands plants are grown in adequate soil conditions.

Soil moisture is crucial in the establishment of wetland plants from seeds or transplanted seedlings or plants. Moreover, adequate soil moisture conditions following the establishment of dense vegetation cover ensures proper functioning of the wetland. Hence, the water supply must be properly managed. The most effective technique to establish rapid vegetation cover is to maintain saturated soil conditions without surface flooding. Once plants are established and growing, the wetland can be flooded for longer periods.

The initial density of plants will greatly influence the establishment of plant cover and the cost of planting, if this approach is used. If the goal is to produce a vegetation cover of > 60 % during the first year, a minimum density of 10,000 plants per ha is required. Plants should be spaced about 1 m apart. Wider spacing is successful in establishing a dense vegetation cover as well; however, plant density will be below desirable levels for two or more growing seasons, and the wetland designated to receive stormwater runoff may not operate as desired or required.

Engineered Natural Stormwater Wetlands would have had an existing plant community. Should this community be compromised following the exposure to stormwater, the above approaches can be used to re-vegetate exposed soils and re-establish a healthy plant community.

3.4.3 Detailed Amenity Design

The detailed design for recreational and aesthetic amenity considerations should be addressed in the detailed landscape and civil drawings, specifications and reporting, especially items requiring infrastructure (e.g., pathways, boardwalks, viewing areas and picnic areas). The conceptual design of amenity considerations should be used to guide detail design.

Detail design to improve amenity potential may also include refinement of educational and information materials. Additional detailed planning information is provided below.

Education and Information Considerations

All wetlands are required to have appropriate signage. Signage is required at all entrances to the wetland and at any other critical points. Locations should be identified on the Site/Overall Stormwater Wetland Concept Drawing. As well, an information sign is required at the most prominent entrance to the wetland. The purpose of the sign is to inform people about the function of the wetland, and to provide a contact number for further information or to report problems. It is the responsibility of the developer to supply and install the sign.

Additional signs promoting public education are encouraged. Signs may include information regarding operation and purpose of the wetland, protection of the environment, water conservation, native landscaping, impact of chemicals and interpretative (e.g., ecological and cultural) information. Enhanced interpretive trails and signage may be considered to educate the public on the unique features of Stormwater Wetlands. These facilities could provide insight into ecological processes and/or stormwater management concepts within the system.

Education material should be developed for neighbourhoods that will have a Stormwater Wetlands associated with their stormwater management system. The purpose of the educational material is to educate residents on: (i) the specific function of Stormwater Wetlands, (ii) the water quality of the wetlands, (iii) permitted recreational uses, benefits and ecological characteristics and, (iv) maintenance and operational concerns.

Educating the public about the importance of wetland functions and their value in producing environmental, social and economic benefits will play an important role in wetland conservation and protection. The primary goal for meeting this principle is:

- Awareness concerning the role that wetlands play in addressing the pressures and demands that population growth and industrial developments are having on the local and regional water supply;
- Understanding that a wetland is one of the most biologically productive and bio-diverse ecosystems within our natural environment; and
- Appreciation of how wetlands contribute to the reduction in flooding and soil erosion, climate moderation, landscape variability, and educational and recreational opportunities.

3.4.4 Maintenance Considerations

An Operation and Maintenance Manual should be prepared for each wetland project and submitted with the detail design plans to the City of Calgary. The plan should identify a list of operational and maintenance tasks that are required to be performed during the life cycle of the wetland to ensure that it continues to function as intended. The plan should detail the frequency and schedule of tasks, the individuals, or bodies responsible, and the type of equipment/planning required for each task. The plan should be prepared in consultation with the key stakeholders including Parks and Water Services departments responsible for approving the plan. The plan should outline specifications and details finalized during

detailed design but likely will not include equipment manuals.

Detail design requirements for maintenance of the wetland that should be verified include:

- Maintenance access ramps and roads;
- Dewatering facilities; and
- A method for identifying the base of the sedimentation pond.

3.4.5 Monitoring Considerations

As outlined in the Design Manual, a permanent remote water level monitoring system is required for all Stormwater Wetlands. In addition to water level monitoring, considerations should be given during the design process for additional monitoring equipment that may be required to monitor ecological components or water quality. Currently, water quality monitoring for wetlands is only required for three years following receipt of the CCC.

3.5 Cold Weather Design Considerations

Calgary's cold winter climate should be considered during Stormwater Wetland planning and design, due to the freezing temperatures, which can cause direct impacts, and indirect issues associated with the management of ice and snow.

Direct impacts that should be considered during conceptual and detailed design phases include:

- Increasing storage volumes to account for volume reductions due to ice and the effects of spring melt where ice effects could significantly impact the residual storage volume (Caraco and Claytor 1997); and
- Sizing and locating inlets and outlets to avoid ice clogging and freeze-up (COC 2000).

Outlet design for cold climates, especially those incorporating low flow orifices and perforations (such as risers), should be designed to consider ice clogging. Orifices should have an opening greater than 50 mm. Perforated riser pipes used in cold climates should incorporate perforations with a minimum diameter of 12.5 mm and a minimum riser pipe diameter of 450 mm. The riser pipe structures should be open on the top, covered with some sort of hood or trash rack device and placed within a wetland embankment (COC 2000).

In general, water quality treatment of stormwater is most essential during above-freezing periods, which include early spring snowmelt freshets and late spring and summer rainfall events; however, considerations that may be considered during the design and assessment of treatment capacity include:

- Reduction in detention time and effective volume due to ice;
- Reduction of biological productivity due to limited vegetation growth; and
- Slowing of chemical transformations due to low temperatures.

Salt load associated with road de-icing is another concern associated with cold climates that should be considered during the design of the wetland layout and the forebay, and selection of plant species. Elevated salt levels in runoff can cause impacts to water quality, vegetation and wildlife. These impacts can manifest themselves at various time scales. For example, water with elevated salt content

entering Stormwater Wetlands can result in a vegetation community shift towards more salt-tolerant species and reduced health and growth of salt-intolerant species, which generally reduces the biodiversity of the wetland plant community (Crowe et al. 2007). An upstream pond and/or forebay providing permanent water storage can dilute salt concentrations and minimize impacts. In addition, sensitive plant species can be avoided to limit die off and loss of biodiversity.

Snow management is another consideration that should be addressed in cold climate areas. Although, dry extended detention ponds can be used to store snow, other storage systems such as Stormwater Wetlands should not be designed or used for this purpose. The permanent pool makes storage impractical and the concentrated pollutants (e.g., sediments and salts) in the snowpack may damage vegetation.

3.6 Discussion of Local Planning and Design Issues

A number of planning and design related issues were identified during the course of the 2008 Wetland Field Assessment Report (WorleyParsons and Aquality 2009), undertaken during development of these guidelines. A brief summary of these issues has been provided to help ensure they are avoided in the future.

Issues identified include:

- Design intent and project objectives poorly defined or non-existent (e.g., lack of consideration for balancing ecological and stormwater management objectives);
- Communication breakdown with design team, Water Services and Parks (e.g., detailed Design Plans approved by one department, when Conceptual Design Plans had not been approved by another);
- City projects not following the same protocols as external applications (e.g., able to circumvent portions of the 'normal' approvals process adding communication issues and affecting quality control);
- Ecological features considered secondary and after design has been completed (e.g., cattail-dominant, low habitat value and maintenance intensive); Inappropriate design of sediment forebays (e.g., too small, too large, short-circuiting);
- Poor wetland design (e.g., location of inflow and outflow locations inappropriate, insufficient flow distribution resulting in short-circuiting); and
- Incorporation of maintenance intensive infrastructure in designs (e.g., waterfalls with pumps).

4. CONSTRUCTION CONSIDERATIONS

Stormwater Wetland construction activities have potential to cause significant disturbance to existing wetland habitats and downstream environments. Careful consideration should therefore be given to when and how construction will be undertaken to ensure that impacts can be minimized. The City currently has several documents that provide information on general construction activities that apply to general construction activities such as those related to construction of a Constructed Stormwater Wetland. These documents include the City's Design Manual, Guidelines for Erosion and Sediment Control (2001a), Field Manual for Effective Erosion and Sediment Control (2001b) and Development Guidelines and Standard Specifications: Landscape Construction (2008). Little to no information, regarding the construction of Engineered Natural Stormwater Wetlands is provided within these documents, beyond requirements set forth for Constructed Stormwater Wetlands.

The following section includes an overview of some of the more pertinent construction issues applicable to Stormwater Wetlands, along with some BMPs and recommendations. Specific focus has been given to the construction of Engineered Natural Stormwater Wetlands and retrofit wetland projects.

Note, construction plans outlining proposed construction methods including erosion and sediment control, and other environmental protection measures to be implemented prior and during construction should be submitted with detailed design documentation.

4.1 Construction Timing and Phasing

Construction timing and phasing for Stormwater Wetlands should be selected to minimize impact on existing habitats and promote rapid stabilization of the wetland and surrounding landscape. Existing information from the BIA should be used to determine sensitive fauna and associated life cycle activity periods. Sensitive life cycle periods (e.g., rearing, breeding) for these species should be used to determine restricted activity periods (RAP) where construction activities should be minimized, mitigated or suspended. As an example, specific RAPs for fish have been developed by Alberta Environment (2006).

Additional considerations should be given to growing season requirements to ensure efficiency and successful planting for habitat as well as erosion control. Construction should be planned so planting occurs in early spring to avoid issues associated with winter conditions and provide plants with the maximum growing season prior to Fall. Planting during early spring will also help ensure some vegetation growth to minimize erosion issues associated with late spring runoff.

4.2 Erosion and Sediment Control

An Erosion and Sediment Control Plan (E&SCP) should be prepared for all projects prior to construction commencing to minimize impacts of surface water runoff, on the site, and the erosion potential and subsequent sedimentation in existing wetlands or downstream water bodies. In the case of development upstream or within an existing

wetland (e.g., Engineered Natural Stormwater Wetlands), special consideration should be given to isolation of sensitive habitats such as riparian and in-wetland areas. Plans should be site-specific, giving consideration to the wetlands characteristics (including flora and fauna), upstream catchment characteristics and the type of soils on site.

The City has specific guidelines relating to the implementation of erosion and sediment control measures provided in the Guidelines for Erosion and Sediment Control (COC 2001a), which should be applied during the construction of all Stormwater Wetland systems. In addition to the measures described in this guideline, sedimentation and disturbance of existing wetland habitat during the construction of Natural Engineered Stormwater Wetlands (and retrofit Stormwater Wetlands projects) should be mitigated using appropriate isolation techniques, such as silt curtains and dams. During the construction and isolation period, special consideration should be given to maintaining pre-development hydrologic conditions of the system.

Some BMPs that should be adhered to during the construction of Engineered Natural Stormwater Wetlands and retrofit Stormwater Wetlands include:

- Using sediment fencing, high flow bypasses, temporary sediment ponds, dams and diversion channels to divert surface water away from the existing wetland during construction;
- Minimizing stripping and grading, and restricting the area of disturbance (e.g., minimizing the number of access points during construction);
- Incorporating good housekeeping, monitoring and maintenance of erosion and sediment control facilities to ensure they remain effective following storm events;
- Constructing forebays/sedimentation basins upstream of existing wetlands as early as possible; and
- Regularly reviewing and updating erosion control measures throughout the construction period to ensure they address site changes and remain effective.

4.3 Landscaping

All landscaping work in upland areas must be conducted in accordance with the City's Development Guidelines and Standard Specifications: Landscape Construction (COC 2008), and be in accordance with the approved construction plans. Construction certificates will not be issued until the required number of inspections has been undertaken and approval has been granted. Special attention should be taken prior and during construction to ensure impacts to sensitive species (flora and fauna) are minimized.

4.4 Access Considerations

The provision of appropriate vehicle and pedestrian access is vital to ensure that wetland systems can be adequately constructed, operated and maintained throughout their life cycle. Consideration needs to be given however, to achieving a balance between meeting access objectives and minimizing disturbance to the wetland system.

Where possible the number of access points to a Stormwater Wetland should be kept to a minimum, but be sufficient to permit access to all areas of the wetland necessary for

construction, and eventual operation and maintenance. The preference should be that the same long-term access provided for operation and maintenance be used and provided during construction. Where possible, pedestrian/cycle paths should be integrated with vehicle accesses to minimize impervious areas.

