GAINING PERSPECTIVE: WHAT DO AFFECTED PERSONS THINK ABOUT OIL SANDS PROCESS-AFFECTED WATER REMEDIATION USING CONSTRUCTED WETLANDS ENHANCED BY GENOMICS?

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ABSTRACT

Effective oil sands remediation requires integrated and holistic knowledge of the problems and potential solutions that can only be acquired through participation and input from affected persons. Mining of Alberta's oil sands consists of water-intensive processes such as hot water extraction, resulting in large quantities of contaminated oil sands process-affected water (OSPW) stored in tailings ponds that require remediation before release. Hence, as mining projects advance, the need for sound policy and improved methods for remediation and release intensifies. Constructed treatment wetland systems (CTWS) have been identified as a viable remediation option, and genomics can be employed to optimize microbial activity, enhancing remediation efficacy. However, researchers have paid limited attention to the priorities and values held by those affected by OSPW remediation and particularly to CTWS enhanced by genomics. To address this gap, I co-designed and performed this research with affected persons, including Indigenous Peoples, oil and gas industry employees, scientists studying CTWS and genomics, and regulators and policymakers considering OSPW remediation. My sequential mixed-method research used a literature review, media review, and focus groups to examine opinions on CTWS and genomics for OSPW remediation and to build a Q-methodology concourse and Q-set for future research to systematically study participant viewpoints.

This study found that affected persons have a wide range of opinions about CTWS and genomics in the context of OSPW remediation. They identified barriers to participating in discussions and decisions about CTWS and genomics, the main ones being confusion around proposed technologies and inadequate communications, which can inform future community engagement processes through recommendations. Some affected persons supported CTWS and genomics when methods were piloted, when they knew CTWS and genomics had been used in

other applications, and when they knew research was underway or completed. Conversely, affected persons argued that information about CTWS and genomics is sparse and that there is no evidence that CTWS and genomics will not harm the environment, wildlife, or human health and culture. Novel findings were the conflict between affected persons from regulatory bodies and affected persons in industry around placement and continuity of CTWS after a mine is closed, and affected persons' assertions that wetlands have a spirit.

Cultural Theory's purpose is to use the typology of five ways of organization to categorize, examine, and critique deliberative quality in engagement with affected persons, noting that the most robust solutions to the most challenging problems emerge when all five solidarities are sought and blended in solution generation. In this study, Cultural Theory's three active solidarities—individualism, hierarchy, and egalitarianism—were observed, while fatalism and autonomy emerged when some participants considered perspectives others might hold. I witnessed synergies between the solidarities, suggesting a capacity for clumsy solutions that incorporate voices from all concerned; however, solidarities are missing in decision-making around remediation policy for OSPW. More research is needed, particularly with local communities, to capture and explore the perspectives of those significantly affected by OSPW remediation. These affected persons could pursue the goals of maximizing accessibility of information and conversations as well as responsiveness to each other's concerns to enhance deliberative quality and implement robust solutions.

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DEDICATION

For Liam, Gabby (11), Daniel (8), Maddy (5), and Talia (2)

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GLOSSARY OF ACRONYMS AND TERMS

Affected person – a person who is directly affected by oil sands remediation through place, rights, livelihood, or experience. This term attempts to remove the economic implications generally felt with the term stakeholder and include rights holders

AER – Alberta Energy Regulator

AEPA – Alberta Environment and Protected Areas

Closure landscape – land at a mine site after the mine is closed

COSIA – Canada's Oil Sands Innovation Alliance

CTWS – Constructed Treatment Wetland Systems – wetlands built to detoxify and degrade wastewater through natural processes performed by locally occurring plants and microbes; also called Constructed Wetland Treatment Systems (CWTS)

Duty to consult – a doctrine that federal and provincial governments must consult, and where appropriate, accommodate Indigenous groups when it considers conduct that might adversely impact potential or established Indigenous or treaty rights

FPIC – Free Prior and Informed Consent – a right granted to Indigenous Peoples recognized under UNDRIP that aligns with their universal right of self-determination where Indigenous Peoples can provide, withhold, or withdraw consent at any time throughout a project in their territories

GE^{3}LS – Research that studies Genomics and its Environmental, Economic, Ethical, Legal and Social aspects

Genomics – the study of the entire genetic makeup of a living organism; used in the GROW project to study wetland plants and microbes to understand how to build, operate, and optimize constructed treatment wetland systems

Genetic modification – a process that uses laboratory-based technologies to alter the DNA makeup of an organism; not used in the GROW project

GROW Project – Genomics Research for Optimization of Constructed Treatment Wetlands for Water Remediation – a research project applying genomics-based methods to provide insight into the mechanisms of wetland plant-microbe interactions toward developing a robust, 'green,' and cost-effective constructed wetland treatment system approach for the remediation of oil sands process-affected water; there is no genetic modification being used in this project

OSPW – Oil sands process-affected water

Precautionary Principle – the ethical principle saying that if the consequences of an activity could be serious and are subject to scientific uncertainties, then precautionary measures should be taken, or the activity should not be carried out at all

P – Pilot – a focus group session performed with academic peers to test the Padlet and Zoom operation and generate data

I – Industry – a focus group session with oil and gas industry employees

IP – Indigenous Peoples – a focus group session with Indigenous Peoples

R&P – Regulator and Policymaker – a focus group session with representatives from the AER and AEPA

S1 – Scientist Interview – a session with one scientist working with OSPW remediation and genomics held due to scheduling restraints using the same methodology as the focus groups

S2 – Scientist Focus Group – a focus group session with scientists working on the GROW project

UNDRIP – United Nations Declaration on the Rights of Indigenous Peoples – a universal framework of minimum standards for the survival, dignity, and well-being of the Indigenous Peoples of the world, elaborating on existing human rights standards and fundamental freedoms as they apply to the specific situation of Indigenous Peoples. Canada implemented the UNDRIP Act in 2021 to provide a roadmap for implementing the UN Declaration

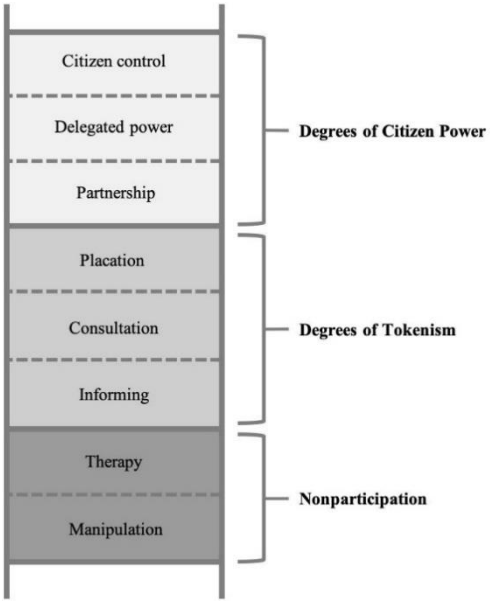
1. INTRODUCTION

Canada holds 10% of the world's proven oil reserves, with 97% of these reserves contained in Alberta's oil sands (Dubé et al., 2021). The oil sands mining process requires three to four barrels of water for every barrel of bitumen produced and solubilizes contaminants, resulting in large quantities of oil sands process-affected water (OSPW) (Natural Resources Canada, 2015; Quinlan & Tam, 2015). OSPW is stored in tailings ponds, which currently cover about 110 km^2 of northern Alberta and will continue to grow as mining continues (OSIP, 2022; Slingerland et al., 2019). Regulations have prohibited the release of OSPW into waterways, but oil sands development, including the building of extraction site mining pits and tailing ponds, has been based on the premise of returning the site to its initial nature, which includes the ultimate release of remediated OSPW (Tanna et al., 2019). One remediation technology shown to reduce OSPW contamination is constructed treatment wetland systems (CTWS) (Hendrikse et al., 2018; McQueen et al., 2017; Rodgers & Castle, 2008). CTWS are wetlands built to detoxify and degrade wastewater through natural processes performed by locally occurring plants and microbes. When considering remediation of contaminated industrial sites elsewhere, community groups and First Nations representatives preferred bioremediation techniques such as CTWS over methods using chemicals (Page & Atkinson-Grosjean, 2013). Research is underway to use genomics-based methods to understand how wetland plants and microbes degrade and detoxify OSPW and enhance the efficacy of CTWS (Muench & Martineau, 2020). Still, CTWS enhanced by genomics have not been widely tested in northern Alberta's harsh climate (McQueen et al., 2017)) and many proposed bioremediation strategies, including treatment wetlands, have not yet gained acceptance from affected communities (Foote, 2012).

Indigenous and local communities are attentive to the environmental concerns presented by OSPW remediation and release and will be particularly impacted if OSPW remediation and release are not done appropriately (Foote, 2012; Westman & Joly, 2019). Without proper remediation, OSPW threatens water quality, while harm to wildlife adversely affects subsistence and spiritual practices as well as intergenerational knowledge transfer for Indigenous Peoples (Westman & Joly, 2019). Despite the direct impacts, the values and priorities of local communities considering remediation and release have received limited consideration (Carter et al., 2017; Foote, 2012)). Public participation in engagement around oil sands remediation has been increasing over the last few decades; for example, Beckett et al. (2020) show how governments legally require public consultation for remediation, Beckett and Keeling (2019) discuss how a mining community sought support for community healing post-remediation, and Blacker et al. (2021) discuss how citizen-science projects for post-remediation monitoring are growing in popularity, but meaningful collaboration with locals and Indigenous communities has been identified as lacking in Alberta's oil sands (Aksamit et al., 2020; Huynh et al., 2018). While Canada's Oil Sands Innovation Alliance (COSIA) members spent $826 million between 2012 and 2020 to develop tailings technologies, social science research in Alberta's oil sands region is "underdeveloped relative to other extractive regions" (COSIA, 2021; Westman & Joly, 2019, p. 234). This gap creates an opportunity for exploratory academic investigation of existing perspectives to improve meaningful engagement and participation. Considering OSPW remediation in the context of Arnstein's ladder of citizen participation as shown in Figure 1.1 (Arnstein, 1969; Eabrasu et al., 2021), the literature places current participation at placation, consultation, or informing levels, not at true engagement as represented by citizen power (Aksamit et al., 2020; Huynh et al., 2018; Westman & Joly, 2019).

Figure 1.1

Arnstein's Ladder of Citizen Participation



Personal philosophy dictates how individuals view who is affected and the validity of each person's opinion (Hays & Singh, 2012). While some individuals hold the ontology that there is a single reality or truth for every situation, some argue that multiple truths exist, with some being more important than others, and still others consider that truth does not exist because there are multiple equally valid truths (Hays & Singh, 2012). For this study, the stance of multiple equally valid truths was taken to attempt to capture opinions without bias from affected persons.

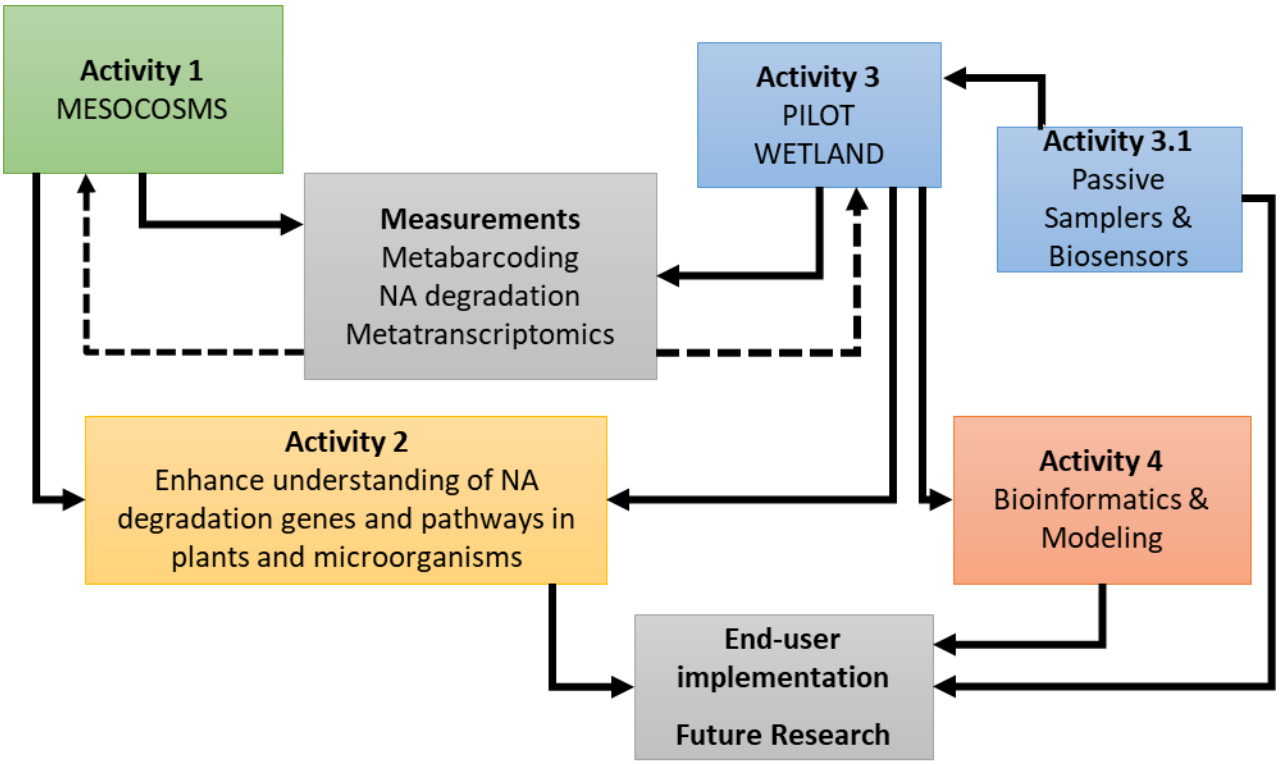
Affected person is used throughout this thesis as an individual directly affected by oil sands remediation through place, rights, experience, or livelihood. This term attempts to remove the economic implications felt with the term stakeholder (Sarkki et al., 2021) and within this study includes members of the Canadian public, scientists, regulators and policymakers, oil and gas industry employees, rights holders, non-local people with experience in similar contexts, and

local community members. Anyone who considers themselves impacted would qualify as an affected person, but different individuals are affected in diverse ways. While I did not set out to differentiate levels of impact in this early research based on gathering the perspectives that exist about CTWS and genomics, this is a necessary consideration for government and industry engagement processes. Environmental, economic, educational, ethical, legal, social, spiritual, and cultural considerations support which persons are most affected, and since Indigenous Peoples are living in the areas that will be most impacted by OSPW remediation, their lives will be affected in all aspects. Policies in Canada, including the duty to consult, emphasize that for issues like resource development and remediation, Indigenous Peoples are highly affected and therefore must be involved in the decision-making process. Thus, in weaving together viewpoints from many of the affected persons, including Indigenous Peoples, industry employees, scientists, regulators, policymakers, and a sample of the Canadian public, this study begins to catalogue perspectives and encourage the sharing of local and professional expertise regarding OSPW remediation and release (Hood, 2020; Jalbert et al., 2017).

My research is part of a five-year, large-scale, mixed-method *Genomics Research for Optimization of constructed treatment Wetlands for water remediation* (GROW) project that started in 2020 and seeks to use genomics-based methods to understand how wetland plants and microbes degrade and detoxify OSPW components including naphthenic acids and enhance the efficacy of CTWS (Muench & Martineau, 2020). As shown in Figure 1.1, the GROW project features multiple activities, including a CTWS pilot and extensive genomics-based measurements (Muench & Martineau, 2020).

Figure 1.2

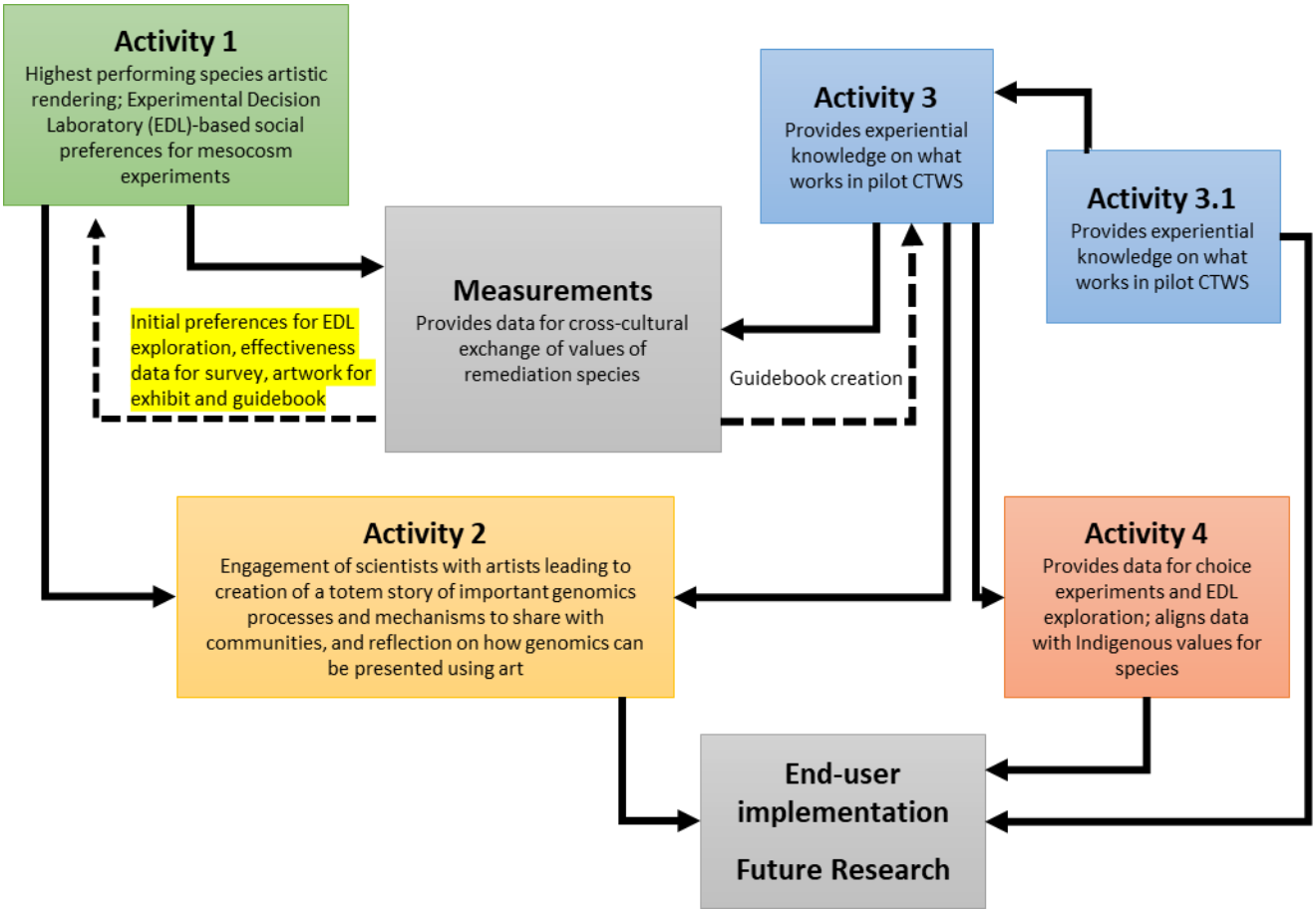
GROW Project Diagram



Within these activities are social science components that consider genomics and its environmental, economic, ethical, legal, and social (GE^3LS) implications. GE^3LS-specific activities are described in Figure 1.2 and include Indigenous engagement, interviews, choice experiments through Experimental Decision Laboratories (EDLs), and local and national surveys (Muench & Martineau, 2020). My study provides data for the EDLs and surveys, as highlighted in Figure 1.2 below and discussed further in the Methods chapter of this thesis.

Figure 1.3

GROW Project GE^3LS Components Diagram



Overall, there is a need to gather perspectives held by affected persons, especially those missing due to currently limited engagement approaches, about the contentious aspects of OSPW remediation using CTWS enhanced by genomics. Learning the existing perspectives will illuminate the information people use to make decisions and, therefore, provide decision points for subsequent research and OSPW release criteria and regulations. Within the framework of Cultural Theory (discussed in Section 2.5 Theoretical Frameworks), my thesis statement is: gathering perspectives from a range of individuals on the use of CTWS enhanced by genomics for OSPW treatment will illuminate the value and limitations of engagement with diverse affected persons. To elicit findings towards that thesis question, I had five objectives:

- Objective 1 – Gather opinions of a range of affected persons about CTWS and genomics from media and participant sources.
- Objective 2 – Identify barriers to participation in OSPW remediation using CTWS enhanced by genomics from the perspectives of a range of affected persons.
- Objective 3 – Identify specific arguments a range of affected persons make for and against CTWS enhanced by genomics.
- Objective 4 – Consider perspectives in the context of Cultural Theory to contemplate the state of participation in OSPW remediation.
- Objective 5 – Compile CTWS and genomics opinion statements with a range of affected persons to co-create a Q-method concourse and Q-set for future research.

2. LITERATURE REVIEW

2.1 Introduction

This review considers literature pertinent to the human dimensions of oil sands remediation. The review is organized into four themes that reflect the contextual information needed to inform my research objectives. The first two themes will provide the origin and urgency of the problem: I will review the background of the oil sands and then remediation of oil sands process-affected water (OSPW) with a focus on constructed treatment wetland systems (CTWS) and genomics. Because my research focuses on people directly affected by OSPW remediation (i.e., scientists involved in this project, Indigenous Peoples, regulators, policymakers, and industry representatives), I will next examine the state of participation in oil sands remediation, discussing transdisciplinary research and inclusive approaches to engaging Indigenous Peoples. Finally, I will describe Cultural Theory, the theoretical framework I used to inform the interpretation of my data.

2.2 Oil Sands Background

2.2.1 Bitumen Sources in the Oil Sands Region

Canada has the third-largest deposit of proven crude oil reserves globally, with 97% of these reserves contained in Alberta's oil sands (Dubé et al., 2021). Oil sands development began in 1967, and most production growth has occurred over the past 15 years (Tanna et al., 2019). The Alberta oil sands are made up of three regions: Athabasca, Peace River, and Cold Lake, with 81% of bitumen reserves within the Lower Athabasca and Cold Lake deposits (Dubé et al., 2021; Aksamit et al., 2020; Beausoleil et al., 2021). Major environmental concerns with oil sands mining include land disturbance, creation of complex by-products that require multi-staged remediation, and impacts to quality and quantity of water. The Athabasca River is the primary

source of water for oil sands processes, and freshwater makes up 0.5-2.5 barrels of the approximately four barrels of water required for each barrel of bitumen produced (Quinlan & Tam, 2015; Natural Resources Canada, 2015).

2.2.2 Oil Sands Surface Mining Process

The Athabasca oil sands deposit is the only one in Alberta shallow enough for surface mining (Dubé et al., 2021). According to websites for the four major oil sands producers, Canadian Natural, Imperial, Suncor, and Syncrude, oil sands surface mining is performed as follows: shovels dig up the sand and load it into trucks that take it to crushers where the ore is crushed into small pieces (Canadian Natural, n.d.; Imperial, n.d.; Suncor, n.d.; Syncrude, n.d.). The small pieces are filtered through screens and mixed with hot alkaline water to create a slurry that is piped to a separation vessel (Canadian Natural, n.d.). Gravity causes the sand and water to separate and settle at the bottom of the vessel, while tiny bubbles trapped in the bitumen cause it to form into froth and rise to the surface (Canadian Natural, n.d.). The bitumen froth is skimmed off, mixed with a diluent, and sent to be further processed, either at upgrading facilities or by paraffinic froth treatment (Canadian Natural, n.d.; Imperial, n.d.; Suncor, n.d.; Syncrude, n.d.). The slurry waste product is called tailings and contains mineral solids, OSPW, and small amounts of residual bitumen (Slingerland et al., 2019). Some coarse sand tailings are used at the mine site to rebuild mined-out areas or build tailings dykes and dams for above-ground tailings ponds (Slingerland et al., 2019). Up to 80% of the OSPW is recycled back to the extraction plant to be used again in the separation process (Canadian Natural, n.d.). The remaining waste slurry is transported to tailings ponds (Canadian Natural, n.d.; Imperial, n.d.; Suncor, n.d.; Syncrude, n.d.).

Oil sands tailings ponds and their associated dam structures, jointly known as Tailings Storage Facilities, are among the largest anthropogenic structures, with at least 16 existing or proposed in northern Alberta, covering 270 km^2 as of 2020 (Hui et al., 2018; OSIP, 2022; Slingerland et al., 2019). Tailings Storage Facilities are unique structures, as they are built continuously throughout the life of the mine, and unlike hydroelectric dams that generate value, tailings dams are a pure capital sink to producers (Hui et al., 2018). Although there have not been any serious tailings dam failures in the Alberta oil sands, such failures have been increasing throughout the mining industry elsewhere over time, resulting in loss of life, high capital expenditure, and damage to the environment (Hui et al., 2018). Further, recent incidents of OSPW seepage in May 2022 and a leak of more than 5,000 m^3 in February 2023 have highlighted tailings containment issues, emphasizing the urgent need for appropriate OSPW remediation and release decisions.

