Decision making: Comprehensive assessment of trade-offs between wetland protection and potential benefits of development.
A Wetland Conservation Strategy for London.

Recommendations for the City of London and Our Development Partners
Prepared for the City of London by the Ecological and Environmental Planning Advisory Committee

1. Introduction

One of the most ecologically diverse and productive ecosystems in the world, wetlands are rich in biodiversity, providing habitat for many species. In the Great Lakes region, wetlands are vital for sustaining populations of a variety of wildlife species and plant life. They also render many ecological services including, water purification, flood regulation, sediment trapping and nutrient cycling. And as we navigate the uncertainties of a changing climate in the coming years, wetlands provide crucial services, removing greenhouse gas from the atmosphere, regulating temperatures and decreasing the urban heat island effect, slowing the impact of droughts, and reducing flood and erosion risks. While they provide 40 percent of all ecosystem services worldwide, they only cover 1.5 percent of the Earth's surface, with Russia and Canada home to the largest wetland areas. Canada's wetlands are diverse, consisting of marshes, bogs, fens, swamps and open water. Wetlands in Ontario currently cover 350,000 square kilometres, comprising 25 percent of all the wetlands in Canada and six percent of the world's wetlands (A Wetland Conservation Strategy, p.2). In addition, they keep communities healthy and safe, and provide opportunities for recreation.

Though wetlands are one of the most important ecosystems on the planet, they are also one of the most threatened due to human activities -- urbanization, economic development and climate change (Pattison-Williams et al., 2017). Wetland loss and degradation around the world has occurred at an alarming rate; over 64 percent of the world's wetlands have disappeared in a little over a century (Pattison-Williams et al., 2017). In Canada, approximately twenty million hectares of wetland have been drained for agricultural purposes since European settlement, totalling an approximately 70 percent loss of wetlands from historical highs (Pattison-Williams et al., 2017). In southern Ontario in the 19th century, two million hectares -- or 25 percent of the terrestrial area -- consisted of wetlands. By 2002, 72 percent (1.4 million hectares) had been lost largely due to agriculture and expanding urban and suburban development. (Ducks Unlimited, p. 1). From 1982 until 2002, southern Ontario lost another 3.5 percent of its pre-settlement wetlands, equally 70,854 hectares, at an average of 3545 hectares per year (Ducks Unlimited, 2010, p.1).

In southwestern Ontario, the loss of wetlands has been the most dramatic, with over 85 percent of the areas originally covered in wetlands converted to other uses. In Middlesex County, 5.1-20 percent of the area was covered by wetlands prior to settlement, but by 2002 less than five percent was covered in wetlands (Ducks Unlimited, 2010, p.9). Between 85 and 100 percent of the wetlands were converted in Middlesex county between 1800-2002 (Ducks Unlimited, 2010, p. 14). These studies only covered wetlands that are greater than 10 hectares in area, which signifies that if smaller wetlands were included, the annual loss of wetlands would be even greater, especially since smaller wetlands are frequently filled in for development projects, such as construction of housing. With that degree of destruction, southern Ontario has foregone ecosystem services locally and beyond, lost essential habitats for threatened, endangered and/or migratory species, and witnessed a decrease in species' populations.

Until recently, our understanding of wetlands -- and the services and functions they provide -- was limited. Though our knowledge is expanding and society increasingly recognizes the importance of wetland preservation and, in some cases, restoration, wetland losses still continue at an astonishing rate. Wetlands are often considered insect-infested wastelands, and as such land use policies have not and do not prioritize their conservation. Instead, they were (and are) drained and/or filled in for roads, agricultural use, housing developments, new shopping complexes, or even used as waste sites. As Pattison-Williams et al. noted, "Loss of riparian wetlands has occurred because natural ecosystems such as wetlands are not currently valued by the market system and few financial incentives exist for landowners to maintain them" (Pattison-Williams et al., 2017).

At the same time that they are threatened by development projects, wetlands are subject to several stressors, such as encroachment by invasive species. sedimentation, nutrient loading and pollution from agricultural and urban runoff (e.g. phosphorus from fertilizers, de-icing salts), and climate change. In London, urban expansion and development pose a serious threat to wetlands. In year 2017, a large number of development projects involving wetlands were undertaken in London, Ontario. Wetlands are rarely exposed to a single threat; multiple stressors usually interact to exacerbate problems. For instance, invasive species thrive in areas where native species are struggling due to a changing climate. Indeed, climate change has emerged as a major threat to wetlands, as alterations in temperatures and weather patterns may lead to shrinking or disappearance of wetlands. With altered rain patterns, and severe rain events, wetlands may shift from one form to another, or the vegetation may change as native species struggle with temperature differences, or animal species' relationships may alter (A Wetland Conservation Strategy for Ontario, 2017).

Ontario's public strongly supports wetland conservation (Lantz et al., 2013). Given the significant loss of wetlands globally and the large area of wetlands in Ontario, the province has a duty to protect the remaining wetlands it has, and to restore and/or rehabilitate destroyed and/or degraded wetlands. Ontario's wetlands contribute to the province's rich biodiversity and promote the health and safety of its citizens. Going forward, the province's population will continue to grow, placing increasing demands on resources. Consequently, efforts to conserve natural areas, like wetlands, will continue bump up against economic interests. Therefore, the City of London requires a clear set of guidelines governing development projects, such as housing plans and expanded transportation infrastructure, to avoid disturbance, reduce impacts and mitigate unavoidable damage.

2. Definitions

- **Wetland** -- An ecosystem which is seasonally or permanently covered in standing water or saturated with water for a least part of the year, or where the water table is close to or at the surface, such that vegetation has adapted for growth in saturated conditions.
- **Swamp** -- A wetland with trees, associated with flowing water, and tends to be highly productive.
- **Marsh** -- A wetland without trees, associated with flowing water, and tends to be highly productive. Dominated by non-woody plants such as cattails, rushes, pond lilies and submerged plants.
- **Bog** -- A wetland with acidic soils that may or may not have trees, with waterlogged soils -- fed solely by precipitation -- that tend to accumulate peat, and is associated with low productivity. They are often very old, perhaps thousands of years. Bogs often have a low diversity of species. Rare in southern Ontario.
- **Fen** -- A wetland dominated by grasses, sedges and rushes that may or may not have trees, with waterlogged soils that tend to accumulate peat. Fens are fed by groundwater and surface water runoff, and is associated with low productivity. Rare in southern Ontario.
- **LID** -- Low Impact Development
- **Restoration** -- Bringing back areas degraded through actions such as in-filling, changes in drainage patterns, sedimentation, vegetation removal and pollution
- **Rehabilitation/Creation/Re-creation** -- Bringing back once-existing wetlands
- **Biodiversity Offsetting** -- Compensating (or attempting to compensate) for losses of biodiversity at an impact site by either creating ecologically equivalent gains or credits at an in-site or off-site location. The purpose of biodiversity offsetting is to incur no-net loss of biodiversity.
- **Mitigation Hierarchy** -- A tool used in biodiversity offsetting to minimize the harm that occurs due to a project. The preference should be given first to avoiding negative impacts, then to minimizing impacts at a project site, followed by restoration/rehabilitation and finally, offsetting biodiversity losses that cannot be avoided.
- **Urban Heat Island Effect** -- When an urban or metropolitan area is significantly warmer than rural areas due both to human activities and the built environment.
- **Additionality** -- To what degree does an offsetting project generate new and additional contributions to biodiversity conservation/wetland conservation.
- **Wetland Offsetting** – Compensation for the negative impacts of development through the restoration or creation of new wetlands to achieve no-net-loss or a net environmental gain.
- **Mitigation banking** – The developer purchases offset credits from a wetland bank, that is, an area that has been previously restored, created, enhanced or preserved and set aside by a third party, and certify for compensation. The banker is responsible for the success of the compensation project.
- **Invasive species** – a non-native species that outcompetes native species and becomes a nuisance or threat to ecosystems.

