INTEGRATING NATURAL WETLANDS AND IMPROVING DESIGN OF NATURALIZED STORM WATER MANAGEMENT FACILITIES IN THE CITY OF EDMONTON

WORKSHOP GUIDE

PREPARED BY

LISETTE ROSS — NATIVE PLANT SOLUTIONS

DAVE MARTZ — Ducks Unlimited Canada, Conserving Canada's Wetlands

DECEMBER 4 & 5, 2013

WORKSHOP PARTNERS

The City of Edmonton

UDI

Alberta Environment and Sustainable Resource Development

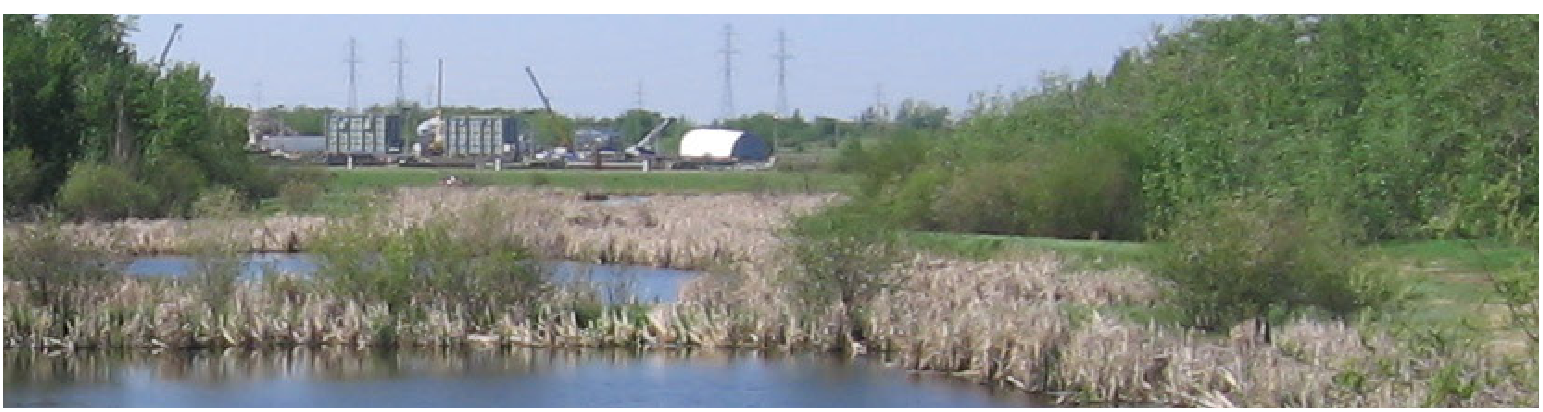


Table of Contents

Table of Contents (con't)

Reference:

Ross, L.C.M. and Martz, D. 2013. Integrating natural wetlands and improving design of naturalized storm water management facilities in the City of Edmonton: Workshop guidebook. December 4th and 5th, Edmonton, AB.

Introduction

The workbook provides a pathway for discovering key concepts necessary to improve decision-making regarding the conservation, restoration and protection of wetlands. It is designed to complement the content presented by the instructors and it encourages participants to find practical applications of the knowledge and theories presented.

The flow of the workshop moves from *what* (knowledge) we know about wetlands in their natural state to strategies for *how* to best maintain them within urban landscapes (decision-making). It also takes key features that dictate wetland class and productivity on Day 1 of the workshop and presents them in an applied format on Day 2 when the instructors discuss the design and construction of naturalized stormwater ponds.

WORKSHOP DAY 1…

The Definition of a Wetland

Agreeing on a common definition for wetlands is an important first step in coming to a common set of terms from which everyone can work from. All wetlands, by definition, share certain characteristics, notably the seasonal or permanent saturation of their soils, the presence of aquatic vegetation (in most years), and water levels near, at, or above the soil surface for all or part of the growing season. The National Wetlands Working Group (1988) defines a wetland as:

> *"Land that is saturated with water long enough to promote wetland or aquatic processes as indicated by poorly drained soils, hydrophytic vegetation and various kinds of biological activity which are adapted to a wet environment."*

The Alberta Wetland Policy defines a wetland as:

> *"Lands saturated with water long enough to promote the formation of water altered soils, growth of water tolerant vegetation, and various kinds of biological activity that are adapted to the wet environment."*

Wetland ***hydrology*** relates to the presence of water either at or above the soil the surface (< 2 m depth) or in the plant root zone so soil is saturated at some point during the growing season.

Wetland ***soils*** form unique hydric soil characteristics different from adjacent uplands as a result of low oxygen conditions.

Wetland ***vegetation*** possesses unique adaptations that allow them to survive in hydrological conditions and grow in hydric soils.

It is important to note that wetlands are those areas that are covered or soaked by ground or surface water often enough, and long enough, to support special types of plants and animals adapted for life under such conditions. They are considered transitional ecosystems between open-water permanent habitats and terrestrial landscapes. As a result they often possess characteristics of both. They represent the aquatic edge of terrestrial habitats and the terrestrial edge of permanent water habitats.

Wetlands in Canada

Canada contains 24% of all the world's wetlands. They cover approximately 14% of Canada's land area. This compares to 9% land coverage for all Canadian lakes and rivers combined. In Alberta, approximately 137,000 km^2 or 21% of the province is covered by wetlands. This accounts for 11% of all Canadian wetlands (Table 1).

Table 1. Canadian wetland coverage by province.

Province	%	Province	%
British Columbia	3	Nova Scotia	3
Alberta	***21***	New Brunswick	8
Saskatchewan	17	Newfoundland	18
Manitoba	41	Northwest Territories	9
Ontario	33	Yukon	3
Quebec	9	Canada: total ha	127,199,000
Prince Edward Island	1	United States: total ha	41,800,000

The Canadian Wetland Classification System (CWCS) (1997) describes 5 types of wetlands in Canada. These include bogs, fens, swamps, marshes, and shallow water wetlands. Wetland development in any given area is a function of climate, hydrology, chemistry, geomorphology, and biology.

- ***Climate***

Includes factors such as precipitation, temperature, and wind. Precipitation influences, to a certain degree the amount of water a region receives. Temperature can influence the rate of plant decomposition within a wetland, leading to the formation of organic soils.

- ***Hydrology***

Hydrology is the study of the movement, distribution, quality and duration of water, both on and below the soil surface. Hydrology can influence the formation of soils in a given location and the types of plants that will grow on the soil surface. It determines the extent and duration of low-oxygen levels that define wetland soil properties and the plants species best adapted to that location. With respect to wetland function and wetland preservation within urban landscapes the four key hydrological aspects to keep in mind are:

- The *timing* of water inputs.
- The *length* of time water is held.
- The *frequency* of change (i.e., wet versus dry periods).
- The *depth* water is held at.

- ***Chemistry (water/soils)***

Water inputs, the interaction of water with soils, and the chemical and physical nature of the parent material all dictate the chemical nature of a wetland. Alberta's wetlands vary greatly in their chemical signatures and this factor must be considered when either preserving a natural wetland in an urban setting or when constructing a wetland using donor soil material. Disturbances in hydrology can lead to changes in chemical reactions that can modify the adsorption or precipitation of elements. Table 2 demonstrates the chemical variability of seasonal, semi-permanent, and permanent prairie wetlands near Saskatoon.

Table 2. Summary of water chemistry results from different wetland classes at St. Denis, Saskatchewan. Note the chemical differences in seasonally flooded (class III) versus more permanently flooded (class IV-V) wetlands for SO_4^-, HCO_3, Mg^{2+} and Ca^{2+}.

Pond #	TN	TP	PO_4^{3-}	HCO_3	SO_4^-	Cl^-	Na^+	Mg^{2+}	K^+	Ca^{2+}	TDS	EC	Wetland Class[X]	Max H_2O level
	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	uS/cm		cm
65[1]	1.83	0.17	0.07	561.8	1619.1	48.1	262.2	322.4	43.8	109.90	2603	2395[Y]	IV	143.9[Z]
66[1]	4.32	0.41	0.02	528.5	24318.5	833.8	4656.4	3576.6	284.2	232.02	38916	35803	V	94.0
67[1]	2.55	0.14	0.02	610.9	3320.0	97.9	496.1	616.9	70.7	158.59	4216	3879	V	154.0
120[2]	3.60	0.89	0.95	144.2	10.0	29.5	1.4	8.2	47.2	27.80	187	313	III	103.0
117[2]	1.83	1.30	0.90	167.7	11.5	38.0	1.3	10.3	64.0	30.33	234	473	III	136.5

1: WEVS data from Dr. Marley Waiser.

2: Data provided by Ducks Unlimited Canada.

[X] Wetland classification system based on Stewart and Kantruds (1987) classification system for prairie wetlands. Class V = permanent, class IV = semi-permanent, class III = seasonal

[Y] The EC values for the WEVS data were calculated as EC (µS cm^{-1}) = 1.087 * TDS (ppm). *From* Chang et al. (1983) Can. J. Soil Sci. 63: 79-86.

[Z] Data from 1968 to 2005 data (provided by Dr. Van der Kamp, NWRI)

- ***Geomorphology (landform and soil material)***

Geomorphology is defined as the science of landforms with an emphasis on their origin, evolution, form, and distribution across the physical landscape. The geomorphology of a region dictates how wetlands form, where they form, and their relationship within the larger landscape.

- ***Biology (fauna, flora)***

The fauna and flora present in and around a wetland are good indicators of the functions provided by the wetland. The presence or absence of both plants and animals can be used to help classify a naturally existing wetland, as well as determine the benefits that the wetland provides. The monitoring of flora and fauna can also be used to determine a wetland's health once its surrounding landscape or watershed has been modified.

Alberta's Wetlands

The Canadian Wetland Classification System (1997) recognizes five wetland types, all of which occur in Alberta. These include wetlands dominated by organic soils, such as bogs and fens, and wetlands dominated by mineral soils, such as swamps, marshes, and shallow water wetlands (Figure 1). Organic wetlands are often referred to as peatlands. They are best defined by their capacity to accumulate organic matter, thus forming an organic soil named peat (i.e., >40-cm). Peatlands tend to occur in areas where the rate of production exceeds the rate of decomposition, leading to the formation of peat. This process tends to be favored in cool, moist climates and in locations where drainage is poor. Mineral wetlands are found where an excess of water collects on the surface but for several reasons produce little or no organic matter or peat.