Mining and extraction of bitumen cause harmful contaminants to dissolve and collect in OSPW (Quinlan & Tam, 2015). The critical contaminant within OSPW is a broad family of organic compounds known collectively as naphthenic acids (McQueen et al., 2017; Muench & Martineau, 2020; Quinlan & Tam, 2015). Naphthenic acids are a primary cause of equipment corrosion during bitumen extraction, and they are also toxic to fish and mammals (Quinlan & Tam, 2015). Fish is prevalent in the diets of local and Indigenous communities, and impacts on wildlife adversely affect harvesting, cultural and spiritual practices, and intergenerational knowledge transfer for Indigenous Peoples (Westman & Joly, 2019). Regulations prohibit the release of OSPW, so tailings ponds have been expanding with accumulating OSPW since 1967, waiting for an effective and efficient remediation technique and policy for release (Tanna et al., 2019).

2.3 Remediation of OSPW

2.3.1 Current Management of OSPW

According to Tanna et al. (2019), responsible management of OSPW must consider multiple approaches, including conservation, reuse or recycling, and release. Conservation is addressed by the Government of Alberta's water usage regulations, and approximately 80% of OSPW is currently recycled (Natural Resources Canada, 2015). There are practical limitations to recycling OSPW as it reduces extraction efficiency, and further issues arise from its reuse, such as corrosion (Tanna et al., 2019). Current government policies for oil sands development rely on the safe return of treated OSPW to the environment, but no releases have been approved so far (Tanna et al., 2019). For industry to either recycle or release OSPW, a treatment method must be found to reduce contaminants, particularly naphthenic acids, to a level deemed acceptable (Quinlan & Tam, 2015) in future regulations, as there are currently no guidelines for naphthenic acids in OSPW (Government of Canada, 2018).

2.3.2 Importance of Remediation

Due to severe and extensive land contamination from industrial development and mining, remediation is a global issue, and remedial actions have significant environmental, social, and economic impacts (O'Connor et al., 2019). Many technologies have been developed to clean up industrial pollution, from excavation to reagents that stabilize toxins; however, according to Page & Atkinson-Grosjean (2013), most technologies developed to remediate contaminated sites use the same depreciative approach that caused the environmental problem in the first place and lead to further environmental concerns. As such, Page and Atkinson-Grosjean (2013) call for the public to scrutinize all remediation technologies. Table 2.1 gives examples of five types of

available OSPW remediation technologies and their processes and issues, as summarized from Quinlan and Tam (2015).

Table 2.1

OSPW Remediation Technology Examples

Remediation Technology	Remediation Process Snapshot	Ongoing Issues (additional needs and problems with the technology)
Advanced oxidation	Oxidation reactions with hydroxyl radicals produced in situ by some stimulus, such as a transition metal catalyst, UV light, or O_3 degrade chemical compounds	• May only partially degrade chemical compounds which may result in even more toxic products than the initial naphthenic acids • Resource intensive, so high operating costs
Bioremediation	Specific microbes naturally metabolize soluble organic matter, resulting in partial or complete degradation	• May only partially degrade chemical compounds • Can be a very slow process
Coagulation/ flocculation	Small particles are coagulated to form larger particles, which are then separated from solution by flotation (physical separation by attaching air bubbles to suspended particles) or sedimentation (physical separation using gravity)	• Usually requires significant chemical coagulants and flocculants, resulting in high operating costs • Produces significant sludge, so further processing would likely be required
Membrane filtration	OSPW is passed through a porous immobilized solid material, which removes select solutes using mechanisms such as electrostatic attraction or size exclusion	• Fouling of the filter slows down the process and may reduce removal efficiency – remedy requires use of water or chemical treatment, which then must be stored or treated
Adsorption	A physical or chemical process where components of a multi-component fluid mixture preferentially concentrate on the surface of a solid adsorbent – most commonly studied adsorbent for removal of NAs is activated carbon	• High efficiency adsorbents may be expensive • Processes are complex, may be energy intensive, and will produce gaseous emissions with particulates and volatile organic compounds

The Green and Sustainable Remediation movement pushes for "informed, integrated, and holistic management of contaminated sites" (O'Connor et al., 2019, p. 295). Such management for oil sands tailings ponds requires consideration that additional obstacles for treatment of OSPW include the presence of bitumen and suspended solids in the tailings ponds, which would likely require preprocessing clarification stages, high salinity and alkalinity which hinder remediation processes, and the cold weather experienced in northern Alberta winters (Quinlan & Tam, 2015). Further deliberation is required about each remediation technology's ability to scale to the level required for the volume of OSPW. Noting the inclusion of 'holistic management' in the remediation movement's goals, the discovery and confident implementation of remediation technology that does not unduly harm social, cultural, and spiritual values alongside environmental, legal, and economic ones is needed (Gerbrandt & Westman, 2020). A remediation technology with the potential to satisfy many of these factors is bioremediation.

2.3.3 Bioremediation

Bioremediation relies on plants, fungi, and/or microscopic organisms such as bacteria to break down contaminants into less toxic forms (Page & Atkinson-Grosjean, 2013). Affected persons, including communities and Indigenous peoples, tend to prefer bioremediation to other methods due to its reduced effects on the environment and, in some cases, are willing to pay an increase in annual taxes to implement natural technologies instead of remediation technologies involving chemicals (Huynh et al., 2018; Page & Atkinson-Grosjean, 2013).

2.3.3.1 Constructed Treatment Wetland Systems (CTWS)

The bioremediation approach of constructed treatment wetland systems (CTWS) is one of few technologies with the potential to reliably handle the large volume of OSPW and its complex mixtures of contaminants (Hendrikse et al., 2018; McQueen et al., 2017; Rodgers & Castle,

2008). CTWS create conditions required for beneficial plants and microbes to grow, and as wastewater flows through CTWS, these microbes alter the chemistry of contaminants through natural metabolic processes and render them inert (Page & Atkinson-Grosjean, 2013). There is proof of concept that CTWS work for OSPW remediation, including pilots by McQueen et al. (2017) and Hendrikse et al. (2018) that successfully decreased contaminant concentrations and degraded naphthenic acids. However, the optimal conditions for a CTWS to degrade and detoxify contaminants in OSPW are not well understood (Simair et al., 2021). Investigation into the processes, pathways, and relationships between functionally important microbes can be done using genomics (Page & Atkinson-Grosjean, 2013).

2.3.3.2 Genomics

Bioremediation using CTWS may be enhanced by applying genomics, which Page and Atkinson-Grosjean (2013) define as "the analysis of genetic material derived from communities of microscopic organisms" (p. 271). Genomic analysis seeks to enhance understanding of the mechanisms of biodegradation, informing methods and increasing bioremediation efficacy (Muench & Martineau, 2020; Page & Atkinson-Grosjean, 2013).

Further research is needed to determine the efficacy of CTWS enhanced by genomics in Alberta's climate, ensure it is safe according to regulatory agencies and against engineering and environmental standards, and learn whether the method acceptable to affected persons (Hendrikse et al., 2018; McQueen et al., 2017; Muench & Martineau, 2020). Knowledge of opinions of affected persons regarding CTWS enhanced by genomics is very limited (Page & Atkinson-Grosjean, 2013) and non-existent in the context of OSPW remediation.

2.4 Participation in Remediation Research and Decision Making

While frameworks on how to build participation from community members and other affected persons emerged from the 1960's onward, such as Arnstein's ladder of citizen participation (Figure 1.1, Arnstein, 1969), there are few examples of moving that participation beyond placation, consultation, and informing levels in the oil sands region (Urquhart, 2019). According to Huynh et al. (2018), more inclusive and participatory approaches for evaluating technologies to remediate contaminated environments have emerged from Western engineers and scientists over the last few decades. These approaches attempt to involve all affected persons, including the public, based on growing awareness that complex environmental challenges require many perspectives, disciplines, and knowledges (Huynh et al., 2018). For example, a government-funded National Framework for Remediation and Management of Contaminated Sites in Australia had an extensive and inclusive companion guideline for stakeholder engagement in 2014 [which was reworked to the National Remediation Framework (NRF) in 2019 found here: https://www.remediationframework.com.au/] (CRC CARE, 2019). Despite this assertion of inclusivity and participation in stakeholder engagement in Australia, Prior (2018) found a gap in knowledge of whether residents near contaminated sites will accept remediation technologies and, if so, which factors influence their level of acceptance. Other researchers assert that deliberate delays in accepting technologies for remediation arise because of three beliefs: a better technology will emerge to resolve lingering problems of existing ones (e.g., better processes for remediating by-products of naphthenic acid); 'political will' will change so more expensive but better remediation processes will be taken up; and/or opportunities for more Indigenous leadership will emerge providing a chance to demand preferred options (Hoberg, 2019; Hoffman et al., 2009; McLaren et al., 2023).

In Australia, the NRF has evolved with a new version in 2019, yet no studies were found to evaluate its impact according to affected persons, or whether it leads to preferred options from the perspectives of affected persons being implemented more often. Another pathway to more acceptance of remediation options by local people includes involving affected persons in the planning stages. However, Aksamit et al. (2020) identified problems with meaningful collaboration in the oil sands, starting with the initial Environmental Assessment (EA) prior to project approval. Participants in that study included EA consultants acting on behalf of an oil company, a member of the EA review panel, provincial and federal regulators, representatives of non-government environmental organizations, and Indigenous representatives (Aksamit et al., 2020). These individuals expressed concern about a lack of Indigenous engagement and communication between project proponents and communities, particularly regarding areas of uncertainty around key issues such as tailings management and remediation, and reclamation measures (Aksamit et al., 2020). Without strong engagement and communication, researchers assert that there cannot be trust between the affected persons (Poelzer et al., 2022). According to Westman and Joly (2019), the individuals and communities most impacted by the oil and gas industry feel marginalized, powerless, and under-informed. In the context of this study, affected persons living downstream of oil sands facilities are essential participants in decisions about OSPW remediation and subsequent releases.

2.4.1 Transdisciplinary Research in the Oil Sands Remediation Context

To encourage engagement and communication and address the gap in social science research on oil sands extraction, we need tools that allow dialogue among participants to bring forward diverse perspectives for consideration in remediation (Westman & Joly, 2019). Transdisciplinary research seeks to weave together different approaches and kinds of knowledge

from people inside and outside academia (Steelman et al., 2021). According to Steelman et al. (2021), a central argument for transdisciplinary research is that robust solutions, such as the use of socially, culturally, and spiritually accepted OSPW remediation techniques, will result from "problem-oriented work in collaboration with partners" (p. 642). This collaboration would happen with affected persons acting at higher rungs in various ladders of participation, such as having a high degree of citizen power (Arnstein, 1969) or as leaders (Connor, 1998). Cash et al. (2002) argue that managing boundaries between science and policy requires information with three attributes: salience, credibility, and legitimacy, with the ultimate problem being that affected persons perceive the attributes differently. Salience is achieved when problems are addressed at the local level with solutions from local people and their knowledge systems (Cash & Belloy, 2020). According to Cornell et al. (2013), knowledge systems are libraries of tangible and intangible information and ways of living made up of agents, practices and institutions that organize knowledge production, transfer, and use. Western science, for example, is one knowledge system, while theological adherence to biblical tenets is another, and a third is following locally held knowledge of ecological processes and stewardship of those processes which support human existence without having to study those processes to discover objective physical truths that govern them (Cornell et al., 2013). Credibility is achieved when knowledge is linked directly to locally effective action, while those involved are attuned to norms and processes in institutions where decision-makers act on trusted information (Cash & Belloy, 2020). Legitimacy is achieved when the most vulnerable or affected are involved and can see the knowledge-action processes as more transparent and inclusive (Cash & Belloy, 2020). In the context of oil sands remediation, inclusivity has been put forward to mean effective, democratic control over the region's expansion, operation, and restoration (Bowness & Hudson, 2014).

However, current engagement methods with affected persons have not led to that democratic control nor effective solutions (Westman & Joly, 2019), with researchers suggesting it is the methods of engagement and the level of participation that need adjustment (Arnstein, 1969; Gerbrandt & Westman, 2020) so that a high deliberative quality of conversation around remediation can occur.

In this study, I sought to achieve the objectives described above through a transdisciplinary co-design approach to creating the research tools for future steps in the GROW project in which my project is embedded, moving up Arnstein's ladder from informing, consultation, and placation to partnership (Arnstein, 1969; Eabrasu et al., 2021). In involving rights holders and stakeholders from across the oil sands region in the work and in the design of future research tools, the goal was to have participants experience the blending of thought from scientists, non-scientists, and local people in the research beyond the placation of unidirectional consultation. Affected persons working together to build a thorough list of perspectives on OSPW and CTWS will advance the problem-solving ability around remediation in the region to involve many perspectives and knowledge systems (Steelman et al., 2021). Jalbert et al. (2017) addressed knowledge disparities between affected persons in the unconventional oil and gas extraction sector and concluded that mobilizing information can encourage public participation in environmental governance. My study's online methods and the mobile nature of the future research activities that my findings will support, including a travelling Experimental Decision Laboratory where decision pathways of participants are studied in a game-like context, can bring together community expertise and professional expertise in diverse venues where the exchange of knowledge can make meaningful contributions to decision-making (Bradford et al., 2019; Hood, 2020; Jalbert et al., 2017; Muench & Martineau, 2020; Strickert et al., 2016).

2.4.2 Inclusive Approaches to Engaging Indigenous Peoples

Indigenous Knowledge and practices regarding water have been largely ignored in favour of Western science and management methods, even though water-related issues disproportionately affect Indigenous communities in Canada (Castleden et al., 2017). As of 2017, little progress had been made to improve drinking water in Indigenous communities despite significant spending (Castleden et al., 2017; Morrison et al. 2015). This failure, among others, has convinced Indigenous Peoples to assert self-determination and Western scientists to move towards bridging Western approaches with Indigenous Knowledge for environmental issues broadly and water issues more specifically (Castleden et al., 2017). Strategies for the successful braiding together of approaches are only beginning to emerge and were summarized into four interconnected themes by Castleden et al. (2017):

- Challenge the privilege held by Western ways of knowing;
- Acknowledge that power dynamics stem from colonialism and eliminate unequal decision-making between researchers and Indigenous Peoples;
- Develop awareness about constitutionally bound and legally derived Indigenous rights and Indigenous responsibilities for or about water;
- Build on existing relationships, approach new relationships with openness, and be responsive and flexible to direction from Indigenous peoples.

In consideration of the need to actively engage with Indigenous perspectives in this work, I sought to make my study methods accessible to Indigenous affected persons by hosting an Indigenous Peoples-specific focus group (explained in Chapter 3 - Methods) and hosting that

session last so that Indigenous perspectives would not be discarded, adjusted, or invalidated by the other groups.

2.5 Theoretical Framework: Cultural Theory

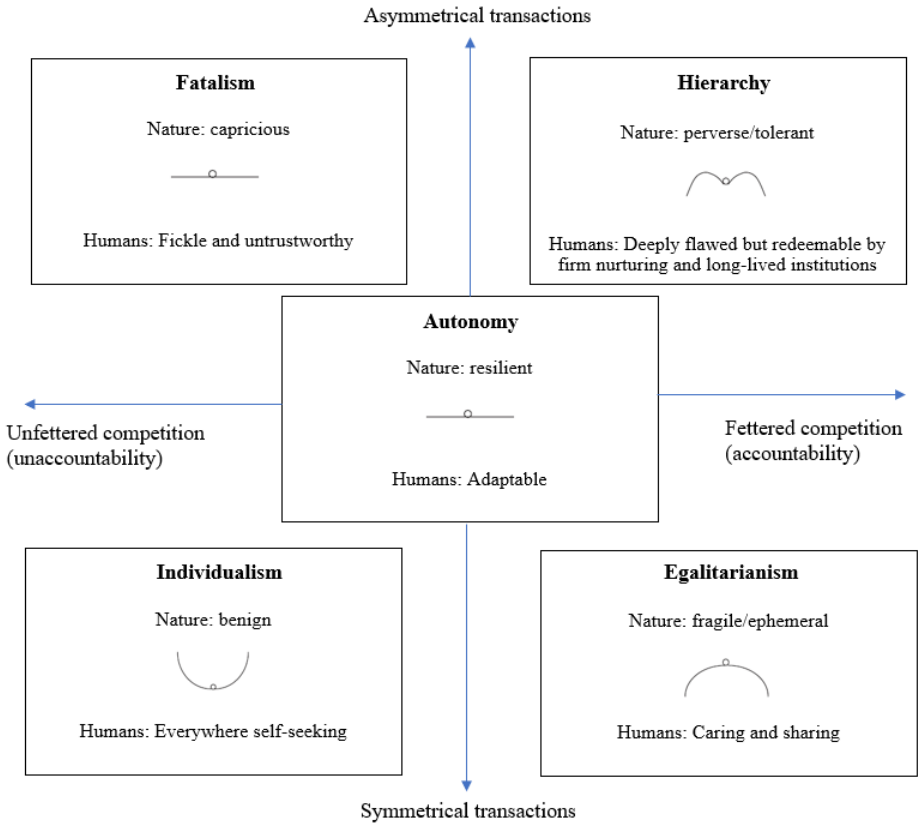
In addition to incorporating multiple viewpoints in OSPW remediation into this research, I also considered a variety of theoretical frameworks that can enhance the understanding of decision-making processes, influences, and leverage points for natural resources projects (Constantino et al., 2021; Francis, 1990; Talley et al., 2016). Three frameworks I considered were Cultural Theory (Beck et al., 2011; Thompson et al., 1990), Political Ecology (Robbins, 2012), and Multi-level Selection (Wilson et al., 2020; Witoszek & Midttun, 2018). Cultural Theory was selected because it allows for consideration of multiple perspectives (Strickert, 2011) and is a useful heuristic for understanding the worldviews held by different individuals and groups (McEvoy et al., 2017).

Cultural Theory presents human and physical nature in terms of a fivefold typology of social solidarities or ways of life: individualism, hierarchy, egalitarianism, fatalism, and autonomy (Thompson et al., 1990; Thompson, 2003). Cultural Theory's roots lie in Durkheim's (1987) work proposing that social organization could be classified into just two dimensions – social integration, which describes how social life is constrained within a group, and social regulation, which considers how social life is structured by rules and roles (Strickert, 2011). Almost 150 years later, Douglas (1970) cross-tabulated the two dimensions on a social spectrum around competition and transactional quality, clearly illustrating four ways of life. Thompson et al. (1990) took Cultural Theory from static to dynamic by introducing a fifth way of life, autonomy, to explain an individual's ability to change based on the situation.

Each social solidarity depends on a social construction or myth of nature (physical and human), as depicted in Figure 2.1 (Beck et al., 2011; Dake & Thompson, 1999; Strickert, 2011).

Figure 2.1

Cultural Theory Social Solidarities and Their Associated Myths of Nature



Douglas' (1970) plot showed how there can be competition between solidarities and collusion between others. With oil and gas development, as with most resource development, collusion is perceived between the hierarchal and the individualistic actors, also known as a colluding dyad (Salam, 2021; Parson and Ray, 2018)

The goal of Cultural Theory is to achieve high deliberative quality by maximizing accessibility and responsiveness, where each group persuasively voices its point of view and

acknowledges a responsibility to hear out the others, resulting in constructive discourse (Thompson, 2003). High deliberative quality means that perspectives from the five ways of knowing are gathered and used in coming to a set of potential solutions to a problem and that a solution emerges that includes these perspectives in a way that satisfies affected persons each to some degree. Cultural Theory, then, through its impossibility theorem (i.e., that there are five, and only five, different ways of approaching a problem or making a judgement on a solution), helps us gauge the quality of deliberations (Dake & Thompson, 1999). Thompson (2003) credits Cultural Theory with the ability to make sense of complicated issues typically beyond the grasp of conventional social science wisdom, but critics of Cultural Theory contend that it is a descriptive theory that does not take a strong stance, allowing for circular, unrelated, and disconnected theoretical arguments (Boholm, 1996). Thompson (2011) considers Cultural Theory to be most applicable in the context of wicked problems, a term developed by Rittel and Webber (1973) to describe unique problems where several characteristics interconnect, such as a wide range of possible causes and solutions that involve many people and groups, where no perfect solution exists, and where attempts to resolve the problem leads to new problems. Remediation of OSPW is a wicked problem for several reasons: the tailings ponds are massive anthropogenic structures; potential solutions are unclear or have serious consequences (as described in Table 2.1); numerous groups (governments, industries, and the public) are all involved, and time is of the essence; therefore Cultural Theory is suitable for this study (Thompson, 2011). According to Thompson (2011), the best solutions to wicked problems are clumsy solutions, where people forgo the solution that best suits their way of life (i.e., the elegant solution), and collaborate with others to find a solution that incorporates experience and wisdom from all ways of organizing. If a clumsy solution is selected, each group receives less of what

they do not want and more of what they do want (Thompson, 2011). Verweij (2023) argues that although Cultural Theory's clumsy solutions may be the key to successful governance for climate change, further elaboration is required to take clumsy solutions from theory to praxis. He points to various decision-making tools that facilitate the interaction required to develop these solutions, such as more conventional research methods like multisector systems analysis (Beck et al., 2018) and emerging methods like "serious games," where stakeholders play carefully designed boardgames with goals of collaboration and social learning (den Haan, 2020; Verweij, 2023).

2.6 Summary

The above contextualizing of issues with oil sands remediation confirms that gaps exist in frameworks used to understand complex environmental and policy intersections, in the knowledge of preferences for remediation techniques, and, more specifically, in overall participation in oil sands decision-making. Co-designing and implementing research with partners, including the public and Indigenous Peoples, about bioremediation is expected to contribute to social science research on preferences for eventual remediation planning and release criteria for the wastes from oil sands development, mobilizing knowledge and stimulating learning. To further enhance inclusivity in decision-making, Cultural Theory is considered a useful framework to ensure I can identify the completeness and quality of the perspectives I collect through my research results.

3. METHODS

3.1 Introduction

My research is part of a five-year, large-scale, mixed-method *Genomics Research for Optimization of constructed treatment Wetlands for water remediation* (GROW) project that started in 2020 and includes a CTWS bioremediation pilot, genomics science and extensive bioinformatics, and a nationwide survey conducted by and interdisciplinary teams of researchers across Canada (see Muench and Martineau, 2020). The GROW project includes research considering genomics and its environmental, economic, ethical, legal, and social (GE^3LS) implications. In the mixed-method strategy used in the GE^3LS investigation, different researchers implement their own individual quantitative and qualitative methods, with interaction and communication between the team being what Greene and McClintock (1985) termed "semi-independent" (p. 525). The project uses concurrent methods, i.e., methods happening independently simultaneously, and development methods in which different methods are applied sequentially to inform and advance the subsequent methods (Greene et al., 1989; Strickert et al., 2010). Development is one of the purposes Greene et al. (1989) identified for mixed-method research design, with the other four being triangulation, complementarity, initiation, and expansion (p. 259). Triangulation seeks to confirm results by minimizing the bias of methods, inquirers, theory, and context (Greene et al., 1989; Flick, 2018). According to Greene and McClintock (1985), the lack of methodological independence within a semi-independent strategy limits the project's capacity for triangulation. Complementarity is achieved through the simultaneous and interactive implementation of qualitative and quantitative methods to enhance and support each other by capitalizing on method strengths and offsetting method biases (Greene et al., 1989; Ramlo, 2022). Initiation seeks to find new perspectives and paradigms, and an

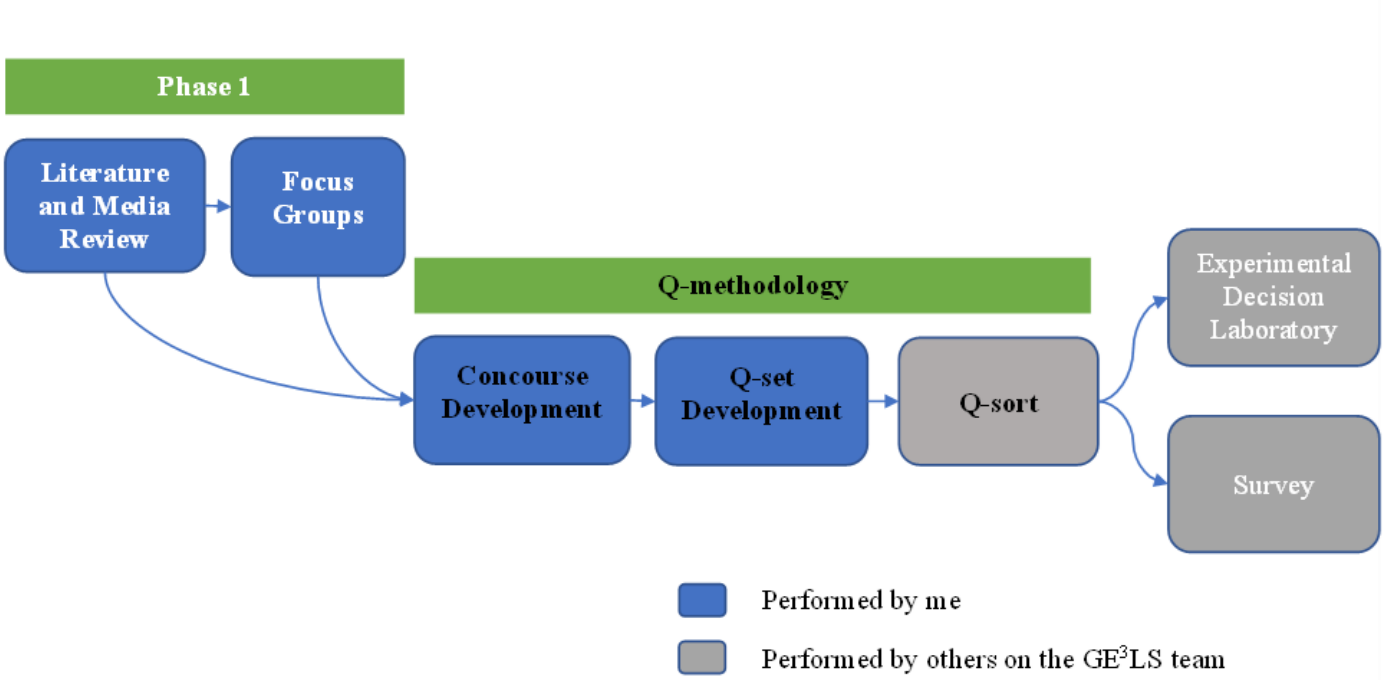
expansion-driven study uses multiple components to increase scope and breadth (Greene et al., 1989).

