DAMMED: MASTER PLANNING ALONG THE LOWER SNAKE RIVER IN A POST DAM-REMOVAL CONDITION

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Title

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The Supervisory Committee certifies that this ***thesis*** complies with North Dakota State University's regulations and meets the accepted standards for the degree of

MASTER OF LANDSCAPE ARCHITECTURE

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ABSTRACT

The four dams on the lower Snake River in Washington state have numerous impacts on the surrounding environment, and although provide benefits of hydroelectric power, irrigation services, and waterway navigation that alter the state of the river and adjacent land ecologically. The question that persists is if these structures need to be maintained, replaced, or removed altogether; since like all man-made structures, they have a finite lifespan that is approaching its end. The following research and methodologies address design solutions for these dam sites in a post-removal condition through case studies, site analysis, site planning, and design interventions from a landscape architectural lens. Although total removal is not certain as it deals with the influence of many different stakeholders, for the approach it will err on the hypothesis of removal. The unique design approach will open the door for greater opportunities along the river corridor.

ACKNOWLEDGMENTS

A special thanks to Craig Larson, Primary Advisor, and Jay Kost, Studio Professor, for the continuous support of this thesis, including aiding in research, design, and presentation for this project.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Figure | Page

1. INTRODUCTION

1.1. Problem Statement

Dams are known to be immensely detrimental to their surrounding environments when installed into an environment, although large feats of engineering that provide hydroelectric power, retaining water, and providing irrigation systems for agriculture. The only free-flowing, undammed river in the United States (over 600 miles long) is the Yellowstone River, which is quite an alarming fact. These dam structures tend to present problems for many species that reside within or around bodies of water, especially migratory ones like salmon and steelhead trout, and not to mention devastated riparian areas rich in native flora. Altering the native ecosystem and its shaping, chemical makeup, and biological qualities has shown how much it can cripple our environment in the long run. Alternatives to these structures must be entertained and there are several rivers with dams that must be removed before greater negative effects have taken place, like the four Lower Snake River Dams in Washington state.

1.2. Objective

A project suitable for this problem will be a large-scale plan with various site programs that not only aim to bring the Lower Snake River back as closely to its original state as possible, but the inclusion of an educational feature is vital to promote alternatives to dams, along with proposed areas for alternative renewable energy to be designed and maintained. These areas would be designed to promote outdoor human activities along with normal wildlife functions that were typical to the area before the massive altering was implemented. A designed and restored riparian area along the affected riverbanks will be described and implemented accordingly to match the native planting arrangements of the local landscape.

2. GEOGRAPHIC HISTORY

2.1 About the Snake River

The Snake River is a large tributary of the Columbia River in the Northwestern United States. Initially beginning below Jackson Lake in Wyoming, winding through southern Idaho within Hells Canyon, then flowing through the hilly Washington plains before dumping into the Columbia River near the Tri-Cities Area, which eventually terminates in the Pacific Ocean. The watershed of the river spans across most of Idaho, and portions of Washington, Oregon, Utah, Wyoming, and Nevada. Precipitation remains scarce for most of this region, due to the imposed effects of the Cascade Range to the West, with higher alpine areas on the eastern portion of the region and semi-arid regions further to the West. Shrubland and rangeland areas cover the lower portion of the Snake River, with sagebrush, bunchgrasses, and wheatgrasses among others covering the hills adjacent to the river. Riparian areas have historically lined the river's shoreline although the construction of dams seems to have fragmented these areas.

2.2 About Hydroelectric Dams

Historically, humans have always been drawn to rivers and their surrounding valleys. Most of the earliest dams throughout history have been used for various agricultural purposes and water supply, and over time also can be used as a way to impound the water and implement a controlled release for power that can be used (Baxter 255). Dams can be constructed through earthen configuration, the earliest form of materials, masonry, and sometimes timber and steel. Most dams also hold a reservoir directly behind the built structure over the body of water, and these reservoirs may sometimes heavily change the configuration behind them. In many cases, the reservoirs tend to erode the banks to promote increased sedimentation and sediment buildup behind the dam structure. The creation of the reservoir also changes the overall composition of the water within it, usually pertaining to factors such as increased water temperature, changes in water flows, decreased dissolved oxygen levels, and less suspended materials. These changes in the composition of the water can create preferable habitats for non-native and even invasive species to the body of water altered by the dam. In the case of the Lower Snake River, one nuisance species called the Northern Pikeminnow, a known predator to young salmonids, ambushing the already struggling fish. There have been bounties placed on the harvesting of these rough fish in the Lower Snake River to aid in mitigation efforts, yet the success of these programs is up for debate.