2. Purpose and Justification

London is a growing and dynamic city. Development projects, especially housing and commerce, continue to expand, regularly coming into conflict with natural areas. With a growing population and economic and social pressures to expand infrastructure and development, project proposals will increasingly come into conflict with our remaining wetlands. Ecosystem services -- considered free, common goods -- provided by wetlands are regularly omitted in the market prices of projects. Consequently, wetland loss and/or disturbance is rarely given adequate consideration in land-use planning decisions. Currently, land conversion is the biggest threat in southern Ontario. Urban pressures are driving up the price of land, making land markets highly competitive, which ultimately leads to significant rates of wetland conversion (Lantz et al., 2013).

Provincial and municipal action is vital to ensure that the region's wetlands can continue to provide ecosystem services, the benefits of which are manyfold for both the environment and society. Ontario is moving forward with a strategy to stop wetland loss and to restore wetlands where the largest losses have occurred. The City of London likewise needs to have clear guidelines regarding wetlands, their preservation, restoration and rehabilitation.

International Law and Wetlands. Globally nations have recognized the need to preserve wetlands. Internationally, the protection of wetlands is governed by Ramsar, adopted in 1971 and came into force in 1975. Canada ratified Ramsar in 1982, committing itself to wetland conservation. Ontario has eight registered wetlands. The Ramsar Convention conceived to protect "the fundamental ecological functions of wetlands as regulators of water regimes and as habitats supporting a characteristic flora and fauna, especially waterfowl" (Birnie and Boyle, 2002, p. 611). It obliges nations to identify special wetland areas, to list them on the List of Wetlands of International Importance, and to "promote" their protection and wise use.

At a subsequent conference in Regina in 1987, "wise use" of wetlands was defined as "their sustainable utilization for the benefit of humankind in a way compatible with the maintenance of the natural properties of the ecosystem" (Birnie and Boyle, 2002, p. 618). Later, the Working Group on Criteria and Wise Use defined "sustainable utilization" as "human use of a wetland so that it may yield the greatest continuous benefit to present generations whilst maintaining its potential to meet the needs and aspirations of future generations" for the purposes of Article 3 of the Ramsar convention (Birnie and Boyle, 2002, p. 618). They also found that activities involving wetlands should be governed by the precautionary principle, and when complete knowledge is lacking regarding the outcomes of an activity, that activity should be prohibited (Birnie and Boyle, 2002). To date however, the majority of nations are not applying the precautionary principle regularly in regards to wetlands, as evidenced by the continued rapid loss of wetlands.
Wetlands are also governed by the 1972 World Heritage Convention, as they form part of our "natural heritage" -- "areas which constitute the habitat of threatened species of animals of outstanding universal value from the point of view of science and conservation" (Article 2).

Beyond Ramsar, wetlands also receive protection through the 1979 Bonn Convention on Migratory Species, through its calls for conservation of habitat for migratory species. Habitat is defined as "any area in the range of a migratory species which contains suitable living conditions for that species" (Birnie and Boyle, 2002, p. 611). Wetlands clearly fall under this realm as these ecosystems provide crucial habitat for a wide range of migratory species.

The Convention on Biological Diversity likewise indirectly provides protection for wetlands through Articles 8(d) which "[p]romote[s] the protection of ecosystems, natural habitats and the maintenance of viable populations of species in natural surroundings". Article 8(e) also asks for signatories to "Promote environmentally sound and sustainable development in areas adjacent to protected areas with a view to furthering protection of these areas. Also relevant to wetlands, given that many have been destroyed and/or degraded is Article 8(f), which asks states to "[r]ehabilitate and restore degraded ecosystems and promote the recovery of threatened species, inter alia, through the development and implementation of plans or other management strategies. Finally, Article 8(h) is important when we consider development projects within the City in or around wetlands as it asks states to "[p]revent the introduction of, control or eradicate those alien species which threaten ecosystems, habitats or species". Invasive species regularly take hold after wetland disturbance, either due to species' stress or due to contaminated construction equipment (like we have seen with the spread of Phragmites in our region). Finally, the Aichi Targets of 2010 (particularly Target 11) requires signatories to protect 17 percent of their nation's terrestrial area by 2020. However, the majority of nations are not on track to meet that goal; Ontario has only succeeded in protecting 11 percent of its terrestrial area so far.

Often conservation is limited to areas within parks and protected areas; more must be done to protect biodiversity and ecosystem services beyond reserves in daily operations and land use planning. The Convention on Biological Diversity states in Article 6(b) Contracting Parties shall [...] "Integrate, as far as possible and as appropriate, the conservation and sustainable use of biological diversity into relevant sectoral or cross-sectoral plans, programmes and policies.
Conservation must be incorporated into all areas of policy and development to ensure that wetlands are afforded the appropriate level of protection.

Finally, since wetlands are an integral part of dealing with climate change, both mitigation and adaptation, their protection also falls under the United Nations Framework Convention on Climate Change 1992.

Provincial Legislation: Since 1982 wetland conservation has grown in importance, as the province recognizes wetlands as one of its most important natural capital assets. In the early 1980s, Ontario issued a discussion paper titled "Toward a Wetland Policy for Ontario". From that, the government developed a policy paper called "Guidelines for Wetland Management in Ontario" (1984). In 1992 the government issued the Wetland Policy Statement. Now, over twenty different pieces of legislation govern wetland management, while five provincial ministries, two federal departments, a provincial agency, 36 conservation authorities (which are meant to support municipalities) and 444 municipalities implement wetland policies (A Wetland Conservation Strategy for Ontario, 2017).

Perhaps the most important piece in wetlands conservation today is the 2014 *Provincial Policy Statement*, which prohibits development or site alterations in all provincially significant wetlands, or in lands adjacent to provincially significant wetlands, unless it can be demonstrated that the wetland and/or its ecological functions will suffer no negative impacts (PPS 2.1.4(a)) and that 2.1.6 "*[d]evelopment* and *site alteration* shall not be permitted in *fish habitat* except in accordance with *provincial and federal requirements*" (PPS 2.1.6). It also states: "The diversity and connectivity of natural features in an area, and the long-term *ecological function* and biodiversity of *natural heritage systems,* should be maintained, restored or, where possible, improved, recognizing linkages between and among *natural heritage features and areas, surface water features,* and *groundwater features*" (PPS 2.1.2). Furthermore, the *Provincial Policy Statement* makes clear that all of the policies contained within it are minimum standards only and that planning authorities and decision-makers are free to take even more stringent measures regarding conservation. The *Provincial Policy Statement* asserts that our natural heritage is a resource: "The Province must ensure that its resources are managed in a sustainable way to conserve biodiversity, protect essential ecological processes and public health and safety, provide for the production of food and fibre, minimize environmental and social impacts, and meet its long-term needs" (p.4).

