# HOW DOES SUSTAINABLE INFRASTRUCTURE LIKE HYDROELECTRIC POWER PLANTS AND THEIR OPERATION IMPACT UNDERREPRESENTED COMMUNITIES?

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On my honor as a University Student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments

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# HYDROELECTRIC POWER PLANTS: THE BIG PICTURE

Hydroelectric power plants transform the hydraulic energy of rivers into renewable electrical energy. They can be examples of sustainable infrastructure, which refers to "the designing, building, and operating of structural elements in ways that do not diminish the social, economic, and ecological processes required to maintain human equity, diversity, and the functionality of natural systems" (Community Research Connections (CRC), n.d.). Meeting global carbon mitigation targets will require rapidly transitioning to more renewable energy sources. However, doing so will make our energy supply more variable and out-of-phase with demand. One approach to balancing supply and demand is to use existing hydropower and pumped storage facilities, which can reduce needed investments in developing battery storage technologies by pumping water back up to a reservoir at night to prepare for peak power demands (USGS, 2018).

While pump storage can effectively manage hydroelectric energy, it can also have negative impacts like environmental degradation, water depletion, economic drawbacks, societal effects, and energy inefficiency. Just as reducing downstream water flow can cause a loss of habitat and reduce available water supply, creating reservoirs for pumped storage hydropower systems often causes upstream flooding that destroys wildlife habitats and agricultural land (EnergySage, n.d.). See Figure 1 for an illustration of the main dam components. Building and maintaining these facilities is undoubtedly expensive, and the costs of constructing them are passed on to consumers through higher electricity rates. The construction of pump storage facilities can also lead to the displacement of local communities and the disruption of cultural and historical sites. Finally, it is an energy-intensive process, and the energy used to pump water is not 100% recoverable, leading to economic losses. It is essential to consider these impacts

when planning and implementing pump storage systems because for all the benefits they may provide for the electric grid's reliability, it is also crucial to maintain sustainable and environmentally-friendly practices in developing hydroelectric energy systems.

