ASSESSING WATER QUALITY GOVERNANCE IN MANITOBA

by

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Executive Summary

This thesis investigates the persistent governance challenges related to nutrient pollution and eutrophication in Manitoba, emphasizing phosphorus and nitrogen management. Despite decades of policy initiatives aimed at curbing nutrient pollution, eutrophication remains a significant environmental concern. Through qualitative methods such as key-informant interviews, document analysis, and policy reviews, the research examines how governance structures—including regulatory frameworks, voluntary programs, and participatory mechanisms affect nutrient management outcomes.

The first manuscript identifies persistent epistemic, social, and political controversies underpinning Manitoba's nutrient governance, particularly around problem definition, policy tools, and scientific credibility. Drawing from Science and Technology Studies (STS), the research highlights that these disputes reflect deeper power dynamics and social-political tensions, especially involving agricultural and industry actors. While Indigenous rights and governance are acknowledged as important, this manuscript notes they are not the central focus due to data and scope limitations.

The second manuscript critically evaluates Manitoba's "hybrid" governance regime, which combines mandatory regulations and incentive-based voluntary approaches. It finds that, despite encouraging innovation and stakeholder engagement, the regime has not significantly reduced nutrient loading to Lake Winnipeg. Key barriers identified include weak enforcement, limited monitoring, resistance from agricultural actors, and insufficient support for marginalized groups such as Indigenous and small-scale farmers. The manuscript argues that successful governance must address underlying issues of power, knowledge hierarchies, and justice.

Overall, the thesis concludes that Manitoba's nutrient management issues extend beyond technical inadequacies, deeply rooted in persistent controversies, power asymmetries, and contested knowledge production. Effective governance therefore requires adaptive, inclusive, and justice-focused approaches. Strengthening genuine collaboration among government bodies,

agricultural producers, environmental organizations, and Indigenous nations is essential. Enhanced monitoring and transparent enforcement mechanisms, participatory adaptive management, and targeted support for marginalized producers are crucial. Additionally, embedding controversy analysis and adaptive learning within governance structures transforms persistent disputes into opportunities for ongoing policy improvement, offering globally relevant insights for sustainable watershed governance.

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Glossary of Key Terms

Colonialism: A historical and ongoing practice characterized by domination, exploitation, and occupation of one territory or population by another, often accompanied by cultural, economic, and political subjugation.

Conflict: A state of disagreement or incompatibility between two or more groups or individuals, often emerging from differing interests, values, goals, or perceptions, particularly in governance and resource management contexts.

Controversy Studies: A methodological and analytical approach focusing on disputes arising from competing claims, knowledge, values, and interests, particularly in policy, governance, and scientific domains. It investigates how conflicts emerge, evolve, and influence decision-making processes.

Eutrophication: The excessive enrichment of water bodies with nutrients, leading to excessive plant and algae growth, oxygen depletion, and adverse impacts on aquatic ecosystems.

Indigenous Peoples: Communities, nations, or groups historically inhabiting specific regions prior to colonization or occupation by external forces. Indigenous peoples possess distinct cultural, social, economic, and political systems and often maintain a strong connection to their ancestral lands and natural resources.

Neoliberalism: A political and economic ideology advocating minimal governmental intervention, deregulation, privatization of public assets, free markets, and individual entrepreneurship. It influences policy frameworks, including environmental governance, often prioritizing market-based solutions.

Nutrient: Essential chemical elements required by organisms for growth and survival, For example, nitrogen and phosphorus in agricultural and ecological contexts. Excessive nutrients, however, can cause environmental issues such as eutrophication.

Political Ecology: An interdisciplinary framework examining the relationships between political, economic, social, and ecological processes. It emphasizes power dynamics, governance structures, resource allocation, and social justice in environmental issues.

Producer: In agricultural context, an entity (e.g., farmers, agricultural enterprises) responsible for producing crops or livestock, often managing land-use practices that significantly influence environmental outcomes, including nutrient runoff and water quality. This research focuses primarily on family-scale individual operators (owner-operators and tenant farmers) within agricultural systems. These producers are distinguished from corporate or financialized agricultural enterprises.

Note: While "producer" in ecology refers to autotrophic organisms (e.g., plants) that generate their own nutrition through photosynthesis, in this research the term is employed in the agricultural and socio-economic sense described above.

Science and Technology Studies (STS): An interdisciplinary academic field exploring how scientific knowledge and technological systems are developed, validated, contested, and embedded within broader social, cultural, and political contexts. STS examines the co-production of knowledge, technology, and society.

Water Governance: The processes, policies, institutions, and mechanisms through which water resources are managed, allocated, and regulated, often involving multiple actors, governance scales, and conflicting interests.

Watershed District: In Manitoba, a regional water management entity established through partnerships with the provincial and municipal governments. Watershed districts administer and implement voluntary water stewardship programs but lack regulatory authority.

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Chapter I Introduction

1.1 Introduction

Nutrient (phosphorous and nitrogen) management stands as a pivotal issue at the forefront of water governance in Canada (Belinskij et al., 2019; Moote, 2017), wielding profound implications for the health and sustainability of aquatic ecosystems. As the primary driver of eutrophication, phosphorus pose a significant threat to water quality, triggering harmful algal blooms, oxygen depletion, and ecological degradation (Schindler, 2012). Against the backdrop of climate change, the importance of phosphorous management assumes even greater urgency, as intensified weather patterns exacerbate nutrient runoff and pollution, further amplifying the risks to freshwater resources (IPCC, 2022). Thus, in the face of mounting environmental challenges, effective nutrient management emerges as a linchpin for safeguarding the integrity of Canada's water bodies, underscoring the imperative for proactive and holistic approaches within water governance frameworks.

In the Canadian prairie regions, high nutrient loading from agricultural activities has driven significant damage upon the water quality of lakes and streams, as evidenced by the degradation of Lake Winnipeg Basin (Environment and Climate Change, 2020; International Institute for Sustainable Development, 2016). Compounded by the looming threat of climate change, which is expected to exacerbate incidences of water pollution, salinization, and eutrophication through intensified droughts, floods, and rising temperatures (Gosling & Arnell, 2016; IPCC, 2022), the urgency to address these environmental challenges has never been more pressing. The Canadian prairie regions are characterized by vast expanses of agricultural land, where intensive farming practices have led to significant nutrient runoff and pollution of water bodies (Manitoba Agriculture and Resource Development., 2020). Lake Winnipeg, the sixth-largest freshwater lake

in Canada and tenth-largest freshwater lake in the world, has been particularly impacted by nutrient loading from agricultural activities, resulting in harmful algal blooms, depleted oxygen levels, and degraded ecosystem health (Environment and Climate Change Canada, 2020).

The pervasive threat of eutrophication poses profound implications for water and watershed security in Canada (Liu et al., 2019; Shuvo et al., 2021), extending far beyond mere concerns of water supply to encompass the holistic well-being and sustained development of individuals, households, and communities (Jepson et al., 2017; Schindler, 2012; Schindler et al., 2016a; A. E. Ulrich et al., 2016; Wassenaar & Rao, 2012). Watershed security, which encompasses the availability of clean and sufficient water for all users, the protection of aquatic ecosystems, and resilience to climate-related impacts, is directly influenced by governance structures (Brandes & Simms, 2020). Effective water governance frameworks facilitate environmental protection and the adaptation to changes such as population growth, land use modifications, and climate variability (Renzetti & Dupont, 2017; Rogers & Hall, 2003). By integrating sustainable practices and diverse perspectives, robust water governance ensures the long-term security of watersheds, safeguarding water.

Phosphorus, drives eutrophication, a process characterized by the proliferation of algae and aquatic plants, leading to oxygen depletion and the formation of harmful algal blooms (Liu et al., 2019; Shuvo et al., 2021). However, nitrogen also plays a significant and often interrelated role in nutrient pollution and eutrophication dynamics, with debates ongoing regarding the relative importance of managing phosphorus versus nitrogen in different contexts (Schindler et al., 2016a; Smith et al., 1999) .These harmful blooms not only compromise water quality but also pose substantial risks to human health and ecosystem function (Liu et al., 2019). Additionally, phosphorous pollution exacerbates water scarcity concerns by amplifying the impacts of climate

change on freshwater resources, further intensifying competition for limited water supplies (Schindler et al., 2016a). As such, addressing nutrient pollution is imperative for upholding the principles of water security, safeguarding the resilience and well-being of both human and non-human communities across Canada.

Over the last three decades, significant efforts have been taken to address the problem of eutrophication in Lake Winnipeg (Environment and Climate Change Canada, 2020). Many of these interventions have involved changes to the water governance system which encompasses the political, social, economic, and administrative structures through which water resources are developed, managed, and water services delivered across different levels of society (Rogers & Hall, 2003, P.7) . These interventions have included updates to laws and regulations, such as amendments to The Water Protection Act and The Environment Act, as well as the introduction of programs like the Growing Outcomes in Watersheds (GROW) program, which incentivizes farmers to adopt practices that reduce nutrient runoff (Manitoba Agriculture, 2021). However, persistently elevated phosphorus concentrations cast doubt upon the efficacy of current policies and practices, underscoring the need for a deeper understanding of the factors shaping the water governance system and outcomes. For instance, power dynamics, both overt and subtle, play a crucial role in shaping decision-making processes, resource allocation, and policy implementation within water and agricultural governance frameworks (McIlwain et al., 2023). To confront these complexities, this research seeks to unravel the intricate interplay between policy objectives, water quality realities, and the underexplored yet profound influence of power dynamics (McIlwain et al., 2023) within water and agricultural governance frameworks. Through a rigorous assessment of the (dis)connection between policy goals and on-ground outcomes, coupled with a nuanced exploration of power asymmetries among actors and Indigenous rightsholders (Baijius, 2021;

Ulrich et al., 2015), this study aims to chart a transformative pathway towards equitable and sustainable water management practices in Manitoba and beyond.

1.2 Literature Review

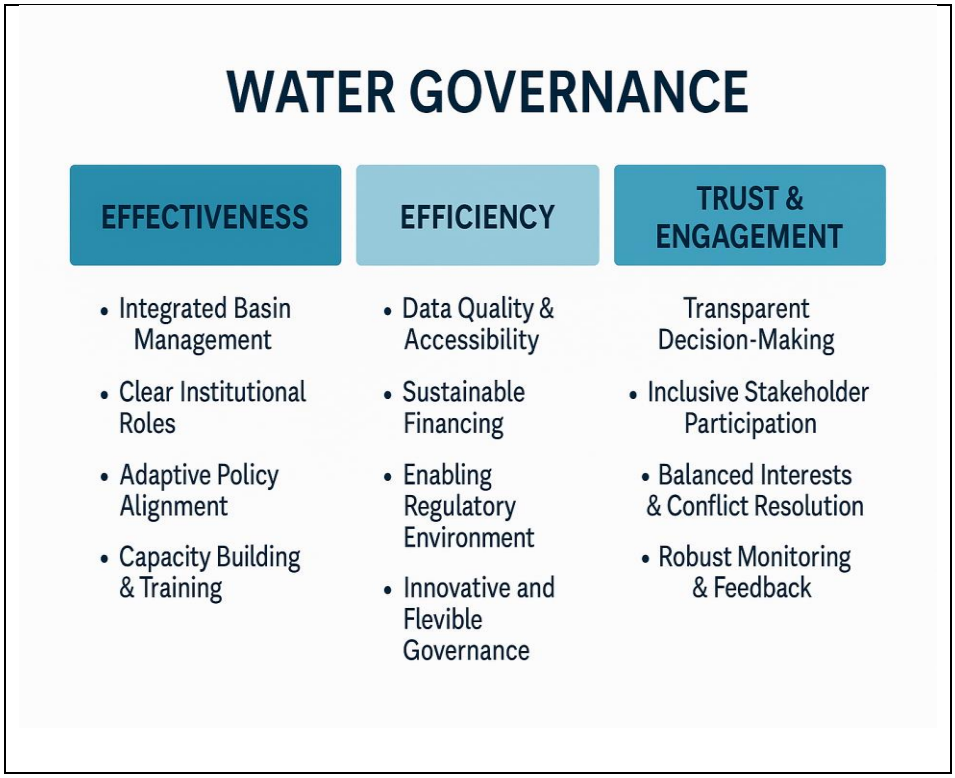
1.2.1 Water governance

Water governance serves as the theoretical backbone for understanding and dissecting the intricate dynamics of water and nutrient management within any context. Defined as "the constellation of institutions, policies, actors, and socio-political processes that shape how societies allocate, manage, and protect water resources" (Rogers & Hall, 2003, P.7), water governance encapsulates both formal regulatory frameworks and the nuanced interplay of informal practices, power relations, and socio-cultural norms that shape water management decisions. Grounded in principles of effectiveness, efficiency, trust, and engagement, water governance serves as the cornerstone for sustainable water management practices worldwide (Gasman, 2021). Yet, not all water governance practices achieve these ideals. In practice, governance systems can be fragmented, exclusionary, or overly technocratic, at times reinforcing existing power imbalances rather than resolving them. Poorly designed arrangements may prioritize efficiency over justice, neglect local knowledge, or fail to adapt to shifting environmental and social contexts (Aleu et al., 2022; McKibbin, 2023). Thus, while international bodies such as the OECD articulate normative principles of "good water governance," real-world applications reveal contested, uneven, and sometimes ineffective systems. Recognizing this tension between the theoretical ideal and practical application is crucial to critically examining water and nutrient governance in the context of this research.

The principles of effectiveness, efficiency, trust, and engagement delineate the framework of water governance, as espoused by the Organization for Economic Co-operation and

Development (OECD) (OECD, 2015). Effectiveness involves the clear definition of goals and targets within policy frameworks, ensuring that implementation at all levels of government aligns with overarching objectives (OECD, 2015). Efficiency aims to maximize the benefits of sustainable water management while minimizing societal costs, optimizing resource allocation and utilization (OECD, 2015). Trust and engagement foster public confidence in water management strategies through actor participation, democratic legitimacy, and fairness in decision-making processes (OECD, 2015).

Figure 1: Overview of principles of water governance adapted from OECD



Source: OECD (2015)

Water governance is a multifaceted endeavor, intricately weaving together various elements to manage the invaluable resource of water. At its core lies water resource management, acting as the linchpin connecting the diverse uses of water spanning across society, the marketplace, and the environment (Akhmouch & Correia, 2016). However, this management is not uniform; rather, it

exhibits rich diversity both within nations and across borders, shaped by the organizational structures in place and the unique water demands inherent to each context (Akhmouch & Correia, 2016). Hence, the concept of 'good' water governance transcends mere procedural efficacy (Akhmouch & Correia, 2016; Gasman, 2021). It is deeply rooted in the ability of governance frameworks to engender fairness and inclusivity. This entails formulating policies and executing strategies that not only harmonize with the long-term societal objectives but also resonate with the overarching aspirations of the global community (Akhmouch & Correia, 2016; Gasman, 2021; Wilson et al., 2019).

Water governance demands engagement with diverse literature to unpack its multiple dimensions. Beyond technical and institutional considerations, recent scholarships have underscored the importance of foregrounding the inherently political nature of water governance. This involves critical attention to issues of justice, equity, and power relations, which shape how water resources are accessed, controlled, and contested across different social, cultural, and spatial contexts (Wilson et al., 2019). Engaging with these perspectives enables a richer theorization of water governance that transcends simplistic notions of ‘good governance’ as mere procedural effectiveness or efficiency.

1.2.3 Justice, equity, and power dynamics

Justice in water governance entails ensuring fair distribution of water resources, inclusive participation, and recognition of diverse perspectives and rights (Boelens, 2015). Equity and power dynamics are crucial considerations in water governance, affecting how resources are allocated and whose voices are heard in decision-making processes. To deepen this understanding, it is important to engage with two interrelated scholarly traditions: Environmental Justice and Political Ecology. These bodies of literature provide critical frameworks for analyzing the socio-political

dimensions of water governance and highlight the ways in which environmental resources, including water, are embedded in broader struggles over power, inequality, and recognition.

1.2.4 Environmental Justice in Water Governance

Environmental justice (EJ) emerged as a field to address the disproportionate environmental burdens borne by marginalized communities, especially along racial, economic, and social lines (Agyeman et al., 2003; Bullard, 2001). In water governance, EJ frameworks emphasize the distributional and procedural aspects of justice: distributional justice concerns the equitable allocation of water resources and protection from pollution or scarcity; procedural justice focuses on ensuring inclusive participation and fair representation in decision-making processes (Schlosberg, 2004; Sultana, 2018). The environmental justice literature critiques dominant technocratic water management paradigms that often obscure or ignore the unequal social relations shaping access to clean, sufficient, and safe water (Boelens et al., 2016; Harris & Roa-Garcia, 2013) . For example, cases of water insecurity frequently reflect legacies of systemic racism, colonialism, and neoliberal economic policies that marginalize Indigenous peoples, low-income communities, and racial minorities (Harris et al., 2016; Pulido, 2016). These inequities manifest in phenomena such as urban water shutoffs, contaminated drinking water supplies, and exclusion from water governance institutions (Baijius & Patrick, 2019). Moreover, environmental justice extends beyond human-centered concerns to incorporate ecological justice, which calls for recognizing the intrinsic rights and value of non-human entities and ecosystems (Schlosberg, 2013; Taylor, 2025). This broader ethical stance challenges anthropocentric water governance models by promoting relational and intergenerational responsibilities toward water and life (Chiblow, 2025) . Integrating these justice dimensions is vital for creating governance frameworks that are both socially equitable and ecologically sustainable.

1.2.5 Political Ecology and Power in Water Governance

Political ecology (PE) complements environmental justice by critically analyzing the structural causes and power relations that shape environmental outcomes, including water governance (Bryant, 1997; Robbins, 2005). It situates water issues within larger socio-economic and political processes such as capitalism, colonialism, and state power (Castree, 2008). PE scholars argue that water governance is never neutral or apolitical but is deeply embedded in struggles over resources, knowledge, and territorial control (Perreault, 2014). Central to political ecology is the concept of hydrosocial cycles (Linton & Budds, 2014), which emphasize that water systems are socio-natural hybrids shaped by the intertwined relations between human societies and hydrological processes. This perspective highlights how water governance institutions reproduce or contest existing power hierarchies through decisions about infrastructure, distribution, and regulation (Swyngedouw, 2004).

PE research also exposes how neoliberal governance reforms, such as privatization, market-based mechanisms, and decentralized management, often exacerbate inequalities and disenfranchise marginalized groups (Bakker, 2009; Boelens et al., 2016). For instance, neoliberal water policies can prioritize efficiency and economic growth at the expense of social equity, resulting in "water insecurity" for vulnerable populations (Sultana, 2018; Harris & Roa-García, 2013). Furthermore, PE interrogates the discursive power embedded in water governance, examining how dominant narratives such as "scarcity," "efficiency," or "modernization" frame water problems and legitimate policy responses while silencing alternative knowledge systems and claims (Linton & Budds, 2014). This includes critical engagements with Indigenous water governance paradigms that challenge colonial and technocratic conceptions of water as a resource,

emphasizing instead relational ontologies that recognize water as a living entity with agency and rights (Chiblow, 2025; McGregor et al., 2023).

Within the dynamics of water governance lies a complex interplay of power dynamics (McIlwain et al., 2023; Parsons & Fisher, 2020). Here, actors from diverse backgrounds exert influence over decision-making processes and resource management. To navigate this landscape effectively, a comprehensive understanding of power relations and asymmetries is indispensable. Power analysis serves as the compass, illuminating the intricate webs of influence underpinning water governance frameworks (Bradford, 2016; McIlwain et al., 2023). By dissecting the distribution of power among various actors – governments, corporations, civil society groups, Indigenous rightsholders and marginalized communities – policymakers gain insights into decision-making authority, priority setting, and the risk of exclusion. In the pursuit of 'good' water governance, power analysis emerges as a pivotal tool for fostering equity and inclusivity (McIlwain et al., 2023). It unveils hidden power imbalances and structural inequities that impede effective water resource management. Armed with this knowledge, policymakers can design interventions to empower marginalized groups and ensure their meaningful participation in decision-making processes.

By integrating power analysis into water governance frameworks, policymakers can address power differentials and champion more equitable outcomes. This approach, grounded in transparency, accountability, and social justice, paves the way for policies and practices that align with the collective aspirations of society and the international community. Ultimately, by acknowledging and engaging with power dynamics, policymakers can fortify the legitimacy and efficacy of water governance systems, steering toward a future of sustainable and resilient water management practices worthy of acclaim. Central to this research is an in-depth analysis of power

dynamics within Manitoba's water governance landscape. By scrutinizing the distribution of power among governmental agencies, Indigenous communities, industries, and civil society groups, the thesis seeks to uncover the underlying influences shaping decision-making processes and resource allocation. Through a nuanced understanding of power relations and asymmetries, the research aims to identify opportunities for enhancing inclusivity, equity, and transparency in water governance practices.

1.2.6 The Neoliberalization of Water Governance

The evolution of water governance in recent decades has been profoundly shaped by neoliberal political-economic ideologies, which emphasize market mechanisms, decentralization, and reduced state intervention in environmental management. This paradigm shift, particularly evident in nutrient pollution governance, has redefined how agricultural regions like Manitoba address ecological challenges while balancing economic priorities. Contemporary scholarship (Bakker, 2015; Castree, 2008; Higgins et al., 2012) demonstrates how neoliberal approaches have increasingly dominated environmental policy frameworks since the early 2000s, with significant implications for water quality outcomes. The shift toward neoliberalism in environmental management emerged from late-20th century ideological, economic, and political transformations that prioritized market mechanisms over state intervention in the "command and control" model (Baldwin, 2019). Neoliberalization was and continues to be driven by the intellectual influence of Hayek and Friedman's arguments for market efficiency (Bakker, 2015), economic pressures from debt crises and structural adjustment programs that promoted private sector solutions (Castree, 2008), and the political expediency of appeasing agricultural and industrial interests through voluntary approaches rather than regulation (Büscher & Fletcher, 2019).

The theoretical foundations of neoliberal environmental governance emerge from the work of Peck and Tickell (2017), who identify two key processes: "roll-back neoliberalism" involving the dismantling of regulatory structures, and "roll-out neoliberalism" characterized by the creation of new market-based governance institutions. In the context of water management, this has manifested through the replacement of command-and-control regulations with voluntary incentive programs and public-private partnerships (Baldwin et al. 2019). Decentralized and participatory forms of water governance have been widely promoted as mechanisms to enhance democracy and water justice by including non-state actors—such as Indigenous communities, farmers, women, and civil society organizations—in decision-making processes (Brisbois & and de Loë, 2016; Harris et al., 2016). However, these governance shifts are also critiqued for reinforcing neoliberal agendas, where the rhetoric of "participation" and "devolution" masks persistent power imbalances and the privatization of water resources (Boelens et al., 2015). The democratization of water governance is often framed to rectify historical exclusions by empowering marginalized groups in decision-making. Polycentric governance models—where multiple, overlapping authorities govern water resources—have been celebrated for their potential to enhance equity and adaptability (Brisbois & de Loë, 2016). However, as Harris (2009) argues, such approaches frequently operate within neoliberal frameworks that prioritize market-based solutions over substantive equity. For instance, in Ecuador, Boelens et al. (2015) demonstrate how water reforms under the guise of decentralization and Indigenous inclusion recentralized authority and weakened community governance structures, reinforcing state and corporate control. Despite claims of inclusivity, collaborative water governance often reproduces existing power hierarchies. Brisbois & and de Loë (2016) use power theory to reveal how state and elite actors dominate participatory processes, even in ostensibly decentralized systems. Their analysis shows that while non-state

actors may gain nominal representation, their influence remains limited by structural inequalities in resources, knowledge, and institutional access. Similarly, Harris (2009) highlights how gender dynamics in water governance reforms often sideline women, despite their critical roles in water management, further entrenching socio-economic disparities under the veneer of participation. Critics argue that participatory water governance often serves neoliberal objectives by shifting responsibility from the state to communities and private actors while maintaining elite control over resources (Harris, 2016; Boelens et al., 2015). For example, Harris (2009) examines how devolution policies in various contexts have facilitated privatization and marketization, framing water as an economic good rather than a human right. This aligns with Brisbois and de Loë's (2016) findings that collaborative governance can function as a form of "roll-out neoliberalism," where participatory mechanisms legitimize existing power structures rather than challenge them.

The neoliberalization of water governance has faced significant resistance from water justice movements globally, challenging the privatization and marketization of water as a commodity rather than a fundamental right (Harris & Roa-Garcia, 2013). From Bolivia's Cochabamba Water War to South Africa's anti-privatization struggles, these movements highlight how market-based approaches exacerbate socio-ecological inequalities (Perreault 2014). Political ecologists and environmental justice scholars demonstrate how neoliberal policies like cost-recovery mechanisms disproportionately burden marginalized communities (Loftus, 2009), while watershed scientists question whether market mechanisms can address complex hydro-social systems, particularly their failure to incorporate Indigenous water knowledge (Pahl-Wostl, 2019). These contemporary struggles must be understood within the longer historical arc of colonial water governance, which established enduring patterns of dispossession and inequality (Dorries et al., 2022). Colonial regimes systematically dismantled Indigenous and peasant water governance

systems, replacing them with extractive models favoring settler agriculture and industry (Boelens et al., 2015). In settler-colonial contexts like Canada and Australia, water licensing systems deliberately excluded Indigenous governance (Marshall & Marshall, 2017), while in the Global South, colonial hydraulic projects created centralized management structures that later facilitated neoliberal privatization. These historical processes established racialized hierarchies of water access that persist today (Dorries et al., 2022).

Contemporary neoliberal reforms often intensify these colonial patterns of water injustice. In Ecuador, despite constitutional recognition of Indigenous rights, decentralization has frequently weakened community autonomy while strengthening corporate water users (Boelens et al. 2015). Similarly, South Africa's post-apartheid water reforms implemented cost-recovery policies that effectively denied access to poor Black communities (Loftus, 2009). These cases reveal how neoliberal governance builds upon and amplifies colonial structures of exclusion and racial capitalism (Dorries et al. 2022). Addressing water injustice requires moving beyond resistance to privatization toward decolonizing water governance. This involves centering Indigenous sovereignty and knowledge systems (Simpson, 2017), challenging racialized policy logics, and developing frameworks prioritizing ecological integrity and collective rights over market efficiency. Such an approach must reckon with both the colonial roots and neoliberal manifestations of water inequality to create truly transformative alternatives.

The neoliberalization of water governance represents a fundamental restructuring of environmental management that privileges market logic over ecological protection. This transformation has unfolded through several interconnected processes that have collectively reshaped how societies address nutrient pollution in aquatic ecosystems. A central feature of this neoliberal turn has been the commodification of water quality protection. As Bakker (2015)

documents, market-based instruments like water quality trading schemes attempt to create economic value from pollution reduction by establishing property rights over nutrient discharges. The neoliberal paradigm has also transformed the role of the state in environmental protection. Rather than serving as the primary regulator of water quality, governments have increasingly positioned themselves as market facilitators - creating frameworks for voluntary action while reducing direct regulatory oversight (Cohen & Bakker, 2014). These approaches reflect what Peck and Tickell (2017) term "roll-out neoliberalism," where the state actively constructs new market-oriented governance institutions rather than simply withdrawing from regulation.