In general, the following recommendations should be considered during construction for pedestrian and vehicular access:

- Facilitate all weather access;
- Accommodate the largest vehicle likely to access the site (at minimum emergency service vehicles), and designed accordingly to meet the structural and geometrical requirements;
- Include Texas gates at the entry/exit point of the site during construction to prevent soiling roadways;
- Gravel roads and pathways to prevent icing during winter;
- Fence construction site and post appropriate signage;
- Restrict access to public vehicles using lockable gates or removable bollards:
- Include appropriate drainage and prevent concentrated flows to minimize erosion; and
- Incorporate ramps capable of supporting machinery as necessary.

In addition, all manholes and structures requiring access from personnel should be designed with safety construction and operation considerations in mind. Confined spaces should be avoided where possible. Structures and facilities should also be vandal proof and made of suitable materials appropriate for the exposure to weather.

4.5 Spoil Disposal

Due to excavation requirements, construction activities for wetlands may result in spoil. Spoil is loose soil or rock material excavated from a wetland, pond, canal or ditch area. Spoil materials may have elevated concentrations of contaminates such as salts, metals or hydrocarbons and, therefore, should be tested using appropriate soil sampling methods before reuse is considered.

Prior to commencement of construction, the developer and their contractors must submit a Contractor Environmental Acknowledgement Form (Appendix 4), acknowledging they are aware of the City's Environmental Policy and the specific components therein. This form addresses the proper handling procedures for offsite disposal of contaminated spoil material associated with Stormwater Wetlands.

The Calgary Wetland Conservation Plan (2004a) promotes the use of salvaged wetland soil and plant materials during the re-development of a natural wetland area. Wetland soils contain unique assemblages of organic material and often retain seed and/or viable propagules even after extensive desiccation and therefore can help speed wetland habitat establishment. Wetland spoil may be retained and reused for the construction of other Stormwater Wetlands in the City once appropriate testing has been performed to ensure the soil is not contaminated.

4.6 Retrofitting Considerations

Retrofitting in a stormwater management context is defined as retrofitting existing stormwater facilities in order to provide multiple benefits (e.g., flood control, increased amenity value or water quality improvement) and to achieve environmental goals and targets (Ontario Ministry of Environment 2003). Construction considerations for retrofitting Stormwater Wetlands should be similar to those associated with the construction of new Engineered Natural Stormwater Wetlands in natural wetland areas. That is, efforts should be made to ensure that potential environmental impacts to the current facility (e.g., wet pond, dry pond or wetland) are minimized, especially if the proposed retrofit facility has ecologically sensitive components. Again, the ecological sensitivity of the proposed area slated for retrofitting should be determined using information gleaned from a pre-development BIA.

4.7 Discussion of Local Construction Issues

A number of construction related issues were identified during the course of the 2008 Wetland Field Assessments (WorleyParsons and Aquality 2009), undertaken on behalf of the City. A brief summary of these issues have been provided below to ensure they are avoided in the future.

Issues identified include:

- Inappropriate disposal of excavated clean spoil from an existing wetland that should have been used for construction of a new wetland;
- Errors in As-Built drawings (e.g., additional/omitted culverts, different material specifications resulting in erosion); and
- Lack of involvement and inspections by the designer/design team during the construction phase to confirm wetland was built as designed and As-Built drawings were correct.

5. OPERATION & MAINTENANCE CONSIDERATIONS

The City of Calgary has several documents that provide guidance as to the appropriate operational and maintenance requirements for constructed wetlands to ensure the long-term function and objectives of wetland systems are maintained, to ensure the protection of downstream environments and to maintain public health interests. These documents include the City's Design Manual (2000), Constructed Wetlands for Water Quality Improvement: A Design Primer for the Development Industry (2004b) and Development Guidelines and Standard Specifications: Landscape Construction (2008). These documents focus on Constructed Stormwater Wetlands.

It is important to stress the relationship between design and maintenance and how incorporating good design practice and principles can directly lead to reduced operation and maintenance requirements. Conversely, a poor design not guided by specific objectives may increase operation and maintenance requirements.

As specified in the City's Design Manual, each Stormwater Wetland must have an Operating and Maintenance Manual prepared and approved by the City prior to the issue of CCC. The Operating and Maintenance Manual is an essential document that should be strictly followed to ensure the integrity of the wetland and that it functions as intended. Operating and Maintenance Manuals should be developed on a case-by-case basis and be specific for each wetland they accompany.

The following section provides an overview of some of the more pertinent operational and maintenance issues prevalent among Stormwater Wetlands, along with some best management practices and recommendations. Also included is an overview of some current costs and schedule information provided by the City to operate and maintain their current inventory of Stormwater Wetlands.

5.1 Frequency and Scheduling

Operation and maintenance requirements of each Stormwater Wetland will vary due to the uniqueness of each system. Likewise, the degree and frequency of operational and maintenance requirements will vary for each wetland depending on: layout and design, size, catchment characteristics, climate, resource provisions and access.

Maintenance activities can be broken into two categories: (i) preventative maintenance and, (ii) corrective maintenance. Preventative maintenance includes scheduled tasks and housekeeping required for the general upkeep of the wetland to ensure it continues to function as intended and includes tasks such as:undertaking inspections, litter collection, sediment removal, monitoring, record keeping, etc. Corrective maintenance includes unscheduled tasks that require immediate attention to prevent flooding, limit liability and protect the Public and environment and includes tasks such as repairing pipe breaks.

The approved Operating and Maintenance Manual approved prior to the issue of CCC should provide an overview of all the operation and maintenance tasks (summer and winter) required to ensure effective wetland operation during the life cycle of the wetland. Details should include a breakdown schedule with frequency of tasks. Equipment and materials required to undertake the work along with

access requirements should also be addressed in this report.

A schedule of responsibility, allocating responsibility for each task and/or wetland component (and surrounding area) to a specific department or authority should, be developed and included in the Operating and Maintenance Manual.

The Operating and Maintenance Manual should be used by the City for budgeting purposes and to determine resource requirements to manage the wetland when ownership is transferred to the City (post Final Acceptance Certificate [FAC]). For this reason, it is vitally important that the content of each manual be captured in a database system, regularly updated and maintained by the City.

5.2 Inspections

Inspections are essential components of the operation and maintenance of Stormwater Wetlands, required to ensure effective operation and function. For preventative measure, regular visual inspections should be carried out in accordance with a predetermined schedule detailed in the Operating and Maintenance Manual. In addition, visual inspections should also be carried out periodically during and after rainfall events to ensure there is no damage or clogging of the inlet/outlet components, and the wetland is continuing to function satisfactorily.

Inspection and maintenance checklists should be developed and included in the specific Operating and Maintenance Manuals on a wetland-specific basis, based on a standardized template that should be developed with the input of all City stakeholders. Specific items that should be inspected and included in these checklists include grading, inlet/outlet/control structures, catch basins/manholes, piping/drain systems, monitoring systems, signage, roads/ramps, irrigation, vegetation condition and coverage, fencing and amenities.

5.3 Performance Monitoring

In addition to regular inspections, performance monitoring of Stormwater Wetland hydrology and water quality must be performed during the three-year post-construction period in accordance with the Wetland Monitoring Program developed for each wetland and included in the approved Operating and Maintenance Manual. Performance monitoring should be performed to determine if the wetland is operating as designed, or requires design alterations to ensure treatment objectives are met. Monitoring of wetland hydrology and water quality should be extended beyond the three-year period in instances where the monitoring reveals the wetland is not meeting the performance criteria approved in the approved Operating and Maintenance Manual. Additionally ongoing monitoring beyond the three year maintenance period should also be considered for instances where a wetland is provided to support an upstream development, not completed by the end of the three year period.

The Design Manual provides a list of water quality parameters that should be considered in the development of a Wetland Monitoring Program.

More detailed monitoring programs should be established for Stormwater Wetlands when design objectives focus on ecological considerations such as those associated with Natural Engineered Stormwater Wetlands. Again, these monitoring programs should be site specific and designed to collect the most

appropriate information for each wetland based on the wetland design intent and the sensitive habitats identified during the BIA. Additional aspects, beyond water quality that should be considered for monitoring for these wetlands and used to assess wetland function and sustainability, include but are not limited to:

- Vegetation community biodiversity, density, production, height, overall health;
- Terrestrial wildlife density, biodiversity and sensitive species;
- Aquatic wildlife and micro-organism biodiversity and abundance;
- Morphological changes to shorelines and benches; and
- Nutrient cycling (uptake, transformation and removal).

5.4 Erosion and Sediment Control

Following construction completion ongoing erosion and sediment control measures may be required to protect the new Stormwater Wetland from erosion and sediment loading. This would be particularly relevant for cases such as subdivision applications where the wetland construction is completed ahead of building on upstream lots, or the installation of upstream stormwater infrastructure may cause high sediment loads to be deposited downstream. The need for ongoing erosion and sediment measures should be identified during inspections.

In all cases, the developer or City must be responsible for the ongoing inspection and maintenance of these controls to ensure they remain effective.

5.5 Upland Vegetation and Buffer Zones

Operational and maintenance issues associated with upland vegetation and buffer zones are briefly addressed in the City's Design Manual and Development Guidelines and Standard Specifications: Landscape Construction (2006). The maintenance of upland vegetation for new Constructed Stormwater Wetlands will focus on vegetation establishment and control of weed species. Upland vegetation and buffer zone maintenance for Engineered Natural Stormwater Wetlands will focus on a combination of establishment in disturbed areas and conservation in natural areas.

Care should be taken during maintenances activities to avoid potential inputs such as grass clippings and fertilizer, which can severely affect wetland function and habitat.

5.6 Wetland Vegetation

The maintenance of the vegetation community in natural and constructed wetlands is crucial in maintaining both their ecological function and habitat and achieving stormwater management objectives. Stresses to vegetation communities can arise due to degraded water quality (higher pollutant loadings) and modifications to the natural hydrologic regime, which may have a detrimental effect on the vegetation community and wetland treatment efficiency.

Wetland vegetation can be maintained using several approaches. Both weed and desirable species respond to water level management (Wong et al. 1999). Water levels and inflows to wetlands can be controlled and adjusted to provide optimum growing conditions for specific species. Wetland vegetation may also be re-established or altered to suite the hydrologic,

water quality and soil conditions apparent in the wetland. Altering may include total removal or harvesting by hand or mechanical means. Care must be taken during harvesting to avoid suspension of sediments and disturbance of properly functioning areas.

Schueler (1992) recommends that the wetland system be inspected at least twice a year during the first three years post-construction to assess vegetation establishment and, if necessary, develop appropriate enhancement plans. Vegetation and site maintenance require good water-level control. Controlling water level can be a simple and powerful management tool.

5.7 Weeds and Algae Control

Aspects of weed and algae control are addressed in the City's Design Manual, Development Guidelines and Standard Specifications for Landscape Construction (2008) and Government of Alberta's Weed Control Act (2008) and associated regulations. Most information on weed control focuses on 'land', which is defined as the land down to the low water mark of a stream, lake or wetland.

A site-specific weed monitoring and control program should be included in the Stormwater Wetland Operating and Design Manual. In wetlands, weed seeds are dispersed by a range of mechanisms including wind, water and consumption/transport by animals. In urban wetland areas, human activities, including clearing and dumping of garden waste, are the main causes of disturbance, which can lead to weed invasion and proliferation. Once established, the growth of riparian and aquatic weeds is often accelerated as a consequence of the discharge of nutrient-rich stormwater into wetlands, which creates a more favourable environment for weed growth.

Weed invasion threatens wetland biodiversity, leading to a decline in both species and habitat diversity. Weeds impact wetland ecology in a number of ways by:

- Directly competing with established native wetland plant communities;
- Restricting native plant regeneration through competition;
- Reducing the resources available for feeding, breeding and shelter of fauna; and
- Increasing fire risk as a result of increased fuel loads.

Weeds that may occur in and around Calgary wetlands (COC 2008): include:

- Restricted Weeds:
  - MILFOIL - EURASIAN WATER *Myriophyllum spicatum L*.
- Noxious Weeds:
  - CLEAVERS *Gallium aparine L*.;
  - CLEAVERS *Gallium spurium L*.;
  - COMMON TANSY *Tanacetum vulgare L.; and*
  - PURPLE LOOSESTRIFE *Lythrum salicaria L.*
- Nuisance Weeds:
  - COMMON CHICKWEED *Stellaria media L.;*
  - DOWNY BROME *Bromus tectorum L*.;
  - GREEN FOXTAIL *Setaria viridis L.;*

- HEMP NETTLE *Galeopsis tetrahit L.*;
- LADY'S THUMB *Polygonum persicaria L.;*
- MOUSE-EARED CHICKWEED *Cerastium vulgatum L.;* and
- ROUGH CINQUEFOIL *Potentilla norvegica L.*

Regular weed monitoring and control should be undertaken by qualified individuals. Once detected, weed control should consist of manual or mechanical (if appropriately designed and planned for) removal, if possible. Harvested weeds should be destroyed in an appropriate manner. Weeds and their seeds should not be deposited where they might spread, such as in a container.