2.1.1 "Natural features and areas shall be protected for the long-term" (PPS, p. 22).

Currently, Ontario's wetlands strategy is guided by "A Wetland Conservation Strategy for Ontario 2017-2030". It strives for a social and political climate where "Ontario's wetlands and their functions are valued, conserved and restored to sustain biodiversity and to provide ecosystem services for present and future generations" (A Wetland Conservation Strategy for Ontario, 2017, p. iii). The strategy comprises two targets: the net loss of wetland area and function will stop by 2025 where wetland loss is the greatest, and a net gain in wetland area and function will occur by 2030 where wetland loss has been the greatest. The Strategy also puts forth the principle that wetlands should be conserved according to three hierarchical priorities -- protect (retain area and functions of wetlands), mitigate (minimize further damage), restore (improve and re-establish wetland area and function).

Most significantly, the fourth principle in "A Wetland Conservation Strategy for Ontario" calls for a precautionary approach regarding wetlands and development and other projects affecting wetlands. This stipulation means incorporating wetland conservation into environmental impact statements provincially and municipally.

Wetland conservation equally appears in other provincial environmental policies. In 2011 Ontario published its biodiversity strategy called "Biodiversity: It's in our Nature", which outlined the province's plan to protect biodiversity from 2012-2020. It specifically includes actions to improve wetland conservation. This strategy falls in line with the *Provincial Policy Statement* what addresses the preservation of the habitat of endangered and threatened species (PPS 2.1.7). Additionally, Ontario's Climate Change Strategy and Action Plan views wetland conservation as key to mitigating carbon emissions and the impacts of climate change. Ontario has been updating its climate change adaptation planning with "Climate Ready: Ontario's Adaptation Strategy and Action Plan, 2011-

2014”, which has many reference to maintaining and restoring ecosystem resilience, including protecting and restoring wetlands. And, the *Provincial Policy Statement* asserts that “Healthy, liveable and safe communities [should be] sustained by promoting development and land use patterns that conserve biodiversity and consider the impacts of climate change” (PPS, 1.1.1(h)).

Municipal Policies: The London Plan

Land use planning has the greatest influence on the conservation of wetlands. Official plans (e.g. The London Plan), local decisions on land use, and community based land use plans have far reaching impacts on the green spaces of our City, and how the City moves forward with approval for development projects that conflict with conservation values.The London Plan has clear provisions for the “identification, protection, conservation, enhancement, and management of our Natural Heritage System” (1293.1). Of particularly importance for London as it considers the retention of its wetlands, no matter how small, is The London Plan’s statement that “[t]he diversity and connectivity of natural features and areas, and the long-term ecological function and biodiversity of Natural Heritage Systems, will be maintained, restored or, where possible, improved, recognizing linkages between and among natural heritage features and areas, surface water features, and groundwater features” (*The London Plan* 1301). The City plans to ensure that its Natural Heritage System is “protected, conserved, enhanced, and managed for present and for future generations by [...] [p]rotect[ing], maintain[ing], and improv[ing] surface and groundwater quality and quantity by protecting wetlands [...]” (*The London Plan,* 1308).

The London Plan specifies that no development or alteration shall occur in provincially significant wetlands as evaluated and confirmed by the Ministry of Natural Resouces and Forests (MNRF), designating them instead as Green Space (*The London Plan,* 1332, 1333, 1390). This provision is in accordance with the *Provincial Policy Statement,* but in essence it only applies to Sifton Bog and Westminster Ponds, the two PSWs located within London.

The key clause of *The London Plan* for the purposes of these guidelines is 1334, which states that “[d]evelopment and site alteration shall not be permitted within a wetland. There shall be no net loss of wetland features or functions. In some instances, and in consultation with the conservation authority having jurisdiction, the City may consider the replacement of wetlands where the features and functions of the wetland may be provided elsewhere and would enhance or restore the Natural Heritage System” (The London Plan, p. 350). Moreover, 1335 goes on to say “Development and site alteration shall not be permitted within and/or adjacent to an unevaluated wetland identified on Map 5 and/ or if an Ecological Land Classification determines that a vegetation community is a wetland that has not been evaluated”. And 1391 again reiterates that ““Development and site alteration shall not be permitted in [...] wetlands [...] unless it has been demonstrated that there will be no negative impacts on the natural heritage features or their ecological functions”. These paragraphs do not specify that the wetland must be “provincially significant” nor does they qualify ‘wetland’ with a size. However, clause 1334 does suggest an opening for relocation and/or offsetting disturbed wetlands, but without specifications on how these projects should be undertaken or monitored. It is this gap that these guidelines will attempt to fill.

2.1 Habitat and Species Impacts

While the economic benefits of wetlands tend to focus on flood control and water purification, wetlands provide other irreplaceable ecological services. One of the economically unappreciated features of wetlands is their contribution to biodiversity conservation and maintenance of the web of life. Since marshes and swamps are usually shallow enough to allow sunlight to penetrate and to allow for seasonal warming, they support photosynthetic activity, making them highly productive areas, full of diverse and abundant species. In Ontario, wetlands are biodiversity hotspots, supporting a variety of plants, birds, insects, amphibians and fish. Wetlands provide food and habitat for a large variety of species, and are particularly valuable to migratory water and shore bird species for breeding and nesting.

Wetlands come in a variety of types each with their own characteristics and suite of species. Wetland types are recognizable by their indicator and keystone species (Table 1).

Table 1: Common keystone and indicator species in Southwestern Ontario's Wetlands

Species	Habitat Types	Habitat requirements
Broadleaf cattail *Typha latifolia*	• Marshes • Bogs • Fens	• A common resident of the marsh environment, it is usually one of the first species to colonize new habitats • It is common in early-seral and open-canopy communities • This species requires full sunlight • Light and warmth from sunlight are required to germinate seeds • Seeds germinate in all conditions, acidic, neutral or basic but will not germinate in waters above 1 atm of osmotic pressure • Seeds will also germinate in low oxygen conditions • Cattails can occur in sand, silt, loam and clay substrates
Small-fruited bulrush *Scirpus microcarpus*	• Marshes • Fens	• A common resident of the marsh environment, it can tolerate both full-sunlight and shade • This species requires silty/mucky soil with a high water holding capacity • This species grows best in neutral but can also grow in acidic conditions
Soft maples *Acer saccharinum, A. rubrum*	• Swamps	• These species are commonly found along the edges of swamps and is tolerant to waterlogged soils and flooding. • They can tolerate sun or shade and in all soil types. • They can thrive in acidic, neutral and basic conditions
Black spruce	• Bogs • Swamps	• This species is indicative of a bog environment and is also found in coniferous swamps. • It is tolerant of highly acidic soils and is most abundant in peat bogs. • It is a pioneer species in bogs and can invated the *Spaghum* spp. mat. It grows well in a variety of soils, moisture levels and light conditions.
Common cottongrass *Eriophorum angustifolium*	• Bogs • Fens • Marshes	• These species are commonly found in bog and fen environments and can be occasionally found in open wetlands