As per Figure 2.1 (the overall figure of GE^{3}LS work earlier), my work is focused on developing the comprehensive list of perspectives held by affected persons about remediation using CTWS for OSPW. My work focuses on social science and does not include natural science or engineering research. I used sequential mixed methods in my research, drawing from the findings of one method and using them to inform my further methods and results. The sequencing encouraged participant engagement and allowed flexibility in methods of gathering perspectives from investigating secondary sources and passive research, to live in-person primary data generation (Greene et al., 1989; Strickert et al., 2010). The primary goals of my mixed-method research were development and complementarity, which means they informed what was discussed at each step and contrasted or reinforced earlier findings from methods I employed initially (Greene et al., 1989; Ramlo, 2022). The flow chart in Figure 3.1 shows the sequencing of methods in my research and other methods my research directly affects within the GE^{3}LS portion of the project.

Figure 3.1

Methods Flow Chart

The literature and media review provided statements and search results that informed



how my focus groups were conducted and used within Q-methodology (explained below). The data from Phase 1 fed into Q-methodology, and the results from Q-methodology will inform the Experimental Decision Laboratory and Survey. While the literature and media review and focus groups provided their own results, they support and reflect on Q-methodology's unique ability to combine the qualitative data of subjectivity with the quantitative method of factor analysis (McKeown & Thomas, 2013; Sardo & Sinnett, 2020; Sneegas et al., 2021). As a result, these methods were used within the context of Q-methodology.

Q-methodology, hereafter referred to as 'Q-method,' was developed by physicist and psychologist William Stephenson and presented in 1935 via a letter to Nature, in which he promoted his novel method of factor analysis, which factored individual perspectives rather than traits (McKeown & Thomas, 2013). Q-method is appropriate to gather perspectives on OSPW treatment and genomics, as it is increasingly being used for research considering diverse

opinions on resource development and management where stakeholders must cooperate on a shared problem (Edgeley et al., 2020). Q-method works by first creating the concourse, or entire discourse about the topic, by gathering all possible subjective perspectives or statements (or photos, words, novels, or whatever collection of tangible and intangible things is being collated to help inform the generation of a solution). Second, that concourse is given to a population of affected persons (the P-set) to sort on a distribution which gives specific instructions (e.g., sort these into a grid from least most like you think to most like you think or least agree to most agree). Third, the sorted collections are factor-analyzed to identify common narratives that will be shared and included when problem-solving so that no voices go unheard at the decision table (McKeown & Thomas, 2013).

Q-method is valid for contentious issues without consensus (Sinnett & Sardo, 2020). According to Sneegas et al. (2021), "Q-method offers researchers replicable, evidence-based results that may support decision-makers in management options assessment, critical reflection, policy appraisal and acceptability, and conflict resolution" (p. 1).

My research considered the steps for Q-method as described by Sardo and Sinnett (2020):

1) Develop the concourse and the Q-set;

2) Determine the participants or P-set;

3) Conduct the Q-sort;

4) Perform Factor analysis;

5) Construct narratives around the factors.

This study covers the first step, with the remaining to be performed in future research. Developing the concourse represents a significant step in the Q-method process because it involves seeking all perspectives on a topic much the way a systematic review would seek out all research findings on a particular intervention; however, with the goal of transdisciplinarity, concourse development for this study involved both reviewing of published works as well as engaging with affected persons. Q-methodology studies are not without constraints. A review of 52 Q-methodology studies in environmental conservation contexts by Zabala et al. (2018) advised that "[t]he various stages in the process take considerable time, and in our experience some researchers underestimate its complexity due to the relatively straightforward quantitative analysis involved" (p.1190). Completing the first step represents a meaningful advance of the entire study because the first step builds the tools to be used in the subsequent steps, which will include an online Q-sort using a platform with embedded coding for analyses and output creation.

Further, contextual factors interfered with the planned engagements with affected persons delaying my study. These factors included COVID-19 pandemic restrictions which meant I could not travel to communities or oil sands industry sites for engagement, and a significant tailings pond seepage event in 2022 at one of the sites with subsequent poor communication with local people. The communications breakdown meant that research related to oil sands remediation, including planned community engagement for social sciences work in the overall project, was paused at the request of communities.

3.2 Concourse Development

The concourse represents the entire discourse about the topic, bringing together all elements subject to diverse interpretations (McKeown & Thomas, 2013). McKeown and Thomas

(2013) recognize two types of concourse material: naturalistic and adapted, or ready-made. Naturalistic statements are derived from participants' communication with the express purpose of concourse building, such as interviews or focus groups, while adapted concourses draw from existing published sources like print media (Damio, 2016; McKeown & Thomas, 2013). My concourse combines the two types into "hybrid samples," using opinion statements developed in focus groups to complement statements pulled from ready-made sources, including literature, news articles, podcasts, and Twitter (McKeown & Thomas, 2013, p. 40). The focus groups will discuss the same topic and add to or alter perspectives on the topic gleaned from literature and media sources. The resulting outputs from Step 1 in the Q-methodology process will deliver a complete set of statements or perspectives affected persons hold about using CTWS enhanced by genomics to remediate OSPW.

3.2.1 Literature and Media Review

I performed a literature and media review (MacNamara, 2005) to develop a baseline of opinion statements on OSPW remediation using CTWS enhanced by genomics. I began my search using defined search terms (genomics, oil sands processed water, constructed wetlands) and synonyms of those terms in Google searches for news and social media sources. I collected 'hits' in a table (Appendix-A) and drew out the perspectives as concrete statements for use in the focus groups. Then I open-coded, which means to label data as conveying the same idea or concept as other data within the category (Moghaddam, 2006). The open coding of literature and social media statements resulted in two broad categories: Remediation and Release, and Bioremediation and Genomics. I set a goal of either 1) inductive data saturation, where researchers allow the data to determine themes which means that continual analysis of data occurs until the point where no new categories or themes are emerging despite ongoing data

collection (Saunders et al., 2018), or 2) 100 statements total as per good practices in Q-methodology theory, where the final Q-set for most studies range from 40 to 60 statements, but settling on the statements is "more an art than a science" (Brown,1980 as cited in Van Exel & De Graaf, 2005, p. 5). I continued searching until I felt that data saturation was reached. While this reflects practice in qualitative analyses, I recognize that there are limitations because of the subjectivity of each researcher in deciding whether a fair representation of perspectives has been achieved (Sebele-Mpofu, 2020).

I focused on direct quotes or published opinion pieces to find these statements written by experts, editors, or public opinions. My initial searches in the USearch database largely found technical papers without opinions. After reviewing all relevant papers in the Genome Canada application, I used the University of Saskatchewan USearch database, which scours University-held sources such as books, e-books, databases and journal publications, theses and other publications uploaded by researchers, news media, and video sources to search for online news articles and YouTube videos. I also searched Twitter and Apple Podcasts for opinion statements (Appendix A). Emerging research is demonstrating that social media channels are rich sources of ethnographical qualitative and quantitative data such as opinions and cultural trends; thus, the search of popular social media and Google news sources was deemed relevant to the objectives of this work, which was to collect and catalogue all potential perspectives on CTWS enhanced by genomics for remediation of OSPW (Giglietto et al., 2012; Snelson, 2016). Little information was available about CTWS and on using genomics to enhance this technique, illuminating the need for an introduction before the focus groups.

3.2.2 Focus Groups

Although Q-method theory lists focus groups as a naturalistic statement source (i.e., arising from everyday conversations), they have not been widely used (Sneegas et al., 2021). This omission is a gap in the existing application of Q-method. Focus groups are a good source of statements because the interaction between participants fosters more discussion than other research methods, such as individual interviews supply (Hay, 2016). They provide a rich variety of statements through a "synergistic effect" and exposure to different points of view (Hay, 2016, p. 204). According to Lunt and Livingstone (1996) (as cited in Hay, 2016), focus groups can be helpful in highly politicized contexts, which appropriately describes the remediation and release of OSPW, CTWS, and genomics. However, focus groups too have drawbacks, which can include tensions and dissent around divergent opinions. In the case of developing a concourse where all perspectives are desired and catalogued, divergent opinions are invited.

3.2.2.1 Focus Group Participants

In seeking to understand the variety of perspectives around CTWS and genomics, I sought representation from a wide variety of affected persons and groups in my focus groups (industry workers, members of Indigenous and non-Indigenous communities, government regulators and policymakers, scientists, and the public having experience in similar contexts living locally or not). As with Bedford and Burgess' (2002) research (as cited in Hay, 2016), each focus group was made up of people from a specific group, resulting in "homogeneity within the focus groups and heterogeneity between them" (Hay, 2016, p. 209). The shared characteristics of focus group members within groups enhanced discussion on our controversial topics, while the diversity between groups supported collecting a range of opinions (Hay, 2016). To ensure there were enough participants to encourage discussion but not so many that each participant did not

have the opportunity to contribute, there were between five and seven participants per group (Hay, 2016). One participant could not attend a group session, so an interview was conducted using the same methods as the focus group.

A pilot focus group was held as an essential step in tool design and development (Rattray & Jones, 2007) with a diverse group of peers from engineering, environment and sustainability, and social science disciplines at the University of Saskatchewan. For oil and gas industry participants, I followed recommendations put forward on industry-university partnership development, which included giving a short background to leaders and/or representatives with research portfolios to attract interest and subsequently build a network for communication with potential participants (Boucher et al., 2004). I began by presenting information about my research to the Canada's Oil Sands Innovation Alliance (COSIA) Mining Subcommittee. Following that presentation, two attendees emailed me lists of potential participants. I created a Doodle Poll (https://doodle.com/en/product/polls/) to determine participant availability, and after some back and forth, we held an online session. Similarly, for the regulator and policymaker group, I phoned the Alberta Energy Regulator (AER) office and was told to email my research information and participant request. The contact who replied snowballed with other AER employees, and again we did a Doodle Poll to select a date. I did the same with the Alberta Environment and Protected Areas Agency (AEPA), and we held a joint AER and AEPA session.

The scientist participants were found through Principal and Co-Investigators from the natural science activities of the GROW project. After networking and another Doodle Poll, interview and a focus group sessions occurred to co-create perspectives with the scientists. To recruit Indigenous participants, my supervisors put me in contact with potential participants through their networks from community-driven research with Indigenous communities and

through Indigenous faculty members. Initial participants included both community members and academics. These contacts snowballed until enough participants for a session with Indigenous Peoples were recruited. This approach is also noted as credible by Indigenous scholars (i.e., Guillemin et al., 2016; Paine et al., 2013).

3.2.2.2 Focus Group Methods

Each session was approximately 60 minutes. Focus groups were conducted following guidelines, including starting with introductions and describing the purpose of the focus group, then using broad questions to prime thinking around a topic before asking more specific questions and eliciting specific examples from participants (Nyumba et al., 2018; Stewart & Shamdasani, 2014), and I used Padlet (http://padlet.com/) (an emerging tool for use in educational and research settings) as a virtual workspace and visual tool to display and develop statements and themes with my focus groups (Deni & Zainal, 2018). I wrote each statement in a box and colour-coded them by theme in Padlet. I held a pilot focus group, and the online format and the Padlet worked smoothly.

Participants were asked to read the opinion statements under each theme at their own pace and then had the opportunity to add, modify, or delete statements. All subsequent discussions began around the existing statements. Added or changed statements were seen by later focus group participants who built on those statements.

The sessions were recorded through Zoom. The pilot recording was transcribed manually, and the remaining recordings were transcribed using Rev Transcription services (Rev.com, 2023) and then reviewed for accuracy.

The transcriptions were analyzed to confirm that statements for the concourse were captured accurately. Although McKeown and Thomas (2013) describe the volume of a concourse as "infinite" (p. 37), my goal was to compile 100 statements *or* to reach saturation, the point where no new information or insights are being learned (Eden et al., 2005; Hay, 2016).

3.3 Q-set Development

Once we had completed the focus groups, the final concourse was curated by obtaining input on the statements from a diverse selection of academics, asking for clarification and justification of their viewpoints, and performing iterative reviews in a modified Delphi approach (Esfandiari et al., 2023). According to Esfandiari et al. (2023), the Delphi method is typically an iterative process with systematic rounds of ranking concepts until group agreement is reached. A modified version asks for input individually and then a group discussion finalizes the results (Esfandiari et al., 2023). The entire concourse was reviewed by me, Dr. Bradford, and Dr. Strickert with the goal of a finalized set of 50 statements, which was in line with Q-methodology (Van Exel & De Graaf, 2005). We went through the statements by theme and distilled the key messages of each theme and all the statements within. We ensured the statements were short and easy to understand, accurately represented what was said in the concourse, and contained "excess meaning," meaning they can be interpreted differently by different sorters (Webler et al., 2009, p. 9). I refined the resulting list of statements, and it was reviewed by members of the Human Dimensions of Water Security Lab Group, and then refined by me again. The final list was sent to one more key stakeholder, a professional editor and linguist, and then refined by me again.

3.4 Theme Development

Once all focus groups were complete, the transcripts were loaded into NVivo and open-coded line-by-line (i.e., using wording that participants used in the focus groups) (Glaser, 2016).

The codes were collated into themes by identifying the common properties and grouping those with the same common properties under the same concept. This step involved my interpretation as a researcher to identify the meaning behind each statement, look for similar word choices, patterns of phrases, and repetitions, for example, genomics was also phrased as genetics, genetic modification, and genetic science where all three terms reflected the study of genome components towards improving the efficiency of CTWS as described by participants. I created codes and nodes in NVivo, and then categorized nodes and codes together into themes.

3.5 Concourse Statement Analysis Using Cultural Theory

Using a framework originally created by Schwarz and Thompson (1990) (Table 3.1), I classified each concourse statement based on which social solidarity it aligned most strongly with.

Table 3.1

Classification System for Cultural Theory

	Individualism	Hierarchical	Autonomy	Egalitarian	Fatalism
Myth of nature	Benign	Perverse and tolerant	Resilient	Fragile/ Ephemeral	Capricious
Perception of time	Short term	Short or long term	Eternity/Now	Long term	Illusion
Ideal scale	Appropriate	Large	Nested	Small	Illusion
Engineering esthetic	Appropriate	High Tech	Depends	Frugal	Denial
Energy future	Business as usual	Middle of the road	Diverse	Low growth	Atomized
Desired system properties	Exploitability	Controllability	Resilience	Sustainability	Copability
Salient risks	Threats to market functions	Loss of the public trust	Ignorance	Catastrophic, irreversible and inequitable developments	Life, the Universe, and everything in it
Risk handling style	Acceptance and deflection	Rejection and absorption	Contemplation	Rejection and deflection	Acceptance and absorption
Model of consent	Implicit Consent	Hypothetical consent	Live and let live	Direct consent	Non consent
Latent strategy	Preservation of the individual's freedom	Secure internal structure of authority	Transcendence	Survival of the collective	Survival of the individual
Commitment to institutions	Only if profitable	Correct procedures and discriminated status. Loyalty.	Commitment to experience and observe without judgment. Zen.	Collective moral fervor. Voice.	None. Trust no one
Decision Making heuristic	Pros and Cons	Heuristics and Biases	Choiceless awareness	Gut feelings	Adapt to other's choices – ad hoc
Behavioural Strategy	+ Grip	+ Grip	0 Zero	- Grip	- Grip

Note: Cultural Theory Ways of Life Categorization Table for Coding adapted from Schwarz and Thompson (1990, Table 5.1. p. 66).

To consider the study results through the lens of Cultural Theory, I cross-referenced the statements with the focus group in which it was created to identify trends in social solidarities within groups and to identify the dominance of specific solidarities over others, thereby assessing the democratic and representativeness of engagement with different perspectives (not groups or people – perspectives). I did this to be able to plot frequencies of perspectives to assess which solidarities were emerging most frequently in each focus group, which, I hypothesize, would give evidence of groups and/or perspectives not being engaged adequately towards solution generation and new policy.

3.6 Summary

This study used sequential mixed methods to address the objectives: gather opinions of affected persons about CTWS and genomics from media and participant sources; identify barriers to participation in OSPW remediation using CTWS enhanced by genomics from the perspectives of affected persons; identify specific arguments affected persons make for and against CTWS enhanced by genomics; and compile CTWS and genomics opinion statements with affected persons to co-create a Q-method concourse and Q-set for future research. To find opinion statements on CTWS and genomics, a literature and media review was performed using the USask library, online news articles, YouTube, Twitter, and podcasts. Focus groups were facilitated online with homogenous groups of affected persons: oil and gas industry employees, regulators and policymakers, scientists considering OSPW remediation, and Indigenous Peoples. Focus group participants co-created a Q-method concourse, and a modified Delphi was performed to distill the concourse to a Q-set. Thematic analysis was performed on the focus

group transcripts. Finally, the concourse statements and focus group transcripts were examined through the lens of Cultural Theory.

4. RESULTS

4.1 Introduction

This chapter will present the findings of my research. First, the literature and media review results will be described, with the final statements providing the baseline for the focus groups. Then I will present results from the focus groups starting with the concourse and Q-set Next, I will lay out the thematic analysis of the transcriptions, with the resulting six themes. Finally, I will provide the results of the Cultural Theory analysis of the concourse statements.

The research was conducted using the term constructed wetland treatment systems (CWTS), but as the GROW project advanced, project leadership settled on the terminology constructed treatment wetland systems (CTWS). However, the focus group scripts, initial opinion statements from the literature and media review, and quotes from focus group participants use the original wording of CWTS.

In the search for all existing opinions on CTWS and genomics, I did not want to influence participants, but I had to provide background as a starting point for focus group discussions. A one-page summary describing the research project was emailed to all participants before the focus group sessions (Appendices B and C), and the concepts of CTWS and genomics were briefly introduced at the beginning of each session when deemed necessary by participants. For the Pilot, Industry, and Regulator & Policymaker sessions, I gave this introduction verbally at the start of the session:

> *The bioremediation approach of constructed wetland treatment systems is one of few technologies with the potential to reliably handle the large volume of oil sands process-affected water and its complex mixtures of contaminants.*
>
> *These wetland systems create conditions required for beneficial microbes to grow. As wastewater flows through the system, these microbes alter the chemistry of contaminants through natural metabolic processes, rendering them inert as they settle into the system's sediment.*

> *Genome Canada explains genomics as the science of deciphering and understanding the entire genetic information of an organism. Using genomics to develop CWTS allows for selecting optimal plants and conditions for microbe growth and efficacy.*

A participant in the Scientist focus group session gave feedback on the statement used above, and I used this feedback to adapt the introduction that I provided verbally at the final focus group with Indigenous Peoples:

> *A constructed wetland treatment system (CWTS) is a passive, engineered system that is able to detoxify large volumes of oil sand process-affected water. The treatment involves cooperative processes between naturally occurring microbial communities and native wetland plants. However, the conditions required to establish optimal wetland biological communities to degrade and detoxify oil sands process-affected water contaminants are not well understood. The goal of this Canada-wide project is to develop and apply genomics-based methods to characterize natural processes occurring in constructed wetland treatment systems with the objective of enhancing the efficacy of CWTS for the treatment of OSPW. Genome Canada explains Genomics as the science of deciphering and understanding the entire genetic information of an organism.*

Verbatim quotations are used generously in this section as this study sought to learn the opinions of participants, and thus it was important "to give participants a voice" (Corden & Sainsbury, 2006, p. 13) by sharing their words exactly as they were said. I selected quotations intentionally to include only those I thought were necessary to illustrate key findings (Pratt, 2009; Strickert, 2011).

4.2 Concourse Development

4.2.1 Literature and Media Review

Between February and October 2022, I reviewed 57 literature and popular media sources (Appendix A) that contained commentary on oil sands remediation and genomics. As shown in Figures 4.1 and 4.2, the final list from the literature and media review included 115 opinion statements from academic papers, reports, projects, online news articles, the Canada's Oil Sands Innovation Alliance (COSIA) website, blogs, podcasts, and YouTube videos: 82 in the category of Remediation and Release and 33 in the category of Bioremediation and Genomics.

Figure 4.1

Remediation and Release Sources

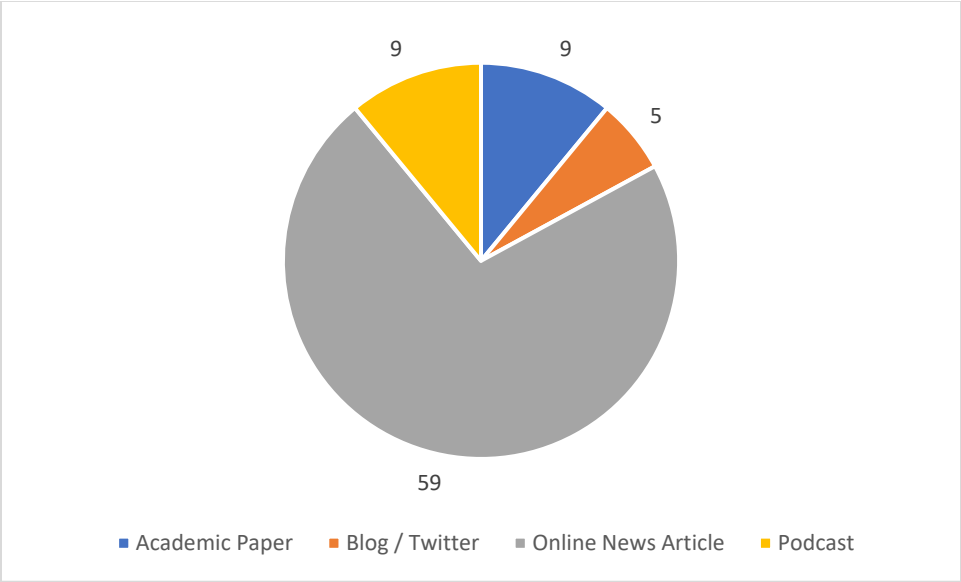
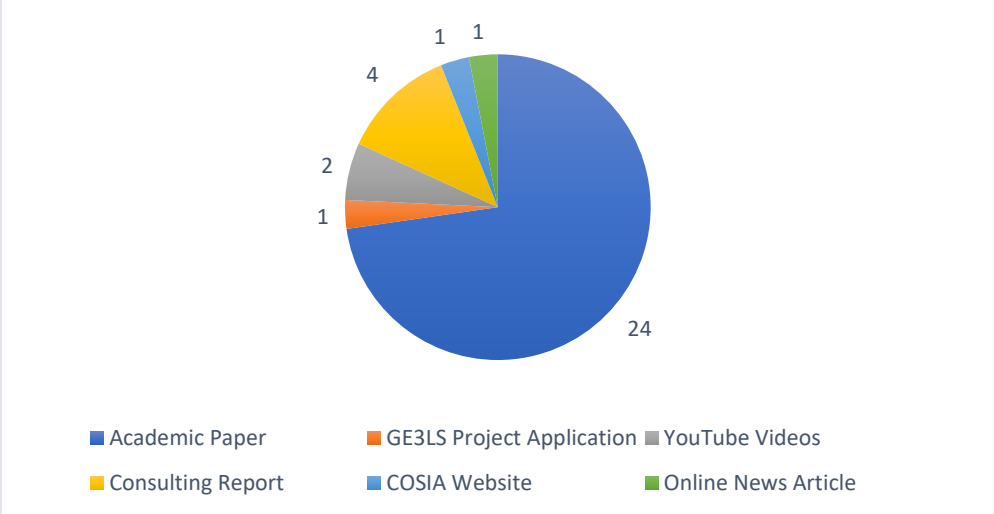


Figure 4.2

Bioremediation and Genomics Sources

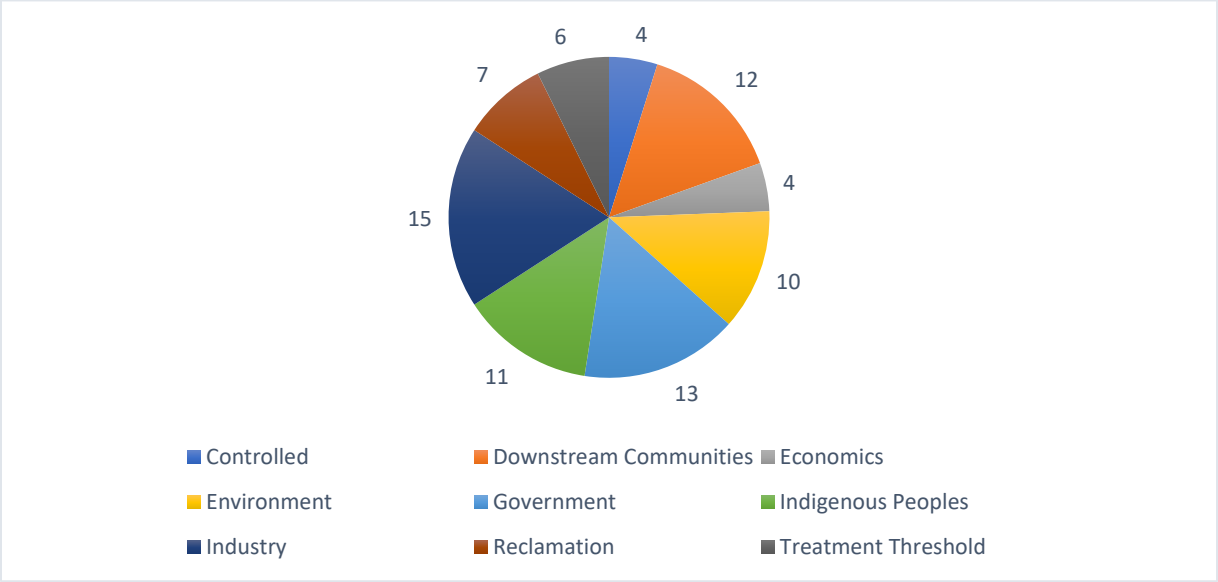


I selected themes inductively based on common ideas in the statements within each category, e.g., the controlled theme contains statements that mention controlled release. There were nine Remediation and Release Themes: Controlled, Downstream Communities, Economics,

Environment, Government, Indigenous Peoples, Industry, Reclamation, and Treatment Threshold. See Figure 4.3.