A critical consequence of this neoliberalization has been the devolution of environmental responsibilities. As Higgins et al. (2012) demonstrate in their study of Australian ecosystem services programs, neoliberal governance increasingly shifts the burden of environmental protection onto individual land managers while providing inadequate resources or support. The neoliberal approach has also fostered new forms of public-private partnership in water governance. Corporate actors, particularly large agribusiness firms, have gained increasing influence in shaping nutrient management policies through voluntary stewardship initiatives and participation in multi-actor governance bodies (Baldwin, 2019). While framed as collaborative solutions, these arrangements often serve to preempt more stringent regulations while allowing continued pollution (Fletcher & Büscher, 2017) . The outcomes of neoliberal water governance have been decidedly mixed. While creating new spaces for innovation and participation, these approaches have largely failed to address systemic water quality challenges. As Pahl-Wostl (2019) argues, effective governance of complex socio-ecological systems like watersheds requires moving beyond market fundamentalism to develop more adaptive, equitable, and ecologically grounded approaches. This ongoing tension between market-based approaches and ecological imperatives suggests the need

for what (Benson et al., 2020) term "post-neoliberal" water governance as frameworks that recognize the limitations of market mechanisms while developing more holistic strategies for protecting aquatic ecosystems. Such approaches would need to address the root causes of nutrient pollution in industrial agricultural systems while creating more democratic and inclusive decision-making processes (Harris & Roa-Garcia, 2013) .

The neoliberal transformation of water governance has fundamentally altered the political economy of nutrient pollution management through three under-examined dimensions that reveal its deeper contradictions. First, the financialization of ecosystem services has created new valuation regimes that attempt to quantify and monetize water quality (Baldwin, 2019) , yet these metrics often fail to capture the complex socio-ecological relationships that sustain watershed health (Kolinjivadi et al., 2019). Second, the neoliberal paradigm has produced new spatial and temporal mismatches in governance. By devolving responsibility to local actors while maintaining centralized control over key policy levers, these systems create what (Eker & Loftus, 2013) term "fractured governance" - where watershed districts are held accountable for water quality outcomes but lack authority over the agricultural intensification driving nutrient pollution. This spatial disconnect is compounded by short-term funding cycles that prioritize immediate, measurable results over long-term watershed resilience (Lave, 2012). Third, neoliberal governance has reconfigured expertise in water management, privileging techno-managerial knowledge while marginalizing other ways of knowing.

The performative nature of neoliberal environmental governance becomes particularly apparent in its treatment of uncertainty. Market-based approaches rely on stable, predictable ecological systems where pollution can be quantified and traded, yet watersheds are inherently complex and unpredictable (Bakker & Hendriks, 2019). This fundamental tension manifests in

Manitoba's water quality trading proposals, which have stalled due to the difficulty of establishing equivalencies between different types of nutrient reductions across varied landscapes (Ruhl & Salzman, 2000). Contemporary research Fletcher et al. (2019) has critically examined the proliferation of market-based instruments (MBIs) in nutrient governance, including water quality trading schemes and payments for ecosystem services. These approaches, grounded in neoclassical economic theory, assume that properly designed economic incentives can efficiently address pollution externalities while maintaining agricultural productivity. However, empirical studies (Pahl-Wostl, 2019; Yates & Harris, 2018) reveal significant implementation challenges that undermine their effectiveness.

A key limitation identified in recent literature (Baldwin, 2019; Higgins et al., 2012) is the inherent difficulty in applying market logic to diffuse, non-point source pollution like agricultural runoff. The transaction costs of measuring and verifying nutrient reductions across diverse farming operations often exceed the theoretical benefits of market flexibility. Furthermore, as Büscher and Fletcher (2019) demonstrate, MBIs frequently fail to account for the complex socio-ecological relationships that characterize watershed systems, leading to unintended consequences and systemic inequities. The neoliberal turn in environmental governance has been accompanied by a marked retreat from strong regulatory frameworks, particularly in agricultural sectors. Recent analyses (Cohen and Bakker 2015) document how governments have increasingly relied on voluntary measures and industry self-regulation to address eutrophication, often with poor environmental outcomes. The limitations of both market-based and regulatory approaches have led to growing interest in hybrid governance models that combine elements of each. Contemporary theoretical work (Pahl-Wostl 2019; Benson et al. 2020) conceptualizes these hybrids as attempts to balance flexibility and accountability in complex socio-ecological systems. However, empirical

studies (Baldwin et al. 2019 reveal that many hybrid systems in practice tend to reproduce rather than resolve neoliberal governance's fundamental tensions.

Recent case studies (Harris et al., 2015) reveal how these frameworks sustain status quo power relationships, favoring corporate and state actors under the guise of environmental cooperation. By prioritizing economic interests through participatory mechanisms that lack binding authority, such systems legitimize business-as-usual practices while marginalizing grassroots and Indigenous voices, ultimately obstructing transformative ecological change. This aligns with broader findings (Bakker 2015; Cohen and Bakker 2015) about the structural limitations of hybrid approaches in contexts where power asymmetries favor agricultural and industrial interests. Recent scholarship has highlighted promising alternatives to neoliberal water governance frameworks that challenge market-based approaches and recenter Indigenous sovereignty and ecological relationships. (Harris et al., 2015; Yates & Harris, 2018) identify rights-based approaches that conceptualize water as a "commons" rather than a commodity, fundamentally challenging the privatization paradigm. These alternatives find their most robust expression in Indigenous-led governance models that center traditional ecological knowledge and assert Indigenous rights and authority over waterways (McGregor et al., 2023; Wilson, 2020).

1.2.7 Water and nutrient governance

The intersection between water and nutrient governance is a critical area of this study, particularly given the widespread environmental impacts of nutrient pollution on water and watershed security (Bakker & Cook, 2011; Canadian Water Network, 2017; Davies & Mazumder, 2003). Nutrient management specifically targets the sources and pathways of nutrient pollution to mitigate its impact on water bodies (Shortle et al., 2020). Key mechanisms include agricultural management practices, advanced wastewater treatment, and urban stormwater management. In agriculture, Best

Management Practices (BMPs) such as controlled fertilizer application, crop rotation, and buffer zones help reduce nutrient runoff (Moote, 2017). Several approaches have been highlighted to achieve effective nutrient management and governance. For example, performance-based approaches to nutrient management have gained traction as a means to enhance water quality through measurable outcomes (Baird, 2012). Baird (2012) underscores the importance of setting clear performance targets and using metrics to evaluate the effectiveness of agri-environmental policies in Canada. This approach incentivizes farmers to adopt BMPs by linking compliance and benefits to specific environmental outcomes. The flexibility inherent in performance-based systems allows for innovation and context-specific solutions, although the success of such approaches relies heavily on robust monitoring and data collection to track progress and adjust strategies as needed.

Collaborative governance frameworks are essential for managing complex environmental issues like nutrient pollution (Graversgaard et al., 2018; Hale et al., 2022). Hale et al. (2022) explore the relationships between farm nutrient measurement and collaborative water governance dynamics in Canterbury, New Zealand and find that accurate nutrient measurement and transparent reporting are crucial for building trust among actors, which in turn supports collaborative efforts. These frameworks involve multiple actors, including farmers, regulatory agencies, and community groups, leveraging diverse knowledge and resources to enhance the effectiveness of nutrient management.

1.2.8 Indigenous Peoples, Colonialism and Water Governance

Indigenous water governance and justice are critical components of this research study, particularly in contexts with a history of settler colonialism. Indigenous peoples have historically been marginalized in water governance frameworks, despite their profound connection to and

knowledge of local water systems. Indigenous water rights and traditional ecological knowledge are often overlooked in policy-making processes, leading to inequitable access to water resources and insufficient consideration of Indigenous perspectives in water management (Baijius, 2021; Ulrich et al., 2015). In Canada, the legacy of colonialism has profoundly impacted Indigenous communities, leading to land dispossession and ongoing water contamination issues. Settler colonialism in Canada involved systematic land dispossession of Indigenous peoples, leading to the loss of traditional territories and resources essential for their cultural and physical survival. Key works such as Alfred (1999) and Coulthard (2014) outline how colonial policies, including treaties and land seizures, disrupted Indigenous land tenure systems and resource access. This historical context is crucial for understanding contemporary water governance issues faced by Indigenous communities.

The legacy of colonial resource exploitation has resulted in significant environmental degradation and water contamination in many Indigenous territories (Datta & Marion, 2021; Sandlos & Keeling, 2016). Studies such as Lieberherr & Ingold (2019) and Mascarenhas (2007) document how industrial activities, including mining and oil extraction, have led to polluted water sources, adversely affecting the health and livelihoods of Indigenous peoples. This historical and ongoing contamination continues to pose significant challenges for water governance and justice. Addressing these challenges, Indigenous water governance is deeply rooted in Traditional Ecological Knowledge (TEK), which emphasizes the interconnectedness of all life forms and the importance of maintaining ecological balance. Scholars like Berkes (2012) and McGregor (2012) illustrate how TEK provides a holistic approach to water management, integrating spiritual, cultural, and practical dimensions. By prioritizing sustainability and the protection of water as a sacred resource, TEK-based governance models offer a comprehensive framework for mitigating

the impacts of historical and ongoing environmental degradation and fostering resilient and just water management practices.

Although recent years have seen the development of legal and institutional frameworks aimed at recognizing and integrating Indigenous water rights into broader governance systems, power asymmetries between Indigenous communities and state institutions continue to impede effective water governance. Scholars such as LaBoucane-Benson et al. (2012) and Simpson (2017) argue that Indigenous voices are often marginalized in policy-making processes, leading to governance frameworks that do not adequately reflect Indigenous perspectives or needs. This marginalization perpetuates injustices and undermines efforts to achieve equitable water governance. Structural barriers, such as legal frameworks, economic disparities, and social hierarchies, contribute to these power imbalances. These barriers can prevent marginalized groups from participating effectively in governance processes and accessing the resources and support needed to address their water management concerns (Hill et al., 2020). The work of Simpson (2017) and Craft, (2014) demonstrates how Indigenous water governance systems offer fundamentally different ontological and epistemological frameworks for understanding and managing aquatic ecosystems (Wilson & Inkster, 2018). These systems emphasize relationality, reciprocity, and responsibility rather than extraction and commodification. As Wilson's (2020) research on Yukon First Nations demonstrates, even within the constraints of modern land claim agreements, Indigenous communities continue to assert their inherent governance authority over water systems. Similarly, McGregor et al. (2023) document how Indigenous knowledge systems in the Great Lakes region provide holistic frameworks for water governance that integrate spiritual, cultural, and ecological dimensions often excluded from Western management approaches.

These Indigenous governance models challenge both colonial and neoliberal water regimes by asserting Indigenous sovereignty and offering different ways of conceptualizing human-water relationships. They provide concrete examples of how water governance might be reimagined outside of market logics, pointing toward more equitable and sustainable futures. However, as Wilson (2020) cautions, meaningful implementation requires moving beyond tokenistic inclusion of Indigenous perspectives to recognize and support Indigenous authority and jurisdiction over water governance.

1.2.9 Science and Technology Studies and Environmental Governance

Science and Technology Studies (STS) is an interdisciplinary field dedicated to exploring how scientific knowledge and technological systems are produced, validated, and integrated within societal, political, and cultural contexts. Historically, STS arose as a critique of the notion that science and technology operate independently of social influences, challenging the perception that they are purely objective, neutral, or universally applicable (Jasanoff, 2004; Latour, 1987). This critical stance encourages examining science and technology as deeply embedded in social processes, shaped by human values, power relations, and institutional arrangements.

STS scholars emphasize that science and technology are socially constructed and co-produced alongside social order. The concept of co-production (Jasanoff, 2004) underscores how scientific knowledge and social norms, laws, and identities are mutually constitutive, each influencing and shaping the other. This challenges the conventional linear model of knowledge transfer, where scientific findings straightforwardly inform policy and technology development. Instead, scientific facts are recognized as contingent on social negotiations, institutional contexts, and cultural meanings (Jasanoff, 2004). For example, the development and acceptance of certain environmental technologies depend not only on their technical merits but also on social values,

political agendas, and public trust. Boundary-work (Gieryn, 1983) further explicates how social actors delineate and maintain distinctions between what counts as "science" and "non-science," or "expert" and "lay" knowledge. These boundaries are not fixed or natural but are actively constructed and contested to protect professional authority and control over knowledge production. This has significant implications for governance, as it determines who is entitled to participate in decision-making processes and whose knowledge is recognized as legitimate. In water governance, for instance, the privileging of scientific hydrology over Indigenous or local knowledge systems reflects such boundary-making practices (McGregor, 2014; Wilson et al., 2019).

STS has had a profound impact on environmental governance by problematizing the assumption that science and technology provide definitive solutions to environmental challenges. Instead, STS highlights the uncertainty, contingency, and contestation inherent in environmental knowledge and technologies (Beck, 1992; Wynne, 1992). This body of work reveals that environmental risks and technological interventions are socially constructed phenomena, interpreted through various cultural, political, and economic lenses, which affect their perceived legitimacy and acceptance.

Within water governance, STS approaches expose how technologies such as water quality sensors, remote sensing tools, and hydrological models do more than just measure or manage water, they actively shape governance priorities, power relations, and access to water resources (Linton & Budds, 2014; Harris, 2013). For example, water monitoring technologies that require costly infrastructure or specialized expertise may privilege well-resourced agencies and exclude marginalized communities from meaningful participation, thereby reproducing existing inequalities (Boelens et al., 2016). Similarly, hydrological models used for water allocation may embed assumptions favoring certain users or economic sectors, illustrating how technical tools are

never neutral but are imbued with social and political significance (Anand & Klein, 2005). STS scholars also emphasize the importance of recognizing alternative epistemologies and knowledge systems, particularly Indigenous ways of knowing, which often conceptualize water relationally rather than instrumentally (Chiblow, 2025; McGregor et al., 2023). Such perspectives question dominant technocratic water governance and open pathways for more inclusive, just, and sustainable approaches.

A notable contribution of STS is its analysis of scientific and technological controversies as sites where the social construction of knowledge becomes visible (Jasanoff, 2004) . Controversies reveal that scientific "facts" are not simply discovered but are produced through complex negotiations involving diverse actors with competing interests, values, and worldviews. In environmental contexts, these controversies often revolve around uncertainty, risk, and the stakes of decision-making, highlighting the politics of expertise (Wynne, 1992). The framework of post-normal science (Funtowicz & Ravetz, 1993) is particularly relevant for water governance, where issues typically involve high uncertainty, contested values, urgent decisions, and multiple actors. Post-normal science calls for an expanded peer community that includes non-experts, actors, and affected publics in the co-production of knowledge and solutions, thus democratizing science and fostering more socially robust governance (Turnhout et al., 2013).

STS critiques technocratic approaches that privilege expert knowledge and technological fixes, arguing for reflexive governance that recognizes the limitations, values, and socio-political context of scientific knowledge (Jasanoff, 2005). This includes promoting participatory technology assessment and citizen science initiatives that engage diverse actors in shaping environmental monitoring and management (Irwin, 1995; Lemos & Morehouse, 2005). Furthermore, STS encourages policymakers to be critically aware of the assumptions and power dynamics embedded

within scientific models and technological interventions. Reflexivity entails questioning whose interests are served by scientific framings and technological solutions and striving for more inclusive, equitable, and adaptive governance structures (Jasanoff, 2004). This is essential to avoid reinforcing existing inequalities or ecological harms under the guise of "neutral" science.

1.3 Theoretical Framework: Water Governance

Contemporary scholarship conceptualizes water governance as a complex system of political, institutional, and socio-economic processes that collectively determine how water resources are managed, allocated, and protected (Rogers & Hall, 2003; Pahl-Wostl, 2015). This conceptualization moves beyond traditional technocratic approaches to water management by explicitly considering the power relations, institutional arrangements, and knowledge systems that shape decision-making. The framework adopted in this study examines three interrelated dimensions of water governance:

First, the institutional dimension encompasses the formal laws, policies, and organizational structures that govern water use. In the Canadian context, this includes federal legislation like the Fisheries Act, provincial regulations such as Manitoba's Water Protection Act, and municipal bylaws. Second, the actor dimension analyzes the power dynamics between various actors, including government agencies, agricultural producers, Indigenous nations, and environmental organizations. Third, the epistemic dimension recognizes the competing knowledge systems - including Western scientific, Indigenous, and local experiential knowledge - that inform water management decisions.

The Organization for Economic Co-operation and Development (OECD, 2015) has established normative principles for evaluating water governance systems, emphasizing effectiveness, efficiency, trust, and engagement. While these principles provide useful

benchmarks, critical scholars argue they often fail to account for structural power imbalances (Molle & Closas, 2019). For instance, the principle of "engagement" may be satisfied through superficial consultation processes that maintain existing power structures rather than enabling meaningful participation by marginalized groups. This tension between normative ideals and on-the-ground realities forms a central theme in our analysis of this study.

1.4 **Research Goal and Objective**

This project aims to assess water quality governance in Manitoba. This study has the following objectives:

1. Critically analyze the current water governance system, including assessing current legislation and policy and relationships among actors in the system.
2. Contribute recommendations for addressing shortcomings identified within water-related legislation and practice.

1.5 Research Setting

This study is situated in Manitoba, Canada, a province characterized by diverse watersheds and significant agricultural activity (Manitoba Environment and Climate Change, 2022). Manitoba's nutrient governance context is marked by intensive agriculture, complex land-water interactions, and persistent eutrophication issues affecting Lake Winnipeg and its tributaries (Ulrich et al., 2015). Agricultural regions, such as the Red River Valley, are especially relevant for understanding nutrient runoff management, given their substantial contributions to phosphorus and nitrogen loading (Yates et al., 2012).

This study is situated in the Seine Rat Roseau Watershed District (SRRWD) in Manitoba, Canada. Geographically, the district forms a rough triangular shape, with its northern point at Winnipeg and its base along the U.S. border, stretching eastward from the Red River to the

province's southeastern corner (Manitoba Environment and Climate Change, 2011). The Seine Rat Roseau Watershed District (SRRWD) is an example of a watershed based governance in southeastern Manitoba in 2001 (Manitoba Environment and Climate Change, 2022). Spanning approximately 3,700 square kilometers, the Seine Rat Roseau Watershed District (SRRWD) is often described as a landscape of *"pristine waterways, fertile farmlands, and vibrant communities." This language reflects a stewardship-oriented vision that highlights ecological health, agricultural productivity, and community well-being—values commonly emphasized by watershed managers, government agencies, and local actors* (Manitoba Environment and Climate Change, 2022) . *At the same time, such framings may not fully capture other perspectives, such as Indigenous relationships to water or the concerns of groups who experience governance differently. Recognizing the values embedded in these descriptions is important for understanding how different actors imagine and prioritize the purposes of watershed governance"*. The district is drained by the Seine River, the Rat River, and the Roseau River, which are all tributaries of the Red River, a major tributary contributing to Lake Winnipeg. Founded in partnership with local municipalities and the Province of Manitoba, the district serves as a hub for collective action, bringing together a coalition of actors including Indigenous governments and communities committed to safeguarding the region's natural heritage. From the Rural Municipalities of De Salaberry to Springfield, and the municipalities of Emerson-Franklin to Ritchot (see Figure 2), the SRRWD unites communities in a shared vision of environmental stewardship and sustainable development (The Watershed Districts Act, 2020). The primary legislative instrument for the creation of the SRRWD is the Manitoba Watershed Districts Act, which was enacted to promote integrated watershed management across the province. This Act replaced the former Conservation Districts Act, reflecting a shift towards a more holistic and collaborative approach to water

management (The Water Protection Act, 2022). The Act emphasizes the integration of water management with land use planning, recognizing the interconnectedness of water resources, agriculture, and ecosystems. It mandates the involvement of local actors and rightsholders, including municipalities, farmers, landowners, and Indigenous communities, in decision-making processes. The Act provides a framework for financial support and technical assistance to watershed districts, facilitating the implementation of conservation projects and practices.

Agriculture, particularly cereal crop production and livestock farming constitutes the dominant land use within the SRRWD. Notably, the Seine River watershed contains the most intensively developed hog industry of any watershed in Manitoba (Seine River Integrated Watershed Management Plan, 2010). This concentration of hog farming activities underscores the significance of understanding and addressing the governance framework governing agricultural practices, particularly within the context of nutrient management. In the governance landscape of hog farming in the SRRWD, regulations and policies play a crucial role in shaping agricultural practices and their impacts on water quality. The regulatory framework governing hog farming typically includes legislation related to environmental protection, water quality, and waste management. For instance, The Nutrient Management Regulation prescribes guidelines for manure storage, application, and nutrient management plans to minimize nutrient runoff and water contamination (Water Protection Act, 2015). Moreover, governmental agencies, such as the Manitoba Department of Agriculture and Resource Development, oversee the implementation of regulations and provide support and guidance to hog farmers regarding best management practices for nutrient management and environmental stewardship (Environment and Climate Change, 2022). This involves initiatives aimed at promoting sustainable agricultural practices, enhancing soil health, and mitigating the environmental impact of intensive livestock operations. In the

context of the Seine River watershed, where hog farming is prevalent, understanding the mechanisms governing agricultural practices is essential for addressing nutrient pollution and water quality concerns. By examining how hog farming activities are governed and regulated within the watershed, this research aims to shed light on the effectiveness of existing governance frameworks and identify opportunities for improvement to achieve sustainable water management goals. In addition to agricultural activities, wastewater treatment plants and lagoons in municipalities throughout SRRWD contribute phosphorus to local waterways.

In terms of the physiography of the SRRWD, the topography ranges from flat plains to gently rolling hills. The Red River Valley, a dominant feature in the western parts of the watershed, is particularly flat and prone to flooding. This flat terrain is primarily a result of glacial activity, where retreating glaciers left behind extensive deposits of clay and silt, forming the fertile but flood-prone plains seen today. In contrast, the Eastern sections of the watershed, especially within the Roseau River Watershed, exhibit more varied terrain. This area includes the Sandilands Provincial Forest, Northwest Angle, Cathills, and Wampum Provincial Forests (Seine River Integrated Watershed Management Plan, 2010).

The Seine Rat Roseau Watershed District (SRRWD), nestled within the Canadian prairie regions of Manitoba, exemplifies the intricate challenges and opportunities inherent in contemporary water management and governance. A 2022 report by the Lake Winnipeg Community-Based Monitoring Network (LWCBMN), coordinated by the Lake Winnipeg Foundation (LWF), identified significant phosphorus hotspots within the SRRWD. Specifically, sampling at Joubert Creek near St-Pierre-Jolys, Main Drain near Dominion City, Manning Canal near Île-des-Chênes, and Tourond Creek near Tourond recorded high phosphorus exports, with total phosphorus (TP) exports of 2.74 kg/ha/y, 1.60 kg/ha/y, and 1.98 kg/ha/y, respectively (LWF,

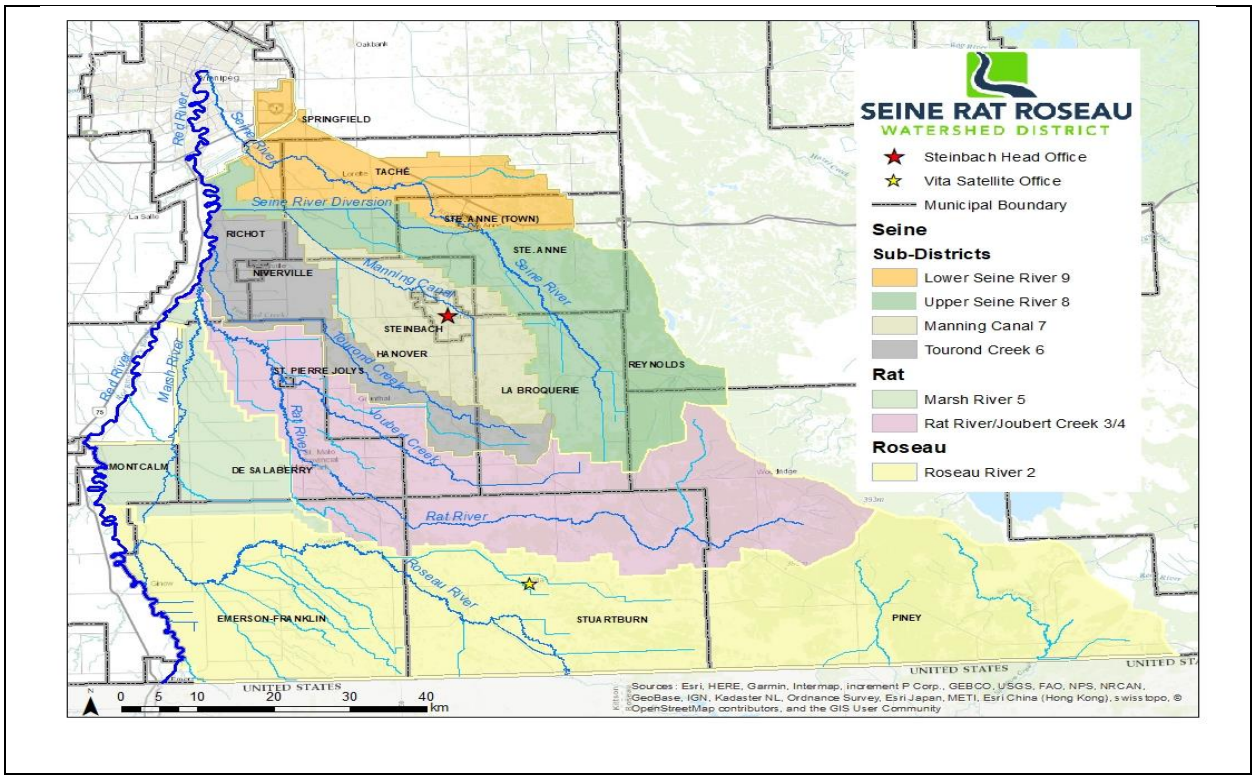
2022). Sampled points that recorded high phosphorous loads and exports drains a largely agricultural area which includes dense livestock and crop land (LWF, 2022). Amidst intensifying agricultural activities and the looming impacts of climate change, the SRRWD stands as a microcosm of the broader environmental and societal complexities confronting water managers and policymakers. Like many watersheds in the Canadian prairies, the SRRWD grapples with adverse impacts from nutrient runoff and pollution due to intensive agricultural practices (Paerl et al., 2014; Yates et al., 2012). The degradation of the nearby Red River, Lake Winnipeg, and their tributaries highlights the urgent need to address water quality challenges. Moreover, climate change exacerbates these issues by increasing the risks of droughts, floods, and temperature extremes, further compounding the watershed's vulnerability. Despite concerted governmental efforts and actor engagements, persistent elevations in nutrient concentrations (Painter et al., 2021; Yates et al., 2012) underscore the necessity for a paradigm shift in water governance approaches.

The Seine Rat Roseau Watershed District is located within Treaty 1 territory. The watershed district is in the traditional territories primarily of the Anishinaabeg and also Cree and Dakota peoples, and within the homeland of the Red River Métis. Roseau River First Nation and Buffalo Point First Nation, both Anishinaabeg First Nations, are located within the area. The primary languages spoken by these communities include Ojibwe (Anishinaabemowin), and Michif (Environment and Climate Change, 2022). Watershed plans in the Seine Rat Roseau Watershed District recognize the importance of these Indigenous contributions (Environment and Climate Change, 2022). They emphasize the need for ongoing collaboration and respect for Indigenous rights and knowledge in water governance. Initiatives such as water retention projects and alternative land use services are developed to enhance water quality, biodiversity, and resilience against climate change.