		• This species prefers calcareus peat and acidic soil. It grows well in poorly drained peat, sand, clay or loam and can survive in chalybeate (iron-enriched) water. • This species survives best in full sun but can grow in partial sun.
Fragrant white water lily *Nymphaea odorota*	• Marshes	• The fragnant white water lily is a perennial plant floating aquatic plant that can grow in up to 8 ' of water. • It is common in wetlands and can be found in wetlands, lakes and slow-moving areas of rivers. • These plants have faunal associations with a large number of insect species and have food value for ducks. • This species prefer slightly acidic water rather than calcareous and alkaline.
Purple pitcher plants *Sarracenia purpurea*	• Bog • Fen	• This species is indicative of a bog environment and has evolved to survive in the low nutrient and highly acidic environment. It can also be found in fens, although is much less common. • This species is adapted to a nutrient poor soil that are deficient from trace elements such as molybdenum. It requires acidic soils for growth. • This species obtains its essential elements by predating upon invertebrates such as flies, ants and spiders. These species fly into the pitcher and drown in the pitcher water. Digestion is performed through a number of digestive enzymes released by the pitcher plants in addition to a digester community comprised of bacteria, protists, rotifers and other invertebrates such as the mosquito *Wyeomyia smithii*, the majority of these species being specialists and reliant on the pitcher plant.

Sphagnum moss *Sphagnum* spp.	• Bogs • Fens	• These species are the keystone species of the bog and fen environments. • They retain a large amount of water while both living and while dead. Further, they do not decay readily as a result of the phenolic compounds found in their tissues. As such, their presence forms large mats of vegetation on acidic water, the basis for bogs. • Their presence helps shape the wetland environment for other species such as carnivorous plants (ie. Purple pitcher plant) and other acidic tolerant plants.

Wetlands are also a home to a number of Ontario's species at risk (Table 2).

Table 2: Species at risk that occur in London's wetlands

Species	Status in Ontario	Habitat type	Habitat requirements	Threats
Eastern Ribbonsnake *Thamnophis sauritus*	Special concern	• Marshes • Fens • Bogs • Swamps	• Found in areas with permanent water near terrestrial habitat (Harding 1997; Schribner and Weatherhead 1995) with shallow water and low, dense shoreline vegetation (Minton 1992; Cosewic 2002) • Habitat includes bare substrate near wetlands including gravel, cobble and boulders (Desroches and Leparé 2004). • Terrestrial habitats close to wetlands include open and sunny areas where there are clumps of grasses, sedges or low shrubbery (Harding 1997; Imlay 2009). • Habitats used by Eastern ribbonsnakes must have a high abundance of amphibians, particularly frogs, as these are their primary food source (Carpenter 1952; Brown 1979; COSEWIC 2012).	• Their biggest threats are loss of habitat including loss of wetland and riparian habitat (Environment Canada 2015).
Eastern prairie fringed orchid *Platanthera leucophaea*	Endangered	• Marshes • Fens • Swamps	• Requires open conditions with full sunlight and is restricted to graminoid-dominated vegetation communities (Bowles 1993). • It requires soil that is neutral to slightly calcareous (Bowles et al. 2005, Case 1987, Bowles 1983) and can tolerate	• The largest threats to the orchid are the lack of suitable habitat due to its specific

			pHs of between 5.3 and 7.5 (Zambrana Engineering Inc. 1998). • It is also found in a range of soil types, including deep, black calcareous silt loams, and muck soils (Zambrana Engineering Inc. 1998). • Wetland habitats where it occurs in ontario are fens dominated by Wire Sedge (*Carex lasiocarpa*), fens dominated by Common Reed (*Phragmites australis*) and other sedges (*Carex* spp.) and poor fen mats around lakes dominated by sphaghum moss and ericaceous shrubs (Eastern Prairie Fringed-orchid Recovery Team 2010) • The eastern fringed-orchid is adapted to fluctuations in water levels (COSEWIC 2003)	habitat needs as well as habitat loss and degradation (Eastern Prairie Fringed-orchid Recovery Team 2010)
Spotted turtle *Clemmys guttata*	Endangered	• Marshes • Bogs	• This species is commonly found in areas with water associated with lake, marsh, pond and bog environments. • These species rely on connected wetlands and do not disperse more than 3km between suitable wetland habitat	• Two of its major threats are habitat loss and degradation. The loss of wetlands and wetland degradation, especially by way of common reed (*Phragmites australis*), are

				devastating to these turtles and the current state of many wetlands may not support populations long term

2.2 Physical Environment Impacts

Wetlands are vital for people and their health and safety, through their ability to control flood waters, protect against natural disasters, mitigate and adapt to climate change, and purify water. In a bid to encourage preservation and restoration of wetlands, the economic benefits of these ecosystems are often highlighted. In particular, economists point to the monetary value of clean water, flood and erosion mitigation and climate moderation. This ability to store flood water and reduce the amount of water flowing downstream alone is valued at billions of dollars a year. The natural water purification system within wetlands removes silt and sediments, preventing them from entering rivers, gathering nutrients and forming fertile agricultural land. Chemical reactions detoxify and neutralize toxic substances in the water, thereby protecting us from pollution. London is surrounded by agricultural land and wetlands easily remove organic material, particularly phosphorus and nitrogen, preventing it from flowing into our river system.
They alleviate drought by holding water when conditions are dry. Water accumulated in wetlands also seeps into the ground, helping to replenish underground aquifers. Wetlands work to mitigate climate change by absorbing greenhouse gases, acting as carbon sinks that stabilize climate conditions. In places in Ontario, such as Lake Simcoe, it has been shown that loss of wetland ecosystems leads to eutrophication of lakes. Simply put, wetlands are an environmentally positive and cost effect means by which to treat a variety of environmental issues
.

3. General Information

3.1 *Wetlands as an important natural heritage feature of our city*

Our wetlands are important for our city. With rapid urban growth and development projects, they are a vanishing ecosystem within and beyond the city limits. They provide green space, stepping stones for species on migratory routes, habitat for insects and amphibians, and recreational opportunities for London's citizens. London's wetlands help maintain and enhance the city's biodiversity, forming a network of linkages connecting species. They are transitional habitats, that connect aquatic and terrestrial habitats. As more of the city's land is transformed with impervious covers, the remaining wetlands become increasingly important for flood management. And with climate change, the city's wetlands lessen the urban heat island effect and help combat drought that comes with altered weather patterns. They form a significant part of our natural and cultural heritage landscapes. London is fortunate to have two Provincially Significant Wetlands in two of its Environmentally Significant Areas -- Sifton Bog and Westminster Ponds.

Wetlands can range in size from very small (only a few metres squared) to hundreds of kilometres squared. Wetlands may be isolated, occur along the edges of lakes and rivers, or exist in conjunction with other natural areas such as woodlands, shrublands and native grasslands. In some cases, closely spaced wetlands related in a functional way can also form what is known as a wetland complex. In southern Ontario the average wetland is 25 hectares and most are swamps, dominated by trees and shrubs. They take many years to develop. London has many small wetlands that frequently come into conflict with development projects and so the city must have clear guidelines on how to deal with wetlands going forward.

3.2 Primary screening when changes to a wetland are proposed
The simple procedure systematically considers key criteria to assess the opportunities and implications of whether or not to implement changes to a specific wetland.