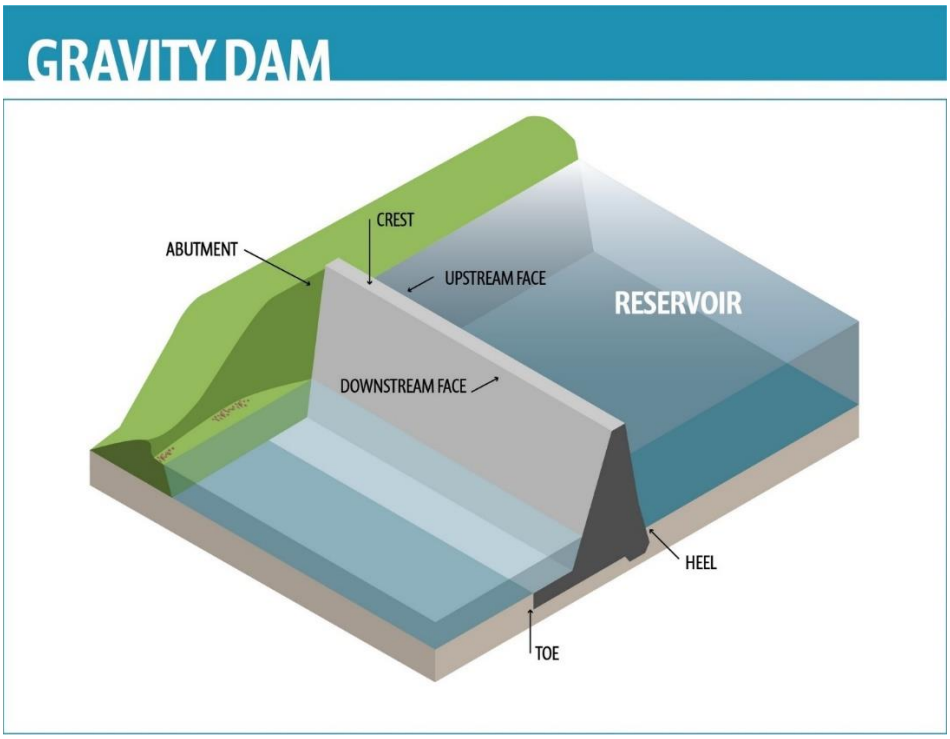


**Figure 1:** A diagram of the most common kind of concrete dam in the U.S.; a gravity dam (Noland, 2021).

The Columbia River Basin (CRB) case in the Pacific Northwest (PNW) exemplifies this dilemma. The main facilities of the "Columbia Basin Project" are the Grand Coulee Dam, its reservoir Franklin D. Roosevelt Lake, three power plants, four switchyards, and a pump-generating plant. The construction and eventual completion of the Grand Coulee Dam in Washington in 1942 led to a rippling wave of effects that permanently changed the lives of numerous social groups. As the largest hydroelectric power plant in the United States, the dam's impacts go beyond the lasting environmental changes. The dam is part of the Columbia River

Treaty, a United States and Canada water management agreement signed in 1961. The treaty has been controversial recently, particularly among indigenous communities in the region, who have raised concerns about the allocation of benefits. In 2019, the updated treaty included provisions for environmental cooperation and the inclusion of indigenous communities in managing the river basin. This research explores the socio-economic implications of the dam, which range temporally from its conception until the present, as well as in scale, from the economy of the United States and Canada, the Pacific Northwest, and down to the communities that played a part in the dam's development. Native communities are an example of an underrepresented community disproportionately impacted by the construction and operation of a project like the Grand Coulee Dam. The narratives put forth by the afflicted tribes and the federal agency in charge can be compared for a more three-dimensional analysis of the dam's impacts.

## History of the Grand Coulee Dam

The Grand Coulee Dam is one of the largest structures ever built by humankind – it is more massive than the Great Pyramid of Giza. The American Society of Civil Engineers (ASCE) lists it as one of the seven civil engineering wonders of the United States. Its reservoir, Roosevelt Lake, stretches 150 miles to the Canadian border. See Figure 2 for a visualization of the dam's size. The local proposal to dam the Columbia River dates back to 1918. However, there was intense competition from another proposal that called for an irrigation canal instead, arguing that the hydroelectricity from the dam would not be needed. After reaching a compromise, they eventually accepted the dam proposal, which included building a dam and an irrigation system. The United States Bureau of Reclamation (USBR) took hold of this proposal because the Reclamation Act of 1902 required that water users repay construction costs from which they

received benefits (irrigation projects were referred to as "reclamation" projects because arid lands were "reclaimed" for human use) (USBR, 2018). The goal was to have a multi-use dam like the Grand Coulee to eventually repay the project's construction cost with the generated revenue from the hydroelectricity, which would decrease the financial burden on irrigators. It took eight years to construct (1934-1942) and was a beacon of hope during the Great Depression.

**Figure 2.** The Grand Coulee Dam, as shown by the USBR (2023).

President Roosevelt took office during a time characterized by great dustbowls and the Great Depression. The Grand Coulee Dam project employed thousands of men, and the USBR received unprecedented funds as a new key player in the New Deal's Public Works Administration (PWA). The concrete placement process alone took workers over 27 million hours, and 45 men died in this phase. Sprouting up around the dam were towns like Mason City (the world's first "all-electric city") to house workers, Engineers Town to house its engineers, and Grand Coulee Town for drinking and gambling past-times. After its completion, the dam facilitated the production of electrical power plentiful enough to make it an essential player in the World War II production of aluminum for ships and planes. With the end of WWII, the

Northwest's economy continued to boom, with its irrigation capabilities transforming the arid region into an agricultural hotspot. Since its construction, the dam has continued to grow to support increasing demands. It remains today the largest hydropower producer in the United States, producing about 11% of the power requirements in the Pacific Northwest. All this is not to say that Grand Coulee has not faced its fair share of criticism in its time. (National Park Service, 2017).