Figure 4.3

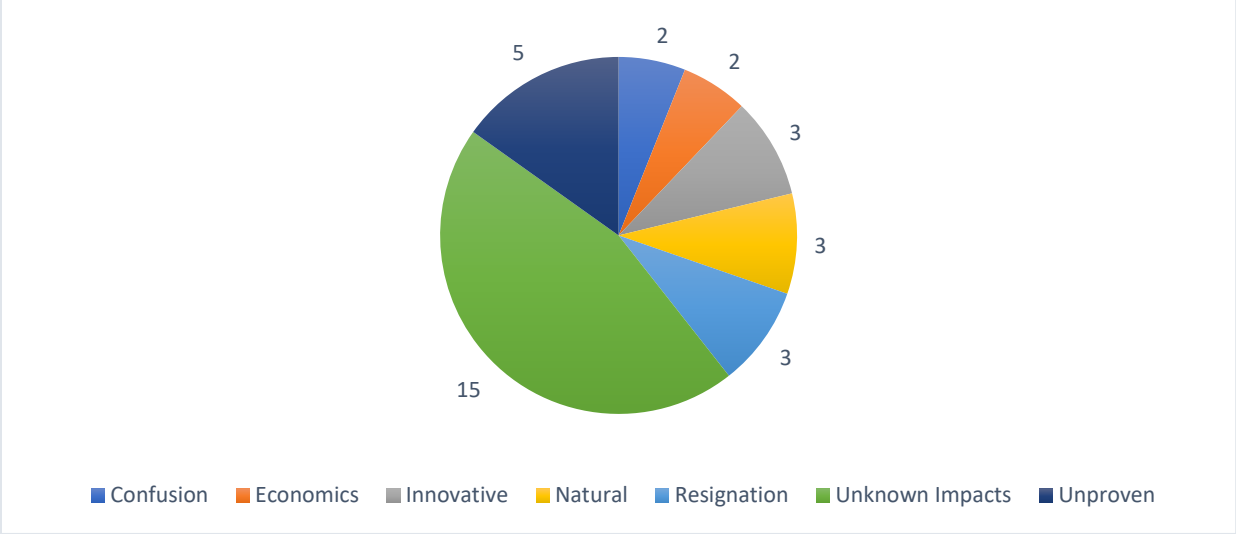
Remediation and Release Themes



The Bioremediation and Genomics themes were originally Confusion, Economics, Innovative, Natural, Resignation, Unknown Impacts, and Unproven. See Figure 4.4.

Figure 4.4

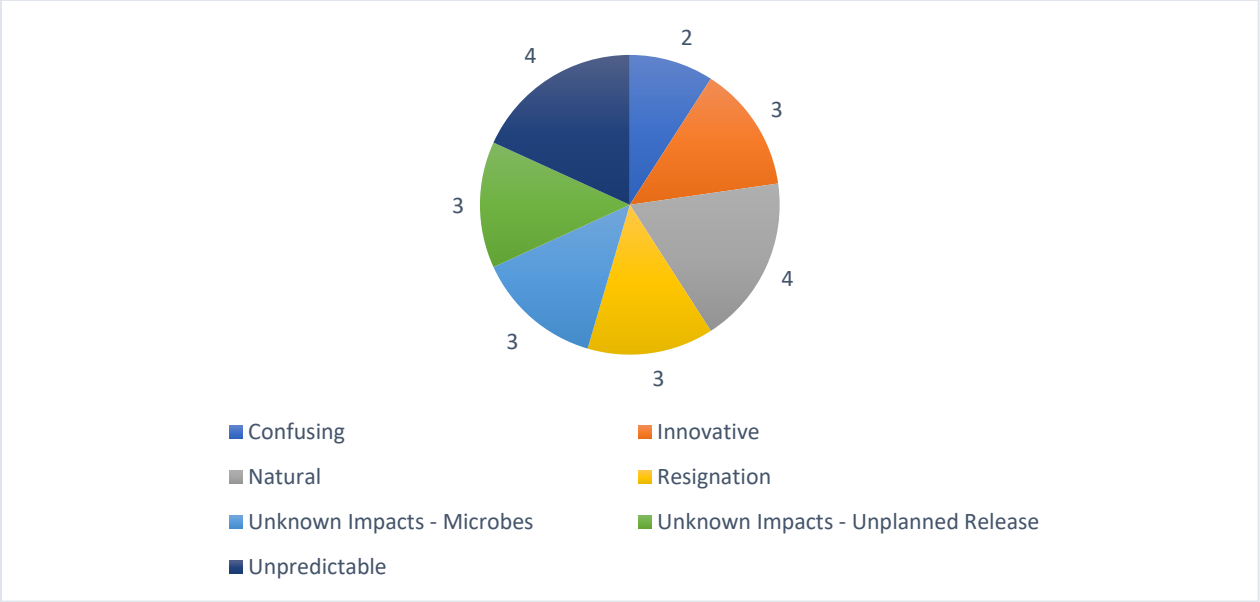
Bioremediation and Genomics Original Themes



In line with Q-method recommendations of 40 to 60 statements in a Q-set (McKeown & Thomas, 2013), I set the goal of 60 statements in total, and I reviewed the statements to ensure clarity and conciseness, removing duplicates and summarizing ideas where possible. Dr. Strickert and Dr. Bradford reviewed the themes and statements, and we determined the scope was too broad. We decided to focus on the Bioremediation and Genomics category because of the gap in published literature on the combination of these topics. Dr. Strickert and I reviewed and adjusted the themes, so that only themes that clearly linked to Bioremediation and Genomics were included with the final list (see Figure 4.5) serving as a starting point for the focus group discussions and including 22 statements across seven themes: Confusing, Innovative, Natural, Resignation, Unknown Impacts – Microbes, Unknown Impacts – Unplanned Release, and Unpredictable.

Figure 4.5

Bioremediation and Genomics Final Themes



The 22 statements and the themes that represent the ideas the statements clustered around are shown by theme in Table 4.1.

Table 4.1

Collated Initial Opinion Statements

#	Opinion Statement	Theme
1	I associate genomics with genetic modification.	Confusing
2	Because I don't understand how genomic study results are presented and ultimately used, I don't want genomics used for oil sands process-affected water remediation.	Confusing
3	I like constructed wetland treatment systems to treat oil sands process-affected water because they are cost-effective.	Innovative
4	I like constructed wetland treatment systems to treat oil sands process-affected water because they are easy to operate.	Innovative
5	Genomics holds the key to developing innovative biological strategies, allowing us to work towards a more environmentally friendly approach to monitoring, managing, and treating mining wastewater.	Innovative
6	I like constructed wetland treatment systems to treat oil sands process-affected water because they are natural.	Natural
7	I support anything that can improve the processes of environmental cleanup.	Natural
8	Anything that can mimic nature has a better chance of success.	Natural

9	Too much technology causes problems.	Natural
10	Genomically-enhanced constructed wetland treatment systems sound like the best option out of anything anybody's come up with so far.	Resignation
11	Bioremediation brings uncertainty, but some types of uncertainty are reducible in principle if the requisite knowledge can be produced.	Resignation
12	I support genomically-enhanced bioremediation if it is coupled with monitoring.	Resignation
13	I worry that microbes could escape from the constructed wetland treatment system and disrupt or displace native microbes, upsetting ecological balance and potentially knocking something else out that's really critical in the natural environment.	Unknown Impacts - Microbes
14	While the microbes may be able to sequester toxic materials, I worry that these do not disappear but remain in the sediment, from where they could work their way into natural systems and become available to food webs.	Unknown Impacts - Microbes
15	I need more information about the microbes and side effects to the environment and people from microbial remediation before I will support it.	Unknown Impacts - Microbes
16	I think toxins will be released from these systems and worry about the potential cumulative impacts of these ‘‘new’’ contaminants in combination with existing sources of pollution in the watershed.	Unknown Impacts - Unplanned Release
17	I worry natural accidents such as floods, storms, droughts, and earthquakes could destroy the constructed wetland treatment system and release sequestered toxins and microbes into water systems.	Unknown Impacts - Unplanned Release
18	I worry small accidents, leaks, and so on may go unnoticed until the system collapses	Unknown Impacts - Unplanned Release
19	The knowledge necessary to reduce uncertainty for constructed wetland treatment systems cannot be produced.	Unpredictable
20	Not only do ecosystems shift and evolve over time, but issues such as climate change affect our ability to predict future conditions.	Unpredictable
21	I do not like the biological complexity of constructed wetland treatment systems as it makes predicting impacts difficult.	Unpredictable
22	I support inoculation of wetland plants with microorganisms having specific metabolic capacities and/or plant growth promoting activities.	Unpredictable

Note: See Appendix D for list with references

These statements were then displayed by theme on a Padlet online bulletin board (http://padlet.com/) for focus group discussion, as shown in Figure 4.6.

Figure 4.6

Example of Padlet Screen for Focus Group Discussion

Note: The original opinion statements from literature and media reviewing are in the colour-coded boxes, and the white boxes below those were created during the Pilot focus group session.

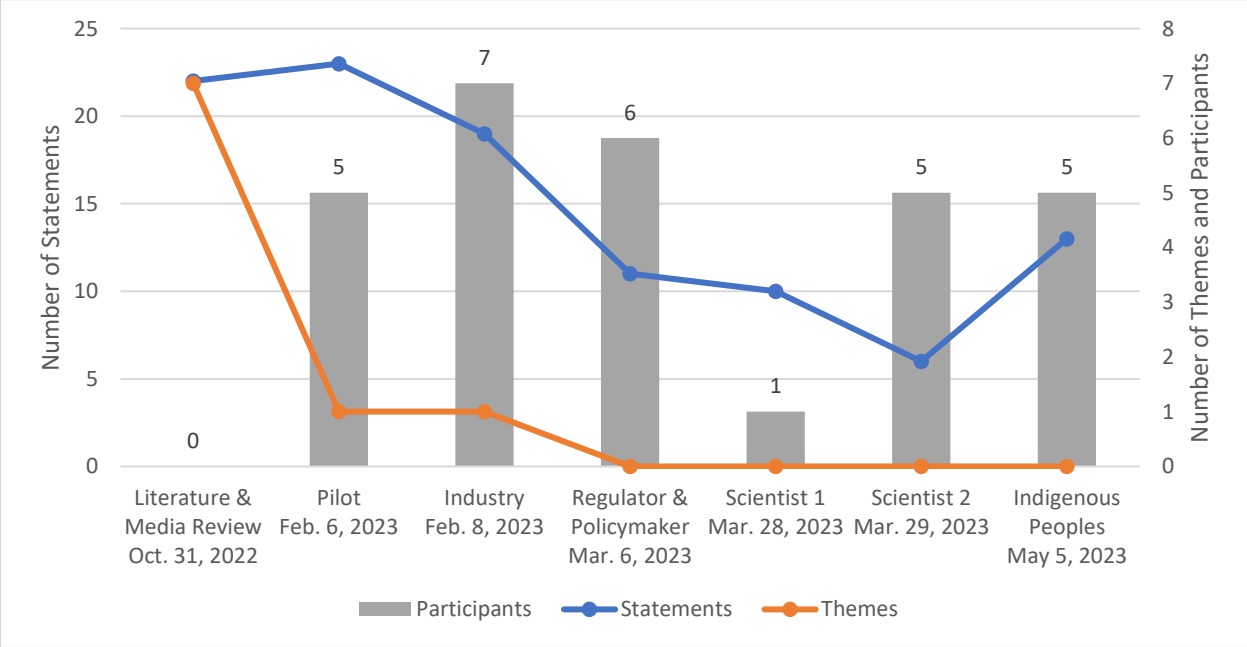
4.2.2 Focus Groups

Six focus group sessions were held between February 6, 2023, and May 5, 2023, online via Zoom (https://zoom.us/), as participants were geographically spread throughout Saskatchewan, Alberta, and New Zealand. As a result of snowball sampling, the Indigenous Peoples focus group included international Indigenous participants with a vested interest in water

and remediation. Persons from New Zealand were included because of their connections to Indigenous communities in the oil sands region through international research collaborations, and because of New Zealand's current focus on developing regulations around the rapidly developing fields of genomics and bioinformatics for remediation. The Pilot focus group (P) had five participants, generated 23 statements, and added one theme. The Industry session (I) had seven participants, generated 19 statements, and added one theme. The Regulator and Policymaker session (R&P) had six participants and generated ten statements. The Scientist interview (S1) generated 10 statements, and the Scientist focus group session (S2) had five participants and generated six statements. The Indigenous Peoples focus group (IP) had five participants and generated 13 statements. This focus group participant and statement and theme data is shown in Figure 4.7.

Figure 4.7

Research Analytics



Each of the first two sessions added one new theme, but no themes were added after that, suggesting thematic saturation was reached or the themes became less important. The number of statements generated trended downward as focus group sessions were held, indicating the approach of saturation before the final focus group with Indigenous Peoples. The number of statements generated in that final session increased, which can be expected with a distinctly different group of participants. More focus groups would be beneficial to see if saturation is stable.

4.3 Q-Set Development

Following the focus groups, the concourse expanded to 100 distinct statements (see Appendix E). This number is lower than the running tally of the statements because participants not only added and modified statements, but they also helped eliminate some as well. For example, the statement from the literature and media review, "Too much technology causes problems" was flagged by participants in the Regulator and Policymaker session for being naïve and unrelatable in the context of OSPW, and ultimately deleted for these reasons, as well as for being too broad (Page & Atkinson-Grosjean, 2012). Focus group participants also helped narrow the concourse by identifying redundant statements, saying things like, "I think you touch upon things that this category, the statements, are actually talking about before" (S2).

Some statements were not included in the Q-set because participants thought they were misleading. For example, participants pointed out that the statements suggesting the microbes were not local were not supported by research and were too complex, such as the now-deleted statement, "I worry that microbes could escape from the constructed wetland treatment system and disrupt or displace native microbes, upsetting ecological balance and potentially knocking something else out that's really critical in the natural environment" (Page & Atkinson-Grosjean,

2012). The sentiment about disrupting the ecosystem was captured in other statements, and clear communication that the microbes are naturally present eliminated the need for this particular statement. Planning to communicate a clear distinction between natural and constructed wetlands also eliminated two statements: “I am confused at the difference between natural and constructed wetlands” (P, 2023) and “There is a big difference between a natural wetland and a constructed treatment system made using the features of a wetland” (R&P, 2023). This results section sought to build the concourse, but differences among themes from group to group are explored in the discussion and Figure 5.1.

Through the collaborative modified Delphi review, the concourse was finalized to the Q-set with 52 statements shown in Table 4.2:

Table 4.2

CTWS and Genomics Q-set

#	Statement
1	I don't understand how genomics is used.
2	I don't understand how CTWS work.
3	Clear language and communication around CTWS and/or genomics are lacking.
4	Genomics is controversial.
5	I associate genomics with genetic modification.
6	Genomics is selecting plants for specific characteristics with an intended purpose.
7	I don't fully understand CTWS enhanced by genomics.
8	If CTWS enhanced by genomics works to remediate OSPW, I would support it.
9	I don't trust CTWS systems enhanced by genomics.
10	I support anything that works to remediate oil sands process-affected water.
11	I like that CTWS are cost-effective.
12	Because CTWS are being used for other mining wastewater remediation applications, I am fine using them for OSPW remediation.

13	I trust genomics because it is being used successfully in other applications.
14	I am fine with CTWS enhanced by genomics on a closure landscape.
15	I like CTWS because they cause less waste than chemical and mechanical processes.
16	Humans can improve nature in its ability to filter OSPW.
17	I like CTWS for OSPW remediation because they are natural.
18	Genomics helps humans mimic nature.
19	Humans put too much pressure on nature. OSPW is one example.
20	CTWS are not natural.
21	We need to approach OSPW remediation with a variety of solutions.
22	CTWS enhanced by genomics sound like the best remediation option anyone has come up with so far.
23	Oil companies follow regulatory requirements.
24	I trust oil companies to do the right thing in regard to remediation of OSPW.
25	The microbes are local, so I'm not concerned about them.
26	Even if the microbes are local, I think optimizing traits will have negative effects on the ecosystem.
27	I am concerned about bioaccumulation in the food chain.
28	I am concerned about the transition from constructed wetland to reclaimed landscape.
29	I think toxins will be released from these CTWS enhanced by genomics.
30	CTWS is not a stand-alone treatment.
31	Industry must provide open, transparent, and inclusive monitoring of CTWS.
32	CTWS don't add more risk than what is already there with the tailings ponds currently holding OSPW.
33	There are too many potential unintended consequences for me to support CTWS enhanced by genomics.
34	Not only do ecosystems shift and evolve over time, but issues such as climate change affect our ability to predict future conditions and make CTWS too risky.
35	Genomics is robust enough to quantify uncertainty.
36	I doubt CTWS enhanced by genomics can be scaled up sufficiently to treat OSPW.

37	Affected Indigenous communities should have veto power over every step in this process.
38	I worry that constructed wetlands will impact cultural ceremonies and practices.
39	I worry that constructed wetlands will impact traditional medicines.
40	CTWS enhanced by genomics is not in alignment with my spiritual and/or cultural beliefs
41	Wetlands have a spirit.
42	CTWS shift the burden of remediating OSPW to Indigenous Peoples.
43	CTWS shift the burden of remediating OSPW to nature.
44	CTWS must be monitored and maintained for decades to ensure they are working.
45	It is not practical to monitor these systems in perpetuity.
46	We must consider alternatives, so we can pivot if the system isn't working.
47	Oil companies hold liability for any CTWS they build.
48	The government holds liability for any CTWS they approve.
49	CTWS enhanced by genomics will take too long to remediate the OSPW.
50	I think CTWS should be implemented immediately to get working on OSPW remediation.
51	I don't think CTWS will naturalize over time.
52	CTWS are safe for wildlife.

4.4 Thematic Analysis of Transcripts

Using NVivo, I reviewed the transcripts and constructed 35 codes, which were then combined into six main overlying themes with subthemes. The next section provides a narrative on each overlying theme and exemplary codes for each theme.

4.4.1 Theme 1: Affected Persons Find CTWS and Genomics Confusing

During focus groups, participants expressed confusion or identified areas of misunderstanding about the concepts we were exploring including CTWS and genomics both individually and together; the ultimate role of CTWS in OSPW remediation; and microbes. The

theme of confusion emerged from commonly expressed emotions of participants when they discussed the project topics and asked clarifying questions or emphasized clarifying statements about the topics. Subthemes of this theme were as follows: affected persons are confused about CTWS and genomics and how they intersect; CTWS enhanced by genomics is not a standalone method; affected persons acknowledge concerns about microbes; and affected persons see opportunities for education. Each is described below.

4.4.1.1 Confusion Subtheme 1: Affected Persons Are Confused About CTWS and Genomics and How They Intersect

Participants in most focus groups had exposure to CTWS, so they expressed less confusion about CTWS than they did with other concepts. Many participants acknowledged that people without a bioremediation background may find the method confusing, and some admitted to being unsure of what the method involved. As one participant explained, "I had the confusion between artificial wetlands with natural wetlands. In my mind, wetlands, there were only natural, and it was not possible to create an artificial one" (P4). Another participant had questions about economics and efficiency, highlighting that there are many unknowns:

> Wonder if it's like economically more efficient to use plants rather than centrifuges or filters or those other things. I'm just, it's just a wonder. So, I don't know if that creates a statement, but I have a feeling others might wonder the same thing (P5).

Most participants admitted being more confused about genomics than about CTWS. As one participant shared, "At the beginning, when you send us the invitation, I had to read, what about, what is genomics?" (P4). Another participant who works with genomics said they had witnessed people's confusion about the term: "I think because of pop culture and a lot of other things, the term genomics gets so associated with mutations and gene manipulation and different things that wouldn't be applicable in using genomics or understanding genomics" (S1). Some

participants acknowledged that although they did not have a good understanding of genomics, they would support its use if they had more information and scientific evidence. One put it this way: “I'm not opposed to genomics being used for water remediation. I just need to be more informed of what it is.... if it works, go ahead and use it” (I4). Another echoed this sentiment: “I'm not opposed to it or anything like that. I just need more information to understand it better” (R&P2). Another participant said genomics is also confusing as the end use for the data is unclear:

> ...what is it actually for and who actually benefits? Because depending on how that data is managed and controlled, the ability of systems now to just store data until they find some use for it is phenomenal. And so, it's a cynical and very skeptical position...but certainly it's a part of an innovation strategy that governments have been trying to implement for many years now (IP5).

As well as having questions about the concept of genomics in general, many participants expressed confusion about the intersection of CTWS and genomics. This theme came up several times in the focus group with regulators and policymakers, with participants acknowledging that they understood CTWS and genomics but did not understand how they work together:

> I would agree with this statement around not understanding how genomics work with constructed wetland treatment systems.... I guess I don't agree with some of the statements, at least for myself personally, things such as the difference between natural and constructed wetlands, I feel like I understand that fairly well. The whole thing about genetic modification, I don't think that that's really something that would be applicable either. I guess I'm just looking at it again from my own personal perspective, it would be around wanting to understand better how genomics work with constructed wetland treatment systems. So, needing more information to understand the subject better (R&P2).

Another participant explained that even those with a technical background in CTWS and genomics can become confused:

> When you talk about genomics, I'm thinking about genetic modifications in terms of living organisms, whether that's plants or animals. And so, in this case, if we are talking about constructed wetlands, we're talking about processed water, I can't immediately make a connection between the term genomics and how the processed water which is mostly the chemical constituents of that would be related then to constructed wetlands.

> So, making that connection between the genomics and the constructed wetlands is kind of, I find it a stretch (R&P3).

Overall, participants expressed that the combined project goals were complex and needed a clearer explanation.

4.4.1.2 Confusion Subtheme 2: CTWS Enhanced by Genomics Is Not a Standalone Method

Participants described that others seemed to be confused about the ability of CTWS to handle the many contaminants present in OSPW as a standalone remediation process. Many participants addressed this misunderstanding of the treatment capabilities of the system by emphasizing that CTWS enhanced by genomics is not a standalone method and would need additional steps before and after the actual wetland use to ensure water meets stringent release criteria:

> It's going to be one of the many options that we will consider to do, uh, reclamation, but we're not going to have one pot that one pot solves all of our problems. We're likely going to have to have multiple pots that solves our problems. And depending on the different water streams they need, may need different levels of treatment (I4).

Some participants shared technical explanations of why additional treatment will be required:

> I think this innovation, I agree with [R&P2] that it's an option. Can we evaluate it? But the performance, if I look at the oil sands mines, the chemicals present, they are toxic. Let's say very difficult to synthesis by bacteria. So the treatment systems are good for bacteria that can consume biodegradable materials like BODs. But there are some chemicals which cannot be removed by treatment systems. One example I'll give you is PAHs, poly-aromatic hydrocarbons. Another solid example is selenium. Removal of selenium is a problem. And you have to create anaerobic condition as well as aerobic condition. And I haven't seen any treatment technologies using constructed wetland. So, there are some limited uses of treatment systems using the constructed wetland (R&P4).

> I'm in the camp of there isn't one treatment method for the water. That's not saying that we need a train of super highly engineered treatment systems all working in tandem. But I think you'll need other forms of treatment, and they could be very passive forms, but there there'll be other needs for the water. It's not a, "This will go from the holding pond through the wetland straight into the river." It's going to require either, at its simplest, and I know people don't view this as treatment, but different mixing strategies on site.

> Because it's not going to remove the salinity of the water, which is what will be a more contentious issue amongst different groups that are managing (S1).

Other participants agreed with this view: genomics and CTWS present not only one transformative solution but, rather, a suite of options, each with 'known unknowns' and 'unknown unknowns.'

