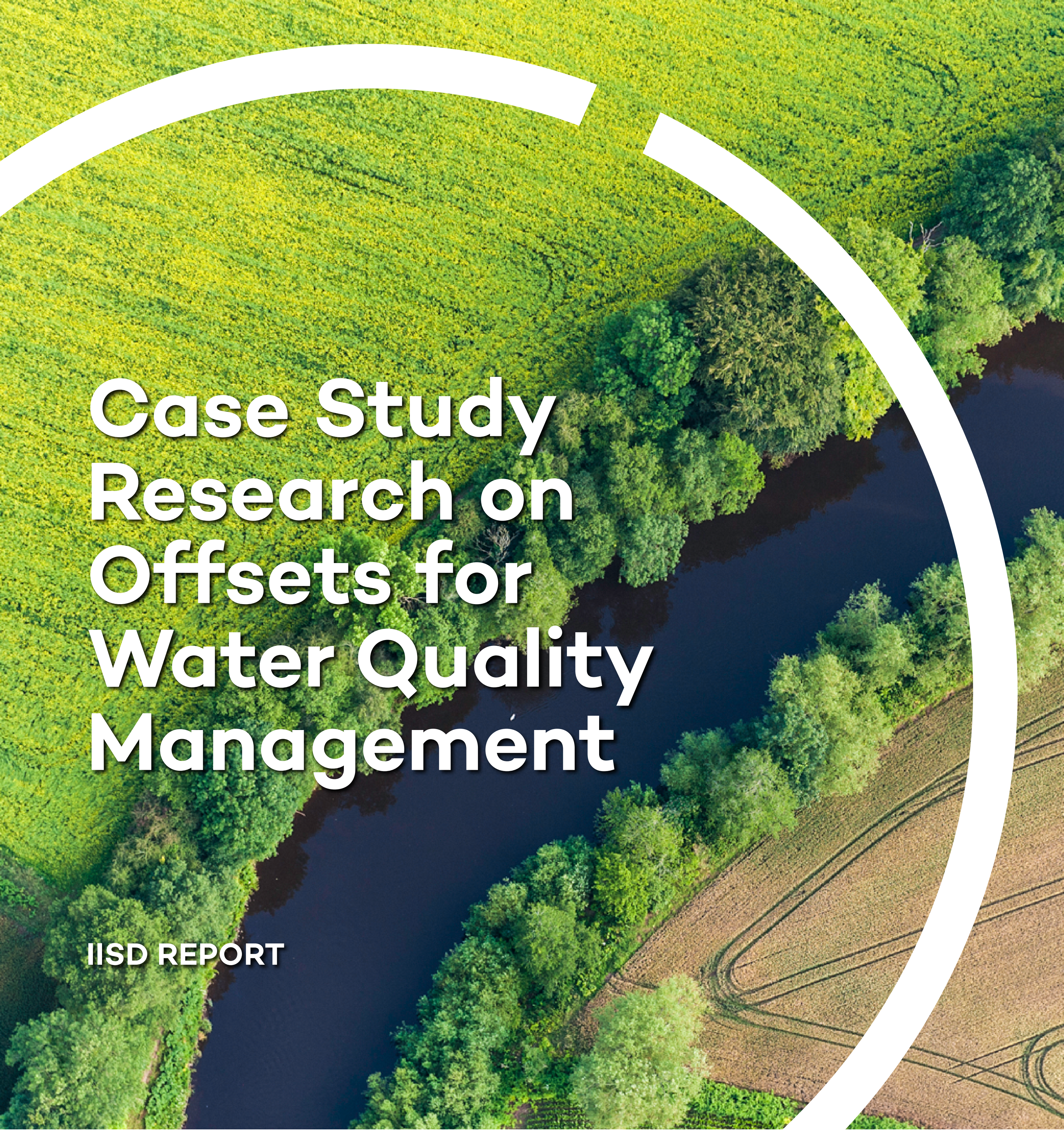

Case Study Research on Offsets for Water Quality Management

IISD REPORT

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Executive Summary

OBJECTIVE OF THE STUDY

This case study research examines six water quality trading (WQT)/offset programs from Canada, the United States and New Zealand and highlights specific policy and program mechanisms that enabled the programs to achieve their goals of reduced nutrient and contaminant loading.

Water quality trading is included in Manitoba's Climate and Green Plan as a means to maintaining water quality in the context of farmlands and municipalities, as well as to reduce overall nutrient loading in the Lake Winnipeg watershed (Manitoba Sustainable Development, 2017). This research provides important lessons for this endeavour on potential offset program design and implementation from other jurisdictions.

The following programs are analyzed:

- Lake Simcoe Phosphorus Offsetting Program (Ontario, Canada)
- South Nation Conservation water quality trading program (Ontario, Canada)
- The Lake Taupō nitrogen trading program (Waikato, New Zealand)
- Clean Water Services' Tualatin River program (Oregon, USA)
- Erie P Market (Western Lake Erie Basin, USA)
- Electric Power Research Institute Ohio River Basin Trading Project (Ohio, USA)

WHAT ARE OFFSETS?

Offset schemes enable cost-effective water quality improvements in a watershed. In situations when a discharger exceeds the regulatory limit on pollutant loads and requires costly infrastructure upgrades to comply, an offset program allows the discharger to purchase water quality improvements (credits) from other entities in the watershed that can achieve the equivalent pollutant reduction by investing considerably less. For example, under a WQT program, a wastewater treatment plant may be able to offset their excess loads through financing best management practice (BMP) projects on agricultural lands in the same watershed and apply water quality improvements toward their compliance requirements.

The main drivers for an existence of an offset/WQT program are:

a) A regulatory agency setting and enforcing the limit (a cap) on pollutant discharges
b) Varying pollution abatement costs across dischargers in the watershed

RELEVANCE TO MANITOBA

In Manitoba, there are currently over 200 wastewater treatment facilities that discharge phosphorus and contribute to the nutrient overloading and eutrophication of Lake Winnipeg. Upgrades to these facilities are resource-intensive and the option of offsetting discharges against nonpoint sources (NPSs) in this agricultural region may provide higher nutrient reductions and several ecological co-benefits in the region.

RESEARCH FINDINGS

Most offset/WQT programs reviewed are point source (PS) to NPS models, where PSs are subject to explicit regulatory limits, while agricultural producers (NPS) are not—they can voluntarily implement BMPs to sell credits.

Some programs, however, make provisions for other trading schemes such as PS–PS (Tualatin River Program), NPS–NPS (Lake Taupō Nitrogen trading program) and stewardship trading (EPRI Ohio River Basin Trading Project).

Based on a review of the six programs, we are able to highlight key elements of successful offsetting and trading operations:

Regulatory framework: Successful offset program design and implementation requires moving from concentration-based to **load-based caps for dischargers**. In the case of concentration caps, the wastewater treatment facilities or lagoons may discharge their effluent at times of peak flow (e.g., in the spring) so that it dilutes to meet the regulated concentration limits on nutrients. This practice may not reduce overall nutrient loading or resulting eutrophication.

Economic incentives: Given a wide range of transaction costs associated with offset/WQT program setup, implementation and operation, **only significant variations in pollution abatement** costs would make offsetting/trading a feasible strategy for the watershed.

Credit: A credit is the **unit of pollution reduction**—the commodity traded in the WQT market. The unit of pollution selected for trading needs to be **measurable and cannot create hotspots** or accumulation of impacts in the watershed. Some programs restrict trading to credits generated upstream of the point of compliance to prevent localized impacts. According to this scenario, a PS may only offset its pollution discharge by purchasing NPS-generated credits located upstream.

Geographical considerations: **A well-defined geographic area** is one of the key elements of success of an offset/trading program and can help ensure that an adequate number of potential buyers and sellers is in place.

Baseline for credit generation: **The baseline takes account of all pre-existing regulatory requirements in the relevant trading area.** It considers all federal, provincial/state and local programs applied before the trading program as the base condition, so that only additional conservation practices, and thus additional benefits, count toward credit generation.

Offset ratios: Offset/trading ratio is a multiplier used to adjust the amount of credits required for purchase in offset program transactions. Trading ratios and their rationale vary from program to program. More commonly, they incorporate some combination of the following variables:

1. Form of the pollutant
2. Geography of polluters (i.e., the location of buyer in relation to seller)
3. Uncertainty associated with the quantification of NPS load and BMP performance (different BMPs perform differently in geographically different contexts and at different times)
4. Credit retirement to ensure a net reduction in water pollution
5. Attenuation of a water quality benefit between the location where credit generation occurs (BMPs are installed) and the point of use
6. Lag in time between BMP installation and BMP producing a full water quality benefit

Offset ratios are very important elements of the offset program design because they ensure equivalency of pollution reductions across trading partners in the watershed. Reliable scientific evidence and consultations with relevant stakeholders are required to support the choice of an offset ratio for the program.

Credit price: In all PS–NPS cases reviewed, a **cost-based pricing model** is utilized in price formation, that is to say, the price is determined by the sum of all cost inputs that go into generating a credit (direct costs of constructing a BMP and indirect costs of project administration). Therefore, the price of unit of pollution reduction is not a competitive price, but often set by a program administrator. In some programs, existing conservation programs were consulted to help determine the credit price for offsets.

Credit stacking: Some BMPs can result in **multiple ecological benefits**, so landowners can receive multiple payments for the ecosystem services they provide. In the case of the Lake Taupō nitrogen trading program, the existence of a carbon offset market made converting lands from livestock farming to forestry more attractive to landowners, since they became eligible for combined benefits of both reduced nitrogen discharge and carbon reduction payments. There, the synergy between the nitrogen trading market and the carbon offset market was a success factor for the uptake of the program.

Engagement with agricultural producers: For those programs that rely on voluntary supply of credits from farmers (most programs reviewed), the success of the offset program will in many ways depend on **communication strategies and institutional frameworks to involve agricultural producers**. Lessons related to this:

- The most successful agricultural trading models make effective use of traditional agricultural soil and water conservation institutions to engage farmers and fund pollution-reduction projects.
- They are also able to ensure **local control and flexibility** of the program design and execution through direct consultation and partnership with local communities and municipalities.
- **Simplifying** eligibility requirements, delivery, verification and other offset procedures for landowners is important to secure their participation.
- Additionally, ensuring **minimal potential liability** for landowners for meeting water quality standards through offsets was determined as a key element.

Program administrator: Using a **trusted intermediary/program administrator** to manage the program is important. Organizations that are independent from government, that work with farmers on a daily basis or that are led by farmers are best suited for marketing and managing the rural part of a PS–NPS program.

Verification and monitoring: In programs involving NPSs, it is important that the **verifier has working knowledge of farm operations** and systems. Ongoing monitoring frequency can be the same for all NPSs (PS–NPS offsetting), or a priority system for monitoring can be established so that farmers who farm intensively are monitored more often and more closely.

The analysis has shown that offset program designs are complex and unique to each watershed, incorporating geophysical, economic and political conditions specific to the area. Nevertheless, some common features and elements, especially for the PS–NPS model, propose some starting points for any WQT efforts that Manitoba plans to undertake. WQT can complement other efforts to incent agricultural BMPs and can act as an interim option in cases where PSs are not meeting regulatory requirements or where upgrades are being planned in wastewater treatment facilities to meet regulatory requirements. Ultimately, leveraging existing local, provincial and federal resources in a coordinated fashion and using WQT by building on existing programs can enable much-needed water quality improvements in Manitoba.

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Acronyms and Abbreviations

BMP	best management practice
CREP	Conservation Reserve Enhancement Program
CWA	Clean Water Act
CWS	Clean Water Services
DEQ	Oregon Department of Environmental Quality
EPA	U.S. Environmental Protection Agency
EPRI	Electric Power Research Institute
GLC	Great Lakes Commission
LEAP	Landowner Environmental Assistance Program
LSPOP	Lake Simcoe Phosphorus Offsetting Program
LSRCA	Lake Simcoe Region Conservation Authority
MOE	Ministry of Environment
NDA	nitrogen discharge allowance
NNWQT	National Network on Water Quality Trading
NPDES	National Pollutant Discharge Elimination System
NPS	nonpoint source
OECD	Organisation for Economic Co-operation and Development
PS	point source
SN	South Nation
SNC	South Nation Conservation
SWCD	Soil and Water Conservation District
TMDL	total maximum daily load
TN	total nitrogen
TP	total phosphorus
TPM	total phosphorus management
TSWCD	Tualatin Soil and Water Conservation District
USDA	United States Department of Agriculture
USRP	Urban Stormwater Retrofit Program
WARMF	Watershed Analysis Risk Management Framework
WLEB	Western Lake Erie Basin
WQT	water quality trading
WRC	Waikato Regional Council

1.0 Background

1.1 Overview

This report comprises case study research to highlight key mechanisms of pollutant offsetting and water quality trading (WQT) programs to derive lessons on the application of such systems in Manitoba, particularly for water quality improvements and drainage management in the Lake Winnipeg watershed. Six case studies are included:

- Lake Simcoe Phosphorus Offsetting Program (Ontario, Canada)
- South Nation Conservation water quality trading program (Ontario, Canada)
- Lake Taupō nitrogen trading program (Waikato, New Zealand)
- Clean Water Services Tualatin River program (Oregon, USA)
- Erie P Market (Western Lake Erie Basin, USA)
- Electric Power Research Institute (EPRI) Ohio River Basin Trading Project (Ohio, USA)

This case study research reviews the regionally implemented programs listed above, examines their frameworks and implementation, and highlights specific policy and program mechanisms for achieving reduced nutrient and contaminant loading and maximizing co-benefits through offsets.

This report contributes the Province of Manitoba's articulated interest in applying WQT to improve nutrient reduction and improve the impacts of drainage (Manitoba Sustainable Development, 2017).

1.2 The Necessity for Water Quality Management in Manitoba

Manitoba houses the 10th largest freshwater lake in the world, Lake Winnipeg. This large, shallow lake has experienced increased eutrophication and resulting algal blooms due to climate change and increasing nutrient runoff, particularly from agriculture and other human activities. The watershed area is nearly 40 times greater than the lake area, ranging from western Alberta to eastern Ontario and from Manitoba down to a portion of South Dakota (Kling, Watson, McCullough, & Stainton, 2011; Lake Winnipeg Stewardship Board, 2006; Roy, Venema, & Barg, 2007) and receives water from many river systems and streams. The vast watershed area and the multiple jurisdictions create difficulty in executing water quality management and improving aquatic health and integrity (Environment Canada, & Manitoba Water Stewardship, 2011)

The lake is known globally for the destructive algal blooms that take over the water surface each year. The increase in size and duration of blooms in Lake Winnipeg has been attributed largely to nonpoint sources (NPSs) such as land fertilizer applications, waste from livestock production, urban runoff and increased frequency of spring floods/extreme precipitation events, as well as point sources (PSs), including wastewater emissions from municipalities and industry (Kling et al., 2011; Schindler, Hecky, & McCullough, 2012). The increased production in algae results in shifts in the aquatic community, a loss of biodiversity, a decrease in dissolved oxygen levels in the water column potentially causing fish kills, a decrease in water clarity and light penetration and a decrease in recreational uses; it can also cause poor taste and odour in drinking water. The enrichment of phosphorus from PS and NPS pollution has caused a low ratio of nitrogen to phosphorus, which is favourable for nitrogen fixing and toxic blue-green algae (Schindler et al., 2012).

Blue-green algae (cyanobacteria) particularly flourish under nutrient-rich conditions and are highly competitive. These algae grow and reproduce when light is limited (Scheffer et al., 1997), for instance in a shallow and large lake such as Lake Winnipeg. The increased fetch distance (open water area) and shallow nature of the lake causes increased wind resuspension of sediments and available nutrients, also causing ideal conditions for blue-green algal production (Anderson, Gilbert, & Burkholder, 2002; Scheffer et al., 1997). In addition to eutrophic conditions, the increase in water temperature causes a shift in algal communities, from diatoms to blue-green algae (Konopka, & Brock, 1978). The pairing of excessive nutrient loading, wind resuspension of sediments and nutrients, and climate change will continue to create ideal conditions for blue-green algal production. Not only can these algae outcompete native algae and shift the nature of the ecosystem, some can produce harmful toxins that can cause liver failure, neurodegeneration, and lung and skin irritation in animals and humans (Faassen, Gillissen, & Lürling, 2012; Li et al., 2010).

The Manitoba portion of the Lake Winnipeg watershed comprises natural land cover, urban developed land and agricultural land. Agriculture is an important part of the Manitoba economy and culture. However, research has shown that there is a strong positive correlation between agricultural land use and nutrient loading, likely attributed to fertilizer application and land manipulation (Donahue, 2013; Liu et al., 2008). Many forms of land manipulation—for example, culvert installation, land drainage including using tile drainage, wetland drainage, or establishment of cropland—cause changes in the ability of the land to hold water and filter nutrients, ultimately increasing water (and nutrient) yield (Liu et al., 2008). Paired with the increase in precipitation and flooding events (Schindler et al., 2012), we observe a drastic influx of nutrient loading to downstream ecosystems at certain times of the year. The high cover of agricultural activities in the Manitoban portion of the watershed and increase in extreme precipitation/flooding events is resulting in excessive NPS nutrient loading and large, severe algal blooms downstream.

Lake Winnipeg and the aquatic ecosystems in its watershed are incredibly valuable to the local people and economy. Watershed benefits include water for drinking, hydroelectricity production, industry, a thriving fishing industry, recreation, habitat, etc. (Yates, Culp, & Chambers, 2012). Manitoba continues to improve nutrient and water management to control the excessive production of algae on its major lakes and rivers, including the iconic Lake Winnipeg.

1.3 Challenges for Wastewater Treatment Plants

Wastewater treatment facilities are critical for nutrient/pollutant management from urban and industrial sources of water. Necessary infrastructure upgrades to cope with increasing loads may be delayed due to costs and the state of the economy (Carey & Migliaccio, 2009). Upgrades are necessary in the context of regulatory and societal requirements to maintain or reduce nutrient loading to downstream water bodies, such as Lake Winnipeg. In addition to the cost, upgrades to wastewater treatment systems take significant time to complete. Due to the significant resource burden for infrastructure upgrades, other efforts to reduce nutrient loading from NPSs are targeted for cost-efficient nutrient management. If there are equivalent impacts for significantly reduced costs, NPS controls might be considered to offset emissions from wastewater treatment facilities.