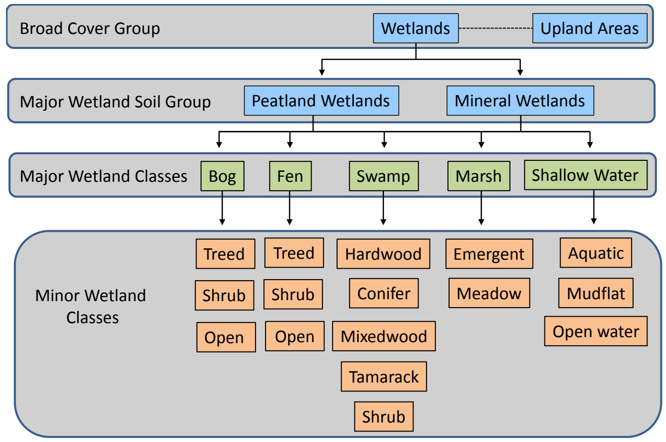


Figure 1. General wetland types and dominant vegetative cover for the 5 wetland types found in Alberta (modified from Smith et al. 2007).

Fens – are peatland systems influenced by flow-through drainage, where enriched water coming from the surrounding watershed provides an array of mineral elements that help support a diverse plant community.

Bogs – tend to be isolated from groundwater and are therefore mostly rain fed systems with poorer mineral nutrients. Bogs often develop from fen habitats as they accumulate more and more peat and eventually become isolated from the nutrients found in groundwater from below.

Swamps – are wetlands dominated by either organic or mineral soils depending on the local drainage patterns. When peat soils are present they tend to be thinner than in bogs and fens. Because soil nutrients tend to be more readily available in swamps, their forest canopy grows taller than in fens or bogs.

Shallow water – have standing water or flowing water less than 2-m deep in mid-summer in most growing years. Water levels tend to be more stable than in marshes. Similar vegetative communities occur in both shallow water wetlands and marshes.

Marshes – have shallow water levels (i.e., < 2-m) that tend to fluctuate either seasonally or annually due to variables such as changes in precipitation, evapotranspiration, and groundwater interactions. Water inputs can come from their surrounding catchment, from stream or lake inflows, precipitation, storm surges or groundwater.

Wetland Classification in Alberta

The types of wetlands found in Alberta shift as you move from south to north. The white zone, or the “settled area” of Alberta, covers the southern part of the province and is mainly dominated by marshes. The northern boreal region of the province, or green zone, is covered largely by forest, bogs, fens, swamps, and shallow water. Fewer marshes exist in the north.

Given these basic descriptions, the approaches used to classify wetlands in white and green zone vary. Two of the most popular systems are Stewart and Kantrud (1971), often associated with prairie marshes, and the Canadian Wetland Classification System (CWCS) (Adams et al. 1997).

Each system has its limitations. The CWCS provides a relatively useful framework for classifying wetlands in the boreal region, while Stewart and Kantrud tends to be better suited for classifying marshes in the white zone. For the purposes of our discussion today, we will apply the Stewart and Kantrud system for wetland classification.

Stewart and Kantrud

This system identifies seven (7) classes of wetlands based first on the nature of its water supply and movements, followed by its effect on aquatic processes, then recognition of the most likely plant life to be present. The first five classes are most commonly used in Alberta (Table 3).

The classes identified in this system are characterized by community structures (life form) and plant species. It is possible that a wetland can possess as many as three or more vegetative zones at one time with the central dominant vegetative zone often dictating what the wetland class will be (Figure 2). Each zone has key species associated with it (Table 4).

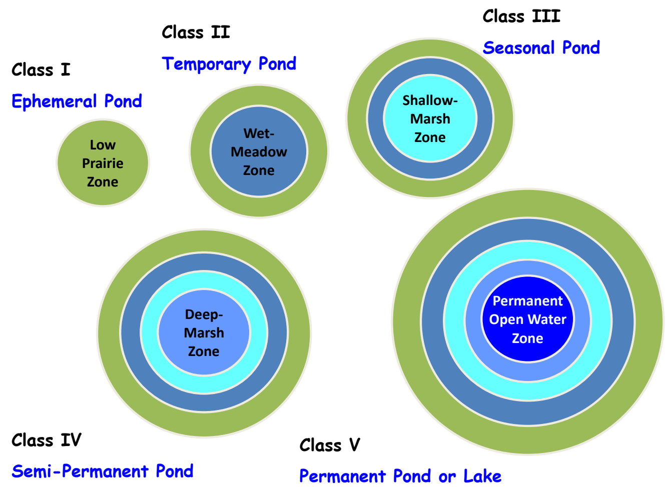


Figure 2. Plant zonation in various prairie marsh classes using the Stewart and Kantrud (1971) system.

Stewart and Kantrud recognized early on that water depth and soil moisture were generally the most important environmental determinants in the positioning of plant species along a coenocline in prairie marshes (Figure 4). Coenclines reflect the shifts that occur in plant species as environmental gradients change along a slope. A number of early studies also documented cyclical changes in the abundance and composition of vegetation and noted that the diversity and productivity of both wetland flora and fauna appeared to be driven by wet and dry cycles in wetlands. These early studies raised many questions about the nature of these cycles and how wetland vegetation responds to both increases and decreases in water levels over time. Stewart and Kantrud also noted that certain wetland plant species were eliminated during years of high-water levels, while other species were eliminated when water levels remained stable. They concluded that natural variability was vital for fueling marsh productivity, making prairie marshes unique to other Canadian wetland types.

"Prairie marshes depend on hydrological disturbance events for maintaining productivity"

Prairie marshes, as we've mentioned, not only fluctuate seasonally, but many also fluctuate cyclically over periods of 5 to 30 years, or more.

Table 3. General nomenclature and characteristics of Stewart and Kantrud's prairie marsh classes.

Class	Name	Characteristics
I	Ephemeral (low prairie zone)	▪ free surface water for short time, usually after snowmelt or storm events ▪ rapid water seepage because of local soils ▪ may establish some wetland or aquatic processes
II	Temporary (wet meadow zone)	▪ standing water usually in spring ▪ more rapid soil infiltration but may linger after heavy rain or colder spring conditions ▪ may establish some wetland or aquatic processes
III	Seasonal (shallow marsh zone)	▪ surface water 1-3 months in spring ▪ shallow marsh vegetation ▪ typically dry up during mid- to late summer
IV	Semi-permanent (May – Sept) (deep marsh zone)	▪ frequently maintains water throughout growing season ▪ tends to hold water at least 4 out of 5 years
V	Permanent ponds and lakes (central open water zone)	▪ permanent open water ▪ central pond area generally devoid of emergent vegetation ▪ can be confused with semi-permanent ponds

Table 4. Key indicator species for prairie wetland vegetation zones (after Stewart and Kantrud 1971).

Wetland Zone	
Low Prairie:	**Primary Species:** *Agropyron sp., Aster ericoides, Poa pratensis, Potentilla anserina, Salix sp.* **Secondary Species:** *Andropogon gerardii, Stipa viridul*
Wet Meadow:	**Primary Species:** *Glyceria grandis*, *Glyceria boreali, Aster simplex, Aster ericoides, Calamagrostis inexpansa, Calamagrostis canadensis, Scirpus cyperinus, Eleocharis sp., Mentha arvensis, Stachys palustris, Carex sp., Juncus sp., Eriophorum sp., Sium suave* **Secondary Species:** *Poa palustris, Potentilla anserina*
Shallow Marsh:	**Primary Species:** *Sparganium hyperboreum, Carex antherodes, Carex aquatilis, Beckmannia syzigachne, Scirpus sp., Scolochloa festucacea, Eleocharis sp., Equisetum fluviatile, Calamagrostis canadensis* **Secondary Species:** *Lemna sp.*
Deep Marsh:	**Primary Species:** *Typha latifolia, Typha augustofolia, Schoenoplectus tabernaemontani, Schoenoplectus acutus* **Secondary Species:** *Scolochloa festucacea, Carex antherodes, Menyanthes trifoliate, Utricularia sp., Myriophyllum exalbescens, Potamogeton sp., Hippuris vulgaris*

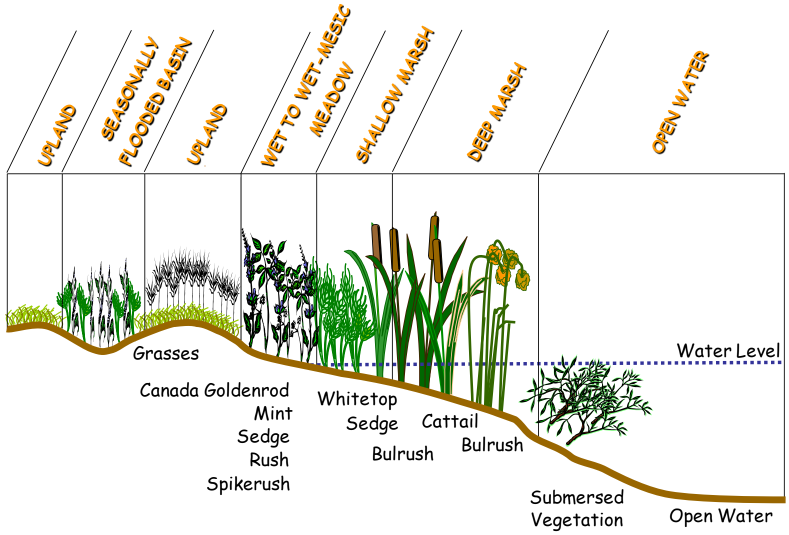


Figure 4. Zonation and placement of wetland plants in relation to water depth (Ross 2011).

Wetland Productivity and Sustainability – The Drivers

While wetland classification helps us understand the types and classes of wetland we're interested in, it does not inform us of the variables needed to maintain wetlands in a productive or functioning state. Prairie marshes are complex systems and no two wetland sites are the same with respect to soil development, hydrology, watershed characteristics or vegetation. Each location requires unique approaches in order for us to maintain their form and function. Investigation of a site-by-site basis should include long-term and local climate regimes, basin physiography, basin morphology, chemistry (both soils and water), hydrology, surrounding land use, and flora and fauna communities (Figure 5).

While we often recognize the values and functions wetlands provide to society, we often overlook the features that make them perform as wetlands in the first place.