Phosphorous management is crucial in the Seine Rat Roseau Watershed District (SRRWD) due to its significant agricultural activities. The district's integrated watershed management plans (IWMPs) include strategies to manage nutrient runoff and improve water quality through both mandatory requirements and voluntary programs (Manitoba Environment and Climate Change, 2022). The Manitoba Water Strategy emphasizes Beneficial Management Practices (BMPs) to enhance agricultural sustainability and protect water quality. BMPs, supported by voluntary programs, include planting cover crops, establishing riparian buffers, practicing conservation tillage, and implementing water retention structures (Manitoba Environment and Climate Change, 2022). These practices reduce soil erosion, enhance soil organic matter, filter nutrients, and manage surface water flow. Programs like Alternative Land Use Services (ALUS), the Environmental Farm Plan (EFP), and the Prairie Watersheds Climate Program provide financial and technical assistance to farmers, encouraging sustainable practices that improve water quality and biodiversity (*ALUS Seine Rat Roseau*, 2024; Borck & Coglianese, 2009; Environment and Climate Change, 2022; Prakash & Potoski, 2012). Despite these efforts, challenges persist in aligning water quality governance with agricultural practices. The nature of BMPs leads to inconsistent adoption, while limited resources for monitoring and enforcement hinder compliance. Collaboration among actors, including farmers, government agencies, and Indigenous communities, is essential but complex and resource intensive.

Examining nutrient management in the SRRWD is vital to develop strategies that better align agricultural practices with water quality goals, addressing environmental challenges and supporting the watershed's sustainability.

Figure 2: A map of the Seine Rat Roseau Watershed District



Source: Manitoba Environment and Climate Change (2022)

1.6 Methodology

This study employs a qualitative research design to explore and assess water quality governance in the SRRWD, with a specific focus on nutrient (phosphorus) management. The qualitative approach allows for an in-depth understanding of the perceptions, experiences, and interactions among diverse actors involved in water governance (Daoud et al., 2022; Raja Ariffin et al., 2023). The study aims to provide insights into the effectiveness of current policies and practices, the challenges faced, and potential areas for improvement.

1.6.1 Reflexivity and Positionality

As the primary researcher for this study, I bring a background in environmental science and policy, with a specific focus on water governance and sustainability. My academic and professional

experiences have shaped my commitment to addressing environmental challenges through equitable and inclusive resource management. I identify as an academic with a strong advocacy stance for environmental sustainability, grounded in scientific inquiry and a desire to develop practical solutions to pressing environmental issues. My work has involved collaboration with diverse communities and actors, which has instilled in me a deep respect for multiple perspectives, particularly those of Indigenous communities, who have historically been marginalized in water governance discussions. While I am not Indigenous, I am committed to integrating Indigenous knowledge and perspectives into my research in a manner that is respectful and inclusive.

Reflecting on my positionality, I remain acutely aware of my biases and strive to approach this research with openness and humility. My goal is to engage with participants in a way that fosters authentic dialogue and mutual understanding. This reflexive approach ensures that the research process is inclusive, respectful, and collaborative, allowing for a more nuanced exploration of the challenges and opportunities in water governance and nutrient management. My perspective is further informed by my identity as an immigrant and international student, having not grown up in Manitoba or Canada. This position offers both distance and curiosity—allowing me to critically examine local dynamics while acknowledging gaps in my lived experience of Canadian environmental and cultural histories. I approach this research with humility, striving to listen deeply and engage collaboratively with participants, ensuring that the process respects diverse knowledge and fosters meaningful dialogue. Reflexivity remains central to my work, helping me navigate biases and power imbalances while pursuing inclusive, solutions-oriented research.

1.6.2 Key Actor Interviews

To gather in-depth insights into the experiences, perceptions, and challenges related to water governance and nutrient management, I conducted semi-structured interviews with 15 key actors (Table 1). These participants included policymakers, local government officials, livestock producers, landowners, Indigenous rightsholders, environmental NGOs, and water management professionals. The semi-structured format allowed flexibility, enabling participants to discuss issues they deemed significant while ensuring that key topics were covered. All interviews were recorded with the participants' consent and later transcribed for analysis. During the informed consent process, participants were given the option to remain anonymous or have their names associated with their responses, ensuring ethical research conduct and fostering candid discussions. Although this research sought diverse perspectives on nutrient governance in Manitoba, some important voices were underrepresented, particularly those of Indigenous governments and knowledge holders. Despite outreach efforts, I was only able to conduct two interviews with Indigenous participants, limiting the breadth of Indigenous perspectives captured. This reflects not only the constraints of this project, but also systemic barriers to engagement: Indigenous governments and organizations often face significant capacity pressures, and their participation in academic research must compete with immediate community priorities. Additionally, legislative frameworks such as the *Canada Water Act* currently limit the ability of Indigenous governments to engage as equal signatories in formal agreements, which further constrains opportunities for co-governance. These gaps mean that while this thesis highlights the importance of Indigenous leadership in water governance, it cannot fully represent the diversity of Indigenous perspectives in Manitoba. Future research should prioritize Indigenous-led approaches and methods co-designed with Indigenous governments to ensure both relevance and reciprocity.

Table 1: Participant Categories and Genger Distribution

Participant Type	Male	Female	Non-binary/ Do not identify	Did not say	Total
University Researchers	2	2	0	0	4
Government Staff/ Researchers	0	2	0	0	2
Watershed District Staff	3	0	0	0	3
Producers/Producer Groups	1	0	0	0	1
Not-for Profit Organizations	1	2	0	0	3
Indigenous peoples/ Government	1	1	0	0	2
Total	8	7	0	0	15

1.6.4 Validation and member checking

To ensure the accuracy and ethical integrity of the interview data, I employed a member-checking process (Birt et al., 2016) . Transcripts were sent back to interviewees for verification, allowing them to confirm the accuracy of their statements, correct any errors, and provide additional clarifications (Mero-Jaffe, 2011). This process not only preserved research ethics but also empowered participants by giving them control over how their contributions were represented. Member checking reinforced the authenticity of the data and strengthened the credibility of the findings.

1.6.5 Policy Analysis

This research incorporated secondary data sources, such as transcripts from the Manitoba Clean Environment Commission (CEC) hearings on hog farming. These transcripts provided valuable insights into the environmental, social, and economic dimensions of intensive hog farming

practices in Manitoba. They captured diverse perspectives on issues such as nutrient runoff, water contamination, land use conflicts, and community health implications, enriching the study's understanding of the complex dynamics shaping water governance and nutrient management.

Policy analysis played a central role in this study, providing a framework for understanding the formulation, implementation, and impacts of water governance policies in Manitoba. I conducted a thorough review of relevant policy documents, legislative frameworks, governmental reports, and watershed management plans, including the Integrated Watershed Management Plans (IWMPs), the Manitoba Water Strategy, and key legislation such as the Watershed Districts Act and the Sustainable Watersheds Act. This analysis traced the evolution of water governance policies, evaluated their implementation, and assessed their impact on nutrient management and water quality. Insights from the policy analysis were triangulated with interview data to ensure accurate findings. This approach allowed me to capture the nuanced shifts in policies, actor dynamics, and contextual influences that shape policy outcomes. By integrating these insights, the study provides a robust understanding of the policy landscape and offers evidence-based recommendations for improving water governance practices in Manitoba.

1.6.6 Data analysis

The qualitative data collected for this study, comprising policy documents, actor interviews, and secondary documents, were analyzed using NVivo, a robust qualitative data analysis software. NVivo was instrumental in systematically coding and categorizing the data, identifying key themes, and exploring the relationships between governance frameworks and nutrient management outcomes in the SRRWD. The coding process adopted both inductive and deductive approaches, allowing themes to emerge organically from the data while also aligning with pre-existing theoretical frameworks on voluntary and regulatory governance (Bingham, 2023). This dual

approach ensured an analysis that was both grounded in the empirical data and informed by established academic perspectives.

1.7 Overview of thesis

This thesis is organized into four substantive chapters, each contributing to a comprehensive and critical analysis of water and nutrient governance in Manitoba. The structure is designed to build from foundational concepts and context, through original research papers, to an integrative synthesis of findings, implications, and recommendations for future scholarship and practice. Chapter I is the overall introductory chapter, and the chapter IV is the concluding chapter.

Chapter II: Contested Knowledges—The Co-Production of Eutrophication Policy in Manitoban Water Governance

Chapter II presents the first manuscript, which deploys a controversy studies framework to explore how knowledge, values, and power shape the co-production of eutrophication policy in Manitoba. This paper unpacks the persistent and dynamic disputes among policy actors—government, agricultural, Indigenous, scientific, and environmental actors—around the causes, consequences, and appropriate solutions to nutrient pollution. Drawing on original interview data and policy analysis, this chapter reveals how contested knowledges and epistemic pluralism both complicate and enrich policy development. It foregrounds the politics of expertise, the challenges of policy transfer, and the need for justice-oriented governance.

Chapter III: Water Governance in Manitoba—Integrating Water and Nutrient Governance for Sustainable Agricultural Practices

The third chapter features the second manuscript, which investigates the hybridization of water and nutrient governance in Manitoba. Focusing on the interplay between voluntary and regulatory policy instruments, this paper examines the strengths and limitations of hybrid

governance models for achieving sustainable agricultural practices and watershed security. Through empirical case study analysis and actor perspectives, the chapter evaluates how Manitoba's governance framework balances flexibility, accountability, and local adaptation, while also exposing gaps in monitoring, enforcement, and equity. This work provides critical insights into the conditions necessary for effective and just hybrid governance in agricultural landscapes.

Chapter II Contested Knowledges: The Co-Production of Eutrophication Policy in Manitoban Water Governance

Abstract

This paper explores the contested nature of eutrophication governance in Manitoba through the lens of controversy studies, emphasizing the co-production of knowledge, policy, and responsibility. Nutrient pollution, specifically phosphorus loading into Lake Winnipeg, serves as a complex environmental issue characterized by divergent interpretations among actors. Drawing upon qualitative analysis of actor interviews and policy documents, the study identifies key areas of controversy, including fragmented responsibilities, tensions between regulatory and voluntary approaches, scientific uncertainties, economic constraints, and jurisdictional mismatches. The research highlights how different actors—including government officials, environmental NGOs, agricultural actors, Indigenous communities, and scientists—frame eutrophication and its solutions in ways that reflect their epistemic positions, institutional roles, and political interests. By unpacking these contested knowledges and their implications, the paper recommends an adaptive, inclusive, and reflexive governance approach, aimed at bridging epistemic divides, fostering multi-actor dialogues, and integrating diverse knowledge systems. Ultimately, this study argues that openly engaging with controversy is not merely a challenge but a critical pathway toward effective, equitable, and sustainable nutrient management in Manitoba.

Key words: Water governance, Phosphorous, Nitrogen, Nutrients, STS, Controversy studies.

Target Journal: Frontiers in Water

2.1 Introduction:

Freshwater eutrophication, the process by which water bodies become excessively enriched with nutrients, leading to algal blooms, oxygen depletion, and ecosystem degradation

(Organisation for Economic Co-operation and Development, 2017) has emerged as both a critical ecological threat and a paradigmatic governance challenge in Canada. Despite overwhelming scientific consensus that phosphorus (P) is the primary limiting nutrient in freshwater systems (Lewis & Wurtsbaugh, 2008; Schindler et al., 2016b), policy responses remain fragmented across provinces. This reveals a fundamental paradox: while actors unanimously acknowledge eutrophication as urgent (Watson et al., 2016), they clash sharply on causal attribution (agricultural runoff vs. wastewater vs. climate change) and solution pathways (P-only vs. dual-nutrient controls).

Canada, renowned for its abundant freshwater, confronts multifaceted challenges in water management and governance including demand-supply imbalances, pollution, and deteriorating water quality (L. E. A. Bradford et al., 2017; Renzetti & Dupont, 2017). These challenges arise from population growth, industrial effluents, agricultural runoff, the looming implications of climate change – all exacerbated by historical inadequacies in laws and regulations (Bakker & Cook, 2011; L. E. A. Bradford et al., 2017; Caretta et al., 2022; Davies & Mazumder, 2003). Freshwater eutrophication occurs when phosphorus inputs exceed the assimilative capacity of aquatic ecosystems (Schindler et al., 2016a). Phosphorus originates from various sources, including agricultural runoff, urban wastewater, and industrial discharges. Upon entering water bodies, phosphorus stimulates the growth of phytoplankton and macrophytes, leading to enhanced primary production. While moderate levels of primary productivity support aquatic food webs, excessive phosphorus loads fuel the proliferation of harmful algae, resulting in the formation of harmful algae blooms (HABs) (Dodds & Smith, 2016; Edmondson, 1970). HABs associated with eutrophication pose multifaceted ecological challenges to Canadian water systems (Canadian Council of Ministers of the Environment, 2016). The rapid growth of algae species such as

cyanobacteria can deplete dissolved oxygen levels, causing hypoxic conditions detrimental to aquatic organisms. Moreover, certain algal species produce toxins that pose risks to human health and wildlife, necessitating precautionary measures to safeguard water quality. Eutrophication-induced changes in water clarity and nutrient cycling further disrupt ecosystem dynamics, potentially leading to declines in native species diversity and ecosystem resilience (Stainton et al., 2003).

Harmful algal blooms (HABs) associated with eutrophication are expected to intensify due to climate change, exacerbating existing ecological and water quality challenges. Rising global temperatures can lead to warmer water bodies, which favor the growth of cyanobacteria and other harmful algae. In addition, increased frequency and intensity of rainfall events may result in higher phosphorus runoff from agricultural and urban areas, accelerating eutrophication processes (Paerl & Huisman, 2008). Climate change-induced alterations in water circulation and stratification patterns could further enhance conditions for algal blooms, reducing oxygen levels and creating hypoxic zones, making it even harder for aquatic ecosystems to recover. These combined factors will make managing phosphorus pollution even more critical in safeguarding freshwater systems.

Phosphorus (P) presents a significant threat to water security due to its role in freshwater eutrophication and harmful algal blooms (HABs), which degrade water quality and ecosystem health (Schindler, 2006). Excessive P loading from agricultural runoff and wastewater leads to toxin-producing cyanobacteria, increasing drinking water treatment costs and posing risks to human health through exposure to compounds like microcystins (Carmichael, 2001). Economically, P-driven HABs disrupt fisheries, tourism, and recreation, with losses in systems like Lake Winnipeg exceeding $50 million annually (IISD, 2020). In contrast, nitrogen (N) contamination—primarily as nitrates (NO_3^-)—threatens water security through distinct pathways:

groundwater pollution from agricultural fertilizers elevates nitrate concentrations beyond the WHO safety limit (10 mg NO_3-N/L), linked to methemoglobinemia and cancers (Ward et al., 2018), while in marine systems, N is the primary driver of dead zones (Paerl et al., 2014). Unlike P, which persists in sediments as legacy pollution (Sharpley et al., 2013), nitrate contamination requires targeted drinking water interventions, as treatment costs are 2–4 times higher than for P (USEPA, 2021).

Through an evaluation of relevant data from qualitative methods using interviews and document analysis, the study aims to discern the conflict related to eutrophication and the effectiveness of Manitoba's regulatory measures in mitigating eutrophication and enhancing water quality outcomes. Furthermore, the study endeavors to provide evidence-based recommendations for refining and enhancing Manitoba's eutrophication management strategies, drawing upon insights gleaned from comparative analysis and best practices observed in other provinces. Initial findings underscore shared priorities across provinces in safeguarding water quality and managing eutrophication. Yet, the growing disparity between scientific consensus on phosphorus-focused eutrophication management and Manitoba's persistent dual-nutrient (P+N) strategy has emerged as a defining sociotechnical controversy in Canadian environmental governance.

The persistent gap between established limnological science on phosphorus control and Manitoba's dual-nutrient (P+N) strategy represents a compelling sociotechnical controversy in Canadian environmental governance. This study employs a Science and Technology Studies (STS) lens to examine how this policy divergence has become institutionalized, focusing on three specific aspects of the controversy: (1) the actor networks and institutional structures that sustain Manitoba's outlier position despite scientific consensus (Latour, 2005), (2) the processes through which competing knowledge claims about nutrient limitation gain or lose policy traction (Jasanoff,

2004), and (3) the consequences of this controversy for environmental governance effectiveness in the Lake Winnipeg watershed (IISD, 2017). Rather than comparing provincial policies directly, we analyze how Manitoba's approach has emerged as a boundary object that different groups - including agricultural actors, environmental organizations, and government agencies - interpret and use in conflicting ways. This approach provides new insights into why scientifically settled questions can remain politically contested in environmental governance. By centering the controversy itself as the unit of analysis, we reveal how Canada's fragmented water governance enables the simultaneous persistence of mutually exclusive nutrient management paradigms—with critical implications for both STS scholarship and evidence-based research Before moving to my case study, I provide an overview of my theoretical framework.

2.2 **Theoretical Framing: Controversy Studies, Science and Technology Studies, and Political Ecology**

Environmental governance increasingly unfolds within contexts marked by complexity, uncertainty, and contestation. Rather than viewing these characteristics as signs of dysfunction, scholars in science and technology studies (STS) and political ecology argue that contestation is intrinsic to how environmental issues are defined, debated, and addressed. Controversy studies, a strand of STS, provides a productive lens for examining how scientific knowledge, political authority, and social values interact in these governance processes (Hilgartner, 2000; Latour, 2005b). Controversies are not treated as mere failures of consensus or breakdowns in policy, but as constitutive sites where facts, norms, and institutional arrangements are co-produced (Bocking, 2004; Latour, 2005a). A foundational insight of STS is that scientific knowledge is not a neutral reflection of nature but is instead shaped by social, political, and material condition (Jasanoff, 2004). Measurements, models, and technical standards are embedded with assumptions that reflect

the priorities of funders, institutions, and broader sociopolitical dynamics. This means that environmental governance tools—such as monitoring regimes, indicators, and risk assessments—are not simply technical artifacts but are also normative and strategic. Controversy studies foreground how such tools are mobilized by actors to support competing claims, revealing how power operates through scientific practices and technologies (Hajer, 1997; Tambini, 2002).

Political ecology complements this perspective by centering questions of power, access, and justice in environmental decision-making (Simon & Kay, 2025). It examines how environmental problems and solutions are unevenly experienced, and how the perspectives of differently positioned actors—especially marginalized or subaltern groups—are often discounted or silenced in governance processes (M. Goldman et al., 2011; Robbins, 2005). Political ecologists draw attention to the historical and material conditions under which environmental governance regimes emerge, including the legacies of colonialism, capitalist development, and state formation. These conditions shape whose knowledge considered authoritative, interests are prioritized, and how responsibilities for environmental degradation and remediation are distributed.

Recent efforts to bridge STS and political ecology have deepened our understanding of environmental controversies by examining how epistemological disputes intersect with questions of justice and legitimacy. As Goldman et al. (2018) argue, environmental governance cannot be fully understood without attending to the ontologies and ethics embedded in both scientific and local knowledge systems. This intersectional approach opens space to ask: whose nature is being governed, by what means, and toward what ends? It also raises critical questions about how governance institutions navigate pluralistic knowledge claims, and how different actors—government agencies, Indigenous communities, scientists, NGOs, and industry actors—struggle over the framing of environmental problems and the legitimacy of proposed interventions.

Controversy mapping, as proposed by Vendurini, (2010), offers a methodological tool for tracing these dynamic fields of contestation. It allows researchers to identify key actors, their alliances and oppositions, and the discursive and material practices through which environmental knowledge and authority are negotiated. By following controversies across institutions, media, and scientific forums, scholars can reveal the relational and performative dimensions of governance: not only how decisions are made, but how certain problems come to be seen as governable—and by whom.

In sum, a theoretical framework informed by STS, controversy studies, and political ecology emphasizes the co-production of knowledge and governance, the embeddedness of science in politics, and the uneven distribution of power and voice in environmental decision-making. This approach is particularly useful for analyzing environmental issues that are characterized by epistemic uncertainty, institutional fragmentation, and competing values. Rather than seeking consensus or closure, such a framework invites attention to the provisional, contested, and negotiated nature of environmental governance, and the possibilities it holds for more inclusive and reflexive forms of intervention.

Building on these foundations, controversy studies also draw attention to the performative nature of governance, that is, how policies, regulations, and public discourses do not merely reflect environmental realities but actively participate in shaping them. Governance instruments such as environmental impact assessments, permitting regimes, and best management practices do not exist independently of social negotiation; rather, they are performative tools that configure roles, responsibilities, and relationships among actors (Torgerson, 1986; Bocking, 2004). These instruments embed worldviews and priorities, often privileging technocratic rationalities while marginalizing alternative knowledge or place-based epistemologies. The performance of

governance thus extends beyond institutional design to include the symbolic, communicative, and normative dimensions through which environmental problems are rendered visible and actionable.

Moreover, controversy studies foreground the heterogeneity of actors involved in environmental governance. These actors include not only governmental authorities and scientific institutions but also Indigenous nations, industry groups, environmental NGOs, local communities, and international organizations. Each brings its own epistemic commitments, political interests, and normative frameworks to bear on governance processes. This multiplicity challenges simplistic binaries such as "experts vs. laypeople" or "science vs. politics," and instead highlights the complex alignments and misalignments that emerge in practice (Callon, 1986; Wynne, 1996). For instance, local communities may mobilize scientific data to challenge official risk assessments, while regulatory agencies may strategically frame uncertainty to delay or justify interventions.

Institutional arrangements further complicate the governance landscape. In multi-level and decentralized governance systems, authority over environmental decision-making is often distributed across overlapping jurisdictions, regulatory bodies, and legal frameworks. This fragmentation can create opportunities for innovation and localized adaptation, but it also opens up space for policy slippage, regulatory inconsistency, and jurisdictional conflict (Bakker & Cook, 2011; McLean, 2017). Federalism, for instance, often enables regional governments to diverge in their implementation of environmental policies, creating contested spaces where enforcement, accountability, and legitimacy are negotiated on a case-by-case basis. Meanwhile, Indigenous self-governance and legal pluralism introduce further complexity, as nation-to-nation relationships and treaty rights increasingly reshape governance expectations and responsibilities.

Critically, questions of justice and equity run through all these dimensions. Political ecology insists on making visible how environmental harms and benefits are unevenly distributed,

and how governance structures reproduce or challenge those inequalities. This includes distributive justice (who bears the costs and gains of environmental decisions), procedural justice (who has voice and influence in governance processes), and epistemic justice (whose knowledge is legitimized or excluded) (Schlosberg, 2007; Temper et al., 2019). STS contributes to this justice-oriented framing by exposing the normative commitments embedded within scientific practices and regulatory mechanisms. Taken together, these perspectives highlight the ethical stakes of environmental governance and call for greater reflexivity, inclusiveness, and accountability.

Finally, a growing body of scholarship at the intersection of STS and political ecology underscores the importance of ontological pluralism, the recognition that different communities and knowledge systems may conceptualize nature, environment, and governance in fundamentally different ways. As Goldman, Nadasdy, and Turner (2011) argue, bridging these ontological divides requires not only technical dialogue but also ethical and political negotiation. Governance systems must grapple not just with competing values or interests, but with radically different understandings of what constitutes a problem, what counts as evidence, and what forms of intervention are possible or desirable. This orientation opens space for transformative governance that does not merely accommodate difference but actively reconfigures institutional logics to support plural and just futures.

2.3 Materials and Methodology

2.3.1 Methodology

This study employs qualitative research design informed by the theoretical traditions of science and technology studies (STS), controversy studies, and political ecology, aiming to understand how nutrient governance is shaped by contestation, power dynamics, and competing knowledge claims. Rather than treating eutrophication governance as a purely technical matter, this approach

highlights the social, institutional, and epistemic conflicts that animate environmental decision-making. The study focuses on Manitoba, where nutrient pollution—particularly phosphorus—has generated ongoing debate among government bodies, agricultural sectors, environmental organizations, Indigenous communities, and scientific institutions. The research combines key informant interviews, policy and media document analysis, and controversy mapping to examine how different actors understand, contest, and shape water governance outcomes. The goal is to map the relational dynamics through which environmental governance is enacted and to analyze the performative, institutional, and political dimensions of water quality regulation.

2.3.1 Reflexivity and positionality

As the primary researcher, I approach this study as an environmental scholar and international student with academic and professional experience in sustainability and water governance. While I am not Indigenous and did not grow up in Manitoba, I bring a deep respect for place-based knowledge systems and a commitment to inclusive, reflexive, and ethical research practices. This positionality allows for critical distance from taken-for-granted assumptions in local water policy discourse but also demands humility and attentiveness to perspectives rooted in lived experience—particularly those of Indigenous nations whose rights and knowledges have historically been marginalized in environmental governance. My aim is to conduct research that is collaborative, justice-oriented, and grounded in dialogue, with constant attention to the ways in which power and bias shape both research and governance processes.

2.3.2 Key informant interviews

To gather in-depth insights into the experiences, perceptions, and challenges related to water governance and nutrient management, I conducted semi-structured interviews with 15 key actors (Table 2). These participants included policymakers, local government officials, livestock

producers, landowners, Indigenous rightsholders, environmental NGOs, and water management professionals. The semi-structured format allowed for flexibility, enabling participants to discuss issues they deemed significant while ensuring that key topics were covered. All interviews were recorded with the participants' consent and later transcribed for analysis. During the informed consent process, participants were given the option to remain anonymous or have their names associated with their responses, ensuring ethical research conduct and fostering candid discussions.

Table 2: Participant Categories and Gender Distribution

Participant Type	Male	Female	Non-binary/ Do not identify	Did not say	Total
University Researchers	2	2	0	0	4
Government Staff/ Researchers	0	2	0	0	2
Watershed District Staff	3	0	0	0	3
Producers/Producer Groups	1	0	0	0	1
Not-for Profit Organizations	1	2	0	0	3
Indigenous peoples/ Government	1	1	0	0	2
Total	8	7	0	0	15

2.3.3 Validation and member checking

To ensure the accuracy and ethical integrity of the interview data, I employed a member-checking process. Transcripts were sent back to interviewees for verification, allowing them to confirm the accuracy of their statements, correct any errors, and provide additional clarifications. This process not only upheld research ethics but also empowered participants by giving them control over how their contributions were represented. Member checking reinforced the authenticity of the data and strengthened the credibility of the findings.

2.3.4 Policy analysis

This research incorporated secondary data sources, such as transcripts from the Manitoba Clean Environment Commission (CEC) Hearings on Hog Production Industry Review Hearings(Manitoba Clean Environment Commission, 2007) These transcripts provided valuable insights into the environmental, social, and economic dimensions of intensive hog farming practices in Manitoba. They captured diverse perspectives on issues such as nutrient runoff, water contamination, land use conflicts, and community health implications, enriching the study's understanding of the complex dynamics shaping water governance and nutrient management.

Policy analysis played a central role in this study, providing a framework for understanding the formulation, implementation, and impacts of water governance policies in Manitoba. I conducted a thorough review of relevant policy documents, legislative frameworks, governmental reports related to water governance, including the Integrated Watershed Management Plans (IWMPs), the Manitoba Water Strategy, and key legislation such as the Watershed Districts Act and the Sustainable Watersheds Act. This analysis traced the evolution of water governance policies, evaluated their implementation, and assessed their impact on nutrient management and water quality. Insights from the policy analysis were triangulated (Carter et al., 2014) with interview data to ensure accurate findings. This approach allowed me to capture the nuanced shifts in policies, actor dynamics, and contextual influences that shape policy outcomes. By integrating these insights, the study aims to provide a robust understanding of the policy landscape and offers evidence-based recommendations for improving water governance practices in Manitoba

2.3.5 Controversy mapping

Controversy mapping served as a central methodological approach in this study, bridging the theoretical foundations of science and technology studies (STS) and political ecology with the

empirical investigation of nutrient governance in Manitoba. Developed within STS, controversy mapping provides a way to trace how complex socio-environmental issues are not simply governed through technical decision-making, but are constituted through disagreement, negotiation, and power-laden processes of knowledge production (Venturini, 2010; Latour, 2005). Rather than seeking policy consensus or evaluating implementation success, this method foregrounds the plurality of actors, perspectives, and framings that structure environmental controversies. It examines how scientific evidence, regulatory mechanisms, and normative claims interact across different sites and scales, thereby constructing what counts as a policy problem and what solutions are seen as legitimate or effective (Venturini, 2012; Callon, 1986).