4.4.1.3 Confusion Subtheme 3: Affected Persons Acknowledge Concern About Microbes

Many opinion statements in the literature and some focus group participants indicated that microbes are a concern when CTWS are implemented. One participant pointed out the damage that pathogens from invasive species can do to an ecosystem, saying, "[communities are] hesitant to incorporate something new in the environment because the possible damages like alien, to get alien plants or alien species...after some time" (P4). Most focus group participants identified fear of microbes as unfounded, but participants acknowledged that this fear is understandable. One participant spoke to the importance of an individual's prior understanding of microbes:

> I think if somebody doesn't understand that microbes are everywhere in the world, in all environments, already...you might have the opinion that "Well, these constructed wetlands are going to be built. We're going to add microbes into them," and then, that's going to inform, maybe, some of the statements that are listed, here. I think that's a little bit, I think, what [S6] is trying to say. That people don't know that there's microbes there, naturally, necessarily so when they make a statement, it just seems strange because they don't know that there's already, microbes there (S3).

Another participant repeated this idea and stressed the importance of teaching people about the role of microbes in CTWS:

> If people don't fully understand what's going on, then they will kind of go here and go, "Okay, well, what's going on with these microbes and are they natural or not?" And just making clear that the part about stimulating you know local existing microbes is very, very important there. (R&P6)

Most participants in this study identified that confusion exists surrounding microbes and CTWS enhanced by genomics.

4.4.1.4 Confusion Subtheme 4: Affected Persons See Opportunities for Education

While there was confusion about the topics and the research methods, many participants said that discussions like those in the focus groups helped identify areas of confusion and opportunities for education. Participants taught me and each other new things by correcting or challenging statements from the literature and media review and earlier focus groups. For example, one statement taken from the COSIA webpage said that CTWS are easy-to-operate, but a participant from the regulator and policymaker session disagreed:

> R&P3: What caught my attention was this notion that treatment wetlands are easy to operate. I don't agree with that statement. And I would probably also add that these are natural treatment systems and potentially there could be, we really need to better understand performance and reliability, control, things of that nature.
>
> Michelle: Great....So [R&P3], easy-to-operate, get rid of that statement altogether based on what you've seen and experienced?
>
> R&P3: Yeah.

One participant said that there is regulatory value in identifying different perspectives:

> Having this kind of information is kind of useful when we're going through and discussing kind of this with companies as they propose kind of constructed wetland treatment systems, that these kinds of issues are ones that come up and that we're trying to address I guess through our approval process (R&P2).

Other participants acknowledged that identifying perspectives, even confused ones, provides the opportunity to learn. As one person put it,

> Yeah, well when I look at under *innovative* and the statements, first thing that comes to my mind is just the educational opportunities or just the educational conversations like the conversations we're having right now and the points that everyone are starting to make, the points that [IP5] had made about the point about the commodities and just to be able to have those conversations with community members, I think it's really important. And a project like this would bring that opportunity for us to have these types of conversations and educate ourselves. So, I do think there's an education piece here, even good or bad, I think all of those pieces are important to understand (IP2).

This opinion was shared by a participant in another focus group:

> I don't know much about this kind of form of research, but I wondered if gathering these types of opinions creates an opportunity for "What do we need to educate people about?" ...It can serve as like, "Okay, this is our jumping off point for education," right? There's a lot of misconceptions...We can, scientifically, contribute to the proper definition, and context (S3).

Participants in this research agreed that discussions about CTWS and genomics with diverse affected persons create value through identifying knowledge gaps and opportunities for affected persons to teach and learn from each other.

4.4.2 Theme 2: Affected Persons Want Better Communication About CTWS and Genomics

Many focus group participants stressed the importance of effective communication. Subthemes of this *Communication* theme were as follows: language and definitions matter when discussing CTWS enhanced by genomics; context matters when considering CTWS enhanced by genomics; and affected persons are concerned about framing biases.

4.4.2.1 Communication Subtheme 1: Language and Definitions Matter When Discussing CTWS and Genomics

Participants recommended using language that is accessible to all, particularly community members, and shared advice on ways to improve communication. One participant drew from their experience with impact assessments in Indigenous communities, recommending explanations in plain language:

> ...you almost have to do a step-by-step process in plain language explaining what each one of those terms and ideas are. Because for some people, for you who work in this all the time, using the technical language and the way you're describing everything and you're talking to colleagues who work on the same thing, it tends to be inaccessible for those of us who don't work on these issues on an everyday basis. And I think there are people that can pick it up quickly, but others are going to need a lot more coaching and explanation from a community standpoint (IP3).

Another participant agreed and suggested developing a common language dictionary:

> I think the issue is that genomics can be a little quite confronting word because of the, what's going through the media, and I think especially what I've sort of seen come out of the States. So that was just my contribution was just that there needs to be a common language dictionary so that everyone's starting from, at the same point. But also, an opportunity, I don't know if it's for this area or it goes in Innovative or another section, but having the opportunity for the Indigenous communities to also create definitions of what these things are as well in language that makes sense to them and to their context (IP4).

One participant added to the conversation by sharing experiences in their community: “I think the only point I would have is maybe to humanize genomics. That's something that we do a lot in our community when we talk about climate action and our ecosystem services. We're always humanizing our ecosystem services” (IP2). Many participants said that language around genomics is unclear, with questions and comments like:

> IP4: There's a lot of confusion about the terminology of genomics. As I'm reading it, it just looks more like a reconstruction of the ecology. Am I correct? You guys aren't doing any kind of CRISPR-type activities on the microbes or the plant material that you're looking in there. You're using the genomics part essentially is like eDNA, you're figuring out what species would exist in a natural wetland and then trying to reconstruct it in a space that where you need to treat the industry that's extracting oil sands. Is that correct?
>
> Michelle: Yeah, there is no modification of plants or...
>
> IP4: I think genomics in itself is a really confronting statement when, for me as I'm reading it, it feels more like this is a discussion around what we would call whakapapa back here at home. It's the familial connections between things, which would be very similar to my science brain is an ecology (IP4).

Another participant saw the need for clear communication to address misinformation surrounding genomics:

> I think it's a natural human instinct to not trust something that is not understood and isn't clear. So, when, you know, a lot of these are the same where I don't understand it, therefore, I'm not I'm opposed to it or I need more information. I think that's very reasonable comment to have when presented something that is important, but the approach being taken is unclear.
>
> So, my reaction to [the *confusing*] column is there needs to be clear language and better communication around what genomics is. I think because of pop culture and a lot of other things, the term genomics gets so associated with mutations and gene manipulation and

> different things that wouldn't be applicable in using genomics or understanding genomics (S1).

One participant put the onus on Industry to ensure CTWS are clearly explained to all stakeholders:

> I think if these are to be implemented, I think there needs to be a better communication of how these work in a way so that stakeholders, the general public, Indigenous groups can really understand how these work and what's going on. Because we're the regulator, we kind of look over these applications, but ultimately Industry's going to have to be able to communicate what they're doing in a way that's understandable to stakeholders and Indigenous groups (R&P1).

The nomenclature surrounding CTWS was also challenged by participants. One participant suggested that calling this treatment method a wetland is a misnomer, saying “My understanding of what a wetland is, is way more complex than just building a filter” (P4). They elaborated this way:

> So, if I like build a wetland, if I build, many people are gonna tell me that it's not a wetland because it doesn't fulfill all the features that a wetland has to have. For instance, and one of them that is very, very important. It's birds that migrate. And wetland has to be birds that migrate from different countries, especially from Canada, because we receive a lot of birds coming from here. Otherwise, it's not going to be a wetland (P4).

Focus group participants emphasized the importance of using plain language and creating common terminology to improve communication about CTWS and genomics.

4.4.2.2 Communication Subtheme 2 – Context Matters When Considering CTWS and Genomics

Many participants indicated that researchers and industry should present the background and specifics of CTWS and genomics more clearly to remove as much ambiguity as possible. One participant said that focusing more on the project itself rather than seeking all perspectives that already exist on CTWS and genomics would benefit the results:

> I guess, for me, I think that, without prefacing what we're asking, using certain clarification of terminology and we're just asking for opinion without clarifying "This is what it means. This is what it means. This is what it means, in the context of this project,"

> we're getting answers that are just all over the place, and, then, you're trying to sort them into categories...For a scientist, it's very hard to wrap my head around because...I feel like without telling people, "So we are working with microbe that's already in the environment. It's, already, in the ecosystem. We're not changing anything. We're not adding anything."... Without hammering that home and letting people know "This is what we're working with. Just drop all the preconceived ideas that you think what it is. But this is what we're just asking."? You're going to get a whole sorts of response that are all over, and then, you're trying to make sense of it. Yeah, it's a little bit challenging, for me (S6).

Some participants recommended that there should be a clearer distinction between natural and constructed wetlands, suggesting that in the research, "somewhere you have to clearly say, are we using the constructed or engineered or treatment system, or we are using the natural one that is available in the ground and just we discharge the wastewater?" (R&P4). Many participants suggested that providing more context would eliminate the confusion around microbes, making statements like this:

> If people don't fully understand what's going on, then they will kind of go here and go, "Okay, well, what's going on with these microbes and are they natural or not?" And just making clear that the part about stimulating you know local existing microbes is very, very important there (R&P6).

One participant described the challenge of gathering perspectives on CTWS and genomics as "a delicate balance to try and get a representative snapshot of people's opinions of the system, as they understand it, versus getting an opinion of the system as they're supposed to understand it" (S5).

4.4.2.3 Communication Subtheme 3 – Affected Persons Are Concerned About Framing Biases

Participants agreed that the way information is presented can influence opinions. When discussing the statements in the *Unknown Impacts* categories, one participant said, "I wasn't as worried until now (laughs)" (P3). When asked if they thought the wording of the statements introduced fear, the same participant replied: "I don't know if there's a way to word it that, that's less worrying because these are worrying things" (P3).

Another participant expressed unease over statements they thought confused genomics and genetic engineering and consequently would provide people with incorrect information about genomics:

> I think there's a conflation in some of these statements that confuses genomics, gathering the genetic information that's present, with genetic engineering, which are two related, but very different disciplines, right? I worry that if focus groups, or whoever, are being asked questions about genomics, but thinking about genetic engineering, or being allowed to get steered into a path of thinking about genetic engineering, that that isn't, really, necessarily, responding to the project, as such. I don't know if anyone else shares that concern.

Finally, one participant voiced concerns over how information and research is presented, particularly to Indigenous communities:

> Just listening to some of the comments, I do think about issues like framing bias and how you frame things will direct people on how they respond. And I think if you are just saying as a general principle, cleaning up the environment is a good thing. Yeah, you'll get everyone from our communities to agree, but I don't think that that logically means then that therefore we must support this project because this is the best way to do it. I think that for me, I would want to see some proof that there wouldn't be impacts, significant impacts to Indigenous communities there before, and some sort of study on these different elements because it tends to be, like I said before, the Canadian approach is just, "Well, we'll try it and if something bad happens then we might respond."
>
> But I know for me I would be much less tolerant of that risk happening. I would want to see, okay, let's look at this in a stepwise fashion. And some of these things I think could be a good thing. And I hope for the people up in the oil sands region that it is a good thing, and it does work and doesn't have significant impacts, but I don't think we can make those conclusions at this point. And so, I guess it's just a kind of question comment for you because this seems to really be steering towards you should support this because... But I don't see it... Supporting cleanup, yes. Supporting this specific way of cleaning it up, maybe if we can show that there'll be less harm doing this than other approaches. (IP3).

Some participants indicated that they believed affected persons may be swayed by how information is presented, and that great care must be taken when selecting methods and wording for research and regulatory discussions.

4.4.3 Theme 3: Affected Persons Have Different Viewpoints

Participants shared many different opinions and viewpoints on CTWS and Genomics.

The theme of *Different Viewpoints* emerged from one participant's reaction to the statements categorized under the original *Natural* theme.

> This is fascinating. And the first thing I was thinking, and when [IP3] was talking as well, that the different worldviews can be applied to every category, even the use of categories. So now we have the term "natural" and "nature", and this is one of the classic dichotomies from colonial viewpoints would be there is the natural world and there is the human world and they're different things. And so even framing something as nature... And there's the term Mother Nature down there as well. And that words used quite often translated for Indigenous words where we are referring to the environment. And [IP4] mentioned it earlier, the familial relationships that Indigenous peoples have with their environment, relationships as family… And so, to construct nature as a different system is a worldview. And then other things, anything that can mimic nature has a better chance of success. I know what's meant and I don't disagree, but then how do you mimic something that you already are? We are a part of nature. And so, anything we do, even really bad things, like a rocket ship is a part of nature, if you looked at it as something that I guess generally billionaires, but it's built from things in the environment, it's an expression of humanity. So, to me I could argue it's equally a part of nature as a wetland, as a fish. So, I thought I'd throw that out there right at the start. And it gets back to that initial sort of challenge to categorization and the starting point of an analysis. (IP5).

The subthemes under this *Different Viewpoints* theme are as follows: affected persons are divided over whether CTWS and genomics are natural, and affected persons have different risk tolerance for CTWS and genomics.

4.4.3.1 Different Viewpoints Subtheme 1: Affected Persons Are Divided Over Whether CTWS and Genomics Are Natural

Participants had conflicting viewpoints about if CTWS and genomics were 'natural,' with opinions expressed on a spectrum from natural to unnatural. Some participants described CTWS as natural, saying things like, "Kind of goes to the point of why reinvent the wheel? I mean if there's something naturally out there that can do it why invent something to do the same thing?" (I2).

Others agreed that OSPW treatment using CTWS is likely to be successful because it was inspired by nature:

> But it's just the fact that nature knows how to, nature is resilient, and nature knows how to heal, treat itself in a way. So, it's like I see this system as a way to learn from nature because there are already opportunistic natural wetlands that are doing treatment by itself. And we're basically the wetland treatments are that is just taking that, I guess knowledge and wisdom from nature and applied that for treatment (I7).

One participant questioned if CTWS would be less natural if building the system "disturbed a lot of natural area" (I6), adding "I'm wondering if there's something to be said about the size of these wetlands that would make them maybe not as natural if we need a big, a lot of hectares to basically process this water" (I6).

Other participants did not view CTWS as natural, with one participant saying, "In my mind, wetlands, there were only natural, and it was not possible to create an artificial one" (P4). Another participant said that to them, the themes highlighted the dichotomy between the viewpoints:

> Yeah, I was just going to mention really quick, when looking at *Natural* and then right under just seeing constructed wetland, to me that's so unnatural. So that's the complete opposite for me. I don't know if any of that makes sense. It's just when I look at natural and then constructed wetland, to me that reads unnatural (IP2).

A couple of participants described the natural viewpoint as naïve. One put it this way:

> If you can scroll up just to, where was it? Oh yeah, "anything that can mimic nature has a better chance of success," and as well as kind of, I don't necessarily agree with that. I think we've kind of already discussed it and on the previous category, that there's a lot of kind of uncertainties. Knowing things that wetlands aren't able to treat for as well. So yeah, making that assumption that if it's a natural or if it mimics nature that it's going to be the solution is again quite naïve (R&P2).

Some participants made efforts to distinguish CTWS as biological or engineered systems. As one said,

> I think from my perspective, I look at constructed wetlands as using biological processes, but I don't look at them as being natural. And I think that's where I struggle here a little bit, in that, yeah, it's a biological process versus a natural system (R&P6).
>
> So those two things somewhere you have to clearly say, are we using the constructed or engineered or treatment system, or we are using the natural one that is available in the ground and just we discharge the wastewater? So, these two distinctions are necessary people to understand, because there are confusion. We are engineers, we know what is

> constructed wetland and what is the engineered wetland. It's the same thing. But other people may not understand that one and that they will consider natural wetland is a treatment system, so we have to make distinction. Like [R&P3] also highlighted that one, we have to clearly define that one. And efficiency, whether genomics will help to improve the efficiency to remove those non-readily biodegradable organics mainly let's say. So, that is my thinking with constructed wetland. So, I'm talking always engineered constructed wetland that is designed and it's a treatment system. Let's not talk about the natural, I'm not talking about natural treatments, natural wetland (R&P4).

Another participant said that even if a CTWS is inspired by nature, placing it in an environment that did not already have a wetland will have consequences:

> ...for me it would be a case of are we putting an ecosystem into a space where it didn't naturally exist before, or are we recreating the ecosystem that used to be there?
>
> Is that the song that that landscape used to sing, or are we forcing it to sing off another song sheet? (IP4).

The debate over whether CTWS and genomics are natural or unnatural highlighted that affected persons have different viewpoints and values.

4.4.3.2 Different Viewpoints Subtheme 2 – Affected Persons Have Different Risk Tolerance for CTWS and Genomics

Participants expressed varying degrees of comfort with the risk posed by CTWS and genomics. One participant discussed the precautionary principle, explaining it as the need to consider "what are you doing, and do you understand all the potential implications and actions this might cause in doing the work?" (IP2). They explained their frustration with the different standards people use to uphold this principle:

> And part of the approach that I've taken over the last five years in this space is really to ask the question and appreciate that when you talk about the precautionary principle as a regulatory concept, there are different standards. And what I've noticed is that the Canadian government, the Alberta government, the American government standard is usually on the very, very low end. Go ahead and do it and then if something bad happens, we'll respond and react later. Whereas Indigenous peoples tend to take a much stronger point of view as it relates to doing these sorts of things. And it's much more akin if you're doing research on this, the European standards of approach. Until you can prove no harm will result from doing this, you shouldn't do it (IP3).

All participants agreed that CTWS enhanced by genomics face substantial amounts of unpredictability, saying things like:

> I think this is one of the more fundamental challenges to be overcome with this type of treatment system is its unpredictability. And a lot of the research being done is working to take the unpredictability out and be able to establish reliable rates of treatment and parameters, which would have to be held fairly constant to achieve the treatment advocacy we'd be looking for.
>
> It is subject to things like climate change and all different kinds of external influences. So, I guess I agree with the concerns, especially around treatment rates would be one area where I'd like to see more predictability. But there's enough promise that it's worth pursuing (S1).

Another participant echoed concern about the potential effects of climate change: "You may build the best biology based on your genomic assessments, but they could go kaput as soon as temperatures start rising or you start getting flood events or wildfires start blasting through those systems" (IP4).

Other participants described ways they felt risk associated with CTWS and genomics is mitigated or justified. Some participants expressed that the pilots performed in the oil sands are adequate to prove a treatment method will work and is safe:

> ...we pilot these technologies to make sure that these things don't release toxins to the environment. And so we do an awful lot of research and reasonably large pilots to validate the technology will work and will not contaminate the watershed…is one of the things that we spend a lot….I mean the size of when I came from metal mining, we did a pilot, it was in a lab and when it worked we said, okay, let's take it to the field. In oil sands, you pretty much do it at 10 or 20% scale and then validate that it's going to work before you implement it because you have to show due diligence to the government, to the stakeholders, the technology that you're applying is the best available technology to use (I4).

Some participants brought up that CTWS are being used for other wastewater cleanup applications, with one participant responding that considerations of other uses may help alleviate discomfort and negativity stakeholders may feel about this project:

> I know that this is mostly looking at oil sands processed water, but I mean there's so many different areas that are looking at using wetland strategies for wastewater management and treatment. I mean, so the second one there, I mean it's specifically for

> mining wastewater, but I mean it's being used for municipalities, other industry, all that kind of stuff... I think that there's a notion that anyone hears anything oil sands or process water, anything like that, they go, oh, that's bad. So, I think if there was more information on specifically what was being looked at versus just saying oil sands treatment, water or mining wastewater, that kind of stuff. It's not really all that different from some other areas where it's being used. And I think that just the negative mindset, unfortunately, that may be in some people's mind just around the oil sands or just oil and gas in general. If it was to be linked with more, in their mind, more positive mindsets for, oh, what's being used there too. Okay, well maybe this isn't such a bad thing after all (I2).

Another participant raised a similar argument in favour of genomics:

> ...genomics is used in other industries. This is not new and I mean, again, because they're going to think because it's oil sand process water, it's new and it's never been tested before, but I think it's been done before I think is an important thing that it's, we're going to try it in our area, but it's been proven successful in other areas (I4).

However, one participant disagreed with this viewpoint: "Success in an industry essentially means it has contributed to growth in that industry, which doesn't mean a success for wider society, let alone Indigenous communities in there" (IP5).

Other participants were less definitive, simply explaining genomics as a potential tool to help improve and evaluate the effectiveness of a CTWS:

> I guess, what I'm thinking is that genomics is kind of, it's a scientific approach, it's a scientific tool, but it has to be used in conjunction with other types of tools, like chemistry, for example, right? You can use genomics to track microbes, but if those microbes aren't removing the chemicals of concern, then it's only part of a solution to figure out the effectiveness of a constructed wetland (S3).

> I think when we say that we're going to apply constructed treatment wetland, and this is a genomics project, I think stakeholders may hear we have a treatment method and we're applying it, and we know exactly how it works. When, in this case, to me, it's unique because we don't fully understand how it works. We know it does work, obviously, that's why we're posing it as a potential treatment option, but we need to better understand the fundamentals behind what's driving it…And so when we talk about a genomic study, I think that's a point of clarification, maybe about this project, but it's not necessarily that we have the treatment in place and we fully understand it. It's just about getting stakeholder buy-in on it. We need to understand using genomics, how this really works so that we can then apply it in the field (S1).

An individual's tolerance for risk is affected by their knowledge and understanding of the technology, as shown by this participant with a background in remediation:

> Well, oil sands process-affected water…it's not that the water is wildly contaminated. I mean, there's a lot of other really nasty wastewater streams that are much more difficult to deal with. It's the scale that's really the challenge in treatment (S1).

Other participants also commented on the magnitude of OSPW, with one participant saying, "I like constructed wetland treatment system because they're scalable...probably that one of the few treatment water treatment options that scales, you know, when you scale it up, it only works better" (I3). This viewpoint was not shared by all participants, with some raising concerns about reclamation complications with large CTWS:

> From a reclamation and closure perspective, a thought has to be put into the acceptance or what these treatment constructed wetlands are going to end up in the closure landscape and if that's acceptable, which has already been said. So scalable is one way to put it, but you really don't want to have too many of them or larger extents of them on the landscape, because we don't know as yet if there is possible or how expensive it would be then to get that constructed wetland back to let's say a natural wetland or even a lake after everything is gone. So, I think the closure aspect has to be thought of. And yes, it's been mentioned, but there's unknowns. And so, the idea of making this scalable and getting them larger and larger may not be acceptable from a stakeholder perspective (R&P5).

Participants expressed various levels of risk tolerance for implementing CTWS enhanced by genomics, with arguments for and against the treatment that highlight different viewpoints.

4.4.4 Theme 4 – Affected Persons Want Information About Liability and Monitoring

Questions about the long-term effects of CTWS enhanced by genomics led to conversations about liability and monitoring. Participants raised concerns about who would hold liability for these CTWS, with one participant saying people might see the issue this way:

> ...oil companies using [CTWS] as a way to shift or hide or whatever their liability, you know, they're just, you know, putting it up here, and also the long term... sometimes...there's like a long-term worry that, oh, what happens after three years when that oil company gets sold or bought and no one's looking at that the wetland" (P2).

Industry participants said liability is held by oil and gas companies and that adaptive managing and monitoring would be part of the plan:

> ...once we build whatever our closure profile is going to be, whether it's a wetland treatment, whatever, we're not going to be able to walk away from these facilities until we've proven that these things are stable, reliable and work. It's part of our due diligence

> is that we're not just going to be able to say, okay, the wetland's built, yeah, okay, sign off on it, we're all done. That's not going to happen. We're going to have to do years and years and years of monitoring and so on to make sure that these work…And if they don't work or there's a problem, then we're going to have to do some mitigation to make sure that they work or to fix it. So, I don't know how to put that in, but it's not as if we're going to be able to build this and walk away. We're going to have to build it, monitor it, maybe have to do some adaptive management during the process, but we're, we're going to have to monitor and maintain these for likely decades after they're built to ensure that they do what they say they're going to do, because there's not a lot of trust (I4).

Regulatory and policymaker participants stressed that there must be the "distinction of using constructed wetlands on...a closure landscape [the after-mining landscape], versus while things are still in operation" (R&P6) saying "if constructed wetlands are treatment systems, then prior to [mine] closure they have to be decommissioned" (R&P3) and "for the area to be considered permanently reclaimed, they can't have an operational constructed treatment system of any sort, whether it's a wetland or a more engineered kind of system" (R&P2).

However, some participants pointed out that "a lot of artificial wetlands, if you leave them long enough, kind of naturalize," (P3) and saw this ability to become a permanent part of the landscape as an advantage of CTWS enhanced by genomics:

> I see that as a benefit of this system where you can transition it to a state that could serve a lot of ecological services and be a good feature on the landscape potentially in addition to providing treatment during the more active phase. So, I've always viewed that as a benefit (S1).

Another scientist referenced their work with wetlands and suggested that wetlands are an inevitable feature of the landscape after the oil sands mines are closed:

> I think this, maybe, comes back to one of the phenomena that we've come across in our work, insofar as, in that region, in that muskeg heavy sort of landscape, where you have considerable dry years, but considerable wet years, whether or not, you, intentionally, place wetlands on the closure landscape, there will be wetlands on the closure landscape, through settling, and compaction, and water finding its path to the low points. They're going to be a part of the landscape, one way or another, so I think that adapting to their presence, whether constructed, opportunistic or otherwise, is probably still wise and relevant (S5).

Participants offered their knowledge and opinions on the long-term consequences of CTWS enhanced by genomics, emphasizing that there are unknowns pertaining to naturalization, liability, and monitoring that must be addressed before OSPW remediation methods will be accepted by affected persons.