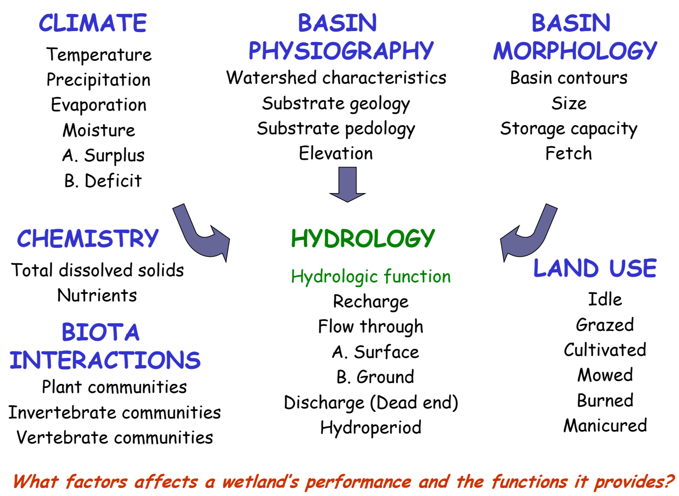


Figure 5. Factors that influence a wetland's form and function over time.

"Wetland function, such as species absence or presence, helps us to evaluate how well we are doing at maintaining a wetland once it is embedded in an urban landscape"

"Understanding and simulating a wetland's form (i.e., inflows/outflows, hydroperiod) is what we need to do in order to maintain it successfully"

1. **Form:** are the naturally occurring physical, biological and chemical processes required to maintain a wetland in its natural state, recognizing that certain processes may have changed over time.
2. **Function:** actions which occur naturally in wetlands as a product of the interactions between the ecosystem structure and its processes. Wetland functions include:
   - Water purification
   - Productivity
   - Regulation of CO_2 and methane levels
   - Water storage (flood control)
   - Carbon storage
   - Groundwater recharge
   - Retention and assimilation of chemicals (filtration)
   - Weather stabilization
3. **Values:** the perceived benefits to society, either direct or indirect, that result from wetland functions.

Climate

Local climate events generally influence the hydrological inputs and outputs to and from a wetland. Climate factors to consider for successfully incorporating and maintaining a natural wetland into an urban setting include:

- The timing of precipitation events and amounts
- Averages versus extreme events
- Short versus long-term trends
- Snow sublimation
- Summer evapostranspiration rates
- Regional trends

Because of the generally cold and dry climate, prairie wetlands often have a negative water balance. Therefore the loss from wetland classes II's and III's often exceeds climate inputs.

Basin Physiography

Basin physiography considers the watershed features and surrounding soil characteristics that on an annual basis can either contribute to or remove water from a wetland basin.

Certain wetlands are considered spill-over wetlands, meaning that in most years they are hydrologically connected to other wetlands or waterways downstream. Other wetlands are considered isolated ponds and rarely, if ever, overspill their basin.

Catchment areas for individual ponds also vary greatly and no single rule of thumb or ratio can be applied to estimate that a wetland of a certain size always receives water from a catchment of a certain size. Factors such as pond depths, soil types, soil infiltration rates, and surrounding land use all influence how much runoff a basin receives from its catchment area. Table 5 shows wetlands studied in Manitoba and Saskatchewan and their catchment areas. Factors such as slope, curvature, and aspect all dictate how water moves overland in a catchment and where, and how much, water eventually pools.

Table 5. Wetland and catchment areas for wetlands of different classes in SK and MB (Ross 2009)

Site	Pond #	Catchment Area (ha)	Wetland Area (ha)	Catchment: Wetland Ratio	Wetland Class
St. Denis NWMA, SK	65	4.9	2.3	2.1	IV
	66	24.0	7.9	3.0	V
	67	13.0	2.2	5.9	V
	67a	1.2	0.4	3.0	III
	109	3.3	1.2	2.8	III
	109a	0.6	0.06	10.0	II
	109b	0.4	0.03	13.3	II
	117	1.7	0.4	4.3	III
	117a	0.4	0.05	8.0	II
	117b	0.4	0.3	1.3	II
	120	3.5	0.3	13.0	III
MZT, MB	216	3.5	0.5	7.0	IV
	222	3.2	0.8	4.0	IV
	232	0.5	0.1	5.0	IV
	232a	0.7	0.13	5.4	III

"Catchment areas for individual ponds vary greatly and no single rule of thumb or ratio can be used to estimate a wetland's catchment area"

Basin Morphology

Even subtle differences in the bottom elevations of a wetland basin can effect calculations for total wetland storage. Many hydrological models assume basin elevations and this can have consequences for either over- or underestimating annual inputs. Table 6 shows the effect using uncorrected LiDAR data when modeling the storage potential of a wetland.

Table 6. Volume calculations for two prairie wetland sites using rectified versus uncorrected elevation data from wetland bottom (Ross 2009).

Site	Pond #	**Precipitation required for Spillover to Occur** *Uncorrected LiDAR* (mm)	**Precipitation required for Spillover to Occur** *Corrected LiDAR* (mm)	Potential Total Wetland Volume (m^3) Uncorrected Data	Potential Total Wetland Volume (m^3) Corrected Data
MZT Site, MB	222	55	355	3012	12197
	232	14	116	70	1168

Chemistry

Generally, the weathering and dissolution of glacial till parent materials in the region have resulted in carbonate and sulfate rich waters in prairie wetlands. Wetlands in the region tend to be more alkaline in nature; however variations in soil deposits on a local scale can influence the chemical nature of a wetland. Depending on the water permanence of a wetland, its specific conductance, or the concentration of dissolved salts in water, can vary from 50 to 200,000 µS/cm. Wetlands that are more permanently flooded tend to be more saline. This relates to the dissolution and precipitation of various ions based on their ionic strength and the chemical nature of the soil. We see this in table 2 where the dominant ions in the water chemistries of class III, IV and V prairie wetlands vary. The main cations/anions present in seasonal Class III ponds are calcium (Ca^{2+}), potassium (K^{+}), and bicarbonate (HCO_3^{-}), compared to magnesium (Mg^{2+}), sodium (Na^{+}), and sulfate (SO_4^{-}) in semi-permanent Class IV ponds. Calcium, bicarbonate and calcite precipitate reflect the influence of fresh water snowmelt chemistry in seasonal Class III wetlands and the importance of atmospheric precipitation and the dissolution and transport of carbonate minerals from the surrounding till soils (Ross 2009). Soil and water chemistries within a wetland determine which plant species grow.

"Changes to chemistries as a result of changes in the permanence of water has the potential to affect plant growth and species diversity in a prairie wetland"

Surrounding Land-Use

In trying to understand and account for how wetlands perform hydrologically over time, it is important to acknowledge how local land-use practices impact the current hydrology of the pond. This is particularly true if one is using aerial photography to determine the frequency of wet versus dry years, wetland edge and the long-term average (or normal) water levels of a pond.

Wetlands located in croplands tend to be both deeper and water levels more variable, particularly class II and class III wetlands (Figure 4). Even a 10-cm difference in water levels can dramatically change wetland vegetation, especially when the water levels become deeper. The compaction and lower organic matter content in cropland soils tends to decrease soil infiltration, leading to greater runoff in these landscapes. On the flip side, wetlands that have their surrounding uplands planted to thick native grass stands can become drier (Figure 5).

"It is important to understand how surrounding land-use influences water inputs, both before and after a wetland is preserved in an urban area"

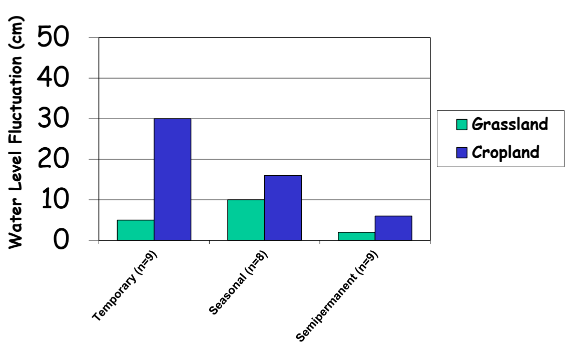


Figure 4. Water level fluctuations as a function of landscape position and wetland class (Euliss and Mushet 1996).

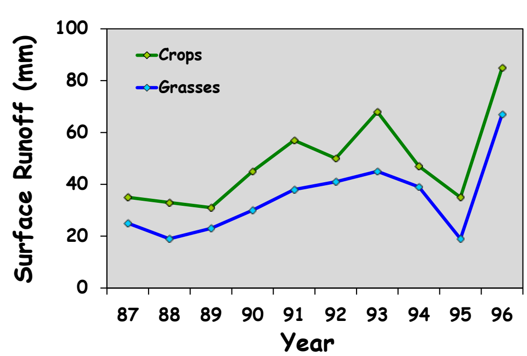


Figure 5. Water level fluctuations as a function of landscape position and wetland class (Su 1998).

Hydrology

The most important variable to consider is hydrology when preserving a wetland in an urban setting. Even small changes in a wetland's hydrology can significantly affect the chemical and physical properties of a wetland. These include nutrient availability, substrate anoxia, soil salinity, sediment properties, and pH. Similarly, when hydrologic conditions change even slightly, plants and animals can respond with major shifts in species composition and richness. Some hydrological changes cause plant species composition to shift and ecosystem productivity to decline. Other changes act to enhance productivity. In comparison to almost all other ecosystems, wetlands are unique in that they depend, if not thrive, on disturbance events (i.e., the wet/dry cycle, Figure 6). The speed with which they move through the cycle depends on the class of wetland. Hydrological disturbance events can be as important for the productivity of southern prairie wetlands as they are for northern boreal wetlands. One of the biggest detriments to the productivity of freshwater marshes is when water levels remain stable.

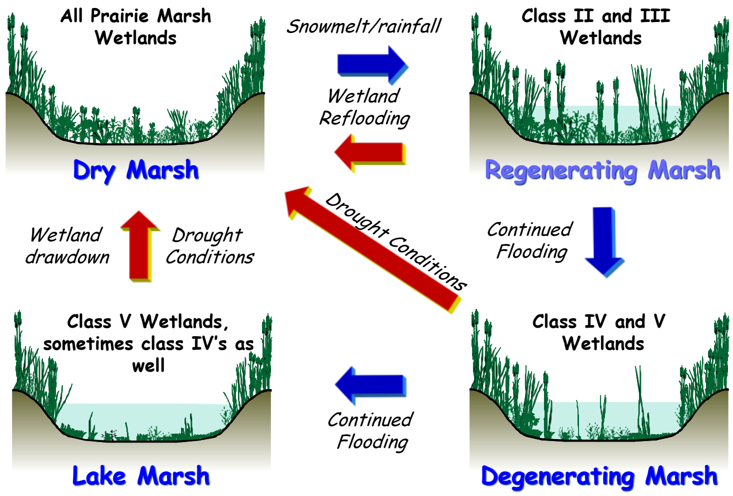


Figure 6. The wet/dry cycle of a prairie marsh (adapted from van der Valk 2000). Blue arrows indicate continuing water inputs. Red arrows indicate water deficits and drawdown conditions.