In this study, controversy mapping enabled a multi-dimensional analysis of how eutrophication and nutrient pollution are problematized, politicized, and governed. First, it allowed the identification of key points of contestation, revealing that nutrient pollution is not understood as a neutral or solely technical challenge, but rather as a highly contested issue in which actors disagree on sources, responsibilities, and appropriate interventions. Second, the method facilitated the mapping of actor-networks, drawing on interview and documentary data to trace relationships and oppositions among diverse actors—regulators, scientists, Indigenous nations, agricultural producers, environmental organizations, and watershed managers. These networks revealed the shifting alliances, tensions, and power asymmetries that characterize governance processes. Third, controversy mapping enabled a detailed analysis of framing conflicts, showing how different actors conceptualize nutrient pollution variously as a scientific uncertainty, a threat to economic livelihoods, a regulatory failure, or a matter of environmental justice. These competing framings have direct implications for how policies are proposed, resisted, or implemented. Fourth, the method examined institutional devices—including phosphorus thresholds, dual nutrient caps, and

buffer zone regulations—not merely as policy tools but as objects of dispute. These instruments were analyzed as governance technologies through which authority is enacted, challenged, or negotiated (Bijker et al., 2009; Jasanoff, 2004).

Finally, controversy mapping captured the temporal and scalar dynamics of nutrient governance, tracing how debates evolve over time and across governance levels—from local watershed planning to provincial regulatory regimes. The method revealed how jurisdictional ambiguities and multi-scalar institutional arrangements contribute to ongoing tensions and governance gaps (Swyngedouw, 2004; Cash et al., 2006). When integrated with qualitative coding of interviews and documents, controversy mapping offered a relational and process-oriented perspective on Manitoba's water governance. It demonstrated that eutrophication management is not merely a matter of implementing science-based regulation, but a dynamic and contested process through which problems, knowledge, and solutions are continuously redefined in relation to broader struggles over authority, legitimacy, and justice.

2.3.6 Analysis

The qualitative data collected for this study, comprising policy documents, key informant interviews, and secondary documents, were analyzed using NVivo, a robust qualitative data analysis software. NVivo was instrumental in systematically coding and categorizing the data, identifying key themes, and exploring the relationships between governance frameworks and nutrient management outcomes in the SRRWD. The coding process adopted both inductive and deductive approaches, allowing themes to emerge organically from the data while also aligning with pre-existing theoretical frameworks on voluntary and regulatory governance (Bingham, 2023). This dual approach ensured a analysis that was both grounded in the empirical data and informed by established academic perspectives.

2.4 Results and Discussion

2.4.1 Eutrophication management in Canada

Eutrophication management in Canada entails a multifaceted approach focusing on mitigating nutrient influx from both point and non-point sources (Gasman, 2021). Point sources predominantly stem from wastewater effluents, while non-point sources primarily originate from agricultural lands and urban runoff. To address these challenges, concerted efforts have been undertaken by the federal government, provinces, and territories through the implementation of pertinent policies and regulations targeting both categories of water pollutant sources. Eutrophication management remains pivotal in managing cyanobacteria blooms, particularly in eutrophic lakes where the risk of bloom formation is high. Several Canadian provinces, including Ontario, Manitoba, Saskatchewan, Alberta, and Nova Scotia, recognize eutrophication as a significant threat to water quality and the primary cause of bloom occurrences. Consequently, they employ a variety of regulated, encouraged, and incentivized programs, policies, and practices to manage both point source (PS) and non-point source (NPS) nutrients (Gasman, 2021). Despite nearly five decades of PS and NPS nutrient management efforts in Canada, reports of cyanobacteria blooms are increasing (Kanada, 2001; Pick, 2016). While measurable reductions in nutrient exports from point sources have been achieved in some regions—notably phosphorus (P) removal at wastewater treatment plants under regulations like Ontario's 0.5 mg/L effluent standard (Dove & Chapra, 2015)—these gains have not yielded proportional improvements in water quality or harmful algal bloom (HAB) frequency in highly eutrophic systems. This paradox reveals critical gaps in current governance.

The governance of wastewater management in Canada involves a collaborative effort among federal, provincial, and municipal authorities, each playing distinct roles in regulating and

overseeing wastewater treatment processes. While provinces and municipalities hold primary responsibility for wastewater infrastructure and permitting, the federal government also plays a direct regulatory role through the **Wastewater Systems Effluent Regulations (WSER)**, established under the *Fisheries Act* in 2012. These regulations set national standards for the discharge of effluent from wastewater systems, prohibiting the release of deleterious substances beyond prescribed limits into fish-bearing waters (Canada, 2020). The Fisheries Act more broadly contains a general prohibition against the release of "deleterious substances" into waters frequented by fish, which can include any material that degrades water quality to the detriment of fish, fish habitat, or human use of fish ((Branch, 2019; Canada, 2007, 2020). In parallel, the *Canadian Environmental Protection Act* (CEPA) governs the release of toxic substances into the environment, empowering the federal government to establish regulations that control or eliminate their use (Canada, 2007, 2020). Together, these federal frameworks complement provincial and municipal systems, forming the backbone of Canada's multilevel approach to wastewater governance.

The Federal government establishes minimum effluent water standards through legislative or regulatory means, often targeting pollutants with potential adverse effects on aquatic ecosystems. The Wastewater Systems Effluent Regulations (WSER; SOR/2012-139) of the Fisheries Act establish baseline municipal effluent quality standards for suspended solids (SS), carbonaceous biochemical oxygen-demanding material (CBOD), total residual chlorine, and un-ionized ammonia (NH3), with secondary treatment or better required to meet these standards (Branch, 2019). Provincial and territorial governments issue permit for wastewater treatment plants (WWTPs) within their jurisdictions, thereby governing their operations under a regulatory framework. Although direct federal legislation addressing municipal wastewater discharge is

absent, regulations under the Fisheries Act provide a foundation for effluent standards nationwide. Moreover, WWTPs with discharge rates exceeding certain thresholds are mandated to monitor and report on the release of various substances, including phosphorus, under the Federal Environmental Protection Act.

To further bolster wastewater management and safeguard environmental and human health, a Canada-wide Strategy for the Management of Municipal Wastewater Effluent was established in 2003. This strategy mandates WWTPs to adhere to national performance standards and site-specific effluent discharge objectives, tailored to the unique characteristics of each facility and its surrounding environment. As part of this strategy, some provinces and territories have entered bilateral agreements with the Federal government, affirming their commitment to upholding standards equivalent to federal regulations.

Implementation of wastewater management strategies often involves upgrading municipal WWTPs to meet national standards. Various techniques are employed for phosphorus removal, including chemical precipitation and biological nutrient removal. While lagoon systems may be utilized in smaller communities, their efficacy in targeted removal of phosphorus and nitrogen may be limited. In eastern Canada, municipalities commonly employ conventional activated sludge with extended aeration, supplemented by chemical precipitation for phosphorus removal. Conversely, in western Canada, biological nutrient removal techniques are more prevalent, effectively removing phosphorus and nitrogen from effluent water (Gasman, 2021). As of 2020, 86.2% of Canadians were serviced by municipal WWTPs, with only 3.7% of the volume of municipal wastewater discharged untreated (Environment and Climate Change Canada, 2023). In Alberta, Manitoba, and Ontario, provincial regulations dictate total phosphorus (TP) effluent water standards for municipally operated wastewater treatment plants (WWTPs) as delineated in Table

3. These standards are designed to curb phosphorus discharge and safeguard water quality against eutrophication and the proliferation of algal blooms, among other concerns. Table 3 shows the total phosphorus and total nitrogen standards across provinces and territories in Canada, and the key legislative instruments that influence these standards.

Table 3: Provincial Nutrient Wastewater Effluent Standards for Provincially Regulated Wastewater Treatment Plants

Provinces	Total Phosphorus (TP) Standard	Total Nitrogen (TN) Standard	Targeted Nutrient	Legislation
British Columbia	>1.0mg/L	10mg/L (Site-specific)	TP	Environmental Management Act
Ontario	0.5-1.0 mg/L (seasonal variations)	N/A	TP	Water Resources Act (1990) Environmental Protection Act (1990)
Manitoba	1.0mg/L	15mg/L	TP & TN	The Water Protection Act
Alberta	1.0mg/L	N/A	TP	Environmental Protection and Enhancement Act
Saskatchewan	<0.75 mg/L	10-14 mg/L	N/A	The Environmental Management and Protection Act
Nova Scotia	N/A	N/A	N/A	Environment Act
Quebec	0.2-1.0 mg/L (varies by region) Stricter near St. Lawrence	N/A	N/A	The Environmental Quality Act
Newfoundland and Labrador,	N/A	N/A	N/A	Environmental Protection Act
New Brunswick	N/A	N/A	N/A	Clean Water Act
Nova Scotia	N/A	N/A	N/A	Environmental Act
Prince Edward Island	No numeric standards	N/A	N/A	Environmental Protection Act Water Act
Yukon	N/A	N/A	N/A	Waters Act,
Nunavut	Case-by-case permits	Case-by-case permits	N/A	Waters Act
Northwest Territories	Case-by-case permits	Case-by-case permits	N/A	Nunavut Waters

Ontario's method of regulating TP effluent covers a wide range of facilities, with the potential for increased stringency based on specific site conditions or for particular water bodies and watersheds. Additionally, seasonal variations necessitate stricter TP levels during warmer months to reduce phosphorus loading, particularly important for combating cyanobacteria blooms (Table 1). On the other hand, Manitoba's TP effluent standard applies uniformly to facilities meeting specific discharge criteria, regardless of their location or treatment capacity. Notably, Manitoba is the only province to implement a TN effluent standard, acknowledging nitrogen's contribution to cyanobacteria bloom formation. However, the effectiveness of TN regulation in addressing such blooms is unclear due to certain cyanobacteria species' ability to utilize atmospheric nitrogen, potentially limiting the impact of regulated nitrogen reduction (Higgins et al 2018). Manitoba's method has received backlash over the years because of the wastewater treatment costs and time it takes to reduce nitrogen (N) (IISD, 2017).

Alberta's approach shares similarities with Manitoba in that both provinces regulate major wastewater dischargers primarily through standards focused on larger treatment plants, while also taking into account treatment capacity and technological feasibility. In both cases, smaller facilities—such as those serving communities under 20,000 people or those operating lagoon systems—are granted exemptions or more flexible requirements, reflecting the practical challenges of upgrading rural and small-town infrastructure. However, important differences also exist. Whereas Alberta has not introduced seasonal tightening of effluent standards, Manitoba has placed particular emphasis on phosphorus control in response to Lake Winnipeg eutrophication, and is actively upgrading major wastewater treatment plants to meet existing requirements. That said, Manitoba's efforts have faced resistance, particularly around the high costs of total nitrogen removal. Saskatchewan and Nova Scotia diverge from the blanket TP effluent limit approach,

opting instead for facility-specific standards set through operational licenses and discharge water site assessments. Consequently, not all facilities are subject to nutrient effluent standards, and considerations regarding bloom mitigation or cumulative effects on water bodies remain uncertain. Quebec's regulatory framework, driven by the Canada-wide Strategy for the Management of Municipal Wastewater Effluent, targets municipalities below the 54th parallel with stringent provisions aimed at safeguarding aquatic ecosystems and drinking water sources, including strict standards for carbonaceous biochemical oxygen demand (CBOD5), total suspended solids (TSS), and effluent pH range, alongside prohibitions on combined sewer overflows and untreated wastewater diversion. The Atlantic Provinces, including New Brunswick, Newfoundland and Labrador, Nova Scotia, and Prince Edward Island, primarily discharge wastewater effluents into marine environments. Historically, these provinces have tended to maintain lower levels of secondary treatment compared to inland regions of Canada (Canadian Water Network, 2017). While these provinces have key legislation guiding effluent management practices, they notably lack specific regulations pertaining to total phosphorus and total nitrogen levels in wastewater discharge.

In Canada's northern territories, local water boards play a crucial role in regulating effluent discharge, establishing regional standards, and overseeing monitoring and reporting procedures. Due to the region's unique challenges, such as cold climates and remote locations, wastewater treatment methods often rely on simplified approaches like oxidation ponds or seasonal facultative ponds with bacterial-algal symbiosis. These methods are particularly common in smaller, isolated communities. While compliance with federal Wastewater Systems Effluent Regulations (WSER) is ensured in Yukon through bilateral agreements, such regulations do not extend to Nunavut or the Northwest Territories (Canadian Water Network, 2017).

Non-point sources of nutrient pollution are a pressing issue for water quality management in Canada, with agricultural activities, urban development, and other land use practices contributing to nutrient runoff. This section provides an overview of legislative frameworks addressing non-point source nutrient pollution in Canadian provinces and territories. It examines key regulations and policies, aimed at controlling nutrient runoff from agricultural, urban, and other land use activities. Provincial regulatory frameworks addressing diffuse pollution from agriculture exhibit notable variations across Canada. In Ontario, the Nutrient Management Act (2002) establishes robust guidelines for specific nutrient management practices, mandating farmers to meticulously document these practices to mitigate water contamination risks effectively. Similarly, Manitoba's Livestock Manure Mortalities Management Regulation (2017) enforces stringent requirements concerning livestock manure utilization, management, and storage, aiming to prevent water pollution. This includes stringent permitting processes for the construction or modification of manure storage facilities. In Quebec, the Agricultural Operations Regulation (2002) emphasizes the equilibrium of soil phosphorus levels to uphold fertility and curtail excessive manure application. This regulation encompasses standards for livestock facilities, meticulous manure management protocols, and land use restrictions geared towards limiting water pollution. Moreover, Quebec implements regulations governing fertilizer and pesticide usage in agriculture, fostering a strategy to combat diffuse pollution.

Table 4: Provincial Legislation and Regulations for Agricultural Non-Point Source Nutrient Management

Provinces	Legislation	Regulation	Phosphorous Threshold Values	Nitrogen Threshold Values
British Columbia	Environmental Management Act	Code of Agricultural Practice for Waste Management	Yes	Yes
Ontario	Nutrient Management Act	1. Ontario Regulation 267/03 2. Ontario Regulation 300/14	Yes	Yes
Manitoba	1. The Environment Act 2. The Water Protection Act	1. Livestock Manure and Mortalities Management Regulation (LMMR) 2. Nutrient Management Regulation (NMR) 3. Nutrient Targets Regulation	Yes	Yes
Alberta	Alberta Operation Practices Act Alberta	Alberta Operation Practices Act Alberta Regulation 267/2001	No	Yes
Saskatchewan	The Agricultural Operations Act	The Agricultural Operations Act Intensive Livestock Provision	No	Yes
Nova Scotia	Fur Industry Act Fur Industry Regulation	Fur Industry Act Fur Industry Regulation	Yes	Yes
Quebec	The Environmental Quality Act	The Agricultural Operations Regulation	Yes	Yes
Newfoundland and Labrador,	Farm Practices Protection Act	N/A	No	No
New Brunswick	Agricultural Operation Practices Act	Agricultural Operation Regulation New Brunswick Regulation 99-32	Yes	Yes
Prince Edward Island	Farm Practices Act	N/A	No	Yes
Northern Regions (Yukon, Nunavut, Northwest territories)	Waters Act, Waters Act, Nunavut Waters and Nunavut Surface Rights Tribunal Act	N/A	No	No

Furthermore, Alberta, Ontario, Quebec, New Brunswick, and Manitoba legislate the regulation of winter manure application, while Alberta, Manitoba, and Ontario mandate setback distances for manure application and storage from watercourses. Notably, only Ontario, Quebec, Manitoba, and Nova Scotia impose limitations on manure application based on soil phosphorus levels. Conversely, Alberta and Saskatchewan incorporate considerations of soil salinity and

nitrogen levels, respectively, into their nutrient management legislation and regulations. This intricate regulatory landscape underscores the diverse approaches undertaken by Canadian provinces to address diffuse pollution in agricultural practices, reflecting nuanced considerations of soil fertility, water resource protection, and sustainable land management.

2.4.2 Manitoba in Comparative Perspective

In the realm of water quality management, a significant challenge within Manitoba, pertains to the gradual yet persistent increase of nitrogen and phosphorus levels in recent decades (Lewtas et al., 2015). While essential for the health of lakes and rivers, excessive concentrations of phosphorus can precipitate algal blooms. Of particular concern in Manitoba are harmful algae blooms, notably those caused by cyanobacteria or blue-green algae, which pose substantial threat to water quality, human and ecosystem health, garnering considerable attention from governmental bodies, environmental agencies, and the public (Stainton et al., 2003). Lake Winnipeg in Manitoba, the 10th largest freshwater lake globally, has gained global attention for another notable attribute: its persistent issue with blue-green algae (Wassenaar & Rao, 2012).

Consequently, both the federal government and the provincial government of Manitoba, alongside various actors including Indigenous communities and Civil Society Organizations (CSOs) have undertaken significant concerted efforts over the past few decades aimed at mitigating phosphorus inputs into surface and ground water through legislative measures, landscape modifications, research and monitoring initiatives, and public engagement and education. Despite these well concerted efforts, phosphorus concentrations persist at elevated levels in Lake Winnipeg, raising doubts about the efficacy of current policies and practices aimed at enhancing water quality and security in Manitoba. A major point of contention in eutrophication management in Manitoba revolves around the “phosphorous and nitrogen debate”. This debate pits

scientists and researchers advocating for phosphorus reduction against those championing phosphorus and nitrogen reduction, each asserting differing views on how nutrient reduction should be prioritized to mitigate eutrophication and the formation of harmful algae in water bodies (Palley, 2016).

Phosphorus reduction is widely recognized an effective strategy for controlling algal blooms in freshwater lakes. Scientists and policy-makers have long agreed on the importance of reducing phosphorus to control algal blooms in freshwater ecosystems (Håkanson & Bryhn, 2010; Schindler, 2012; Schindler et al., 2016a). As a result, aggressive phosphorus-reduction policies have been implemented in many jurisdictions since the 1980s. According to Schindler (2016), the strategy of reducing phosphorus emerged as a prominent solution for addressing eutrophication in the North American Great Lakes and various lakes across Europe and North America. This preference for phosphorus regulation stemmed primarily from three key sources of evidence: an examination of the eutrophication issue, large-scale experiments conducted on entire lakes, and a thoroughly documented successful instance of ecosystem recovery.

While there has been some advocacy regarding nitrogen reduction as a key component of nutrient reduction, the predominant scientific evidence overwhelmingly supports phosphorous reduction as the most effective strategy for controlling algal blooms in freshwater ecosystems (Schindler et al DATE). Decades-long whole-ecosystem experiments, such as the Lake 227 experiment and the case history of Lake Washington (Edmondson, 1970; S. N. Higgins et al., 2018), have consistently demonstrated that phosphorus is the primary driver of algal growth in lakes like Lake Winnipeg. Moreover, real-world examples from jurisdictions like the Laurentian Great Lakes (Dove & Chapra, 2015) have shown the success of phosphorus reduction policies in mitigating algal blooms. In recent years, there has been a growing chorus advocating for the

reduction of nitrogen inputs into freshwater lakes, challenging the prevailing focus on phosphorus reduction alone. This call has been fueled by studies suggesting that targeting phosphorus inputs alone may not be sufficient to effectively mitigate eutrophication. Reports have highlighted the limited effectiveness of phosphorus reduction efforts, along with findings from bottle-scale experiments revealing nitrogen's role as a limiting factor in estuaries and certain lake ecosystems (Schindler et al., 2016).

However, the push for nitrogen reduction has been met with controversy and considerations regarding scientific feasibility and cost. Arguments favoring nitrogen reduction often rely on limited and inappropriate small-scale experiments that fail to capture the complexities of the natural ecosystems (Dodds & Smith, 2016; Paerl et al., 2014). As articulated by Schindler (2012), these scientific findings advocating for nitrogen reduction in lakes and water ecosystems stem from short-term experimental manipulations of nutrients conducted in controlled environments such as bottles and mesocosms which fail to accurately capture the complexities and dynamics of natural ecosystems and overlook crucial factors such as biogeochemical nutrient cycles, nutrient fluxes from sediments, and ecological community dynamics. The significance of whether small-scale nutrient enrichment experiments indicate nitrogen limitation seems negligible, as such approaches only assess short-term nutrient limitation, while addressing eutrophication necessitates mitigating the influx of nutrients that exert long-term control. Additionally, other scientific studies (Håkanson & Bryhn, 2010; Schindler, 2012) have emphasized that the management of nitrogen at point sources, either instead of or alongside phosphorus, presents considerable challenges in terms of cost and technical complexity compared to addressing phosphorus alone.

Advocates for nitrogen or dual nutrient control have successfully influenced policymakers, arguing for more nutrient management strategies. Notably, the European Union's Water

Framework Directive mandated the removal of nitrogen, underlining its significance in combating eutrophication in lakes. Concurrently, the United States Environmental Protection Agency (EPA) pledged to collaborate with states to expedite the reduction of both nitrogen and phosphorus inputs into water bodies. This commitment was underscored by the adoption of dual nutrient criteria for lakes, rivers, and estuaries, reflecting a recognition of the importance of addressing both nutrients in eutrophication management (Dodds & Smith, 2016). Yet, others have raised concerns about the practicality and feasibility of nitrogen control measures, particularly when compared to phosphorus reduction efforts. They contend that controlling nitrogen, especially alongside phosphorus, poses greater technical challenges and financial costs, underscoring the need for a thorough evaluation of the efficacy of single versus dual nutrient control approaches (Dodds & Smith, 2016; Paerl et al., 2014). As a result, action to address eutrophication in Manitoban water bodies, including Lake Winnipeg, faces obstacles due to an ongoing debate about the necessity for additional nitrogen reduction measures. The uncertainty surrounding the evidence supporting nitrogen reduction, coupled with demands from the provincial government for such measures, has hindered progress on phosphorus reduction efforts

Key legislative instrument such as the Water Protection Act (2005), Nutrient Management Regulation (2008) and the Phosphorous Reduction Act (2010) enforces the regulation of both phosphorous and nitrogen reflecting the province's commitment to dual nutrient management. Furthermore, other pertinent actors, such as the Prairie Provinces Water Board, which oversees transboundary water quality among Alberta, Saskatchewan, and Manitoba, have established water quality objectives for phosphorus and nitrogen in rivers that traverse these provinces and flow into Lake Winnipeg (*Prairie Provinces Water Board*, 2023). Moreover, the International Joint Commission recently issued recommendations for both phosphorus and nitrogen targets and

objectives for the Red River at the US/Canada border. It is noteworthy that Manitoba actively participates in the initiatives of both the Prairie Provinces Water Board and the International Joint Commission regarding the Red River. Additionally, numerous major wastewater treatment facilities across the Canadian prairies, such as those in Calgary and Regina, are equipped with systems for removing both phosphorus and nitrogen. This approach is echoed in other jurisdictions within the Lake Winnipeg watershed, such as North Dakota and Minnesota, where nutrient reduction strategies encompass both nitrogen and phosphorus (Manitoba Agriculture and Resource Development., 2020).

Manitoba's initiatives to mitigate both phosphorus and nitrogen levels in water bodies have garnered significant attention, largely propelled by advocacy from various organizations, scientific bodies, and academic circles. The provincial government's approach, particularly towards reducing nitrogen, has sparked criticism due to its perceived costliness and debatable effectiveness in combating eutrophication. A seminal report (Higgins et al., 2018) raised questions about Manitoba's substantial investment of $1.4 billion in upgrading sewage treatment facilities with the aim of curtailing the discharge of both phosphorus and nitrogen compounds (CBC News, 2018). In an interview with CBC, the director of the Lake Winnipeg Foundation Alexis Kanu, highlighted the pivotal role of phosphorus as the primary limiting nutrient in exacerbating eutrophication (CBC News, 2017). Drawing upon decades of scientific research, she emphasized the imperative of focusing efforts primarily on phosphorus reduction as the most effective strategy for addressing eutrophication. She noted, however, that policy decisions are not determined by science alone but are also shaped by political will and public advocacy. As she stated, *"I think it's a question of political will in a lot of cases. We have the science that we need, and now we need citizens who care about these lakes to speak up"* (CBC, 2018). This highlights that citizen engagement and

advocacy are essential in translating scientific consensus into meaningful policy action. At the same time, the debate over whether to adopt single- or dual-nutrient control strategies remains ongoing. Given the considerable costs associated with nitrogen removal, it is prudent for policymakers including the Minister of Environment and Climate Change of Manitoba to carefully assess the evidence for both approaches to ensure management practices that are scientifically grounded, cost-effective, and sustainable.

2.4.3 Mapping actor perspectives on Manitoba's dual-nutrient regulations – Interview Findings

This section presents insights from interviews conducted with key actors involved in the development, implementation, or response to Manitoba's dual-nutrient regulations. The findings reveal fundamental disagreements about the scientific justification, hydrological relevance, and policy effectiveness of regulating both phosphorus and nitrogen. These disagreements highlight the complex interplay of science, policy, and knowledge, and illustrate the tensions discussed in previous chapters.

A major point of contention among interviewees was the need to regulate nitrogen alongside phosphorus. Actors in the agricultural sector argued that nitrogen does not pose the same environmental risk in Manitoba as in other regions, citing the province's distinctive soil characteristics. One participant noted that, "sandy soils have lower nitrate limits because they leach more, but our heavy clay soils naturally hold nitrogen." This view reflects a broader concern that current regulations overlook regional soil and climate differences. Another respondent pointed out that the focus on nitrogen seemed misplaced, stating, "these rules are mainly for groundwater, not lake health. And out here, groundwater isn't the main concern." By contrast, some scientific actors supported nitrogen regulation, citing recent evidence that nitrogen can play a role in the persistence and severity of algal blooms, especially under changing climate conditions. However, even within

the scientific community, views varied. One scientist questioned the need for regulation by pointing out the economic incentive farmers already have to reduce nitrogen use: “farmers already minimize nitrogen because it’s expensive. Why regulate it like phosphorus?” Others disagreed, arguing that relying solely on economic self-interest is insufficient. According to another interviewee, “there’s growing evidence that phosphorus-only controls can make things worse, especially with nitrogen-fixing cyanobacteria adapting to the conditions.” These controversies underscore how scientific knowledge itself is contested and negotiated in policy debates.

Another area of disagreement involves the timeline of policy goals—whether nutrient regulations should address present environmental conditions or prepare for future risks. Several participants emphasized that current hydrological conditions in Manitoba do not support strong nitrogen controls. As one explained, “cold, clay-heavy soils reduce nitrogen leaching. That’s not the same problem you see in Ontario.” These views highlight the importance of local environmental knowledge in evaluating the appropriateness of regulatory measures. Others, however, pointed to anticipated climate changes as a reason to maintain or even strengthen regulations. One interviewee explained, “warmer winters mean more water movement, more runoff. We’re not just dealing with today’s soil.” This future-oriented reasoning reflects a broader shift in environmental governance towards managing potential rather than proven threats. These differing perspectives illustrate a key challenge: balancing immediate, measurable conditions with long-term, uncertain risks.