## The Ethnography of Infrastructure

There are stakeholders involved in every facet of this problem – the public sector, the private sector, and citizens, to name a few – and they are often in conflict with each other. For example, power companies that want to maximize hydropower production clash with eco-advocacy groups that push back for increased salmon protection (via spillways or fish ladders). Unlike the groups with prominent voices in the discussion behind infrastructure development, there will be groups that are inadvertently and disproportionately impacted. The operation of the Grand Coulee Dam has caused hydro-ecological changes that disproportionately impact native tribes in the area. These communities had a history in this region for over 10,000 years and, with such a monumental technological development, suffered a loss of salmon populations, flooding, and displacement, to name just a few disruptions. As a result, this irreparably altered the stability of their livelihoods. Thus, as we adapt hydropower operations to support renewable energy transitions and freshwater sustainability, it is crucial to investigate the social and human connections, especially regarding how they impact underrepresented communities.

Infrastructure, by definition, is the basic physical and organizational structure needed to operate a country, city, or area (Masterclass, 2022). Designing and operating hydroelectric power

plants aims to minimize diminishing social, economic, or ecological processes. Of course, it is more complex in application than may be in theory, as the functionalities of the natural, built, and social environment are interconnected in ways that make it extremely difficult to appease all actors involved. According to "Ethnography of Infrastructure" by Star (1999), infrastructure appears as a relational property, as it differs in meaning to different groups of people. For example, the construction of the Grand Coulee Dam blocked spawning salmon from the upper Columbia River (see Figure 3), drastically changing the fish-based culture of the native peoples in the area (USBR, 2021a). However, many others, like the workers, contractors, and government bodies, are supported by the Grand Coulee Dam area's economy, which depends on the dam for its power and irrigation. The nine properties of infrastructure defined by Star are: embeddedness, transparency, reach or scope, learned as part of membership, links with conventions of practice, embodiment of standards, built on an installed base, becomes visible upon breakdown, is fixed in modular increments (Star, 1999).


**Figure 3.** Salmon run accessibility in the Columbia River Basin. Grand Coulee Dam is labeled just under the Canadian border. (The Economist, 2014).

In this case, the investigation of the Grand Coulee Dam will use "embeddedness," "reach or scope," and "built on an installed base ." Infrastructure is sunk into and embedded inside other structures, social arrangements, and technologies, with people seldom distinguishing the coordinated components of the infrastructure (Star, 1999). The dam's facilities are embedded in the power grid and irrigation systems. The sheer size of the dam means that the builders, operators, managers, and citizens only see what they are directly interacting with. The reach or scope of the infrastructure can be spatial or temporal, extending beyond a single event or one-site practice. As the largest hydropower producer in the United States, the Grand Coulee Dam supplies electricity to 8 western states (USBR, 2021b). Lastly, Star (1999) argues that

infrastructure inherits the strengths and limitations of the existing installed base upon or within which it is built. The concrete dam modeled itself after nature's path during the last Ice Age over 13,000 years ago. The Cordilleran Ice Sheet blocked the Columbia River where the dam sits today, diverting the Columbia River to cut a new channel that would become a vast canyon. These scoured channels or canyons are called coulees, and one of the largest coulees was rightfully dubbed “Grand Coulee” (National Park Service, 2017). This canyon is where the Grand Coulee Dam pumps water for irrigation today (USBR, 2021c). Since its completion in 1942, the Grand Coulee Dam has undergone several additions, including a pump-generating plant, another power plant, and another dam (Northwest Power and Conservation Council, n.d.).

## RESEARCH QUESTION AND METHODOLOGY

The research question is: How has the construction and operation of the Grand Coulee Dam affected specifically the Colville and Spokane tribes? This question fits the broader context of how intended sustainable infrastructure like hydroelectric power plants impact underrepresented communities. The Colville and Spokane tribes were selected for this case study analysis because they are the most closely associated with the Columbia Basin Project and thus share more history with the Grand Coulee Dam construction. Secondary accounts from the Bureau of Reclamation and the native tribes of interest were compared for a case study analysis using the ethnographic framework, which considers how decisions made regarding economic, environmental, and institutional metrics excluded or disproportionately impacted these native tribes. Access to published information about the cultural and construction history of the Grand Coulee Dam is available through the Bureau of Reclamation, which will provide perspective into what the federal agency chooses to present to the public regarding the dam’s impacts.