"In comparison to almost all other ecosystems, prairie marshes are unique in that they depend, if not thrive, on disturbance events"

Fundamental principles underscoring the importance of hydrology in prairie wetlands consist of the following (modified from Mitsch and Gosselink 2000):

1) Hydrology leads to a unique vegetation composition but can limit or enhance species richness and coverage depending on the depth of the water, the duration of flooding, and the frequency of disturbance events.
2) Primary productivity and other ecosystem functions in wetlands are often enhanced by a pulsing hydroperiod and are often depressed by stagnant or stable water levels.
3) Nutrient cycling and availability are significantly influenced by hydrologic conditions.

Hydroperiod for prairie wetlands is defined as the depth, length of time, and the portion of the year a basin holds ponded water. It defines the rise and fall of a wetland's surface and subsurface water and the rate with which these processes occur. For wetlands that are not permanently flooded, the amount of time a wetland is in standing water is called the flood duration, and the average number of times that a wetland is flooded in a given period is known as its flood frequency (Ross 2011). Hydrological modeling for natural wetland sites should consider:

1) LiDAR Data
   - Is it rectified for the surrounding uplands and wetland area
   - Have you captured the bottom elevations of pond correctly
   - How does your model interpolate data
   - What level of grid detail is most accurate
2) Water Inputs
   - Are you using the correct water inputs from the right time of year
   - Are your runoff estimates accurate
   - Did you consider that many wetlands hold water from year to year
3) Spill-over Wetlands
   - Is your wetland catchment area isolated from other water bodies or connected
4) Model Selection
   - How does it handle the bathymetry of the wetland
5) Which factors are most sensitive to mistakes?
   - Where would you spend your money if you needed to gather more information

As mentioned earlier, excessive flooding or drought conditions can quickly lead to either the stimulation or the deterioration of a natural wetland in an urban setting. Accounting for the appropriate frequency of wet/dry cycling in natural wetlands is important for maintaining a wetland's productivity. Figure 7 provides insight into how wetland plant and animal communities change as wetlands sequence through the wet/dry cycle.

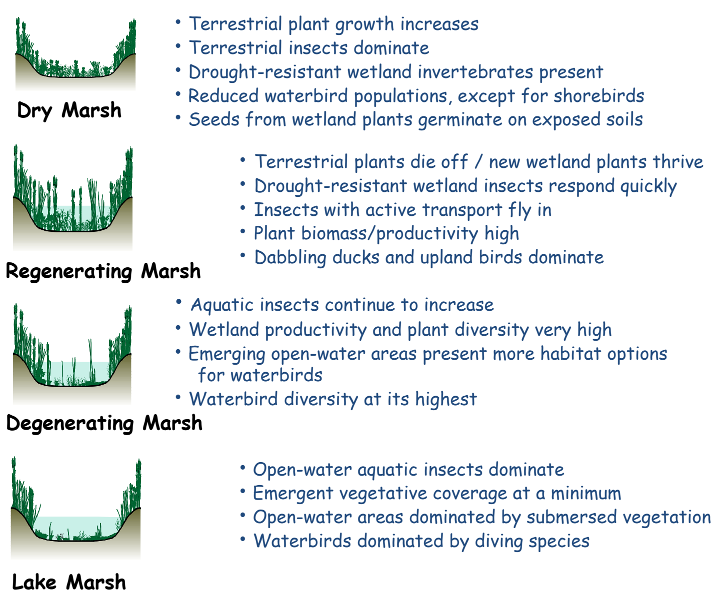


Figure 7. The effects of the wet-dry cycle on wetland flora and fauna.

Excessive Flooding and Stable Water Levels - Effects on Wetland Productivity

- Marshes flooded for too long or too deep will begin to exhibit a decrease in plant diversity in combination with an increase in open water. Above- and below-ground plant biomass will decrease and overall wetland productivity will decline.
- Shallow marsh species will disappear quicker at the upper end of their water depth range than deep marsh species will.
- The depth of flooding will dictate how fast a vegetation community disappears from a basin. Flooding depths of 70-cm to 1-m can cause many species of emergent plants to die within only one growing season.
- Extended periods of deep flooding can be used as a management tool to manipulate emergent communities within a wetland complex.
- Stable water levels in a natural wetland will lead to a decline in plant diversity over time.

Drawdown Conditions – Effects on Wetland Productivity and Plant Growth

- Most wetland plant seeds only germinate during the drawdown (or drought) phase of a wetland.
- Intermittent drawdowns can be effectively used, or built into a project, to help revitalize plant diversity, abundance and wetland productivity.
- Soil moisture, the severity of the drought and the salinity of the soil surface can impact what seeds germinate and where they'll germinate within a wetland basin.
- Seed germination can be inhibited by very dry soils, whereas the germination of annual seeds can be inhibited by flooded or very wet soils.
- Studies show that the viability of seeds diminishes the longer they remain submersed. Only the seeds of deep emergent plants can withstand several years of flooding and still germinate when exposed to light and air.
- Drawdowns that occur earlier in the growing season (i.e., May) result in better seedling growth and survivability.
- Drawdowns that begin in May can reduce the recruitment of potential problem species.
- No benefits are observed in drawing down a wetland longer than one growing season.

Nutrient Loading

Nutrient loading and excess nutrients should be addressed as part of the hydrological calculations for inputs into natural wetland sites. Wetlands are efficient at removing, sequestering and breaking down excess nutrients such as phosphorous and nitrogen. However, natural wetlands should not be considered as sites where stormwater runoff can be treated. Excess sediment loads can affect the chemical processes that sequester or breakdown incoming nutrients. Excess nutrient may also overwhelm a wetland's ability to process incoming inputs. While water quality improvement is a function most prairie wetlands provide, naturalized stormwater ponds have been shown to provide the same benefits for water quality improvements as do natural wetlands.

"Natural wetlands should never be considered as sites where stormwater runoff can be treated"

Flora and Fauna

Prairie marshes are intimately linked to the life cycles of a variety of both plants and wildlife. As prairie marshes move through their wet and dry periods, various plant and animal species take advantage of the opportunities presented for germination, reproduction, food, or habitat (Figure 7). While vegetation identification is a critical step in classifying existing wetland sites, wildlife can also be helpful in understanding where a wetland is in terms of its health. While monitoring vegetative and wildlife communities is a critical step in assessing a wetland before it is preserved in an urban landscape, it can also be very helpful for determining how successful your preservation of the wetland is once the project is complete.

"Monitoring vegetative and wildlife communities are important for assessing how successful the integration of a natural wetland is once construction is complete"

The Importance of Good Data – When to Begin and What to Collect

Preserving Natural Wetlands Requires a Team Approach

One of the most important steps for ensuring success in assimilating natural wetlands into urban environments is assembling the right professional team with the right expertise early on. Wetlands are complex systems. Even wetlands with the same descriptive name, such as marshes or fens, may vary considerably from one year to the next depending on climate and other disturbances. Their size and edge can vary on an annual basis. Their vegetative and wildlife communities can change as water levels fluctuate from one year to the next. Being able to identify and record the variables important for a wetland's productivity before development occurs is critical for ensuring that productivity is maintained post-development as well.

"***It is important to fully document what "normal" means for a natural wetland before site plans are designed and submitted"***

One of the biggest missteps in wetland projects is not including wetland specialists or biologists in the planning process until the process is almost complete. Including experts from all the required fields not only improves efficiencies in planning, design, construction, and commissioning, it also saves on the project's bottom line.

The planning, design and site assessment team should include expertise in:

- Engineering – to develop site designs, assess hydrological and physical property performances and needs both pre- and post-development, identify and outline system and infrastructure requirements, and infrastructure integrity post-construction
- Biological – to develop and participate in site requirements and designs, assess current hydrological and physical property performance and future requirements, to conduct and interpret data collected across multiple years in both pre- and post- construction phases, to coordinate and execute vegetative planting, complete site commissioning and site development post-construction

- Landscape Architects – to ensure the integration of functional, attractive and economically feasible natural environments within the overall urban design, and to aid in the development and coordination of the master site plan for the neighborhood in terms of flow, functionality and usability
- Technical – to oversee water inputs/outputs, construction scheduling and activities, BMP practices, infrastructure and hydrological performance post-construction, power and pumps
- Land planners, Regulatory, Certification – for input and guidance on goal setting, monitoring and construction requirements, project documentation, and meeting standards

Project Planning

The planning and data collection for natural wetland sites should begin at least 2 growing seasons prior to when high level design plans are submitted for approval. Growing seasons and climates differ from year to year and wetlands change as a result. The opportunity to collect data early on, and in certain situations, across multiple years improves our assessment of important wetland variables. Variations in wetland classification, ground and surface water flows, and wetland delineations can happen as a result of the climatic variability in any given year. Therefore, data collected across multiple years ensures that site assessments are based on consistent data points collected across multiple growing seasons.

Wetland Delineation

Wetland delineation is important since it establishes the existence (location) and physical limits (size) of a wetland for the purposes of federal, provincial, and local regulations. Furthermore, it aids in establishing the "true" wetland / upland edge. This "edge" assists in determining the correct line between the wetland and its surrounding uplands for the purposes of establishing a buffer zone and for water modelling activities. In order to meet the requirements of both regulators and to support other decision making requirements in the project, wetland delineation should result in three things:

1. A wetland boundary that is clearly marked in the field and digitally.
2. A map that clearly identifies data collection points and the boundaries of the delineated wetland. (Topographic and aerial site maps are very helpful)
3. A report that explains how the boundary was determined. It should include:
   - A description of what data was collected, how it was obtained and when the delineation was done
   - The data forms used to delineate the wetland area with the raw data included
   - The map described in #2 above
   - A soil survey map
   - The wetland class with supporting documentation

It is important to recognize that certain types of field data may be compromised due to surrounding land-use practices. Research has shown that in almost all cases, prairie wetlands in agricultural landscapes have lost their wet meadow and/or low prairie zones or they have been either significantly reduced in width or in species diversity (Ross 2009). In these circumstances, we rely on other data to help us verify a wetland's true hydrological edge.