While herbicides are effective for controlling weeds, their use should be the last choice or if needed used in such a manner as to minimize impacts on wetland aquatic communities. In circumstances where weeds cannot be controlled by manual or mechanical means, a weed control professional should be consulted to develop an appropriate site-specific weed control in coordination with stakeholders.

5.8 Pest Control

Mosquitoes inhabit most wetland habitats, however, nuisance level and population varies substantially with the type of wetland (LEC 2000). Effectively designed treatment wetland should maximize continuous flow and shaded areas to minimize the formation of pools of warm stagnant water preferred for breeding. Habitat can also be provided for martins, swallows and bats that consume adult mosquitoes as they emerge from the wetland. Additional information regarding pest control is provided in the City's Integrated Pest Management Plan (1998).

5.9 Discussion of Local Operation and Maintenance Issues

A number of operation and maintenance related issues were identified during the course of the 2008 Wetland Field Assessments (WorleyParsons and Aquality 2009), undertaken on behalf of the City. A brief summary of these issues have been provided below to ensure they are avoided in the future.

Issues identified include:

- Separate FAC processes employed by Parks and Water Services leading to communication issues, poor service, and possible inheritance of poor assets requiring long term maintenance/funding;
- Disputed roles and responsibilities among City Staff requiring clarification;
- City staff inaccurately filling out checklists and signing off on incomplete or deficient items; Staff may not have had appropriate training for these roles;
- General maintenance and housekeeping insufficient (e.g., observed build-up of debris and litter and amenities and signage requiring cleaning and repair);
- Deficiencies or non-existence of submitted reports (e.g., missing operations manuals and detailed monitoring programs);
- Follow up required on items requiring replacement/repair during the maintenance period (e.g., components/ structures essential to the design and

operation that required replacement or repair and were not addressed);

- Erosion due to overgrazing/public use (areas requiring replanting);
- Maintenance vehicle access deficiencies (e.g., insufficient for type of equipment necessary to maintain wetland, not provided to all areas requiring maintenance access, and access requirements not considered during conceptual planning and design); and
- Common complaints due to algal mats and odour.

5.10 Current Wetland Operation and Maintenance Roles and Responsibilities

Following expiration of the three-year maintenance period and upon issue of a FAC by the City Parks and Water Services departments, the Stormwater Wetland becomes part of the City's assets and the responsibility of Parks and Water Services to maintain and manage. As discussed in Section 2 of this document, the terms of these roles and responsibilities are as follows:

- Parks (Resource Management and Natural Areas Management divisions) maintain and operate all areas above the HWL or, in certain cases, below the HWL if manicured lands exist in that area or vegetation has been planted which requires maintenance. Land designated as Environmental Reserve or Municipal Reserve also becomes the responsibility of Parks; and
- Water Services maintain and operate all areas below HWL that are not manicured or contain vegetation requiring maintenance.

A breakdown of preventative and corrective maintenance tasks currently undertaken by Parks and Water Services with costs, to maintain the City's existing Stormwater Wetlands is provided below. Based on observations made during the 2008 Wetland Field Assessments (WorleyParsons and Aquality 2009), all of the Stormwater Wetlands Assessed required some form of additional maintenance or monitoring. The current maintenance and annual funding therefore appears inadequate to adequately maintain wetlands within the City in accordance with the recommendations included in this document. The opinion that insufficient resources (funding) are currently being provided for the operation and maintenance of the City's existing Stormwater Wetlands is shared by City Parks and Water Services Staff.

5.10.1 Current Parks Maintenance Responsibilities and Funding

A list of operation and maintenance tasks currently undertaken by Parks to maintain an area covering approximately 4,000 ha surrounding the City's existing Stormwater Wetlands is provided below in Table C. Also included, is a summary of future tasks identified by Parks staff that they would like to see undertaken.

Table C Parks Department Operation and Management Tasks and Costs for City Wetlands

Parks Department Operation and Maintenance Tasks	Currently Undertaken or Required
Weed Control/Vegetation Management	Current
Litter Control	Current
Access Maintenance	Current
Erosion and Sediment Control	Current
Habitat Monitoring Required	Current
Irrigation	Required
Interpretation and Education (signage)	Required
Mosquito Control	Required

As shown in the above table, the current maintenance tasks undertaken by Parks generally include litter pick-up and the spraying of invasive weeds (weed control). Some trail and sign maintenance of the information of interpretive signs owned by Parks is also undertaken on a needs basis. The schedule for these maintenance tasks is currently once in April, May or June (beginning of season) and then on a complaint-driven basis.

Similar to Water Services, the date, extent or nature of maintenance tasks and costs incurred by Parks have never been tracked on an individual wetland basis and it is therefore difficult to forecast what adequate costs are to maintain the City's existing wetlands. Current annual funding for Parks maintenance is estimated at $220/ha/year (excluding labour).

Significant additional resources, including technical staff will be required to expand the current monitoring program and undertake consistent habitat monitoring. It may also take a number of years to see noticeable improvements arising from this work.

5.10.2 Current Water Services Responsibilities and Funding

A list of operation and maintenance tasks currently undertaken by Water Services to maintain the City's existing Stormwater Wetlands, along with a breakdown of costs estimated for 2008 are provided below in Table D.

Table D Water Services Department Operation and Maintenance Tasks and Costs for City Wetlands

Operation and Maintenance Tasks	Estimated Annual Costs	Estimated Annual Unit Costs
Inspection/Cleaning/Repair	$239,800	$4,870/ha
Chamber Cleaning	$62,400	$1270/ha
Gate Inspection	$3,800	$80/ha
Total Costs	$306,000	$6,220/ha

As indicated in the table above, current operation and maintenance tasks undertaken by Water Services include a number of general preventative measures including inspections and cleaning of the sediment forebay/chamber and access facilities. According to staff, these are carried out on a weekly or bi-weekly basis along with corrective measures, as required, and often following large storm events.

As discussed previously, current resources and annual funding do not appear adequate to operate and maintain the City's Stormwater Wetlands, in accordance with the requirements and recommendations specified in this document i.e., ongoing monitoring programs are no longer being undertaken by the City to provide a broader understanding of wetland functions, improve design practices and ensure long-term wetland sustainability. Funding instead is resource limited, and derived from actual costs incurred in previous years for a few field crews to perform the general maintenance tasks provided above. (Table D). Unit costs presented above are based on a total wetland area of 49.82 ha, estimated for the 20 existing Stormwater Wetlands in the City. The average forecast cost to maintain a Stormwater Wetland in the City in 2008 was $15,300.

Considering the costs to operate and maintain a wetland are dependent on a number of variables, including size, catchment characteristics etc., a database system setup to track the date, extend, and nature of costs incurred on an individual wetland basis, is required to assess more accurate funding and resource requirements for the City's Stormwater Wetlands.

Consideration should also be given to whole life cycle costs incurred for the City's Stormwater Wetlands, and whether this information should be provided by developers during the planning process. MUSIC, an Australian based Water quality assessment model (CRC 2005), has a life cycle costing module that can be used for this purpose.

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Appendix 1 Workshop Minutes and Questionnaires

MEETING RECORD

Project No: C67440000

Project: City of Calgary, Guidelines for Stormwater Wetlands Management

Workshop #1 Minutes

PARTICIPANT NAME & ORGANIZATION		DATE	June 5, 2008
CLIENT	City of Calgary (COC)	**TIME START**	1:00 PM
ATTENDEES	Erika Almasi-Klausz, Joel Armitage, Shima Asadi-Ghafari, Robert Biegun, Bob Brick, Jack Buckley, Launie Burrows, Christy Caswell, Johnson Chan, Tricia Grieef, Glen Guest, Lam Huynh, Kim Jaska, Mona Keffer, Neil Kennedy, René Letourneau, Lily Ma, Janice Mah, Kristine Malmqvist, Chris Manderson, Robert May, Annie Rodrigues, George Stalker, Greg Stewart, Zhong – Xiang – COC Tim Burch, Jennifer Rowell – WorleyParsons (WPK) Jay White – Aquality (AQ)	**TIME FINISH**	3:00 PM
		LOCATION	5th Floor Public Building Parks Boardroom
		RECORDER	J. Rowell, J. White
		FILE LOC.	Calgary

ITEM	ITEM DETAILS	ACTION BY AND DATE
1.	Introductions – Participants introduced themselves and indicated what they hoped to gain from this workshop. During the introductions, participants identified the following issues and concerns regarding stormwater wetlands management: • the need for defined monitoring and ongoing assessment regimes and schedules for stormwater wetland and infrastructure cleaning and maintenance and operations as well as associated budgets • need for design guidelines for stormwater wetlands with defined regulatory requirements	

ITEM	ITEM DETAILS	ACTION BY AND DATE
	• clarification of differences in requirements for constructed wetlands and wet ponds e.g. signage • need for an integrated approach to stormwater management with respect to design and construction of wetlands, wet ponds, and forebays incorporating views from various departments e.g. from a maintenance point of view • the need to improve communication and information exchange between departments to enable identification of issues associated with specific stormwater wetlands prior to these sites being turned over to City • clarification of requirements for existing natural and constructed stormwater wetlands within annexed areas e.g. from the MD of Rockyview • the need to preserve open spaces within urban development and improve open space amenities around stormwater wetlands • need to define ways to amend wetlands that function as stormwater wetlands but no longer provide viable habitat for wildlife • define and improve wetland compensation management with respect to natural areas, accountability, liability • the need for a defined high level overview of the municipal approvals process • define design specifications of engineered wetlands and reporting requirements for development approvals	
2.	Jay White provided the participants with a project overview through a PowerPoint presentation. From the Terms of Reference – "The City of Calgary Parks and The City of Calgary Water Resources require the services of a consulting firm to research and develop a set of management procedures for the ongoing ecological design and maintenance of stormwater wetlands in Calgary." It was noted that Jay White co-wrote "Constructed Wetlands fro Water Quality Improvement: A Design Primer for the Development Industry, June 2004" with Dr. Angus Chu and Bernie Amell. Tim Burch updated the group on the progress of the database development portion of the project.	

ITEM	ITEM DETAILS	ACTION BY AND DATE
	It was noted that a key goal of this workshop is to identify some of the issues and concerns of City staff and incorporate them into the guidelines. Participants were asked to distribute themselves into one of two break-out groups to highlight concerns in one of two areas: 1. Design, Operations and maintenance from Parks perspective 2. Design, Construction, and Maintenance from Engineering/Infrastructure perspective	
3.	Break-Out Group 1: Parks, Natural Resources, Natural Areas, Parks Planning and Development Brainstorming session indicating sections participants would like to see in the Guidelines: • Life cycling: management and maintenance guidelines • Defined long-term maintenance schedules, responsibilities, financial obligations, liabilities and accountability • Clear requirements for sediment control and erosion control, water control functions (e.g. mechanics) including equipment for both operations and maintenance • Stormwater wetland design standards addressing functionality, slope requirements, open space amenity/design, practicality, the incorporation of natural (organic) design i.e. vs. manicured aesthetics, long-term viability and sustainability, ecological footprint • Clear delineation of PUL's vs. ER – with respect to compensation and maintenance responsibilities • Defined uses and intent of each stormwater wetland for long-term functionality indicating which use or function (i.e. as stormwater and natural wetland/habitat) prevails in management decisions • Defined monitoring schedules and components thereof, e.g. water quality, vegetation, identify standards e.g. total loadings etc. • Education	