2.3 Greater Impacts to Surrounding Communities

Not only has the construction of dams on the Lower Snake River changed the native landscape surrounding the river, but greater impacts to surrounding communities have persisted. One of the most notable being the local tribal communities that have relied on the migratory fish species that once flourished. Fishing for the salmon on the river was once a main part of the cultural and dietary standards for these local tribal communities that have lived along the corridor for many generations, tying back to humans' gravitation to bodies of water. It is also known that the construction of these dams has washed away many ancient settlements and areas of gathering along the river through the swelling of the waters from the reservoirs formed behind the dams. The rapid displacement of the water not only alters the ecosystem but displaces the people that once had a deep connection for many generations.

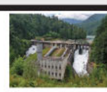
3. RESEARCH METHODS

3.1 Case Studies

The case studies method of research observes other dam removal projects throughout the United States, taking on many different scales and prior vulnerability of the rivers. The case study matrix figure shown below analyzes the different characteristics of each project and river, along with taking a look into the environmental impact prior to dam removal, the project's overall performance, benefits of the process, and then finally the current status of the river in a post-dam removal condition. From there, further summaries and recommendations can be made to aid in the final research analysis that transitions into the design portion of the thesis project. These dam removal sites include the Elwha + Glines Canyon, Copco #2, Boardman River, Milltown, and the Red River Lowhead Dams. See the table below.

Table #1. Case Study Research Matrix

CASE STUDY RESEARCH MATRIX // RIVERS ANALYSIS

NAME	LOCATION	BACKGROUND INFORMATION	ENVIRONMENTAL IMPACT	PROJECT PERFORMANCE	BENEFITS	CURRENT STATUS
ELWHA DAM + GLINES CANYON DAM	WA	 -Located on the Olympic Peninsula and built in 1913, with waters running through Olympic National Park.	-70+ miles of salmon spawning habitat severed. -Much sediment has built up behind the dams. -Native reservation's prime harvest waters altered.	 -Project was to have a slow release of structure, with the largest release of sediment by humans ever.	-River was restored similar to its prior shaping, with the salmon reconnected. -New overlook trail installed.	 -Elwha river's ecology is said to be "bursting with new life..."
COPCO #2 DAM	CA	 - This dam resided on the Klamath River, with a powerhouse downstream and associated diversion.	- The effects of this dam contributed to lessened steelhead and salmon runs, dewatering, and the flooding of Ward's Canyon which displaced many people.	 -Part of a larger dam removal project on the Klamath, with gradual reshaping of river.	-According to some, this project may come too late to fully save the salmon, yet riparian areas may be improved.	-Other dams are set to finish being removed by end of 2024. -Property values along the current reservoirs are decreased.
BOARDMAN RIVER DAMS	MI	 -Several dam sites near Traverse City Michigan along a coldwater river.	-The effects of these dams limited fish passage and decreased water quality including warmer temperatures. -One of the top trout fishing streams in Michigan. (Blue ribbon)	-Public and private stakeholders.  -USACE started dam removal in 2012, with the updating and replacement of a smaller Union Street Dam nearby.	-River has returned flow to a more natural state, reconnecting over 200 miles and around 250 acres of natural wetlands.	 -Aquatic life from migrating fish down to microorganisms has been found that wasn't prospering before.
MILLTOWN DAM	MT	-Scenic river near Butte, MT which is one of the most treasured rivers by recreational enthusiasts and nearby Tribes. -River is currently considered one of the most endangered.	-River continimated with toxins form nearby waste dumps, sludge ponds, and Smurfit-Stone mill. -Poisoning can happen from consumption of fish and groundwater.		-Removal of these toxins to help over time, and through federal funding, those responsible for pollution are to clean up the site.	 -Still a destination for angling and Tribal subsistence.
RED RIVER LOWHEAD DAMS	ND	 -3 dams were built near Fargo for agricultural purposes and drinking water span the width of the river.	-Native fish blockage from spawning areas due to structures. -Larger sedimentation and erosion along banks.	-Although expensive projects, the threat of humans drowning outweighs the inital purposes, killing at least 300 people since 1960 -Public/Private joint project.	-Fish habitat has been restored and lower erosion along banks. 	 -Gently rushing, designed rapids now replace the spanning structures.
SUMMARY		-Dams are designed and built for various reasons, yet some have different lasting effects that may last longer than their inital purpose.	-Issues like fish passage, changing the quality and temperature of water, and ecological effects like erosion remain consistent.	-Many dam removal projects can come at high costs, yet with jointed funding amongst stakeholders and precise removal processes these projects can be successful.	-Ample opportunities for connection to the river, recreation, subsistence and cleaner energy are needed.	-Restoring the river as close to the prior shape and composition allows for aquatic life to thrive, including the release of sediment and lowering of reservoirs.
RECOMMENDATION		-Snake River project to use careful consideration to similar projects.	-Since the Snake River has similar ecological issues, close environmental inventory/analysis to take place.	-Temporary construction processes while removal takes place to be considered, with project phases.	-Design programming to include much interaction.	-Management and maintenance plans must be put in place for future status.