One of the more recent advances in western Canada for determining the hydrological edge of a wetland are studying its soils. While this approach has long been used in the U.S. it is only recently that we have gained a better understanding of the types of prairie soils in and around class II, III, IV and V wetlands. The benefit of using soils to determine edge is that they tell no lies. Characteristic features in soil profiles require thousands of years to develop. While land-use practices may have altered drainage patterns in a location in recent decades, deeper attributes within the soil profile will have remained unchanged. This holds true whether you are examining the soil profile collected in the center of a pond or at its historical hydrological edge. Figure 8 provides an example of a number of soil profiles collected along a catena in central Saskatchewan where a class III seasonal wetland exists (Ross 2009). While carbonates at the soil surface in positions S5, 6, and 7 show the influence of more recent cultivation, carbonates at the soil surface in position S4 demonstrates the influence of groundwater discharge moving upwards through the soil profile due to fluctuating water levels in the pond over thousands of years.

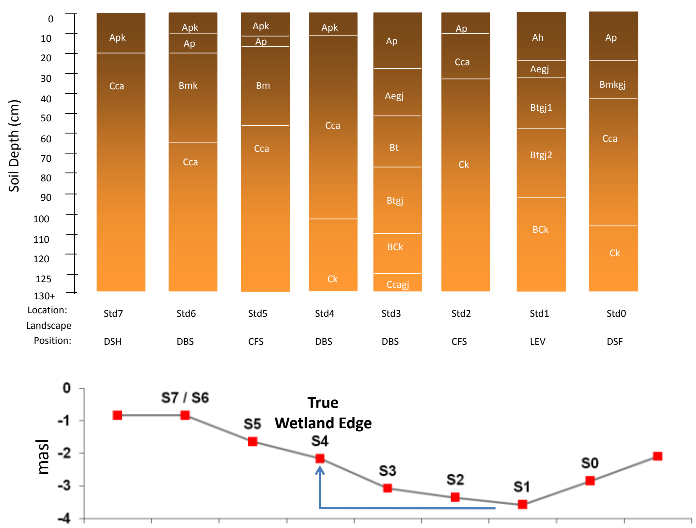


Figure 8. Soil profiles collected along the catena of a class III wetland existing in an agricultural landscape in central Saskatchewan (Ross 2009).

Monitoring Programs

Wetland monitoring programs benefit the wetland project before construction begins and after the project has been completed. Understanding the site well in advance of the work helps to:

1. identify potential cost savings early on;
2. verify that stormwater plans are designed and connected in a way that supports the ongoing water needs and sustainability of the natural wetland site;
3. verify that the calculations for wetland inflows/outflows and variable water level control plans are correct; and
4. provide biological, chemical and physical data that can be used to verify that the wetland is functioning in the intended way, post-development.

Getting the hydrology right for a natural wetland to be protected is the most important first step for ensuring project success. While the collection of plant data is often the focus of wetland monitoring programs, the real value of this data occurs once the wetland site is preserved within the urban landscape. It will be during this post-development phase of the project when subtle changes in vegetative communities help to verify whether the initial estimates for inflows, outflows and storage capacities are correct. Shifts in vegetation occur as a result of water levels that are too high, too low or too stable. They are often used as the first indication that a project is not performing as expected.

The timing and frequency, and types of samples collected in a monitoring program vary depending on the objectives of the project and the desired outcomes for wetland performance. Sampling schedules should be timed to capture important phenomena in the cycling of a wetland. Wildlife should be studied at those times of the year when target species are most likely to occupy the wetland. Vegetation should be assessed at those times of the growing season when growth is at its peak (i.e., late July/early August for aboveground growth, mid-September to early October for belowground growth). Soils can be assessed at any point during the growing season. For all classification, delineation and monitoring activities one should consider:

- Present vegetative and hydrological conditions compared to previous years
- What data to collect – soils, vegetation, hydrology, wildlife, aerial imagery, ground elevations
- When to collect the data – spring, summer, fall
- How often to collect the data – is once enough to capture variability?
- How might existing anthropogenic impacts affect the data you collect

Incorporating Natural Wetlands into Urban Landscapes – The Checklist

In conclusion, a number of important steps are required before the project begins and after construction is complete. As mentioned earlier, pre-development monitoring and data collection should begin at least two growing seasons prior to when high level design plans are submitted for approval. Post-development monitoring and data collection begins in the very first spring of stormwater or natural wetland operation, either immediately after construction is complete or the system is functioning hydrologically. Normally, monitoring and data collection during the post-development phase of a natural wetland site should occur over a period of 3 to 5 years, with the first two years requiring the most rigorous assessments.

Pre-development assessments should include:

- Wetland classification (Wetland biologist**)
- Wetland delineation (Wetland biologist, Soil specialist, Surveyor)
- Characterization of the physical setting of the wetland (size, water depth, surrounding slope, catchment characteristics) (Wetland biologist, Engineer, Hydrologist, GIS specialist)
- Characterization of the watershed (size, topography, geology, ecological linkages) (Hydrologist, Engineer, Wetland biologist, GIS specialist)
- Characterization of water quality, sediment inputs, surrounding soils (Wetland biologist, Engineer, Technician)
- Wetland hydrology (surface water, groundwater, water levels, hydrological regime, and overall water balance) (Hydrologist, Engineer, Wetland biologist)
- Assessment of the vegetation communities and sensitive species (biodiversity, production, density, general health, presence of pathogens, pests, or invasive species)

- Assessment of the wildlife biodiversity and sensitive species (birds, mammals, fish, reptiles, invertebrates, micro-organisms) (Wetland biologist)
- Heritage potential within and around the wetland (Landscape Architect, Wetland biologist)

Post-development assessments should include:

- Ongoing verification of the physical and hydrological performance of the wetland (size, water levels, inputs/outputs (ground and surface water) hydrological regimes, system water balances) (Hydrologist, Engineer, Technician, Wetland biologist)
- Monitoring of water quality, sediment inputs, and erosion sources (Technician, Engineer, Wetland biologist)
- Monitoring of the vegetation communities and sensitive species, including species diversity, densities, spatial coverage, and invasive or weedy species establishment (Wetland biologist)
- Monitoring of the wildlife species, including biodiversity, densities, and seasonal use (Wetland biologist)
- Assessment of local Community engagement and uptake (Landscape architect, Land developer, Wetland biologist)

** *Highlights which professionals may be involved for that particular assessment.*

WORKSHOP DAY 2…

Introduction

Fresh water is a vital resource for human society. We depend upon water for drinking, hydropower, irrigation, cooling, and cleaning; for products such as food, plants, and minerals; and for services such as waste purification, transportation, and recreation (Naiman et al. 1995). The goal for proper watershed functioning should be to maintain high quality water supplies whenever possible. Watersheds collect water as rainfall, snowmelt, and runoff. Water is then stored for varying lengths of time before it is discharged as surface runoff, groundwater flow or both. What we've lost in recent years is the concept of ***Improve then Move***. Our general practice has been to move water off the land and into end points, such as lakes and rivers, as quickly as possible. In doing so, we've not only taxed the capacity of our infrastructures, but we've also lost the cleansing powers that natural habitats, such as wetlands, provide.

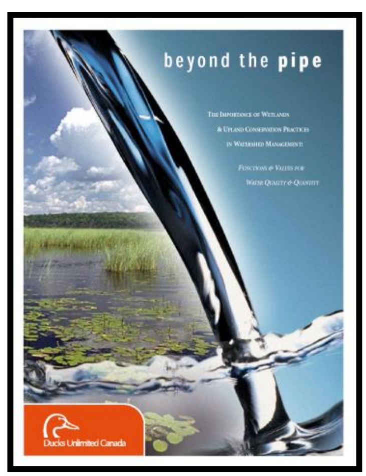
In the last two decades is has become apparent that while our stormwater systems are meeting our water storage requirements, they are not necessarily meeting our water quality needs. We've drastically changed what we put into our waters and how water flows overland. Farming has increased, urban centers are expanding and in turn, we have straightened and "sped up" our waterways. Natural buffers that once surrounded and protected our waterways have been replaced with lawns, cottages, eroded soil, pavement or crops. As a result, there has been an increasing demand to employ strategies that help to improve water quality as it moves through our stormwater systems. There is also more pressure to design stormwater systems that are more sustainable and less management intensive. This is especially true as budgets and resources become more restricted.

The good news is we can do better because we now know more. The new options we have are ones that Mother Nature has been using naturally for centuries to improve water quality. These new options are also economical and less management intensive.

Wetlands and Water Quality

From the 1960's through the 90's most of our research efforts were focused on understanding the ecology of wetlands. While those research efforts continue today, current research is providing us with a much better understanding on the role wetlands play in improving water quality.

The real shift in our thinking about wetlands and land-use practices occurred at the beginning of the last decade as almost 2,000 people in the Ontario community of Walkerton fell ill because of poor water quality as a result of local land use practices. This was followed by a similar event in North Battleford one year later in 2001. At the same time it was becoming apparent in urban centers such as Winnipeg that traditional stormwater designs were failing at improving water quality, and our larger lakes, such as Lake Winnipeg, were just beginning to show signs of excess nutrient loading.



In 2001, the Walkertown inquiry commissioned a scientific literature review on the ability of different land-uses practices for improving water quality. This review of more than 300 papers helped us to better understand the potential for wetlands, riparian areas and upland vegetative cover to remove excess nutrients, and in turn, improve the quality of the waters running through them (Gabor et al. 2001) (Table 7).

Table 7. Range of percent retention for nitrogen, phosphorous, sediment, coliforms and pesticides in wetlands, riparian zones, and native grass uplands (Gabor et al. 2001).

	Wetlands % Retained	Riparian % Retained	Upland Grasslands % Retained
Nitrogen	Up to 95%	67 – 96%	2.8 – 14.4%
Phosphorous	Up to 92%	27 – 97%	Up to 30%
Sediment	Up to 70%	75 – 91%	22 – 37%
Pesticides	< day to months	8 – 100%	Up to 50%
Pathogens	Up to 95%	70 – 74%	-

Wetlands, in particular are able to improve water quality through a number of naturally occurring biological, chemical and physical processes that sequester, breakdown, transform, or digest the nutrient (Figure 9).

Wetlands help to retain *__sediments__* by dissipating and dispersing flow energy which allows time for sediment particles to settle out before it moves into connecting waterways.

There is also a great demand by wetland plants for *__nutrients__* such as nitrogen and phosphorous, for their growth. This not only benefits emergent plants such as cattail, but algae and bacteria populations as well. This process offers a transfer of nutrients into usable and sustainable forms. Wetlands also have the capacity to transform nutrients into less volatile forms.