In Manitoba, the regulatory thresholds for total phosphorus (TP) output concentrations is 1 mg/L and for total nitrogen (TN) is 15 mg/L (Government of Manitoba, 2011). Treatment facilities and standards require regular reviews to take into account increasing populations and changing industries to ensure regulatory thresholds are appropriate and being met.

In addition, offsets are being considered under proposed drainage regulations in Manitoba, as a means to enable agricultural drainage, particularly in the context of increased flooding. Potential loss in water and nutrient retention could be offset against alternative water retention or wetland restoration under current considerations.

1.4 Drainage and Water Management

Another aspect of water management in Manitoba is the need for extensive drainage that is required for maintaining agricultural productivity, as well as for protecting communities and infrastructure from the impacts of excess water and flooding (Province of Manitoba, 2014). Future scenarios under a changing climate include a higher probability of both floods and drought (Hirabayashi et al., 2008). This implies that, while there is a need to drain, a climate adaptation strategy for watershed management must include drainage as well as water retention and the strategic management of water *quantity* while managing water quality.

The Province of Manitoba is exploring such sustainable drainage options where excess water is removed from agricultural, municipal and other lands, while some is retained for access during drier times of the year and for maintaining co-benefits such as nutrient sequestration, habitat and other priority needs in the region (Grosshans, Bath, & Roy, 2017). Offsets are already being used in the context of highways and other infrastructure development where wetlands are negatively impacted. The wetland functions are offset through restoring wetlands in another area such that overall impacts are mitigated and potentially improved (personal communication, Manitoba Habitat Heritage Corporation, February 12, 2018). Offsets provide a broader strategic policy option to enable drainage where it is most necessary while ensuring that overall water retention and wetland capacity is maintained in the province. Such a commitment to “no net loss of water retention capacity in Manitoba” is made in Manitoba’s Climate and Green Plan (Manitoba Sustainable Development, 2017).

1.5 Offsetting as a Potential Regional Policy Option

Offsets might be feasible in a number of water management contexts in Manitoba. In the context of water quality management, there are currently wastewater treatment technologies available that achieve lower phosphorus levels (i.e., <1 mg/L TP), but the upgrades are costly (Kives, 2017). The estimated cost to update the North End Wastewater Treatment Facility in Winnipeg, MB, is over CAD 1 billion (Kives, 2017). While upgrades are necessary for a number of regulatory and operational reasons, the logic of offsetting and WQT to achieve cumulative benefits is being considered.

Trading and offsetting programs are designed to treat the watershed as a unit; for example, discharger operations may be allowed to contribute phosphorus loads above regulatory thresholds as long as increased phosphorus loads are reduced or controlled from NPSs within the same watershed. Specific ratios between the operation and the offset are determined based on the activity and the specific context of each watershed (Ogilvie, Ogilvie & Company, 2013). For example, if a farmer drains a wetland on cropland, the farmer may be responsible for constructing or restoring approximately 2.5 to four wetlands within the same watershed. The ratio between drainage and construction/restoration may be increased if there is uncertainty in the level of nutrient reduction (Ogilvie, Ogilvie & Company, 2013).

Offsets can help reduce costs to meet regulation compliance standards while meeting environmental goals. Offset systems are being used in a variety of contexts globally to manage a variety of environmental issues, such as excess carbon, water quality and quantity, and biodiversity.

1.6 Additional Ecological Benefits of Offsets

Offsetting often involves land-use changes that yield other benefits in addition to limiting the specific pollutant targeted in a WQT system. In addition to the cost-saving practices associated with offsetting, this approach may introduce additional ecosystem and public services including:

- Increased wetland habitat
- Water retention and flood mitigation
- Nutrient sequestration (reducing phosphorus loads)
- Carbon sequestration (reducing greenhouse gas emissions)
- Biomass production (development of renewable energy, fertilizer and new revenue systems)
- Reduction in downstream eutrophication

Water quality offsetting practices may delay the requirement for upgrades to wastewater treatment facilities, but they should not be viewed as a "licence to pollute" (O'Grady, 2008; Ogilvie, Ogilvie & Company, 2013). Offsetting and trading practices should be used as an economic tool to pair with environmental regulations and policies (e.g., pollution taxes and agri-environmental payments), not as an alternative (Marcano, 2015; Organisation for Economic Co-operation and Development [OECD], 2012). For instance, offsets could be used as an interim measure while they plan and implement upgrades to meet their regulatory limits. In certain circumstance, they could be used as a permanent solution, but this option needs to be revisited to ensure continual compliance and overall outcomes.

1.7 Offset Design and Framing

Offset program designs are complex and unique to each watershed. The design must incorporate the geophysical, economic and political conditions specific to the area. These considerations include regulatory caps, credit units, offset ratios, buyers and sellers, contracting systems, monitoring and so on.

This research draws lessons from six global case studies that use water quality offset programs between different combinations of PSs and NPSs. Lessons from these jurisdictions and their unique challenges will guide the Province of Manitoba in determining if and how an offset program could be implemented across the watershed to improve water quality and provide other benefits for our landscapes, lakes and rivers.

2.0 Case Study Descriptions

This section summarizes the key characteristics of the case studies chosen for this review and provides the selection criteria and elements of WQT/offset[1] programs applicable to Manitoba (see criteria for selection, below).

It has been rightly noted in McNeil that "as no two watersheds are exactly the same, no two trading systems will be either" (2013, p. 3). This case study research demonstrates that a successful offset program design is dependent on local conditions and circumstances: watershed boundaries, land-use profile, existing organizations operating in the area, visionary leadership, its long-term commitment to improving water quality and other local factors.

A number of program design elements are highlighted in these brief case studies. These include: watershed description, including physical characteristics, scale and socioeconomics; motivations for offset programs (e.g., nutrient loads, pollutants, economic challenges); regulatory or program basis for offset systems; institutional systems for the programs (such as a means of engaging agricultural producers, specific roles and characteristics of an intermediary/program administrator); and lessons related to implementation and impact where possible.

This report presents a review of six case studies from the following OECD countries:[2]

- United States (3)
  - Clean Water Services' (CWS) Tualatin River program ***(CWS Tualatin River)***
  - Erie P Market ***(Erie P Market)***
  - EPRI Ohio River Basin Trading Project ***(Ohio River)***
- Canada (2)
  - Lake Simcoe Phosphorus Offsetting Program ***(LSPOP)***
  - South Nation Conservation water quality trading program ***(SN River)***
- New Zealand (1)
  - The Lake Taupō nitrogen trading program ***(Lake Taupō)***

CRITERIA FOR SELECTION OF CASE STUDIES

While offset programs are context specific, studying six diverse offset systems broadly applicable to the Manitoba context can help us derive lessons related to what might be working and why. For this reason, our selected case studies demonstrate some range related to geography, scale, water-related issues, use of market instruments, trader types (different NPS and PS combinations), stage of development/implementation, and other key elements relevant to their development and success. These considerations are briefly summarized below.

Stage of development: The review examines not only fully operational programs (e.g., CWS Tualatin River program) but also a program framework (Erie P Market) that carefully details many of the design elements of interest.

[1] Terminology: there is no significant difference between the terms "trading" and "offsetting." "Trading" may emphasize the development of traditional markets (e.g., market mechanisms in price formation) and is a more common term in United States, where it is built into federal legislation as "water quality trading" (see U.S. Environmental Protection Agency [EPA] Water Quality Trading Policy [January 13, 2003]). However, some programs in the United States (e.g., the CWS Tualatin River Program), though they are referred to as WQT programs, do not necessarily make active use of market mechanisms. They are essentially community-based models operating through traditional agricultural soil and water conservation institutions to recruit farmers and fund alternative land-use projects. Offsetting is a term more common in Canada. Offsets refer more to case-by-case arrangements between polluters (usually sole-source offsetting structures).

[2] OECD countries are selected to reflect socioeconomic applicability to Manitoba.

Geography: Three out of six case studies reviewed are programs from the United States, where WQT is enabled through legislation.[3] Two water quality offset programs from Ontario—the LSPOP and the SNC water quality trading program—are included, providing important insights on Canadian experiences in water quality offsetting. One case study is from New Zealand.

Scale: Watersheds in the reviewed case studies range in size. The smallest watershed, Tualatin River watershed in Oregon, United States, measures 1,844 square kilometres; the Ohio River watershed is by far the largest (286 times bigger than Tualatin River watershed), encompassing several states and measuring 528,202 square kilometres.

Watershed issues: The programs selected for this review focus on water quality impairments ranging from thermal loading to TP pollution (See Table 1). Phosphorus is the most common, with four programs out of six targeting this pollutant.

Types of traders: PS–NPS trading is the most common among the case studies reviewed, due to a predominance of NPS pollutant loads: five out of six programs encourage this type of offsetting to improve watershed health. For example, in the Tualatin River watershed, approximately one third of the land is used for agriculture and the NPS thermal load contributes nearly 88 per cent of the anthropogenic heat load in the basin (Oregon Department of Environmental Quality [DEQ], 2007).

In addition, some programs make provisions for other trading schemes such as PS–PS (the Tualatin River program), NPS–NPS (the Lake Taupō nitrogen trading program) and stewardship trading (the EPRI Ohio River Basin Trading Project).

Existence of a program administrator: Most of the trading programs reviewed are managed by a non-profit or watershed authority, with the exception of the Lake Taupō nitrogen trading program, where the Lake Taupō Protection Project Joint Committee acts as the program lead.

Use of market instruments: Projects differ in their use of market instruments, that is to say, market-based pricing. In many cases, prices are set by the program administrator, sometimes by buyers and sellers when they are engaged directly in trading (Lake Taupō). The most successful agricultural trading models to date make effective use of traditional agricultural soil and water conservation institutions to engage farmers and fund pollution-reduction projects (OECD, 2012).

> Watershed projects do not always fit into well-defined market structures, and achieving watershed objectives may be more successful if more thought is given to institutional change rather to than [sic] market conditions. (O'Grady, 2011, p. 47)

The summary of programs' general characteristics can be found in the Table 1.

[3] In 2003 national policy guidelines for WQT under the federal Clean Water Act (CWA) were established. These incorporated a National Pollutant Discharge Elimination System (NPDES) permit as a compliance option for regulated point sources. In addition, in 2007 the EPA released the EPA Water Quality Trading Toolkit for Permit Writers, which is a manual for state and regional permitting authorities as well as other stakeholders interested in trading designed to assist in planning and implementing WQT programs consistent with the CWA.

Table 1. Case studies: Summary of the general information

Offset Program	LSPOP[a]	SN River[b]	Lake Taupō[c]	CWS Tualatin River[d]	Erie P Market[e]	Ohio River[f]
Watershed/ basin/ country	Lake Simcoe Watershed, Ontario, Canada	South Nation River watershed, Ontario, Canada	Lake Taupō catchment, Waikato, New Zealand	Tualatin River Basin, Oregon, USA	Western Lake Erie Basin, USA	Ohio River Basin, Ohio, Indiana, Kentucky, USA
Watershed area, sq. km	3,576	4,384	3,487	1,844	28,490	528,202
Program stage	Pilot Project Phase 1	Fully operational program	Fully operational program	Fully operational program	Trading framework	Pilot project[4]
Pollutant traded	Phosphorus	Phosphorus	Nitrogen	Temperature	TP[5]	TN, TP
Jurisdiction	Ontario	Ontario	Waikato region	Washington County, Oregon	Binational[6]: USA (Indiana, Michigan, Ohio), and Canada (Ontario)	Interstate: Ohio, Kentucky, Indiana
Year implemented	January 1, 2018–launch date	2000	2011	2004	2018	2012
Type of offsetting	Land developers–NPS	PS–NPS	NPS–NPS	PS–NPS, PS–PS[7]	PS–NPS[8]	PS–NPS; Currently: stewardship trading with NPS generating credits
Transaction model	Fee in lieu[9]	Clearinghouse	Bilateral negotiations	Sole source	Bilateral negotiations	Clearinghouse

[4] A new amendment extends the pilot phase to 2020 (Electric Power Research Institute [EPRI], 2017).

[5] Includes both sediment-attached/particulate phosphorus as well as dissolved reactive phosphorus.

[6] The framework is proposed for the U.S. portion of the basin. Ontario is largely an observer in the process of developing this framework; however, it is committed to working collectively to improve the health of Lake Erie through multiple agreements and acts such as the Great Lakes Water Quality Agreement, Ontario's Great Lakes Protection Act, 2015 and the Western Basin of Lake Erie Collaborative Agreement (Great Lakes Commission [GLC], 2017).

[7] Types of trading allowed according to Oregon WQT rules. There have been no PS–PS trades to date in the state. The CWS program is a sole-source offset program (with a single buyer).

[8] "However, trades between any combination of PS and NPS are also allowed under this Framework" (GLC, 2017).

[9] A regulated discharger pays a fee to a program instead of purchasing its own credits (National Network on Water Quality Trading [NNWQT], 2015). For example, in the LSPOP, land developers make payments to LSRCA, the program administrator and an oversight body. In turn, LSRCA accumulates this funding to invest in retrofit projects on existing development and ultimately generate water quality improvements (XCG, 2014b).

Offset Program	LSPOP[a]	SN River[b]	Lake Taupō[c]	CWS Tualatin River[d]	Erie P Market[e]	Ohio River[f]
Program lead/trading administrator	Lake Simcoe Region Conservation Authority (LSRCA)	South Nation Conservation (SNC)	Lake Taupō Protection Project Joint Committee, Waikato Regional Council	Clean Water Services (CWS)	The Great Lakes Commission[10]	EPRI
Program goals	Reduce phosphorous loading into the lake from 77 tonnes/year to 44 tonnes/year.	0 kg of phosphorous loading.	Remove 153 tonnes of nitrogen/year (revised to 170 tonnes) by 2018; equal to 20 per cent annual reduction of nitrogen.	Reduce the temperature impact by 95 per cent, from 90 x 10^7 kcal/day down to 4.4 x 10^7 kcal/day (2001 total maximum daily load [TMDL]).	Reduce TP entering WLEB by 40% by 2025 as compared to 2008.[11]	Remove 30,000 lbs of phosphorus and 66,000 lbs of nitrogen over the period of 2013–2015.
Outcomes	No results are available yet.	269 verifiable trades were completed between 2001 and 2009; phosphorous removed is estimated at 11,843 kg/year.	Achieved 153 tonnes/annum by 2018 goal early—three years ahead of time and on budget. No further deterioration in the lake water quality was detected.	BMPs have generated 295 million (29.5 x 10^7) kcal/day of credits during initial permit period (2004–2008).	No results are available yet.	6,500 lbs of TN reductions and 2,500 lbs of TP reductions were sold as of March 2014 with an additional 66,000 lbs of TN and 30,000 lbs of TP available for purchase in 2015.

[a] Government of Canada, 2016; Government of Ontario, 2016; [b] South Nation Conservation, n.d.; O'Grady, 2011; South Nation Conservation, 2010; [c] Duho, McDonald, & Kerr, 2015; OECD, 2015; [d] Little, 2017; Hennings, 2014; Cochran, & Logue, 2011; [e] U.S. Department of Agriculture, 2016; GLC, 2017; [f] Ohio River Foundation, n.d.; Fox, 2015; EPRI, n.d.d; EPRI, 2014b.

[10] In this role until the end of September 2018.

[11] According to the Western Basin of Lake Erie Collaborative Agreement between Ohio, Michigan and Ontario signed on June 13, 2015.

2.1 Lake Simcoe Phosphorus Offsetting Program

Lake Simcoe is the largest lake in southern Ontario outside of the Great Lakes and has an area of 722 square kilometres. Thirty-five rivers flow into the lake, and through Lake Couchiching and the Severn River it empties into Georgian Bay. The Lake Simcoe watershed has a total land and water surface area of 3,576 square kilometres and it is situated north of Toronto (Government of Canada, 2016).

Lake Simcoe supplies drinking water to eight municipalities (Environment and Climate Change Canada, 2017), assimilates waste from 14 sewage treatment facilities that discharge into the lake (Government of Canada, 2016b), and supports commercial and recreational fisheries. Overall, tourism and recreational industries built around the lake contribute CAD 200 million annually to the local economy (Government of Canada, 2016b). Forty-seven per cent of the watershed area is productive agricultural land (Government of Ontario, 2016).

Figure 1. Lake Simcoe watershed

Source: Government of Canada, 2016.

2.2.1 Watershed Issues

Recently, pressures from rapid population growth and urban development as well as trends toward larger intensive farms have resulted in nutrient enrichment into Lake Simcoe and deterioration in the lake's water quality. Phosphorus carried by storm water from urban hardscapes has been a major point of concern. Unabsorbed by the ground, contaminated water flows directly into the waterbody carrying pollutants from fertilizers, pesticides, pet and yard waste.

Overall, the annual phosphorus loading into the lake has reached 77 tonnes/year (Environment and Climate Change Canada, 2017). As more urban development is occurring in the region,[12] pressures on the lake through phosphorus stormwater runoff will only continue to increase.

2.1.2 Basis for the Offsets Program

Recognizing that the watershed and lake health needs to be protected to ensure the future well-being of the region, the Phosphorus Reduction Strategy, released in July 2010, set a provincial target of a maximum loading of 44 tonnes/year[13] into Lake Simcoe for the future.

A number of stewardship projects aiming to reduce phosphorus loading were completed between 2008 and 2017. They prevented an estimated 27,800 kg of phosphorus from reaching Lake Simcoe and its tributary rivers

[12] An additional 9,990 ha of urban growth was approved from 2014 to 2031 (LSRCA, 2015a).

[13] A target for dissolved oxygen of 7mg/L in Lake Simcoe.

(Environment and Climate Change Canada, 2017). Despite this improvement, more is needed to be done to reach the goal of 44 tonnes of annual phosphorus discharge. The ambitious phosphorus target called for an innovative solution.

The LSRCA[14] proposed a "Zero Export" policy for the Lake Simcoe watershed that required all new development to control 100 per cent of the phosphorus from leaving their property (LSRCA, 2017). In order to accommodate new urban development, the LSPOP was established.