RIVER CONDITION: MODERATE — CRITICAL

4. RESULTS

4.1 Discussion

Summaries and recommendations for each individual case study can be viewed at the bottom of the matrix in Table 1, but there are several overall conclusions that can be made regarding the results of the research. Some similar themes within the summaries include the removal of dams for outlying ecological improvements like allowing migratory fish to access their prior spawning grounds and limiting the effects of erosion on some of the bodies of water in the post removal condition. One aspect to note from these case studies can be the method of removal of the dam structures. Removal can be done in many different ways, some more aggressive like knocking down the foundation and letting the flowing water overcome the structure, or creating a temporary diversion as the dam is disassembled. Should the dams on the Lower Snake River be removed, professionals should approach each dam individually as they see fit, steering clear of a one-size-fits-all approach which is never the case. As a caveat, the design portion of this project does not highlight the actual removal process yet designing elements in the post dam-removal condition. Although, it is important to study beforehand how other projects have been successfully performed. Several recommendations that must be noted going forward include precise inventory/analysis of the surrounding context, temporary construction processes, re-use of the dam structure materials appropriately, allowing for ample interactions with the reinvigorated river, and adequate maintenance and management plans to be put in place in the end condition.

4.2 Limitations

- The study of this thesis is highly exploratory in nature and uses mostly qualitative measures for research findings. Quantitative findings, including migratory fish returns, would most likely need be measured through success of the final design, should the Lower Snake River Dams be removed.
- Local interviews and charrettes regarding post-removal performance were not able to be conducted on case study dam removal sites.
- Since the topic of removing the Lower Snake River Dams is polarizing in nature, biases do occur from stakeholders and communities affected in the region.
- Although there are many instances and case studies of dam removal projects, the Lower Snake River Dams would be one of the most massive dam removal projects in the United States to date and limitations do occur when taking into account the massive scale and scope of this project.
- Due to time constraints and the overall rigor of this thesis project and course, some of the research had to be done simultaneously with the design portion of this process.