1.Identify present ecological classification of the wetland

a) Is the wetland "evaluated wetland" Ontario Wetland Evaluation System
    i) Yes……………………..Access the evaluation file
    ii) No……………………..Go To 2. Perform Comprehensive evaluation

Wetlands are ranked to determine whether they should receive special protection as "provincially significant". Significance is determined by the Ontario Wetland Evaluation System (OWES) . Provincially Significant Wetlands (PSWs) are those areas identified by the province as being the most valuable. Provincially Significant Wetlands are identified using objective criteria based on the best available science The OWES ranking system is a standardized method of assessing wetland functions and societal values, which enables the province to rank wetlands relative to one another. A wetland that has been evaluated using the criteria outlined in the OWES is known as an "evaluated wetland" and will have a "wetland evaluation file. As wetlands may change over time OWES files for a given wetland is considered as an "open file".

2. Perform Comprehensive evaluation of Present Ecological Condition

a) Undisturbed ………………. Go To 3.1, 3-2
b) Moderate disturbed………... Go To 3.1, 3.2, 3,3
c) Highly disturbed……………..Go To 3.1, 3.2, 3,3

3. Perform Comprehensive evaluation of Present Ecological Services and Restoration

(3.1) Services	**(3.2) 1= no effect, 10=highest effect**	**(3.3) Restoration strategy**
Regulating		
Influence on air quality how if <.5ha size?		
Climate regulation How if <.5ha?		
Moderation of extreme events		

How if <.5ha?		
Regulation of water flows Is it part of complex, connected to water table?”		
Waste treatment?		
Erosion prevention		
Maintenance of soil fertility		
Pollination		
Biological control		
Habitat Service/Gene Pool	**Identify diverse species**	
Plant Species		
Animal Species		
Microbes		
Cultural	**1= No effect 10=High**	
Aesthetic		
Recreation/tourism		
Cognitive information		
Total Evaluation		

4. If Total evaluation is poor (scale less than) Wetland Relocation can be considered
5. If Total evaluation is moderate (scale between xxxx) wetland Restoration recommended
6. If Total evaluation is high Wetland need to be protected

4. General Recommendations

The purpose of wetland conservation is to both halt wetland loss as well as to restore and rehabilitate wetlands that have been lost.

4.1 *Preservation should be the norm*

“Natural ecosystems provide the foundation of a functioning human society” (Pattison-Williams et al., 2017, p. 400).

According to the mitigation hierarchy, preservation or avoidance of harm should always be the first priority. Wetlands are, in fact, afforded even greater protection under any offsetting policy and multiplier ratios due to the recognition of the vital ecosystem services they provide, and the realization that wetland areas have already declined dramatically. Consequently, in London, preservation of our wetlands, no matter their size, should be paramount. The possibility of relocating a wetland for a development project should not be used as an excuse to undertake that project, when avoidance of disturbance is equally an option. Economic concerns should not be given greater weight that environmental concerns where wetlands are concerned.

The more complex the hydrology or the ecological system, the more difficult it is to restore a wetland completely and in fact, in many cases it may be impossible. Very little is known about restoring inland freshwater wetlands, such as ponds, forested wetlands, bogs or fens (Kentula). With forested woodlands, woody vegetation takes so long to grow that often monitoring has ceased before these species have had time to establish. For London, where many of the affected wetlands are in, near or support woodlands, this time lag is significant and should be accounted for in development and post-disturbance monitoring plans.

International, national and provincial legislation and policies stress the importance of employing the precautionary principle in regards to environmental problems. This principle should be applied more rigorously in regards to wetlands where our knowledge of their functions and processes is limited. Instead, too much faith is put into the ability of restoration, relocation and recreation of wetlands to recover lost biodiversity (Maron et al., 2012). This misguided faith has led to an increase in biodiversity loss, as decision-makers, believing that restoration can deliver equivalent or better results, approve development projects that promise to damage ecosystems and functions. Time lags, uncertainty and problems with the measurability of the value being offset can seriously limit the technical success of offsets (Maron et al., 2012). As long as evidence is lacking to prove that restoration science and practice can achieve no-net loss of biodiversity, the precautionary principle should prevail. As Maron et al. advise, “the less certain we are that we possess the knowledge and technological ability to restore a biodiversity value, the less appropriate is offsetting as a response to potential loss of the value” (Maron et al., 2012, p. 145). It is the case that “project impacts cause immediate and certain losses, whereas the conservation gains of an offset are uncertain and may require many years to achieve” (McKenney and Kiesecker, 2010,p. 171).

Of particular importance to London where most of the wetlands that would be affected by development are quite small, studies have shown that larger wetlands recover faster than smaller ones, and that restored and/or created wetlands that are small may become more isolated, surrounded by fragmented landscapes. Small wetlands may only be able to support a limited number of individuals and they may not be connected enough to larger systems for local biota to restore the wetland to pre-impact functioning (Moreno-Mateos et al., 2012).

Restoration, relocation and recreation projects seldom meet targets. As Poulton and Bell noted, "[n]owhere is there a resounding success story, where offsetting has been demonstrated to achieve its full potential" (Poulton and Bell, 2017, p. i). In a study by Suding (2011), reviewing the successes and failures of restoration projects around the world, it was found that only a third to a half of projects were successful where restoration was used to fix a degraded system, and that when restoration was used to re-create a habitat, the success rate was even lower (Maron et al., 2012). Re-vegetated areas on highly degraded sites rarely resemble the target ecosystem (Maron et al., 2012). The actual recovery after ecological restoration is uncertain. In a meta-analysis of restored wetland systems around the world by Moreno-Mateos et al. (2012), it was found that even after a century, the biological structure (i.e. plant assemblages) and biogeochemical functioning (storage of carbon in wetland soils) was on average 26 percent and 23 percent lower respectively than reference sites. Recovery is clearly very slow, or in some cases the post-disturbance systems move toward an alternate state that is different from the reference conditions (Moreno-Mateos et al., 2012). Therefore, wetland offsetting should be used as an absolute last resort in the mitigation sequence, especially in the absence of proof that offsetting consistently leads to no net loss or a net gain in biodiversity. Preservation should always be the first option.

4.3 *Relocation and Monitoring*

Wetland relocation (a compensation plan) is considered when the wetland feature does not achieve a provincially or municipally significance designation or significant wildlife habitat is not confirmed, but the wetland feature provides productive amphibian breeding habitat and habitat for terrestrial crayfish. Under the 'The London Plan' (2016) all wetlands regardless of size, are to be protected under the Natural heritage system policies. In every case before we relocate or alter a wetland, we must consider the merits of destroying the functionality of an existing wetland and replacing it with a wetland that may in the future only operate at 75 percent functionality (in the best case scenario) or which may transform into a different type of wetland. In that case we need to ask, is the existing or replacement function more important, will the proposed wetland increase wetland diversity, and is the increased biodiversity worth any loss to habitat of endangered species that may result from a project (Kentula).

If the wetland functions can be replicated, a similar habitat is created elsewhere on the subject lands and target wildlife are gathered and trapped from the wetland habitat lost due to the development project and transported to the compensation wetland.