MEETING RECORD

ITEM	ITEM DETAILS	ACTION BY AND DATE
4.	Break-Out Group 2: Water Resources, Urban Development, Water Services Brainstorming session indicating issues participants would like to see addressed in the Guidelines: • Developer to provide life cycle costs and acceptable maintenance plan • Integrated development approvals process - Requirements for pre-FAC developer clean out, schedule for department/proponent input (i.e. from Maintenance, Parks, Roads) during approval and planning stages, triggers for prolonging developer maintenance period (i.e. past 3 years) prior to FAC approval, enforcement or FAC holdback if not meeting criteria ,tools and criteria for Key Performance Indicators for forebay e.g. TSS, Size • FAC's should have an Inspections and design checklist – Maintenance …inspector should look at …x, y, z etc – Operations… inspector should look at …x, y, z etc – If x, y, z, then FAC gets issued • Ensure implementation of current stormwater guidelines, e.g. monitoring to ensure 85% TSS removal • Design guidelines which address ideal locations/sites (i.e. assess surrounding land-use) and maintenance plans (e.g. access, boat ramp, aeration systems) and criteria, separate access to forebay and wetland (e.g. ability to drain ponds and/or include bypass), toxic spill ERP • Amended guidelines for retrofits (e.g. space constraints) • Guidelines on erosion and sediment control in plan e.g. include silt fencing to reduce development impacts • Definitions: clarification of wetland vs. wet pond i.e. vegetation differences • Maintenance guidelines addressing nutrient inputs/algal bloom/odour complaints, design changes for nuisance concerns, garbage and sediment/silt/grit removal, forebays designed for maintenance, weed control/shoreline protection • Maintenance issues such as access to influent/inlet grit chambers and weir systems, sumps • Source control measures which address pre-input removals of BTEX	

ITEM	ITEM DETAILS	ACTION BY AND DATE
	- Ensure solution does not cause more problems i.e. 200 BMP's to maintain vs. 1 wetland	

5. General discussion points:

- We have failed where developers have filled ponds with sediment during construction
- Sediment management- is the killer
- Maintenance guidelines
- Natural areas vs. habitat vs. aesthetic green park
- Land use, manicured MR, PUL, PR
- Site by site- based on what was there first
- Dredging, how much?
- UDI- financial obligations up-front; must be dredged before released to community. Tie release conditions to erosion in ponds and control on site.
- Planning: PUL (storm ponds, limited strictly to functionality) VS. ER VS wetland (compensation) 5:1 slopes up to 3:1 grassed
- Gaps between concepts approved by parks and the detailed engineering (as-builts)
- Current practice now is wetlands for stormwater treatment, but should be wetlands after some pre-treatment body (forebay or other)
- Truck access/ maintenance access
- Best example: Priddis slough, water flows into a pond with volume and sediment control, then released to a wetland
- Education: Developers, contractors, maintenance staff, etc.
- Separate Guidelines for Design and for Maintenance
- Where you want wildlife/treatment wetland must be a larger footprint
- Wet pond with cattails planted is not a wetland.
- Developers using storm water ponds for wetland compensation, add cattails to "tart it up"

MEETING RECORD

ITEM	ITEM DETAILS	ACTION BY AND DATE
5.	General discussion points cont'd: • 36,000 catch basins, 14,000 ICD's • Concrete swales e.g. Silverado – who is supposed to maintain those? • Bridlewood sediment was removed this winter, it was not supposed to need cleaning for 20 years; 30 year clean-out frequency 15 or less actual • Cash prepayments being accepted without clean-out • Vac truck access: approval products/services;5:1 slope under normal conditions • Draining system to drain pond so you *can* clean it • Ring mats long reach hose • Twinning at 52 St between 90th and Glenmore…..access to chamber is in the middle of the 52 St. How do we get a bobcat into the chamber for cleaning? • Some sloughs have no designs or numbers on file! • Planning receives application, it passes it to Transportation/ Infrastructure/ Maintenance/Corporate Properties/Urban development/water services • ~ 10 ponds are built/approved per year • Learn from Fort Calgary retrofit problems • River 2D – AMEC fluid dynamics, short circuiting…tools/modelling • Outlet 2.5' above pond- pre-clean; now 4.5' above pond level • Coventry Hills – parking lot..gated! • Bridlewood – Forebay is undersized and short circuits…sediment curtain removed, is forebay shape functioning? Is outlet is too low? • Source controls. Enforcements. • Products e.g. CDS/Vortex – cleaning problems, skinny manhole for hydrocarbons	

ITEM	ITEM DETAILS	ACTION BY AND DATE
	• BMP/LID maintenance is 100X more difficult i.e. 1 pond or 300 BMP's • 400 weirs to clean (on outfalls)	
6.	Some ideas around wetland design: • Life cycling for maintenance and management: • Will turn into cattail marshes over time—how to compensate • No forebays on wetlands • Better ability for water level control • Long term management • Uses for irrigation? What about salts and SAR?	
7.	Other issues (within the City): • Staff turnover- secondments? • Joint reviews; disconnect between Parks and Water Resources planning • Stripping and grading issues • Standards for input into storm/ wetlands • Set performance measures for developers • Compensation wetlands • Fitting ponds in communities, varying slopes, trees, shrubs • Marry design guidelines between 2 departments • LID practices- need more of these ideas within these open space plans • Developers see MR as free PUL. Don't know how to design. Developers using MR as free PUL not knowing what that is. • Functions and values; Functional assessment tool - being assessed by Westhoff Engineering • Parks and water resources - need to work well together • Communications and education around sediment control (i.e. Yellow fish road program)	

ITEM	ITEM DETAILS	ACTION BY AND DATE
	• Marketing by developers: Wetlands are not urban lakes as described by developers – misconception; e.g. aerators • Garbage cans, space problems for City vehicles, need heavy equipment to have access e.g. B-3 outfall no way in or out, chain and padlocks • Parks MR around pond are not real MR so Parks don't want them PUL designation …not set rules for designation • MR and PUL Engineering drawings and parks drawings…who trumps? • Compensatory wetland – function as habitat and stormwater pond	
8.	Wrap-up discussion points: • Planning phase issues – sedimentation, access, algae, customer complaints, process deficiencies, communication between departments regarding development approvals, enforcement of guidelines, staffing, guidelines theoretical performance indicators need to be tested and calibrated to determine how it is actually performing • 6 wetlands assessments • Pilot project • MUSIC specific to stormwater BMP's and modelling calibration • Buy-in from the public • Increase community protection; guidelines that include conceptual design provisions for design; prescriptive guidelines or Key Performance Indicators • Sediment management, physical, cheap or vacuum dredge.15ft max • Monetary obligation of stormwater wetlands up front i.e. UDI • Forebay cleaning prior to release to City e.g. condo –type fee by community • Wetland vs. Wet pond Ownership of different portions of ponds by different departments • Larger facility take more Municipal Reserve or Environmental Reserve • Wetlands require 3-5 cm of accumulated organic matter	

ITEM	ITEM DETAILS	ACTION BY AND DATE
	• Hemi-marsh 50% water; 50% vegetation state…Cattail marsh …end state • Staff turnover/ secondment opportunities between department • Marrying design guidelines between departments. • What will wetland look like? What do we want it to look like? • Functional assessment tool • Educating public: Stormwater goes to wetlands, rivers, creeks	
	Summary of Staff & Stakeholder Questionnaire Responses (Attached)	

GUIDELINES FOR STORMWATER WETLANDS MANAGEMENT IN THE CITY OF CALGARY – STAFF QUESTIONNAIRE

Q1. In a few sentences what do you hope to gain from the Stormwater Wetlands Management Guidelines being developed?

Manual for implementation of guidelines; consistent approach for management specifically for Calgary climates; all parties work together during inspection/construction to reduce missed or duplicity of functions; cleaner and better maintained wetlands; defining roles and responsibilities between developers and consultants', define costs, functions, timelines, and liabilities; site specific flexibility.

Q2. What improvements could be made to the current approvals process for constructed wetlands within the City to both streamline and ensure the best quality outcome for design and construction?

Funding for maintenance and contract people; change pond design guidelines; clear roles and responsibilities of staff/consultants; define persons in charge of design/approvals; identify function/intent (dual or not i.e. habitat and stormwater treatment); update design standards and effective communication of all parties; distinguish between constructed and natural wetlands.

Q3. Do you think developers currently submit sufficient or too little information with applications for new wetlands? If too little, what additional information would be beneficial with applications?

Generally too little, each wetland and developer is different…information detail provided needs to be equal i.e. all developers held to same standard; general lack of management methodology and maintenance, construction, monitoring and funding source details

Q4. What changes / improvements could be made to the way current roles and responsibilities are shared between Parks and Water Resources Departments, and the way wetlands are currently being operated and maintained in the City?

Clarify responsibility and understanding of roles (i.e. from planning to maintenance); and document and share maintenance agreements, information of inspections and performance review; define pond vs. wetland differences.

Q5. What are some of the common design issues experienced with stormwater wetlands that the guidelines could address?

Maintenance access routes (pads for heavy equipment), weed harvesting, supplement water; plant type; post gates restricting vehicle access ; contours/side slopes; erosion/sediment control-who is responsible – timing, funding; visual quality; functionality; stormwater capacity; size/depth/shape; forebay design, short-circuiting, location of forebay and ponds.

Q6. What are some of the common construction issues with stormwater wetlands that the guidelines could address?

Erosion and sediment controls; silt skirts; tackifiers; track off dirt onto city streets; accessible cleaning chambers; access to ponds; algae/water movement; maintenance and warranty period, vegetation below HWL.

Q7. What are some common operations issues experienced with stormwater wetlands that the guidelines could address?

Access, maintenance, algae; better planning; manpower and equipment for cleaning; setback distances; boundaries; best practice measures; minimize sediment and erosion.

Q8. What are some common maintenance issues experienced with stormwater wetlands that the guidelines could address?

Sediment removal; landscape maintenance; monitoring; accountability/liability; disposal methods; erosion/sediment control; access.

Q9. What department do you work for?

Water Resources – 4; Parks Planning – 4; WS-Storm/Infrastructure Cleaning – 2

Q10. What design and maintenance elements would ease the transition of ownership and responsibility between the developer and the City?

Clean pond transition; sharing of cost/maintenance; continuity of engineers; planning/approval from one group; capacity of pond is at FAC; guidelines on specific elements to be gauged as acceptable.

Q11. Do you think developers should play a more active role in the funding and maintenance of wetlands over their full 'life cycle'? If yes, what are some ideas that might make this feasible?

Yes – for design and maintenance; depends on function; clarify roles/responsibilities; full life cycle; commitment of funding/manpower/accountability; wetland fee spread among community.

Q12. Are there any other issues or concerns with the current design, operation and maintenance of wetlands you would like to see addressed in the guidelines?

Include monitoring stations for efficiency and effectiveness; design modification; age progression; identifying maintenance requirements; design for more natural appearance; retention of functionality.

Please bring the completed questionnaire to the Workshop June 5, 2008.

Thanks

GUIDELINES FOR STORMWATER WETLANDS MANAGEMENT IN THE CITY OF CALGARY – STAKEHOLDERS QUESTIONNAIRE

Q1. What are some common obstacles experienced during the development approvals phase regarding stormwater management and proposed wetlands on a site?

Introduce more innovative ideas and creative solutions outside the current standards, BMP's

Q2. What improvements would you suggest could be made to the current approvals process for constructed wetlands within the City to streamline the process whilst maintaining best quality outcome for design and construction?

Collaborative approach between engineering and biological principles, with flexibility in incorporating effective technology.

Q3. Do you think developers currently submit sufficient or too little information with applications for new wetlands? If too much, what information do you consider to be onerous or insignificant to an application?

Sufficient, and should all be held to same standards.

Q4. What are some of the common design issues experienced with stormwater wetlands that the proposed guidelines could address?

Variability of side slopes, access for maintenance; 1 in 100 yr flood release into natural areas causing infrastructure damage, forebays.

Q5. What are some of the common construction issues with stormwater wetlands that the proposed guidelines could address?

Salvage and handling of wetland soils.

Q6. What are some common operations issues experienced with stormwater wetlands that the proposed guidelines could address?

City not following maintenance programs established by developers; monitoring species composition/water quality; defining staff responsibilities to manage wetland to ensure effective function, provide funding.

Q7. What are some common maintenance issues experienced with stormwater wetlands that the proposed guidelines could address?

Invasive species; maintaining species diversity, garbage, siltation, City to follow maintenance programs established by developers once wetland is turned over.

Q8. What design and maintenance elements would ease the transition of ownership and responsibility between the developer and the City?

No comment

Q9. Would checklists be of assistance to developers to clarify what is required for an application? Similarly would design checklists be of benefit to clarify requirements for design and construction?

Application checklists to help clarify information required; maintenance, monitoring, and funding checklists.

Q10. Do you think developers currently provide sufficient or too much funding for each wetland proposed/built within a subdivision? Do you think it be reasonable for the City to base funding on measured life cycle costs for a wetland?

Funding not sufficient for long term monitoring and maintenance. Funding should be based on life cycle costs.