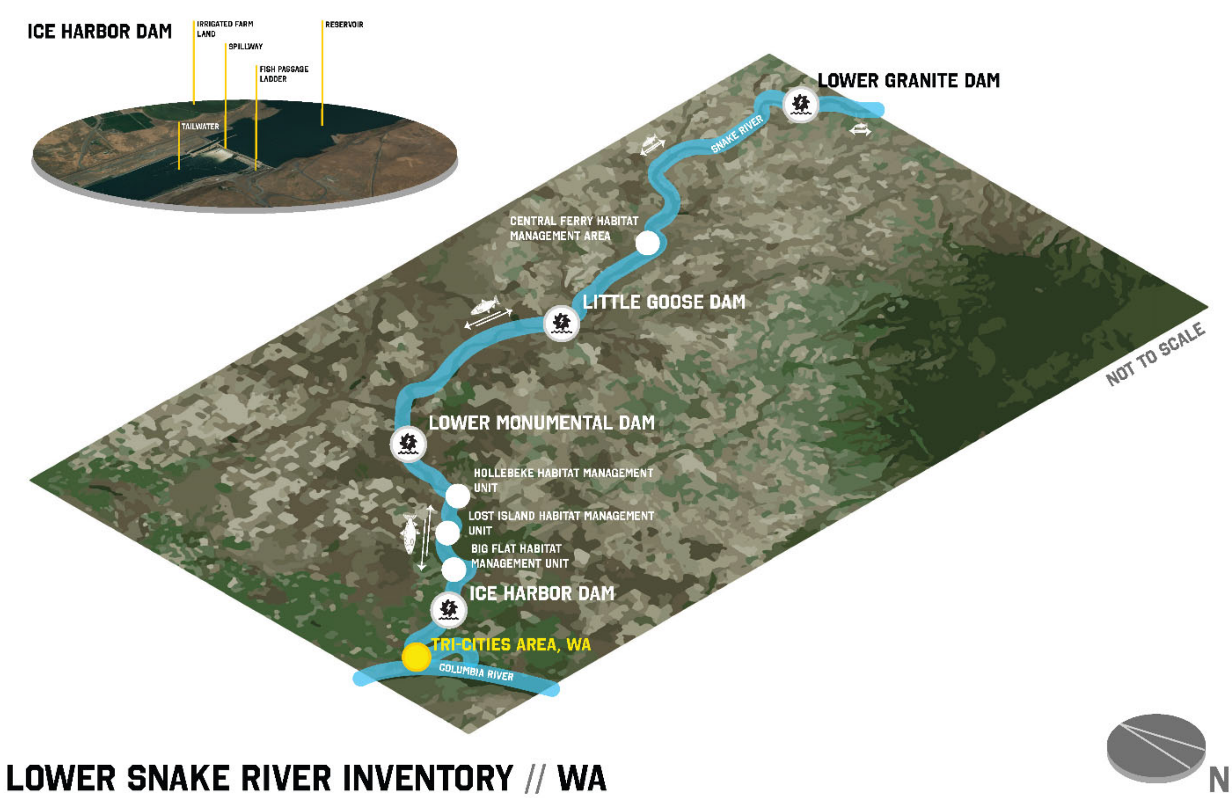
5. RESEARCH CONCLUSIONS & APPLICATION

Much can be concluded and applied to the design portion of the project going forward regardless of limitations that came about during the research phase. Although there are many examples of case studies that are worthwhile to be observed to help with the master planning along the Lower Snake River, case studies for the actual design process that includes the incorporation of landscape architecture are not as prevalent as simply analyzing dam removal, so therefore the designing aims to be innovative, hoping to provide guidelines and building blocks going forward on different dam removal projects. Designing for an enhanced habitat and revamping the surrounding ecological elements will remain at the forefront of the design, yet the incorporation of human interactive elements and a designed plan will also be conceptualized. Applying similar removal tactics to this site, along with an innovative use of the realm of landscape architecture should aid in a successful master plan along the Lower Snake River corridor.