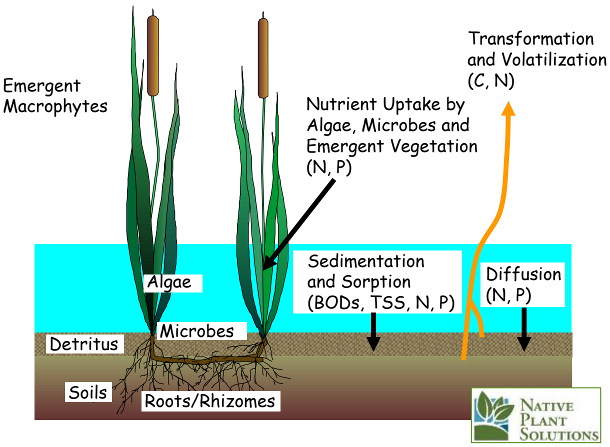


Figure 9. Wetland processes that improve water quality.

Wetlands are able to dissipate *__pesticides__* because of their high biological activity and shallow nature. They adsorb pesticides to plant and soil surfaces. They break them down through photolysis and hydroloysis, as well as microbiol action.

Somewhat similar processes occur for *__pathogens__*. Wetlands intercept and retain pathogens on the surface areas of plants; through digestion by microbes, fungi and algae; and grazing by aquatic insects.

Incorporating Wetland Elements into Naturalized Stormwater Designs

It is has become clear that our traditional approach to stormwater management is no longer working as well as we would like at improving water quality. Many existing "traditional" stormwater ponds or stormwater retention basins (SRBs) were built with the best information we had at the time. These older ponds were designed to function like small pristine lakes and sold to the local residents as such. Overtime, however, it became apparent that they could not function year after year in a pristine state. In many locations submersed vegetation and blue-green algae blooms have overtaken the open water areas of these ponds and many city departments across Canada struggle year after year to maintain good water quality. Unfortunately, these practices are not only time consuming, but costly as well.

The challenges we've observed with traditional stormwater designs across Canada has been consistent. Water quality, wildlife and management challenges include:

- Poor water quality
- Turbidity
- Excess algae/submersed plant growth
- Invasive species
- Excess of grazing geese
- Intensive upland management of grassed areas

Traditional stormwater pond in Winnipeg

Furthermore, what we've observed is a weak understanding of what stormwater naturalization means for improving water quality:

An eyebrow of wetland vegetation

Naturalization around the pond, but no vegetation in the pond

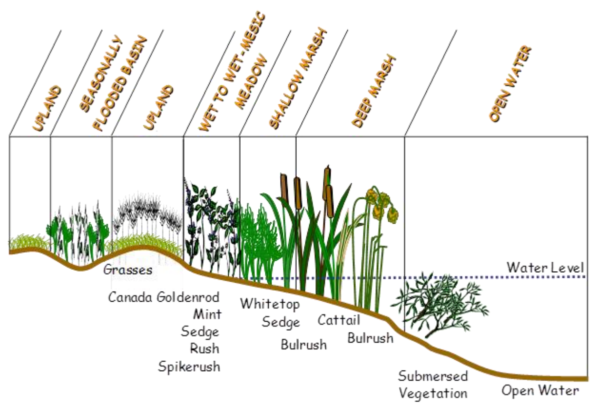
The main difference between traditional SRBs, and ones that have been naturalized, is vegetation in the pond itself. Instead of a shoreline of crushed rock or eyebrow of wetland vegetation, the naturalized SRB supports a robust shoreline community of wetland plant species such as cattail, bulrushes, sedges and more. Add in some shoreline curves, expanded vegetated shallows, and peninsulas and the naturalized SRB look even more like a natural wetland. With nesting Red-wing blackbirds, marsh wrens, and singing chorus frogs, it even has the capacity to support many wetland wildlife species as well.

The goal is to incorporate wetland vegetation into stormwater designs so that water quality is not only improved using natural and sustainable processes, but in a cost effective manner for the life time of the SRB.

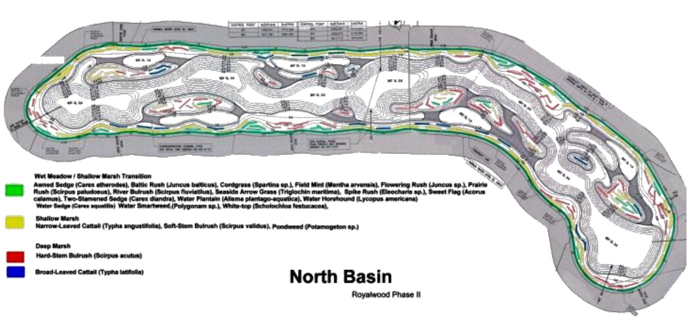
Naturalized stormwater pond in Winnipeg

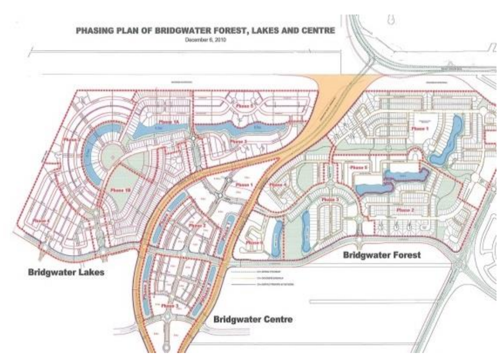
The design and construction principles of naturalized SRBs draw upon many of the topics covered on Day 1 of this workshop. These include:

- our knowledge of how wetlands function
- the role of the wet/dry cycle
- how plants position themselves along a coencline
- The uptake and cycling of nutrients in plants



With a good foundation and understanding of wetland productivity and wetland plant ecology, naturalized SRBs can be designed with a certain "*look*" in mind.





In addition to the advantages wetland plants provide for improving water quality in naturalized SRBs, integrating upland native species into site designs provides further benefits for water quality, site management and nuisance wildlife species.

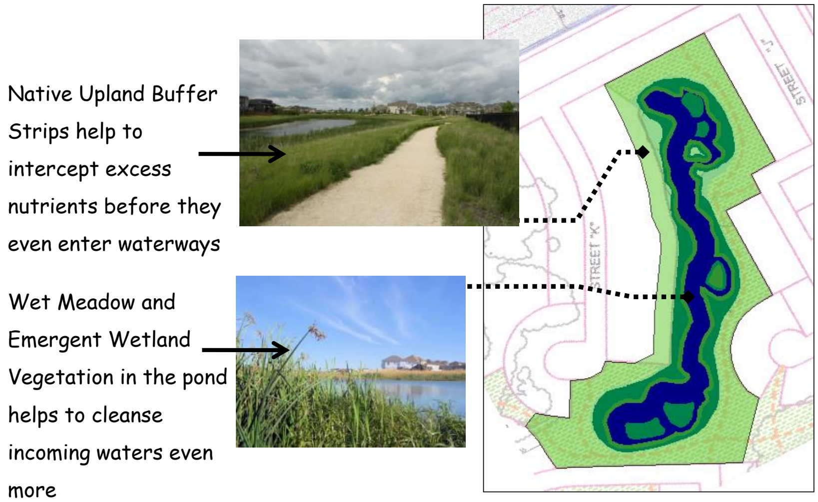


Figure 10. Example of the integration of wetland and upland native species into an SRB design.

Why Naturalize?

Costs for construction and ongoing maintenance are similar to, if not cheaper than, traditional stormwater pond construction

- Less soil removal
- No need to import rock or soil to a site
- Reduced construction time
- Pond construction can occur during slower times of the year
- Maintenance of surrounding native grassland uplands are a fraction of the cost to maintaining sod around the ponds
- No maintenance required to remove or manage unwanted algal blooms or excess submersed vegetation in future years

Increased Commercial and Tax Revenue

- Higher property values around naturalized ponds results in good economic returns for Developers in addition to higher tax revenues

Environmental and Community Benefits

- Improved water quality and watershed health
- No toxic algal blooms or unwanted submersed vegetation
- Increased biodiversity
- Improved carbon sequestration and decreased greenhouse gas emissions
- Fewer concerns with loafing Canada Geese
- Introducing natural elements of our historic prairie landscape into urban environments

Above/Below: **Construction and development of South Pointe naturalized stormwater pond, Winnipeg**

Cost Comparisons

Construction and Commissioning

One concern often raised by land developers is, "will the construction of a naturalized SRB cost more?" Table 8 provides a cost comparison for constructing a traditional SRB and a naturalized SRB of the same size. The naturalized pond includes costing for planting native species both below the normal water level (NWL) and between the high water level (HWL) and NWL.

Table 8. Cost comparison of a traditional SRB and a naturalized SRB in 2012 (NPS data).

Native Plant Solutions

Pond Construction Cost Comparison

16,900m² HWL; 9500m² NWL (2.35 acres)

Winnipeg Estimate – YR 2012

Traditional Stormwater Pond

- **Construction Costs:**
  - Pond Excavation — $316,620
  - Granite rock, geotextile & excavation — $146,575
  - Design and professional fees (est. 7%) — $38,640
- **Planting Costs:**
  - Sod & 4'' screened soil — $88,800
- **Initial Maintenance Costs (3 years):**
  - Mowing lawn grass — $9000
  - Weed control
  - Litter management

TOTAL $599,635

Naturalized Stormwater Pond

- **Construction Costs:**
  - Pond excavation — $269,000
  - Design fee (est.) — $16,450
- **Wetland Revegetation:**
  - Continuous and planting divots — $11,805
  - Placement of wetland growth medium — $7,600
  - Plant extraction, hauling, placement — $29,400
  - Emergent zone and wet meadow seed — $2,850
- **Native Grass Establishment:**
  - Upland/Bufferstrip topsoil placement — $22,200
  - Upland/Bufferstrip peat amendments — $18,500
  - Bufferstrip native grass seeding — $33,300
  - Erosion Control — $36,000
- **Initial Maintenance Costs (3 years):**
  - Goose deterrence activities — $31,000
  - Weed control — $4,500
  - Wetland commissioning — $15,000
  - Post-establishment maintenance — $3,700
  - Professional services — $12,500

TOTAL $513,805

Cost differences lie in the different approaches to construction. Traditional SRBs require more earthworks, geotextile, and hard infrastructure.

Ongoing Management and Maintenance

Traditional SRBs require very different management strategies compared to naturalized SRBs as shown in Table 9.