Interviewees also identified significant implementation challenges, particularly around monitoring and enforcement. Many expressed concerns about the lack of reliable data to evaluate whether nutrient reduction strategies are working. One respondent stated, “we pay farmers to plant riparian buffers, but we have no idea how much nitrogen or phosphorus they actually stop.” This

uncertainty arises primarily because rigorous monitoring is often limited or absent, and scientifically quantifying nutrient capture by riparian buffers can be methodologically challenging due to variability in soil conditions, buffer design, seasonal changes, and localized hydrological dynamics. This inability to quantify outcomes weakens accountability and undermines confidence in the effectiveness of the policy. Enforcement was another area of concern. Actors pointed to continued wetland losses despite existing protection. One described the situation bluntly: "We keep losing wetlands year after year. The rules exist, but they're not stopping it." Another noted, "No regulation can fix that. It's too far gone, and there's no one checking anyway." These comments reflect deep frustration with the gap between policy on paper and what happens in practice. They also illustrate how limited resources and lack of monitoring can hinder environmental governance.

Two interviewees acknowledged that policy decisions are not based solely on science. One recurring theme was the influence of public perception, particularly regarding phosphorus. Several participants noted that phosphorus tends to receive more attention because its effects are more visible. One remarked, "people panic when they see green water. That's why phosphorus gets all the headlines." This aligns with the idea that visible environmental threats are more likely to provoke public concern and political action (Hannigan, 2014). Importantly, phosphorus is harmful to both human and aquatic life, not merely perceived to be harmful; however, it's obvious or striking appearance likely amplifies the public attention it receives. Others questioned whether Manitoba's dual-nutrient approach was tailored to local conditions or simply adopted from other jurisdictions. One actor commented, "they copied New Zealand's model without asking if our watersheds are the same." According to Snelder et al. (2020), New Zealand does employ both phosphorus and nitrogen concentration criteria in its water quality framework. However, the literature does not provide clear evidence that Manitoba explicitly adopted or adapted New

Zealand's model. The respondent's observation nonetheless reflects a broader skepticism about the appropriateness of transferring policy frameworks without adjusting them for regional differences in ecology, governance, and land use.

The interviews reveal a regulatory regime under pressure from competing expectations, knowledge systems, and governance realities. First, there are deeply divided opinions on whether nitrogen should be regulated at all, with some actors relying on economic logic and local hydrological conditions, while others point to emerging environmental risks. Second, a key tension exists between regulating based on current, measurable conditions and anticipating future climate-driven challenges. Third, even where there is agreement on principles, the absence of robust monitoring systems and weak enforcement mechanisms severely limits the impact of existing regulations. Finally, policy choices are shaped not only by science, but also by political pressures and public perception—particularly around visible environmental threats like algal blooms.

Together, these findings show that nutrient regulation in Manitoba is not just a technical issue, but a contested process involving different forms of knowledge, conflicting priorities, and uneven capacity for implementation. The province's dual-nutrient approach reflects a broader dilemma in environmental governance: how to act decisively when the science is complex, the outcomes are uncertain, and the capacity to enforce is limited.

2.4.4 Competing knowledge systems in nutrient governance

The debate over nutrient management in Manitoba reveals a deeper struggle over whose knowledge counts in shaping environmental policy. At the heart of the controversy are five key communities—scientific researchers, provincial policymakers, Indigenous Peoples, agricultural actors, and environmental organizations, each advocating different approaches to managing eutrophication in Lake Winnipeg and beyond. This section analyzes how these groups construct

and apply evidence to justify their positions, and how these competing narratives influence the governance of nutrient pollution. The scientific consensus on freshwater eutrophication is grounded in decades of whole-lake experimentation, especially the long-term studies conducted at Canada's Experimental Lakes Area (Schindler, 2012; Schindler et al., 2008). These studies consistently demonstrate that phosphorus is the primary nutrient driving algal blooms in freshwater ecosystems. In particular, the landmark Lake 227 experiment (Schindler et al., 2008)—spanning nearly four decades—provides compelling empirical evidence that phosphorus reductions lead to significant water quality improvements, while nitrogen reductions alone yield negligible results. Complementary large-scale studies across North American lakes, including Lake Washington and the Great Lakes, have echoed these findings. Syntheses of data from hundreds of systems have further confirmed phosphorus's dominant role, strengthening the case for phosphorus-focused interventions as the most ecologically effective and policy-relevant strategy. This body of evidence has shaped international best practices and continues to be cited by researchers and advocacy groups alike as the scientific foundation for eutrophication control.

Despite the strength of the scientific case for phosphorus reduction, Manitoba's regulatory framework supports controlling both phosphorus and nitrogen. This policy stance is justified through a blend of technical, legal, and precautionary arguments. Regulatory documents cite smaller-scale studies that suggest nitrogen limitation may play a role in certain conditions. Although these findings are less conclusive than whole-lake data, they are used to support a risk-averse, precautionary approach. Manitoba's 2020 nutrient strategy frames dual-nutrient control as a safeguard against scientific uncertainty and future ecological shifts. Economic and logistical considerations also factor into the province's approach. The feasibility of upgrading wastewater treatment facilities to handle both nutrients is often weighed against the cost implications. Thus,

scientific and economic rationales are blended in policymaking, leading to a broader nutrient management strategy than what is prescribed by ecological evidence alone.

Environmental NGOs play a critical role in publicizing the scientific case for phosphorus control. Through public campaigns, educational outreach, and collaboration with researchers, these groups work to bridge the gap between academic findings and civic awareness (Winnipeg Citynews, 2024). Media outlets have amplified the voices of leading scientists, drawing public attention to the health of Lake Winnipeg and the consequences of nutrient pollution. For instance, CityNews Winnipeg (2024) quoted Ducks Unlimited scientist Pascal Badiou, noting that "some wetlands do a really good job in processing nutrients" and play an outsized role in reducing phosphorus loading. The same coverage highlighted Manitoba's aggressive phosphorus reduction goals—cutting from ~5,000 to 2,800 tonnes annually—and underscored the need for both engineered and natural infrastructure investments (Winnipeg Citynews, 2024). The nutrient governance debate in Manitoba is not simply a matter of science versus politics. It reflects a deeper contest over how knowledge is produced, validated, and acted upon. Scientific consensus clearly supports prioritizing phosphorus reduction, yet policy choices are shaped by political, economic, and social factors that influence how evidence is interpreted and used. Understanding these competing knowledge systems is essential for designing more responsive and inclusive water policies—ones that balance ecological integrity with the practical needs of agriculture, the cautious mandates of regulators, and the ethical commitments of environmental advocates. Only by recognizing the plural nature of expertise can we hope to move toward more effective and legitimate governance of our shared water resources.

2.4.5 Controversies over the sources and solutions of eutrophication

Drawing on both interview data and media discourse, this chapter maps the controversies around the sources and solutions to nutrient pollution, using a controversy studies lens to highlight the ways in which scientific knowledge, political accountability, and governance arrangements co-produce conflicting narratives and responses. Interviews with provincial officials, environmental NGOs (ENGOs), and water management scientists reveal divergent diagnoses of the eutrophication problem. Government officials often frame nutrient pollution as the cumulative effect of widespread human activity, avoiding specific attributions of blame. One provincial staff member described the issue as the product of "all of us together, collectively," arguing that assigning blame is unproductive. By contrast, ENGO representatives focused on specific practices and sectors, such as fertilizer use, land drainage, and wetland degradation, particularly in southern Manitoba. One ENGO staffer noted, "There are some activities on the land that do lend to poor water quality… phosphorus is a big one." Water agency scientists added further nuance, emphasizing that cross-border nutrient flows from the United States and city-scale wastewater management failures complicate the picture. One scientist remarked, "Over 50% of the phosphorus load to Lake Winnipeg comes from the Red River, and a lot of that is from south of the border. It adds an extra challenge with respect to how we address the issue." This division in framing is mirrored in the media. Reports from Global News and the Winnipeg Free Press show how ENGOs emphasize wetland loss and agricultural runoff, while industry representatives, such as those from Manitoba Pork, insist on their environmental stewardship and deflect focus toward municipal wastewater or climate variability. Sewage treatment centres in Winnipeg have also drawn scrutiny for their phosphorus output into the Red River, with the North End Sewage Treatment Plant cited in several media reports as a major point source of nutrient pollution (CBC News, 2020; Winnipeg

Free Press, 2021). One report noted that “the North End sewage plant is the single largest point source of phosphorus entering Lake Winnipeg” (CBC News, 2020).

Both interviewees and media reports underscore the gaps in empirical data needed to measure, monitor, and manage nutrient pollution. One ENGO actor noted that many Integrated Watershed Management Plans (IWMPs) lack concrete nutrient targets, and that data collection at the watershed level remains patchy. "At the time I did my research, there weren't specific nutrient reduction targets for the watersheds… the data on nutrients is not readily available," they stated. A water agency representative echoed this concern, highlighting the lack of detailed data on phosphorus contributions from both natural and anthropogenic sources. "There isn’t necessarily a good understanding of how vegetation and natural landscapes contribute phosphorus, especially during spring runoff," they said. News coverage from CityNews Winnipeg has likewise drawn attention to the absence of clear phosphorus baselines and the difficulties in evaluating the impact of mitigation strategies. This scientific incompleteness creates space for strategic ignorance and competing interpretations, enabling actors to question both the scale and sources of the problem.

Agriculture is widely acknowledged as a significant contributor to nutrient runoff, but its role is interpreted differently across actors. Farmers and agricultural associations often stress the economic logic of nutrient application: fertilizers are expensive, and their use is tightly controlled. As one ENGO representative observed, “Fertilizers are really expensive, so producers are not applying them liberally—they're very strategic.” Yet NGOs and some scientists argue that the sector remains under-regulated. One interviewee pointed to international examples, such as nitrogen cap-and-trade systems in New Zealand, as models for binding commitments. A provincial official, however, suggested that attention should shift from inputs to drainage infrastructure, arguing that hydrological dynamics play a more decisive role than nutrient application rates alone.

This controversy reflects broader tensions in Manitoban environmental governance—between voluntary stewardship and mandatory regulation, between protecting economic interests and addressing environmental degradation.

Another underexplored but crucial dimension of nutrient controversy is the legacy of land drainage and hydrological modification. A provincial official recalled how the Red River Valley was historically a swamp, radically transformed over the last century through extensive drainage infrastructure. “The Red River Valley was a swamp, and we drained the entire thing over, I don't know, 100 years… That drainage has a huge impact,” they explained. A water agency scientist added that Manitoba’s shallow lakes and fast-flowing drainage systems increase nutrient mobility and reduce natural retention capacity. These infrastructural legacies are rarely emphasized in policy debates, yet they fundamentally shape how nutrients move across the landscape. They also challenge the assumption that nutrient reductions will yield immediate water quality improvements, pointing instead to legacy phosphorus stored in soils and sediments. Media coverage increasingly acknowledges these factors but often frames them as background rather than primary drivers, thus limiting their visibility in public discourse and governance strategies.

One of the most persistent and politically significant controversies concerns the exclusion of Indigenous voices and governance systems in nutrient management planning. An ENGO representative noted that only a few watershed districts, like Swan Lake, have attempted meaningful collaboration with First Nations, and even these are rare exceptions (Wiebe, 2024). “I don’t think watershed districts have active partnerships with Indigenous communities… it’s really rare,” they said. This exclusion not only raises questions of justice and equity but also represents a lost opportunity for incorporating Indigenous knowledge systems, which could offer more holistic, place-based understandings of watershed health. Media coverage, while occasionally

addressing Indigenous perspectives, tends to treat them as secondary to technical and policy narratives, thereby reinforcing existing epistemic hierarchies.

2.4.6 Fragmented solutions and epistemic conflict

The interviews reveal a contested landscape of proposed solutions. A university-based scientist framed eutrophication as the result of "a very large number of small contributions," suggesting that it should be approached as "our collective responsibility." This respondent criticized policies that scapegoat specific sectors, advocating instead for systems-based strategies and regulatory oversight through bodies like the Clean Environment Commission. A provincial policy actor took a pragmatic stance, warning against overly expensive “Cadillac solutions” for wastewater treatment and instead promoted "something less expensive" that could still yield incremental improvements. ENGO representatives supported voluntary programs and best management practices (BMPs), including 4R nutrient stewardship, wetland conservation, and water retention. These measures were seen as cost-effective and consensus-driven, though one respondent admitted that adoption remains uneven and politically sensitive, especially among late adopters in the agricultural sector. Urban wastewater emerged as a recurring point of tension. Multiple interviewees cited Winnipeg’s North End facility as the "largest point source contributor" of phosphorus to Lake Winnipeg. While many viewed this as a priority target for regulation, one provincial official cautioned that this framing risks oversimplifying the issue by ignoring distributed responsibilities and the high economic costs of infrastructure upgrades. A Canada Water Agency scientist further emphasized the challenge of international nutrient flows from the United States and highlighted natural sources such as riparian vegetation and atmospheric deposition. “We don’t have a good handle on where all the phosphorus is coming from, especially in spring runoff and from across the border,” they noted. These divergent views highlight how solution pathways

are shaped by institutional roles, epistemic commitments, and resource constraints. They show that eutrophication governance in Manitoba is not driven by consensus, but by contested understandings of what is practical, fair, and effective.

The controversies surrounding nutrient sources and solutions in Manitoba are not merely scientific disagreements—they are disputes over what kind of knowledge counts, who has the authority to govern, and what values should guide environmental policy. The co-production of these controversies occurs through interviews, policy documents, scientific studies, and media representations, all of which frame the problem in different, sometimes incompatible, ways.

Rather than seeking a singular solution, this chapter argues for a pluralist and reflexive approach to eutrophication governance—one that acknowledges complexity, values diverse knowledges, and creates space for negotiation, accountability, and adaptive learning. Only then can we move from fragmented problem definitions to more integrated and just solutions.

2.5 Conclusion and Recommendations

2.5.1 Recommendations

The author proffers the following recommendations: The controversies surrounding eutrophication governance in Manitoba are not merely technical debates but manifestations of deeper political, social, and epistemic tensions. This analysis highlights that nutrient management is characterized by fragmented responsibilities, contested regulatory approaches, scientific uncertainties, economic trade-offs, and jurisdictional complexities. Each of these controversies underscores the reality that eutrophication cannot be addressed effectively through isolated or oversimplified solutions. Instead, a nuanced and inclusive approach is necessary, one that acknowledges and engages with these contentious dynamics as opportunities for dialogue, learning, and adaptive governance.

To effectively navigate these controversies, multi-actor forums should be established, fostering inclusive dialogue that clarifies roles and responsibilities among agriculture, municipalities, Indigenous communities, and various governmental actors. This balanced approach can mitigate blame-driven politics and facilitate shared understanding and collective action. Additionally, regulatory frameworks need to complement voluntary stewardship efforts, integrating incentives with phased and sensitive enforcement measures, especially targeting critical sources such as urban wastewater and agricultural runoff. Given the persistent scientific uncertainties, particularly around natural nutrient contributions, climate variability, and transboundary nutrient flows, an adaptive management approach is vital. This approach should integrate continuous scientific research and collaboration between Manitoba, Indigenous knowledge holders, environmental NGOs, and transboundary partners. Economic pragmatism should also be prioritized through incremental infrastructure upgrades and strategic investments, leveraging cost-sharing mechanisms to balance economic feasibility with long-term environmental goals. Addressing jurisdictional gaps and scalar mismatches demands robust coordination mechanisms across municipal, provincial, federal, Indigenous, and international boundaries. Strengthening watershed district capacities through legislative reform and dedicated funding can enhance their capability to address basin-wide nutrient management challenges effectively. Integrating Indigenous perspectives and traditional ecological knowledge through formal partnerships and co-management frameworks is essential, recognizing Indigenous authority and contributions to sustainable water governance.

Furthermore, enhancing public understanding via strategic communication led by environmental NGOs and scientific institutions is crucial. Media engagement should amplify scientifically-informed messages to ensure public awareness of the complexities surrounding

nutrient pollution. Lastly, fostering governance structures capable of reflexivity is essential, encouraging regular, transparent reviews through independent bodies like the Clean Environment Commission. Such reflexive practices will promote accountability and adaptive responsiveness to the evolving controversies inherent in nutrient governance. In summary, embracing the complexities and controversies in eutrophication governance through inclusive, adaptive, and reflexive practices provides the most robust pathway toward sustainable, equitable, and scientifically informed nutrient management in Manitoba.

2.5.2 Limitations

This study, while exploring the governance controversies surrounding eutrophication in Manitoba, has limitations. First, the research primarily focused on qualitative interviews and document analysis, which might not fully capture all actor perspectives or the quantitative nuances of nutrient loading. For future research, it is recommended to incorporate broader quantitative analyses and spatial modeling to provide a more detailed understanding of nutrient contributions and flows. Expanding the scope of actor engagement to include more diverse voices, particularly from underrepresented groups, can offer deeper insights into governance dynamics. Further investigation into the effectiveness and acceptability of specific policy interventions through longitudinal studies and comparative analyses with other jurisdictions could also enhance understanding and inform better governance practices. Ultimately, addressing these limitations through targeted research will enrich the understanding of eutrophication governance and contribute to more effective, equitable, and adaptive management strategies.

2.5.3 Conclusion

This paper delves into the intricate dynamics of eutrophication governance in Canada, shedding light on the complexities inherent in managing nutrient pollution in water bodies. Manitoba's

regulatory framework emerges as a notable case study, characterized by its dual approach to regulating both phosphorus and nitrogen. This emphasis underscores Manitoba's commitment to nutrient management, acknowledging the interconnected nature of nutrient dynamics in aquatic ecosystems. However, amid ongoing debates surrounding nutrient reduction strategies, it becomes imperative to subject these policies to rigorous scientific scrutiny. Effectively addressing emerging challenges requires a robust assessment of scientific evidence to inform decision-making and ensure the efficacy and sustainability of management practices. In this context, aligning regulatory policies with scientific insights assumes paramount importance. By integrating the latest scientific findings into policy development and implementation, provinces like Manitoba can enhance their capacity to tackle eutrophication and safeguard water quality effectively. Furthermore, fostering multilevel governance arrangements, involving collaboration between government agencies, scientific institutions, industry actors, and local communities, can amplify the impact of regulatory measures. Such collaborative approaches facilitate knowledge sharing, resource pooling, and coordinated action, thereby maximizing the effectiveness of eutrophication strategies.

Looking ahead, sustained collaboration among diverse actors, coupled with informed decision-making processes, will be pivotal for achieving holistic and sustainable water management outcomes across Canada. Adopting adaptive management strategies that allow for iterative adjustments based on monitoring data and evolving scientific understanding will further enhance the resilience of water nutrient governance frameworks. By embracing evidence-based, collaborative, and adaptive approaches, provinces can navigate the complexities of nutrient management and pave the way for a healthier and more sustainable water future for all Canadians.

2.6 Linking Chapter II to the Thesis

The analysis in Chapter II contributes to the overall project by showing how nutrient regulation in Manitoba is not only a technical or scientific matter but also a site of contested knowledge and co-production. By examining the debates around phosphorus and nitrogen management, this chapter demonstrates how epistemic controversies shape policy outcomes and reveal the tensions between expert authority, agricultural interests, and environmental advocates. These findings highlight the importance of understanding governance as a socially and politically embedded process, setting the stage for Chapter III's exploration of how these dynamics play out in watershed-level governance practices.

Chapter III Evolving Watershed Governance: Exploring Hybrid Approaches to Water and Nutrient Governance in Manitoba

Target Journal: Journal of Environmental Management

Abstract

Freshwater ecosystems worldwide face ongoing eutrophication threats, exemplified by Manitoba's Seine-Rat-Roseau Watershed District (SRRWD), where intensive agriculture and climate change intensify nutrient loading into Lake Winnipeg. Analyzing policy documents, stakeholder perspectives, and literature, this study identifies critical governance gaps despite Manitoba's hybrid approach—combining voluntary programs (e.g., GROW initiative) and regulations (e.g., Nutrient Management Regulation). Findings highlight persistent phosphorus pollution, tensions within neoliberal governance frameworks, and structural inequities affecting small-scale and Indigenous farmers. While market-based incentives promote innovation among early adopters, they fail to engage resistant producers effectively. Regulatory approaches, despite providing necessary baselines, encounter resistance related to agricultural autonomy. Additionally, inadequate integrated monitoring hinders clear assessment of governance effectiveness. To enhance adaptive and equitable nutrient governance, the study recommends: (1) equity-centered incentive structures, (2) flexible, outcome-based regulations, and (3) participatory monitoring approaches. Centering adaptability and justice, these insights provide a pathway toward watershed resilience applicable to Manitoba and similar agricultural regions.

Key words: Eutrophication, Neoliberalism, Watershed governance, water governance

3.1 Introduction

The health of freshwater ecosystems worldwide is persistently threatened by eutrophication, with agricultural runoff representing one of the most significant and persistent

sources of phosphorus and nitrogen loading (Foulon et al., 2019; Kakade et al., 2021; Munawar & Fitzpatrick, 2018). Eutrophication - the process by which water bodies become overly enriched with nutrients - has emerged as one of the most pressing global water quality challenges, affecting an estimated 40% of lakes and reservoirs worldwide (UNEP, 2017). This ecological imbalance triggers excessive algal growth that depletes oxygen levels, creates toxic algal blooms, and degrades aquatic habitats, with estimated annual damages exceeding $2 billion in the United States alone (Dodds et al., 2009). The problem has become particularly acute in agricultural regions where intensive fertilizer use and livestock production have dramatically altered natural nutrient cycles (Belinskij et al., 2019; Munawar & Fitzpatrick, 2018). International studies demonstrate that despite decades of policy interventions, many watersheds continue to experience worsening eutrophication, suggesting existing governance approaches may be insufficient to address this complex environmental challenge (Foulon et al., 2019; Watts, 2015; Wiering et al., 2020). The persistence of nutrient pollution across diverse political and ecological contexts highlights the need for more sophisticated governance frameworks that can effectively balance agricultural productivity with ecosystem protection. Nowhere is this challenge more apparent than in the Lake Winnipeg Basin, where decades of intensive agricultural production have contributed to recurring algal blooms that threaten biodiversity, drinking water supplies, and economic livelihoods (Environment and Climate Change, 2020). At the heart of this crisis lies a fundamental governance dilemma: how can watershed governance effectively reduce nutrient pollution while remaining socially equitable, economically viable, and adaptable to climate change?

This research examines this critical question through a case study of the Seine Rat Roseau Watershed District (SRRWD) in southern Manitoba, a region that encapsulates both the urgent need for action and the complex trade-offs inherent in environmental governance. The Seine-Rat-

Roseau Watershed District (SRRWD) forms part of the larger Red River Basin, a transboundary watershed that spans portions of North Dakota, Minnesota, and Manitoba before draining into Lake Winnipeg (International Joint Commission, 2020). While the entire Red River system contributes approximately 70% of the phosphorus entering Lake Winnipeg (Manitoba Environment, Climate and Parks, 2022), the SRRWD represents a critical management area where intensive agricultural practices - including high livestock densities and extensive row-crop production on drained landscapes - intersect with ongoing water quality challenges (IISD, 2022). The Lake Winnipeg Foundation's hotspot monitoring has identified several SRRWD tributaries as persistent sources of phosphorus loading, with concentrations frequently exceeding 0.3 mg/L during critical runoff periods (Lake Winnipeg Foundation, 2022). This combination of landscape characteristics and documented water quality impacts makes the SRRWD a revealing case for examining the tensions between agricultural land use and aquatic ecosystem protection in prairie watersheds.

Water governance in Manitoba, in the SRRWD exemplifies many of the challenges in agricultural systems. Manitoba has implemented a coordinated framework that includes: (1) regulatory baselines like the *Nutrient Management Regulation* (MR 62/2008) setting mandatory application limits and buffer zones, and (2) voluntary programs such as *Growing Outcomes in Watersheds (GROW)* that provide financial incentives for conservation practices (Manitoba Agriculture, 2022). This dual approach faces mounting pressure as Lake Winnipeg's ecological crisis persists despite decades of intervention, with recent research confirming the lake's phosphorus levels remain 2.5 times higher than pre-1990 concentrations (Manitoba Agriculture and Resource Development, 2020).

The SRRWD serves as a revealing case study of both the potential and limitations of hybrid governance models for nutrient management. While the district has implemented various conservation measures combining regulatory and voluntary approaches, monitoring data reveals persistent challenges - phosphorus hotspots continue to affect 35% of monitored tributaries(Lake Winnipeg Foundation, 2022). This paradox raises critical questions: Can voluntary measures like GROW – be sufficient to meet ecosystem-scale targets? And how effectively do regulatory "floors" address systemic drivers like legacy nutrients and climate-intensified runoff? Overall, this research contributes to this debate by systematically comparing voluntary and regulatory approaches in the SRRWD, assessing their respective efficacy, equity implications, and actor acceptability. Before turning to my case study, I draw on insights from water governance, behavioral economics, and environmental justice scholarship to develop a theoretical framework for evaluating the strengths and limitations of existing approaches in the SRRWD.

3.2 Literature Review

3.2.1 **Theoretical framework**

Neoliberalism has become a defining force in the transformation of water governance worldwide, reshaping how water resources are conceptualized, managed, and contested. At its core, neoliberal governance promotes the substitution of regulatory authority with market-based mechanisms, privatization, cost-efficiency, and a re-scaling of responsibilities from centralized governments to local actors and private entities (Castree, 2008). This ideological shift is not merely administrative—it represents a fundamental reorganization of environmental governance rooted in capitalist rationality and technocratic control.

Peck and Tickell (2017) distinguish between two temporal waves of neoliberalization: *roll-back neoliberalism*, which involves dismantling public regulatory frameworks, and *roll-out*

neoliberalism, which constructs new institutions and instruments aligned with market ideologies. In water governance, this has led to the widespread deployment of payment for ecosystem services (PES), water markets, voluntary stewardship programs, and public-private partnerships. States increasingly act as market enablers, designing conditions for "self-regulation" rather than imposing direct environmental controls (Bakker, 2005; Cohen & Bakker, 2015).

This market-centric model is often paired with rhetoric around participation, decentralization, and adaptive management. However, as political ecologists have shown, these narratives frequently obscure the reproduction of existing power structures. Governance reforms presented as democratic or inclusive often result in the superficial inclusion of non-state actors—such as Indigenous peoples, women, and civil society groups—without shifting authority or redistributing decision-making power (Brisbois & de Loë, 2016; Harris, 2009). Rather than empowering communities, these reforms often responsibilize them, transferring the burden of environmental protection without offering adequate resources or autonomy. Neoliberal water governance also entails the commodification and financialization of water itself. Under this logic, water is treated not as a commons or a right but as an economic good to be bought, sold, or traded. Tools such as water quality trading schemes or ecosystem service valuation attempt to assign monetary value to pollution reduction or conservation outcomes (Sullivan, 2017). However, as Kolinjivadi et al. (2019) argue, these approaches reduce complex hydrosocial relationships to quantifiable metrics, erasing cultural, relational, and ecological meanings of water. Moreover, they privilege technocratic forms of knowledge, sidelining local, experiential, and Indigenous ways of knowing (Patel et al., 2020).