2.1.3 Roles and Requirements

Based on the "Zero Export" policy, the offsetting program focuses solely on new urban development or redevelopment property greater than 0.50 hectares in the Lake Simcoe watershed (XCG, 2014b). For these projects, the developer is required to install effective stormwater management and treatment technologies on the property to control phosphorus runoff to the maximum extent (LSRCA, 2017). The residual load per hectare, estimated at 0.38 kg (LSRCA, 2015a), is targeted through the phosphorus offset program. Developers need to purchase offsets and the payments will go into implementing urban stormwater retrofit projects on the existing development in the watershed. The retrofit projects would promote local infiltration of the surface runoff. The trading ratio 2.5:1 applied to the purchases means that, in order to offset 1 kg of phosphorus per year, 2.5 kg of phosphorus needs to be abated through retrofit projects (LSRCA, 2017). It is estimated that offsets would cost developers approximately CAD 32,200 per hectare of undeveloped land or about CAD 1,820 per residential unit (XCG, n.d.).

LSRCA acts as an administrator for the program as a whole, which consists of two major parts. The Urban Stormwater Retrofit Program (USRP) is a newer program, and it forms the primary pool of offsets to apply toward the new development or redevelopment projects (XCG, 2014b). LSRCA will obtain purchase commitments from land developers, which will cover the costs of project implementation and various administrative and monitoring costs (XCG, n.d.; XCG, 2014a). LSRCA is also relying on the existing Landowner Environmental Assistance Program (LEAP), which assists individual landowners in implementing environmentally oriented projects to form the back-up pool of offsets (XCG, n.d.; XCG, 2014a).

2.1.4 Implementation and Lessons

After years of feasibility research and consultations, LSRCA has released the Phosphorus Offsetting Policy in September 2017, which went into effect as of January 1, 2018. It is expected that, as the result of this program, the cost of building a new home will increase by CAD 500 to CAD 2,000, depending on the lot (Simon, 2017). As of March 2018, four projects have been implemented as part of the LSPOP, with another eight projects under development (personal communication, Mike Walters, March 2018).

[14] Municipalities in Ontario can join together with the province to form a Conservation Authority within a specific area. Conservation Authorities in Ontario are organized on a watershed basis and are "mandated to ensure the conservation, restoration and responsible management of Ontario's water, land and natural habitats through programs that balance human, environmental and economic needs" (Conservation Ontario, n.d.).

2.2 South Nation Conservation Water Quality Trading Program

The South Nation River watershed is located in southern Ontario. It covers an area of 4,384 square kilometres and consists of predominantly small rural towns and villages (16 municipalities in total) (SNC, n.d.). The jurisdiction has a population of about 150,000 (O'Grady, 2008). The area surrounding the river is used primarily for agriculture (60 per cent of the watershed) with a mix of livestock and cash crop production (Agriculture and Agri-Food Canada, 2013a).

2.2.1 Watershed Issues

As a result of the growing pressures coming from agricultural intensification and urban development, the water quality in the SN River watershed has deteriorated. It was determined that the greatest share of phosphorus pollution in the SN River originated from NPSs—an estimated 90 per cent (O'Grady, 2008). The main agricultural practices adversely affecting water quality were direct cattle access to streams and manure runoff from fields (O'Grady, 2008).

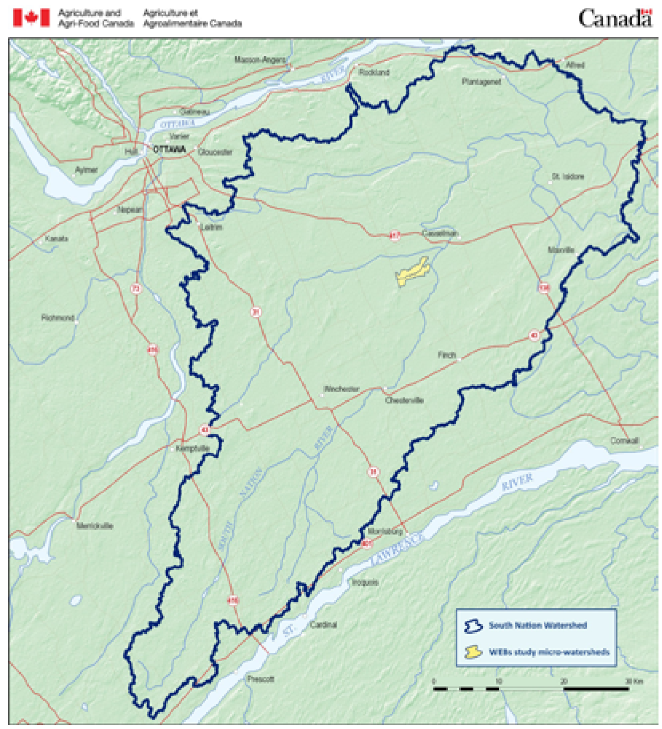

Figure 2. Map of South Nation River watershed

Source: Agriculture and Agri-food Canada, 2013b.

2.2.2 Basis for Offsets Program

The Ministry of Environment (MOE), responsible for managing water quality in the Province of Ontario, revised permitting systems in 1998 to discontinue new permits to PS emitters and introduced the new regulation that required no further phosphorus loading. This implied enforcing a zero phosphorus discharge limit on new and expanding municipal or industrial wastewater discharge facilities (SNC, 2010). Existing plants operating under permits already issued to them did not have to change their phosphorus loading (O'Grady, 2008).

Acknowledging that higher levels of sewage treatment would not dramatically improve water quality in the watershed, the new regulations enabled a cost-effective approach to managing phosphorus discharge to the SN River and its tributaries. Under the Total Phosphorus Management (TPM) strategy approved by the MOE, PSs could offset their phosphorus loading by investing in NPS BMP projects elsewhere in the watershed (SNC, 2010). BMPs included manure storage, proper storage and handling of milkhouse washwater, preventing livestock access to watercourses and buffer strips. The program was advertised to landowners as a grant program (O'Grady, 2011). The participation was voluntary for landowners, municipalities and industry (O'Grady, 2011).

2.2.3 Roles and Requirements

SNC, a community-based watershed organization, was a key stakeholder in the TPM strategy and acted as a broker for the trades. It administered the program, handled transactions between PSs and NPSs, and performed necessary clerical and research work such as calculating phosphorus reductions from improved land management practices, calculating an average credit price and determining an appropriate trading ratio. On these decisions and other elements of program design, SNC consulted with the agricultural community (O'Grady, 2008; personal communication, Dennis O'Grady, February 8, 2018). The entire decision-making process (grant rates, program eligibility and so on) was delegated to the multistakeholder Clean Water Committee that consisted of farmers, industry, municipalities, farm organizations and SNC. Overall, the committee had more than 50 per cent agricultural representation (O'Grady, 2006). Farmer field representatives (usually well-known farmers in the area) would visit farms, discuss funding options, assist with filling out application forms and present the project to the committee for review on the applicants' behalf (O'Grady, 2006). Farmers also acted as verifiers. Discussing a project with a peer was more comfortable to landowners, and this process helped to build trust in the program, while the committee acted as an effective mechanism to manage disputes, taking pressure off SNC (personal communication, Dennis O'Grady, February 8, 2018). A high trading ratio (4:1) was applied to account for uncertainty around phosphorus reductions: PSs needed to purchase 4 kg of phosphorus reductions for each kilogram they needed to offset.

2.2.4 Implementation and Lessons

Between 2000 and 2009, 269 projects generating phosphorus reductions were completed and 11,843 kg/year of phosphorus discharge was abated (O'Grady, 2011). The total value of grants allocated to these projects was estimated at CAD 708,404. According to participants, the TPM program has also resulted in increased property values (O'Grady, 2011).

The SNC WQT program is one of the first trading programs developed in North America (Weber, & Cutlac, 2017). The program is still fully operational; however, the lack of recent offset activity is explained by the fact that no existing plants needed to expand and therefore comply with the zero phosphorus discharge policy (personal communication, Dennis O'Grady, February 8, 2018).

Some of the success elements of the SNC WQT program design were:

- Putting farmers in charge of all decision making around agricultural projects including funding decisions and monitoring.
- Keeping procedures simple for landowners (e.g., monitoring, reporting): "The program focus is BMP delivery to local landowners, not a P reduction trading program" (Dennis O'Grady, 2011, p. 47).
- Putting trust in farmers to do what is needed, in their professionalism and environmental awareness (personal communication, Dennis O'Grady, February 8, 2018).

Farmers were not liable for any failure of the program (e.g., shortage of credits). This was enforced by a contract signed by the Federation of Agriculture, MOE and SNC (personal communication, Dennis O'Grady, February 8, 2018).

2.3 Lake Taupō Nitrogen Trading Program

Lake Taupō, the largest lake in New Zealand by surface area, is located in the central North Island of the country. The natural beauty of the surrounding landscape and near pristine waters make it a popular tourist and recreation destination. Moreover, the lake is known for trout fishing, an important economic activity in the area. The Lake Taupō catchment is 3,487 square kilometres (Waikato Regional Council [WRC], n.d.a), and land is used for a variety of purposes including conservation, farming, forestry and urban development (Duhon et al., 2015). Farms occupy approximately 18 per cent of the land (Rutherford & Cox, 2009).

2.3.1 Watershed Issues

In 1999 it was found that water in the lake had become less clear, and that land-use intensification was likely having an adverse impact on the lake's water quality (Environment Waikato, 2007). It was determined that nitrogen leaching from the lake's catchment was the leading cause of deteriorating water quality (Environment Waikato, 2007). Further analysis revealed that pastoral farm land contributed most (93 per cent) of the human-generated nitrogen entering the lake (Environment Waikato, 2007), and hence this contribution could be controlled.

2.3.2 Basis for the Offsets Program

In 2000/01, public opinion was sought to determine a desirable course of action to protect the lake. The outcome of the consultations was to "maintain current water quality by reducing nitrogen output from existing land uses and preventing further land use intensification" (Environment Waikato, 2007, p. 4).

Figure 3. Map of the Taupō Lake catchment

Reprinted with permission from Waikato Regional Council.

2.3.3 Roles and Requirements

This awareness has led to a long process of developing a policy that:

- *Placed a cap on nitrogen losses for the farmers in the catchment by limiting nitrogen losses at historical levels:* Regional Plan Variation No. 5 – "Lake Taupō Catchment," operationalized in July 2011, set out rules and outlined procedures to cap the amount of nitrogen entering Lake Taupō from urban and rural activities (WRC, n.d.b.). Land users were allocated Nitrogen Discharge Allowances (NDAs) based on their highest productive year between 2001 and 2005 (OECD, 2015). The year of highest nitrogen leaching in this time period was set as a cap. Software (OVERSEER) was used to arrive at the farm-specific nitrogen emissions by inputting farm data such as stock, fertilizer and cropping into the model. By 2013 all farms had been benchmarked for their NDA as part of their resource consent[15] (OECD, 2015). The Lake Taupō Protection Trust (see below) covered the costs of initial benchmarking and NDA allocation (personal communication, Rod Edwards, February 14, 2018).

[15] The resource consent lists conditions that one will need to meet in order to discharge nitrogen in the Taupō catchment.

- *Established a NZD 80 million public fund—the Lake Taupō Protection Trust—with a goal to reduce the amount of nitrogen coming from farmland and urban areas by 20 per cent:* The trust aimed to achieve this target through a number of activities, including purchasing pastoral and cropping land from willing landowners and permanently converting it to low-nitrogen land uses (e.g., retiring the farmland to forest) and purchasing NDAs from willing landowners, thus permanently removing that nitrogen from the catchment (OECD, 2015). The fund consisted of contributions from the following government departments: Taupō District Council (22 per cent), WRC (33 per cent) and the central government (45 per cent) (OECD, 2015).
- *Established a nitrogen trading system that allowed farmers to trade allowances with other farmers or with the trust* (Duhon et al., 2015): Farmers willing to trade needed to find another consented farmer in the catchment to buy or sell nitrogen and negotiate a price, quantity and a date of transfer (WRC, 2011). There was no trading platform—trading partners were found by knowing the neighbours in the area or through a rural community newsletter (personal communication, Rod Edwards, February 14, 2018). Farmers could buy, sell or lease with another farming operation (WRC, 2011). According to Regional Plan Variation No. 5 described earlier, intensively farmed lands had a higher tradable NDA. This increased capital value to a farmer's land asset and made leasing rather than selling an NDA more attractive to farmers. Therefore, through leasing, farmers could retain the additional value of an NDA associated with the land (personal communication, Rod Edwards, February 14, 2018). To permanently remove nitrogen discharge, the trust could more easily buy NDAs from land that was less suitable for agriculture (unproductive land) (personal communication, Rod Edwards, February 14, 2018).

2.3.4 Implementation and Lessons

Finally, in July 2011 the cap-and-trade policy process was finalized, the institutional framework was put in place and the nitrogen trading program was fully operational.[16] This innovative program had become the first in the NPS–NPS cap-and-trade scheme in the world (Duhon et al., 2015).

Out of 468 tonnes of manageable nitrogen, the program has succeeded in permanently removing 153 tonnes of nitrogen/annum, and it achieved this target early (Hall, 2014). The effect of this reduction in nitrogen discharge to the lake is difficult to assess given the soil profile of the catchment where the land-use changes that occurred some decades ago may continue to increase nitrogen inputs into the lake via groundwater (Environment Waikato, 2007). Nevertheless, no further deterioration in the lake water quality was detected since the policy implementation (personal communication, Rod Edwards, February 14, 2018). A review of the program and its achievements is scheduled for 2018. The ultimate goal of the policy is to restore water quality and clarity to 2001 levels by 2080 (OECD, 2015).

The program was successful due to a number of factors:

- It recognized the economic benefits of a clean lake. Forestry or tourism provide the greatest economic growth opportunities for the region, and both are associated with low nitrogen losses (Environment Waikato, 2007).
- A strong local ethic for environmental protection came from the community, which recognized and appreciated the special status of the lake as a national treasure.
- A strong enabling institutional framework (OECD, 2012).
- The timing of the policy, which coincided with a national carbon trading legislation. This made converting lands from livestock farming to forestry more attractive to landowners. The existence of a carbon market made some landowners eligible for the combined benefits of both nitrogen discharge and carbon reduction payments (OEDC, 2015).
- The patience and commitment of policy-makers throughout a 10–11-year policy process.

[16] However, the Lake Taupō Protection Trust started to buy the NDAs in 2009 (OECD, 2015).

2.4 Clean Water Services Tualatin River Program

The Tualatin River is a 134-km river that flows through rural and urban settings in Washington County, Oregon. The Tualatin River watershed is located on the west side of the Portland metropolitan area and covers an area of 1,844 square kilometres (Little, 2017). It supports 12 municipalities and a growing population of more than 560,000 people (DEQ, 2012). The land-use profile of the area is predominantly forestry (49 per cent) and agriculture (39 per cent) (DEQ, 2007). The urban and rural residential zones occupy around 12 per cent of the basin (DEQ, 2007). The urban part of the basin is served by four wastewater treatment facilities operated by CWS (Rounds, Wood & Lynch, 1999).

2.4.1 Watershed Issues

Due to the lack of riparian shade, the Tualatin River had been experiencing higher-than-normal temperatures, especially in the summer due to higher temperatures and low streamflow (Hennings, 2014). Thermal loading is a critical problem since elevated stream temperatures can cause harm to aquatic life (DEQ, 2012). Warmer water holds reduced dissolved oxygen, and this affects the survival of trout and salmonid eggs, juveniles and adults that depend on the oxygen supply (Hennings, 2014).

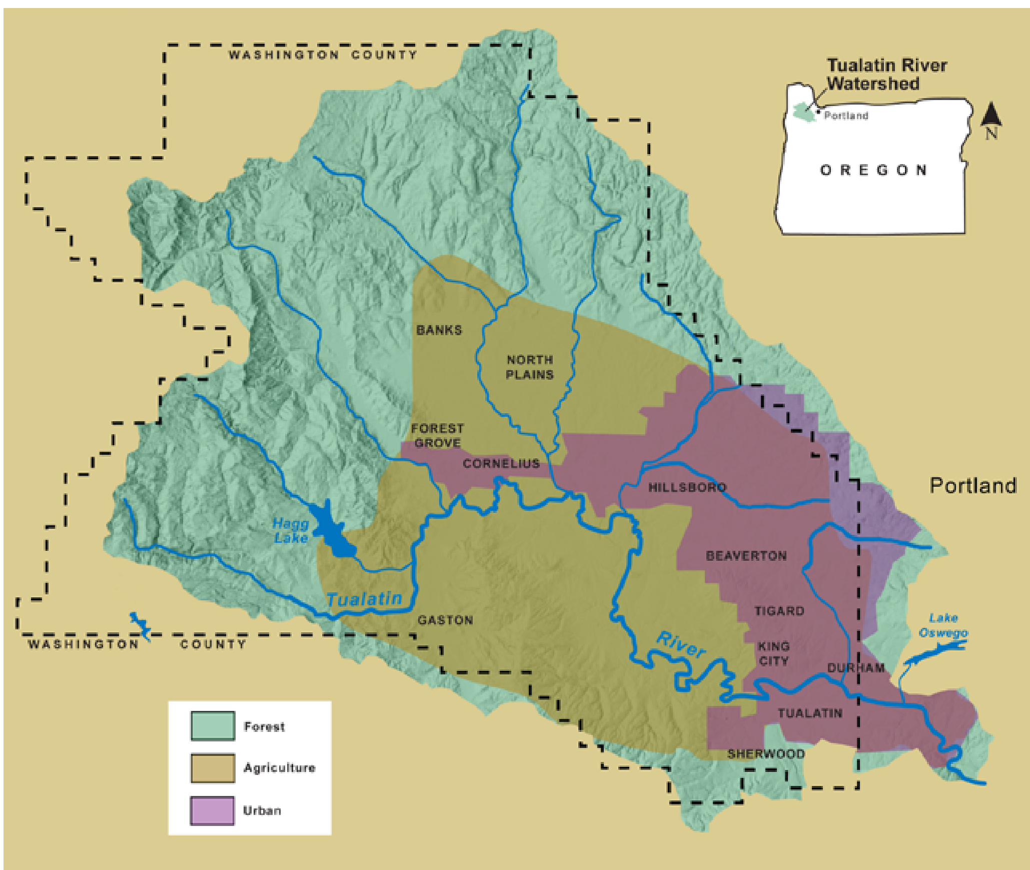

Figure 4. Map of the Tualatin River watershed

Reprinted with permission from the Tualatin River Watershed Council.