Table 9. Annual management and maintenance costs for traditional SRBs and naturalized SRBs in the City of Winnipeg.

Native Plant Solutions

Pond Maintenance Cost Comparison: City of Winnipeg Costs

Activity	Traditional Stormwater Pond	Naturalized Stormwater Pond
Upland vegetation maintenance	$320/ha, 10x/year Equates to $3200/ha/yr	$6500/ha every 5 years (i.e. upland native grass burn) Equates to $1300/ha/yr
Remove shoreline debris	$300/year	n/a
Remove floating debris	$300/year	n/a
Herbicide weed control Aquatic weed harvesting	$1000/ha, 1-3x/year* $1,200/ha + $350, 1-3x/year*	n/a n/a
Shoreline vegetation maintenance	$0.18/m shoreline every 5 years	n/a
Inlet/outlet pipe maintenance	$500/year	$500/year
Revetment replacement	$8000 every 25 years	n/a
Operation, technical & maintenance support	$300/year	$300/year
TOTAL ANNUAL COST	**$10,048 / ha**	**$2,100 / ha**

Pond maintenance cost comparison was obtained from SEG Engineering (January, 2006) Report on 'Proposed wetland stormwater retention basins capital and life cycle cost comparison.', prepared for the city of Winnipeg; * - frequency of weed control and harvesting – provided by the City of Winnipeg

Environmental Benefits – A Review of Supporting Scientific Studies

While the Walkerton review of the scientific literature indicated that naturalized SRBs with wetland elements should improve water quality, there still remained a lot of skepticism. So a number of studies were conducted to compare the water quality performance of traditional SRBs to naturalized SRBs. These studies were followed up by further investigation on the effectiveness of different management approaches in traditional ponds for improving water quality.

Study 1 – Smart Park (Traditional SRB) versus Royalwood (Naturalized SRB)

Objective: To study the water quality and algal communities in a traditional and naturalized SRB, both constructed in the same year

Study Period: Weekly in 2003 and 2004, from May through October

Parameters: Nitrogen/phosphorous and algae

Researchers: Native Plant Solutions (NPS)

Findings: **Nitrogen and Phosphorous**

- N:P ratio in the Smart Park SRB never rose above 4:1 in 2003 and 2004
- Ratio of N:P maintained itself near 20:1 for most of the summer in both years in the Royalwood SRB
- Dissolved phosphorous levels (TDP) were 30 times higher in Smart Park than in Royalwood

Algae Populations

- Phytoplankton biomass in the Smart Park Pond was heavily dominated by blue-green algae
- Overall, algal biomass was 18 times greater in the Smart Park SRB than in the Royalwood SRB
- Blue-green nitrogen fixers were 2200 times greater in the Smart Park SRB

Study 2 – Constructed Wetlands for Storm Water Management in the City of Winnipeg: Implications for Greenhouse Gas (GHGs) and Water Quality

Background: Winnipeg has in excess of 70 traditional storm water retention basins whose primary function is to act as land-drainage storage reservoirs for the City

The conventional stormwater ponds often become choked with vegetation and algae. This aggravates property owners who have been led to believe that the ponds should function like pristine "lakes"

Objective: The study compared greenhouse gas (GHG) emissions, algae and water quality in traditional SRBs versus naturalized SRBs

15 SRBs were monitored: 5 naturalized SRB's, 5 traditional SRBs (no treatment) and 5 traditional SRB's (with treatment)

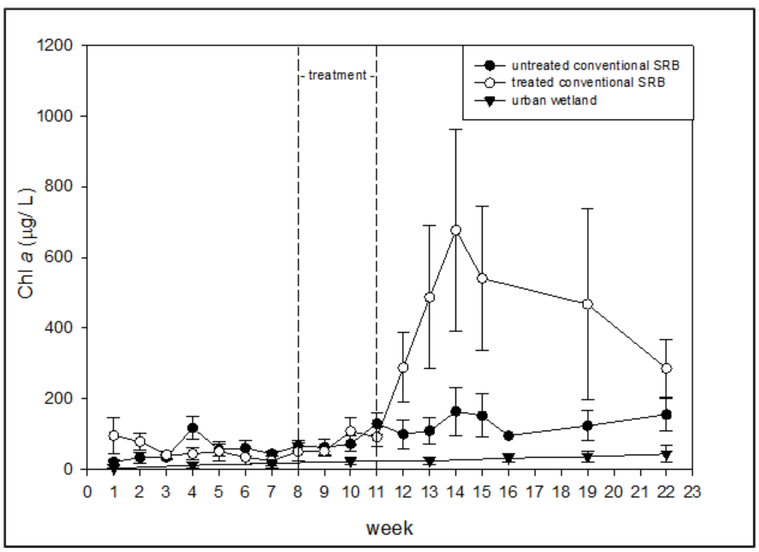
Treatment consisted of either chemical or physical removal of algae/submersed vegetation

Study Period: H_2O weekly in 2007, GHG every 3rd week

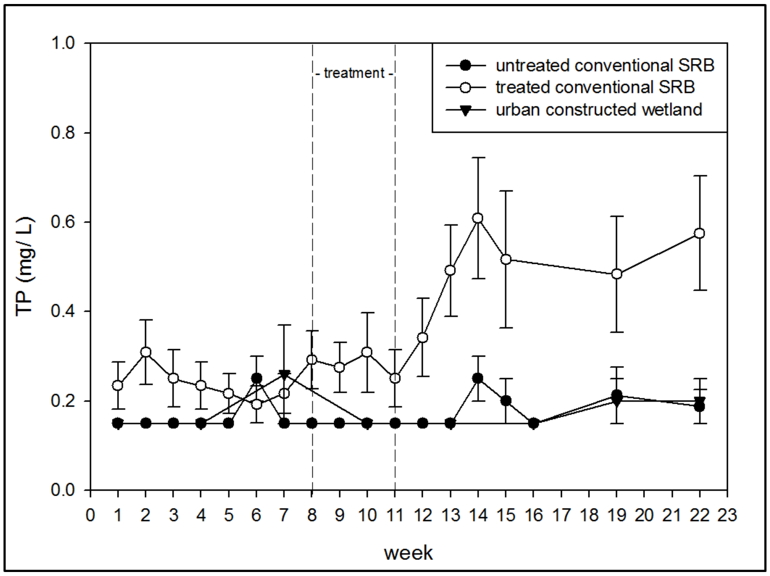
Parameters: Nitrogen/phosphorous, chlorophyll *a* and GHGs

Researchers: Ducks Unlimited Canada, City of Wpg, Native Plant Solutions

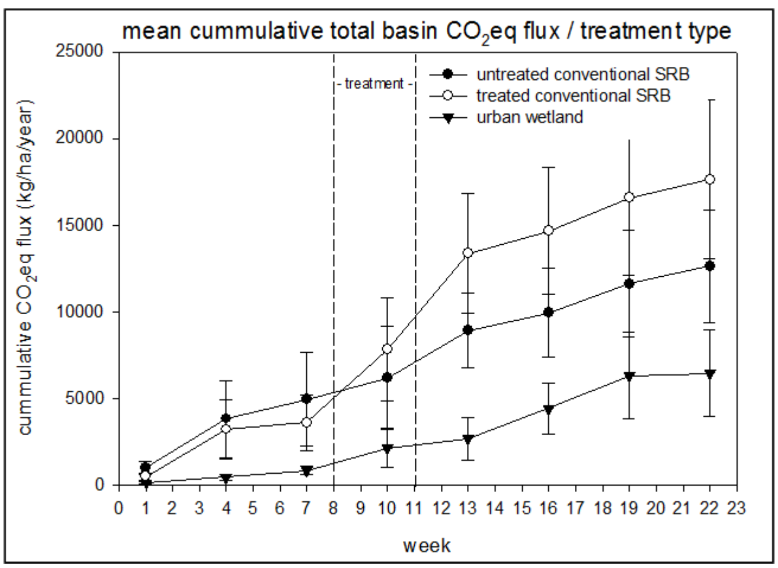
Findings: **Chl *a***



Total Phosphorous



GHG Emissions



- Water quality in naturalized SRBs were superior to that of conventional SRBs (both treated and non-treated)
- GHG emissions from naturalized SRBs were significantly lower than emissions in conventional basins (both treated and untreated)
- The chemical and physical treatments used by the City of Winnipeg to control excess submersed plant and algal blooms appears to worsen water quality and increase GHG emissions

Moving Forward - The Professional Team

As we discussed on Day 1, one of the most important steps for ensuring project success is the professional team, whether it is for the construction of a naturalized stormwater pond or incorporating a natural wetland into an urban landscape. This is important for the design and construction phases of the project and also for commissioning the site through those early years of development. Wetlands, either constructed or natural, are some of the most biologically diverse and productive ecosystems in the world. As a result, they possess many unique chemical, physical, hydrological and biological features. Many of these features are interrelated or connected, and because of this, when one part of the system is not performing as expected, other areas of the system will be impacted as well. Consequently, newly constructed systems often require the expertise from a variety of professionals who have skill sets in various areas, and who also have the ability to interpret site data in a meaningful way. Every project steam should include professionals that possess expertise in the following areas:

- Engineering
- Biological
- Technical
- Regulatory and Certification

It is important the project team clearly understand the objectives of the project, are familiar with the site design, have been involved through the construction phase of the project, and have the ability to interpret results and respond quickly if required. Newly constructed wetland sites will quickly show you if something is not performing as expected. Therefore, those first few years of operation are critical for the long-term success of the project. Much of that success will depend on our ability to pull together the right professional team.

Project Coordination and Scheduling

The most successful projects are those where the project team is in place and working together well in advance of a final stormwater design being submitted for approval. Final designs will be improved and project costs can be reduced. For those involved in projects that include naturalized SRBs and the preservation of natural wetlands it is important to consider:

1) The placement of naturalized SRBs in relation to natural wetlands early-on in the planning process.
2) That stormwater design plans improve, and costs are reduced, when site data is collected early in the development stage.
3) Naturalized SRBs require a level of pre- and post-planning not required when constructing traditional SRBs.