Q11. Are there any other issues or concerns with the current approvals processes, design, operation and maintenance of wetlands you would like to see addressed in the guidelines?

Maintenance – Tasks need to be clarified and departments need to take ownership of tasks; Multi-functioning systems – i.e. design a system to purify water but also publicly accessible. Where conserving biodiversity is not the goal – possibly design sites for use as plant harvesting sites e.g. willows for other City bioengineering projects.

To have your comments considered, please forward the completed questionnaire to the City by no later than June 13, 2008.

Thankyou for your time.

Appendix 2 Supporting Documents on Local Stormwater Wetland Design and Management

Table A2 Documents for Local Information on Stormwater Wetland Design and Management

Author	Publication Date	Document	Summary
Alberta Environment	March, 2000	*Guidelines for the Approval and Design of Natural and Constructed Treatment Wetlands for Water Quality Improvement.*	Provides guidance on assessing feasibility of using natural and constructed water quality treatment wetlands
City of Calgary, (contracted to Westhoff Engineering Resources)	In process at time of guideline preparation	*The Functional Assessment Planning Tool*	Will address issues pertaining to compensation and mitigation.
The City of Calgary, Parks Department	2008	*Development Guidelines & Standard Specifications: Landscape Construction*	Provides Concept Planning Requirements at the Land Use Outline stage and CCC FAC requirements.
City of Calgary	DRAFT- April 2006	*Stormwater Best Management Practices*	Technical review/research of best management practises (BMPs) for Calgary
City of Calgary	Fall 2006	*ECO Plan*	Environmental Responsibilities for City Projects
City of Calgary	Fall 2006	*CPAG Conditions*	Development Conditions for subdivisions
City of Calgary	Fall 2006	*Approved Products lists*	Approved materials for stormwater and sanitary sewer (subdivisions and City Projects)
City of Calgary	Fall 2006	*Standard Specifications for Sewer Construction*	Materials and installation for storm and sanitary sewer (subdivisions and City Projects)
City of Calgary	September 2005	*Drainage Bylaw 37M2005*	Addresses the drainage of waste materials and contaminants into storm drainages
City of Calgary	2004	*Design Guidelines for Subdivision Servicing*	Storm, sanitary and drainage design for subdivisions

Author	Publication Date	Document	Summary
City of Calgary / Riparia Ltd.	May 2004	*Efficacy of a Constructed Wetland to Treat Urban Stormwater*	Results of experimental wetland treatment facility (Elbow Valley Constructed Wetland) on mass removal of nutrients and sediment. This document is also referenced in support of discussions on Stormwater Wetland design and maintenance.
City of Calgary	2003	*Open Space Plan*	Provides use of open space requirements in the City of Calgary.
City of Calgary / UDI	Annually	*Residential Development Agreement*	Residential Development Agreement conditions for subdivisions between City of Calgary and Urban Development Institute
City of Calgary		*Design Guidelines for Development Approval Process and Drainage and Site Servicing Plans*	Storm, sanitary and drainage design for subdivisions.
City of Calgary & Government of Alberta – Municipal Affairs	various	*Area Structure Plans*	Adopted by Council as a bylaw pursuant to the *Municipal Government Act* that provides a framework for future subdivisions, development, and other land use practices of an area, usually surrounding a lake.
City of Calgary & Government of Alberta – Municipal Affairs	various	*Municipal Development Plans*	The plan adopted by Council as a municipal development plan pursuant to the *Municipal Government Act*.
Government of Alberta – Alberta Water Council	2008 (draft)	*Alberta Wetland Policy*	Provides direction and a framework for protecting, conserving and restoring Alberta's wetlands.

Author	Publication Date	Document	Summary
Government of Alberta	2008 (draft)	*The Provincial Land-Use Policy*	Provides a vision and a framework for managing land use in Alberta and an overall direction for growth and development activities on Alberta's landscape.
Government of Alberta, Alberta Environment	January 2006	*Standards and Guidelines for Municipal Waterworks, Wastewater and Storm Drainage Systems*	Performance standards and design requirements in the province of Alberta
Government of Alberta – Environment & Sustainable Resource Development	2000	*Environmental Protection and Enhancement Act*	Management of storm water, contaminated sites, storage tanks, landfill management practices, hazardous waste management practices and enforcement
Government of Alberta – Tourism, Parks and Recreation	2000	*Provincial Parks Act & Wilderness Areas, Ecological Reserves, Natural Areas, and Heritage Rangelands Act*	Both Acts can be used to minimize the harmful effects of land use activities on water quality and aquatic resources in and adjacent to parks and other protected areas.
Government of Alberta – Alberta Environment	March 2000	*Guidelines for the Approval and Design of Natural and Constructed Treatment Wetlands*	Provides standardized guidelines for the approval of candidate treatment wetland sites and design guidance on natural and constructed wetlands for wastewater polishing.
Government of Alberta – Alberta Environmental Protection	January 1999	*Stormwater Management Guidelines for the Province of Alberta*	They outline the objectives of stormwater management and the available methodologies and concepts for the planning, design, and operation of stormwater drainage systems.
Government of Alberta – Alberta Environmental Protection	1996	*Water Act*	Governs the diversion, allocation and use of water. Regulates and enforces actions that affect water and water use management, the aquatic environment, fish habitat protection practices and in-stream construction practices

Author	Publication Date	Document	Summary
Government of Alberta – Municipal Affairs	1994	*Municipal Government Act*	Provides municipalities with authorities to regulate water on municipal lands, management of private land to control non-point sources, and authority to ensure that land use practices are compatible with the protection of aquatic environment.
Government of Alberta – Sustainable Resource Development	1984	*Wildlife Act*	Regulates and enforces on protection of wetland-dependent and wetland-associated wildlife, and endangered species (including plants)
Government of Alberta – Sustainable Resource Development	1980	*Public Lands Act*	Regulates and enforces on activities that affect Crown-owned beds and shores of water bodies and some Crown-owned uplands that may affect nearby water bodies.
Government of Canada – Fisheries and Oceans	1985	*Fisheries Act*	Regulates and enforces on harmful alteration, disruption and destruction of fish habitat in Section 35.

Appendix 3 Design and Approvals Process

Appendix 3
Overview of the Planning, Design and Approvals Process for Development of Stormwater Wetlands within the City of Calgary

Planning Phase	Task	Initiated By	Completed By	Submitted Plans / Reports, Checklists, Forms & Schedules	Coordination	Notes
Pre-development City Planning	Perform Environmental Significance Assessment	P			Concurrent with Community Plan in conjunction with the Habitat and Environmental Significance Assessment of all Natural Areas.	Performed by the City for all Wetlands to determine whether they are Environmentally Significant (ES), using the Stewart and Kantrud Wetland Classification System.
	Stormwater Management and Municipal Land Use Planning	A / UD	UD / P / WS / AENV / SRD / DFO / EC / CAA	Watershed Plans (WP); Master Drainage Plans (MDP); Area Structure Plans (ASP) or Community Plans (CP); Land Use/Outline Plans (OP); and Staged Master Drainage Plans (SMDP).	Developed by the City or developer / consultants in conjunction with Province. Application submitted to AENV / ASRD and pertinent Federal Authorities as required.	Generally prepared in advance of new development occurring in accordance with timeframes set by City, except where developer proposes to develop prior and prepares plans on City's behalf to support wetland / development application.
Preliminary Planning & Design Intent	Initial Communication with City	A	UD / P / WS	Possible written communication.		Written or verbal request for a meeting with City to discuss new proposal.
	Meeting between developer / consultants and City to discuss proposal and Submission Requirements	A	UD / P / WS		Involve all stakeholders / departments associated with the review and approval processes to ensure all requirements and objectives are considered.	Purpose and objective: to discuss viability of proposal and determine submission requirements for application and BIA, if required. If BIA exists for larger development site determine if additional information is required.
	Prepare and Submit Biophysical Impact Assessment	A	UD → P / WS / AENV	BIA (if required).	In collaboration with P & WR to ensure mutual objectives are considered. Stormwater Wetlands require AENV review and approval of BIA. Submission of BIA required prior to or in conjunction with MDP or SMDP report.	Following positive outcome from meeting, if required BIA undertaken by developer's consultants to determine baseline characteristics and the potential impacts of development on biophysical elements to successfully integrate stormwater management within planning area. The BIA is typically a stand-alone report. A Wetland Functional Assessment will also be required at this stage if natural wetlands exist on site.

Planning Phase	Task	Initiated By	Completed By	Submitted Plans / Reports, Checklists, Forms & Schedules	Coordination	Notes
	Prepare and Submit Design Intent and Objectives	A	UD → P / WS	Report Summarizing Design Intent and Objectives.		Most Critical Step in Design and Planning Process - governs the design. Define Intent should address: Stormwater Management (Quality and Quantity Performance) Objectives; Ecological (Function and Habitat) Objectives; and Amenity Objectives.
	Review, Revise & Approve Design Intent and Objectives	A ↔ P / WS	UD → A		To be undertaken in collaboration with P & WR to ensure a balance of objectives are considered.	Review / Revise Process in consultation with A to address deficiencies and satisfy City requirements.
Conceptual Planning & Design	Prepare and Submit Conceptual Planning and Design	A	UD → P / WS / UD / R / AENV / SRD / DFO	Wetland Landscape Plans, Wetland Report-refer Checklist for Master Drainage Plans, Staged Master Drainage Plans and Pond Reports (Appendix 4).	Application / Plans submitted (by CP) to AENV / ASRD and pertinent Federal Authorities for review and approval (as required).	Concept should address design intent and objectives identified in preliminary planning phase; and describe major attributes (e.g. size, flora / fauna, habitat, layout, inlet / outlet, operating philosophy, etc.) of the Stormwater Wetland. A pond report may be either a stand alone report or, if required, be included as part of a MDP / SMDP report.
	Review & Revise Conceptual Design	P / WS / UD / R / AENV / SRD / DFO ↔ A	P / WS / UD / R / AENV / SRD / DFO	Revised Conceptual Design Plans.	Imperative review process seeks feedback from all stakeholder involved in the design, operation and maintenance of the Stormwater Wetland and provides opportunity to ensure objectives are being met.	Review / Revise Process in consultation with A to address deficiencies and satisfy City / External Authority requirements. Design to comply with all relevant existing plans, policies, guidelines, requirements, Stormwater Wetland design intent and objectives and address outcomes of the BIA.
	Approve Conceptual Planning and Design	CPAG	CPC → A	Approved Conceptual Design Plans. Issued Letter of Authorization and Conditions of Consent.	Application to be determined only after resolution of the review / revision process by all stakeholders.	Report and Condition of Approval prepared by the CPAG recommending approval / refusal of application. Report presented to CPC for review and revision. CPC provides proposed Conditions of Consent.
Detailed Design	Prepare and Submit Detail Design Drawings	A	UD → P / WS / UD / R / AENV / SRD / DFO	Detail Design Drawings and Plans including specifications and associated information: grading, structural details and landscape / planting details. Wetland Operating and Maintenance Plan (Draft).	Application / Plans submitted (by CP) to AENV / ASRD and pertinent Federal Authorities review and approval (as required).	Details concept design and satisfies Conditions of Consent approved by CPC. Focuses on refining the conceptual design and developing a set of detailed design drawings that specify how the wetland will be constructed. A Wetland Operating and Maintenance Plan (Draft) should be submitted prior to the issue of CCC and address operation and maintenance requirements.
	Review & Revise Detail Design Plans	P / WS / UD / R / AENV / SRD / DFO ↔ A	P / WS / UD / R / AENV / SRD / DFO	Revised Detail Design Drawings and Plans. Revised Wetland Operating and Maintenance Plan (Draft).	Imperative review process seeks feedback from all stakeholders involved in the design, operation and maintenance of the wetland and provides l opportunity to ensure objectives are being met.	Review / Revise Process in consultation with A to address deficiencies and satisfy City / External Authority Requirements. Design to comply with all relevant existing plans, policies, guidelines, requirements and the approved Conceptual Design Plans and Conditions of Consent.