2.4.2 Basis for the Offsets Program

The Oregon DEQ is a regulatory agency tasked with implementing the CWA in Oregon. DEQ assigns pollutant load allocations and issues permits that control discharges. Under the CWA, no PS is allowed to discharge any pollutant without obtaining a permit (Environmental Protection Agency [EPA], n.d.a). In 2001, the DEQ developed a TMDL for temperature loading in the Tualatin watershed. The DEQ required the temperature impact to be reduced by about 95 per cent, from 9 x 10^8 kcal/day down to 4.4 x 10^7 kcal/day (DEQ, 2007). This regulation affected two of CWS's wastewater treatment facilities.

2.4.3 Roles and Requirements

CWS is a water resource management utility that operates four wastewater treatment facilities, two of which discharge in the summer. CWS constructs and maintains surface water management, flood attenuation and water quality-focused projects. Confronted with extremely high costs of cooling/refrigeration upgrades required to meet their assigned temperature waste load allocation in the TMDL, CWS decided to pursue an alternative cost-effective approach to mitigating the temperature loads—WQT. In order to allow for this compliance option, the DEQ developed an Internal Management Directive for its staff to incorporate WQT into the permit. In 2004 CWS was issued a new watershed-based NPDES permit that authorized the offsetting of temperature loads from the wastewater treatment facilities by investing in projects to reduce thermal loading elsewhere in the watershed (DEQ, 2007).

The Environmental Quality Commission is a five-member panel appointed by the governor of Oregon for four-year terms to serve as the Oregon DEQ's policy and rulemaking board. In addition to adopting rules, the commission also establishes policies, issues orders, judges appeals of fines or other DEQ actions and appoints the DEQ director. In December 2015 the Environmental Quality Commission adopted rules for WQT after a public process. Today, WQT is available as a voluntary tool for permit holders to use to comply with their permit requirements (personal communication, Wade Peerman, February 9, 2018). The new rules allow for multiple water quality parameters to be traded, such as temperature, ammonia, sediment and nutrients (DEQ, 2015a). However only trades involving temperature have been executed to date, and no demands for other trades are expected in the near future (personal communication, Wade Peerman, February 9, 2018). The program supports trading through three entities around the state: CWS, Medford and Port of St Helens.

CWS acts as a convener and manages a large portion of the program, including paying for all exotic vegetation management or eradication, native plant installation, annual maintenance and monitoring activities that can last for at least 20 years of the life of a project (DEQ, 2016; personal communication, CWS, March 28, 2018). Since 2004 CWS has worked with a variety of partners to gain access to riparian land rather than through direct purchase wherever possible. For example, the organization partners with the local Tualatin Soil and Water Conservation District (TSWCD), which in turn acts as a bridge between CWS funding of incentives and farmers/landowners to allow access to unused land along streams. The Soil and Water Conservation District (SWCD) plants these using CWS approaches, and CWS is able to use the shading as part of their Temperature Management Program (personal communication, CWS, March 28, 2018). Many important partners—including Metro Regional Government Parks and Natural Areas, the U.S. Fish and Wildlife Service, local cities and park districts, and many private business landowners—implement hundreds of projects, establishing a successful thermal trading program that exceeds at least a mile of riparian reforestation per year (EPA, 2007; personal communication, Laura Porter, February 9, 2018; personal communication, CWS, March 28, 2018).

Eligible actions to offset the thermal loading and comply with the TMDL requirements include: tree planting to increase streamside shading and augmenting flow to increase the amount of water available in the river (Porter et al., 2014).

In the case of rural landowners, CWS works closely with the TSWCD. First, farmers apply to be part of the program; SWCD and CWS review and decide which projects to fund based on certain preapproved criteria. Next, the necessary fieldwork is performed: GIS mapping is used to determine the area to be planted, the credit calculations are made and payment to the landowner is set (personal communication, Laura Porter, February 9, 2018). Land rental compensation prices are determined by the TSWCD, CWS and other funding partners, but may vary project by project, depending on circumstances (personal communication, Laura Porter, February 9, 2018). Professional teams are hired to implement the actions. The trading ratio 2:1 is used for the riparian planting projects to address the lag time between the initial installation of the projects and the realization of the benefits based on the time for the trees to grow (DEQ, 2016).

Moreover, in addition to generating credits for compliance, CWS and partners were able to successfully emphasize and realize a multitude of ancillary ecological benefits through the basin-wide restoration efforts. The native trees planted along the streams cool the river, reduce soil erosion, filter stormwater runoff, reduce the levels of phosphorus discharge, restore habitat, create opportunities for recreation and education, and increase climate change resilience and carbon sequestration (Porter et al., 2014). One of the main outcomes of the program is the project called TreeforAll,[17] which grew into a broad landscape conservation program across urban and rural communities.

2.4.4 Implementation and Lessons

As the result of the WQT initiative and the collective effort that it involved, 8 million trees and shrubs were planted along 100 stream miles, enhancing and conserving at least 7,500 acres of riparian or wetland habitat along basin streams (personal communication, Laura Porter, February 9, 2018). Moreover, the goals were reached sooner than anticipated: in 2005 the cities in the urban portions of the watershed were tasked with planting 1 million trees in 20 years, but they met this target in less than 10 years (Porter et al., 2014). Moreover, while water quality is the primary driver of these activities, the Tualatin River basin now has greatly restored ecosystem functions and supports more diverse wildlife, including returning keystone ecosystem managers such as beavers. It has also helped to build and strengthen the local people–nature connection and involve youth in restoration projects (Little, 2017). Translating the shade increases into *actual* temperature load reductions occurs through modelling using Heat Source and is reported to the DEQ through discharge monitoring reports and annual reporting. Yet understanding the results of implementation on the improvement of water temperature conditions requires in-stream monitoring, carried out by the DEQ and its partners (personal communication, Wade Peerman, February 9, 2018).

Some key characteristics and success elements of the CWS Tualatin River program are:

- The primary focus on collaborative partnerships in the watershed versus purchase of land for projects.
- Accommodating partners' unique needs with regards to their land (e.g., replacing invasive plants with native species, long-term environmental education) to realize mutual benefits.
- Visionary leadership to pioneer a different policy and regulatory approach (DEQ and EPA).
- Appreciation of the value of the additional ecological benefits by all stakeholders involved.
- Seeing real changes in the landscape (e.g., wildlife enhancement) strengthened confidence in and satisfaction in the program.

[17] See more on the TreeforAll program at www.jointreeforall.org

2.5 Erie P Market

Lake Erie is the shallowest of the North American Great Lakes.[18] Roughly 95 per cent of the water that enters this lake comes from the other Great Lakes and rivers from five U.S. states and the Province of Ontario (Curell, 2015). The Western Lake Erie Basin (WLEB) encompasses parts of Indiana, Michigan, Ohio and Ontario and has a total area of approximately 28,490 square kilometres. Being shallow, it is the warmest and most fertile of the Great Lakes, producing more fish than all others combined and supporting a thriving commercial fishery (The Nature Conservancy, n.d.). Moreover, millions of people depend on the lake for various recreational activities, such as swimming, boating, sailing and bird-watching.

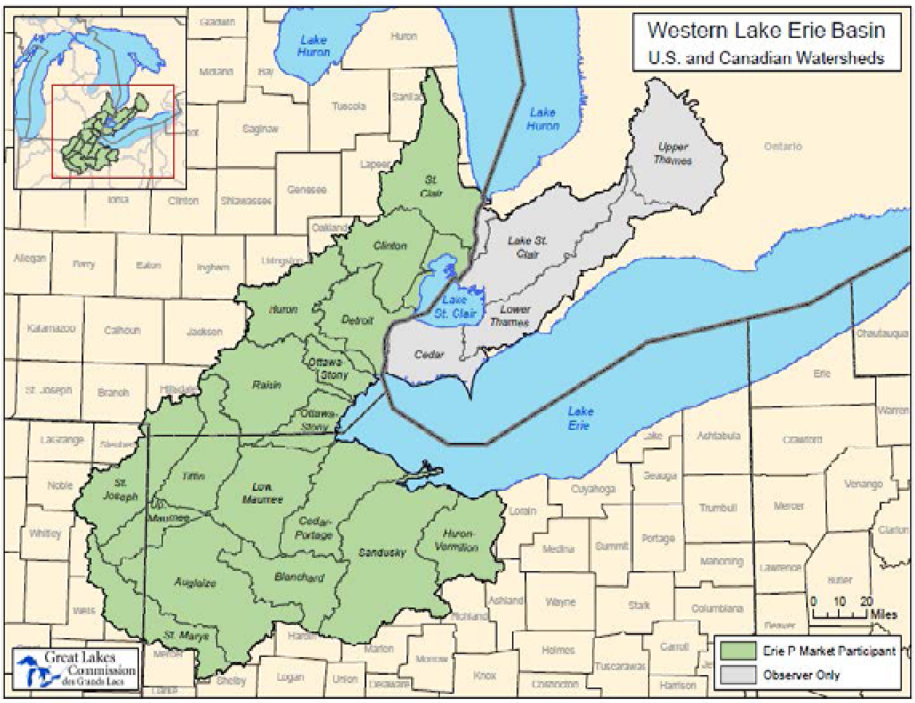

Figure 5. Map of Western Lake Erie Basin

Reprinted with permission from the Great Lakes Commission.

The basin is home to more than 2 million people, many of whom are heavily reliant on agriculture for income and economic development. Agricultural activities take place in about 70 per cent of the WLEB area (U.S. Department of Agriculture [USDA], 2016); sales from agricultural crops generated a revenue of around USD 3 billion in the region, according to the 2007 census of agriculture (USDA, 2016).

2.5.1 Watershed Issues

Since the mid-1990s, Lake Erie has experienced an increasing frequency and intensity of cyanobacterial/algal blooms resulting from the excess phosphorus contributions from agriculture (Indiana State Department of Agriculture, n.d.). Numerous federal and state reports have identified Lake Erie as impaired[19] due to excessive

[18] The Great Lakes contain 20 per cent of the planet's total freshwater reserves (USDA, 2005).

[19] An impaired watershed designation means the waterbody is considered too polluted and does not meet the water quality standards set by regulatory agencies under Section 303(d) of the Clean Water Act. In this case, states are required to develop TMDLs for these waters (Gross, Baas, & Curell, 2017).

concentrations of phosphorus and nitrogen, leading to eutrophication (USDA, 2005). Harmful algae blooms are causing toxins in drinking water supplies, killing fish, leading to unsafe swimming conditions, and consequently affecting the health and economic well-being of the region (e.g., through limiting tourism economy). It was found that 71 per cent of the phosphorus discharge into Lake Erie from the western part of the drainage basin originates from NPSs such as agriculture, with only 21 per cent originating from PSs (Ohio EPA, 2010).

2.5.2 Basis for the Offset Program

In June 2015 the WLEB Collaborative Agreement, signed by Michigan, Ontario and Ohio, set a target of reducing the amount of total and dissolved reactive phosphorus entering WLEB by 40 per cent by 2025 as compared to 2008 (USDA, 2016). One proposed action to reach this target was cooperation between certain federal agencies and stakeholder groups to develop and implement a pilot Lake Erie Basin nutrient trading and credit program to help address the nutrient pollution problem (Ohio EPA, 2017).

2.5.3 Roles and Requirements

The Erie P Market is a market framework launched in 2016 that constructs a uniform approach to WQT in the U.S. portion of the WLEB (Ohio, Michigan and Indiana): it specifies eligible trading partners, trading boundaries, and rules for quantifying, certifying and verifying phosphorus load reductions from agricultural NPS practices, contract systems and other key elements of a phosphorus trading scheme (Great Lake Commission [GLC], 2017). A formal Memorandum of Understanding between Michigan, Ohio and Indiana signed in December 2017 commits them to using this framework to guide the trade of phosphorus credits in the WLEB (GLC, 2018). The project is funded by a Conservation Innovation Grant from the U.S. Department of Agriculture's Natural Resources Conservation Service (GLC, 2017). The GLC, a public agency, has assumed the role of trading broker for the program until the end of September 2018 and is currently testing the applicability of the WQT tool to WLEB.

The main focus of the framework is PS–NPS trading, where PSs act as credit buyers and NPSs (typically agricultural producers) act as credit sellers. However, other combinations (i.e., NPS–NPS, PS–PS) are also possible subject to demand. Both downstream and upstream crediting are considered under the framework. In order to calculate phosphorus reductions, the U.S. EPA Region 5 spreadsheet model for particulate phosphorus and the Pennsylvania Department of Environmental Protection model modified for trading within the WLEB for dissolved reactive phosphorus are used. Twenty-one BMPs taken from USDA–NRCS Field Office Technical Guide Practice Standards are eligible for TP load reductions. The framework recommends a 3:1 trading ratio (GLC, 2017).[20]

2.5.4 Implementation and Lessons

Given the lack of demand to purchase credits to meet permit requirements, the GLC opened the possibility of stewardship crediting, which would involve more diverse buyers interested in environmental benefits in the WLEB (GLC, 2018). Stewardship credits generated through farmers' conservation practices during the pilot period may be available for purchase in 2018 (personal communication, Nicole Zacharda, April 18, 2018).

[20] Contract templates to facilitate the trading process can be viewed at https://www.glc.org/work/eriepmarket/products.

2.6 Ohio River Basin Trading Project

The Ohio River is a 1579-km-long river that flows through or borders six states: Illinois, Indiana, Kentucky, Ohio, Pennsylvania and West Virginia (Ohio River Foundation, n.d.). In addition, its vast, 528,202-square-kilometre watershed drains water from a total of 14 states. It is home to over 25 million people, almost 10 per cent of the U.S. population (Ohio River Foundation, n.d.).

Moreover, the Ohio River is the largest tributary to flow into the Mississippi River, with waters eventually reaching the Gulf of Mexico (EPRI, 2014a). It was estimated that the Ohio River basin contributes about 35 per cent of the Mississippi River's total flow (Olszowka, Heath, & Tennant, n.d.). Therefore, improvements in the water quality in the Ohio River basin will ultimately create ecosystem benefits all the way down to the Gulf of Mexico beyond the Ohio River basin or the Midwest.

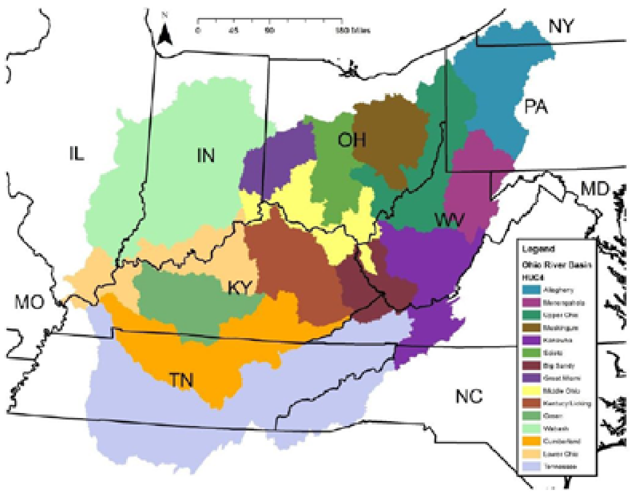

Figure 6. Map of Ohio River watershed

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2.6.1 Watershed Issues

The Ohio River was ranked the most polluted river in the United States for multiple years in a row (Cory, 2015). Pollution from diffuse sources (i.e., urban and agricultural runoff) significantly affects water quality and has led to elevated nutrient concentrations in the river system (Ohio River Foundation, n.d.).

2.6.2 Basis for the Offsets Program

The EPRI Ohio River Basin Trading Project is a collaborative effort to improve water quality in the Ohio River basin. In 2012 representatives of the state environmental agencies from Ohio, Indiana and Kentucky signed *The Pilot Trading Plan 1.0 for the Ohio River Basin Interstate Water Quality Trading Project*, which outlined terms for TP and TN trading and made it possible to trade credits between states (EPRI, 2014a). If the pilot project stage is successful, the program is expected to expand in the future with the addition of six more states. At full scale, 230,000 farmers are expected to create credits for 46 power plants and thousands of other industrial and municipal PSs (EPRI, 2014a).

This program became the first interstate WQT program attempted in the United States (EPRI, n.d.c) and demonstrates a science-driven initiative (personal communication, Jessica Fox, February 21, 2018). The program emphasized a watershed approach to creating solutions for water quality problems and was not constricted by the policy differences among jurisdictions (personal communication, Jessica Fox, February 21, 2018). The sophisticated trading framework was developed in anticipation of new or more stringent water quality regulations as an "economically, socially, and ecologically viable option for compliance" (EPRI, n.d.a, p. 1).

> Our commitment to an adaptive management approach and defensible science and transparency has been fundamental to the project (Fox, 2015).

2.6.3 Roles and Requirements

The EPRI, an independent research organization, acts as an intermediary and manages a large portion of the program. The EPRI engages with relevant stakeholders, conducts research and modelling, and manages all credit transactions. The EPRI trading program is funded by grants from the U.S. EPA and the USDA, which are used for developing critical infrastructure, modelling and stakeholder engagement. It is also funded by private money, which mostly pays for the conservation projects on the ground (EPRI, 2014a).

Challenges associated with uncertainty in calculating pollution reductions were dealt with by using the best available science. The EPA Region 5 spreadsheet model was used to estimate load reductions achieved at the edge of the farm field. The Watershed Analysis Risk Management Framework (WARMF) model was used to estimate nutrient attenuation from the edge-of-field to the point of use. By accounting for multiple factors such as location of buyer and seller, in-stream fate and transport and specific form of pollutant, the WARMF model has provided a solid scientific foundation to calculating appropriate trading ratios (EPRI, n.d.a). Additionally, a sophisticated online credit registry was developed by Markit Ltd. and launched in March of 2013. It enabled a secure infrastructure to bring buyers and sellers together and provided open information to the public. The WARMF model was built in the platform, and, for every credit transaction, the value of the credits could be recalculated based on buyer's location in real time (EPRI, n.d.b). The registry also ensures that the same process and protocols are applied across multiple states (Fox, 2015).