Another central critique concerns the spatial and temporal mismatches produced by neoliberal governance. Devolution policies place accountability for water quality on local or

regional entities (e.g., watershed councils), while decision-making power and funding mechanisms often remain centralized. This creates what term Eker & Loftus (2013)"fractured governance", a fragmentation that impairs coherent, long-term water management. Short funding cycles, performance-based metrics, and the pressure to demonstrate quick returns further reinforce short-termism, undermining investments in systemic change or ecological resilience. Additionally, the performative nature of neoliberal environmental governance is increasingly scrutinized. It constructs the illusion of action and progress—through indicators, benchmarks, and market performance—while frequently failing to deliver substantive ecological improvements (Fletcher et al., 2019). As Moore (2015) argues, this dynamic reflects a broader "socio-ecological fix," whereby environmental crises are managed in ways that temporarily stabilize capitalist accumulation, even as they generate new contradictions. Resistance to neoliberal water governance has emerged from diverse social movements and epistemic communities. From anti-privatization uprisings in Latin America (Perreault, 2014) to the global water justice movement, these actors challenge the reduction of water to a commodity and demand recognition of water as a right, a sacred entity, or a commons (Yates, 2017; Harris, 2017). These counter-movements illuminate alternative governance logics rooted in relational accountability, community sovereignty, and ecological integrity. In response to the growing recognition of neoliberalism's limitations, contemporary scholarship increasingly calls for *post-neoliberal* water governance (Benson et al., 2020; Pahl-Wostl, 2019). These frameworks reject the primacy of market logic and instead emphasize justice, plurality, and co-governance. They advocate for the reinvigoration of public institutions, the formal integration of Indigenous and local knowledge systems, and the recognition of water as more than an economic resource—as a living being, a legal person, or a site of reciprocal obligations.

In sum, neoliberalism has profoundly reshaped water governance through the institutionalization of market-oriented principles and the marginalization of regulatory, rights-based, and relational frameworks. A critical theoretical lens reveals not only the mechanisms of this transformation but also the contradictions, exclusions, and resistances it engenders. Addressing these dynamics is essential for building more inclusive, adaptive, and just water governance systems that move beyond the constraints of neoliberal environmentalism.

3.2.2 Water governance in Manitoba

The tensions between decentralization, neoliberal governance, and Indigenous sovereignty present important questions for examining water governance in Manitoba. The provincial government's role in this system requires scrutiny - does it function as a facilitator of local governance or as a centralized authority maintaining ultimate control through frameworks that appear devolved? The establishment of watershed districts as a form of devolved governance raises critical questions about whether these structures represent meaningful delegation of authority or simply administrative deconcentration - a distinction that requires careful empirical investigation (Brisbois & de Loë 2016). This tension between formal decentralization and actual state control speaks to broader questions about how governments navigate the neoliberal shift from regulator to facilitator while often retaining key powers.

Manitoba's Growing Outcomes in Watersheds (GROW) program, which provides financial incentives for conservation practices rather than regulatory requirements, exemplifies the state's potentially contradictory role in simultaneously promoting market-based approaches while maintaining oversight capacity. This invites analysis through the lens of payment for ecosystem services (PES) models and their potential neoliberal implications (Fletcher & Büscher 2020). The

state's positioning in this arrangement - as both architect of incentive systems and ultimate authority - warrants critical examination.

The watershed governance approach in Manitoba may be productively examined through the concept of "eco-scalar fix" (Cohen & Bakker 2014), which prompts questions about whether rescaling management to watershed levels represents a genuine redistribution of governance authority or a strategic reconfiguration that maintains state control while appearing decentralized. A key area for investigation is how this governance structures engage with Indigenous governance systems, particularly in light of the state's historical and ongoing role in managing (and often limiting) Indigenous jurisdiction over water resources (McGregor et al. 2023). These questions about the state's role become particularly salient when considering potential governance reforms. Transformative approaches to water governance in Manitoba would need to seriously engage with Indigenous-led governance models (Wilson 2020; Craft 2018) while fundamentally renegotiating the state's relationship to water management authority. This would require not just recognizing Indigenous law and knowledge systems (Simpson 2017) but also confronting how state structures and legal frameworks have historically prevented their full expression in water governance. The extent to which current governance structures and state actors can support this transformation remains an open question that this research seeks to address.

3.2.3 Voluntary and Market-Based Approaches in water governance

The literature on voluntary and market-based approaches to nutrient governance emphasizes their potential to address environmental challenges while maintaining economic productivity. Market-based instruments (MBIs), including water quality trading systems, pollution taxes, and cap-and-trade programs, operate on the principle of creating economic incentives for pollution reduction (Shortle et al., 2020). Voluntary programs, such as environmental certification schemes and

Payments for Ecosystem Services (PES), rely more on moral suasion and social norms to encourage adoption of best management practices (Engel et al., 2008). Critical scholarship has identified several limitations of these approaches. Lemos and Agrawal (2006) argue that voluntary mechanisms often suffer from participation bias, where only those already predisposed to environmental stewardship engage, while major polluters may opt out. Market-based approaches face challenges in accurately pricing environmental goods and accounting for non-point source pollution (Grafton et al., 2018). Furthermore, both approaches tend to favor larger, wealthier operations that can afford to participate, potentially exacerbating inequities in society (Bakker, 2010). Behavioral economics research suggests these limitations stem from cognitive biases where farmers discount future environmental benefits against immediate economic costs (Thaler & Sunstein, 2008).

3.2.5 Regulatory Approaches to Water Governance

Command-and-control regulatory approaches represent the traditional framework for addressing water quality issues. These measures typically involve legally enforceable standards for nutrient application, mandatory buffer zones, and technology requirements for wastewater treatment (Dietz et al., 2003). Regulatory approaches are particularly effective at setting minimum environmental standards and preventing the "tragedy of the commons" in shared water resources (Hardin, 1968).

However, critics highlight several shortcomings of purely regulatory systems. Sterner et al. (2019) note that uniform standards often fail to account for spatial and temporal variability in hydrological systems, leading to either over- or under-regulation in different contexts. Implementation costs can be high, particularly for monitoring and enforcement of non-point source pollution (Lubell et al., 2023). From an environmental justice perspective, Pellow (2016) argues

that regulatory systems often reflect the interests of powerful actors, potentially marginalizing small-scale farmers and Indigenous communities in policy formulation.

3.2.6 Hybrid Governance

The limitations of both voluntary and regulatory approaches have led to increasing scholarly interest in hybrid governance models. Polycentric governance theory (Ostrom, 2010) provides a framework for understanding how multiple, overlapping decision-making centers can address complex environmental challenges. Hybrid systems combine the certainty of regulatory baselines with the flexibility of voluntary measures, creating what Benson et al. (2021) term "adaptive governance" - systems capable of responding to ecological and social feedback. Behavioral economics contributes important insights to this framework, suggesting that "nudge" strategies can complement regulations by aligning individual incentives with collective goals (Thaler & Sunstein, 2008). For instance, default options in conservation programs or social norm messaging can significantly increase participation rates. Environmental justice scholarship emphasizes the need for procedural equity in hybrid systems, ensuring that marginalized groups have meaningful participation in governance design and implementation (Schlosberg, 2013). This is particularly important in nutrient governance, where historical patterns of land use and water access often reflect broader social inequalities.

3.3 Materials and Methods

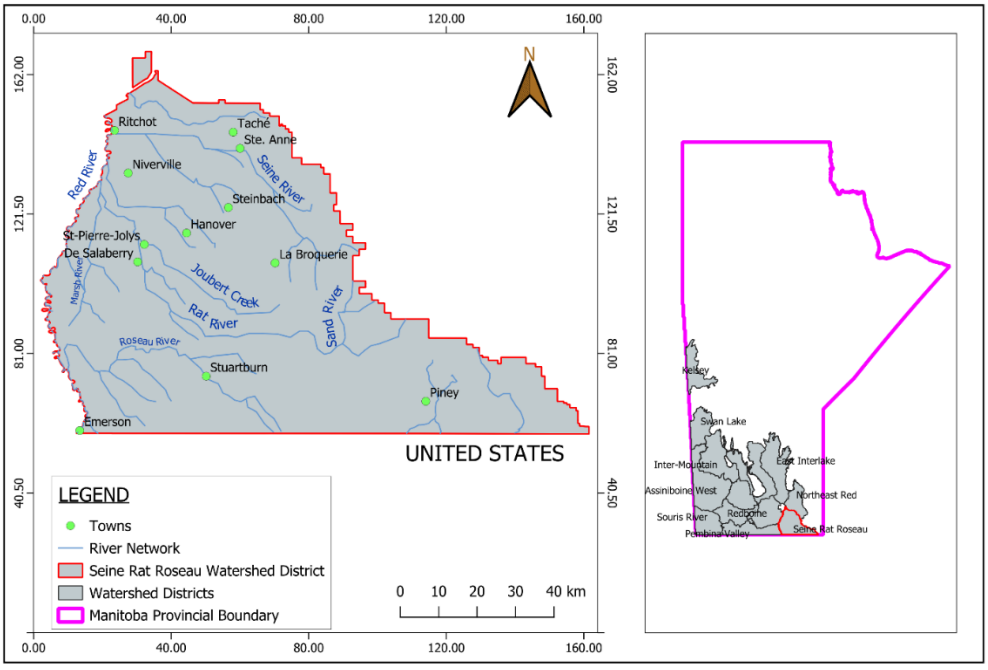
3.3.1 Research Setting

The Seine Rat Roseau Watershed District (SRRWD) is in Southern Manitoba within the Lake Winnipeg Basin (LWB), a transboundary watershed spanning four provinces (Manitoba, Saskatchewan, Ontario, and Alberta) and four U.S. states (North Dakota, Minnesota, South

Dakota, and Montana) before draining into Lake Winnipeg (Lake Winnipeg Basin Program, 2023). The size and jurisdictional complexity of the LWB present significant governance challenges, with nutrient inputs—particularly phosphorus—originating from diverse sources beyond the scope of this study. The SRRWD lies within the Red River Basin, which contributes 70% of the total phosphorus load to Lake Winnipeg despite only accounting for about 15% of the total inflow to the lake (Manitoba Environment, Climate and Parks, 2022).

The SRRWD's diverse landscape supports a predominantly rural population, with agriculture as the primary land use (Seine River Integrated Watershed Management Plan, 2010) (See Figure 4 below). The SRRWD is located on Treaty 1 and on the original lands of the Anishinaabeg, Ininiwak, Anisininewuk, and Dakota Oyate and on the National Homeland of the Red River Métis. We acknowledge and respect the water rights, relationships and authorities held by these nations.

Figure 3:Map of the Seine Rat Roseau Watershed District

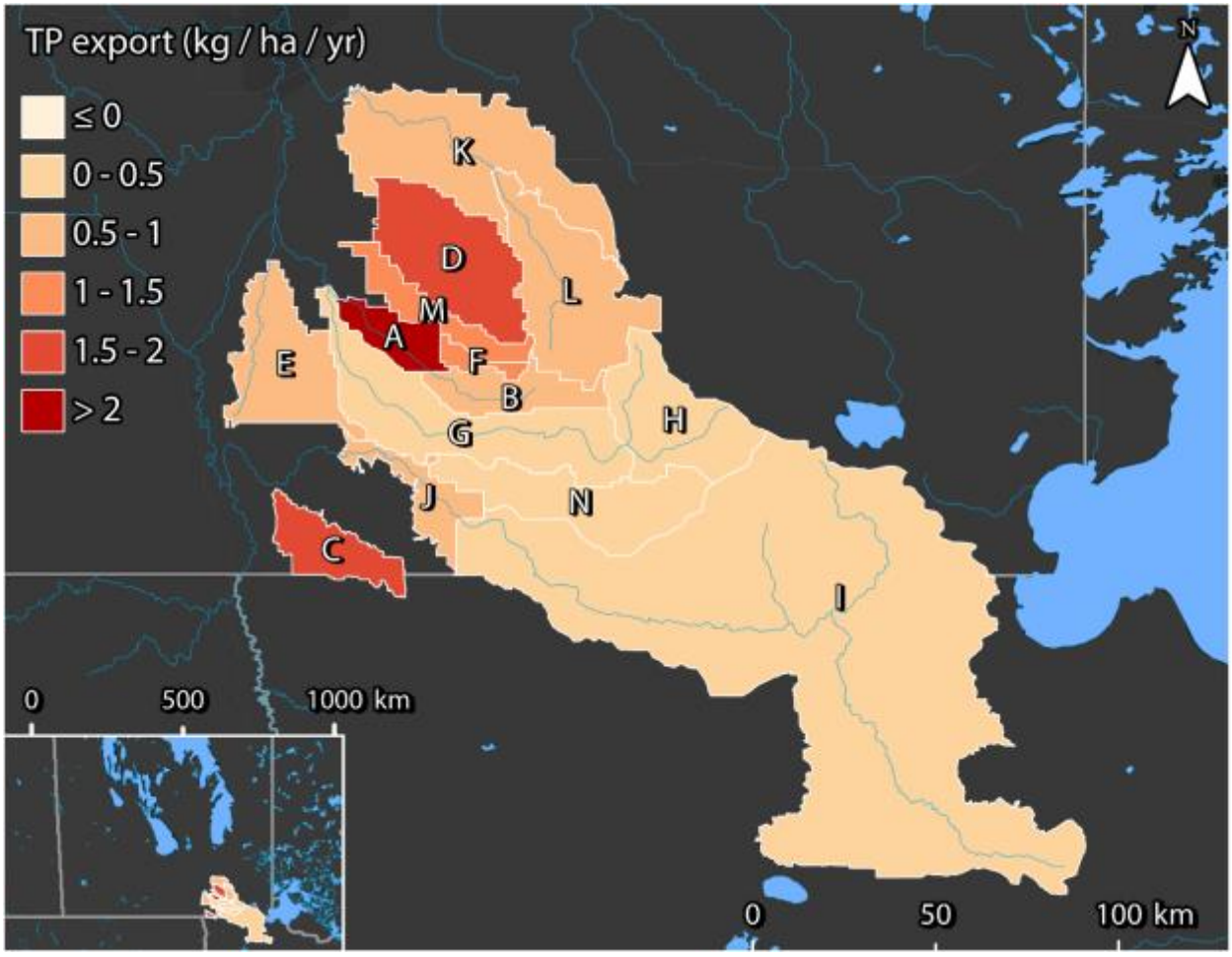


Source**:** Author's source. Data from Manitoba LMMMR Watershed Information Map (https://www.arcgis.com/home/item.html?id=353ae7f5b73f49c5b3b5b89a44313b98)

The SRRWD reflects many of the challenges within the broader LWB and other watersheds on the Canadian Prairies. The SRRWD is situated within Red River catchment, which is the source of 70% of the phosphorus that enters Lake Winnipeg (Manitoba Environment, Climate and Parks, 2022b). The Lake Winnipeg Community-Based Monitoring Network (LWCBMN) has identified significant phosphorus hotspots in the SRRWD including Joubert Creek near St-Pierre-Jolys, Main Drain near Dominion City, and Manning Canal near Île-des-Chênes (See figure 4elow) (LWF, 2022). High livestock densities and intensive crop production in these areas contribute significantly to phosphorus loading, impacting downstream ecosystems like Lake Winnipeg. Persistent nutrient pollution, despite ongoing mitigation efforts (Painter et al., 2021), and increasing climate variability underscore the urgency of integrated and adaptive governance approaches.

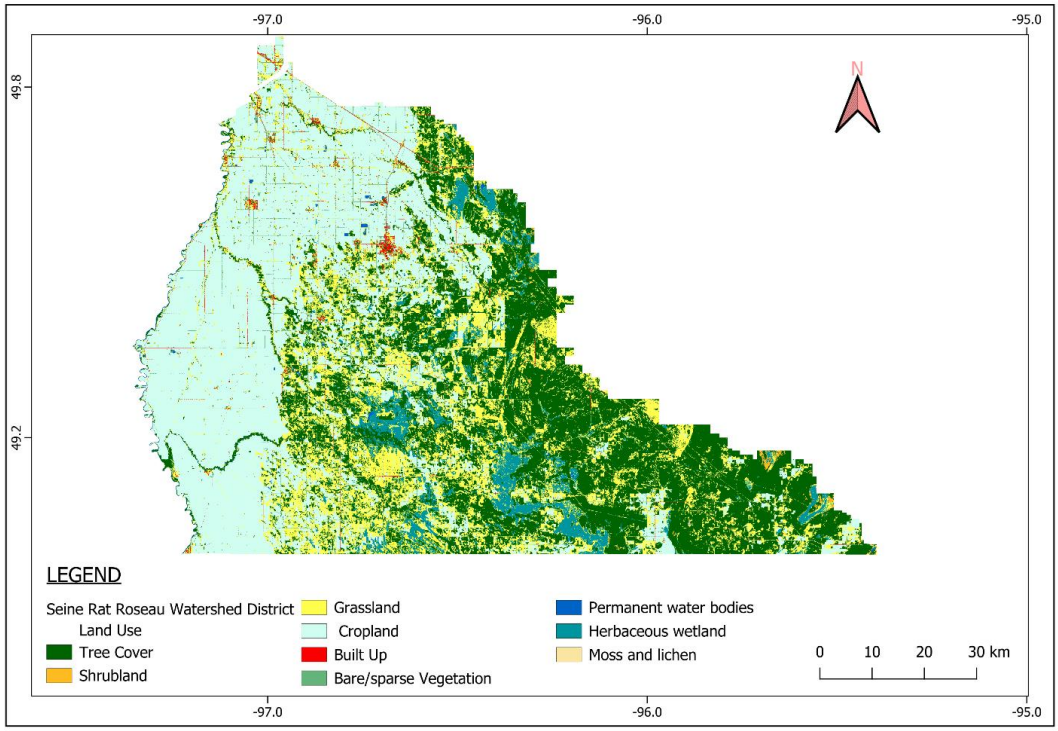
The primary legislative instrument for the creation of the SRRWD is the Manitoba Watershed Districts Act, which was enacted to promote integrated watershed management across the province. This Act replaced the former Conservation Districts Act, reflecting a shift towards a more holistic and collaborative approach to water management (*The Water Protection Act*, 2020). The Act emphasizes the integration of water management with land use planning, recognizing the interconnectedness of water resources, agriculture, and ecosystems. It mandates the involvement of local actors and rightsholders, including municipalities, farmers, landowners, and Indigenous communities, in decision-making processes. The Act provides a framework for financial support and technical assistance to watershed districts, facilitating the implementation of conservation projects and practices.

Figure 4: A map showing the Phosphorous exports (kg/ha/yr) in the Seine Rat Roseau Watershed District



Source: LWCBMN 2022 Regional Report

Figure 5: Land Use Map of the SRRWD



Source: Image Created by Author. Data from ESA World Cover 2021 (https://esa-worldcover.org)

3.3.2 Methodology

This study employs a qualitative research design to explore and assess water quality governance in the SRRWD, with a specific focus on nutrient (phosphorus) management. The qualitative approach allows for an in-depth understanding of the perceptions, experiences, and interactions among diverse actors involved in water governance (Daoud et al., 2022; Raja Ariffin et al., 2023). The study aims to provide insights into the effectiveness of current policies and practices, the challenges faced, and potential areas for improvement.

As the primary researcher for this study, I bring a background in environmental science and policy, with a specific focus on water governance and sustainability. My academic and professional experiences have shaped my commitment to addressing environmental challenges

through equitable and inclusive resource management. I identify as an academic with a strong advocacy stance for environmental sustainability, grounded in scientific inquiry and a desire to develop practical solutions to pressing environmental issues. My work has involved collaboration with diverse communities and actors, which has instilled in me a deep respect for multiple perspectives, particularly those of Indigenous communities, who have historically been marginalized in water governance discussions. While I am not Indigenous, I am committed to integrating Indigenous knowledge and perspectives into my research in a manner that is respectful and inclusive.

Reflecting on my positionality, I remain acutely aware of my biases and strive to approach this research with openness and humility. My goal is to engage with participants in a way that fosters authentic dialogue and mutual understanding. This reflexive approach ensures that the research process is inclusive, respectful, and collaborative, allowing for a more nuanced exploration of the challenges and opportunities in water governance and nutrient management. My perspective is further informed by my identity as an immigrant and international student, having not grown up in Manitoba or Canada. This position offers both distance and curiosity—allowing me to critically examine local dynamics while acknowledging gaps in my lived experience of Canadian environmental and cultural histories. I approach this research with humility, striving to listen deeply and engage collaboratively with participants, ensuring that the process respects diverse knowledge and fosters meaningful dialogue. Reflexivity remains central to my work, helping me navigate biases and power imbalances while pursuing inclusive, solutions-oriented research.

To gather in-depth insights into the experiences, perceptions, and challenges related to water governance and nutrient management, I conducted semi-structured interviews with 15 key

actors (Table 5). These participants included policymakers, local government officials, livestock producers, landowners, Indigenous rightsholders, environmental NGOs, and water management professionals. The semi-structured format allowed flexibility, enabling participants to discuss issues they deemed significant while ensuring that key topics were covered. All interviews were recorded with the participants' consent and later transcribed for analysis. During the informed consent process, participants were given the option to remain anonymous or have their names associated with their responses, ensuring ethical research conduct and fostering candid discussions.

Table 5: Participant Categories and Gender Distribution

Participant Type	Male	Female	Non-binary/ Do not identify	Did not say	Total
University Researchers	2	2	0	0	4
Government Staff/ Researchers	0	2	0	0	2
Watershed District Staff	3	0	0	0	3
Producers/Producer Groups	1	0	0	0	1
Not-for Profit Organizations	1	2	0	0	3
Indigenous peoples/ Government	1	1	0	0	2
Total	8	7	0	0	15

To ensure the accuracy and ethical integrity of the interview data, I employed a member-checking process (Birt et al., 2016). Transcripts were sent back to interviewees for verification, allowing them to confirm the accuracy of their statements, correct any errors, and provide additional clarifications. This process not only preserved research ethics but also empowered participants by giving them control over how their contributions were represented. Member checking reinforced the authenticity of the data and strengthened the credibility of the findings. This research incorporated secondary data sources, such as transcripts from the Manitoba Clean Environment Commission (CEC) Hearings on Hog Production Industry Review Hearings (Manitoba Clean Environment Commission, 2007). These transcripts provided valuable insights into the environmental, social, and economic dimensions of intensive hog farming practices in Manitoba. They captured diverse perspectives on issues such as nutrient runoff, water contamination, land use conflicts, and community health implications, enriching the study's understanding of the complex dynamics shaping water governance and nutrient management.

Policy analysis played a central role in this study, providing a framework for understanding the formulation, implementation, and impacts of water governance policies in Manitoba. I conducted a thorough review of relevant policy documents, legislative frameworks, governmental reports related to water governance, including the Integrated Watershed Management Plans (IWMPs), the Manitoba Water Strategy, and key legislation such as the Watershed Districts Act and the Sustainable Watersheds Act. This analysis traced the evolution of water governance policies, evaluated their implementation, and assessed their impact on nutrient management and water quality. Insights from the policy analysis were triangulated with interview data to ensure accurate findings. This approach allowed me to capture the nuanced shifts in policies, actor dynamics, and contextual influences that shape policy outcomes. By integrating these insights, the

study aims to provide a robust understanding of the policy landscape and offers evidence-based recommendations for improving water governance practices in Manitoba.

The qualitative data collected for this study, comprising policy documents, Key informant interviews, and secondary documents, were analyzed using NVivo, a robust qualitative data analysis software. NVivo was instrumental in systematically coding and categorizing the data, identifying key themes, and exploring the relationships between governance frameworks and nutrient management outcomes in the SRRWD. The coding process adopted both inductive and deductive approaches, allowing themes to emerge organically from the data while also aligning with pre-existing theoretical frameworks on voluntary and regulatory governance (Bingham, 2023). This dual approach ensured an analysis that was both grounded in the empirical data and informed by established academic perspectives.

3.4 Results

The analysis of current water and nutrient governance in the SRRWD critical insights into the strengths, limitations, and contextual dynamics shaping the effectiveness of existing strategies. Rather than being defined solely by the dichotomy between regulatory and incentive-based approaches, the governance landscape in the SRRWD reflects a complex interplay of institutional frameworks, actor relationships, historical land-use practices, and socio-political factors. Drawing from key informant interviews and document analysis, this section presents key findings and explores their implications for water governance.

3.4.1 Voluntary Approach: Balancing Flexibility and Reach

The voluntary approach to water and nutrient governance, including initiatives like Manitoba's Growing Outcomes in Watersheds (GROW) program, Alternative Land Use Services (ALUS), Lake Winnipeg Water Stewardship Project, and Prairie Watersheds Climate Program (PWCP)

highlights the delicate balance between encouraging participation and ensuring meaningful environmental outcomes. Integrated Water Management (IWM) plans often serve as foundational frameworks for these efforts, outlining strategies for sustainable water use and nutrient management. However, their voluntary nature means that while they provide guidance and are also created through a collaborative process, they lack binding enforcement mechanisms. These plans frequently address nutrient pollution by recommending best practices, such as reducing fertilizer runoff or protecting riparian areas, but their effectiveness hinges on actor buy-in. Programs like GROW operationalize aspects of these plans by incentivizing farmers to adopt recommended practices, such as riparian buffer zones and wetland restoration, through financial compensation. Watershed programs like Manitoba's GROW initiative have successfully engaged many agricultural producers by framing conservation practices as community-oriented agriculture, with one watershed district program manager explaining, "You're farming for the community good... We're paying you to do that." In other words, the Manitoba GROW program provides financial incentives to producers who adopt environmentally beneficial practices such as riparian buffer zones, wetland restoration, and improved nutrient management techniques. This approach has fostered meaningful participation among producers. The success of watershed programs like GROW lies in their ability to reframe conservation as a collective endeavor rather than an individual burden. By emphasizing "community-oriented agriculture," the initiative appeals to producers' sense of stewardship while offering tangible economic benefits. The statement, "You're farming for the community good... We're paying you to do that," encapsulates this dual appeal, combining moral persuasion with financial incentives to encourage practices like improved nutrient management and wetland restoration. This strategy has proven effective in engaging

farmers who might otherwise resist top-down regulations, demonstrating the potential of voluntary, market-based approaches to drive participation.

Beyond the numbers, the value of this program to producers is evidenced by producers actively recommending programs to colleagues after experiencing benefits firsthand, with one producer noting they frequently share successful programs with fellow farmers. Indeed, these voluntary programs facilitate valuable peer-to-peer learning through meetings that bring producers together with technical experts and other participants. A producer involved in these programs described how knowledge transfer occurs organically through social networks: "When we find some watershed programs work for us, we recommend them to fellow producers." This grassroots spread of information and practices has proven an effective engagement strategy within the agricultural community.

The research also revealed three significant challenges facing voluntary approaches. First, these programs struggle to reach resistant participants, as noted by a provincial agricultural extension specialist who observed, "Voluntary, incentivized programming attracts early adopters but does not address your issues with the laggards." Voluntary nature inherently limits participation to those already inclined toward conservation, leaving behind more resistant operators. These "laggards" producers who may be skeptical, risk-averse, or financially constrained—often remain unmoved by incentives alone, perceiving conservation practices as misaligned with their immediate economic interests. Without additional regulatory pressure or tailored engagement strategies, voluntary programs struggle to recruit these hesitant participants, ultimately constraining their broader impact.

Second, financial sustainability poses a major concern, with programs relying heavily on temporary government grants and provincial funding. A watershed staff member described the

constant challenge of unstable funding: "We're always scrambling when multi-year grants expire." Current incentive structures include direct payments such as $50 per acre for buffer establishment, cost-share arrangements covering 50-70% of infrastructure costs for projects like manure storage, and tax benefits for conservation easements. Funding comes primarily from provincial environmental funds (60%), federal agricultural programs (30%), and private foundations (10%), creating vulnerability to political shifts, as a government policy analyst noted: "Every change in administration brings new priorities." This funding volatility aligns with findings from (Claassen et al., 2018) on conservation programs, which show that inconsistent funding streams can disrupt long-term planning and implementation of watershed management initiatives. The challenge mirrors experiences in other agricultural regions where environmental programs struggle to maintain stable financing across political cycles (Mase et al., 2017) Such financial uncertainty complicates efforts to build lasting partnerships with producers and measure cumulative program impacts over time.