   Pre-planning activities include:

   - Locating donor plant material and acquiring native grass seed
   - Infrastructure requirements that can be different from traditional SRBs

- Planning for unique water requirements in terms of amounts and timing
- The timing of construction activities in terms of plant movement/commissioning and wildlife impacts (i.e., summer versus winter)
- Additional erosion control measures

Post-planning activities in the first few years include:

- A guaranteed water source at the time of commissioning (both naturalized SRBs and natural wetlands)
- Water level manipulations (potentially all sites)
- Additional plant enhancements (wetlands) / weed control (uplands)
- Monitoring on all sites (infrastructure, asbuilts (SRBs), water levels, vegetation, wildlife, erosion, water quality, etc.)
- Wildlife control - SRBs

One of the most important roles the project team can play is keeping the developer of the land informed. The processes and steps involved for constructing and commissioning naturalized SRBs are quite different from traditional SRBs. This is also true for preserving natural wetlands in urban plans. Integrating the two systems requires additional considerations. Therefore, those first few on-the-ground projects will benefit greatly if everyone is kept informed and educated along the way.

Integrating Wetlands into Stormwater Systems from a Hydrological Perspective

It is important to recognize that wetlands in and around the City of Edmonton (and almost anywhere) have already been impacted by development. As a result, it is valuable to understand how their "natural" state may have already been impacted or altered. Some of these impacts include:

Drainage improvements to both natural water courses and roadways may have:

- Altered natural flow patterns
- Impacted both the volume and timing of inflow
- Drained or changed the spill level of wetlands
- Increased the effective drainage area

Agricultural improvements to uplands may have:

- Removed tree and/or native grass cover increasing runoff
- Allowed tillage to increase sediment loads
- Drained or filled wetlands

Natural wetlands whose drainage basins fall within developing urban areas will be impacted. This impact will start when development occurs anywhere in the drainage basin. Development on adjacent properties could have impacts as significant as those impacts from development on the property containing or partially containing the wetland of interest. Some impacts will include:

Alteration of the effective size of the drainage basin:

- This can include either increases or decreases
- Can occur from both internal improvements and diversions

Basin yield can be impacted through:

- Loss of permeability
- Loss of storage

Sedimentation from:

- Tillage
- Construction

Finally wetlands will be impacted by development immediately adjacent to them through:

- Lowering of water table
- Increases in impermeability
- Increase in sediment
- Changes in runoff regime in both volume and timing

Challenge/Impact	Mitigating Strategies
Increase in Annual Volume of Runoff	Partial Diversion to Constructed Wetland/Pond. LID to limit increases. Adjustments to Basin Size.
Increase in Sediment/Nutrient Loads	Silt Traps Upstream. LID. Construction BMPs. Selective Basin Area. Linking naturalized SRB's to wetlands
Increase in Flood Peaks	Diversion to Constructed Wetlands/Ponds. Basin Wide BMPs.
Timing of inflows	LID. Water Level Management (Annual Drawdown). Diversions.
Integration with Storm System	Plan for Topographical Challenges (pipes lower than wetland). Only utilize "natural wetland" storage at frequencies 1:2 to 1:5.
Mitigating Unavoidable Impacts	Identify. Avoid. Minimize. Replace.

Truly integrating existing wetlands into an urban environment will be challenging and will probably never achieve 100% predevelopment values. However, this should not stop us from trying to meet the challenges. We are still learning and it is important that we continue to learn from both our failures and successes.

Design Criteria & Elements: Naturalized SWM Facilities and Natural Wetlands

Naturalized SWM Facilities

Design guidelines for naturalized SWM facilities, such as the City of Edmonton`s, generally apply but engineers and landscape architects will need to work as part of a team, particularly with those responsible for the upland and wetland landscape designs and installations. A review of those design guidelines with an approach that attempts to provide for “naturalized” wet ponds as opposed to the two separate categories or approaches of wet ponds versus constructed wetlands may be useful in simplifying the process for everyone. Stormwater ponds and constructed wetlands for the improvement of water quality need not be mutually exclusive. As we’ve observed in Day 2, stormwater ponds can be designed to include natural wetland elements that function to improve water quality.

Hydrologists will need to be prepared to provide additional information, specifically hydro-periods. Landscape designers will require frequency, depth and duration of flooding in order to plan appropriate plantings and for commissioning of the naturalized pond. A variety of slopes and benches will be required for vegetative and aesthetic purposes. Those detailed site designs should be included as part of the final suite of deliverables once the commissioning phase is complete.

One important consideration before site hand-off occurs is the time it requires to get naturalized ponds up and running. Unlike sod, wetland plants can take two to three years to mature and expand across a newly constructed pond. Water levels may need to be manipulated to encourage wetland plant growth in years 1 and 2 of operation. In the upland areas, native grass species often require 2 years of intensive weed management in order to ensure successful survival. As a result, the commissioning times between traditional versus naturalized stormwater systems can vary and this difference should be taken into account.

Integrating Natural Wetlands

No amount of planning, designing and execution can eliminate all the impacts of urbanization on a wetland and therefore we will be faced with avoiding impacts when possible, minimizing them through smart site designs, and mitigating for those locations where integration is just not feasible.

Work should start at the planning stage to ensure wetlands can be conserved. Ensuring stormwater is directed to the wetland is not enough.

Step one - is understanding the type of wetland that exists.

Step two - is identifying if the wetland has already been impacted by developments? If so, when did these occur? Does it have significant impacts on groundwater interactions or surface water flows?

Step three - is verifying the wetland's current or natural water regime. How often does it spill? How high does it flood and for how long? How frequently does it dry out?

Step four - for conserving a wetland is designing a flow regime that attempts to mimic the predevelopment regime. Achieving this would be ideal.

Step five - seeks to understand the influence of, and plans for, the impacts of land grading and construction on the drainage basin including topsoil stripping and erosion. Water availability throughout the construction process will be crucial for the viability of the wetland.

Step six - investigates how groundwater movements will be impacted by development. Will the minor system lower the water table? Will the basin seal be impacted and what would be the impact?

Step seven - asks if the minor system can bypass the wetland? Could this minimize the summer flows that are not typical of prairie wetlands?

Step eight – investigates if overland flow can provide enough water to maintain the wetland. Can large grassed areas make up a significant portion of the wetland's drainage basin? Consider the expeditious placement of schoolyards, park sites and rear yard drainages. Recognize that all over land flows entering a natural wetland should include BMP's for improving water quality before it reaches the wetland.

Step nine – recognizes that annual drawdown and drought cycles are significant factors in the establishment and maintenance of wetland vegetation. Can they be mimicked through the control of inflows? Can variable controls be used to mimic these fluctuations? To what degree do we need to mimic them to conserve the wetland?

Step ten – respects that the judicious placement of a naturalized pond adjacent to a conserved wetland could allow for the use of the wetland footprint for storage of large infrequent flood events. If the constructed pond can handle the 1:2 to 1:5 events without impacting the conserved wetland, what impact would occur from the larger events? Would these be minor?

Step eleven – realizes that conserved natural wetlands will probably need to be managed to some degree in order to maintain their functions and values. Is the expertise available to assess when a management intervention needs to occur?

Step twelve – recognizes that not all natural wetlands are suitable for integration and not every wetland can be saved in its entirety. Can reliable and timely options be developed to provide mitigation where impacts cannot be avoided?

Conclusion

The main objective in constructing stormwater systems that integrate naturalized SRBs and/or wetlands should be to construct them in a way that management interventions are kept to a minimum over the lifespan of the project. This requires project planners to identify and clearly define measurable goals from the beginning. The most common causes of project failures are often unrealistic expectations or undefined objectives and poor planning. A lack of clearly stated objectives in addition to a lack of monitoring both pre- and post-construction often results in, at best, a subjective view of success at the end of the project. In too many cases, our assessment of what a wetland should be depends on observations made either too hastily, over too short a period of time, or across too narrow a landscape perspective. Project planning and adaptive management strategies are interrelated and both vital pursuits for any organization involved in constructing naturalized SRBs and preserving urban wetlands. Good project planning that considers the right variables from the start helps to set the proper direction and provide the team with early warnings that the project is straying of course. Adaptive management strategies that are aligned with monitoring activities will help define and develop measurements for project accomplishments that are biologically meaningful, affordable, and useful for informing management actions, not only on the project in question but on future projects as well.

References

Adams, G., Buteau, P., Dignard, N., Grondin, P., Jeglum, J., Keys, D., Mills, G., Price, J., Rothwell, R., Rubec, C., Selby, C., Veldhuis, H., Warner, B., Wells, D., and Zoltai, S. 1997. The Canadian Wetland Classification System, Second Edition. B.G. Warner and C.D.A. Rubec (Eds.). National Wetlands Working Group, Canadian Wildlife Service, Environment Canada.

Euliss, N.H., and Mushet, D.M. 1996. Water-level fluctuation in wetlands as a function of landscape condition in the prairie pothole region. Wetlands 16: 587-593.

Gabor, T. S., Kiers North, A., Ross, L.C.M., Murkin, H.R., Anderson, J.S., and Turner, M.A. 2001. Beyond the pipe: The Importance of Wetlands and Upland Conservation Practices in Watershed Management, Functions and Values for Water Quality and Quantity. A report commissioned by the Ontario Walkerton Inquiry.

Mitsch, W.J., and Gosselink, J. G. 2000. Wetlands. John Wiley & Sons, New York, NY, USA.

Naiman, R.J., Magnuson, J.J., McKnight, D.M., and Stanford, J.A. (Eds.). 1995. The Freshwater Imperative: A Research Agenda. Island Press, Washington, D.C.

Ross, L.C.M. 2009. Vegetation and soil properties as indicators of the hydrology and ecological health of northern prairie wetlands in native and agricultural landscapes. M.Sc. Thesis. University of Manitoba, Winnipeg, MB.

Ross, L.C.M. 2011. Minimal ecological management. Cumulative Environmental Management Association, CEMA Contract #2011-0033. 90 pp.

Smith, K.B., Smith, C.E., Forest, S.F., and Richard, A.J. 2007. A field guide to the wetlands of the boreal plains ecozone of Canada. Ducks Unlimited Canada, Western Boreal Office, Edmonton, AB.

Stewart, R. E., and Kantrud, H. A. 1971. Classification of Natural Ponds and Lakes in the Glaciated Prairie Region. Bureau of Sport Fisheries and Wildlife, Fish and Wildlife Service, United States Department of the Interior.

Su, M. 1998. Modeling the water balance of a small prairie wetland. M.Sc. Thesis. University of Saskatchewan, Saskatoon, SK.

van der Valk, A.G. 2000. Vegetation dynamics and models. Pages 125-162 *in* H.R. Murkin, A.G. van der Valk and W.R. Clark (Eds.). Prairie Wetland Ecology: The Contribution of the Marsh Ecology Research Program. Iowa State University Press, Ames, IA.