4.4.5 Theme 5 – Affected Persons Are Concerned About Cultural Impacts with CTWS Enhanced by Genomics

Participants in all focus groups stressed the importance of considering cultural impacts. The theme of *Cultural Impacts* encompassed concerns raised throughout all sessions by participants, starting with the Pilot focus group adding the opinion statement theme *Unknown Impacts – Spiritual and Cultural*. Subthemes here are the following: affected persons want collaboration with local communities; affected persons want Indigenous decision-making; affected persons don't want the burden of remediation placed on the environment and Indigenous communities; and affected persons believe wetlands have a spirit.

4.4.5.1 Cultural Impacts Subtheme 1: Affected Persons Want Collaboration with Local Communities

All focus groups discussed the need for collaboration with local communities. Many participants tried to imagine themselves in the position of community members, expressing sympathy and saying things like, "if I was living close by, I wouldn't want to see a forest come down to fit in a, a wetland that someone's constructing" (P2).

One participant said the different standards for the precautionary principle highlighted the need for true collaboration with Indigenous communities (IP3):

> What I've noticed is that the Canadian government, the Alberta government, the American government standard is usually on the very, very low end. Go ahead and do it and then if something bad happens, we'll respond and react later. Whereas Indigenous

> Peoples tend to take a much stronger point of view as it relates to doing these sorts of things.

One participant asked, “Is it then okay for me to suggest a statement that says that Indigenous peoples have the right to veto at any stage of that, that they do not feel comfortable, and the precautionary principle is not being addressed?” (IP4) The original speaker then described the duty to consult, and further challenges faced by Indigenous communities:

> So just building off that last comment, I guess the question I have is one that I don't know how much you deal with the duty to consult here in Canada, or you've thought about that or looked at that as a space. I made this point a number of times in the last few weeks. The duty to consult here in Canada is really covered up by this whole air of, I don't know what the word would be, unreality is probably the best way I could describe it. Because when you have industry or government talk to us about issues or projects. Communities will sit and think and talk and pray on the issues and come back with feedback. And the response from the Crown and the response from proponents is always, "Don't worry, we'll take care of all the problems." And then suddenly, it's as if you wave the magic wand and all the problems that the communities are concerned about have gone away. And really that's not true. There is almost nowhere left in Northern Alberta that you might have called a virgin territory. In my grandfather's time, you could go to any body of water and drink the water. You could harvest any plant or any animal and eat it safely without concerns about toxicity or bioaccumulation of toxins. And so, that's part of the challenge here. And is this something... For the local communities, is this one of the, there's very little left there that I would say is safe to harvest plants or animals or bird species, and it's really that question of what will this sort of impact do and have on what's remaining? Because by and large, there's not a lot left there that hasn't been touched or scarred by development.
>
> And so really just trying to understand for me, like I said at the beginning, cleanup, I think we can all get behind that, but will this process of cleaning up have more cause more harm than good? I haven't seen any sort of assessment that tells me that this would impact our traditional medicines up there or any of the plants that we might consume or animals that we might harvest fish or animals that we might harvest. So, I think it's really just trying to understand and urge you to proceed cautiously with this and try to understand what those implications might be for the people there. Does this, after you weigh in, evaluate everything, will this improve the situation, will it improve the situation, not just for people but for those plants and for those animals? Will you inadvertently cause some harm, that [IP4] was speaking about, by doing this?
>
> It's not something that should be taken lightly and really needs to be done in collaboration with the leadership and local communities up there and make sure that they're comfortable with this. Because I appreciate that I am from Treaty Eight but I'm not from that region of Treaty Eight and I would defer to them and their concerns, but certainly making sure that they're a key part of this process and can help make decisions, and that you're thinking about how do you address the concerns that they're going to raise.

> Because I think that that really at the end of the day, we are here all of us Indigenous people on this call, but that's not our territory. That's not where my ancestors are buried. So, I would defer to them, and we need to make sure that they're a fulsome part of any project going forward (IP3).

Participants shared their thoughts and experiences to make the case for collaboration with local communities when evaluating CTWS enhanced by genomics for remediation of OSPW.

4.4.5.2 Cultural Impacts Subtheme 2: Affected Persons Want Indigenous Decision-making

Further to collaboration with local communities, some participants mentioned the importance of Indigenous decision-making. The focus group session with Indigenous Peoples included participants from New Zealand, which created the opportunity to discuss how things are done in the different countries. One Canadian participant spoke about the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) Act and Free Prior and Informed Consent (FPIC):

> So here in Canada, the federal government created, 2021, they created a United Nation Declaration Act. And as part of that Declaration Act, all laws and are supposed to go through consistency and changed all federal legislation and regulations to be consistent with the declaration. And it just so happens that we put in an action plan measure around Indigenous participation and decision-making. And this is actually part of the discussion that we want to be able to have at what place are you coming to us, and just using Michelle as the example, to what extent is Michelle, we're talking to Michelle as a decision-maker, and to what extent are we as Indigenous peoples here are also decision-makers? And that's the kind of question where it's still all up in the air, but I would think from the community standpoint when you apply FPIC that certainly that there would be some desire to say, "Okay, no, we don't agree with that. No, you can't." And I've heard federal ministers say FPIC is the law of the land now and that there should be, but we're in this weird space of the act's been passed. But there's really been no, I guess behind the scenes, but there's really no public work that's really been done to show how FPIC is being implemented across the country. And this would be a space where I would expect oil sands communities to want to have a big say and a big voice in decision-making on this (IP3).

One participant suggested that Indigenous Peoples should have the power to stop CTWS enhanced by genomics at any point:

> Right to veto, to ensure that whatever's being generated meets with their cultural values and what they are expecting from this. At every stage, there should be a stop-go where the indigenous communities at place can say, "No, no more. We don't want you to go any further. We don't trust the process." (IP4).

4.4.5.3 Cultural Impacts Subtheme 3: Affected Persons do not Want the Burden of Remediation Placed on the Environment and Indigenous Peoples

Some participants expressed concern that a CTWS enhanced by genomics places a further burden on the environment and Indigenous Peoples than those already existing with the tailing's ponds. One participant questioned the effects of a CTWS enhanced by genomics:

> Are we putting an ecosystem into a space where it didn't naturally exist before, or are we recreating the ecosystem that used to be there? Is that the song that that landscape used to sing, or are we forcing it to sing off another song sheet? (IP4).

> We put too much pressure on Mother Earth, we call her Papatuanuku. We put far too much pressure on her to have to keep fixing up our mistakes and that we then get innovative and look to nature for that innovation, and then we use that as an excuse to continue to expect her to clean up our mistakes. And I think that's the thing that struck me as I was reading through this is that, where is the point when we say enough is enough?
>
> Here in Aotearoa, the space of the wetlands is actually very, is a strong female element to wetlands. And so, I guess there's kind of this parallel with the way that we treat women in western society and the way that we are treating this landscape that has a very strong feminine essence within it. And again, you're relying on Mother Earth and these, we call them Atua, our female deities, to keep on continuing to fix up the mistakes that we are making as humans. And I think for me that's what I wanted to raise is where's the line? When do we stop? When do we start taking responsibility for what we are doing and we start changing our behaviours, rather than expecting Mother Earth to keep on taking the brunt of it and absorbing that? (IP4)
>
> Just one thing that hit me as I'm reading the whole thing, it goes back to the statement I raised before about are we forcing the song sheet on the landscape? I think it's really important to bear in mind, I don't know if it's the same for you guys over there in Canada and it probably is, there's always a concern that if you are recreating a system in a place that it hasn't been before, not only are you recreating a system on the land that it doesn't recognize it, but you could also be inadvertently introducing new things into those spaces even though they're native or they're endemic to the region.
>
> And that can sometimes put quite a lot of pressure on the Indigenous people at place who may then feel compelled spiritually and culturally that they have to take responsibility for the care of those things as the people of that space. And so I guess the thing that concerns me across the whole thing is bearing in mind it might be native, but you could be introducing it to a space where it never was seen before or felt or tasted before, and the

> pressure that it then puts on that local Indigenous community to then become the guardians or the protectors of those things that are not from their space naturally (IP4).

As this extract from the focus groups demonstrates, participants raised the issue of whether CTWS enhanced by genomics will place new stress on the environment and local communities.

4.4.5.4 Cultural Impacts Subtheme 4: Affected Persons Believe Wetlands Have a Spirit

Another cultural impact shared by focus group participants was that some affected persons believe wetlands have a spirit, which would have implications for CTWS enhanced by genomics. One participant expressed their thoughts this way:

> Everything, everything has a spirit. Um, like this rock is, has spirit to it, but as soon as humans take and manufacture something, it loses that it not necessarily loses it, but it does not have it. Anything human made does not have that spirit.

Many participants respected this belief but did not share it:

> I guess, my thought is I've never thought about wetlands as being spiritual. It's just not something that I've thought about, right? I don't think that, necessarily, it's right or wrong, but I've just never given it thought. I've never thought of wetlands like that. I could be convinced they are; I could be convinced they aren't. I can see both sides of the picture, right, so I can understand the different perspectives, but I, personally, have not associated spirituality with wetlands (S3).

Some affected persons said they believed wetlands have a spirit, which may have consequences when making decisions about CTWS enhanced by genomics.

4.4.6 Theme 6 – Affected Persons Shared Opinions on Research Methods

While most of the conversation was around genomics, CTWS, and OSPW and their potential effectiveness and impacts, some participants also included meta-level analysis of the methodology in use to gather their data. Some participants responded well to the online method and Padlet, such as the participant who said “I think it worked. Also, I like that you can colour coordinate everything because you know, I have this OCD thing, and it's like nice and organized immediately” (P1). However, some participants strongly disliked the approach. One participant

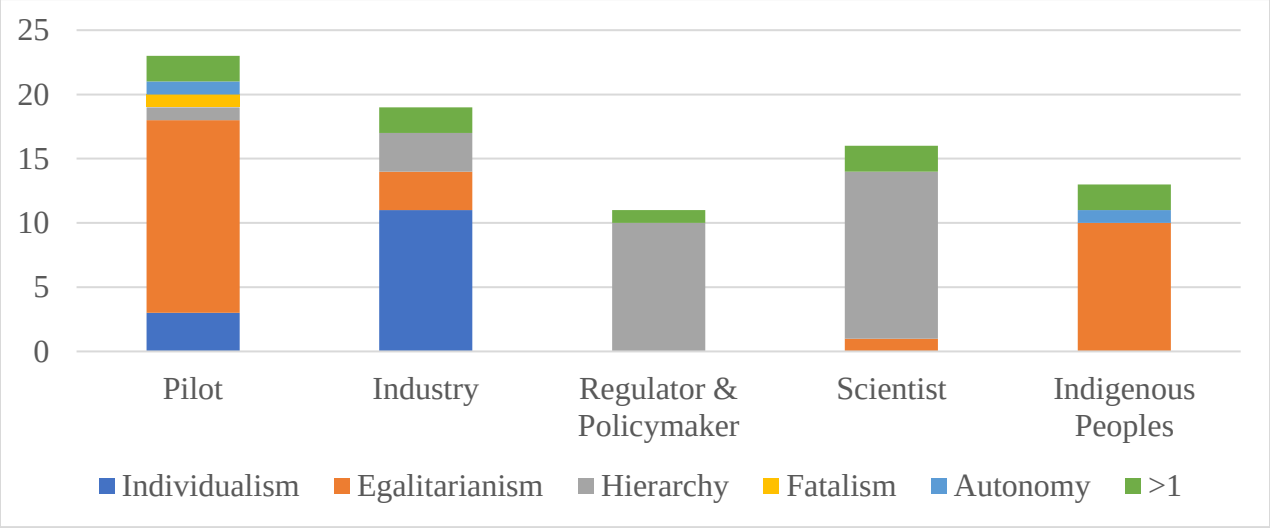
said, “It's really hard I think as an Indigenous person to break it down into these columns like this. It's a lot easier sometimes for us to be able to go boof and go over the whole thing” (IP4). Participants often challenged the themes and statement placement, with participants saying things like, “I have another statement that I don't know where to put it. Maybe might be in the natural part, but to me, it's the fact that maybe it's also related to spiritual, I don't know” (I7). These methodological questions align with the complexity discovered in the thematic analysis: There are wide-ranging viewpoints on using genomically-enhanced CTWS, as well as on *how to study* the human dimensions of these systems.

4.5 Cultural Theory Analysis of Concourse Statements

Following the assignment of Cultural Theory social solidarities, I plotted the statements according to which group created the statement, as shown in Figure 4.8.

Figure 4.8

Concourse Statements Sorted by Group and Social Solidarity



Notes: The >1 category includes comments about not understanding or wanting more information that did not clearly fit one solidarity. The data table can be seen in Appendix F. I acknowledge bias with this categorization as I facilitated the focus groups and know which group created each statement.

Individualism was encountered most in the industry-created statements, which shared sentiments aligning with the individualistic viewpoint that Thompson (2011) used to explain how the environment is forgiving enough to recover from anything humans do to it. Participants expressed an individualistic position through technological optimism with strong belief in science and technology and frustration with restrictions in place through regulations as was described in Adams (1995) and Thompson (2011).

Hierarchical viewpoints were most evident in both the Regulator and Policymaker-created statements and the Scientist-created statements in comments about requirements for strict regulations for CTWS enhanced by genomics and the belief that other viewpoints were naïve, unrealistic, and in need of education. Like Schwarz and Thompson (1990), comments in both sessions expressed the hierarchical desire for command and control, and the hierarchical risk-handling style of rejection is apparent in Regulator and Policymaker participant comments on the inability to accept CTWS on a closure landscape.

Egalitarian viewpoints were common in the Indigenous Peoples focus group-created statements. Comments like “enough is enough” (IP4) and the recommendation to not implement a treatment until it is certain “no harm will be done” (IP3) align with the egalitarian view of environmental stewardship and the precautionary principle expressed in findings by Schwarz & Thompson, (1999), Thompson (2008), and Thompson (2011). Participants clearly expressed the desire for direct consent for CTWS enhanced by genomics from communities most affected by OSPW remediation and release, which aligns with the egalitarian viewpoint as described by Schwarz and Thompson (1990).

While a fatalist would not see value in attending a focus group session and an autonomous hermit would simply observe and listen in search of wisdom as per Dake and Thompson (1999),

I did see glimpses of these perspectives, particularly in statements created in the Pilot session, where a fatalist viewpoint was given through hopeless skepticism about the methods, and the autonomous viewpoint was expressed with choiceless resignation to find a way to make this work because it will happen regardless of the individual's opinions. The presence of fatalist and autonomous viewpoints makes sense because the Pilot group methodically created statements both from their individual personal perspectives and also, what they thought others, including non-participatory affected persons and individuals separate from direct impact, might think.

4.6 Summary

This chapter has presented the results from this study. The literature and media review provided a baseline of 22 opinion statements. Focus groups participants added, modified, and deleted statements, co-creating a final comprehensive Q-method concourse. A modified Delphi was performed to distill those statements into the 52-statement Q-set that will be used in future research. Next a thematically coded selection of participant viewpoints was presented via five content-specific themes and one methodological theme. Themes related to project content were as follows: affected persons find CTWS and genomics confusing, affected persons want better communication about CTWS and genomics, affected persons have different viewpoints, affected persons want information about liability and monitoring, and affected persons are concerned about cultural impacts. A sixth theme addressed the methodology of gathering this information: affected persons shared opinions on research methods. Analysis of the concourse statements through the lens of Cultural Theory showed that there are trends in social solidarities within and between groups. The Q-set, the thematic analysis, and the Cultural Theory analysis illuminated the opinions affected persons hold about CTWS and genomics for OSPW remediation.

5. DISCUSSION

5.1 Introduction

This chapter unpacks the results of this research. My overall objective was to capture insights from affected persons about the contentious issues surrounding OSPW remediation using CTWS enhanced by genomics, and this was achieved through thematic analysis of focus group discussions, the creation of a Q-methodology concourse and Q-set, and analysis using Cultural Theory. This chapter puts my study's results in the context of the literature on Cultural Theory, transdisciplinary research, barriers to participation in remediation research and decision-making, CTWS, and genomics. It also discusses the significance of remediation.

5.2 Application of Cultural Theory

In this study, Cultural Theory was used as both a framework and a tool to analyze transcripts and statements. The diverse ways of organizing described in Cultural Theory provided a starting point to reflect on the perspectives emerging from the focus groups (Thompson, 2011; Thompson et al., 1990; Schwarz & Thompson, 1990). Thompson (2011) indicates that the ways of organizing are visible anywhere you look, and this study shows that focus group discussions about OSPW remediation using CTWS enhanced by genomics are not an exception. In this study, the three active voices —individualism, hierarchy, and egalitarianism—were represented (Beck et al., 2011), and fatalism as well as autonomy showed up as perceived opinions, i.e., opinions participants thought others would have (Beck et al., 2011; Dake & Thompson,1999)

Cultural Theory gave me a standardized way of classifying perspectives and enumerating which ones were expressed most among diverse groups. The social solidarities that emerged as the most represented by each group-created statements were in line with the perceived opinions of these groups: individualism was most encountered in Industry-created statements, hierarchy in

Regulator & Policymaker-created and Scientist-created statements, and egalitarianism was most common in Indigenous Peoples-created statements. Considering this with the findings that focus group participants from every session stressed the need for engagement and decision-making with Indigenous Peoples, this study proves that the egalitarian viewpoint is essential when considering OSPW remediation using CTWS enhanced by genomics, but that it is not currently well-represented in decision-making.

Although the statements each group created signalled thinking that primarily aligned with a specific way of organizing, at least two social solidarities were encountered within each group's statements. This result aligns with Douglas' (1992) argument that individuals and groups do not entirely fit one cultural worldview and that each is individualist, hierarchical, egalitarian, or fatalist to varying degrees (McEvoy et al., 2017). There were many instances where distinct groups agreed with or acknowledged the merit of statements created by other groups that fit another social solidarity, indicating that focus group discussions contained places where thinking overlapped and participants appreciated other experiences and wisdom. This finding suggests that affected persons have the capacity and desire for clumsy solutions. Thompson's (2011) work on Cultural Theory and clumsy solutions reminds us that a simple, elegant solution from only one way of organizing is not attainable for complex problems such as OSPW remediation, thinking that parallels the participants' contention that CTWS enhanced by genomics is not a standalone treatment method. Like the need to weigh all options for remediation, consideration of all solidarities and perspectives should lead to more robust decisions (Beck et al., 2010; Beck et al., 2011). The methods used in this study did not lend to initiating the necessary clashes between the ways of life because the attention was on the opinion statements and not on solution

generation. The focus groups provided a starting point for collaboration and social learning that will be further advanced with the Q-sorts, EDLs, and surveys.

Engagement specialists for the oil and gas industry and regulatory bodies would benefit from the use of a framework such as Cultural Theory to assess the quality of their engagement, understand how their different communication objectives and strategies may be biased towards a certain way of organizing or taken up differently by different individuals, and places where solidarities are dominating decision-making processes. Further benefits come from combining Cultural Theory with Arnstein's ladder; Cultural Theory-based analyses of qualitative data can act as an indicator for what is being discussed and/or missed, thereby moving up the ladder from non-participation and tokenism to citizen power (Arnstein, 1969; Koehler et al., 2018). This method is analogous to statistical testing where T-tests and tests of significance are used to give a baseline gauge of how an experiment is going, but comprehension deepens when the analysis is deepened to understand skew. In the same way statistical tests are expanded on quantitatively, I have used Cultural Theory to indicate the quality of the qualitative data. My study is early in the GROW research project, so the next steps will expand on this work (i.e., the Q-sort will show patterns in the way of thinking, which is akin to trying to find a regression line in data points on a graph.)

5.3 Transdisciplinary Research

Developing the concourse and Q-set and capturing the opinions from the diverse groups of new useable knowledge co-created by affected persons is what Steelman et al. (2021) described as a primary goal of transdisciplinary research. As Steelman et al. (2021) asserted, it is challenging to quantify the effects of transdisciplinarity on research productivity, but in this study, participants acknowledged that statements from other groups taught them new things and

made them think about and consider other perspectives. Thus, this study confirms the work of Cash et al. (2002), who found that affected persons have different perceptions of what is salient, credible, and legitimate. The results also support the findings of Cash and Belloy (2020). They argued that to manage the boundary between science and policy in OSPW remediation using CTWS enhanced by genomics and to achieve credibility, problems must be addressed at the local level and involve those most affected by them.

The findings of this study supported those arguing that challenges to research engagement with Indigenous Peoples are substantial (Castleden et al., 2017; Davis et al., 2017; De Costa & Clark, 2016; Guillemin et al., 2016; Paine et al., 2013). Participants in the Indigenous Peoples focus group told personal stories about issues with colonialism and unequal decision-making between researchers and Indigenous Peoples, as Castleden et al. (2017) described in their research. The current study underscored the need for effective local and Indigenous engagement by confirming that local communities and Indigenous Peoples may experience a loss of cultural and spiritual connection with CTWS enhanced by genomics (Westman & Joly, 2019). As Westman and Joly (2019) found, and my research confirmed, these losses may be associated with the belief that wetlands have a spirit, and Indigenous Peoples may feel burdened because they feel responsible for caretaking the CTWS.

5.4 Participation in Remediation Research and Decision-making

While Huynh et al. (2018) concluded that complex environmental challenges such as OSPW remediation require input from many perspectives, participants in this study identified several key barriers to participation in discussions and decisions regarding CTWS enhanced by genomics. These barriers included confusion about the concepts, particularly about genomics and how CTWS and genomics fit together; miscommunication through inaccessible language, terms

without a common definition, and lack of context; and misunderstanding about viewpoints, all preventing inclusive and participatory approaches.

In this research, participants reinforced earlier findings (i.e., Prior, 2018) that it is important to learn whether local communities will accept remediation technologies and what factors influence their level of acceptance. This study confirmed Schwarz and Thompson's findings (1990) that different solidarities and thus affected persons exhibit a wide range of risk tolerance and risk handling styles. People consider many factors before deciding to support a remediation method. Those discussed in this study included whether there have been pilot projects that are deemed valid, whether the method has been used elsewhere, and whether tools like genomics are used to monitor and enhance the method. None of these factors are adequate for some affected persons, and they require proof that the methods will have zero negative effects.

All focus groups acknowledged the need for meaningful collaboration with local communities (Aksamit et al., 2020), and the study confirmed concerns in the literature about a lack of engagement and communication about OSPW remediation measures, resulting in an absence of trust between affected persons (Aksamit et al., 2020; Poelzer et al., 2022). Participants in this study echoed Westman and Joly's findings (2019) that the individuals and communities most impacted by OSPW remediation feel marginalized, powerless, and under-informed, referencing issues with policy, including UNDRIP, FPIC, and the duty to consult.

5.4.1 Constructed Treatment Wetland Systems (CTWS)

Although the literature has identified CTWS as one of the few technologies with the potential to handle the magnitude of OSPW and its complex mixtures of contaminants, focus group participants emphasized that CTWS is not a standalone method and that other treatments

are required to handle all contaminants, reinforcing the findings of other remediation research (Hendrikse et al., 2018; McQueen et al., 2017; Rodgers & Castle, 2008; Tanna et al., 2019). This distinction is important as all affected persons need to understand that there is no silver bullet treatment method and that further work and acceptability considerations are required. Some participants liked the scalable nature of CTWS to treat the large volume of OSPW, but others did not want large treatment systems on the landscape. This finding suggested that more research is required to support local decision-making on acceptable remediation plans.

5.4.2 Genomics

Participants confirmed Page and Atkinson-Grosjean's findings (2013) that genomics is polarizing and misunderstood, especially when considered with CTWS. The repeated themes of confusion and uncertainty within the media and literature reviewed, and my focus groups reinforced that genomics research is advancing at a rate at which public education about genomics technologies cannot keep up. This knowledge gap creates challenges around public support of genomics-based methods to enhance remediation.