6. SITE

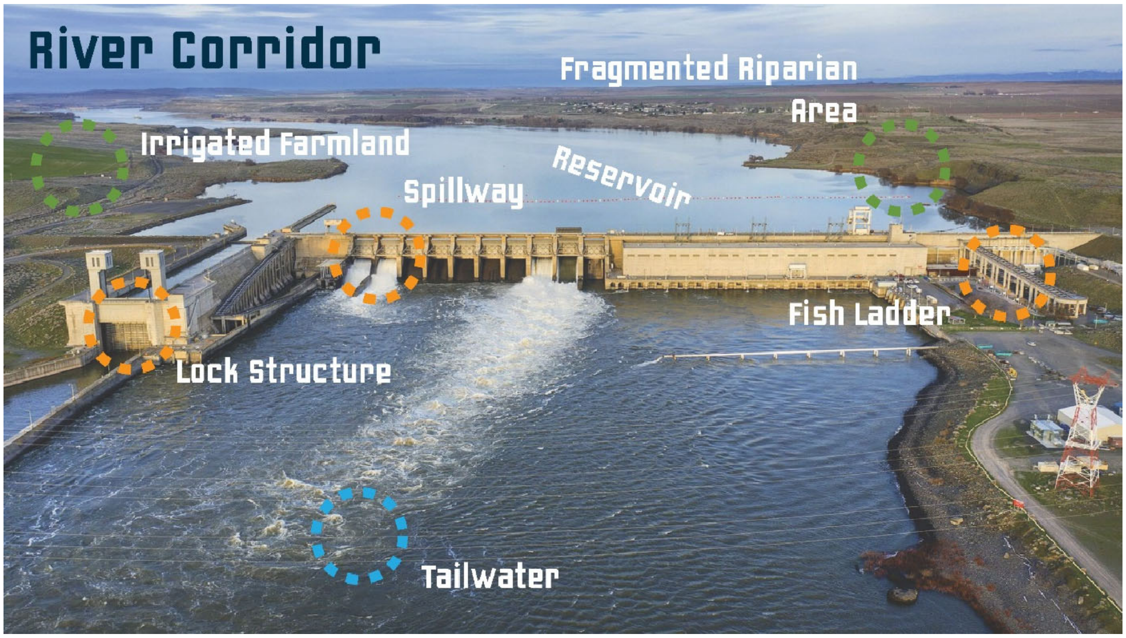
6.1 Site Context

Figure #1. Lower Snake River Context



6.2 Site Inventory

Figure #2. River Corridor Inventory



7. PRE-DESIGN PROGRAMMING & DESIGN PRECEDENTS

7.1 Programming Elements

- Ecological Restoration
    - Restored Riparian Areas
    - Restored Shrubland Areas
    - Restored Aquatic Habitat Areas
- Parkway & Recreational Amenities
    - Nature Center Building
    - Connected Walking Trail System
    - Wildlife Viewing Areas
    - River Interaction Features + Structures

- Walk-In Fishing Zones
    - Boat Launches
    - Wayfinding + Interactive Exhibits
    - Campground
- River Configuration & Waterfront Shaping
    - River Channel Restoration
    - River Bank Stabilization
    - River Overlook
    - River Walk Structure

7.2 Design Precedents

- Restoring river back to its native configuration.
- Balance between environmental (untouched) and interactive (touched) elements.
- Ample room for educational opportunities and exhibits.