Additionally, the Colville and Spokane tribes published their accounts of their history and experience regarding the dam.

While reading through the narratives from these two contesting sides, it is pertinent to note any differences between the narratives presented by the federal agency and the afflicted native communities, especially regarding negative impacts. These accounts will have converging points, but the divergences can reveal much more about the lived experiences and perception of the dam for an underrepresented community oft left out of discussions regarding their lives. The properties of the Grand Coulee Dam – its embeddedness in the PNW's economy and social culture, the reach and scope of the dam's impacts, and its development on an installed base already enriched with cultural and geological history – can provide focal points for the case study analysis. This analysis is valuable because it relates to the treatment and involvement of all people in developing, implementing, and enforcing environmental laws, regulations, and policies (Office of Legacy Management, n.d.).

## Results

The construction and operation of the Grand Coulee Dam have had significant socio-economic impacts on underrepresented communities in the Pacific Northwest region of the United States. One of the most significant consequences has been on displaced Native American communities because of the construction of the dam and its reservoir. However, the displacement of tribes did not begin solely because of the dam.

### *The Colville and Spokane Reservations*

Throughout the mid-19th century, disputes over land ownership between natives and European and Canadian settlers increased fervently, resulting in President Grant's Executive Order of 1872. The order attempted to mitigate the conflicts by establishing the Confederated Tribes of the Colville Reservation, which consisted of 12 tribes and included the Colville Tribe. However, Grant discovered that not every Native American nation was ready or willing to embrace his administration's proposed changes. As a believer that natives should assimilate to "become civilized," the President stated that those "who will not put themselves under the restraints required will have to be forced, even to the extent of making war upon them…." Some native tribes supported Grant's efforts for peace, like the delegation of Cherokee, Choctaw, Creek, and Chickasaw leaders that praised Grant at the beginning of his presidency. Though ultimately, his assimilationist policies were rooted in destroying Native American culture to fulfill westward expansion or "Manifest Destiny". (National Park Service, 2022).

Nine years after Grant in 1881, President Hayes established the Spokane Reservation through another Executive Order for the Spokane natives who had refused to leave their lands to the Colville [Indian] Reservation. However, this Reservation only included the main village sites of the lower Spokane, so most of the middle and upper Spokane again refused to relocate. They suffered increasing marginalization with the growing population of white settlers, and the need to reach an agreement became more pressing than ever. Even with an agreement to provide off-Reservation Spokane with funds to relocate and settle, many still did not leave their residences. Unfortunately, they were forcibly displaced when the Grand Coulee Dam was built. (Bureau of Indian Affairs (BIA), 2018). See Figure 4 below for a map of the current Colville and Spokane Indian Reservations.