Planning Phase	Task	Initiated By	Completed By	Submitted Plans / Reports, Checklists, Forms & Schedules	Coordination	Notes
	Approve Detail Design	P / WS / UD / R	UD / P / R / WS → A / LIM	Approved Detail Design Drawings and Plans. Approved Wetland Operating and Maintenance Plan (Draft).		Detail Design Drawings and Plans approved following resolution of issues / deficiencies by all City and External Authority Departments. Approved set of plans issued to A & LIM.
	Issue Permission to Construct and Enter Wetland Information in to City Inventory	A	UD / LIM	Issued Permission to Construct.	UD or City Project Manager ensures all Approvals are in place.	Once formal approval received from External Authorities Approval to Construct is Issued. Wetland information entered into the ponds / wetlands inventory along with proposed construction start date.
Construction	Construction Planning	A	U / P / WS	Contractor Environmental Acknowledgement Form (Appendix 4).	To be undertaken in consultation with P & WR to ensure mutual objectives are considered.	Plan manner in which work will be conducted including; phasing, timing, erosion and sediment controls and re-use of excavated spoil. Components of the construction planning will be included with the detailed design materials.
	Conduct Site Inspections throughout Construction	A (designer) / P / WS	A (designer) / P / WS	Parks Construction Inspection Checklists and Schedule (Refer Appendix 4). Revised Construction Plans (if required) based on Construction Inspections.	A to coordinate with P for inspections at 5 critical stages: Construction Start-up, Sub-grade, Tree and Shrub Planting, Irrigation and Finish Grade.	Ensure being built per Approved Design Drawings. Address deficiencies; and modify design and construction activities (as required). Ensure erosion and sediment controls measures are in place and adequate, and construction is being undertaken having consideration for the Public and environment, and is in accordance with City policy and procedures.
	Prepare and Submit Application for CCC including As-Built Drawings	A (designer)	UD → P / WS	As-Built Drawings. Parks Construction Inspection Checklist (refer Appendix 4). Water Services Wet Pond / Wetland Inspection Checklist (refer Appendix 4),Pond As-Built Drawings.		As-Built Plans should provide an accurate record of what has been constructed
	Conduct Preliminary CCC inspection	A ↔ P / WS	P / WS	Parks Construction Inspection Checklist (refer Appendix 4). Water Services Wet Pond / Wetland Inspection Checklist (refer Appendix 4).	Should be conducted by P and WR together to ensure synergy and quality outcomes for all stakeholders.	Identify deficiencies based on checklists and observations that need to be addressed prior to issue of CCC. Inspections to be undertaken by staff appropriately trained and qualified.
	Address deficiencies from preliminary CCC inspection and revise As-Built Drawings	A / A (designer) ↔ P / WS	UD / P / WS	Revise As-Built Drawings Parks Construction Inspection Checklist (refer Appendix 4), Water Services Wet Pond / Wetland Inspection Checklist (refer Appendix 4),Pond As-Built Drawings	Should be reviewed by both P and WR to ensure synergy and all objectives are satisfied.	Review / Revise Process required to ensure As-Built Drawings are accurate.

Planning Phase	Task	Initiated By	Completed By	Submitted Plans / Reports, Checklists, Forms & Schedules	Coordination	Notes
	Conduct Final CCC Inspection and Issue CCC	A ↔ FAC Pond Group	UD / FAC Pond Group	Approved As-Built Drawings Parks Construction Inspection Checklist (refer Appendix 4) Water Services Wet Pond / Wetland Inspection Checklist and CCC Checklist (refer Appendix 4) Approved Wetland Operating and Maintenance Plan (Final)	Should be performed by P, WR and other pertinent stakeholder together to ensure synergy and quality outcomes. CCC issued by P and WR based on inspection satisfactory inspection results.	Ensure all deficiencies have been addressed, and As-built Plans provide an accurate representation of the Stormwater Wetland constructed. Ensure all electrical and phone line equipment are working and functioning monitoring system is confirmed with Bonnybrook. Ensure all Conditions of Consent approved by CPC have been satisfied. Circulate Approved As-Built Drawings to LIM.
Operation & Maintenance	Manage and Operate wetland (3 years post CCC)	A	A	Approved Wetland Operating and Maintenance Plan (Final)		Operation and Maintenance of the Wetland should be undertaken in accordance with the Wetland Operating and Maintenance Plan approved during detail design and finalized following construction. This plan includes monitoring requirements to demonstrate the wetland is performing as intended.
	Prepare and Submit Application for FAC including submission of a Stormwater Wetland Maintenance and Operations Report	A	UD → P / WS	Stormwater Wetland Maintenance and Operations Report		Following expiration of the 3-year Maintenance period, developer can submit an application for FAC. Must have prepared a report summarizing operation, maintenance and monitoring over the three year period.
	Conduct Preliminary FAC inspection	A ↔ FAC Pond Group	P / WS	Parks Final Acceptance Inspection Checklist (refer Appendix 4), Water Services Final Acceptance Wet Pond / Wetland Inspection Checklist (refer Appendix 4),	Should be conducted by P and WR together to ensure synergy and quality outcomes for all stakeholders.	Determine if wetland is functioning as per design objectives and performance criteria. Assess if alterations required. Inspections to be undertaken by staff appropriately trained and qualified.

Planning Phase	Task	Initiated By	Completed By	Submitted Plans / Reports, Checklists, Forms & Schedules	Coordination	Notes
	Address deficiencies from preliminary FAC inspection and Stormwater Wetland Maintenance and Operations Report	A ↔ P / WS	UD / P / WS	Revised Stormwater Wetland Maintenance and Operations Report Parks Final Acceptance Inspection Checklist (refer Appendix 4), Water Services Final Acceptance Wet Pond / Wetland Inspection Checklist (refer Appendix 4),	Should be reviewed by both P and WR to ensure synergy and all objectives are satisfied.	Review monitoring results to ensure adequate, or determine what additional monitoring / design changes required prior to issue of FAC.
	Conduct Final FAC Inspection & Issue FAC	A ↔ FAC Pond Group	UD / FAC Pond Group	Revised Stormwater Wetland Maintenance and Operations Report Parks Final Acceptance Inspection Checklist (refer Appendix 4), Water Services Final Acceptance Wet Pond / Wetland Inspection Checklist (refer Appendix 4),	Should be conducted by P, WR and all other stakeholder together to ensure synergy and quality outcomes. FAC issued by P and WR based on inspection satisfactory inspection and monitoring results.	Ensure all electrical and phone line equipment are working and functioning monitoring system is confirmed with Bonnybrook.

NOTES:

CITY DEPARTMENTS AND DIVISIONS

CPAG = Calgary Planning & Advisory Group
CPC – Calgary Planning Commission
FS – Field Services
DA – Development Approvals
ID – Infrastructure Delivery
LIM – Land Information and Mapping
P – Parks
R – Roads
WS – Water Services
UD – Urban Development

DOCUMENTS

BIA – Biophysical Impact Assessment
CCC – Construction Completion Certificate
EPEA – Environmental Protection & Enhancement Act
FAC – Final Acceptance Certificate
MDP – Master Drainage Plan
SMDM – Stormwater Management and Design Manual
SMDP – Staged Master Drainage Plan
SMR – Stormwater Management Report
WP – Watershed Plan

GENERAL

A – Applicant (Developers/Consultants or City Projects)
AENV – Alberta Environment
ASRD – Alberta Sustainable Resource Development
CAA – Calgary Airport Authority
ER – Environmental Reserve
ESA – Environmentally Significant Area
MR – Municipal Reserve
PUL – Public Utility Lot
WQ – Water Quality
SWMF – Stormwater Management Facility

Appendix 4 Existing City Checklists, Forms and Schedules

Checklist #1
Wastewater Development Approvals

Master Drainage Plan;
Staged Master Drainage Plan; and
Pond Report

The City of Calgary
Wastewater Development Approvals

Checklist for
- Master Drainage Plan,
- Staged Master Drainage Plan and
- Pond Report

Project: _____

Developer: _____

YES	NO	N/A	
☐	☐	☐	1. Checklist items marked as "NO" or "N/A" are explained in the comment section.
☐	☐	☐	2. Submit six copies of report that are signed and include the Professional Engineer's stamp and the company's permit number.
☐	☐	☐	3. Cover letter highlights any unresolved issues or areas where guidelines cannot be met.
☐	☐	☐	4. Include Outline Plan Number.
☐	☐	☐	5. Include plastic sleeve behind title page for future correspondence.
☐	☐	☐	6. State design objectives.
☐	☐	☐	7. Identify Watershed, Master / Staged Master or any other drainage plans appropriate to submission.
☐	☐	☐	8. Identify Biophysical Impact Assessment and Biophysical Inventory reports appropriate to submission and discuss any items that have to be addressed prior to report approval.
☐	☐	☐	9. Explicitly state that all details conform to the City of Calgary Standard Specifications and Stormwater Management Design Manual, or explicitly state items that have to be addressed prior to report approval.
☐	☐	☐	10. Study Area and Location sketches include overall site description and show location, section number and major roadways. It is best to include two figures: one showing the location of the area with respect to the City of Calgary, and the other showing the study area and surrounding master/staged master plans including those not in control of the developer.
☐	☐	☐	11. Include drawing showing catchment and subcatchment area boundaries on preferably 11" x 17" size paper.
☐	☐	☐	12. Site description includes legal land location and area in hectares.
☐	☐	☐	13. Explicitly state all overland flows crossing boundary limits and their locations with references to related reports.
☐	☐	☐	14. Boundaries match those of existing reports, or supplemental information is included to rationalize the changes.
☐	☐	☐	15. State the permitted release rate (L/s/ha) for minor system and stormwater ponds.
☐	☐	☐	16. Identify approximate trunk sizes and alignment, servicing routes and overland drainage routes.
☐	☐	☐	17. Identify receiving water body and outfall.
☐	☐	☐	18. Any increase in flow offsite has been reviewed for the impact on affected downstream works.
☐	☐	☐	19. Include brief description of computer model, methodology, design storm parameters, and computer input parameters.
☐	☐	☐	20. Include schematic that matches the submitted drawings and computer model.
☐	☐	☐	21. Attach computer model input and output files including continuous and single event simulation for stormwater storage requirements.
☐	☐	☐	22. Master or Staged Master Drainage Plan delineates drainage basin beyond plan limit if appropriate.

(Over)

The City of Calgary
Wastewater Development Approvals

Checklist for
- Master Drainage Plan,
- Staged Master Drainage Plans and
- Pond Report

YES	NO	N/A	
☐	☐	☐	23. Identify and locate stormwater ponds or other Best Management Practices within study area.
☐	☐	☐	24 All stormwater management facilities are entirely located within developers property limits or offsite details are provided.
☐	☐	☐	25. Explicitly state the developer controls the land that offsite facilities occupy or statement of agreement with affected stakeholders is enclosed.
☐	☐	☐	26. State if pond report will follow.
☐	☐	☐	27. Address water quality issues/improvements.
☐	☐	☐	28. Include completed Alberta Environment 'Application Checklist for Storm Drainage Treatment Facilities within the City of Calgary'.
☐	☐	☐	29. All plans and engineering drawings submitted include quarter section lines and street names. Pertinent information on the plans uses legible font sizes.
☐	☐	☐	30. Include a digital copy of the drawing displaying catchment and subcatchment area boundaries in .dxf format with report.

Comments:

I, the undersigned, have reviewed the Stormwater Reports Checklist.

Signature of Report Author	Name (Please Print)	Date

Checklist #2
Water Resources Construction Completion Certificate

THE CITY OF CALGARY
WATER RESOURCES

Infrastructure Planning, Development Approvals
Pond As-Built Requirements for
CONSTRUCTION COMPLETION CERTIFICATE

Pond: _____

Developer: _____

YES	NO	N/A	
☐	☐	☐	1. Checklist items marked as "NO" or "N/A" are explained in the comment section.
☐	☐	☐	2. Submit one complete Check-set of labeled pond as-built drawings to Infrastructure Planning, Development Approvals.
☐	☐	☐	3. Cover letter highlights any unresolved issues or areas where the approved design was not met and includes the following: • Development Agreement Number • Pond Report, Staged Master Drainage Plan, or Stormwater Design Report Title associated with the pond • Alberta Environment Approval Number and Pond ID Number (supplied by Development Approvals once Letter of Authorization is issued by Alberta Environment)
☐	☐	☐	4. As-built conditions for the following items are shown (and labeled) on the Check-set drawings as per the approved design and meet City of Calgary Sewer Construction Standard Specifications and Stormwater Management Design Manual Guidelines: • Pond Signage • Maintenance Vehicle Access • Monitoring Equipment (location and type) • Pond Volume • Pond Contours and grading showing bottom, PWL, HWL, and FB elevations where applicable • Pond Depth • Side Slopes • Sediment Forebay • Inlet Details • Rim, Gratings, Orifice, Trash Rack, and Gate Valve • Outlet Control Structure Details • Piping Information (inverts, size, type, length, and slope) and block profiles where applicable • Pond Discharge Rates (Provide as-built Stage-Storage-Discharge Table) • Overland Escape Route (location and spill elevation)
☐	☐	☐	5. Check-set drawings include complete as-built cross-sections of final grades for the entire pond. Please note that City of Calgary Digital Aerial Survey mapping is not considered complete as-built information.
☐	☐	☐	6. As-built block profiles for sections upstream of the pond inlet and downstream of the outlet structure are submitted to Land Information Mapping Utility Records Coordinator.
☐	☐	☐	7. All drawings submitted (including block profiles where applicable) are as per the approved design and meet guidelines as noted in the Standard Block Profile Specification for CAD and Manual Format. The following items are also provided: • Co-ordinates NAD 83 (sea level) or dimensions required for structures, manholes, outfalls etc. • Consistency between repeated information between drawings. (e.g. as-built inverts have been updated correctly on all drawings)
☐	☐	☐	8. Upon approval of the Check-set, a letter will be sent to the Consultant for approval notification and advising that complete mylars and digital files are to be submitted to the Pond Engineering Graphic Technologist in Land and Information Mapping, Infrastructure Info, Wastewater Drafting.