8. SCHEMATIC DESIGN

Figure #3. Overall Site Master Plan

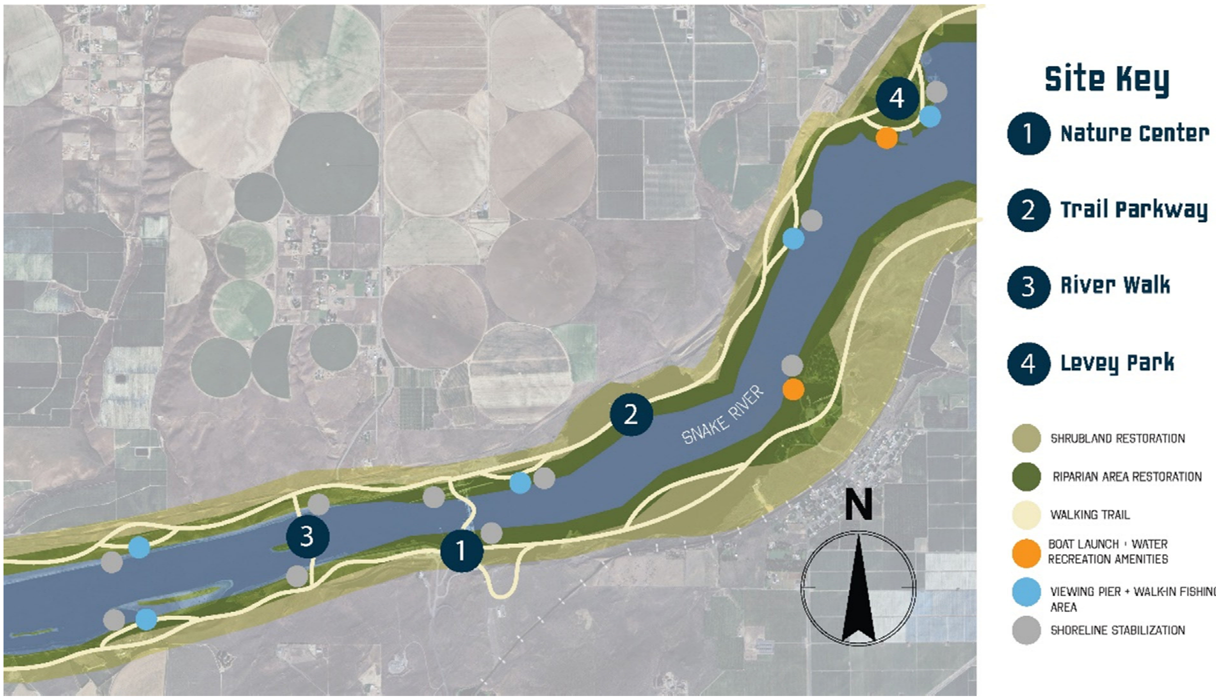


Figure #4. Examining Restored Shrubland, Riparian, and Aquatic Zones

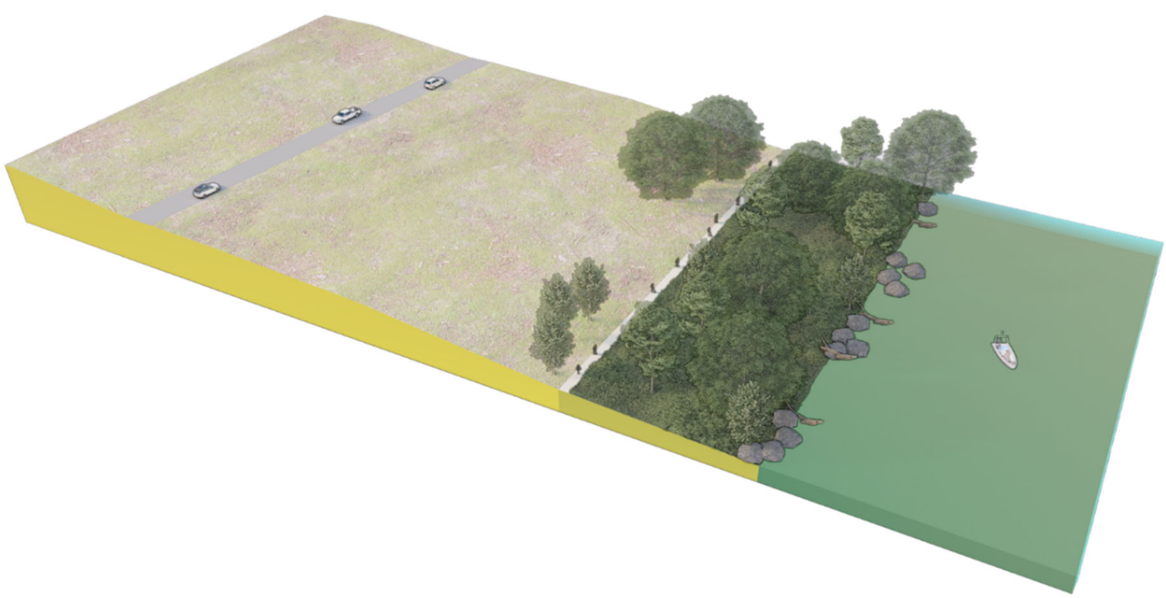
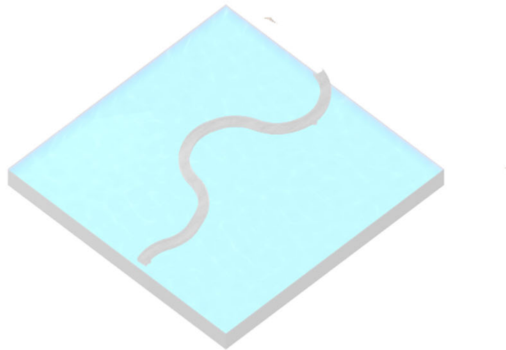
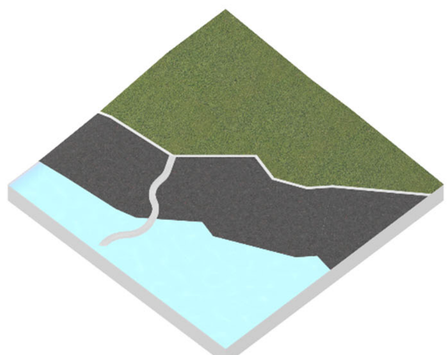