5.4.3 Importance of Remediation

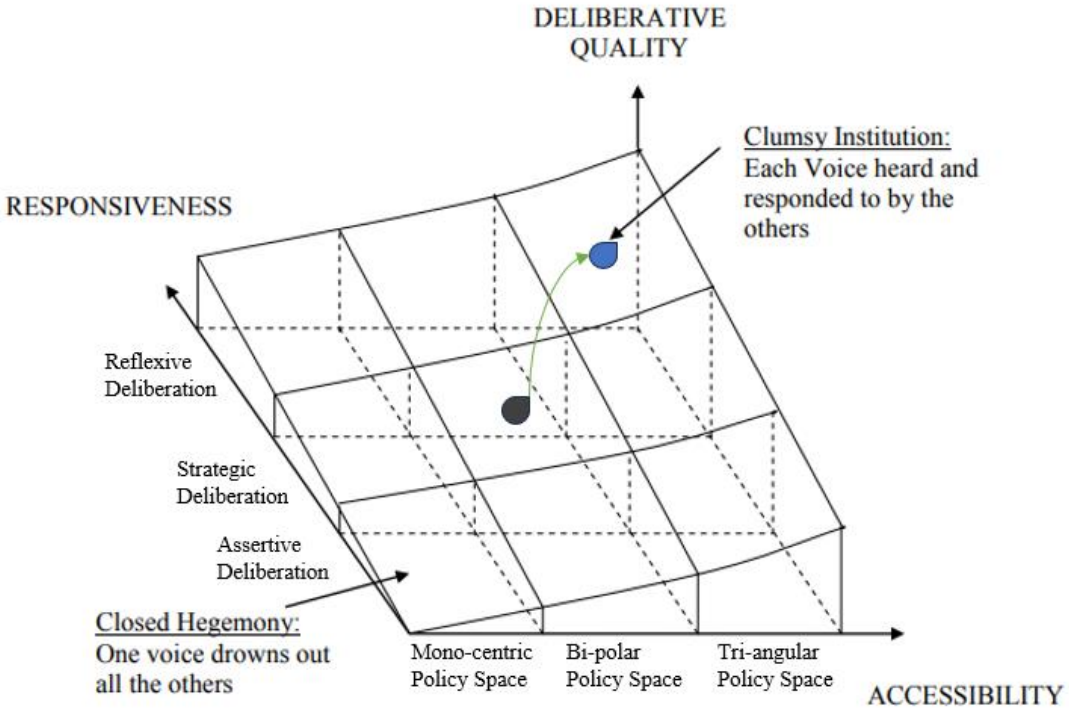
Throughout the study, there was no question about the importance of the remediation of OSPW and the social, environmental, and economic impacts, as discussed by O'Connor et al. (2019). All focus group participants treated the issues with gravity. There was great debate about whether a CTWS is natural or unnatural, highlighting the importance of both language and the diversity of viewpoints. Although Page and Atkinson-Grosjean (2013) found community participants preferred CTWS enhanced by genomics for its "perceived 'natural' character", participants of this study were divided, mainly due to the use of the term natural (p. 277). A study by Huynh et al. (2018) found a preference for techniques that improved the "environmental

quality of the community," which included the markers gardening, outdoor water, and various air quality measures (p. 1012). The wide diversity of viewpoints expressed in the current study suggests it would be challenging for a large group to pinpoint what is a community improvement, thus highlighting the importance of understanding the opinions of local community members who are most affected.

To implement CTWS enhanced by genomics, the areas of confusion must be addressed with meaningful communication and engagement to develop the trust required to work together to address this wicked problem of OSPW remediation – trust in the methods, trust in the communication, trust in the language, trust in the people in power, trust among actors, trust in viewpoints, and trust in the monitoring. This study reinforced the findings of Baillie and Levine (2013) that dominant groups need to learn to consider not just the benefits of technologies but also whose benefits and costs are weighed in decision-making. This reflection would transform remediation decision-making from a hierarchy- and individualistic-dominated discourse (i.e., a colluding dyad) into a clumsy one that also engages and responds to egalitarian ways of organizing (Baillie & Levine, 2013; Thompson, 2011). For clumsy solutions to prevail, according to Cultural Theory, governance systems must maximize accessibility (i.e., all three active solidarities have a voice) and responsiveness (i.e., each participant in a project listens to ensure they understand the other positions and articulates how they would adapt their plans based on what they have heard) (Ney, 2003; Strickert, 2011; Thompson, 2008). As depicted in Figure 5.2, this level of deliberation was not achieved in this study because there was limited input from local communities, where OSPW remediation affects all aspects of their lives.

Figure 5.2

The State of OSPW Remediation Based on Results of This Research Plotted on the Three-Dimensional Refurbishment of Clumsy Institution



Note: The oil droplet is the current state of OSPW remediation based on findings of this study, and the green arrow represents weaving in the voices from local communities to decision-making, increasing accessibility and responsiveness to reach the water droplet at a clumsy solution (Adapted from Strickert, 2011; Thompson, 2008).

5.5 Methods Discussion

This study has met the goals of mixed-method research, with the literature and media review informing and developing the focus groups, and then Q-methodology drawing from both previous methods (Greene et al., 1989; Strickert et al., 2010). Initiation and expansion were also achieved by learning new perspectives and using multiple research components to increase scope and breadth (Green et al., 1989).

The literature review did not reveal many opinion statements about bioremediation and genomics. Most of the statements used in this study's literature review came from a single article (Page & Grosjean, 2013). These limited results aligned with findings that social science research is lacking in the oil sands (Westman & Joly, 2019) and could suggest that oil sands scientists constrain their published literature to factual reporting without including polarizing or contentious opinion statements, solidifying the findings of others (Pauly, 2015).

The two methods used in Phase 1 provided a starting point for discussion and enhanced, elaborated, and clarified the information collected (Greene et al, 1989). Running the focus groups without the foundation of Q-methodology would have yielded different results. The benefit of using the Q-methodology concourse development was that we could focus on co-creating a list of discrete statements relevant to the study and reflexive of conversation, which encouraged participants to think broadly about all aspects of the topics and rendered viewpoints explicit (Eden et al, 2005).

Although the Padlet initially worked well, its effectiveness decreased as the number of statements increased, and it was not well-received by some groups. I attempted to trim the number of statements, but the Padlet did not feel inclusive to the subsequent participants. This study reinforced that Padlet can be a useful engagement tool, but the volume of content and the audience needs to be carefully considered (i.e., Deni & Zainal, 2018; Mehta et al., 2021). As suggested by Castleden et al. (2017), I tried to be responsive and flexible when participants identified that the columns of the Padlet were not conducive to their way of thinking.

Reinforcing the findings of De Costa and Clark (2016) and recommendations by Castleden et al. (2017), the weight of the responsibility tied to research with Indigenous Peoples was strongly present, and I am committed to improving my engagement skills. As described by

Davis et al. (2017), I acknowledge that in scientific work where there is perceived power, there is a need for settlers to reflect on how they manage relationships.

5.6 Challenges and Limitations

This research experienced several challenges and limitations, confirming that it is hard to have effective engagement and get good, informed research. First, the First Nation and Métis communities we planned to work with had encountered hardships, including an oil spill, tailings pond seepage, and wildfires, making it inappropriate to interact with community members and meaning that we did not yet work with all these communities. While the participants in the Indigenous Peoples session stressed that more members of Treaty Eight directly affected by oil sands development should have the loudest voice in this conversation, this raised the question of who is responsible for ensuring members of Treaty Eight have total capacity to engage. With sufficient capacity and communication in various modalities, Indigenous Peoples from Treaty Eight could take the lead on future remediation work.

Although I tried to adjust to feedback that the presentation of information was not conducive to discussion with participants in the Indigenous Peoples session, it was difficult to modify methods mid-session and scheduling restraints did not allow for follow-ups. Future research could seek input about what methods to use before setting up any meetings. Further, because the affected persons were geographically spread, finding participants and arranging focus group sessions was challenging. The resulting online format made connection more difficult, so there was less rapport between participants than necessary to call this truly successful transdisciplinary research. Future research could continue relationships with and snowball from engaged participants in this study.

Although this study intended to execute the Q-sort, challenges with participant recruiting and scheduling, COVID-19 illness and precautions, and family responsibilities meant timing became an issue. My supervisors determined the scope was too broad, and the focus was narrowed to Phase 1 and the first step of Q-methodology. The Q-sort activities would have remediated the siloed nature of the focus groups and enhanced engagement with affected communities, and these activities would have had a broad reach through an online format and community visits. Finally, as with all focus groups, there was the additional limitation of potential for cohort effects due to geographical, temporal, or other global or local events influencing the sample's perspectives, observation and social desirability biases, and language constraints with participants who use English as an additional language. Members of the focus groups expressed opinions in line with the roles they hold, but I question how much the homogenous focus group setting influenced their responses: were participants saying what was expected of them as oil and gas company employees or regulators, or would their responses have been different using a different method like an individual interview? Future work could be done to compare results with other research underway in the GROW project.

Considering this future work in this project and other engagement projects by natural scientists and engineers, this study confirms that engagement is particularly challenging. I set out to reach as many affected persons as possible and encountered many obstacles, including the oil spill, tailings pond seepage, and COVID. Effective engagement takes time, effort, and identification and consideration of existing and potential barriers. Barriers sometimes prevent us from moving up the ladder of participation, but that doesn't mean we should be satisfied with just a placation level. The Cultural Theory results demonstrate why a deeper level of engagement is important despite barriers.

This research was exploratory in that perspectives of OSPW remediation using CTWS enhanced by genomics have not been studied, and the topics are complex, so it was challenging to select and implement methods and to narrow the focus of the study (Swedberg, 2020). This study had a small sample size, but the future Q-sort may complement this work, and future research performed independently within this project should help with triangulation (Green, 1985).

6. INSIGHTS, RECOMMENDATIONS AND CONCLUSIONS

6.1 New Insights

While many findings confirmed that previous research is relevant in OSPW remediation, there were new insights. One unexpected finding was that industry employees and regulators & policymakers held different perspectives on whether CTWS would be allowed on a closure landscape. Considering that the perception is that industry employees and regulators & policymakers are aligned, it is helpful to consider through the lens of Cultural Theory that although individualistic and hierarchical actors frequently collude, they still typically fall into different social solidarities. This finding reinforces that it is valuable to gather perspectives in homogenous groups, and that engagement must move beyond the assumption that it is enough to consult with these groups once rather than maintain long-term meaningful communication.

The other new findings are around the cultural impacts of CTWS, particularly the belief that wetlands have a spirit. Many participants outside of the Indigenous Peoples groups were surprised to hear that belief. Unique viewpoints like these invite new dialogue and alternative ways of looking at problems. If engagement remains on the placation rungs of Arnstein's ladder, the opportunity to create innovative solutions will be missed.

6.2 Recommendations

Bolstered by data gathered in this study, I recommend the following actions be taken to increase accessibility and responsiveness in OSPW remediation: To begin to address communication issues, I recommend that the GROW project add the deliverable of a common language dictionary about OSPW remediation, particularly CTWS enhanced by genomics, developed by affected persons working together with project personnel. Terminology could be available in all languages spoken by affected persons, improving accessibility. Considering the

need for future work that weaves together viewpoints from local communities, I recommend the communities become aware of OSPW remediation methods and consequences, draw attention to power imbalances, and seek any support they need from scientists and regulators as they share their knowledge and preferences regarding OSPW remediation using CTWS enhanced by genomics. Being privileged to assist with capacity and communication, natural and social scientists could remember that not everyone knows the context, and few have the information they have. Regulators and policymakers could learn the perspectives about all OSPW remediation options through discussions like those held in this study. Using a framework and tools like the ones available from Cultural Theory would help engagement specialists to gauge the diversity of perspectives in affected people they are engaging with and to identify the level of participation they are situated in on participation ladders. The diversity of views I found in homogenous focus groups is a signal that just counting the people at the table is not enough to justify meaningful consultation, the diversity of views shared within each group, and how perspectives outnumber or interact (actively or passively) within a collection of groups is also essential to demonstrate diverse participation.

Scientists, regulators, and policymakers could support local communities and seek to understand their existing viewpoints before attempting to educate or inform them. All affected persons could forget about the elegant solutions and lean into the clumsy ones by creating opportunities for engagement and decision-making with all affected persons.

6.3 Conclusions

In this study, I set out to learn perspectives about OSPW remediation using CTWS enhanced by genomics. I had five objectives: gather opinions of a range of affected persons about CTWS and genomics from media and participant sources; identify barriers to participation

in OSPW remediation using CTWS enhanced by genomics from the perspectives of a range of affected persons; identify specific arguments a range of affected persons make for and against CTWS enhanced by genomics; consider perspectives in the context of Cultural Theory to contemplate the state of participation in OSPW remediation; and compile CTWS and genomics opinion statements with a range of affected persons to co-create a Q-method concourse and Q-set for future research. By studying the media, reviewing the literature, and conducting focus groups, I gathered the opinions of affected persons, finding that a wide range of opinions exist about CTWS and genomics. In this study, participants and I built a 100-statement concourse and created a Q-set with 52 statements. This study found that while some affected persons have strong negative or positive opinions about the treatment method, many are unsure or confused about it and want more information. The main barriers to participation in OSPW remediation using CTWS enhanced by genomics identified in this study were a lack of understanding, particularly about genomics and how CTWS and genomics intersect; ineffective communication, with a need for more apparent context and more accessible terminology; and lack of awareness of different viewpoints. The reasons affected persons gave for personally supporting CTWS enhanced by genomics are trust in pilot projects, reassurance that both CTWS and genomics are being used successfully elsewhere, and an understanding that research has been done to study the methods and that research will be ongoing. Participants emphasized that CTWS is not a standalone method, and this study found a range of views about the acceptability of CTWS on a closure landscape, with some participants thinking a benefit of CTWS is the ability to naturalize and provide ecosystem services and others being adamant that a CTWS would have to be removed for the land to be considered reclaimed. The main arguments against CTWS enhanced

by genomics were that there is not enough information and there is no proof that this treatment method will not cause harm to the environment, wildlife, or human health and culture.

The overall goal was to gather insights about the contentious issues around OSPW remediation using CTWS enhanced by genomics, and this study learned or confirmed opinions and provides data for future GROW project research, including a Q-sort, EDLs, and a survey that will help illuminate what information people use to make decisions and therefore provide decision points for subsequent research and regulations. Analysis of the focus group data through the lens of Cultural Theory supported my thesis statement that gathering perspectives from a range of individuals on using CTWS enhanced by genomics for OSPW treatment will illuminate the value and limitations of engagement with diverse affected persons. To move to a higher quality, reflexive, and inclusive policy space so that a clumsy solution can emerge where the perspectives of affected persons in different groups are used to create solutions, regulators need to include more voices in creating OSPW remediation and release criteria. This study found that while the expected Cultural Theory worldviews dominate within each group of affected persons that participated—individualism with oil and gas industry employees; hierarchy with regulators, policymakers, and scientists; and egalitarianism with Indigenous Peoples—overlap in thinking and appreciation of other opinions suggest a desire and capacity for clumsy solutions in OSPW remediation.

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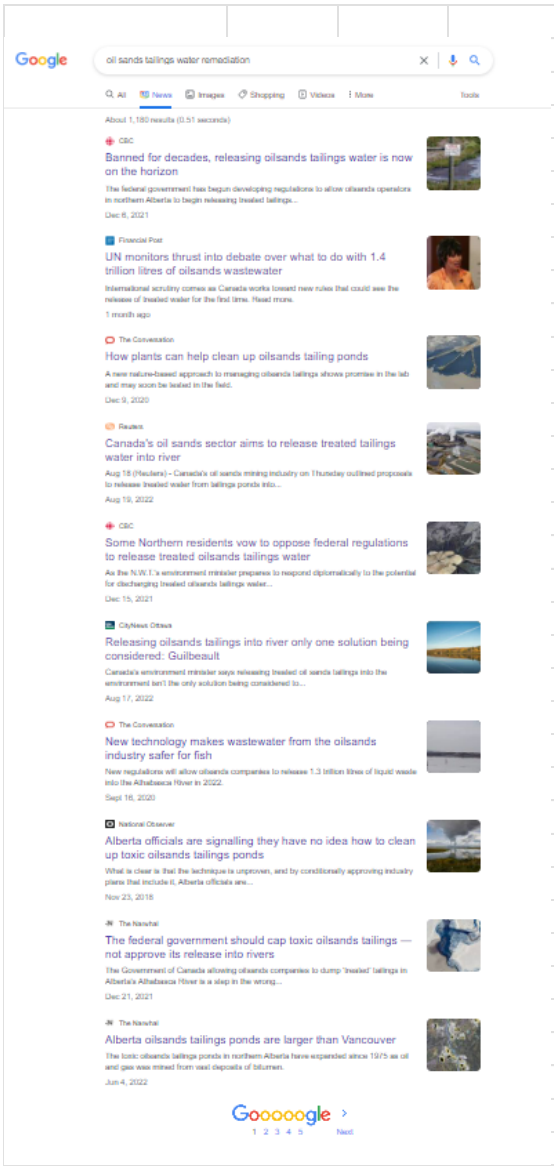
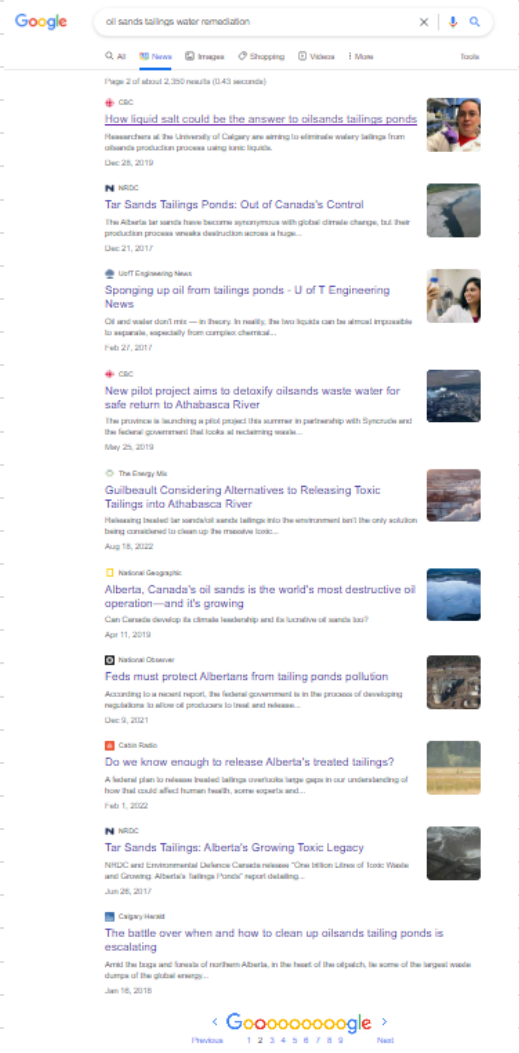
Appendix A – Media Review Tracking

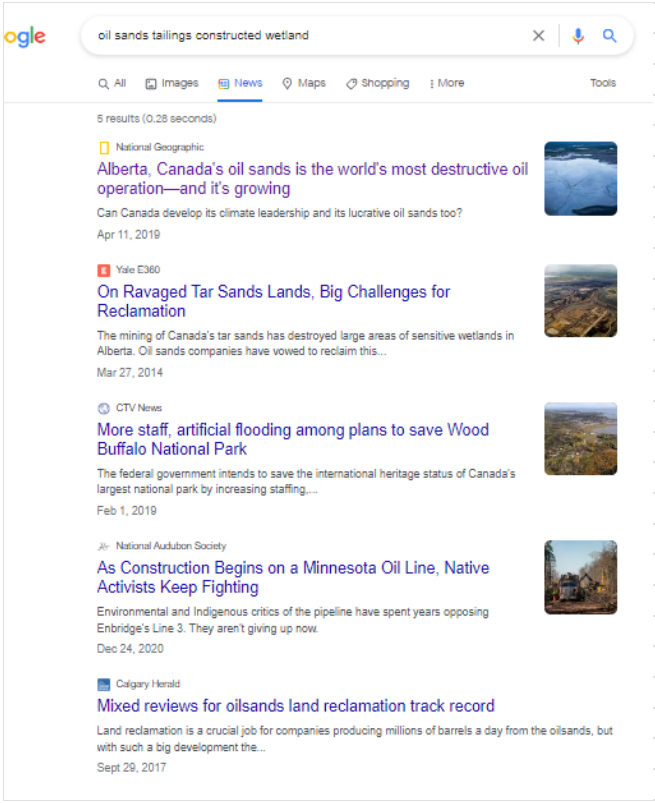


	Source of Statements?	If N, Why?
	Y	
	Y	
	N	Not CWTS and no opinions
	Y	
	Y	
	N	Short and no opinions
	N	Research results on titanium dioxide remediation technique
	Y	
	Y	
	N	Opinions are more on tailings ponds and reclamation than remediation

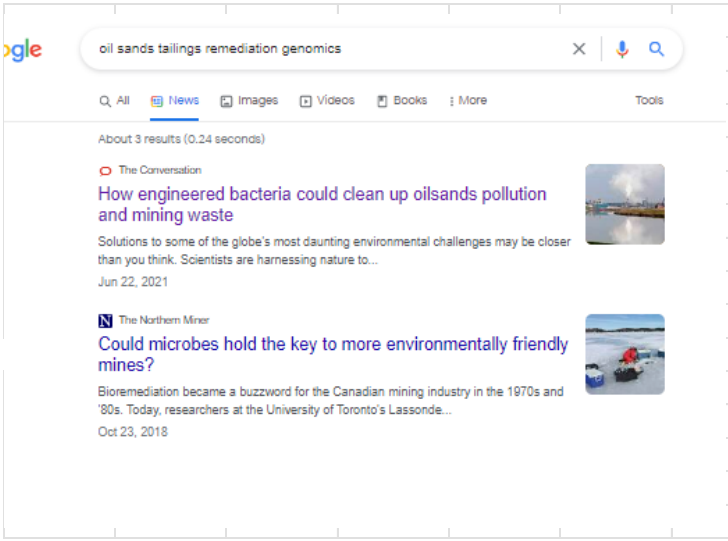


Source of Statements?	If N, Why?
N	Discusses extraction method using liquid salt
N	Gives some regulatory history, but no remediation and release opinions
N	Discusses research
Y	
N	Nothing new to add
N	Overview of oil sands
N	No access
N	Focus is on release
N	Gives some regulatory history and action items for the government

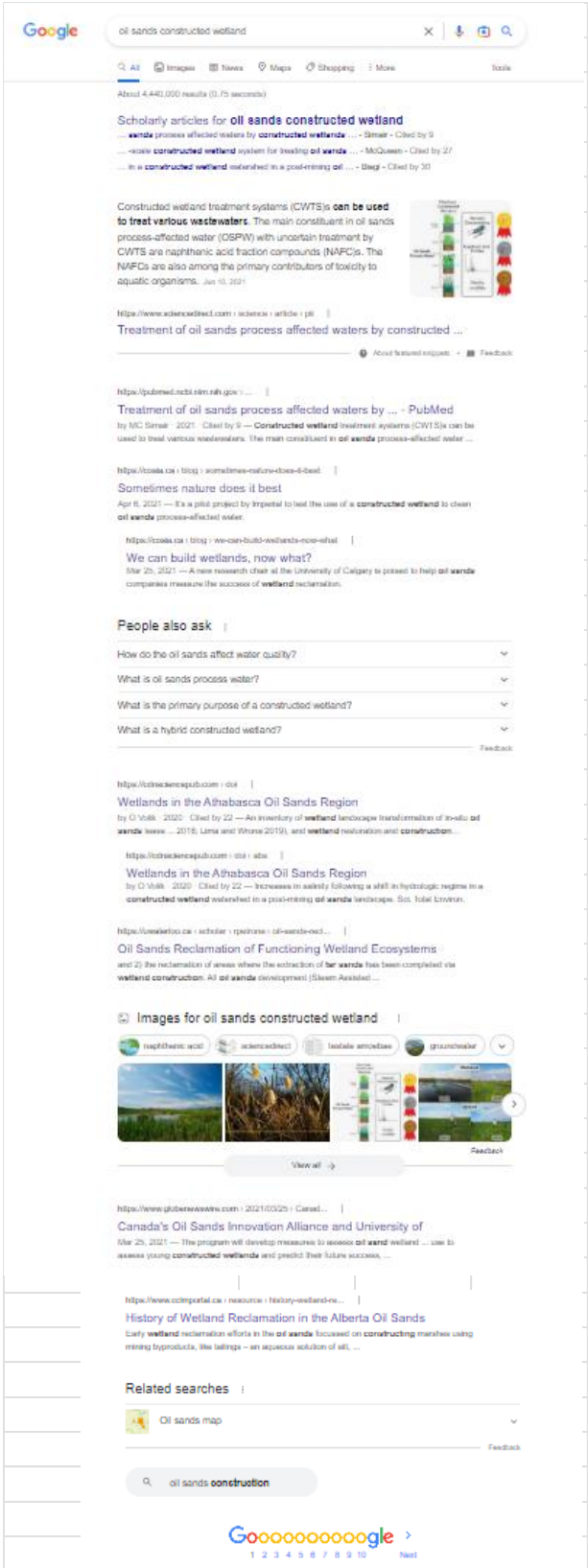
Source of Statements?	If N, Why?
N	Reclamation



	Source of Statements?	If N, Why?
	N	Overview of oil sands
	N	Reclamation
	N	Not relevant for concourse
	N	Not relevant for concourse
	N	Reclamation



	N	No relevant opinions
	Y	



Source of Statements?	If N, Why?
N	Technical paper with no opinions
N	Same paper as above
Y	
N	No opinions
N	No opinions
N	Same paper as above
N	No opinions
N	No opinions
N	No opinions

Appendix B – One-pager sent to COSIA members

GRoW
Genomics Research for Optimization of constructed treatment Wetlands for water remediation

GE³LS investigation

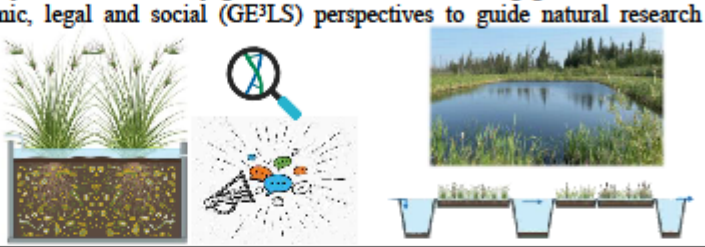
SCHOOL OF ENVIRONMENT AND SUSTAINABILITY

Michelle Tilford-Shaw, MES Candidate
Supervised by Graham Strickert and Lori Bradford

What is this research about?

This research is part of a larger research project funded by Genome Canada and Genome Alberta and committed to searching for more nature-friendly ways to treat oil sands process-affected water. The science-based component of the project was presented during the COSIA water management workshop in October 2022. This research seeks to identify the perspectives affected persons hold about constructed wetland treatment systems enhanced by genomics. We are considering genomics and its ethical, environmental, economic, legal and social (GE³LS) perspectives to guide natural research priorities.