(Over)

THE CITY OF CALGARY
WATER RESOURCES

Infrastructure Planning, Development Approvals
Pond As-Built Requirements for
CONSTRUCTION COMPLETION CERTIFICATE

YES NO N/A

☐ ☐ ☐ 9. One digital copy (CD) and one hard copy of the Operations & Maintenance Manual is submitted to Development Approvals and includes the following information for any, special equipment and non-standard components or features installed at the pond: (Note: Manuals are not to be left in the pond monitoring cabinet)

- Manuals that come with any, special equipment and non-standard components or features installed at the pond.
- If there are any valves, weirs, chambers etc. that have adjustable components there should be manufacturer's literature on the components and the operation of the unit
- Control logic for the pond (e.g. Note information if the pond operates as a surcharge or by-pass pond)
- Note any special actions required by maintenance crews for any, special equipment and non-standard components or features installed at the pond (e.g. if the pond has an under drainage system and clean-outs, information on how the under drainage system is to be maintained or cleaned should be included in the manual)
- If there is any special equipment and non-standard components or features at the pond that needs to be operated, cleaned, reset, controlled, or replaced, specify the purpose of the component and note maintenance & operations procedures for it
- Include Interim and Ultimate scenarios of pond operation where applicable

☐ ☐ ☐ 10. Acknowledge that a Maintenance Record* will be kept for any special equipment and non-standard components or features at the Pond during maintenance period and will be submitted to Development Approvals as part of conditions for Final Acceptance Certificate** release.
*Contact Field Services Systems Maintenance for more information on requirements for the Maintenance Record.
** Refer to FAC Checklists for detailed items.

Comments:

I, the undersigned, have reviewed the Pond As-Builts Checklist.

Signature	Name and Company (Please Print)	Date

Checklist #3
Water Resources Wet Pond/Wetland Inspection (Sheets 5-8)

WET POND/ WETLAND INSPECTION CHECK SHEET (Last Updated July 2007)

Pond ID/ Name: _____ C.C.C. Issue Date: _____
Developer/Consultant: _____ F.A.C. Issue Date: _____

Item	Description	C.C.C.				F.A.C.			
		Acc.	N/A	Init	Date	Acc.	N/A	Init	Date
1.	**Grading.**								
	· as-built cross sections of final grade submitted (1ABDR/ 2VIO,N/A)						✓		
	· side slopes (see requirements) (1ABDR/ 2VIO, N/A)						✓		
	· design volume (1ABDR/ 2VIO,N/A)						✓		
	· no signs of erosion around the pond (2, 2)								
	· overland escape route/spillway as per construction drawing. Spillway in proper location at proper elevation (1ABDR/ 2VIO,N/A)						✓		
	· sediment forebay(s) properly constructed (1/2, N/A)						✓		
2.	**Inlet/Outlet Structure. (to be checked prior to water being introduced)**						✓		
	· invert of grating(s) if required (1ABDR/ 2VIO, N/A)								
	· invert of incoming/outgoing pipe (1ABDR/ 2VIO, N/A)						✓		
	· gratings bolted down or secured if required (2, 2)								
	· no signs of erosion (2, 2)								
	· little or no build-up of silt or debris (2, 2)								
	· no damage (cracking, honeycombing, spalling) (2, 2)								
3.	**Control Structure.**								
	· rim and invert elevations (1ABDR/ 2VIO, N/A)						✓		
	· little or no build-up of silt or debris (2, 2)								
	· no damage to structure (cracking, honeycombing, spalling) (2, 2)								
	· **gate valve** - valve works properly (easily engaged) (2, 2)								
	- valve face seals properly (2, 2)								
	- automatic control gate(s) setup & working properly where applicable (3/ SP, 3/ SP)								
	· **trash rack** - trash rack removable and easily cleaned (2, 2)								
	- trash rack free of debris (2, 2)								
	· **weir wall** - elevation of top of weir wall (1ABDR/ 2VIO, N/A)						✓		
	- size of opening (1/2, N/A)						✓		
	· **orifice** - centerline or invert elevation (1ABDR/ 2VIO, N/A)						✓		
	- dimensions of orifice (slot size, diameter) (1/2, N/A)						✓		
	- orifice plate fits snugly to wall to minimize leakage around the plate (2, 2)								

Item	Description	C.C.C.				F.A.C.			
		Acc.	N/A	Init	Date	Acc.	N/A	Init	Date
4.	**Storm Pipe System.**						✓		
	· invert elevations (1ABDR/ 2VIO, N/A)								
	· upstream piping fitted with rubber gasket (1/2,N/A)						✓		
	· storm manholes designed with bolt-down covers properly installed (2, N/A)						✓		
	· free of silt and debris (2, 2)								
5.	**Sanitary Pipe System.**								
	· no sanitary sewer manholes are permitted within the pond (2, N/A)						✓		
6.	**Monitoring System.**								
	· all level/alarm sensors are easily and safely accessible (3, 3)								
	· all sensors/alarms installed at proper elevations (3, 3)								
	· approved service provider must ensure: – alarm conditions ring through to E.E.C.C. at Bonnybrook. Requires alarm sensors programmed to alarm at specified elevations. A calibration certificate is required and a schematic of the inside of the structure from service provider (3/SP, 3/SP)								
	· doors on electrical control box close and seal properly (3, 3)								
	· electrical control box in good condition. No signs of rusting or damage (3, 3)								
	· landscaping slopes away from electrical control box (2/3, 2/3)								
	· all conduit into electrical control box sealed to prevent infiltration of water and/or humidity (3, 3)								
	· all electrical equipment (fans, heaters) works properly and has been properly installed (3, 3)								
	· electrical control box with WWD “construction” lock (2/3, 2/3)								
	· datalogger recording properly. Phone number(s) supplied (3, 3)								
7.	**Signs.**								
	· approved signs placed at entrances to ponds as per design. No damage to signs (2, 2)								
8.	**Miscellaneous.**								
	· **ramp** – 4m wide (min.) gravelled or paved ramp (or equivalent) from adjacent street or lane provided for emergency or maintenance access. Pathways or gravelled road to control structure provided for maintenance purposes (1/2/3, 1/2/3)								
	· **access road** – no signs or cracking or heaving (2, 2)								
	· final as-built construction drawings submitted in mylar material after a set of print drawings has been checked and approved (N/A, 2/1)		✓						
9.	**Landscaping and Irrigation.**								
	· inspection by Parks to Landscape Construction Standard Specification & approved drawings (PDO, PDO)		✓				✓		
	· all vegetation & landscaping must be healthy (PDO/2, PDO/2)								

Item	Description	C.C.C.				F.A.C.			
		Acc.	N/A	Init	Date	Acc.	N/A	Init	Date
10.	**Maintenance Requirements.**								
	· Maintenance Manual is provided (Refer to CCC Requirements from Development Approvals) (1/ 3, 1/ 3)		✓						
	· Maintenance Records are provided (Refer to FAC Requirements Checklist from Development Approvals) (N/A, 1/ 3)								
	· Maintenance period met for F.A.C. (N/A, 2)		✓						
11.	**Accounting Requirements.**								
	· Copy of F.A.C. submitted to Systems Maintenance (N/A, 3)		✓						
	· telephone and utility accounts changed to Water Recources (N/A, 3)		✓						

Contacts

Design & Datalogger: Water Resources, Infrastructure Planning, Development Approvals[1]

Inspection: Water Resources, Infrastructure Delivery, Subdivision Inspections[2]

Electrical/Monitoring: Water Resources, Field Services, Systems Maintenance[3]

Designations:

(1/3,2)	C.C.C. Inspection done by group 1 and group 3, F.A.C. Inspection done by group 2 (groups are identified above)
PDI	Parks Development Inspector
SP	Approved service provider for monitoring system
ABDR	As-Builts Drawings Review
VIO	Visual Inspection Only
N/A	Not Applicable

Comments

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_____

_____

Checklist for Electrical Inspection (Last Updated July 2007)

Pond ID/ Name: _____ C.C.C. Issue Date: _____
Developer/Consultant: _____ F.A.C. Issue Date: _____

Item	Description	C.C.C.				F.A.C.			
		Acc.	N/A	Init	Date	Acc.	N/A	Init	Date
1.	**Monitoring System.**								
	· all level/alarm sensors are easily and safely accessible								
	· all sensors/alarms installed at proper elevations								
	· doors on electrical control box close/seal properly								
	· electrical control box in good condition. No signs of rusting or damage								
	· landscaping slopes away from electrical control box								
	· all conduit into electrical control box sealed to prevent infiltration of water and/or humidity								
	· all electrical equipment (fans, heater) works properly and has been properly installed.								
	· electrical control box locked with Water Services “construction” lock								
	· pond water level data is connected to the system								

Contacts

Design & Datalogger: Water Resources, Infrastructure Planning, Development Approvals[1]

Inspection: Water Resources, Infrastructure Delivery, Subdivision Inspections[2]

Electrical/Monitoring: Water Resources, Field Services, Systems Maintenance[3]

Electrical/ Monitoring: Water Resources, Infrastructure Planning, Planning & Analysis[4]

Comments

_____
_____
_____
_____
_____
_____
_____

Checklist #4
Parks Construction Inspection

1. Construction Inspection Checklist

Construction Inspection Checklist

& C.C.C. Report

Community		Subdivision	Report #
			Plan Block Lot
Description	Phase	Developer	
			Development Agreement #
Legal/Municipal Address			
Consultant	Contact Person		Phone
Contractor	Contact Person		Phone
C.C.C. Application Received ___ Yes ___ No			Date YYYY MM DD | | | |

	Work Inspected	Approved Yes	Approved No	Date YY/MM/DD	Parks Ins.	Dev. Rep.	Def. Cor.	Comments & Notes
A.	**Inspection # 1**							
	Approved Plans, Letter							
	Line Assignment							
	Layout P.L. Stakes							
	Erosion/Sediment Controls							
B	**Inspection # 2**							
	Approved Plans & Letter							
	Survey Stakes - Grades							
	Subgrade Preparation							
	Irrigation Layout							
	Plumbing Permit							
	Layout, pathways, trees, furniture							
	Sports Fields, Playgrounds etc.							
C	**Inspection #3**							
	Approved Plans & Letter							
	Topsoil Test as per specification							
	Tree/Shrub Pits							
D.	**Inspection #4**							
	Approved Plans & Letter							
	Trees & Shrubs as per Drawing							
	Meter Received By Contractor	Tag #			Serial #			
	Open Trench Inspection							
	Trees Planted at Specified Grade							
	Rootball, Caliper Standards Met							
	C.N.L.A. Specifications Met							
	Insect/Disease/Damage Free							
	Tree Setback Spacing							
E	**Inspection #5**							
	Approved Plans & Letter							
	Finish Grade to Plan & Spec.							
	Topsoil & Finished Grade to Pre-existing Native Profile & Pre-Development Drainage Patterns & Rates							
	Seeding/Sodding							
	Burlap Straps Wires Removed/Rolled Back							
	Amenities to Plan & Spec.							
	Playgrounds to Plan & Spec							
	Certificate of Compliance Letter							
	Asphalt Pathway to Plan & Spec							
	Asphalt Compaction/Density Reports							
	Two Copies Irrigation As Builts							
	Annual DCV Report							