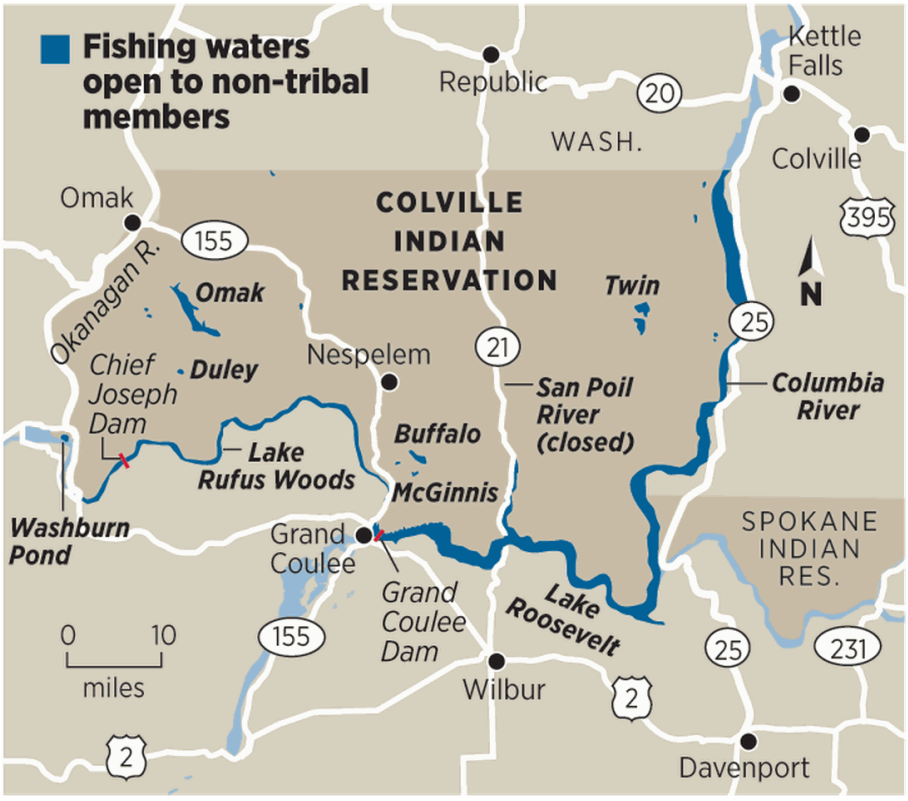


**Figure 4.** Current Colville Indian Reservation, the waters open to fishing by non-tribal members, and the Spokane Indian Reservation to its right. (Quinn, 2014).

Socio-Economic Impacts Post-Construction

From the USBR's official website, the Cultural History page for the Grand Coulee Dam acknowledges the significant impacts following the dam's construction, like flooding lands and burial sites (USBR, 2021a). The BIA negotiated with the USBR on behalf of tribes, which led to a burial relocation project in 1939. The relocations discovered many artifacts, but the collection methods destroyed archaeological evidence. (National Park Service, 2003). Tribal leaders reported an additional 2,000 graves in 1940, but the USBR would not continue grave relocation and water soon covered the sites. These communities were forced to leave their ancestral lands, including fertile farming areas, hunting and fishing grounds, and sacred sites. This resulted in the loss of cultural knowledge and traditional practices and the decline of tribal languages and cultural identity. The displacement caused increased stress and trauma and reduced access to traditional food sources and medicines, leading to diet-related health problems such as diabetes. The flooding caused the decline of their fishing and agriculture industries, leading to unemployment and poverty in the region. Many Native American families were forced to rely on government assistance, causing further marginalization and loss of self-sufficiency. (McGill, 2016).

Many tribes worked to preserve their traditional cultures and practices, including efforts to document and pass down their knowledge and language. (USBR, 2021a). The Colville Confederated Tribes have amassed a comprehensive collection of resources and documents on their official website, including a historical documentary titled "Building the Grand Coulee Dam: A Tribal Perspective". In this documentary, members of the Colville Confederated Tribes share their perspectives on the impact of the Grand Coulee Dam on their communities. A common

theme in these stories is how highly they prioritize their relationship to the land, their ancestors, and their traditions. (Horsethief, 2017). When Kettle Falls, the second largest salmon fishery on the Columbia River and popular gathering place for thousands of natives, slipped under the rising water levels of Lake Roosevelt in 1940, a final ceremony, "The Ceremony of Tears," was held (see Figure 5). It marked the end of a 10,000-year-long reign of a historical and cultural site. Politicians, spectators, media, and natives were all in attendance, including U.S. Senator Homer Bone, who understood the value of Kettle Falls and tried to minimize the dam's impact on local tribes. Despite the attention, the dispute over compensation to the tribes lasted decades, with the Colville Confederated Tribes eventually winning a lawsuit for 53 million dollars in 1994 and an additional 15 million annually in 1996. (Justine, n.d.).