From left to right: illustration of the mesocosm experiment with soil microbiome represented; sketches of project steps, such as genomic investigation and connection with end-users to learn about their perspectives; photo of the Kearl constructed water treatment wetland (source: Imperial 2022 Corporate Sustainability Report).



What is being asked of participants?

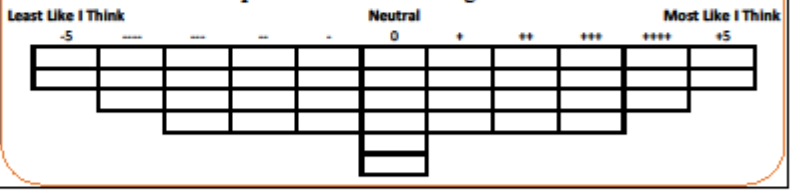
This research includes three sequential methods. Your participation would involve your choice of participating in one to three sessions of approximately one hour each. All three activities can be performed online or in person.

Focus Group A participants will collaboratively review statements on oil sands process-affected water remediation and release, constructed wetland treatment systems, and genomics and create additional opinion statements to co-design the Q-sort.

Focus Group A → Q-sort → Focus Group B

Focus Group B participants will discuss and make sense of the viewpoints that emerge from the research.

Q-sort participants will individually rank-order the opinion statements on a grid like this:



What can you expect from us?

We are committed to inclusivity, and we want to listen to your thoughts and perspectives regarding the use of optimized constructed wetlands for water treatment, also counting on your help for research data co-creation. We will focus on four groups of affected persons: Indigenous Peoples, Oil and Gas Employees, Regulators & Policymakers, and Scientists. We have ethics approval for this project (BEH-REB#3147). Participant and company names will not be released, and all data will be anonymized and shared with participants before being presented in a thesis and/or any publication.

What is the proposed timeline for participation?

2022		2023			
Nov-22	23-Dec-22	Jan-23	Feb-23	Mar-23	Apr-23
Identify Participants		Focus Groups A		Q-sorts	Focus Groups B

GenomeCanada

Please contact us with questions or to partcipate through
Michelle Tilford-Shaw at mkt425@usask.ca.

UNIVERSITY OF SASKATCHEWAN

Appendix C – One-pager sent to potential participants for R&P, S, and IP sessions

GRoW
Genomics Research for Optimization of constructed treatment Wetlands for water remediation

GE³LS investigation

SCHOOL OF ENVIRONMENT AND SUSTAINABILITY

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Supervised by Graham Strickert and Lori Bradford

What is this research about?

As part of a larger research project funded by Genome Canada and Genome Alberta and committed to searching for more nature-friendly ways to treat oil sands process-affected water, this research seeks to identify the perspectives affected persons hold about constructed wetland treatment systems enhanced by genomics. We are considering genomics and its ethical, environmental, economic, legal and social (GE³LS) perspectives to guide natural research priorities.

From left to right: illustration of the mesocosm experiment with soil microbiome represented; sketches of project steps, such as genomic investigation and connection with end-users to learn about their perspectives; photo of the Kearl constructed water treatment wetland (source: Imperial 2022 Corporate Sustainability Report).

What is being asked of participants?

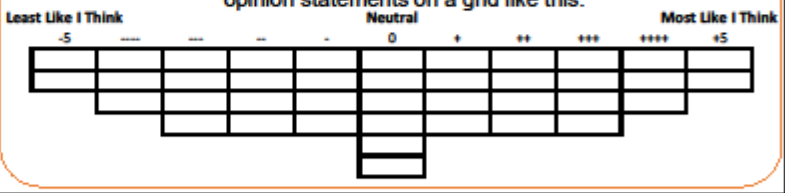
This research includes three sequential methods. Your participation would involve your choice of participating in one to three sessions of approximately one hour each. All three activities can be performed online or in person.

Focus Group A → Q-sort → Focus Group B

Focus Group A participants will collaboratively review opinion statements on constructed wetland treatment systems and genomics in the context of oil sands process-affected water remediation, modifying and creating additional statements to co-design the Q-sort.

Focus Group B participants will discuss and make sense of the viewpoints that emerge from the research.

Q-sort participants will individually rank-order the opinion statements on a grid like this:



What can you expect from us?

We are committed to inclusivity, and we want to listen to your thoughts and perspectives regarding the use of optimized constructed wetlands for water treatment, also counting on your help for research data co-creation. We will focus on four groups of affected persons: Indigenous Peoples, Oil and Gas Employees, Regulators & Policymakers, and Scientists. We have ethics approval for this project (BEH-REB#3147). Participant and company names will not be released, and all data will be anonymized and shared with participants before being presented in a thesis and/or any publication.

What is the proposed timeline for participation?

2023				
January	Februrary	March	April	May
Focus Groups A			Q-sorts	Focus Groups B

GenomeCanada

Please contact us with questions or to participate through Michelle Tilford-Shaw at mkt425@usask.ca.

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Appendix D – Literature Review Statements with References

#	Opinion Statement	Theme	Reference
1	I associate genomics with genetic modification.	Confusing	Shirokova & Kennedy, 2015
2	Because I don't understand how genomic study results are presented and ultimately used, I don't want genomics used for oil sands process-affected water remediation.	Confusing	Shirokova & Kennedy, 2015
3	I like constructed wetland treatment systems to treat oil sands process-affected water because they are cost-effective.	Innovative	COSIA, 2021
4	I like constructed wetland treatment systems to treat oil sands process-affected water because they are easy to operate.	Innovative	COSIA, 2021
5	Genomics holds the key to developing innovative biological strategies, allowing us to work towards a more environmentally friendly approach to monitoring, managing and treating mining wastewater.	Innovative	Genome Atlantic, 2016; Dixon, 2016
6	I like constructed wetland treatment systems to treat oil sands process-affected water because they are natural.	Natural	COSIA, 2021
7	I support anything that can improve the processes of environmental cleanup.	Natural	Page & Atkinson-Grosjean, 2013
8	Anything that can mimic nature has a better chance of success.	Natural	Page & Atkinson-Grosjean, 2013
9	Too much technology causes problems.	Natural	Page & Atkinson-Grosjean, 2013
10	Genomically-enhanced constructed wetland treatment systems sound like the best option out of anything anybody's come up with so far.	Resignation	Page & Atkinson-Grosjean, 2013
11	Bioremediation brings uncertainty, but some types of uncertainty are reducible in principle if the requisite knowledge can be produced.	Resignation	Page & Atkinson-Grosjean, 2013
12	I support genomically-enhanced bioremediation if it is coupled with monitoring.	Resignation	Page & Atkinson-Grosjean, 2013
13	I worry that microbes could escape from the constructed wetland treatment system and disrupt or displace native microbes, upsetting ecological balance and potentially knocking something else out that's really critical in the natural environment.	Unknown Impacts - Microbes	Page & Atkinson-Grosjean, 2013
14	While the microbes may be able to sequester toxic materials, I worry that these do not disappear but remain in the sediment, from where they could work their way into natural systems and become available to food webs.	Unknown Impacts - Microbes	Page & Atkinson-Grosjean, 2013

15	I need more information about the microbes and side effects to the environment and people from microbial remediation before I will support it.	Unknown Impacts - Microbes	Page & Atkinson-Grosjean, 2013
16	I think toxins will be released from these systems and worry about the potential cumulative impacts of these ‘‘new’’ contaminants in combination with existing sources of pollution in the watershed.	Unknown Impacts - Unplanned Release	Page & Atkinson-Grosjean, 2013
17	I worry natural accidents such as floods, storms, droughts, and earthquakes could destroy the constructed wetland treatment system and release sequestered toxins and microbes into water systems.	Unknown Impacts - Unplanned Release	Page & Atkinson-Grosjean, 2013
18	I worry small accidents, leaks, and so on may go unnoticed until the system collapses	Unknown Impacts - Unplanned Release	Page & Atkinson-Grosjean, 2013
19	The knowledge necessary to reduce uncertainty for constructed wetland treatment systems cannot be produced.	Unpredictable	Page & Atkinson-Grosjean, 2013
20	Not only do ecosystems shift and evolve over time, but issues such as climate change affect our ability to predict future conditions.	Unpredictable	Page & Atkinson-Grosjean, 2013
21	I do not like the biological complexity of constructed wetland treatment systems as it makes predicting impacts difficult.	Unpredictable	Page & Atkinson-Grosjean, 2013
22	I support inoculation of wetland plants with microorganisms having specific metabolic capacities and/or plant growth promoting activities.	Unpredictable	Muench & Martineau, 2020

Appendix E – Q-method Concourse

#	Opinion Statement	Source
1	I associate genomics with genetic modification.	L&M Review
2	Because I don't understand how genomic study results are presented and ultimately used, I don't want genomics used for oil sands process-affected water remediation.	L&M Review
3	I like constructed wetland treatment systems to treat oil sands process-affected water because they are cost-effective.	L&M Review
4	Genomics holds the key to developing innovative biological strategies, allowing us to work towards a more environmentally friendly approach to monitoring, managing, and treating mining wastewater.	L&M Review
5	I like constructed wetland treatment systems to treat oil sands process-affected water because they are natural.	L&M Review
6	I support anything that can improve the processes of environmental cleanup.	L&M Review
7	Anything that can mimic nature has a better chance of success.	L&M Review
8	Too much technology causes problems.	L&M Review
9	Genomically-enhanced constructed wetland treatment systems sound like the best option out of anything anybody's come up with so far.	L&M Review
10	I support genomically-enhanced bioremediation if it is coupled with monitoring.	L&M Review
11	I worry that microbes could escape from the constructed wetland treatment system and disrupt or displace native microbes, upsetting ecological balance and potentially knocking something else out that’s really critical in the natural environment.	L&M Review
12	While the microbes may be able to sequester toxic materials, I worry that these do not disappear but remain in the sediment, from where they could work their way into natural systems and become available to food webs.	L&M Review
13	I think toxins will be released from these systems and worry about the potential cumulative impacts of these ‘‘new’’ contaminants in combination with existing sources of pollution in the watershed.	L&M Review
14	Not only do ecosystems shift and evolve over time, but issues such as climate change affect our ability to predict future conditions.	L&M Review
15	I worry natural accidents such as floods, storms, droughts, and earthquakes could destroy the constructed wetland treatment system and release sequestered toxins and microbes into water systems.	L&M Review
16	I worry small accidents, leaks, and so on may go unnoticed until the system collapses	L&M Review
17	I do not like the biological complexity of constructed wetland treatment systems as it makes predicting impacts difficult.	L&M Review
18	I need more information about the microbes and side effects to the environment and people from microbial remediation before I will support it.	L&M Review
19	I am confused at the difference between natural and constructed wetlands.	Pilot
20	I don't understand how constructed wetland treatments systems work.	Pilot
21	I don't understand how genomics work with constructed wetland treatment systems.	Pilot
22	I want to use genomics with constructed wetland treatment systems to increase the efficiency of the system.	Pilot

23	I like constructed wetland treatments systems to treat oil sands process-affected water because there is less waste compared to industrial processes.	Pilot
24	Genomics are a natural way to enhance constructed wetland treatment systems.	Pilot
25	Using wetlands enhanced by genomics to treat oil sands process-affected water aligns with my views of sustainability.	Pilot
26	Genomics is inevitable, so we should be learning how to use it for the environment.	Pilot
27	Oil companies will do what they want anyways, so we might as well work with them to figure this out.	Pilot
28	I am skeptical that this process is going to work.	Pilot
29	I worry about how these microbes will interact with animals.	Pilot
30	I worry about how these microbes will interact with people.	Pilot
31	I worry about legacy impacts - what will happen to this wetland in the future if this oil company is sold.	Pilot
32	I don't want this wetland to disrupt the land around me.	Pilot
33	I want to have input on the planning and management of constructed wetland treatment systems enhance by genomics near my community.	Pilot
34	It is not possible to remove the uncertainty of constructed wetlands, so I am unable to support this process.	Pilot
35	I don't have enough information about the expected social impacts to feel comfortable with constructed wetland treatment systems enhanced by genomics.	Pilot
36	I wonder if this will impact cultural ceremonies in my community.	Pilot
37	I wonder how these wetlands will affect traditional medicines.	Pilot
38	I believe a wetland has a spirit, which makes this process concerning to me.	Pilot
39	There is a spirit to wetlands that cannot be reconstructed by humans.	Pilot
40	Constructed wetland treatment systems enhanced by genomics are in agreement with my spiritual and cultural beliefs.	Pilot
41	Humans using plants to filter chemicals that humans created goes against my beliefs.	Pilot
42	I don't understand genomics, but I'm still not opposed to it being used.	Industry
43	I would like more information.	Industry
44	Constructed wetland treatment systems are being used in a variety of wastewater treatment applications, so I am comfortable using them for OSPW treatment.	Industry
45	Genomics has been used successfully in many other industries.	Industry
46	Why reinvent the wheel? If there is something natural that can fix the problem, why not use it?	Industry
47	If we are disturbing nature to create the wetlands, are they less natural?	Industry
48	Oil companies adhere closely to the regulations and policies given from government and stakeholders.	Industry
49	There will not be one solution to this problem. Genomics may be one of many.	Industry
50	Oil companies do cutting-edge research and follow the science.	Industry
51	Companies working in the oil sands have to follow regulations and work side-by-side with stakeholders.	Industry
52	The microbes are local, so I am not worried about them.	Industry

53	Large pilots have been successfully run to ensure the technology will work and will not contaminate the watershed. Pilots are done in controlled environments and are done at a large enough scale to prove the technology.	Industry
54	I like constructed wetland treatment systems because they are scalable - it is one of the few treatment systems that only works better when you scale it up.	Industry
55	Will the science of genomics do what it says it's going to do? Is the science of genomics intact or accurate enough to make predictions?	Industry
56	Nature is resilient and knows how to heal itself, so I see this system as a way to learn from nature. There are existing wetlands that are doing treatment by themselves, so we are inspired by nature.	Industry
57	I wonder if there will be bioaccumulation to the food chain that will affect hunting and fishing.	Industry
58	How will these wetlands affect the growth of my traditional plants?	Industry
59	These wetlands must be monitored and maintained for decades after they are built to ensure they do what is expected.	Industry
60	Liability of these wetlands over time is held by the companies.	Industry
61	I cannot immediately make a connection between the term genomics and how OSPW would be related - the term genomics which is usually associated with modification of DNA of living things is hard to associate with process water.	R&P
62	If constructed wetland treatment systems are to be implemented, there needs to be better communication of how this work so that all affected persons can understand how they work and what's going on; industry must communicate what they are doing in an approachable way.	R&P
63	CWTS offers another option for treatment of OSPW.	R&P
64	These are natural treatment systems, and we need to better understand performance and reliability.	R&P
65	There is a big difference between a natural wetland and a constructed treatment system made using the features of a wetland.	R&P
66	Constructed wetland treatment systems cannot treat all constituents of concern present in oil sands process affected water, so the system has limited uses.	R&P
67	I support using a constructed wetland treatment system while a mine is operating, but not on a closure landscape.	R&P
68	Constructed wetland treatment systems use biological processes, but they are not a natural system.	R&P
69	Multiple factors determine what science Industry pursues - economics are a major factor.	R&P
70	If constructed wetlands are treatment systems, then before closure, they must be decommissioned. Regulators cannot accept constructed wetland treatment systems on a reclaimed landscape, as they must be monitored - for an area to be considered permanently reclaimed, it can't have any engineered systems.	R&P
71	I don't want many constructed wetland treatment systems on the landscape because there are many unknowns, such as costs, with constructed wetland treatment system closure.	R&P
72	There needs to be clear language and better communication around what genomics is.	S1
73	Constructed wetland treatment systems have a lot of complicated biological features, so optimizing to make it a commercial system requires work to understand the variables. Genomics may help.	S1

74	The system may be engineered, but I think it is still a natural system - we are setting the stage for Mother Nature and giving natural processes a leg up.	S1
75	Industry must uphold standards set out by regulators and policymakers and stakeholders and monitor that targets are met. If things don't work as planned, I trust there will be a pivot.	S1
76	I don't think there is any additional threat to containing the water in a constructed wetland treatment system vs any other treatment system; they would all require some form of containment.	S1
77	There is research underway to remove unpredictability.	S1
78	If research supports it, I am fine with leaving the constructed wetland in place after mine closure.	S1
79	We need to fully understand the microorganisms and the biological, physical, chemical factors that drive constructed wetland treatment systems before we apply them as a treatment or optimize the treatment.	S1
80	A benefit of constructed wetland treatment systems is the ability to transition it to a state that could serve a lot of ecological services and be a good feature on the landscape in addition to providing treatment during the more active phase of treatment.	S1
81	We don't hear enough about how successful the geotechnical engineers are in this region. They do a very, very good job and it's really unfortunate when things do happen, but it is very rare.	S1
82	Genomics is a scientific tool that can be developed to monitor constructed wetland treatment systems for desirable activities. It is part of a solution for effectiveness and must be used with other tools like chemistry.	S2
83	Genomics requires more concrete research but is a good strategy going forward.	S2
84	Constructed wetlands will become more natural over time.	S2
85	Genomics is a tool to address unpredictability in constructed wetland treatment systems.	S2
86	I do not associate spirituality with wetlands.	S2
87	I have not associated spirituality with wetlands, but I am open to the idea.	S2
88	We need the generation of common language dictionaries for genomics.	IP
89	Genomics can be a confronting word because of what is in the media.	IP
90	Genomics fits within a wider means to commodify the environment - we need to consider what is the data for, and who benefits?	IP
91	I think genomics are part of an innovation strategy governments are trying to implement.	IP
92	Innovation needs to be balanced with nature. Are we putting an ecosystem into a space it wasn't before? Is that the song the landscape used to sing, or are we forcing it to sing from a different song sheet?	IP
93	Until you can prove no harm can come from this, you shouldn't do it.	IP
94	The impacts to Indigenous health are not well understood.	IP
95	We are a part of nature, so anything we do is an expression of humanity.	IP
96	We put too much pressure on Mother Earth to have to keep fixing up our mistakes, and then we get innovative and look to nature for that innovation, and then we use that as an excuse to continue to expect her to clean up our mistakes.	IP

97	I think we should start taking responsibility for what we are doing and start changing our behaviours rather than expecting Mother Earth to keep on taking the brunt of it and absorbing everything.	IP
98	Indigenous Peoples should have veto power to ensure whatever is being generated meets with cultural values. At each step, a stopping point.	IP
99	Indigenous peoples should have the right to veto at any stage of remediation that they do not feel comfortable, and the precautionary principle is not being addressed.	IP
100	I am concerned CWTS enhanced by genomics will put pressure on the Indigenous Peoples at place who may then feel compelled spiritually and culturally that they have to take responsibility for the care of those things as the people of that space.	IP

Appendix F – Cultural Theory Ways of Life Categorization

Focus Group Session	Opinion Statement #	Cultural Theory Ways of Life Categorization (Schwarz & Thompson, 1990)												Way of Life Classification
		Nature	Time	Ideal	Eng Esthetic	Energy Future	Desired System	Salient Risks	Risk Handling	Consent Model	Latent Strategy	Institutions	Decision Making	
Pilot	19	E	x	X	x	x	x	x	x	x	x	x	x	**E**
Pilot	20													**>1**
Pilot	21													**>1**
Pilot	22	x	I	X	I or H	x	I or H	I or H	x	x	x	x	x	**I**
Pilot	23	E	E	X	x	x	E	E	x	x	x	x	x	**E**
Pilot	24	E	E	X	x	x	E	x	x	x	x	x	x	**E**
Pilot	25	E	E	X	x	x	E	x	x	x	x	x	x	**I**
Pilot	26	x	I	X	x	x	I	I	I	x	x	x	F	**I**
Pilot	27	x	x	X	x	x	A	x	A	A	A	x	x	**A**
Pilot	28	x	x	X	x	x	x	F	x	F	x	F	x	**F**
Pilot	29	E	x	X	x	x	E	E	x	x	E	x	x	**E**
Pilot	30	E	x	X	x	x	E	E	x	x	E	x	x	**E**
Pilot	31	x	E or H	X	x	x	E or H	E	x	x	E or H	x	x	**E**
Pilot	32	E	E	X	x	x	E	E	E	x	x	x	x	**E**
Pilot	33	X	x	X	X	x	H or E	H or E	H or E	E	H or E	E	x	**E**
Pilot	34	x	x	X	x	x	H	H or F	H	H or E	x	x	H	**H**
Pilot	35	x	E or H	X	x	x	E	E or H	E orH	E	E	E	H	**E**

Pilot	36	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Pilot	37	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Pilot	38	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Pilot	39	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Pilot	40	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Pilot	41	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Industry	42	x	I	I	I	x	I	x	I	x	x	x	x	**I**
Industry	43													**>1**
Industry	44	x	x	I	I	x	x	x	I	x	x	x	I	**I**
Industry	45	x	x	I	I	x	x	x	I	x	x	x	I	**I**
Industry	46	I or H	x	I	I	x	I	I	I	x	x	x	x	**I**
Industry	47	E	E or H	X	E	x	E	x	x	x	x	x	x	**E**
Industry	48	x	x	I	I	x	x	x	I	x	I	I	x	**I**
Industry	49													**>1**
Industry	50	x	x	I	I	x	x	x	I	x	I	x	I	**I**
Industry	51	x	x	I	I	x	x	x	I	x	I	x	I	**I**
Industry	52	I or H	x	I	x	x	x	I	I	I	x	x	I	**I**
Industry	53	x	x	I	I	x	x	x	I	x	x	x	I	**I**
Industry	54	x	x	I	I	x	x	x	I	x	x	x	I	**I**
Industry	55	x	x	X	H	x	H	H	H	x	H	x	x	**H**
Industry	56	I or A	x	I or A	I or A	x	I or A	x	I or A	x	x	x	I	**I**
Industry	57	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Industry	58	x	E	X	x	x	E	E	x	x	E	E	E	**E**
Industry	59	x	H or E	X	x	x	H	H or E	H or E	x	H or E	x	x	**H**

Industry	60	x	H or E	X	x	x	H	H or E	H or E	x	H or E	x	x	**H**
R&P	61	x	x	X	x	x	x	x	H	x	H	H	x	**H**
R&P	62	x	x	X	x	x	H	H	x	E	H or E	H or E	x	**H**
R&P	63													**>1**
R&P	64	H	x	X	x	x	H	H or E	H	x	x	x	x	**H**
R&P	65	H or E	x	X	H	x	x	x	H or E	x	H	H	H	**H**
R&P	66	x	x	X	H	x	H	x	H	x	x	x	x	**H**
R&P	67	x	H or E	X	x	x	H	H or E	H or E	x	H	H	x	**H**
R&P	68	H or E	x	X	x	x	x	x	x	x	x	H	x	**H**
R&P	69	x	x	X	x	x	x	H	H	x	H	H	x	**H**
R&P	70	x	H or E	X	x	x	H	H or E	H or E	x	H	H	x	**H**
R&P	71	x	H or E	X	x	x	H	H or E	H or E	H or E	H	H	x	**H**
Scientist	72	x	x	X	x	x	H	H	H	H or E	x	x		**H**
Scientist	73	x	x	X	x	x	I or H	x	x	x	x	H	x	**H**
Scientist	74	H or A	x	X	x	x	I or H	x	x	x	x	H	x	**H**
Scientist	75	x	H or E	X	x	x	H	H or E	H	x	H	H	x	**H**
Scientist	76	x	x	X	x	x	x	H	H	x	x	x	H	**H**
Scientist	77	x	x	X	I or H	x	H	x	x	x	x	H	H	**H**
Scientist	78	H or A	H or E	X	x	x	H or E	H or E	x	x	x	x	H	**H**
Scientist	79	E	x	X	E	x	H or E	E	H or E	x	x	H or E	H	**E**

Scientist	80	H or E	H or E	X	x	x	H or E	x	x	x	H or E	H	H	**H**
Scientist	81	H	x	X	H	x	H	x	H	x	x	H	H	**H**
Scientist	82	x	x	X	x	x	I or H	x	x	x	x	H	x	**H**
Scientist	83	x	x	X	x	x	I or H	x	x	x	x	H	x	**H**
Scientist	84	H	H or E	X	x	x	H or E	x	x	x	x	x	H or E	**H**
Scientist	85	x	x	X	x	x	I or H	x	x	x	x	H	x	**H**
Scientist	86													**>1**
Scientist	87													**>1**
IP	88													**>1**
IP	89													**>1**
IP	90	E	E or H	X	E	x	x	x	E	E	E	E	x	**E**
IP	91	x	x	X	x	x	x	E	x	x	x	E or F	E	**E**
IP	92	E	E or H	X	E	x	E	x	x	x	x	x	E	**E**
IP	93	E	E or H	x	x	x	E or H	E or H	E	E	x	x	x	**E**
IP	94	E	E or H	x	x	x	E	E	E	x	E	E	x	**E**
IP	95	x	x	x	x	x	x	x	x	A	x	x	x	**A**
IP	96	E	x	x	x	x	x	E	E	x	E	E	x	**E**
IP	97	E	x	x	x	x	x	E	E	x	E	E	x	**E**
IP	98	x	x	x	x	x	x	x	x	E	E	E	x	**E**
IP	99	x	x	x	x	x	x	x	x	E	E	E	x	**E**
IP	100	E	x	x	x	x	x	E	E	x	E	E	x	**E**