General Comments & Prior to F.A.C. Conditions

Is there non-engineered fill on this site? Yes No If yes, see attached Non-Engineered Fill Drawing

		Print Name	Signature
☐ No Deficiencies Noted	Developers Rep.		
Report Distribution			
☐ Developers Representative	Park Inspector		
	Inspection Date		
☐ Design & Development File	Application Expiry Date		

Checklist #5
Water Resources Final Acceptance Certificate

THE CITY OF CALGARY
WATER RESOURCES

Infrastructure Planning, Development Approvals
Pond Requirements for
FINAL ACCEPTANCE CERTIFICATE

Pond: _____

Developer: _____

YES	NO	N/A	
☐	☐	☐	1. Checklist items marked as "NO" or "N/A" are explained in the comment section.
☐	☐	☐	2. Submit one Check-set of final updated pond as-built drawings to Infrastructure Planning Development Approvals, to illustrate that the pond is functioning as designed and approved. Drawings indicate engineering survey information and show complete as-built cross-sections of the pond. If there is sediment build up, pond has been cleaned to maintain quality and capacity.
☐	☐	☐	3. Cover letter highlights any unresolved issues or areas where the approved design was not met and includes the following: • Development Agreement Number • Pond Report, Staged Master Drainage Plan, or Stormwater Design Report Title associated with the pond • Alberta Environment Approval Number and Pond ID Number (supplied by Development Approvals once Letter of Authorization is issued by Alberta Environment) • Pond Construction Completion Certificate (CCC) Release Date • Maintenance Period Duration
☐	☐	☐	4. Submit Maintenance Records (hard copy and digital) to Development Approvals and include the following (contact Development Approvals if this item cannot be met): • A plan for scheduled maintenance of the pond. • Date and time of routine inspections of the pond, and any actions initiated from the inspection (removal of debris, shopping carts, bicycles, etc.). • Date and time of all water quality actions (algae treatments, aquatic weed control, etc.) Include information on products (provide trade names and quantities) and/or processes (e.g. weed cutting) and observations as to its effectiveness. • Date, time, and the reason for so doing for any changes to hydraulic controls (gate elevations, weir elevations, permanent water level, etc.). • Date, time, and the reason for so doing for maintenance to mechanical, electrical, or electronic equipment. • Date and time of response to public concerns. The record shall include a record of all complaints to the developer detailing, name, contact information, nature of the complaint, action (including is no action was required) taken by the developer to resolve the complaint, results of the actions taken.
☐	☐	☐	5. Upon approval of the FAC as-builts Check-set and Maintenance Record, a letter will be sent to the Consultant for approval notification and advising that complete mylars and digital files are to be submitted to the Pond Engineering Graphic Technologist in Land and Information Mapping, Infrastructure Info, Wastewater Drafting.

Comments: _____

I, the undersigned, have reviewed the Pond FAC Requirements Checklist.

Signature	Name and Company (Please Print)	Date
_____	_____	_____

Checklist #6
Parks Final Acceptance Certificate

THE CITY OF CALGARY
PARKS

*FINAL ACCEPTANCE INSPECTION CHECK LIST & REPORT

R 1307 (R2003-05)

COMMUNITY		SUBDIVISION
DESCRIPTION	PHASE	DEVELOPER
LEGAL/MUNICIPAL ADDRESS		
CONSULTANT	CONTACT PERSON	PHONE
CONTRACTOR	CONTACT PERSON	PHONE

F.A.C. APPLICATION RECEIVED: ☐ YES ☐ NO DATE YYYY MM DD

WORK INSPECTED	DEFICIENCY	INSPECTOR'S REPORT DETAIL
A. SURFACE CONDITION:		
settlement		
ponding/drainage		
repair required		
B. TURF:		
turf quality acceptable		
bare spots requiring top dressing and overseeding		
weed problems		
others		
C. TREES:		
tree replacement		
pruning required		
straping removed		
wires removed		
burlap removed		
guying removed		
tree well cultivated		
soil settlement ie. tree too low		
others		
D. SHRUBS:		
shrubs replacement		
pruning required		
bed cultivated		
weed free bed		
mulch intact		
others		
E. FENCING		
F. PLAY EQUIPMENT:		
G. PATHWAYS/HARD SURFACE:		
H. AMENITIES:		
benches		
garbages receptacles		
others		
I. GENERAL COMMENTS:		
J. IRRIGATION SYSTEM:		
as-built drawings		
maintenance manuals received		
Annual D.C.V. report		
Irrigation Information sheet		
Meter Information sheet		
K. EXTENDED WARRANTY REQUIRED:		
L. MAINTENANCE LOG SUBMITTED:		
M. MYLARS RECEIVED (LANDSCAPE & IRRIGATION		

*NOTE: Contract documents and the Development Guidelines and Standard Specification for Landscape Construction override the Inspection Check List and Report.

☐ No deficiencies noted

☐ Application Expiration Date: _____

Report Distribution

☐ Industry Rep.

☐ Area Superintendent ☐ Design & Development File

Parks Area Rep.: _____

Industry Rep.: _____

Park Inspector _____

Inspection Date _____

Forms
Contractor Environmental Acknowledgement Form

THE CITY OF CALGARY

CONTRACTOR ENVIRONMENTAL ACKNOWLEDGEMENT FORM

X 502 (2005-08)

As a Contractor for The City of Calgary, your review and acknowledgement of this document is necessary prior to beginning work. The items in this checklist are in addition to any specific environmental requirements identified in the Tender/Contract document. **Please complete this Form by initialing each item in the checklist and then by signing the acknowledgement at the bottom of the document.** It is possible that during the course of the contract work, The City of Calgary may review the information in this document with you and your personnel.

Initial	**Environmental Policy** I acknowledge that I have been made aware of and will follow The City of Calgary's Environmental Policy. The Policy includes the following obligations: **Comply** with applicable legislation. **Conserve** resources and prevent pollution. **Continually** improve our environmental performance.
Initial	**Compliance** I am aware of the environmental regulatory requirements applicable to the project. I understand the importance of compliance with environmental legislation, approvals or permits and the consequences of non-compliance.
Initial	**Awareness and Competence** I acknowledge that I am responsible for ensuring that environmental responsibilities contained in the Contractor Environmental Responsibilities Package are communicated to all onsite personnel including Subcontractors. I acknowledge that I am responsible for ensuring that all personnel working for this project are competent to perform the assigned work based on training, education and experience.
Initial	**Erosion and Sediment Control** Recognized practices will be utilized that minimize erosion and prevent the movement of sediment into watercourses and storm infrastructure. Where one has been created, the Erosion and Sediment Control Report or Plan will be followed. Any required erosion and sediment control devices will be frequently inspected and maintained during the project, will be removed once the area has been stabilized against erosion and will be disposed of appropriately.
Initial	**Dewatering** Discharges of surface and subsurface water resulting from dewatering activities will be conducted following City of Calgary procedures. Written authorization will be obtained from Wastewater to dispose of water that has accumulated on construction sites by precipitation or groundwater infiltration into the storm/sanitary system.
Initial	**Saw Cutting and Coring** When undertaking saw cutting or coring activities, slurry will not be allowed to enter the stormwater system.
Initial	**Soil Conservation and Stockpiles** Appropriate soil conservation and stockpiling practices will be implemented to prevent erosion and the loss of topsoil.
Initial	**Tree Protection** Adequate protection will be taken to not damage City-owned or controlled trees on site and on adjacent properties.
Initial	**Site Management** The work site will be maintained free from accumulations of debris or waste. The effects of noise, odor, light, dust emissions, and tracking of dirt and mud will be minimized. Appropriate non-hazardous and hazardous materials management procedures will be implemented. Chemical, fuel and lubricant storage areas will be suitably located and protected to minimize releases. Site specific hazardous materials management procedures will be communicated to all Contractor and Subcontractor personnel.
Initial	**Waste Management** All waste materials generated from activities will be removed and disposed of in accordance with regulatory requirements and facility procedures.
Initial	**Recycling** Generation of waste will be avoided or minimized. At a minimum, the recycling of cardboard, wood, concrete and metal will be considered and assessed. Construction materials with recycled content will be used where reasonably practical and safe.
Initial	**Fuelling** Contractor and Subcontractor personnel will be present during fuelling operations for the duration of the fuelling process. Fuelling or maintenance of equipment will not take place within 30 m of waterways including the stormwater system or environmentally sensitive areas unless a written Standard Operating Procedure is developed.

Initial	**Spill Prevention** Measures will be taken to prevent pollution of land or waterways, including the stormwater system.
Initial	**Release Reporting and Cleanup** Spills and releases will be reported to the appropriate regulatory agencies as required by law. Spills and releases will be reported to The City of Calgary Project Designate* at the earliest possible opportunity. If a spill or release into the environment occurs, the affected area will be cleaned-up and remediated to the satisfaction of The City of Calgary and appropriate regulatory agency.
Initial	**Contamination Discovery** Suspected or potential contamination encountered during the work will be reported to The City of Calgary Project Designate,* HazMat** (264-1022) and Alberta Environment. All releases will be immediately reported to the appropriate regulatory agencies as required by law. Any suspected or potentially hazardous building materials exposed during the work will be reported to The City of Calgary Project Designate* immediately.
Initial	**Offsite Disposal of Excavated Soil or Material** Excavated soil or material that is not required for fill or other purposes will be properly disposed of.
Initial	**Imported Fill Material** The source location of any imported fill material will be reported to The City of Calgary Project Designate* prior to material being brought onsite. If requested, the suitability of the material will be verified.
Initial	**Vehicle Idling** Idling of vehicles not essential for performance of work will be minimized.

*The Project Designate is The City of Calgary contact for a specific construction job. This could be a Project Manager, Contract Manager, Site Supervisor, Project Engineer, Foreman or Safety/Environmental Specialist.

**HazMat is the Hazardous Materials response unit within the Fire Department.

I _____ , acknowledge that I have been made aware of these expectations, and I understand it is my responsibility to comply with them and communicate this information to all onsite personnel that are engaged in carrying out the work or providing material to the job site.

Contractor signature	Title	Company	Date

SUPPLEMENTAL INFORMATION (optional) – to be completed by the Project Designate and Contractor if required.

Special instructions were provided to the Contractor: Yes ❒ No ❒

Description of Information:

_____

_____

Project Designate Name	City of Calgary Business Unit	Contractor Name
Project Designate Signature	Date	Contractor Signature

Schedules
Parks Construction Inspection Schedule

CCC CONSTRUCTION INSPECTION SCHEDULE

Natural Environment Parks & Engineered Storm Water Wetlands

NOTE: Approved biophysical impact assessment, environmental significance assessment, wetland development assessment, and construction & restoration plans required prior to work.

Work Inspected	Seasonal Limits	Timing	% Essential Prior to CCC
Site Layout, Grades, Topsoil and Native Seed/Sod			
Layout P.L. and Approved Utility/R.O.W. Encroachments	6" frost and/or no snow	Inspection 1	100
Erosion/Sediment Controls	None	Inspection 1	100
Survey Stakes - Grades	6" frost and/or no snow	Inspection 2	100
Sub-grade Preparation	6" frost and/or no snow	Inspection 2	100
Site Layout (e.g. trees, pathways, amenities, etc.)	6" frost and/or no snow	Inspection 2	100
Predevelopment Topsoil Stored	Frost Free	Inspection 2	100
Topsoil Depth & Finished Grade to Pre-existing Native Profile & Pre-Development Drainage Patterns & Rates	Frost Free	Inspection 5	100
Seeding	Frost Free	Inspection 5	100
Sodding	Frost Free	Inspection 5	100
Compaction Reports	None	Inspection 5	Within 60 days
Native Trees/Shrubs			
Tree/Shrubs Pits/Beds	None	Inspection 3	100
Correct Number and Species	None	Inspection 4	100
Rootball/Caliper Standards Met	Frost Free	Inspection 4	100
Trees Planted at Specified Grade	Frost Free	Inspection 4	100
CNLA Specifications Met	Frost Free	Inspection 4	100
Insect/Disease/Damage Free	Active Growth	Inspection 4	100
Set back Spacing	No Snow	Inspection 4	100
Burlap Strapping/Wires Removed or Rolled Back	Frost Free	Inspection 5	100
Pathways			
Pathway Alignment	6" frost and/or no snow	Inspection 2	100
To Approved Plan & Specification	No snow	Inspection 5	100
Amenities/Fencing			
Restoration/Reclamation Signage	No snow	Inspection 1	100
To Approved Plan & Specification	Prior to CCC	Inspection 5	Prior to FAC