<u>Wildlife Transfer Steps use by Stantec at 905 Sarnia Road</u>
1. Construction of the compensation wetland. (timelines between construction and transfer??)
2. Grading of the new habitat features, and the addition of root wads to the new feature banks.
3. Native seeds are broadcast in the deep pool, shallow pool, riparian areas and dry upland areas surrounding the feature.
4. Dewatering and water transfer of the old pond.
5. Wildlife transfer begins with 7 days of baited minnow trapping.
6. On the drainage date, wildlife capture techniques included dip netting, seine netting and

hand picking. Captured wildlife are placed in tall buckets and transported to the compensation pond.
7. Selective transfer of riparian vegetation from the existing to the compensation pond. Riparian top soil is not transfer because of the possible presence of invasive seed banks.
8. Aquatic and substrate are removed from the existing wetland and released in the compensation wetland along with the wildlife captures.
9. Downed woody debris are collected from around the existing wetland and placed strategically around and in the compensation area to provide basking opportunities for wildlife transfers.
10. On the final day, additional muck is transferred to the compensation pond.
11. Timing: Period length of transfer? Preparation of compensation pond?

'Target' Wildlife in a Wetland

The ecology and life history of 'target' wildlife such as terrestrial crayfish, western chorus frogs, northern leopard frog, eastern newt, brock stickleback, midland painter turtle, and snapping turtle must be considered before wildlife transfer.

For Example:

1. Terrestrial Crayfish
There are nine species of crayfish in Ontario and three of them are consistent (obligate) burrowers . Their names are: Cambarus d. Diogenes (Meadow or Devil crayfish), Fallicambarus fodiens (Chimney or Digger crayfish) and Orconetes immunis (Calico or Papershell crayfish).

Orconetes immunis (Calico Crayfish)

Calico crayfish are found in stagnant ponds and ditches and slow-moving streams. The bottom is mud with a heavy growth of rooted aquatic vascular plants. Because this species can burrow (1 metre deep) in the ground when necessary, it can utilize temporary pond habitat and spend the winter in the burrows. This species is largely herbivorous, feeding on the abundant vegetation of a pond, or, at night, on terrestrial plants close to shore. They are active both by day and night, but the adults are more strictly nocturnal. The species can travel across dry land at night, especially if there is rain or a heavy dew, and in this way can move from pond to pond. Copulation takes place from mid-July to early October, mostly yearling individuals participating. Eggs are laid in late October, and are carried on the underside of their abdomen through the winter. Hatchling .. Juveniles spend the summer growing, may become sexual active in September, but most wait until late the following summer. The normal lifespan is two years. (Crocker, 1968)

2. Pseudacris triseriata (Western Chorus Frog)

These small frogs weigh as much as a paperclip and are less than half as long as your thumb.

Adaptations prevent their cells from freezing. They require 25 days to travel 200 metres. Most individuals live no longer than 1 year, some for 2-3 years. They feed on small insects and other invertebrates.During breeding, western chorus frogs use shallow, fishless ponds and large puddles that dry up in the summer. Reproduction happens just after ice-out in early spring. Eggs hatch and tadpoles grow into adults in as little as two months depending on the water temperature. After breeding, the adults move overland to protected areas (woodlands) where they remain active the rest of the summer and spend the winter in undisturbed soft soil.
Meadows and forests located right next to breeding ponds provide great habitat where frogs can spend the summer and overwinter undisturbed.(Bird Studies Canada pamphlet)

Annual Post-Construction Monitoring

Before the monitoring process even begins, practitioners, developers, and the City must clearly define what a "successful" relocation or restoration would entail for each *individual* project, and outline a clear set of objectives. For instance, even if a site has revegetated, it could be functionally inadequate, and/or the plant composition may differ from the initial goals.

The three, five, ten year annual monitoring report includes qualitative and quantitative observations of water level, riparian and aquatic vegetation, overflow, breeding birds, amphibians, terrestrial crayfish chimneys and incidental wildlife associated with the constructed feature. However, given that significant time lags occur before a mitigation project can be determined a success, the time scale may require adjustment. Evidence has demonstrated that even 100 years after disturbance and restoration, the functions of a wetland may not have fully recovered. Indeed, to date restoration ecologists have been unable to re-create full functional replacement; it may not even be possible to fully re-create all the functions of a wetland. Careful and regular monitoring over a long period of time is vital to catch any problems that may arise (wetland shrinkage, incursion by invasive species) and to ensure greater probability of success of any wetlands project. In the absence of sufficient monitoring and adaptive management,designing wetlands to be self-sustaining and self-managing will better guarantee that they succeed.

Quantitative observations include an amphibian call survey (3 spring visits), crayfish burrow count using the quadrat method, baited minnow trapping, riparian and aquatic vegetation inventory, and the measuring of spring, summer and fall water levels.

Qualitative observations include turtles, any incidental wildlife, backyard encroachment and the health of neighbouring woodlots and other vegetation (invasive species) near and beyond the wetland.

If monitoring indicates that certain populations are in decline, additional individuals can be transferred into the compensation wetland (e.g. import tadpoles, broadcast more native seeds). Wetlands are particularly vulnerable to invasive species, due to their interconnection with waterways, their proximity to roads (paths along with invasive species may travel), and due to climate change which puts stress on wetlands due to changing weather patterns (increased rainfall

and/or drought). Re-created, restored or relocated wetlands will be particularly vulnerable to invasive species as they have suffered a disturbance and opportunistic plants can establish themselves quickly in areas where native species are stressed. If an invasive species (e.g. phragmites, purple loosestrife) is observed, the growing
population can be carefully removed.

4.4 Wetland Offsetting

An option to prevent the net loss of wetlands in Ontario is the development of a wetland offsetting policy. Recently offsetting has become a popular approach to balance development projects with the need to protect biodiversity. However, it must be made clear that offsetting will not replace other legislation that provides protection for certain wetlands (i.e. provincially significant wetlands) where disturbance is prohibited. Wetland offsetting involves mitigating negative impacts upon one wetland by intentionally restoring or creating a new wetland at a different location. This type of policy is typically set within a mitigation hierarchy and involves the hierarchical progression of alternatives, including avoidance of impacts, minimization or mitigation of avoidable impacts and offsetting of impacts that cannot be avoided. The Ontario government remains committed to offsetting only being used as a last resort (OMNF, 2017). Wetland offsetting is meant to ensure no net loss of biodiversity, and, ideally, a net gain of biodiversity. However, there is always the risk that the offset never achieves an equivalent conservation value.

Several jurisdictions in Canada and around the world have developed wetland offsetting policies. Accepted methods of compensation include wetland restoration, creation, enhancement and preservation. The London Plan touches on offsetting or "compensatory mitigation" in 1402, stating that it may be provided through "[a]dditional rehabilitation and/or remediation beyond the area directly affected by the proposed works" and/or "[o]ff-site works to restore, replace or enhance the ecological functions affected by the proposed works" (The London Plan, 1402).

Biodiversity offsetting usually involves restoration as a way to offset specific losses in biodiversity or to trade for losses that may occur in the future. Biodiversity offsetting and wetland offsetting in particular, is meant to follow the mitigation hierarchy which calls for projects to avoid impacts, then minimize impacts that cannot be avoided, to then mitigate unavoidable impacts and finally to offset impacts that cannot be avoided. The Ontario government has said that it will use offsetting as a last resort in regards to wetlands. A common concern with biodiversity offsetting is that it exchanges "certain losses for uncertain gains" (Maron et al., 2012). And uncertainty regarding the outcome of an offset are significantly higher if the restoration is occurring at a significantly modified site.