The cost-based pricing model is used to calculate the credit price. The price incorporates the full cost of creating and managing credits, that is: (1) the cost of project activity done on the farm, (2) the cost of project administration and (3) the cost of addressing project risk (EPRI, 2014b). Nevertheless, the market-based pricing is a long-term goal of the project (EPRI, 2014b).

2.6.4 Implementation and Lessons

Given the current absence of stringent regulations on PS discharges, there is no demand for credit trading; only stewardship credits are transacted. Stewardship credits are not used for compliance purposes, and no trading ratios are applied in the transactions. Generally, businesses and private organizations buy the stewardship credits to meet their corporate sustainability goals. The first corporate buyers in the Ohio River program were American Electric Power, Duke Energy and Hoosier Energy (EPRI, 2014b).

By March 2014 the EPRI had sold a total of 9,000 stewardship credits for USD 10 each to the first corporate buyers. Thirty-two farmers were funded (Fox, 2015). The target for the initial pilot trading period of 2013–2015 was to reduce nutrients by 13,607 kg of phosphorous and 30,000 kg of nitrogen (EPRI, 2014b).

Overall, the program was the first to develop and introduce a sophisticated framework for WQT and push the science around WQT forward. As a research organization, EPRI took on extra risks associated with managing a project of such large scale. Faced with uncertainly surrounding the tightening of permit regulations and, hence, the demand for credits, the program plans to continue to pursue strategies to attract credit buyers based on corporate sustainability and stewardship trading (personal communication, Jessica Fox, February 21, 2018). While finding demand is challenging, the organization is safe in knowing that the credits are real, that water quality in the Ohio River basin has been improving and that there is a considerable research base backing the trading process (personal communication, Jessica Fox, February 21, 2018).

3.0 Key Elements of Offset Programs

This section of the report analyzes the case studies in four broad categories: preconditions for offsetting, credit characteristics, institutional structure, and verification and monitoring. Each of these broad categories in turn expands on a number of aspects. For instance, the section on preconditions focuses on regulatory framework underpinning offset programs, as well as issues around cost effectiveness. “Credit characteristics” tackles issues around scale and boundary, baselines, credit price, credit life, credit reserve and credit stacking. The section on institutional structure covers roles and responsibilities, transaction costs and integration with existing programs. Overall, this extensive analysis highlights some of the key features of these offset programs that might be relevant in any new offset program being considered for management of Manitoba’s water resources.

3.1 Preconditions to Support Offsets

A number of market and policy preconditions is necessary in order for water quality offsetting to be a feasible alternative to traditional abatement means and technologies.

The following can act as incentives to push market participants to pursue WQT or offsetting:

1. **Regulatory:** A regulatory agency sets and enforces the limit (a cap) on pollutant discharges.
2. **Economic:** Existence of varying pollution-reduction costs across discharges in the watershed.
3. **Voluntary:** Usually occurs in the absence of the first two incentives. Businesses and other private and sometimes public organizations purchase offset credits to advance their conservation and corporate sustainability goals and create net pollution-reduction benefits for the watershed. Offset credits that are not used for compliance purposes are referred to as stewardship credits. Alone, voluntary incentive is a weak driver to generate sufficient demand and support offsetting.

The combination of the first two incentives is the main driver of most WQT programs examined in this report, **necessary to create demand for offsetting**, and will be explored in more detail in the following subsections.

3.1.1 Regulatory Framework

Regulation of pollution levels (e.g., load limits or caps on discharge) is *essential* for creating demand in the water quality offsetting/trading programs. A realistic and enforceable regulatory framework creates incentives for polluters to seek out cost-effective pollution-control options (OECD, 2012, p. 88).

In the case of the Tualatin River trading program, regulation was highlighted as a key factor behind the success of their large-scale restoration project: “Regulatory requirements prompted the utility to create Tree for All, an innovative approach to restoring native vegetation” (Little, 2017).

In the case of the LSPOP, demand is created by knowing that even the best available stormwater management technology installed on new urban developments will not be able to control phosphorus load discharge 100 per cent effectively, leaving a residual phosphorus runoff to be offset under the “Zero Export” policy (XCG, 2014b).

The absence of the stringent water quality regulations, like in the case of the Ohio River basin states, can still enable stewardship credit selling. Even though important achievements have been made (three states signing on the same rules for WQT and creation of a trading platform), it is still uncertain whether, in the near future, the EPRI Ohio River Basin Trading Project will be able to transition to operating as a system where the market forces and regulatory drivers create supply and demand (personal communication, Jessica Fox, February 21, 2018). Currently, the main incentives for buyers in the program are concern for the environment and creating a net environmental benefit for the watershed. Also, PSs may purchase credits in anticipation of a new regulation, if those credits count for compliance at the later date.

The full list of the regulated entities, regulatory agencies and regulation caps for the selected case studies can be found in Table 2.

In addition to specific discharge limits enforced by regulating authorities, there often exists a long-term environmental goal/vision for the watershed and/or the waterbody of concern (i.e., river or lake). For example, the Lake Simcoe program has set a whole-lake goal of 44 tonnes of phosphorus per year.

Table 2. Regulatory limits on pollutant levels

Offset Program	Lake Simcoe[a]	SN River[b]	Lake Taupō[c]	CWS Tualatin River[d]	Erie P Market[e]	Ohio River[f]
Who is regulated	Developers	PSs	NPSs: farms	PSs[21]	PSs	PSs
Regulating authority	Ontario MOE	Ontario MOE	Waikato Regional Council (formerly Environment Waikato)	Oregon DEQ	Various state regulatory agencies	Various state regulatory agencies
Discharge cap	Zero Export policy: all new development must control 100 per cent of the phosphorus from leaving their property.	MOE had stopped issuing discharge permits to wastewater treatment plants: **Zero phosphorus discharge policy** for the new construction and expanded capacity.	Catchment-wide cap on nitrogen losses: **NDAs** allocated to farms based on historical use of nitrogen in their highest productive year (2001-2005).	**TMDL[22] for temperature** as part of NPDES discharge permits.[23]	Depends on the state.	**Regulations are not stringent enough** to generate demand.

[a] *XCG, 2014b;* [b] *O'Grady, 2008;* [c] *OECD, 2015;* [d] *DEQ, 2012;* [e] *GLC, 2017;* [f] *Fox, 2015; personal communication, Jessica Fox, February 21, 2018.*

3.1.1.1 THE CASE OF REGULATED NPSS

For a fully capped program: The Lake Taupō Nitrogen trading program is a fully capped NPS–NPS trading program. The capping procedure (i.e., setting a baseline) became one of the most difficult in the policy development process (OECD, 2012). Individually calculated NDAs are assigned to farms based on their historical use of nitrogen (see Table 2). A common concern with capping relative to historical emissions can be a tendency to reward

[21] Durham and Rock Creek wastewater treatment facilities of CWS's four municipal wastewater treatment facilities.

[22] A TMDL identifies specific pollutant limits for all sources within a watershed (point, nonpoint and natural background). This allocation ensures that, by discharging the pollutant into the waterbody, the water quality standards are still being met (EPA, n.d.b; DEQ, 2012; Pharino, 2007).

[23] The NDPES permit program was created in 1972 by the federal Clean Water Act in the United States. It helps control water pollution by regulating PSs. It provides two levels of control: technology-based limits and water-quality-based limits. Under this program, the EPA provides authorization to state governments to perform many permitting, administrative and enforcement aspects of the program (EPA, n.d.c).

the "bad" actors and penalize the "good." The farms that have already installed the most efficient practices or do not farm intensively will be limited in expanding their agricultural production and generating nutrient reductions, since installing additional practices would become more expensive. In turn, producers farming intensively and, hence, polluting more originally, can install the least costly BMPs and demonstrate relative benefits and credits more easily. In the case of the Lake Taupō program, the WRC argued that, if another formula was applied (e.g., allocation based on land area), many farmers would need to purchase allowances in order to continue their operations. This was not a preferred scenario for the economy, as it would lead to many farmers going out of business (OECD, 2012). In order to address farmers' concerns, who expressed that the proposed capping approach was inequitable, some flexibility was incorporated into the capping process, so that allocation was based on the "best year" (i.e., most productive year) in the previous five years to enable a more generous allocation.

For partially capped programs: In PS–NPS trading models that are partially capped, PSs are subject to explicit regulatory limits; however, agricultural producers are not. NPSs are not obligated by law to reduce nutrient loading and are expected to voluntarily implement BMPs to sell credits. Therefore, in order for this model to operate, the existing regulation should not extend to BMPs that are supposed to be installed voluntarily. For example, in Oregon's CWS Tualatin River trading program, NPSs were already regulated at the time of the program development. Oregon Senate Bill 1010 (Oregon Department of Agriculture, 2002) set out water quality rules for farmers, such as a legal requirement for landowners to have vegetated buffers to separate farmed land from streams. However, a number of gaps and, hence, opportunities for trading were identified; the regulation did not specify the types of vegetation to be grown on the land (e.g., native versus non-native) and did not require farmers to actively manage the growth of the stream buffer areas. Therefore, the existing regulation of NPSs did not become a barrier to trading, as there was opportunity for additional actions (Cochran, & Logue, 2011).

3.1.2.2 FLEXIBILITY CONSIDERATIONS

How flexible should the water quality regulation be? The Tualatin River program case demonstrates that a certain degree of flexibility is preferred when designing a permit that allows for WQT. The regulating authority (DEQ) developed and enforced the five-year target for a thermal load reduction; however, annual thermal reduction targets were set as benchmarks rather than requirements. This way, the permit explicitly indicated the desired outcomes, but allowed for flexibility on the modes of achieving those outcomes (Cochran, & Logue, 2011).

Pharino (2007) reviewed many trading programs in the United States and concluded that too loose and too stringent regulations may discourage trading. Regulation that is too loose (e.g., generous initial load allocations) may allow PSs to meet the limits with strategies other than trading (e.g., in the case of the EPRI Ohio River Basin Trading Project). However, regulations that are too stringent may put pressure on PSs to upgrade instead of trade. Even though the capital costs are high, operating costs and discharge concentration can be reduced. Therefore, trading is a feasible tool when there is enough flexibility and enough control to require a good response to regulatory or market pressures to meet environmental outcomes.

3.1.2.3 CONCENTRATION-BASED REGULATION VERSUS LOAD-BASED REGULATION

Moving from concentration-based to load-based caps for the watershed is essential to enable offsetting and improve water quality, especially in the case of PS–NPS programs (personal communication, Dennis O'Grady, February 8, 2018). If there are no load-based caps in the watershed, the wastewater treatment facilities (lagoons) may discharge their effluent at peak flows (e.g., in the spring) so that it dilutes to meet the concentration limits on nutrients enforced by regulatory agencies, increasing nutrient loading downstream.

Furthermore, in terms of measurement, it has been recognized that measuring total pollutant loads, albeit expensive, is a more accurate approach to evaluating the impact of individual sources of pollutants (NPS) on water quality in the watershed (Cahn, & Hartz, n.d.). For example, a small farm may produce runoff that has a significantly higher TP concentration than an industrial barn, but the industrial barn contributes 1,000 times the water yield of the small farm downstream. Due to the larger water yield, it actually has a higher (negative) cumulative impact on water quality downstream than the small farm, despite the difference in concentrations. For PSs, the pollutant load can be easily estimated if concentration is known by accounting for the total water yield.

The load of a given pollutant can be calculated for various sources without the watershed exceeding the water quality standard, which is the basis of TMDL in the United States.

3.1.2 Cost Effectiveness

In addition to the regulatory incentive, varying pollution-reduction costs in the watershed are necessary for any offset program. This means that the cost of reducing a unit of pollutant from one source must be significantly different from the cost of removing a unit of pollutant from another source. As transaction costs resulting from activities such as mandatory monitoring and credit certification may outweigh cost savings, the difference in the pollution abatement costs across dischargers has to be sufficiently large.

Generally, agricultural producers have much lower marginal abatement costs for pollutants such as phosphorus and nitrogen. Therefore, PS–NPS programs tend to yield the highest cost savings (Pharino, 2007). Programs such as the SNC WQT program and the CWS Tualatin River program were able to reach their water quality goals by spending considerably less.

At the start of the program development, cost–benefit and feasibility studies are conducted to assess the potential of a WQT program to reduce pollution in the area. In the process of determining the feasibility of trading projects, ancillary ecological benefits of BMPs are important to consider and calculate, if possible.

In the case of Lake Taupō, Waikato Regional Councillors requested a cost–benefit analysis of the Protecting Lake Taupō project to be undertaken (Environment Waikato, 2007). The results showed that it was economically feasible and desirable to implement urgent actions to improve water quality in the lake. Benefits outweighed the costs: by considering only the change in value between "dairy" and "tourism" land uses, the present value of benefits was estimated at NZD 395 million and costs were NZD 116 million (Environment Waikato, 2007).

The CWS Tualatin River program has resulted in significant cost savings to CWS and its ratepayers. By trading temperature, CWS was able to avoid costs between USD 60 million and USD 150 million necessary to install and maintain refrigeration equipment at two of its wastewater treatment facilities (CWS, 2005a, as cited in Cochran, & Logue, 2011). Moreover, the program saved about USD 2 million a year in electricity costs needed to operate the refrigeration units (Cordon, 2006, as cited in Cochran, & Logue, 2011). By adopting offsetting, adverse impacts of electricity generation were also avoided (e.g., air pollution that ultimately contributes to global warming).

3.2 Credit Characteristics

A credit is the commodity being traded in the WQT market. It refers to a verified unit of pollution reduction, measured as pollutant mass load over a period of time (e.g., kg of phosphorus/year). Credits are generated when dischargers in the watershed reduce pollution below the baseline levels (Ogilvie, Ogilvie & Company, 2013; EPRI, 2014a) and, in a typical offset/trading program, can be purchased to satisfy water quality standards for a non-compliant source. Credits that are purchased for a net environmental gain only and cannot be used for compliance purposes are called stewardship credits.

The unit of pollution selected for trading needs to be measurable and cannot create hotspots or accumulation of impacts in the watershed (NNWQT, 2015).

This section will focus on elements of program design as they relate to credits: credit price formation mechanics, offset ratio, trading areas, retirement ratios, credit reserves and others. The summary of these characteristics for the reviewed case studies is presented in the Table 3.

Table 3. Summary of the main credit characteristics

Offset Program	Units	Offset Ratio	Retirement Ratio[24]	Credit Price Formation Mechanism	Credit Reserve
Lake Simcoe[a]	kg/ha/year	2.5:1	—	Price is formed based on estimated total implementation costs for all planned retrofit projects, an estimated kg/year load reduction: CAD 32,200 per hectare of greenfield area or about CAD 1,820 per residential unit	LEAP
SN River[b]	kg/year	4:1	—	The price of 1 kg of phosphorus removed was averaged based on SNC historical costs of delivering BMPs. The price CAD 400 (2009) is adjusted annually for inflation	No credit reserve. Uncertainty factor is incorporated in a high trading ratio.
Lake Taupō[c]	kg N/ha/yr	No trading ratio	20%	Purchasers have the ability to negotiate different prices with different sellers. Market price in 2012 was NZD 300. In 2018, around NZD 450	—
CWS Tualatin River[d]	kcal/day	Depends on the management strategy: 1) Augmented flows: no trading ratio 2) Riparian planting: 2:1	5%	Credit price is established on a project-by-project basis	CWS enhanced additional land and planted more trees than necessary to serve as insurance in case of fire or a site needing to be removed from the program.
Erie P Market[e]	lbs/year	1) PS–PS trades 1.1:1 2) PS–NPS trades 3:1		Cost-based pricing model: price is a sum of all direct and indirect costs of credit generation. Established on a case-by-case basis	10%
Ohio River[f]	lbs/year	Variable trade ratio; currently no trading ratio is applied for stewardship trades.	10%	Pilot stage: cost-based pricing model (USD 10).	10%

[a] XCG, n.d.; [b] O'Grady, 2011; [c] Duhon et al., 2015; personal communication, Rod Edwards, February 14, 2018; [d] Cochran, & Logue, 2011; personal communication, Laura Porter, February 9, 2018; [e] GLC, 2017; [f] EPRI, 2014b; EPRI, n.d.a; personal communication, Jessica Fox, February 21, 2018.

[24] Portion of credits set aside for the net environmental benefit. It may also be implemented to compensate for uncertainty by creating a margin of safety (NNWQT, 2015).

3.2.1 Offset Boundaries

What scale and geographic boundaries are offsets implemented within?

Offset boundaries refer to an area where buyers and sellers can trade with each other and where water quality goals must be met (NNWQT, 2015). Well-defined geographic areas is one of the key elements of success of an offset/ trading program and can help ensure that an adequate number of potential buyers and sellers is in place.

In the case studies, the geographic boundaries for offsetting coincide with **watershed boundaries** (i.e., trading occurs within same lake or river basin). For example, in the CWS Tualatin River program, temperature trading was limited to the area established by the August 2001 Tualatin sub-basin TMDL.

The watershed area can also be divided into subsections for the purposes of program administration. For example, the LSPOP is organizing the USRP by dividing the watershed into five geographic eligibility zones, so that offset transactions must occur within a single zone. Therefore, the primary pool of offset credits generated by USRP will be administered as five zone pools, whereas the back-up pool of credits generated by LEAP will not have any geographic restrictions (XCG, 2014b).

Some programs restrict trading to only **credits generated upstream of the point of compliance** to prevent localized impacts. According to this scenario, a PS may only offset its pollution discharge by purchasing NPS-generated credits located upstream. In this case, upstream crediting is preferred to downstream, since pollutant reductions achieved by the seller located upstream of the buyer are carried downstream, effectively offsetting the pollution impact of the buyer on the receiving waterbody. In case of downstream crediting, the area downstream of the buyer and upstream of the seller does not receive the net water quality benefit and may be at risk of further degradation.