**Figure 5.** Colville women in the Ceremony of Tears (UW Special Collections, 2005).

Today, organizations like the Upper Columbia United Tribes (UCUT) and Save Our Wild Salmon are successfully fighting for salmon restoration (Justine, n.d.). The Colville Confederated Tribes are involved in other mitigative efforts to manage the Columbia River basin

more sustainably and equitably. These efforts include habitat restoration, hatchery programs, fishing regulations, archaeological surveys, cultural resource management plans, partnerships with other tribes and organizations, and advocating for renegotiation of the Columbia River Treaty for more just distribution of benefits. (Horsethief, 2017). The Spokane Tribe Preservation Program (STIPP) is a similar effort undertaken by the Spokane Tribe in 1995. This program aims to preserve the cultural sites, material, and knowledge of Spokane's inundated ancestral territory. By working with federal agencies like USBR, STIPP can expand its work to encompass cultural resource management and provide cultural resource compliance surveys at local, state, and private levels. (Spokane Tribe of Indians, n.d.). As further evidence of the cooperation between the USBR and the tribes, Congress authorized fish hatcheries to mitigate the construction of the Grand Coulee Dam, to be operated by the Colville Tribes. The tribes fish the waters below the salmon hatcheries and are allowed to take up to 50% of the fish raised by these hatcheries. Congress also set aside one-quarter of the entire reservoir for the members of the Confederated Tribes and Spokane Tribe for fishing, boating, and hunting purposes (USBR, 2021c).

Perhaps unsurprisingly, there are significant differences between how federal agencies like the Bureau of Reclamation present information about the Grand Coulee Dam's impacts and how the disproportionately impacted Indigenous tribes present their perspectives and experiences. The Bureau of Reclamation presents the Grand Coulee Dam as a significant engineering feat that brought about immense economic development in the region. The agency extensively highlights the dam's positive impacts, such as job creation and economic growth. In contrast, the information about its negative impacts is vague or excludes details about the tribal efforts to preserve their way of life. The Colville Confederated Tribes and the Spokane Tribe, in contrast, discuss in-depth how deeply the impacts of the Columbia Basin Project permeated their lives, as

well as their various undertakings to maintain their livelihood. These discrepancies highlight the narrative and informational divergences between the federal agencies that focus on the dam's economic benefits and the Indigenous tribes that emphasize the cultural and environmental costs disproportionately borne by their communities.

## DISCUSSION

In this case study analysis, the investigation of the Grand Coulee Dam used "embeddedness", "reach or scope", and "built on an installed base," according to Star's study of the ethnography of infrastructure. The dam quickly became deeply embedded in the way of life and economy. The Pacific Northwest relied heavily on the jobs, energy, and irrigation provided by the dam, especially during the Great Depression and wartime. It represented a beacon of hope and political power for America. The disproportionately impacted natives suffered all the adverse effects without reaping any of the benefits. That is, unless they took legal action and even then, would endure dismissal for years before being given insufficient reimbursement. Secondly, when considering the Grand Coulee Dam, what looks like a point on a map reverberates its impact extensively past its singular location and demonstrates the *reach and scope* defined by Star. Though the exact population of the indigenous peoples in the Pacific Northwest region is difficult to determine due to a lack of accurate historical records, estimates suggest that tens of thousands of indigenous people lived in the area. They had been inhabitants for over 11,000 years (USBR, 2021a) before floods destroyed over 21,000 acres of prime bottomland (Blaine, 1996). Lastly, the nature of infrastructure means that it inherits the strengths and limitations of the existing installed base it is built upon or within (Star, 1999). Since its completion in 1942, the Grand Coulee Dam has undergone several additions, including a pump-generating plant, another power plant, and another dam (Northwest Power and Conservation

Council, n.d.). Making additions without a proportional (or greater) amount of effort into increasing sustainability, conservation efforts, and cultural preservation is neglectful. Just as the dam is built on an installed base and continues to grow onto itself, the communities impacted also have a right to build upon themselves.

The fight to support and nurture the indigenous communities is far from over and not entirely one-sided. The Department of Energy (DOE) has put forth efforts to address the adverse impacts of environmental hazards on underrepresented communities. This includes working with communities with minority and low-income populations, as well as the American Indians and Alaskan natives that are disproportionately impacted. Those who have been historically excluded must have the same access to environmental decision-making and a working knowledge of the subject matter for their participation to be meaningful. DOE's environmental justice program aims to give stakeholders opportunities to participate in DOE decision-making to the greatest extent possible and to ensure they have the tools to strengthen their economies. (Office of Legacy Management, n.d.). Many environmental justice issues revolve around issues of risk. That is, perceived risk rather than real risk; differences in the perception of risk are escalated where there are outstanding issues or distrust between the agency and a community. (Office of Legacy Management, 2017).