Third, measuring actual environmental outcomes remains challenging for voluntary programs. A natural scientist involved in monitoring the region acknowledged the difficulty in quantifying impacts, stating, "It's hard to figure out what those actions... are actually reducing. It's all quite theoretical." This measurement gap makes assessing program effectiveness significantly more difficult compared to regulatory approaches that have clearer compliance metrics and enforcement mechanisms. The combination of these challenges - limited reach, financial instability, and measurement difficulties - highlights critical areas where voluntary approaches may need to be supplemented with other governance strategies to achieve watershed management goals. A primary challenge is the lack of robust impact measurement, as voluntary programs often rely on estimated rather than observed outcomes. This contrasts with regulatory systems like the U.S.

Clean Water Act, where enforceable discharge permits provide quantifiable compliance metrics (Keiser & Shapiro, 2018). Participation bias further undermines voluntary initiatives, as they disproportionately attract "low-hanging fruit" participants while missing high-impact polluters, a pattern documented in agricultural conservation program (Baumgart-Getz et al., 2012). Financial instability compounds these issues; Wunder (2015)'s systematic review of Payments for Ecosystem Services (PES) found that short-term funding cycles frequently disrupt long-term ecological gains.

A notable perspective emerged from a representative from one local conservation NGO, who raised serious concerns about the monitoring challenges inherent to voluntary approaches. She argued, "voluntary approaches simply don't make monitoring realistic - it's extremely difficult to track real progress when participation and implementation are inconsistent and decentralized." This critique highlights a fundamental tension in market-based governance, where the flexibility that makes voluntary programs attractive to participants simultaneously creates obstacles for systematic evaluation. Without mandatory reporting requirements or standardized implementation - hallmarks of regulatory approaches (Schreefel et al., 2024) - assessing the actual environmental benefits of voluntary measures becomes an exercise in uncertainty. The NGO representative emphasized that this monitoring gap makes it nearly impossible to determine whether the substantial investments in voluntary programs are yielding commensurate ecological returns, particularly for complex issues like non-point source pollution where multiple variables affect outcomes. This perspective underscores a critical weakness in relying solely on voluntary mechanisms for environmental governance.

The effectiveness of voluntary approaches like Manitoba's GROW program ultimately hinges on two unresolved questions: First, how do we know these initiatives are improving water

quality? And second, who benefits—and who might be left behind—in this market-driven system? The fundamental uncertainty about measurable outcomes represents the Achilles' heel of market-based governance, but it is not the only weakness. Even if monitoring efforts could definitively prove that voluntary programs enhance water quality (e.g., through reduced nutrient runoff or restored wetlands), this narrow focus on environmental metrics risks obscuring deeper equity concerns. Market-based mechanisms often exacerbate inequalities by disproportionately rewarding larger, wealthier producers who can afford to adopt conservation practices quickly, while smaller or resource-limited farms struggle to meet eligibility requirements or absorb upfront costs (Piñeiro et al., 2020). For example, financial incentives like those in GROW may inadvertently favor agricultural operations with existing capital, land security, or access to technical expertise, leaving marginalized farmers, including Indigenous producers, young farmers, or those operating on marginal lands unable to participate.

This equity gap undermines both the legitimacy and long-term sustainability of voluntary approaches. If programs like GROW improve water governance for some while reinforcing systemic barriers for others, they risk perpetuating the very imbalances that collaborative environmental governance seeks to address. A truly effective assessment of voluntary initiatives must therefore grapple not only with *whether* they work ecologically, but also *for whom* they work—and who bears the hidden costs of their limitations. Without explicit attention to participation biases, data disparities (e.g., underreporting from excluded groups), and alternative models that address structural inequities, market-based solutions may achieve localized successes while failing to deliver just or scalable outcomes. While these programs successfully engage willing participants and foster community stewardship as evidenced by peer-to-peer adoption of

practices like buffer strips and wetland restoration, their environmental impact remains largely anecdotal rather than empirically verified.

3.4.3 Regulatory Approach

The regulatory approach has proven essential for ensuring broad compliance and addressing systemic environmental challenges, particularly for issues like nutrient pollution that require consistent, watershed-scale solutions. A prime example is Manitoba's Nutrient Management Regulation (MR 62/2008), which establishes clear rules for fertilizer and manure application, including restrictions on winter spreading and requirements for nutrient management plans. These regulations have reduced phosphorus loading, as one agricultural scientist noted: "If we didn't see that type of regulation, there'd be a lot more phosphorus." The regulation specifically prohibits manure application on snow-covered or frozen ground between November 10 and April 10, a measure directly targeting seasonal runoff risks. Other regulatory measures include Livestock Manure and Mortalities Management Regulation (MR 42/98), Nutrient Management Regulation (MR 62/2008) and Nutrient Targets Regulation.

The regulatory approach often generates resistance rooted in complex social and political dynamics. As one government employee cautioned: "The regulatory approach... is a little bit more adversarial, because there would be, presumably, consequences if you didn't adhere to the regulation." His perception stems from multiple factors including the historical culture of agricultural independence and economic pressures facing family farms. In areas where land ownership is predominantly private, farmers often perceive their land as an extension of their autonomy and livelihood. This perception fosters a strong sense of independence and skepticism towards external interventions. Regulatory measures are frequently viewed as threats to this autonomy, leading to resistance, as highlighted in the government staff member's observation.

Literature supports this sentiment, noting that private property regimes can limit collaborative efforts in environmental governance. For instance, the Yale Environment Review discusses how private property arrangements can hinder the coordination necessary for landscape-scale agroecological systems, emphasizing the need to reform these regimes to unlock transformative potential (Reynar, 2024). The inflexibility critique points to a fundamental challenge in regulatory design. As one government staff observed: "You'd want to make sure that whatever programs you were putting in place were actually going to have the benefit that you want them to have." This speaks to the difficulty of creating uniform rules that account for Manitoba's diverse landscapes - what works for clay soils in the Red River Valley may not suit sandy soils in the Interlake region. The "one-size-fits-all" nature of many regulations can lead to inefficient outcomes, where farmers must comply with rules that may not address the most pressing risks on their specific operations. A conservation specialist gave the example of buffer strip requirements: "A rigid 10-meter buffer might be overkill in some areas but completely inadequate in others with steeper slopes or more vulnerable soils." These findings reveal the paradox of regulatory approaches - while essential for establishing baselines and preventing worst-case scenarios, their top-down nature often creates implementation challenges that can undermine both effectiveness and actor buy-in. The case of Manitoba's nutrient regulations illustrates how even scientifically justified rules must navigate complex social, economic and geographic realities to achieve their intended environmental benefits.

3.4.5 Hybrid approach

The findings reveal that Manitoba's current water and nutrient governance system - which already combines voluntary and regulatory approaches – could achieve greater impact through more strategic integration of these mechanisms. While the province has an existing hybrid framework

through initiatives like GROW (voluntary) paired with the Nutrient Management Regulation (regulatory), key gaps remain in how these approaches reinforce each other. Several participants emphasized the need to move beyond viewing these as separate strategies, recognizing that the most effective solutions emerge when the innovation of voluntary programs is supported by the structure of regulations. This perspective reflects an understanding that regulations establish essential baselines while voluntary initiatives encourage progressive improvements beyond minimum requirements.

The present dearth of monitoring in the region, with the exception of LWF, leaves many questions about the effectiveness of the present governance arrangements at addressing the problem of eutrophication. Therefore, a notable gap in the current system relates to monitoring and evaluation capabilities. There appears to be limited capacity to directly connect program implementation with measurable water quality outcomes, creating challenges in assessing effectiveness and guiding improvements. Indeed, much of the present monitoring is conducted by non-governmental actors like the LWF (Lake Winnipeg Foundation, 2022). Hot spot mapping conducted by LWF with University of Winnipeg offers clear indication that phosphorus is an ongoing issue. Non-governmental actors often fulfill this role when they perceive the government to have insufficient monitoring and evaluation (Carlson & Cohen, 2018; Irwin, 1995). This disconnect between actions and results was identified as a critical area needing attention to strengthen approaches. The lack of robust outcome tracking makes it difficult to determine whether and which combinations of voluntary and regulatory measures work best in different contexts. The disconnect between policy interventions and measurable ecological improvements underscores the need for stronger outcome-based evaluation frameworks. As noted by Moyer *et al.* (2008), participatory monitoring such as community-based approaches in Manitoba's hog industry can

enhance transparency and bridge data gaps. However, without systematic tracking, governance systems struggle to determine which policy mixes (voluntary, regulatory, or hybrid) are most effective in specific contexts. This challenge mirrors findings from Kotamäki *et al.* (2024), who emphasize that fragmented monitoring often obscures causal links between management actions and ecological recovery in water systems. Similarly, Birgé *et al.* (2016) argue that adaptive management requires iterative feedback between monitoring data and policy adjustments, yet such loops are rare in practice due to resource constraints or institutional inertia. Closing these monitoring gaps is essential not only for accountability but also for ensuring that eutrophication strategies are grounded in evidence rather than assumptions.

Equity and accessibility are critical concerns within current environmental governance frameworks. Research indicates that existing systems often fail to accommodate diverse approaches to land and water management, particularly those practiced by Indigenous communities and small-scale producers (Jasanoff, 2004). Administrative requirements, such as complex application procedures or rigid eligibility criteria create disproportionate barriers for marginalized groups, limiting their meaningful participation in both voluntary and regulatory programs. As one federal participant explained, capacity constraints are particularly acute for Indigenous communities, which 'are dealing with so many other things… and just don't have the people and the resources' to fully engage in water governance (Interview, 2024). These challenges are compounded by structural exclusions, such as the Canada Water Act, which prevents Indigenous governments from entering into formal agreements on equal footing with provinces and territories. Even where funding is available, the reliance on 'application-based processes' and rigorous evaluations adds another layer of administrative burden (Interview, 2024). Collectively, these dynamics highlight how institutional design and bureaucratic procedures can unintentionally

reproduce inequities in access and participation." (Castleden et al., 2017; Mascarenhas, 2007). These structural inequities underscore the need for more inclusive governance models that recognize varied management philosophies and socio-ecological contexts. Co-governance approaches that integrate Indigenous knowledge systems have shown promise in addressing these limitations (Castleden et al., 2017; von der Porten et al., 2015). However, without deliberate efforts to reduce administrative burdens and enhance accessibility, governance systems risk reinforcing exclusion (Whyte, 2017).

A persistent issue undermining hybrid governance approaches is the instability of funding for voluntary conservation initiatives. Many such programs rely on short-term grants or politically contingent budgets, which create uncertainty and erode the long-term engagement necessary for effectiveness (Emerson & Nabatchi, 2015). This cyclical funding pattern is particularly detrimental to voluntary programs, which depend on consistency and trust-building to complement regulatory frameworks. Evidence from the U.S. Farm Bill's Conservation Title suggests that more stable financing mechanisms—such as endowments or legislated commitments—can enhance program continuity and impact (Claassen & Ribaudo, 2016). Without such financial stability, the potential of voluntary programs to contribute to nutrient reduction or broader watershed goals remains constrained.

Our research highlights significant resistance to regulatory approaches in agricultural communities, where personal autonomy and skepticism of government are deeply rooted. This observation contrasts Baldwin et al. (2013) argument that well-designed regulations those seen as fair, transparent, and inclusive can be broadly accepted. This divergence suggests that regulatory legitimacy is deeply context dependent. In areas where mistrust toward state-led regulation persists, trust-building strategies such as participatory rulemaking, transparent science

communication, and local demonstration projects may be required (Lubell, 2007). Responsive regulation frameworks—which combine enforcement with education, capacity-building, and actor engagement—offer a promising alternative (Gunningham & Grabosky, 2017).

Hybrid governance models do not automatically address systemic inequities; instead, justice must be an explicit, guiding principle. Scholars caution that technocratic or managerial approaches can inadvertently reproduce power imbalances by privileging dominant actors and marginalizing others (Sovacool et al., 2017). To counteract this, hybrid governance frameworks must integrate three dimensions of environmental justice: procedural equity (ensuring meaningful participation in governance processes), distributional equity (fair sharing of benefits and burdens), and recognitional justice (respecting and validating Indigenous knowledge systems and worldviews) (Schlosberg, 2013; Walker, 2012; Whyte, 2017). When these principles are neglected, hybrid systems risk exacerbating rather than mitigating inequality (Koontz & Thomas, 2006) (Koontz & Thomas, 2006). Conversely, initiatives that center justice—such as Canada's Indigenous Protected and Conserved Areas (IPCAs)—demonstrate that inclusive governance can support both ecological integrity and community well-being (Zurba et al., 2019).

Context specificity represents another area for improvement, as current regulatory approaches often apply uniform requirements across diverse landscapes. Participants noted that more adaptable frameworks could allow producers to meet environmental goals through different practices suited to their specific conditions while maintaining consistent water quality outcomes. This suggests potential value in exploring outcome-based regulatory approaches that provide flexibility in implementation methods. An outcome-based regulatory approach could address this by shifting the focus from standardized practices to measurable environmental results. For example, instead of mandating that all farmers adopt a 30-meter riparian buffer zone, a watershed

district might set a nutrient-loading target (e.g., ≤1 mg/L phosphorus in runoff) and allow producers to meet it through a range of approved methods. A dairy farm in a clay-rich area might achieve this by combining narrower buffers with precision manure injection, while a grain farmer on sandy soils might opt for wider buffers paired with cover cropping. This flexibility acknowledges ecological variability while maintaining accountability for water quality outcomes.

These insights point toward several concrete enhancements for Manitoba's water governance model. An integrated monitoring system connecting practices with water quality outcomes would provide valuable feedback for continuous improvement. More accessible program designs could broaden participation across diverse producer groups. Graduated response mechanisms could address marginal cases more effectively, while stable funding would support long-term voluntary initiatives. Incorporating greater spatial flexibility into regulatory frameworks could improve both effectiveness and acceptability. Together, these improvements could help create a more cohesive and responsive governance system that better addresses Manitoba's complex water management challenges. The key opportunity lies in better integrating existing components rather than developing entirely new approaches, focusing on how different elements can work together more effectively.

Education and community engagement play a crucial role in enhancing the effectiveness of both voluntary and regulatory approaches to water governance. Financial incentives alone often prove insufficient to drive meaningful change; actors need opportunities to learn from experts and each other to truly understand the importance of their actions. As one participant noted, “if people don't understand why they should care about an issue, they have no reason to act”. This highlights the critical need for targeted communication and capacity-building initiatives that foster intrinsic motivation for change. By creating spaces for dialogue and knowledge exchange, organizations

can cultivate a culture of collaboration and shared responsibility around water quality issues. Effective education strategies might include workshops demonstrating best practices, local success stories that make abstract concepts tangible, and youth programs that build environmental stewardship from an early age.

A recurring theme in the interviews is the importance of trust and open communication between governmental organizations and community members, particularly farmers. As one interviewee noted: "If you don't have trust and open communication, then people are going to be upset at anything you're asking them to do." This sentiment underscores the need for participatory approaches that prioritize dialogue and collaboration. In regions like the Seine Rat Roseau Watershed District, where population density is low and enforcement of regulations is challenging, trust becomes a precondition for success. Education plays a pivotal role in building this trust, as it helps actors understand the "why" behind environmental practices. For example, another participant emphasized: "If you educate people on why it's important to do something, they're more often than not willing to do it." This aligns with broader literature on environmental governance, which highlights the role of social learning and community engagement in fostering collective responsibility and long-term behavioral change. The imperative of trust-building in environmental governance takes on additional complexity when engaging systemically disadvantaged groups, including Indigenous communities, small-scale farmers, and economically marginalized residents. In the Seine-Rat-Roseau Watershed District (SRRWD), interviews revealed that standard outreach strategies often fail to reach these actors, despite their disproportionate vulnerability to both water quality degradation and policy impacts. This reflects a systemic communication gap where procedural requirements become box-ticking exercises rather than genuine dialogue.

3.4.6 Compliance

Regulatory approaches provide essential baseline protections by mandating compliance across all actors. Measures like Manitoba's ban on winter manure spreading or wastewater treatment standards create consistent expectations and consequences for inaction. These rules are particularly important for addressing the "laggards" - those who resist change without enforcement pressure. However, regulations can sometimes be perceived as punitive, leading to resistance or attempts to circumvent rules. They may also lack flexibility to account for local variations in geography, farming practices, or economic conditions. Without complementary education efforts, communities may comply with regulations grudgingly rather than embracing the underlying environmental values.

Voluntary and incentive-based programs, on the other hand, excel at engaging willing participants and fostering innovation. These approaches allow for tailored solutions that account for local contexts and encourage experimentation with new practices. Farmers might try cover cropping or buffer strips if given technical support and partial compensation, even if they wouldn't adopt these measures under regulatory pressure alone. Community-based programs often generate social pressure and peer learning that reinforce positive behaviors. However, voluntary measures typically only reach those already predisposed to participate, leaving significant gaps in implementation. Their effectiveness also depends heavily on sustained funding, which can fluctuate with political and economic cycles.

The most effective water governance strategies likely combine elements of both approaches in a phased, context-sensitive manner. Initial efforts might focus on voluntary programs with strong education components to build awareness and demonstrate benefits. As knowledge spreads and practices prove effective, these can be supplemented with targeted

regulations for persistent problem areas. Hybrid models, like Manitoba's GROW program that combines incentives for wetland restoration with regulatory backstops, offer promising templates. Ultimately, lasting improvements in water quality require both the structure provided by regulations and the engagement fostered by voluntary initiatives, all supported by ongoing education that helps communities understand and take ownership of solutions. This approach recognizes that protecting water resources is both a technical challenge and a social one, requiring changes in both policies and mindsets.

Looking forward, water governance could benefit from expanded participatory monitoring programs, particularly those led by Indigenous communities, to build trust in data and decision-making. Long-term behavior changes campaigns that move beyond one-time workshops to create sustained engagement will be crucial. Rigorous evaluation of existing programs can help identify which combinations of incentives, education and enforcement work best in different contexts. By prioritizing both policy tools and community relationships, Manitoba can develop more durable solutions to its complex water quality challenges. However, entrenched issues—such as governance structures inherently biased toward private property owners—pose significant challenges. Addressing this bias requires confronting deeper systemic inequities, including uneven power distributions that privilege private landholders, potentially limiting participation and benefits for renters, Indigenous communities, and smaller producers. To achieve truly equitable and effective water governance, Manitoba must intentionally redesign policies and institutional frameworks to mitigate this bias and support historically marginalized groups, ensuring broader representation and more inclusive decision-making.

3.5 Discussion

This study critically examines the effectiveness of voluntary (market-based) and regulatory approaches to water and nutrient governance in the Seine Rat Roseau Watershed District (SRRWD), revealing insights that both align with and challenge existing literature. The discussion is organized into three sections: (1) persistent challenges in the current hybrid governance model, (2) potential solutions for more just and sustainable watershed governance, and (3) contributions to broader theoretical and policy debates.

3.5.1 Challenges in the Hybrid Governance System

While voluntary programs like Manitoba's GROW initiative are lauded for their flexibility, innovation, and ability to cultivate community stewardship, their reliance on individual landowner participation reproduces inequalities tied to colonial land imaginaries (Beingessner et al., 2023). For instance, low enrollment in phosphorus hotspot areas reflects not just "resistant" farmers but systemic barriers—financialized farmland consolidation (Bihun, 2021). Consistent with Wunder et al. (2008) and Chan et al. (2016), this study also finds that voluntary initiatives can effectively mobilize early adopters by aligning environmental action with local values such as "farming for the community good." Social learning and peer-to-peer engagement—features emphasized by Pretty (2003 and Reed et al. (2010) are also central to their success. However, the programs face significant challenges in inclusivity, effectiveness, and sustainability. Persistent phosphorus hotspots in low-enrollment areas highlight how voluntary diffusion fails to engage resistant or marginalized producers, echoing critiques by Jack et al. (2008) Ostrom (2009). In addition, funding volatility due to dependence on short-term government grants undermines long-term stability, a concern also raised by (Dunlap & Sullivan, 2020). Lastly, both program administrators and researchers express frustration over difficulties in quantifying environmental outcomes—problems

that weaken accountability and adaptive management. On the regulatory side, mandates are better equipped to ensure baseline compliance, as seen in improved nutrient outcomes aligned with findings by Carpenter et al. (1998) Gunningham & Grabosky (2017). However, regulatory measures are frequently met with resistance in agricultural communities, where they are perceived as threats to autonomy. This adversarial dynamic complicates trust-building, diverging from Baldwin et al. (2012), who argue that well-crafted regulations can be seen as fair and legitimate.

3.5.2 Toward More Equitable and Effective Governance

The findings suggest that hybrid governance models—those combining both voluntary and regulatory elements—hold the most promise but require targeted refinement. Two critical gaps must be addressed. First, the fragmented monitoring system prevents the integration of participation data from voluntary programs with water quality outcomes from regulatory monitoring. Without this link, it is impossible to assess the actual environmental impact of combined interventions, rendering adaptive governance ineffective. This undermines the potential of hybrid systems envisioned by Lemos & Agrawal (2006). Second, education and outreach efforts disproportionately engage those already inclined toward stewardship, leaving behind operators managing high-risk lands. This results in a participation bias that limits the ecological reach of voluntary efforts. Targeted outreach, as well as differentiated incentive structures—e.g., offering 80% cost-sharing for high-impact practices and 30% for others—could enhance both equity and efficiency, a nuance underrepresented in existing literature.

3.5.3 Implications for theorizing water governance

This study contributes to environmental governance literature in four significant ways. First, it reinforces that the effectiveness of governance instruments is deeply dependent on context. In regions like the SRRWD characterized by low population density, diverse producer attitudes, and

complex watershed dynamics neither voluntary nor regulatory approaches alone suffice. Hybrid models must be contextually grounded, flexible, and responsive to local social and ecological realities, extending insights from Young et al. (2008) and Lemos and Agrawal (2006). Second, the research adds nuance to the understanding of social learning and trust. Consistent with Ostrom (2009) and Pretty (2003), this study finds that informal networks and peer-based outreach foster innovation. However, it also reveals the limits of these networks, which often fail to reach marginalized or resistant landowners. First, reliance on 'farmer-to-farmer' knowledge transfer privileges those already embedded in dominant social and professional networks—typically larger, wealthier landowners whose operations align with colonial 'good farmer' ideals (Beingessner, 2021; Bihun, 2021). Marginalized groups (e.g., Indigenous producers, tenant farmers, or financially strained smallholders) are often excluded from these circles due to systemic barriers like land consolidation (Bihun 2021) or cultural-linguistic differences. Second, peer networks tend to amplify solutions compatible with the status quo (e.g., incremental precision-agriculture tweaks) while sidelining transformative practices (e.g., Indigenous-led land repatriation or agroecology) that challenge capitalist property relations (Beingessner et al. 2023). Finally, the assumption that trust-building occurs organically through peer interactions ignores historical grievances—such as colonial land dispossession—that require formal redress, not informal socialization. Thus, while social learning models are effective for diffusion among homogeneous groups, they risk conflating participation with equity, leaving structural power asymmetries intact. Trust in governance remains uneven—particularly when regulatory measures are perceived as intrusive—suggesting that trust must be co-produced through ongoing, inclusive engagement and not presumed based on participatory design alone. Third, the findings spotlight the crucial but often overlooked role of funding architecture in shaping governance effectiveness. The financial precarity of voluntary

programs, reliant on short-term provincial grants or shifting political agendas—creates uncertainty and limits scalability. This echoes Ostrom's (2009) critique of fragmented institutional support and underscores the need for more stable, long-term investment in environmental programs. Fourth, this study critically engages with the broader political economy of neoliberal environmental governance. Voluntary initiatives like GROW reflect a market-based, incentive-driven logic that aligns with the neoliberal paradigm described by Bakker (2014). These programs reframe environmental stewardship as an individual economic choice rather than a collective responsibility, positioning farmers as service providers in an ecosystem marketplace. While such approaches foster innovation and autonomy, they risk depoliticizing environmental governance by sidestepping the structural inequalities and regulatory frameworks needed to address systemic environmental degradation. The reliance on voluntary uptake, targeted incentives, and outcome-based metrics exemplifies how neoliberalism reshapes governance by emphasizing flexibility, efficiency, and market rationalities—often at the expense of accountability, equity, and long-term sustainability.

Together, these contributions call for a rethinking of governance models that goes beyond blending regulatory and voluntary measures. They demand a more critical reflection on the ideologies, power dynamics, and institutional structures underpinning current governance paradigms, and a commitment to equity, resilience, and adaptive capacity in the face of ongoing environmental and political change.

3.6 **Conclusion and Future Directions**

This study reveals that Manitoba's current approach to nutrient governance—combining regulatory measures with voluntary, incentive-based programs—has achieved partial success but remains hampered by systemic gaps, particularly in monitoring and accountability. While the

province's hybrid model is theoretically sound, integrating the flexibility of market-based initiatives like the GROW program with the binding force of regulations such as the Nutrient Management Regulation (MR 62/2008), its effectiveness is undermined by inconsistent implementation and a lack of robust mechanisms to track outcomes.

A critical finding is the absence of a monitoring framework to evaluate whether voluntary actions or regulatory compliance translate into measurable water quality improvements. For instance, while Manitoba mandates nutrient management plans for large livestock operations, there is little evidence that these plans are systematically audited or linked to downstream phosphorus reductions. Similarly, voluntary programs, though successful in engaging willing participants, often lack the data to demonstrate their cumulative impact on watershed health. This monitoring deficit perpetuates uncertainty, making it difficult to assess which strategies work, for whom, and under what conditions. The research also highlights disparities in governance participation. Regulatory decision-making remains dominated by agricultural and governmental actors, while Indigenous communities and smaller-scale producers—particularly those most affected by downstream eutrophication—have limited influence. This imbalance reflects broader environmental justice concerns, as the burdens of nutrient pollution are disproportionately borne by those with the least power to shape policy.

3.6.1 Limitations

This study has several limitations. First, its focus on the SRRWD, though illustrative of prairie agricultural watersheds, may not capture the full diversity of governance challenges across Manitoba. Second, while interviews with key actors provided rich qualitative insights, the absence of long-term water quality data linked to specific policies makes it difficult to draw definitive causal conclusions. Third, the research primarily reflects the perspectives of institutional actors; a

broader survey of farmers, Indigenous leaders, and rural residents could yield a more nuanced understanding of governance barriers.

3.6.2 Future Research and Action

Moving forward, Manitoba must prioritize research that bridges the gap between policy intent and environmental outcomes. This includes longitudinal studies tracking phosphorus loads in sub-watersheds with different governance interventions, as well as socio-legal analyses of how regulations are enforced (or circumvented) in practice. Crucially, future work should examine Indigenous-led monitoring initiatives, which could offer alternative models for data collection and stewardship grounded in local knowledge. Equally important is investigating the political economy of nutrient governances specifically, how agricultural lobbying and jurisdictional fragmentation between federal, provincial, and watershed authorities hinder integrated solutions (Oates & Portney, 2003) Comparative research with jurisdictions like the Netherlands, where strict nutrient quotas are paired with farmer compensation, could inform more adaptive policies for Manitoba.