The EPRI Ohio River Basin Trading Project specifies that a PS can only buy credits that are generated upstream of it (Fox, 2015). The Erie P Market framework, on the other hand, allows for both upstream and downstream credits, while specifying that the WQT “may not cause or contribute to the formation of local water quality hot spots” (GLC, 2017).

3.2.2 Baseline

Baseline refers to a standard on water quality that needs to be achieved before a PS or NPS can generate credits (NNWQT, 2015). Therefore, it usually refers to *supply* of credits. If pollution levels are reduced below the baseline levels, credits are generated and may be available for purchase after proper certification and verification.

The LSPOP sets the baseline definition more broadly, referring *both to demand and supply* side as standards that need to be achieved before a project can be considered eligible to participate in an offset program. For example, offset purchasers are required to install pre-agreed erosion and sediment control measures on new developments first, *before* they are able to offset the residual phosphorus load (XCG, 2014b). The baseline for the supply side is required for existing developments before they can be retrofitted to create phosphorus reductions for the program (XCG, 2014b).

For NPSs as buyers and sellers:

Baseline is likely to reflect the current conditions of the fields (maintained after having complied with any landowner-level obligations and regulatory requirements on water quality), for example, levels of nutrient runoff resulting from the land management practices already in place. Appropriate farm records need to be presented to document current field conditions. In the case studies, the baseline is set using different methods for the non-regulated NPS by reviewing:

- Three years of farm practice history (EPRI Ohio River Basin Trading Project; EPRI, n.d.a)
- Three years of cropping data, including at least one round of phosphorus sampling in soils (Erie P Market; GLC, 2017)
- Five years of farm data with the baseline set as the year of highest leaching (Lake Taupō; OECD, 2015)

For PSs as sellers:

The Erie P Market framework outlines the similar procedure for PS sellers, where they need to demonstrate performance over at least three years prior to any application to sell credits. The baseline for PSs is the lower of the water quality standard (TMDL) or the current pollutant discharge level.

Regardless of the participant types, the baseline takes into account all pre-existing regulatory requirements in the relevant trading area. Moreover, it considers all federal, provincial/state and local grants and incentive programs applied for before the trading program to achieve current conditions, so that **only additional conservation practices**, and thus additional benefits, will count toward credit generation.

3.2.3 Offset Ratios

What is the purpose of offset ratios?
How are offset ratios determined?

In a situation without uncertainty, a discharger (PS buyer) only needs to offset the same amount of pollutant that it contributes to the watershed. However, in many programs, the 1:1 equivalency between PS and NPS reductions does not take into account context-specific conditions, temporal and spatial variations, and perhaps co-benefits. As well, there are challenges related to pollution-reduction measurement and monitoring that contribute to this uncertainty (see Section 3.4 on verification and monitoring).

Therefore, offset ratios are often incorporated in the trading/offsetting program design. An offset ratio is a multiplier used to adjust the amount of credits required for purchase in offset program transactions. They provide a buffer against uncertainty and help achieve environmental equivalency between controlling discharges at a PS and implementing BMPs at an NPS, so that pollutant reductions resulting from the program have the same or an even better effect on environment as compared to simply mitigating excess pollution at the PS. For example, in the SNC program, the trading ratio is set at 4:1, so that a PS has to buy four times more pollution-reduction credits generated from on-farm practices for every unit of pollutant it contributes (O'Grady, 2008).

Trading ratios and their rationale vary from program to program. More commonly, they incorporate some combination of the following variables (NNWQT, 2015; DEQ, 2015b):

- Form of the pollutant
- Geography of polluters (i.e., the location of buyer in relation to seller)
- Uncertainty associated with the quantification of NPS load and BMP performance (different BMPs perform differently in geographically different contexts and at different times)
- Credit retirement to ensure a net reduction in water pollution
- Attenuation of a water quality benefit between the location where credit generation occurs (BMPs are installed) and the point of use
- Lag in time between BMP installation and BMP producing a full water quality benefit

In the case studies, the offset ratios are approved by a regulatory agency.

The reasoning behind offset ratios for the reviewed programs is presented below.

- **SN River: 4:1** is the highest offset ratio in all of the case studies. It was designed to account for variability in phosphorus removal from a range of practices eligible for implementation and buffer against any force majeure situations that may affect BMPs' effectiveness. This offset ratio was determined through consultations with the farming community (NPSs) who felt that it was an appropriate multiplier to achieve equivalency in phosphorus reductions (O'Grady, 2010). Main consideration: **uncertainty**.
- **CWS Tualatin River: 2:1** trading ratio was applied in the riparian planting projects. It addresses the time lag between planting trees and having the full amount of shade in 20 years (Porter et al., 2014). The CWS Tualatin River program is the only offset program among those reviewed that applied an offset ratio to account for time lag between implementation and realizing the actual water quality benefits of the practices. This is due to the nature of projects and characteristics of the pollutant. No trading ratio was used for credit derived from augmented flows. Main consideration: **time lag**.
- **Lake Taupō: 1:1** equivalency in pollution reduction among program participants. The trading partners were of the same type (NPSs, except for the Lake Taupō Protection Trust), so the simplified approach was adopted.
- **Ohio River: variable** trading ratio that incorporates location-specific nutrient attenuation factors and is dynamically calculated with the use of the EPA Region 5 spreadsheet model and WARMF model. The models account for a number of variables, such as location of buyer and seller, in-stream fate and transport, specific form of pollutant, and uncertainty, to calculate unique trade ratios for every single transaction. For example, the further buyers are located from sellers, the greater the uncertainly in the model and thus, the higher the trading ratio, which makes it more expensive to buy credits (Fox, 2015). Main consideration: **attenuation, geography**.
- **LSPOP: 2.5:1** offset ratio that is introduced to create a net environmental benefit from each transaction (XCG, 2014b). Main consideration: **net environmental benefit**.
- **Erie P Market: 3:1** trade ratio, which is the sum of the following components: 1:1 for direct pollution reduction between sources; 1:1 for addressing uncertainty in load calculations, fate and transport in the environment, and pollutant equivalence; 1:1 for implicit credit retirement to ensure a net water quality benefit (GLC, 2017). Main consideration: **uncertainty and net environmental benefit**.

Offset ratios are very important elements of the offset program design because they ensure equivalency of pollution reductions across trading partners in the watershed. The same offset ratio can be applied to all PS–NPS partners in the watershed (five out of six case studies) or it can change dynamically based on a number of trade-specific factors (one case is the Ohio River). Reliable scientific evidence is required to support the choice of an offset ratio for the program. Nevertheless, it should be noted that the appropriate offset ratio is set not only through scientific research but also through consultations with relevant stakeholders to ensure that the final decision will not discourage the trading process. In the absence of scientific evidence and data, the precautionary principle suggests the application of a higher offset ratio. Clouston et al. (2014) noted that higher offset ratios may discourage trades. However, this should not be viewed as a rule. The high trading ratio in the SN River program, for example, was an outcome of negotiations between agricultural community and PS dischargers and adjusted upward from 2:1 to 4:1 (O'Grady, 2011).

3.2.4 Credit Price

How is the price for offset credits determined?

In all PS–NPS cases reviewed, a **cost-based pricing model** is utilized in price formation (i.e., the price is determined by the sum of all of the cost inputs that go into generating a credit):

- **Direct costs** of the credit generating practice (cost of constructing BMP)

- **Indirect costs** (refers to some combination of transaction costs) such as:
    - Lake Erie: "fees for certification, verification, and contract reviews" (GLC, 2017)
    - SN River: "costs of project management, water sampling, communications to promote the grants available to landowners, and yearly reporting" (O'Grady, 2011)
    - Ohio River: the cost of project administration and the cost of addressing project risk (Fox, 2015)
    - LSPOP: program administration costs (XCG, 2014a)

The unit price/project payments may also incorporate opportunity costs of lost farmland and ancillary ecological benefits resulting from the projects.

In our case studies, existing conservation programs were consulted to learn about existing costs of eligible practices and help determine the credit price for offsets. For example, the Erie P Market framework specifies that the prices are derived from NRCS-Environmental Quality Incentives Program Practice List and Payment Schedules. In some instances, existing incentive programs needed to be reviewed and updated to guide price formation and implementation. In the case of the CWS Tualatin River program, an existing incentives program was reviewed, then better terms and higher payments were made available to farmers.

Therefore, the price of unit of pollution reduction is not a competitive price, but often set by a program administrator (SN River, LSPOP, Ohio River). The program administrator buys and sells credits at a pre-announced price, so that program administrator's role in trading is more accurately described as a clearinghouse than a market-trading institution[25] (SN River, Ohio River, Lake Erie).

Prices are managed in a variety of ways in our case studies:

- Price per credit can be fixed for all transactions (e.g., LSPOP; Ohio River).
- Price can be adjusted annually for inflation (e.g., SN River).
- Price can vary from project to project based on the program administrator's decisions, for example, in a sole-source offset program where a program administrator and a regulated discharger is the same organization (e.g., CWS Tualatin River).

In this offset structure, it can make more sense to base farmers' compensation on total project installation costs rather than a cost per credit of pollution reduction they generate. In the CWS Tualatin River program, payments to farmers are based on the acreage enrolled rather than the desired outcome of thermal load reduced (Cochran, & Logue, 2011).

In a special NPS–NPS trading case (Lake Taupō), the price of a unit of pollution reduction (i.e., NDA) is formed through a combination of market forces and a fixed price (Duhon et al., 2015). The degree of market forces forming the price largely depends on the number of market participants and the trading activity overall. The price can be negotiated between individual NPS buyers and sellers, and therefore Duhon et al. (2015) concluded that there was no "market price." At the start of the Lake Taupō program, the price mostly depended on the first buyer's (Lake Taupō Protection Trust) funding availability. The trust established a standard price for all transactions it was involved in to retire NDAs (Duhon et al., 2015; OECD, 2015). The trust's website specifies that it may tender or auction to purchase nitrogen, that there is no floor price for nitrogen, and that there may be a different dollar value offered for nitrogen depending on the farm system or circumstance (Lake Taupō Protection Trust, n.d.). The most recent evidence suggests that there is a market price of around NZD 450 (personal communication, Rod Edwards, February 14, 2018).

[25] A clearinghouse is characterized by a centralized third-party agency acting as a broker that aggerates pollution reduction credits from multiple sellers (NNWQT, 2015). In such a program, credits are available "off the shelf," and it is well suited for PS–NPS offsetting (NNWQT, 2015). In the market exchange model, buyers and sellers trade directly in a web-based platform that facilitates credit auctions. This structure implies open information and high transaction volumes and results in low transaction costs (Voora et al., 2012; NNWQT, 2015).

There are also variations in payment modes: single payment or annual payment, depending on the program. Payments can be upfront (Tualatin River) or occur after on-site confirmation of practice installation (Ohio River, LSPOP). In the case of EPRI Ohio River Basin Trading Project, the program administrator, EPRI, signed 40-year agreements with farmers. Farmers' payments are spread out over the duration of the contract in consideration that farmers need to invest to maintain BMPs over the contract period. If the BMPs are more capital-based, farmers may get a larger payment at the start of the contract period (e.g., 75 per cent) with the remainder (e.g., 25 per cent) spread out over the rest of the term (personal communication, Jessica Fox, February 21, 2018).

In summary, the case studies provide lessons on successful price formation. First, it is important to ensure the revenue certainty and to reduce risk for trading partners, and this is achieved through a set price per unit of pollution reduction. Second, the price must be enough to cover the actual cost to the seller, plus transaction costs of program administration. However, price must not exceed the cost that the buyer could have paid to achieve the same reduction itself (e.g., through upgrading wastewater infrastructure).

3.2.5 Credit Life

When are credits generated and available for sale?
How long do they remain valid?

Credit life refers to the time period in which a credit can be used for compliance purposes (DEQ, 2016) and considers when it is actually generated and its lifetime. It will depend upon the BMP project type and the length of time a practice is expected to generate pollution reductions. For example, benefits from stormwater management practices installed on new development can be expected to last in perpetuity, whereas augmented flows to cool down the river are effective only for one season—in summer when temperatures are high. The expected credit duration guides the development of contracts between a regulated entity and a project developer or landowner.

Oregon's WQT rules state that credits will be effective for as long as they are maintained and can be used when permits are renewed (DEQ, 2016). The EPA (2004) specifies that, for the CWS Tualatin River program, Oregon DEQ has limited the duration of each credit to 20 years to correspond to the useful life of mechanical refrigeration equipment.

Generally, credits are available immediately upon verification of practice installation (Lake Erie, Lake Taupō, Tualatin River, SN River, Ohio River). For Tualatin River, credits are available immediately upon the release of water through flow augmentation and putting trees in the ground through riparian enhancement. Since the credits are released immediately, the lag time between a project's installation and its full benefit is incorporated into the offset ratio discussed earlier.

In the terminology of the NNWQT (2015), the project life ("the period of time over which a project or BMP is anticipated to function") is different from the credit life. The credit life is the period of time from the date a credit becomes usable as an offset by a PS to the date that the credit expires, which is usually a year. Thus, a project life can have multiple credit lives within its duration. Many projects in the reviewed case studies continue to generate credits for many years. For a permanent practice, credits can be renewed each year. For example, the Erie P Market framework specifies that, for permanent practices, it is possible to regenerate a credit each year (GLC, 2017). The EPRI Ohio River Basin Trading Project sets a minimum 12-month term for a credit that may be renewed for successive terms provided that it continues to be implemented and verified (EPRI, n.d.a).

The ongoing renewal past the initial credit life in this case is important because it will ensure that the practice continues to be effective on the ground and provide water quality benefits (NNWQT, 2015).

3.2.6 Credit Reserve

Are there additional mechanisms to deal with uncertainty?

A credit reserve is an optional risk mitigation mechanism in an offset program design, which implies setting some portion of credits aside. It buffers against unforeseen events such as extreme weather conditions (e.g., storm or natural disasters that destroy farm projects) or lack of landowner maintenance, which may lead to BMPs failing to generate credits.

Three out of six programs made explicit provisions for a credit reserve (EPRI Ohio River Basin Trading Project, Erie P Market, LSPOP). In the SNC water quality trading program, this risk of the program not delivering the necessary amount of pollution reductions (e.g., through rare occasions of BMP failure) was incorporated into a high trading ratio.

The Ohio River and Erie P Market programs set the standard reserve size of 10 per cent of the total credit pool. The Ohio River program, although having established a credit reserve, has not yet utilized it to date (personal communication, Jessica Fox, February 21, 2018). The LSPOP is forming a back-up offset pool through an already existing incentives program (LEAP) as a temporary and occasional measure (XCG, n.d.). CWS, as an administrator of the Tualatin River program, has enabled a credit reserve through investing in projects to generate temperature load reductions above the permit requirements (personal communication, Laura Porter, February 9, 2018).

3.2.7 Liability

Is there liability for failed credits?
Who is liable?

A related topic to mitigating the risk of inadequate credit supply due to force majeure situations is the question of who holds liability for failed credits. As a general rule, the discharger that is offsetting to comply with water quality standards (e.g., the permit holder in United States) is responsible for delivering necessary pollution reductions and therefore is subject to an enforcement action if a credit is proven to be invalid (Pharino, 2007). As for NPSs failing to deliver valid credits, special provisions in contracts with landowners usually make note of any penalties that they may incur if they fail to maintain the site according to standards (Pharino, 2007). In the case of the EPRI Ohio River Basin Trading Project, if land landowners do not maintain the site, they will not receive their full payment, which is spread out over multiple years (personal communication, Jessica Fox, February 21, 2018).

O'Grady (2011) emphasizes that the liability for landowners has to be minimized. In the SNC water quality trading program, landowners did not bear any legal responsibility if phosphorus reduction targets were not met by the program. In its Certificate of Approval to Operate a Wastewater System, SNC has legally agreed to provide necessary phosphorus reductions. Nevertheless, as a broker, it ensured a legal protection for itself. First of all, it engaged in extensive consultations with wastewater treatment plants prior to them entering the trading program to avoid any misunderstandings and future conflicts. Second, the wastewater discharger was allowed to have a representative on the Clean Water Committee, which was in charge of decision making. Therefore, in case of a lawsuit, the PS dischargers would in fact be suing themselves (O'Grady, 2011).

3.2.8 Credit Stacking

Are multiple benefits from offsetting actions taken into account?

Some BMPs can result in multiple ecological benefits. For example, reducing fertilizer use, wetland restoration and forest planting provide a combined benefit of both nutrient removal and carbon sequestration. Credit stacking involves expansion into different ecosystem markets.

Credit stacking of water quality and carbon credits is being explored by EPRI in relation to the Ohio River Basin Trading Project. The focus is on incentivizing forestry as a conservation practice and adding quantified carbon credits as a project outcome (EPRI, 2014a; EPRI, 2017).

Under credit stacking, landowners can receive multiple payments for the ecosystem services they provide. This approach provides multiple revenue streams, so that landowners are encouraged to develop higher quality projects (e.g., restoring a wetland versus simply planting a vegetative buffer) (Cooley, & Olander, 2011).

Credit stacking is currently the topic of debate, since, in addition to benefits, the concept has some potential issues, for example, stacking could result in payments to landowners exceeding those needed to initiate the alternative land use project (Cooley, & Olander, 2011).

It is too early to evaluate the success of credit stacking, since most environmental markets are in their early stages in this regard and the governing rules for sales of the stacked credits are still in development.

Nevertheless, the successful interaction of two ecosystem markets has occurred in the Lake Taupō program in New Zealand. There, the synergy between the nitrogen trading market and the carbon offset market was a success factor for the uptake of the cap-and-trade program. Converting the land from livestock farming to forestry became economically more viable from a business standpoint since farmers could earn income from selling both nitrogen allowances and carbon credits (Duhon et al., 2015).

3.3 Institutional Structure

3.3.1 Roles and Responsibilities

Who is responsible for what parts of the program?