There really is no one-size-fits all guidance for offset; local contexts can provide a variety of challenges. As McKenney and Kiesecker (2010) point out, no two areas are exactly ecologically identical and we cannot expect with relocation or re-creation to produce an exactly equivalent wetland. So then, how do we best create "equivalency" to address the losses of biodiversity and functionality? Questions that must be addressed prior to any relocation or offset project are: where should the offset be located, when and for how long should it be operational, how should we manage risk of failure, and what will we do if an offset fails to reach its goals (McKenney and Kiesecker, 2010). Timing is a major issue with offsetting, whether restoring, relocating or re-creating. It could be many years, if ever, that a wetland project reaches maturity. Sometime policy statements require offsets to be in place before a project takes place, but with the pace of development in London, this provision may not be practicable.

Multiplier ratios. To address the problem that restoration or re-creation projects rarely, if ever, produce an equally biodiverse and functional wetland, multipliers are used to determine the scope of an offset project. Since wetlands are particularly valuable, the offset multiplier for wetlands is usually higher compared to other areas. Specifically, a restoration area should be several times larger than the impact site to compensate for the very high risk of failure or low performance. The London Plan species that "mitigation shall mean the replacement of the natural heritage feature removed or disturbed on a one-for-one land area basis (The London Plan, 1401), which seems insufficient given the uncertainties of success and the the goal of the provincial wetland strategy aiming for a net gain of wetland area. However, The London Plan goes on to say "[c]ompensatory mitigation shall mean additional measures required to address impacts on the functions of the Natural Heritage System affected by the proposed works. The extent of the compensation required shall be identified in the environmental impact study, and shall be relative to both the degree of the proposed disturbance, and the component(s) of the Natural Heritage System removed and/or disturbed" (The London Plan, 1401). And 1402 (3) does state that "[r]eplacement ratios greater than the one-for-one land area [are] required to mitigate the impacts of the proposed works" (The London Plan, 1402).

Duration. Ontario is still determining the duration of wetland offsets, whether they should be for the duration of the negative impacts or whether they should be in perpetuity. Given the ongoing losses of wetlands across southern Ontario, it can be assumed that wetland restoration projects or relocation should continue in perpetuity, especially since it has been demonstrated that evidence does not exist that these wetlands recover full functionality. Moreover, once a wetland has been moved for one project, that "relocated" or offset wetland, should not then itself become the subject of another development project and be relocated again.

A number of factors will have to be determined for offsets: the appropriate policy mechanisms for implementation, the roles and responsibilities for implementation, reviewing long-term results of wetland offsetting and restoration, and establishing monitoring requirements to make sure that the wetlands' functions have been properly restored (A Wetland Conservation Strategy for Ontario). The three existing mechanisms for compensation are permittee-responsible mitigation and two forms of third party mitigation: mitigation banking and in-lieu mitigation. In permittee-responsible mitigation the development permit holder is responsible for delivering the offset. In the case of mitigation banking, the permit holder purchases offset credits from a wetland bank. In-lieu fee mitigation involves paying funds to an in-lieu fee sponsor (e.g. Ducks Unlimited) that later uses the funds for mitigation purposes (Poulton, 2017).

As Ontario develops its own unique wetland offset policy, lessons learned from other jurisdictions have helped to establish four key considerations (Poulton, 2017). Four of these lessons are:

1. Need for reliable tracking, reporting and record keeping: Baseline data on wetland functions lost to development must be recorded. Establish long-term monitoring requirement to ensure that wetland functions are restored.
2. Need for a watershed-based approach: Rather than a piecemeal approach, decisions are based on an assessment of the wetland needs in the watershed and the potential for the compensatory wetland to persist over time. The individual offset site should be designed to maximize the likelihood that they will make an ongoing ecological contribution to the watershed.
3. Need to adhere to the mitigation sequence: Avoidance and minimization of adverse impacts must be vigorously applied first. Skipping directly to the compensation step leads to opportunities lost to preserve natural heritage.
4. Need to ensure compliance: Compliance monitoring before and after project construction should endure inspection and enforcement by the municipality.

4.4.1 *Restoration and Rehabilitation*

There is two kinds of restoration: “re-establishment” which is returning the natural or historic function of a former wetland with the goal of increasing wetland area, and “rehabilitation” which is repairing the natural or historic functions of a wetland, such that there is an increase in functions but not in the area of wetlands (McKenney and Kiesecker, 2010). Wetland restoration rehabilitates a degraded wetland or it recreates a wetland that was destroyed. It takes place on land that is or was a wetland. In North America (Canada, US, Mexico) US$70 billion spent attempting to restore 3 million hectares of wetlands from 1992-2012 (Moreno-Mateos et al., 2012). Restoration ecology is a relatively young discipline. Insufficient evidence is available to demonstrate that it is successful.

Several authors warn that “it cannot be assumed that restoration efforts will successfully return a degraded area to a state which is comparable or equivalent to the reference condition” (Matthews and Spyreas, 2010, 143). Hydrologic structure in restored and created wetlands is usually only followed 1-15 years following a project so the long-term changes are unknown (Moreno-Mateos et al., 2012). The abundance, species richness and diversity of native animals and plants in affected wetlands decreases dramatically following disturbance. Many macro-intervertibrates cannot recolonize created or restored wetlands by themselves; they must be brought in by flowing waters or be brought in by other organisms (Moreno-Mateos et al., 2012). Moreover, climate variability and changing weather patterns will make predicting restoration outcomes difficult.

Restoration ecologists are increasingly recognizing that, given their complexity, restoring or (re)creating an ecosystem to some specified state, especially within a short time frame, is not particularly feasible (Hobbs et al., 2011 in Maron et al., 2012). Restoring just the functions of ecosystems can take several decades, and evidence has shown that even after a century, wetlands on average only operate at 75 percent functionality compared to reference sites (Moreno-Mateos et al., 2012). So, while plant biomass or species richness may return to pre-disturbance levels in a shorter period of time, the actual composition of the plants may differ, and the soil composition, chemical properties and ecosystem functions (i.e. nutrient cycling) take significantly longer to be restored (Maron et al., 2012). For instance, Hossler et al. (2011 in Maron et al., 2012) discovered that even though restored and reference wetlands may have similar vegetation and hydrology, restored and created wetlands stored significantly less carbon in their soils and litter and also had much lower rates of denitrification.

Plant assemblages actually take the longest to be restored or created, particularly woody vegetation. It takes an average of thirty years for restored/created wetland sites to converge with the reference states of wetlands. However, the absolute average values of the structural features of plant assemblages was shown to be lower than reference levels even after a hundred years (Moreno-Mateos et al., 2012). Slow or incomplete recovery may be due to dispersal limitation, vulnerable early life history stages or sensitivity of any life stage to altered conditions (Moreno-Mateos et al., 2012). In addition, opportunistic invasive or non-native species may quickly colonize a disturbed area, outcompeting native species, thereby altering the plant assemblage in comparison to reference sites. Moreno-Mateos et al. (2012) also found that carbon and nitrogen storage and cycling drastically decreased in comparison to pre-impact levels.