2.6.3 Policy Recommendations

To strengthen Manitoba's hybrid governance system, three reforms are urgent. First, the province should establish an independent watershed monitoring network, capable of verifying compliance and quantifying the impact of both voluntary and regulatory measures. This would require dedicated funding, standardized metrics, and transparent reporting to rebuild trust among actors. Second, regulatory frameworks must be made more responsive to local conditions. Rather than uniform buffer-strip requirements, for example, Manitoba could adopt outcome-based rules that allow farmers to meet phosphorus-reduction targets through flexible means, such as wetland restoration or cover cropping. Such an approach would require investing in extension services to help producers navigate options. Finally, governance structures must be decolonized. This means

formalizing roles for Indigenous nations in watershed boards, creating equitable funding streams for small-scale producers to adopt best practices, and ensuring that downstream communities—including those around Lake Winnipeg—have a voice in upstream land-use decisions. Without these steps, Manitoba's nutrient governance will remain fragmented, leaving the province's waters vulnerable to further degradation. In sum, Manitoba's challenge is not choosing between voluntary or regulatory approaches, but making them work together—with science, equity, and accountability at the core. The SRRWD case demonstrates that policies alone cannot solve eutrophication; they must be coupled with the tools, resources, and inclusive processes needed to turn intentions into results.

2.7 Bridging paragraph after Chapter III

The insights from Chapter III extend the focus of the thesis from provincial nutrient policy to the lived practices of governance within the Seine Rat Roseau Watershed District. By analyzing hybrid approaches that combine regulatory, voluntary, and incentive-based instruments, the chapter shows how governance innovations are shaped by neoliberal logics and structural inequities. This chapter complements the policy-level controversies examined in Chapter II by revealing how governance frameworks are implemented, negotiated, and contested at the watershed scale. Together, the two chapters underscore the thesis's central argument: that controversies and hybrid arrangements in nutrient governance are both products of, and contributors to, broader struggles over water security, justice, and sustainability in Manitoba.

Chapter IV Conclusion

This thesis critically examines the complex and evolving landscape of eutrophication and water governance in Manitoba, with a particular focus on the Seine Rat Roseau Watershed District (SRRWD). Through two interlinked manuscripts—one analyzing the hybridization of voluntary and regulatory governance approaches, and the other deploying a controversy studies framework to unravel epistemic and political disputes—this research offers a holistic assessment of watershed security and policy effectiveness in the Canadian Prairies.

The findings reveal several persistent and deeply embedded challenges in Manitoba's current water governance regime. Chief among these is the ongoing gap in monitoring and evaluation. Despite decades of policy reform and significant investments in water governance, there is a lack of robust, integrated, and participatory monitoring systems. This deficit undermines the effectiveness of both regulatory and voluntary initiatives, as actors are left without clear, credible evidence of what works and where progress is being made or lost (Lake Winnipeg Community-Based Monitoring Network [LWCBMN], 2022; Interview Data, 2024). Fragmentation of responsibilities among agencies and the reliance on local watershed districts—often without sufficient resources or technical capacity—has resulted in persistent gaps in tracking nutrient reductions, allowing phosphorus hotspots and legacy nutrients to persist in the system (Painter et al., 2021; Lake Winnipeg Foundation, 2023).

Closely related to this monitoring gap is the issue of enforcement and accountability. While Manitoba's Nutrient Management Regulation and related statutes articulate clear standards for nutrient application and protection of water bodies, enforcement is widely perceived as inconsistent and under-resourced. Many interviewees described the regulatory framework as a "paper tiger"—strong on paper, but lacking in the inspection capacity and political will to change

on-the-ground behaviors, particularly among large-scale and well-connected agricultural producers (Cohen & Bakker, 2015). This has allowed a degree of regulatory avoidance or minimal compliance, further undermining the effectiveness of the hybrid approach.

Another major finding of this research is the persistence of inequitable power dynamics in watershed governance. While large-scale agricultural actors and industry organizations do exert considerable influence, often advocating for voluntary, incentive-based models over stronger regulatory interventions, the dominance of these approaches cannot be attributed to producers alone. As one federal official observed, producers themselves are not a monolithic group: *"some farmers are very actively engaged, doing really good things, and then other farmers that are not so much"* (Interview, 2024). This variation suggests that while industry actors lobby for incentive-based programs, the broader institutional environment is equally, if not more, decisive. Governments themselves have increasingly embraced voluntary instruments in alignment with broader neoliberal policy shifts that emphasize market-based solutions, decentralized governance, and reduced regulatory burden (McIlwain et al., 2023). Interview data further illustrate that this reliance on voluntary tools is not merely a concession to producer demands, but also a matter of political expediency: as one participant explained, *"if everything is regulatory to the nth degree, nobody's going to get voted anymore"* (Interview, 2024). Taken together, these findings underscore that the privileging of voluntary instruments reflects not only producer influence but also government choices and institutional logics that systematically favor private landowners in decision-making processes.

Governance frameworks in Manitoba—especially those reliant on voluntary stewardship—tend to privilege actors who hold land and economic capital, reinforcing longer-standing inequalities rooted in settler-colonial land dispossession and consolidation. Those without land or

formal ownership rights—such as many Indigenous peoples, renters, or marginalized community members—often lack meaningful influence, regardless of their stake in watershed health. This systemic privileging of landowners creates barriers to more inclusive governance and constrains the transformative potential of both voluntary and regulatory tools. As a result, the hybrid model risks reinforcing the very inequities it purports to overcome, contributing to policy inertia and the dilution of enforcement capacity.

Perhaps most critically, this research demonstrates that despite official commitments to reconciliation and the inclusion of Indigenous rights holders, most watershed governance processes in Manitoba remain deeply entrenched in Western scientific and bureaucratic paradigms. While the enactment of the Watershed Districts Act (2020) formally enabled Indigenous communities to participate in watershed district boards—a significant policy shift from previous exclusion—meaningful inclusion remains limited. Indigenous knowledge systems and legal orders are rarely operationalized in shared management, and participation is often restricted to consultation rather than substantive decision-making authority (Craft & Borrows, 2023; Baijius, 2021).

Empirical work, such as Wiebe, (2024), shows that even when First Nations are formally involved—such as in the Swan Lake region—systemic challenges persist. These include jurisdictional ambiguity, lack of funding for capacity development, and governance structures that prioritize Euro-Western frameworks of land and water management. Indigenous participants in that study expressed concern that their involvement was often symbolic, with limited space to influence planning or integrate Indigenous ecological knowledge meaningfully. These barriers reflect the enduring colonial logics embedded in Manitoba's water governance institutions. As such, the failure to realize genuine co-governance not only limits the potential for more holistic

and context-sensitive decision-making, but also perpetuates patterns of exclusion that undermine both ecological integrity and Indigenous rights (Simpson, 2017).

Compounding these governance gaps is the persistent controversy surrounding nutrient policy design and implementation. The adoption of policy models adopted from other jurisdictions, such as New Zealand's dual-nutrient approach—was a recurring source of skepticism among actors. Many questioned whether these frameworks were tailored to Manitoba's specific biophysical and governance context, highlighting the ongoing clash between local, Indigenous, and global scientific knowledges (Snelder et al., 2020; Interview Data, 2024). These epistemic divides further fragment policy implementation, making it difficult to build consensus or legitimacy around the chosen path forward.

Against this backdrop, the research concludes that hybrid governance is a double-edged sword. On the one hand, combining regulatory "floors" with flexible, incentive-based and participatory approaches theoretically promises adaptability, local tailoring, and broader buy-in. On the other hand, in practice, Manitoba's hybrid model has too often allowed actors to "pick and choose" among tools, blurring lines of responsibility and enabling regulatory avoidance or minimal compliance (Bakker, 2015). Without strong and enforced regulatory baselines, robust and integrated monitoring, meaningful resource alignment, and genuine Indigenous co-governance, voluntary measures risk becoming mere window-dressing rather than a catalyst for transformative change (McIlwain et al., 2023; Craft, 2021).

These findings have clear implications for policy, scholarship, and practice. First, hybrid governance must be rebalanced—regulatory floors must be both robust and consistently enforced, and voluntary or incentive-based measures must be targeted, well-resourced, and designed to address participation bias and equity gaps (Baldwin et al., 2019; Shortle et al., 2020). Second,

monitoring frameworks need to be institutionalized as transparent, collaborative, and multi-actor systems, capable of providing real-time feedback for adaptive management and fostering public trust (LWF, 2022; Moyer et al., 2008). Third, the structural power imbalances in Manitoba's governance landscape must be tackled head-on, with policy design and implementation processes that center the interests and voices of smaller producers, marginalized communities, and especially Indigenous nations (Craft, 2023; Harris et al., 2015). This includes moving beyond tokenistic consultation to true co-governance arrangements, where Indigenous legal orders and knowledge are operationalized in watershed planning and management (Baijius, 2021).

Looking forward, this research highlights several critical directions for future inquiry. Longitudinal and comparative studies are needed to assess which hybrid governance arrangements produce the most durable improvements in both water quality and equity outcomes. There is also an urgent need for pilot projects and policy experiments that operationalize co-governance with Indigenous nations, and that test innovative models for participatory monitoring, knowledge co-production, and adaptive management (Benson et al., 2020; Pahl-Wostl, 2019). Additionally, future research should examine the on-the-ground effectiveness of Beneficial Management Practices (BMPs) in reducing nutrient runoff under varying ecological, economic, and institutional conditions. While BMPs are widely promoted as part of nutrient governance strategies, there remains a need for more empirical, site-specific evaluation of their long-term impacts (Walter et al., n.d.). Finally, attention must also be paid to the enduring challenge of legacy nutrients and the necessity of coordinated, cross-jurisdictional efforts to address both historical and ongoing sources of phosphorus and nitrogen pollution (Ulrich et al., 2016).

Empirical data from actor interviews and policy analysis reveal that controversy in Manitoba's nutrient governance is constructed and sustained through active processes of framing,

contestation, and boundary-drawing. For example, disputes about the scientific justification for nitrogen regulation are not only about data or evidence, but about whose knowledge and experience counts in defining the "problem" and the "solution." Many agricultural actors, including producers and their associations, voiced skepticism about the relevance of nitrogen limits in Manitoba's heavy clay soils, arguing that policy was imported wholesale from international models—most notably New Zealand's dual-nutrient approach—without adequate adjustment for local conditions (Snelder et al. 2020; Interview Data). This sense of policy mismatch was reinforced by a perceived lack of transparency and trust in the data used by government agencies to justify regulatory action. Conversely, environmental NGOs and scientists emphasized the importance of a precautionary approach and cited evidence of cumulative nutrient loading, pushing for stronger regulatory baselines even in the face of uncertainty. These disputes reveal what Jasanoff (2004) terms "civic epistemologies"—locally specific ways in which knowledge claims are made credible or contestable in public policy.

The controversy chapter of this thesis maps how epistemic disagreements in Manitoba's water governance are deeply entangled with structural and political power dynamics. Interviewees from smaller farms, municipalities, and Indigenous communities frequently described feeling marginalized in consultation and decision-making processes. For Indigenous participants in particular, this marginalization was rooted not only in overt exclusion but also in the province's ongoing failure to meaningfully recognize Treaty rights, incorporate Indigenous legal orders, or embed Indigenous knowledge systems within governance frameworks (Craft, 2021; Baijius, 2021). While watershed districts and other institutions may express a willingness to engage Indigenous partners, participation is often impeded by invisible systemic barriers—including jurisdictional ambiguity, lack of long-term funding, limited capacity in both Indigenous and settler

institutions, and the absence of mechanisms for shared authority or legal recognition. In some instances, the state's invocation of "consultation" was perceived as largely symbolic, with Indigenous and local perspectives ultimately overshadowed by dominant policy actors or scientific authorities. These dynamics reflect not just a lack of intent, but the persistence of settler-colonial governance structures that continue to define the boundaries of inclusion. The strategic deployment of science, "best practices," and procedural neutrality can serve to reinforce these boundaries, shaping whose knowledge is validated and whose is excluded (Simpson, 2017; Bakker et al., 2018). Addressing these systemic barriers requires moving beyond invitations to participate toward co-governance models that redistribute power, authority, and resources.

A particularly acute source of controversy in nutrient governance lies in the design, control, and interpretation of monitoring systems. Disputes often emerge over the legitimacy and authority of data, especially between state agencies and community actors. Government institutions frequently cite resource limitations and the need for standardized methodologies to justify their reliance on centralized, top-down monitoring frameworks. In contrast, community organizations and environmental NGOs advocate for more transparent, locally embedded, and participatory approaches, such as community-based science initiatives (Lake Winnipeg Community-Based Monitoring Network, 2022). These divergent positions reflect deeper tensions over the credibility, ownership, and political uses of environmental data—raising questions not only about technical accuracy, but about power, accountability, and inclusion. As Herman-Mercer et al. (2018) cite, scientific institutions often contest the validity of community-generated data, despite its local relevance and potential for democratizing knowledge production. The chapter reveals how such disputes are not merely procedural but epistemic, shaping whose knowledge counts, who evaluates progress, and whose interests are ultimately served by the indicators chosen. In this context, the

concept of *data justice*—concerned with who collects, controls, and acts upon environmental data—emerges as a critical flashpoint in the politics of watershed governance.

Importantly, the controversy chapter shows that these disputes are not static. They shift and evolve as new scientific findings emerge, as political leadership changes, and as crises (such as algal blooms or flooding events) create windows for new actors or perspectives to enter the debate. Rather than viewing controversy as a barrier to be eliminated, the thesis argues that controversy is a generative and even necessary feature of environmental governance in complex, multi-actor systems (Wynne, 1992). The active negotiation of difference, disagreement, and even mistrust is what makes democratic governance possible and adaptive. However, not all controversies are equally productive. When disputes are rooted in deep-seated power asymmetries, historical exclusion, or a lack of meaningful participation, they can become entrenched and corrosive, leading to policy stagnation and continued ecological decline (Latour, 2005).

Thus, one of the most significant findings from the controversy chapter is that technical and institutional fixes, no matter how sophisticated, cannot substitute for the ongoing work of building legitimacy, trust, and shared purpose among actors with divergent worldviews and interests. In Manitoba, this means that future governance reforms must grapple directly with underlying issues of equity, recognition, and knowledge pluralism. This could involve the co-design of monitoring systems, more transparent and deliberative forums for controversy negotiation, and institutional reforms that redistribute authority and resources to historically marginalized groups—especially Indigenous nations. The thesis ultimately contends that policy and scholarship must learn to "stay with" controversy: to see it not as a sign of failure, but as an enduring feature and even a potential source of creativity in water and nutrient governance (Molle et al., 2019; Jasanoff, 2004). Recognizing and constructively engaging with controversy allows for more resilient, adaptive, and

just responses to persistent challenges like eutrophication and watershed insecurity. Rather than seeking a premature closure of debate through technical consensus or procedural fixes, Manitoba—and other regions facing similar dilemmas—can benefit from cultivating the institutional and social capacity to negotiate, revisit, and even embrace controversy as part of the ongoing pursuit of sustainability and justice.

4.2 Implications

The findings from this study demonstrate that addressing eutrophication in the SRRWD requires moving beyond technical nutrient management to confront systemic governance barriers. While hybrid voluntary-regulatory approaches have increased participation in best management practices (BMPs), their failure to engage high-risk landowners has perpetuated phosphorus hotspots in critical sub-watersheds. This pattern aligns with global studies showing that voluntary programs often attract early adopters while failing to reach intensive operations responsible for disproportionate nutrient loading (Kroeger & Casey, 2007). In Manitoba's agricultural context, this participation bias reflects deeper structural issues, including farmland financialization (Bihun 2021) and the marginalization of Indigenous stewardship paradigms (Baijius 2021).

Effective eutrophication management requires governance innovations that address these systemic dimensions. First, regulatory frameworks must move beyond uniform BMP promotion to implement risk-based zoning, with mandatory measures for critical areas and differentiated incentives tied to land use intensity. Second, monitoring systems should integrate Indigenous water knowledge (Bradford, 2016) with Western scientific approaches, creating more holistic indicators of watershed health that reflect both ecological and cultural values. Third, governance structures need to institutionalize power-sharing with Indigenous nations, including co-management of drainage approvals and resource allocation for Indigenous-led monitoring programs. These

reforms would address the core governance failures revealed by this study: the disconnect between participation and impact, the exclusion of Indigenous knowledge systems, and the persistence of colonial land use paradigms. As the SRRWD case demonstrates, eutrophication solutions require not just better nutrient management technologies, but a fundamental rethinking of who governs the landscape and what forms of knowledge guide those decisions. Such transformative approaches offer the best promise for achieving both ecological integrity and environmental justice in watershed management.

4.3 **Future Directions in Research and Practice**

Building on these insights, several priorities emerge for future research, policy innovation, and governance practice. First, there is a clear need for longitudinal and comparative studies that can track how hybrid governance models and controversies evolve over time, and under different socio-ecological and political conditions in other places. Such research should include rigorous evaluation of pilot projects, such as co-governed watershed boards, equity-focused incentives, or participatory monitoring frameworks—to identify what works, for whom, and why. Second, future scholarship must prioritize Indigenous-led and community-driven research, moving beyond extractive models to co-design and co-implementation. This includes the development of Treaty-based and rights-based governance experiments, which have the potential to model new relationships between the state, Indigenous nations, and other actors. The findings of this thesis underscore that any proposals to strengthen nutrient governance must grapple with systemic barriers that limit participation by Indigenous peoples and marginalized actors. Without structural reforms, even well-intentioned policies risk reproducing colonial patterns by privileging state and industry voices over Indigenous governance. Making recommendations implementable therefore requires not only technical adjustments, but also political and institutional changes to support

Indigenous leadership. This includes addressing persistent capacity limitations—such as funding instability, staffing shortages, and jurisdictional exclusions—that constrain the ability of Indigenous governments to fully participate in water governance.

The newly established Canada Water Agency (CWA) offers a critical opportunity to reimagine water governance in ways that address many of the limitations highlighted in this thesis. Because the *Canada Water Act* currently restricts formal agreements to provincial and territorial governments, Indigenous governments remain excluded from equal participation. A modernized Act could create pathways for Indigenous governments to be full signatories to federal-provincial agreements, ensuring that Indigenous knowledge and priorities are embedded in decision-making. In addition, the CWA could help address persistent capacity limitations by investing in long-term funding for Indigenous water governance initiatives, supporting Indigenous-led monitoring programs, and creating mechanisms for more equitable knowledge co-production. These reforms would not only strengthen nutrient governance in Manitoba, but also align with Canada's broader commitments to reconciliation and environmental justice.

Finally, Manitoba and similar jurisdictions should deepen their commitment to policy innovation by testing adaptive regulatory frameworks, outcome-based approaches, and genuinely collaborative governance models that not only tolerate but actively engage with controversy as a catalyst for institutional learning and transformation. While programs such as the Watershed Districts (WDs) and the Growing Outcomes in Watersheds (GROW) initiative are often presented as examples of such innovation, it remains unclear whether they fully embody this spirit. These initiatives signal progress by promoting local participation and offering incentives for ecological goods and services. However, their reliance on voluntary measures, limited enforcement

mechanisms, and the absence of comprehensive monitoring and evaluation systems raise important questions about their effectiveness, both in terms of ecological outcomes and equity.

Current monitoring systems exacerbate challenges of nutrient governance by maintaining divisions between regulatory water quality data and voluntary program metrics. This fragmentation, characteristic of neoliberal environmental governance, prevents accurate assessment of intervention effectiveness. One limitation of this study is that it could not directly examine the relationship between land ownership patterns and nutrient outcomes, due to the lack of available data. However, emerging evidence suggests that such connections may be significant. For example, other studies have noted that rented or corporately owned farmland may show lower adoption of best management practices and higher nutrient export, while the colonial history of wetland drainage and land dispossession continues to shape the landscape of nutrient risk (Beingessner et al., 2023). Future research should therefore explore how land tenure, drainage legacies, and policy frameworks intersect with nutrient governance, as these factors may be critical to understanding why Manitoba's nutrient reduction targets remain elusive despite decades of regulatory adjustments and voluntary programming.

More research is needed to critically assess whether these programs are achieving their intended goals. Key areas of inquiry include the distribution of benefits and burdens across different actor groups, particularly marginalized and Indigenous communities; the extent to which power-sharing and co-governance are realized in practice; and whether ecological improvements, such as reductions in phosphorus loading or biodiversity gains, are measurable and sustained. Innovation in water governance should not only be about introducing new programs but about rethinking the foundational relationships between knowledge, power, and policy. Embracing

controversy—as opposed to managing or avoiding it—can help surface these tensions and create opportunities for more adaptive, just, and ecologically grounded governance.

4.4 **Significance of Research**

This thesis critically interrogates the governance dimensions of freshwater eutrophication, with a focus on how policy, science, and power intersect to shape both environmental outcomes and institutional responses. Rather than treating eutrophication as a purely technical or ecological problem, the research situates it as a deeply political and contested issue—one that reflects broader tensions around knowledge legitimacy, regulatory authority, and the distribution of environmental responsibilities. By examining how nutrient pollution is governed in the prairie province of Manitoba, the thesis explores both the structural and epistemic challenges that hinder effective and equitable watershed management. Together, the two chapters make significant empirical, theoretical, and practical contributions. Empirically, they provide grounded, case-based analyses of water and nutrient governance, drawing on qualitative interviews, policy review, and controversy mapping. Theoretically, the research brings together insights from science and technology studies (STS), political ecology, and Indigenous studies to develop a critical analysis of environmental governance. These frameworks are not used in isolation but are integrated to interrogate how authority, rights, and knowledge claims are negotiated across two overlapping yet distinct problem domains.

Practically, the thesis offers actionable pathways for policymakers, watershed managers, and communities. It calls for more adaptive, transparent, and justice-centered approaches to governance, backed by evidence from key-informant interviews and policy analyses. The research highlights that progress toward watershed security and eutrophication management will depend on the ability to harness, rather than suppress, ongoing controversy and pluralism. Ultimately, this

thesis affirms that just and effective water governance requires more than technical solutions—it demands the cultivation of relationships, institutions, and processes that can adapt to complexity, respect diverse knowledges, and confront power imbalances head-on. By advancing this integrated perspective, the work provides a foundation for innovation, learning, and reconciliation in the governance of water, nutrients, and the broader social-ecological systems they sustain.

In summary, this thesis has examined the complexities of nutrient governance in Manitoba, highlighting how phosphorus and nitrogen pollution challenges are embedded within broader social, political, and epistemic controversies. Through qualitative methods, including key-informant interviews, document analyses, and controversy mapping, the research identified persistent tensions within Manitoba's hybrid governance framework—combining voluntary incentive programs and regulatory measures—and uncovered the structural inequities and power dynamics that shape environmental outcomes. These findings underscore that nutrient pollution is not simply a technical or ecological issue but one fundamentally rooted in governance processes that mediate conflicting interests, diverse knowledge claims, and uneven power relations. Ultimately, this project calls attention to the necessity of shifting governance paradigms toward greater inclusivity, adaptability, and justice. Effective eutrophication management requires addressing deeply embedded institutional biases, especially toward private property owners, and elevating marginalized voices—particularly Indigenous communities and small-scale agricultural producers—within policy formulation and implementation. By advocating for participatory monitoring, adaptive learning, and genuine co-production of knowledge, this thesis contributes practical strategies aimed at fostering resilient and equitable watershed governance. In doing so, it provides pathways not only for Manitoba but also for other regions navigating similar complexities at the intersection of agriculture, governance, and freshwater ecosystem health.

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Appendices

Appendix A — Key Policies and Regulations in Water and Nutrient Governance in Manitoba

1. **The Conservation Districts Act, C.C.S.M. c. C175 (1987):**

   This Act established the foundational framework for managing natural resources—particularly water and land—through the creation of Conservation Districts. These

districts aimed to promote local, collaborative approaches to natural resource management. The Act has since been replaced by the Watershed Districts Act (2020).

2. **The Environment Act, C.C.S.M. c. E125 (1998):**

   Provides a legislative framework for environmental protection and sustainable management of Manitoba's natural environment, aiming to safeguard the well-being of present and future generations.

   a) **Livestock Manure and Mortalities Management Regulation (MR 42/98):**

      A regulation under the Environment Act that governs the storage, handling, and application of livestock manure. It aims to minimize nutrient runoff and prevent the contamination of surface and groundwater sources.

3. **The Water Protection Act, C.C.S.M. c. W65 (2005):**

   This legislation is designed to protect Manitoba's water resources and aquatic ecosystems. It seeks to ensure a sustainable supply of clean water for social, ecological, and economic needs.

   a) **Nutrient Management Regulation (MR 62/2008):**

      A regulation under the Water Protection Act that sets guidelines for the application of nutrients (including fertilizers and manure) to prevent water quality degradation. It includes setbacks from water bodies and conditions for nutrient application based on soil test phosphorus levels.

4. **The Water Rights Act, C.C.S.M. c. W80 (1988):**

   This Act regulates the licensing of water withdrawals in Manitoba. It also includes

provisions intended to minimize nutrient runoff by managing how water use interacts with surrounding land use and environmental conditions.

5. **The Watershed Districts Act, C.C.S.M. c. W95 (2020):**

   Enacted to replace the Conservation Districts Act, this Act formalized the creation of Watershed Districts across Manitoba and mandated the development of Integrated Watershed Management Plans (IWMPs). It emphasizes collaborative and inclusive governance, requiring participation from a wide range of actors, including municipalities, landowners, and Indigenous communities. The Act represents a shift toward holistic, watershed-scale planning and management, supported by both regulatory and voluntary measures.

   a) *Note:* With the enactment of this Act in 2020, **First Nations were formally included as active participants** in watershed governance, ensuring their involvement in planning and decision-making processes related to water and nutrient management in Manitoba.

6. **Nutrient Targets Regulation, Man. Reg. 77/2024:**

   Introduced under the authority of the Water Protection Act, this regulation establishes science-based nutrient reduction targets aimed at improving water quality in Lake Winnipeg and its major tributaries. The regulation sets the following goals:

   a) A 50% reduction in phosphorus loading to Lake Winnipeg relative to 2009 levels.

   b) Specific concentration targets for major rivers:

      - Red River: 1.0 mg/L

- Winnipeg River: 0.08 mg/L
- Dauphin River: 0.05 mg/L

The regulation also commits the Province of Manitoba to regular progress reporting and the implementation of targeted actions to achieve these reductions, with a focus on addressing harmful algal blooms, improving aquatic health, and restoring public trust in water governance.

Appendix B — Interview Guide

Demographic Questions

1. What gender do identify as?
2. What organization or entity are currently associated with?
3. How long have you been involved in water governance or nutrient management?
4. What are the primary objectives of your organization or community concerning water quality management and nutrient pollution mitigation?

Assessing Current Water Governance Frameworks and Power Dynamics

1. How do you perceive the current state of water quality in the Seine Rat Roseau Watershed District? What are the main issues affecting water quality?
2. What are the solutions to water quality issues in Seine Rat Roseau Watershed District?
3. Can you describe the current water governance system and practices in your region (Rat Seine Roseau Watershed District), particularly those related to nutrient management and phosphorous control?
4. In your opinion, how effective are these practices in addressing water quality issues? Can you provide specific examples or experiences?
5. What challenges do you face in implementing effective nutrient management practices and policies?
6. What do you think could be done differently to improve water quality governance in the RSRWD?
7. How are actors, including government agencies, Indigenous communities, NGOs, producers and landowners, in engaged water governance? What opportunities exist for meaningful engagement and partnership in addressing water quality issues?

8. Can you describe the nature of relationships and collaboration among the different actors involved in water governance in this region? Is there anything that could be done to improve these relationships?

Voluntary/Market-based vs Regulatory Governance

1. What are the benefits and challenges associated with voluntary/incentive-based governance for nutrient management?
2. What are the benefits and challenges associated with regulatory governance for nutrient management?
3. Which approach (voluntary/incentive-based vs regulatory governance) do you think is more effective and why?
4. How do voluntary programs encourage engagement and participation?
5. In your opinion, which approach has had a more significant impact on improving water quality in the watershed?