The roles and responsibilities of the key players in the program must be clearly defined, including but not limited to buyer, seller, program administrator, regulating authority and verifier.[26]

A Statement of Roles and Responsibilities is a useful document to draft to avoid misunderstandings and legal action as the program moves to an implementation phase. Such a document was an outcome of the extensive consultation process with the agricultural community in the SN River program design (O'Grady, 2008). It clearly outlined the roles and responsibilities of all partners involved in the program, including landowners; the Ontario Ministry of Agriculture, Food and Rural Affairs; the Clean Water Committee; the South Nation Conservation; municipalities/industries; and the MOE (SNC, 1997). Most importantly, the Statement of Roles and Responsibilities absolved landowners from any legal responsibility in case phosphorus loadings were not reduced and the buyers were not in compliance. The document was signed by local agricultural organizations, the provincial government and SNC, and was instrumental in the success of the trading program (O'Grady, 2011).

[26] For the discussion on the verifier types see section Verification and Monitoring.

3.3.1.1 BUYERS AND SELLERS

Who should be allowed to buy credits?
Should non-dischargers be allowed to buy credits?

In most of the case studies, the trading programs are designed as flexible options for compliance for regulated entities. In these cases, buyers are dischargers with regulated baselines. Some programs, however, also incorporate stewardship trading. For example, watershed groups may buy and retire credits from the market to further reduce pollution. Sellers in most programs are rural landowners. Buyers and sellers for each project are presented in Table 4.

Table 4. Types of buyers and sellers of pollutant reductions (credits) in water quality offset/trading programs

Offset program	Buyers/Demand		Sellers/Supply
	For compliance	For stewardship	
LSPOP[a]	Land developers		Stormwater retrofit projects in existing built-up areas
SN River[b]	• Municipal wastewater treatment plants • Municipal and commercial landfill sites • Waste treatment company • Milk processing plant		Landowners
Lake Taupō[c]	Farmers/landowners	Lake Taupō Protection Project Joint Committee through Lake Taupō Protection Trust	Pastoral farmers / landowners
CWS Tualatin River[d]	• Publicly owned treatment works • Industrial facility stormwater discharges • Municipal separate storm sewer system discharges		Landowners (urban and rural areas)
Erie P Market[e]	NPDES permittees	Any interested private, public or non-profit entity (e.g., permitted facility, conservation organization, local business)	• Traditional row crop agriculture producers • Conservancies • County farms • Park districts that own or manage rural (working) lands
Ohio River[f]		Businesses and private organizations	Farmers

[a] LSRCA, 2017; [b] SNC, 2010; [c] Duhon et al., 2015; personal communication, Rod Edwards, February 14, 2018; [d] EPA, 2007; [e] GLC, 2017; [f] personal communication, Jessica Fox, February 21, 2018.

As can be seen from the Table 4, all programs, except for Lake Simcoe, depend on voluntary supply of credits from farmers and landowners for the offsetting program to operate. In this regard, building an effective working relationship with the farming community is of paramount importance. The success of the offset program will in many ways depend on communication strategies and institutional frameworks to involve agricultural producers. The next section will explore trading programs' experiences of building connections with the agricultural community.

3.3.2 Farmers' Participation

How are farmers engaged?
How are collaborations sustained?

The supply of credits in the PS–NPS and NPS–NPS models reviewed in this report comes from landowners (often, agricultural producers) who voluntarily install BMPs on their land. In this regard, constructive engagement of landowners is crucial and will ensure sufficient (and, if needed, sustained) supply of credits and most importantly water quality improvements in the watershed.

Different programs approached this task by using different strategies; however, all aimed at engaging farmers early on in the process, providing clarity on procedures and expectations, listening to and incorporating farmers' feedback in program design and thereby building trust in the program.

In many cases, there was initial resistance from the farming community and the general public. Farmers do not want to be seen as polluters. Farmers' opposition was especially pronounced in the cases of the South Nation WQT program and the Lake Taupō nitrogen trading program (OECD, 2012; O'Grady, 2011).

Following are some lessons from the programs on effectively engaging the farming community in water quality offsetting/trading.

ENGAGING FARMERS EARLY ON IN THE DESIGN PROCESS THROUGH EXTENSIVE CONSULTATIONS

The failure of many WQT programs is attributed to not involving the agricultural community early enough in the program design (EPRI, n.d.c). Most of the reviewed programs were able to constructively engage farmers and incorporate their feedback. In the case of the EPRI Ohio River Basin Trading Project, consultations with the agricultural community were instrumental in highlighting important concerns farmers had surrounding the program and ultimately secured their participation. The consultations resulted in a series of recommendations applicable to many programs that work with farmers: mechanisms to avoid swings in credit prices, options for dealing with non-performance, access to technical assistance, information about how credited BMPs will affect crop yields, and consistent and transparent rules (EPRI, n.d.c). Furthermore, a document was developed that addresses barriers to farmers' participation (see Fox, 2012).

Over three years, South Nation trading program consultations have led to an agreement on the roles and responsibilities of various partners and modified the program's design elements (e.g., adjusted the trading ratio from 2:1 to 4:1) (O'Grady, 2008).

In the case of the Tualatin River program, consultations with the rural community focused on an existing incentive program for landowners—the USDA's Conservation Reserve Enhancement Program (CREP) and the Vegetated Buffer Areas for Conservation and Commerce Program (EPA, 2012). Farmers were dissatisfied with the program, and, among many concerns, they felt that, through CREP, they were not compensated enough for the actual cost of maintaining buffer areas over time (Cochran, & Logue, 2011). The consultation process with farmers reviewed and modified the existing incentive program, making it more attractive for participants by enabling fairer compensation and more flexibility. The reviewed version of the program, called *Enhanced* CREP for the Tualatin River basin, was implemented to generate credits from rural riparian shade projects and was largely financed by CWS, an offsetting

PS (Cochran, & Logue, 2011).[27] CWS paid all upfront costs and was later reimbursed for the federal share of the standard CREP program (Cochran, & Logue, 2011). Initially, to form working relationships with landowners and move the Tualatin River program forward, CWS provided an option to supply trees for the rural riparian restoration projects free of charge and without contracts (Cochran, & Logue, 2011).

In New Zealand's Lake Taupō project, a decision was made to involve an agricultural science expert to act as a bridge between the Waikato Regional Council (WRC) staff and the farmers of the Lake Taupō catchment. The expert stayed involved throughout the policy development process and helped smooth relationships between government officers and landowners, enabling them to better understand each other's needs (OECD, 2012).

KEEPING THINGS SIMPLE: MINIMUM PAPERWORK

Onerous eligibility requirements, application forms and reporting requirements are significant barriers to agricultural participation (Weber, & Cutlac, 2017). This prevented some existing government incentive programs from successful uptake, like in the case of the Environmental Quality Incentives Program for Ohio River basin farmers (EPRI, n.d.a). In addition, simple application and delivery processes were emphasized by O'Grady (2011), based on experiences of the SN River WQT program.

FARMERS PERFORMING MONITORING ACTIVITIES (PEER-TO-PEER APPROACH)

The SN River WQT program in Ontario took farmers' engagement a step further and created a unique and successful mechanism where farmers were hired to act as field representatives. They oversaw BMP implementation by visiting farms, discussed funding options and assisted with filling out application forms. Later they presented projects to the multistakeholder Clean Water Committee for the review on the applicants' behalf (O'Grady, 2006). The committee, which had more than 50 per cent agricultural representation, decided which projects to fund and established grant rates. Moreover, farmers were in charge of project follow-up and verification. This peer-to-peer process helped to build farmers' trust in the program. This approach is rare among WQT programs, which often rely on full-time professional staff for field inspections (O'Grady, 2008).

USING A TRUSTED INTERMEDIARY TO MANAGE THE PROGRAM

All of our case studies have benefited from a trusted intermediary working with farmers. Organizations that are independent from government, that work with farmers on daily basis or that are led by farmers are best suited for marketing and managing a rural part of a PS–NPS program. In the United States, program administrators are working with existing agricultural organizations such as SWCDs, who have developed a credible and long-standing relationship with local communities.

Below are some useful considerations from case studies regarding intermediaries working with farming communities:

- **EPRI Ohio River Basin Trading Project:** Due to cultural considerations, farmers were more willing to accept grants for their land management projects from the EPRI than from a government agency. Since the program involved businesses as the main buyers, farmers considered accepting a grant from EPRI as a type of business arrangement, which made the transaction more attractive to them (personal communication, Jessica Fox, February 21, 2018).
- **Erie P Market:** This flexible market framework allows agricultural producers to work with their preferred local conservation partner to design a conservation plan (GLC, 2017).

[27] Prior to the trading program, the CREP program in the Tualatin basin had no enrollment.

- **Clean Water Services Tualatin River Program:** CWS provided a general oversight of the riparian planting program in the rural parts of the watershed. However, a farmer-led organization was necessary to take on marketing and managing responsibilities. Tualatin SWCD, an organization with a board of directors entirely made up of farmers, acted as a "the public face of the trading program" in the rural areas, managing planting, maintenance and landowner payments (Cochran, & Logue, 2011, p. 36).

MINIMIZING RISK FOR FARMERS

Based on our case study research and interviews, it was stressed that farmers should not be held liable in case PSs fail to deliver necessary phosphorus reductions; potential legal liabilities for farmers must be minimized. The CWS Tualatin River program has ensured this through signing an explicit agreement with landowners specifying that, if appropriate, liability for project outcomes will be shifted from landowners to sponsoring entities (Cochran, & Logue, 2011; Guillozet, 2015). Contracted restoration crews were mainly made responsible for planting and maintenance. The South Nation trading project absolved landowners from any legal responsibility in case phosphorus loadings were not reduced and the buyers were not in compliance through a Statement of Roles and Responsibilities document, mentioned earlier (O'Grady, 2011). However, landowners were obligated to install and maintain the BMP project for a minimum of five years.

Second, farmers will be more willing to participate if they have revenue certainty for BMP installation, regardless of whether the credits are transacted. Payment upfront or immediately upon on-site confirmation of practice installation shifts the risk of not selling the pollution reductions from farmers to the intermediary, as in case of the EPRI Ohio River Basin Trading Project (Fox, 2015).

Overall, lessons for program success from this section include education and trust-building strategies (e.g., involving an organization with strong institutional presence working with the farmers, engaging farmers early on in the design phase of the project, reducing onerous paperwork) and involving the agricultural sector. These require adequate time commitments and resources for program planning and implementation.

3.3.3 Program Administrator

What organization should act as a program administrator?
Should it be a new or an existing organization?
What tasks will the program administrator perform?
What resources would it require to do its work?
Where would the funds come from?

The administration of an offset program is successful when performed by a credible, long-standing, transparent and accountable organization (O'Grady, 2010; LSRCA, 2015b). An appropriate program administrator is able to leverage partnerships and resources that serve to obtain community support in the best way.

In the reviewed programs, the following types of organizations are assuming the lead in offset programs:

EXISTING CONSERVATION AUTHORITY

Generally, Conservation Authorities have excellent reputations for working with landowners in the watershed, possess the required knowledge of local issues and have the capacity to build on existing partnerships.

The LSRCA in the Lake Simcoe watershed is in regular contact with various public and private sector stakeholders, such as government agencies and the local and regional municipalities, which puts this organization at a clear advantage as an offset program coordinator. As the program administrator, the LSRCA is responsible for contracting offset buyers and sellers, determining offset costs, assuring the quantity and quality of offsets, maintaining a back-up pool of offsets, and public and stakeholder outreach and education (for the full list of responsibilities, see XCG, 2014c, pp. 8–9).

SNC in the South Nation River watershed is a sole trading broker and has a long-standing relationship with landowners. SNC worked with them to deliver landscape BMPs for 25 years prior to the trading program (O'Grady, 2011). SNC handles all financial transactions between PSs and NPSs, keeps record of trades, takes meeting minutes and performs other administrative duties. Moreover, it provides research support as needed, calculating a credit price, trading ratio and other technical elements. However, the entire decision-making process regarding program eligibility and grant rates for BMP installation is handed over to the farmer-led Clean Water Committee (O'Grady, 2010).

INDEPENDENT RESEARCH ORGANIZATION

An independent research organization has the role of program administrator in the larger interstate Ohio River Basin WQT project that brings three states under the same trading framework. As a trading broker, the EPRI took on administrative responsibilities similar to SNC (e.g., overseeing market transactions, maintaining trade registry, conducting research). However, screening of landscape BMP projects and grant decisions are carried out by a farmer-led entities (Soil and Water Conservation Districts [SWCDs]), similar to the South Nation program. SWDCs are considered the most trusted market intermediaries and engage with farmers and landowners directly (Fox, 2015). SWCDs perform various outreach activities; review projects for eligibility, size, and value; and make recommendations to the EPRI on which project to fund. They also oversee BMP implementation (Fox, 2015).

EPRI entered into agreements with three state agricultural agencies (Ohio Department of Natural Resources, Kentucky Division of Conservation and Indiana State Department of Agriculture) in order to initiate the flow of funding raised by the EPRI to SWCDs. The relevant state agencies in turn enter into agreements with the SWCDs and arrange to periodically monitor, inspect and verify the BMPs. Subsequently, the SWCDs enter into agreements with eligible landowners to fund the implementation of BMPs (Fox, 2015).

REGULATED DISCHARGER

In the case of the sole-source offset program[28] in the Tualatin River basin, CWS, a regulated PS, developed and implemented a program to offset the thermal load discharged from two of its wastewater treatment plants. It acted as a convener, carried all transaction costs and most of the BMP implementation costs, and had to report on compliance with water quality standards.

Similar to other PS–NPS programs, CWS worked with existing agricultural organizations to implement projects (i.e., tree planting along streams) in rural areas. CWS contracted with the Tualatin SWCD to provide incentives for landowners to enrol in the updated government incentive program, the Enhanced CREP, discussed earlier. Farmers apply to be part of the program, and SWCD, with input from CWS, reviews and decides on the better projects to fund based on certain criteria (personal communication, Laura Porter, February 9, 2018). In urban areas, a network of cities and non-profit organizations was utilized to implement restoration programs along urban streams (Porter et al., 2014).

[28] "Sole source" refers to a single buyer in the offset program.

Credit registry: The program administrator is responsible for maintaining the credit registry. The credit registry is a central database that publicly documents offset transactions and tracks performance. In the credit registry, credit-generating practices are serialized and the transfer of credits between accounts may be possible. The design of the credit registry and its functionality will depend upon the size of the program and number of market participants. Examples of the information on credit generation that can be inputted into credit registry can be found in the Erie P Market framework (GLC, 2017, pp. 14–15). One of the most complex and sophisticated online water quality credit registries was created by Markit Ltd. for the Ohio River Basin Trading Project.

LOCAL GOVERNMENT ORGANIZATION

In the NPS–NPS program case in the Lake Taupō catchment, the WRC acts as a program administrator, providing necessary oversight of the program. It keeps the trading registry, gives out certificates of ownership, reviews and approves land management plans,[29] and enforces penalties for non-compliance under the Resource Management Act (OECD, 2015). The Lake Taupō Protection Joint Committee, consisting of the WRC, the Taupō District Council and the Crown, was established for ongoing long-term governance and management of the project. The Joint Committee was involved in the formation and signing of the Project Agreement and funding deed, and the establishment of the Lake Taupō Protection Trust (personal communication, Rod Edwards, February 14, 2018). The trust assisted in a number of ways by performing three important functions: research organization (seeking cost-efficient ways of using farmland differently to reduce nitrogen outputs), independent buyer (purchasing NDA) and farm operator (purchasing farms). Moreover, the trust financed initial benchmarking of the farms' nitrogen discharge levels (OECD, 2015).

The program administrator types vary; however, the tendency is to use a sole broker to match buyers and sellers, handle all transactions and, in some cases, carry out important research tasks. It is important, especially in PS–NPS programs, to involve a credible organization that is able to leverage community support with existing partnerships. The decision-making process on BMP installation and verification is ideally delegated to farmer-led institutions or a network of committees and groups with significant agricultural representation and agricultural science knowledge.

3.3.4 Transaction Costs

What kind of transaction costs need to be considered?
Who is responsible for paying them?

The costs of project implementation (BMP installation) are paid for by the offsetting entity either in full or in part. Payments are made to landowners for the installation (Ohio River, SN River) or for land use, with professionals contracted to perform the installation (CWS Tualatin River program). In some programs, the PS pays the full cost of installation; in other programs (Ohio River, SN River), only a portion of costs associated with project installation is paid by the trading program, and the remainder has to be matched with other governmental grants. South Nation specifically did not want to fund projects where the main rationale from the farmer to improve water quality is "they're paying me to do it" (O'Grady, 2011).

Apart from the costs of BMP installation, many types of transaction costs occur in the offset programs. They need to be considered and minimized. Broadly, transaction costs are comprised of:

- Cost of developing trading program rules (e.g. research, policy development, education and outreach).
- Costs involved in program implementation and operation (e.g., cost of initial benchmarking, project approval, verification, enforcement, certification, ongoing monitoring) (Rees, & Stephenson, 2014).

[29] A plan that is required to continue farming, it details how farming practices on the property meet the assigned NDA.

Generally, it is the **entity pursing trading that bears the transaction costs.** The magnitude and types of transaction costs depend on the specific project context (Guillozet, 2016). Nevertheless, since an offset program needs to ensure equivalency between NPS pollutant reductions and PS requirements, modelling and monitoring costs can be quite substantial due to the involvement of highly skilled professionals in design and development (e.g., the EPRI Ohio River Basin Trading Project) (Fox, 2015).

When a regulated entity trades or offsets directly, for example in sole-source offsetting (CWS) or trading between regulated NPSs (landowners in Lake Taupō catchment), the regulated entity is responsible for paying most of the transaction costs associated with the trades.

For example, in the Lake Taupō catchment, regulated farmers face record-keeping and legal costs associated with holding a resource consent (Duhon et al., 2015). The WRC charges landowners for monitoring, auditing and other activities, but the transaction costs generally do not exceed NZD 1,000 per year (personal communication, Rod Edwards, February 14, 2018). As for the time of trade, the magnitude of the landowners' transaction costs varies depending on the transaction partner. Transaction costs tend to be lower when selling NDAs to the Lake Taupō Protection Trust, rather than another farmer, since the trust covers all consulting and legal fees associated with the trade (Duhon et al., 2015). This way it makes it more attractive for farmers to sell their allowance to the trust. Since the trust uses public money to permanently remove some nitrogen discharge in the catchment, such a transaction is preferable, as it creates a net environmental benefit.