The endangerment of salmon runs is a particularly contentious disparity that continues to aggrieve the parties involved with the Columbia and Snake Rivers. A court case was brought to the Supreme Court by fishing and conservation groups joined by the state of Oregon, the Nez Perce Tribe, and the Biden administration, filed against the U.S. Army Corps of Engineers, USBR, Bonneville Power Administration, U.S. Fish and Wildlife Service, and the National Marine Fisheries Service. They sought to challenge the latest federal plan issued by the Trump

administration in 2020 for hydropower operations that are blamed for killing salmon. Four dams built in the Columbia River Basin (Ice Harbor, Little Goose, Lower Monumental, and Lower Granite) are most faulted for the near-extinction of salmon. A federal judge has ordered a stay in this case, which means the case will not move forward as the judge considers whether the government's ongoing environmental impact statement (EIS) process is sufficient to address the issues. A similar event occurred in Oregon, with the Yakama and Lummi nations calling for removing the Bonneville, The Dalles, and John Day dams (see Figure 6). These lower Columbia River dams severely endangered salmon runs and the orcas that rely on them. The issue of these dams' impact will likely remain contentious, with both sides continuing to advocate for their respective positions (essentially environment vs. economic benefit). (Geranios, 2021).

**Figure 6.** JoDe Goudy, chairman of the Yakama Nation, calls for removing the three dams on the lower Columbia River. "Dams or salmon," he said in an emotional plea at the Celilo Village Park near The Dalles Dam. (Ringman, 2019).

The results provide insights into the impacts of the Grand Coulee Dam construction and operation on relevant native communities and how this multi-objective problem can manifest as

conflicting tradeoffs between afflicted parties. However, note the limitations of the methodology. First, a disclaimer that acknowledges the breadth and complexity of the relationship between the Columbia Basin Project and the Indigenous communities in the Pacific Northwest region. This paper is limited in space for discussion, but readers should not be discouraged from pursuing further research into the rich history of the dam and the tribes if it is of interest. Secondly, because of how directly they were affected, the Colville and Spokane Tribes are in close cooperation with related federal agencies and are governed by the federal government (though they are recognized as sovereign nations), so their information may be "biased" or abridged in the same way as well, even if it may be to a lesser extent. Of course, this does not invalidate or discredit their personal experiences shared online.

This research directly supplements the technical aspect of the capstone project, which aims to optimize the operation of the Grand Coulee Dam such that the conflicting objectives yield some benefit for all parties. The ongoing history of the Columbia Basin Project and the efforts undertaken by all stakeholders exemplify the need to prioritize the interests of marginalized communities. As the Columbia River Treaty continues to undergo renegotiation, it is crucial to consider the impacts of large development projects on these communities' cultural and economic well-being. Many Indigenous nations advocate for their rights and interests in the renegotiation process, but they should not shoulder these burdens alone.

## CONCLUSION

In conclusion, the Grand Coulee Dam stands as a symbol of America's economic and political power. However, its construction and operation have profoundly impacted the indigenous communities in the Pacific Northwest. Using an ethnographic framework to

understand how decisions made regarding economic, environmental, and institutional metrics excluded or disproportionately impacted native tribes, the far-reaching and immediate changes can be better evaluated for ongoing endeavors of ethical engineering and equitable policy application. The future of environmental justice depends on the collaboration between indigenous communities, federal agencies, and other stakeholders to address the impact of environmental degradation on marginalized communities. The voices and perspectives of the underrepresented must be included in the decision-making process to ensure meaningful participation. The efforts taken by advocacy groups and conservation organizations to promote inclusive practices, protect natural resources, and address climate change are a large part of this movement. Ultimately, infrastructure development must be carried out to promote sustainability, conservation efforts, and cultural preservation and respect all affected parties' rights and interests.

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