Restoration can be even more difficult due to challenging situations occurring outside of the site, such as continued urbanization or new development projects that exercise negative influences on the restoration site (Maron et al., 2012). Stranko et al. (2012) looked at the effectiveness of stream restoration in urban areas and found that these restoration activities failed to improve any of eight biodiversity indices. The authors determined that the impacts of urbanization on stream ecology are irreversible and consequently it is unlikely that any biodiversity gains can come from stream restoration projects in urban areas (Maron et al., 2012). The same is likely true of wetlands, and particularly small wetlands, in urban settings.

Recommendations for using restoration to deliver biodiversity offsets or to compensate for wetland loss with development projects.

1. The impacted biodiversity and ecosystem values should be clearly defined and measured.
2. Time lags and uncertainties should be explicitly accounted for in any loss/gain calculation. Time lags should not pose an interim threat to biodiversity values.

Moreno-Mateos et al. (2012) found in their survey of restored wetland ecosystems that those restored wetlands that enjoyed the greatest success were larger wetland areas (greater than 100 hectares) in temperate or tropical climates. Smaller wetlands in colder climates faired least well, which is something important to consider regarding restoration projects in London which are going to involve smaller wetlands in a non-tropical setting. Current restoration practice does not recover original levels of wetland ecosystem functions, even after many decades (Moreno-Mateos, 2012).

4.4.2 *Artificial Wetlands*

Before constructing artificial wetlands, the impacted wetland should be looked at within a larger landscape context and a social context to determine what roles it plays within the larger ecosystem/social structure. For instance, is the current wetland a stop on a migratory route? Does it contribute to the watershed levels? It is necessary to look beyond municipal boundaries, which are artificial limits when applied to ecosystems.

Wetland creation -- construction of a wetland where one did not previously exist -- is much more complicated than restoration.
The elements that must be considered when planning to design and create a wetland are:

- Site-selection
- Hydrologic analysis
- Water source and quality
- Substrate augmentation and handling
- Planter material selection and handling
- Buffer zone placement
- Long-term management (Kentula)

Site selection usually is determined based on the availability of land or on policies that require the restored or created wetland to be in close proximity of a wetland loss (usually due to migration considerations). Location is extremely important in terms of influencing the structure and function of the wetland, and guaranteeing its longevity. Planners must consider both present and future land uses.

The hydrologic conditions are probably the most important factor for determining what type of wetland can be established and what kind of wetland processes can be maintained (Kentula). These include inflows and outflows of groundwater and surface water, the resulting water levels and the timing and duration of soil saturation and flooding (Kentula). Hydrology is greatly influenced by the configuration of the basin (i.e. the depression which will contain the wetland). The position of the basin surface relative to the water table affects the degree of soil saturation and flooding (Kentula). To ensure that water is present year-round, many wetlands are excavated such that the deepest part of the basin is below the lowest anticipated water level. The slope of the basin banks determine how much of the site will become vegetated, and by what kinds of plants (Kentula). In a properly constructed freshwater marsh wetland, the lowest point of the wetland will be inundated with water to a depth and for a period long enough that emergent vegetation can persist, but not for so long that it destroys the plants (Kentula).

The water quality of the wetland is highly important, yet often overlooked. If there are chemical inputs from the surrounding area, these can overwhelm a wetland. This is particularly important if the wetland is close to a road due to the de-icing salts. They can alter the productivity and composition of the plant community of the wetland, possibly favouring nuisance species, and they may harm animal species that cannot survive and breed in highly chemically altered waters.

The soils of a wetland are also really important, since though a created wetland may be structurally similar to a natural wetland, its hydrology may differ greatly if the permeability of the substrates are different (Kentula). Often the soils in created wetland contain less organic matter, which may affect plant growth. Using soils from a "donor" wetland or the impacted wetland to help create the new wetland may be able to increase the soil organic matter and provide the nutrients necessary for plant species, microbes and invertebrates (Kentula). Created wetlands will do better if the plants chosen closely resemble those of similar, local wetlands.

Microbes in the wetland play a crucial role in biogeochemical reactions which causes nutrient cycle and sustain other higher plants and animals. Comprehensive understanding of microbial composition and population will facilitate better understanding about a wetland condition (Bodelier and Dedysh 2013).

Garbisch (1986) suggested choosing herbaceous species that would rapidly stabilize the substrate and have potential value for fish and wildlife; to select species that can adapt to a wide range of water depths; to avoid choosing only species that are favoured by animals or you risk denuding the site (i.e. with geese), and to select "low maintenance" vegetation (Kentula).

Ducks Unlimited Publication - Wetlands on My Lands?

Steps to Creating a Wetland

1.Site Selection - Select the site during spring runoff to get an idea of where water flows and lies in your property. The catchment area (area that provides surface runoff into your wetland) should also be estimated at this time. A topographic survey can also provide more accurate data about surface flow. If the survey determines that there is less than a 0.6 m drop across the site, then excavating a basin is required.

2. Test the Soil - Impermeable soils are an important characteristic of wetlands. Soils that are fine-textured and not sandy and gravelly are suitable. It is also possible to bring in suitable soils(clay) to line the basin so the wetland will hold water.

3. Size and Shape - Wetlands come in all sizes. Make the wetland irregular in shape with many bends in the shoreline to mimic a natural wetland.

4. Wetland Depth - Excavate the wetland with an undulating bottom to encourage various types of vegetation. Emergent vegetation will grow in water depths of 1 m or less. It is advisable that approximately 25% of the area is 1 m or more in depth to ensure an ideal mixture of vegetation and open water. Excavating some deeper pockets will ensure some area will remain free of vegetation and allow the addition of native fish.

5. Wetland and Upland Enhancements - Establish a buffer around the wetland of undisturbed grasses, trees and shrubs. Install nest boxes to increase cavity nesting birds. Drag a few branches or logs into the wetland to provide basking areas for frogs, turtles and ducklings.

5. Conclusion

We need better scientific understanding of biotic and abiotic factors that hamper the success of restoration and relocation projects before we embrace these policies as a means to compensate for losses stemming from development and urban expansion.

6. Policy Recommendations

a. When wetlands are involved in an infrastructure project, the priority should always be to avoid impacts to the maximum extent possible.

b. Any wetland conservation strategy should integrate climate change adaptation and mitigation into its policies and outlook.

c. Compensatory mitigation should not be used to make a potentially avoidable project seem more acceptable.

d. Economic criteria should not be given priority over ecological criteria in development decisions.

e. Restoration and recreation wetlands should be designed to both technically and legally last in perpetuity.

f. A wetland which has been restored or relocated in compensation for another project should not subject to removal or further threats because of its “unnatural” status. It cannot be used as an excuse for future disturbance. See recommendation d.

g. All restored and relocated and disturbed wetlands must be monitored for a period of no less than 10 years.

h. Adaptive management must be incorporated into any and all wetland restoration and relocation projects, including removal of invasive species and other necessary actions to achieve desired outcome.

i. The precautionary principle should influence all projects involving wetlands.

j. Buffer zones are very important especially in urban areas. There should be undeveloped, vegetated land around wetlands and/or a fence or barrier. The composition and width of the buffer depends on the land use that is occurring adjacent to the created wetland, and also the requirements of the animals that will use the wetland and the buffer area.

k. The guidelines should apply to ephemeral water bodies (i.e. those present in spring and early summer). Such bodies are present in many areas of London and play a significant role in the maintenance of life systems in green areas.

7. References