Similarly, in the case of the CWS Tualatin River program, transaction costs are borne by the entity pursing trading, which is CWS. CWS pays for all monitoring activities, for example, paying Tualatin SWCD to maintain the sites, while the organization is collecting the data and directly reporting it back to DEQ. The costs are absorbed into the capital funds that are generated by utility ratepayers. Since trading is cheaper than building infrastructure in relation to a wastewater treatment plant, there are significant savings that are passed on to the ratepayer (personal communication, Wade Peerman, February 9, 2018).

In the offsetting scenarios where the intermediary acts as a trading broker bringing multiple buyers and sellers together, the intermediary pays for all transaction costs (e.g., EPRI, SNC); however, the transaction costs (e.g., certification, verification costs) are incorporated into the credit price (see Section 3.2.4 on credit price). In the case of the LSPOP, the total costs (project costs, administrative and monitoring costs) will be covered by purchase commitments from land developers (XCG, n.d.). However, in some trading programs such as Ohio River, the intermediary (EPRI) is not always backed by the purchase commitments from buyers ahead of the credit generation.

For the success of any offset program, transaction costs should be kept low. Evidence from New Zealand (Lake Taupō trading program) indicates that the amount of fixed transaction and time costs for trading (around NZD 2,000–8,000 per trade) is limiting the nitrogen trade to only large transactions, so that the ratio of fixed transaction costs relative to the value of the trade is small (Duhon et al., 2015). Transaction costs at the time of trade can be somewhat reduced by ensuring that participants have easy access to information (Duhon et al., 2015).

Given the range of transaction costs associated with the WQT/offsetting program setup, implementation and operation, especially for the entity that offsets, it is important to reiterate that only significant variations in pollution abatement costs would make trading a viable strategy for the watershed (see Section 3.1.4 on cost effectiveness).

3.3.5 Integration with Existing Programs

What policies and programs are already in place to address water pollution in the watershed? How can an offset program build upon them?

Integration with existing programs provides a good way to use existing infrastructure and connections to landowners to pilot an offsetting/trading program.

Existing incentive programs have been used in a number of ways:

- **To recruit landowners and ensure adequate supply of credits.** The CWS Tualatin River program has made changes to an existing program in the rural part of the watershed (Enhanced CREP) to create incentives for landowners to engage in conservation practices as part of the offset program. The federal government continued to finance the standard portion of the program, whereas CWS payed for additional incentives for appropriately vetted and geographically advantageous projects on private rural lands. Nevertheless, CWS was able use all pollutant reductions generated from the projects toward its compliance requirements. In the EPRI Ohio River Basin Trading Project, farmers who had previously applied for the cost-shared funding through other programs were the first ones to be contacted by SWCDs and became early adopters of the pilot WQT project (Fox, 2015). Therefore, trading/offset programs that are building on existing programs familiar to producers improve chances of successful uptake.
- **To create a back-up pool of credits.** LSPOP Phase 1 is using the existing LEAP that funds rural and agricultural projects as a back-up pool of phosphorus offsets (XCG, 2014b).
- **To minimize costs.** Integrating a new offset program into existing program infrastructure presents a good opportunity to lower overhead costs (e.g., administrative costs of program startup), for example, in the case of the LSPOP integrating into existing stormwater management permitting and stewardship efforts, such as LEAP (XCG, 2014a).

Scaling up existing programs and blending them into one delivery framework has been widely employed in the case studies and is a mechanism to consider.

3.4 Verification and Monitoring

What conservation practices are eligible to generate credits?
How should the pollutant reduction value be calculated for each type of alternative land use project?
What organization verifies installed BMPs?
What is the frequency of ongoing monitoring and what specifically does it involve?

To create measurable environmental outcomes from offset programs, the following steps are critical: determining practices eligible to generate credits, quantifying credits and establishing protocols for inspecting the status of installation, operation and maintenance of BMPs. In a PS–NPS program, verification ensures that the credits are real, which is fundamental to buyers who often rely on these credits to fulfill regulatory compliance requirements and other stakeholders who need have confidence in the program (Fox, 2015).

Programs usually specify a particular set of eligible management practices that are linked to a level of certainty in generating credits (Table 5). Certain programs allow for new BMPs to be added into the eligibility list on a case-by-case basis upon presentation of appropriate documentation (e.g., that details proposed quantification procedures: Lake Erie, GLC, 2017).

Table 5. Eligible BMPs, measurement and monitoring

Offset Program	Eligible BMPs	Measurement Model	BMP Verifiers
Lake Simcoe[a]	1) Retrofitting stormwater pond 2) Stream bank erosion control 3) Decommissioning and/or replacing septic systems	Watershed Management Model Load Estimation Method.	Third-party verifiers unaffiliated with the LSRCA, local area municipalities or the development industry
SN River[b]	1) Manure storage 2) Milkhouse wastewater 3) Clean water diversion/ barnyard runoff control 4) Fencing 5) Septics 6) Controlled tile outlet	Formulas have been developed for each type of BMP based on published scientific literature.	Farmer field representatives
Lake Taupō[c]	A particular set of management practices to de-intensify farming (e.g., reducing the number of cattle, reforestation)	OVERSEER®	WRC
CWS Tualatin River[d]	1) Planting trees and shrubs along streams to increase the amount of shade 2) Release of stored water from two reservoirs to cool down water in the river	The Shade-a-lator model for the riparian shade restoration projects	Self monitoring and reporting to DEQ
Erie P Market[e]	21 BMPs from USDA–NRCS Field Office Technical Guide Practice Standards	EPA Region 5 spreadsheet model for particulate phosphorus; Pennsylvania Department of Environmental Protection model for Dissolved Reactive Phosphorus modified for trading within the WLEB (WLEB–DRP calculator); direct edge-of-field monitoring	State agencies, SWCDs, or approved third parties as long as individuals are trained in agricultural conservation practice design and installation
Ohio River[f]	1) Cover crops 2) Nutrient management 3) Vegetative filter strips 4) Grass waterways 5) Livestock exclusion 6) Heavy use protection areas 7) Conservation tillage 8) Reforestation	EPA Region 5 spreadsheet model for estimating nutrient reductions at the edge of the field; WARMF model for estimating nutrient attenuation from the edge-of-field to the point of use	SWCD, resource management specialist, state agency or inspector, typically an official with the department of natural resources

[a] McNeil, 2013; XCG, 2014b, 2014d; [b] SNC, 2010; O'Grady, 2011; [c] Duhon et al., 2015; [d] Cochran, & Logue, 2011; personal communication, Wade Peerman, February 9, 2018; [e] GLC, 2017; [f] Fox, 2015

3.4.1 Measurement Challenges and Modelling

The entire objective of using offsets or trading mechanisms is to ensure desired environmental outcomes, such as the reduction of certain water pollutant emissions.

Quantification of pollution reductions is instrumental in establishing credits for offsetting. PS and NPS measurements of discharge must be calculated differently, as PS can be measured at a specific point and NPS is diffuse over a large area.

PS load measurement can be achieved by monitoring an end-of-pipe point discharge (such as at a culvert or wastewater treatment facility) for volume and pollutant concentration. This allows the monitor to calculate the total load of the pollutant. In turn, credits generated by agricultural NPS, which equal the load reductions achieved at the edge of the farm field, are more difficult and expensive to measure due to spatial and temporal variation, such as watershed hydrology and precipitation events/climate, respectively. As a measurement option, Voora et al. (2012) notes that NPS can be monitored at their point of convergence so they can be treated as a combined PS. This method of cumulative monitoring supports a watershed-based delivery of offset programs.

Due to the difficulty and uncertainty in NPS measurements, models are used to measure pollutant loads on watercourses based on hydrology, land use and weather. All case studies use models of different degrees of complexity to estimate discharges based on a number of observable inputs (Table 5).

For example, in the Tualatin River program, the "Shade-a-Lator" model relies on variables such as stream width, tree height and vegetation density to find the amount of energy blocked by shade and calculate credits that are measured in kcal/day (EPA, 2007; Porter et al., 2014).

Models do not provide a perfect measure of actual pollutant loads in the waterways. However, they effectively reduce transaction costs and enable equity, treating all NPSs consistently (OECD, 2015). It is important to mention that the success of measurement models will depend on accurate and complete disclosure of farm-specific information (Duhon et al., 2015). This can impose some difficulties in cases where farmers and accountants are not familiar with complex models and reporting regimes, a challenge faced in the Lake Taupō program (Palmer, & Coup, n.d.).

3.4.2 Verifying and Certifying Credits

Credits cannot be used until verification of the installed practice is successfully completed.

The term "verification" is employed differently in various trading/offsetting programs (NNWQT, 2015). In some programs, verification refers to the complete process of project review, whereas in others it specifies a certain step in the process, such as an on-site inspection (NNWQT, 2015). In all cases, project verification activities ensure BMPs are installed and operating as per program requirements.

In some of the cases, verification is based on the review of records provided by the landowner as well as on-site inspection to confirm that the practice meets certain design standards (Ohio River: EPRI, n.d.a). The outcome of each verification event is a report (EPRI, n.d.a). For example, in the case of the EPRI Ohio River Basin Trading Project, the state agriculture agency completes a "verification" form after on-site inspection.

Some programs (Ohio River, Erie P Market) specify certification as a separate step in the monitoring process. According to their description, certification is realized after BMP verification and is a final administrative step of project approval for Point of Generation Credits (NNWQT, 2015; EPRI, n.d.a). It involves synthesizing all available information on the project (e.g., records, photos, baseline confirmation) that can be used to demonstrate load reductions. The "certification" form is completed by the state permitting authority (EPRI, n.d.a; GLC, 2017).

3.4.3 Ongoing Monitoring

Apart from verification and certification of credits, ongoing monitoring of the installed practices is required to ensure that the water quality benefit is maintained. Ongoing monitoring can include self-reporting and on-site or remote sensing visits (NNWQT, 2015). The frequency of ongoing monitoring is dependent upon the type of credit and the nature of the land use on which the project is located (NNWQT, 2015).

For example, in the Tualatin River program, CWS verifies its projects internally and submits its monthly and annual reports to the DEQ. Some entities that offset in Oregon may hire third parties like the Willamette Partnership to conduct verification (personal communication, Wade Peerman, February 9, 2018). The DEQ is authorized to physically inspect any of the projects any time and is responsible for certifying that CWS has met its permit obligations through the program (Cochran, & Logue, 2011).

The NPS–NPS trading program in the Lake Taupō catchment requires farmers to self-monitor, keep detailed annual accounting records, provide information on request and allow access to sites so that the WRC can check compliance (Duhon et al., 2015; OECD, 2015).

As for the frequency of ongoing monitoring, in many of the programs it is scheduled once a year (Lake Erie, Tualatin River) (Cochran, & Logue, 2011; GLC, 2017). Moreover, a priority monitoring system may be established to monitor particular sites. A priority system developed for Lake Taupō farmers imposes greater requirements on those who have traded more frequently and farm more intensively (Duhon et al., 2015). The Priority 1 group consists of farmers who farm close to the limits of their NDA or have sold nitrogen (Duhon et al., 2015; OECD, 2015; Palmer, & Coup, n.d.). They receive 1–2 visits per year from WRC officers and require an annual audit (OECD, 2015). Farmers of the Priority 2 group are less likely to receive an annual visit and similarly require an annual audit. Priority 3 farms may randomly be audited but are required to submit annual production records (Duhon et al., 2015; OECD, 2015).

3.4.4 Who Are the Verifiers?

A number of factors, such as administrative considerations, levels of expertise and resource availability, will determine who takes on a role of a verifier (GLC, 2017). In the programs reviewed as part of this research, the following organizations either already conduct project reviews, certification and monitoring or were suggested as potential verifiers:

- Department of Natural Resources (Ohio River)
- Conservation Districts (Erie P Market)
- Independent third-party verifiers – external consultants (LSPOP, Ohio River)
- Farmer field representatives (SN River)
- Regulatory agencies (Lake Taupō, CWS Tualatin River)

Tovilla (2015) notes that using independent third-party verifiers (e.g., an engineering consultant) for monitoring and evaluation may provide benefits of accountability to demonstrate successful operation of the project. As for the credit certification process, according to the protocols of the Lake Erie framework, a regulatory agency, a third party, a SWCD or the program administrator may perform this function (GLC, 2017). Hence, certifiers and verifiers can be the same organizations.

Furthermore, since several agencies may be eligible to verify, the Lake Erie program framework allows buyers and sellers to choose the verifiers they prefer to work with, usually the organizations that they have pre-existing professional relationships with (GLC, 2017). According to the Erie P Market framework, program administrators may intervene in the verification disputes between credits generators and verifiers to negotiate mutually-acceptable terms (GLC, 2017).

3.4.5 Lessons

Some common decisions related to monitoring exist in all offset programs (NNWQT, 2015):

- What project information needs to be collected?
- Who verifies and gives a final approval for credits and when?
- What intervals are used for project reviews?
- How are disputes resolved, including about verification?
- How is the public engaged in the review and approval process?

In programs involving NPSs, it is important that the **verifier has working knowledge of farm operations** and systems (EPRI, n.d.a, Appendix E; Palmer, & Coup, n.d.). For example, to ensure that verifiers understand the complex business of farming, the SN River WQT program engaged full-time farmers to act as verifiers and perform field visits (O'Grady, 2011). Ongoing monitoring frequency can be the same for all NPSs (PS–NPS offsetting), or a priority system for monitoring can be established so that farmers who farm intensively are monitored more often and more closely.

Depending on the nature of BMPs, necessary measures can be taken at the installation phase that will reduce monitoring need in the future. In the Tualatin River program, appropriate techniques are implemented (e.g., planting native vegetation) so that the site can maintain itself in the future without extra monitoring, saving money for CWS in the long run (personal communication, Laura Porter, February 9, 2018).

4.0 Conclusion

Our case studies expand on a variety of methods and details that offset programs have used to enable success in achieving environmental outcomes in different parts of the world. Our reporting and analysis of these case studies has focused on expanding on the key features of these programs, particularly on common elements that may have enabled success. In some cases, we highlight unique features that might also create challenges in planning, implementation and achieving desired outcomes.

The Province of Manitoba has a clearly documented problem of chronic loading of phosphorus to Lake Winnipeg. An interlinked issue is one of excess drainage based on flooding cycles in the region. Offsets are being considered as potential solutions to these different but interlinked water quantity and quality management challenges.

In Manitoba, there are currently over 200 wastewater treatment facilities that discharge phosphorus and contribute to the nutrient overloading and eutrophication of Lake Winnipeg. Upgrades to these facilities are resource-intensive, and the option of offsetting discharges against NPS in this agricultural region may provide higher nutrient reductions, as well as a number of ecological co-benefits in the region. Solutions to reduce nutrient loading based on technological upgrades to wastewater treatment facilities are expensive[30] and considered environmentally unsustainable since they exhaust natural resources and create pollution in order to produce energy for plants (Porter et al., 2014).

Significant water quality improvements may be achieved in a cost-effective manner through an offsetting program involving NPSs. In addition, effective nature-based solutions such as managed wetlands and green infrastructure can create additional benefits of flood and drought mitigation, carbon sequestration and critical wildlife habitat. For example, in the PS–NPS program type, regulated PS dischargers are able to offset their excess loads through financing NPS pollution-reduction projects elsewhere in the same watershed to apply toward their compliance requirements. Agreements between PSs and NPSs are most common in nutrient trading programs (Weber, & Cutlac, 2017).

The presented case study research provided reporting and analysis of existing WQT/offset programs in Canada, the United States and New Zealand. The programs reviewed have demonstrated some range in parameters such as watershed size, pollutant types and stage of implementation. Most offset programs discussed in this report have been developed as a compliance option for PS discharges through partnering with NPSs. Our analysis focused on synthesizing common design and implementation elements (e.g., benchmarking for nutrient loads, credit quantification, modelling), institutional setup (e.g., regulatory caps, role of program administrator), credit characteristics (mechanisms of price formation, offset ratios), transaction costs, verification procedures and other protocols and mechanisms. While we focused on common enablers of success, it is important to note that a watershed's unique physical, geographic, demographic and socioeconomic characteristics determine somewhat unique parameters for all programs (Fox, 2015; Marcano, 2015).

Even though currently there are no efforts to address nutrient pollution through PS–NPS or NPS–NPS offset programs in Manitoba, the present report provides evidence to suggest that offsetting/WQT can be at least a **successful interim measure** to improve water quality. The life span of a PS–NPS trading program, for example, can be aligned with the specifications and lifespan of the PS infrastructure (Clouston et al., 2014).

Some overarching lessons on design and implementation of an offset program based on the existing programs reviewed include:

- **Leverage existing** local, provincial and federal resources in a coordinated fashion and build on existing programs (Tualatin River: Porter et al., 2014).

[30] Upgrades to Winnipeg's North End Sewage Treatment Plant are expected to cost CAD 1 billion (Kives, 2017).

- **Simplify** eligibility requirements, delivery, verification and other offset procedures[31] (Miller, 2014; O'Grady, 2010; Weber, & Cutlac, 2017).
- Ensure **local control and flexibility** of the program design and execution through direct consultation and partnership with local communities and municipalities (SN River: O'Grady, 2011).
- Create a **strong regulatory driver** to enable demand for water quality offsets (Selman et al., 2009).
- Secure **minimal potential liability** to the regulated community (especially NPSs) for meeting water quality standards through offsets (O'Grady, 2010; Selman et al., 2009).
- **Leadership and commitment** from governments and regulators are required to advocate for trading/offsetting and not delaying action.

Incorporating these success factors when introducing this innovative and flexible offset approach to improving water quality in the watershed would not only reduce water pollution but also create ancillary ecological benefits and nurture successful relationships between various stakeholders (Pharino, 2007) and across multiple federal and provincial priority areas.

A proposed next stage of work in the context of developing an offsets program in Manitoba is to explore, in some detail, the implications of these lessons in the Manitoba context. This would entail a detailed institutional analysis and science review to determine credit design and trade ratios, for example, and a cost review to determine prices for relevant actions.

[31] Manitoba Ombudsman (2008) outlines continuing backlogs around licensing of water drainage in Manitoba. Delays in processing may result in illegal and potentially detrimental water retention structures and discourage interested landowners overall from installing these BMPs.

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