Figure #5. River Walk Structure Typologies

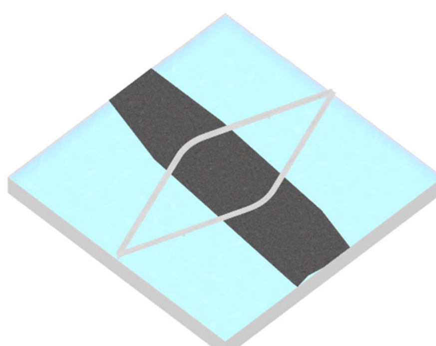
Meandering Walkway



Trail System Connection



Island Observation Loop



9. DESIGN DEVELOPMENT

Figure #6. Nature Center + River Walk Section

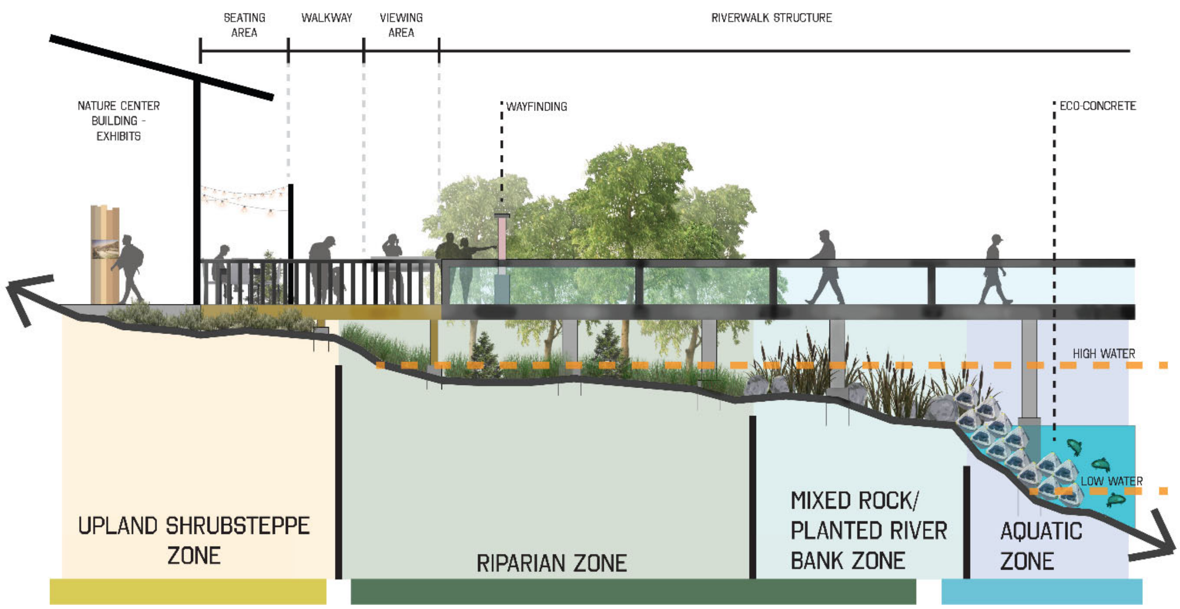


Figure #7. Nature Center Site Perspective

Figure #8. River Shoreline Interaction Structure + Trail Parkway Section Detail

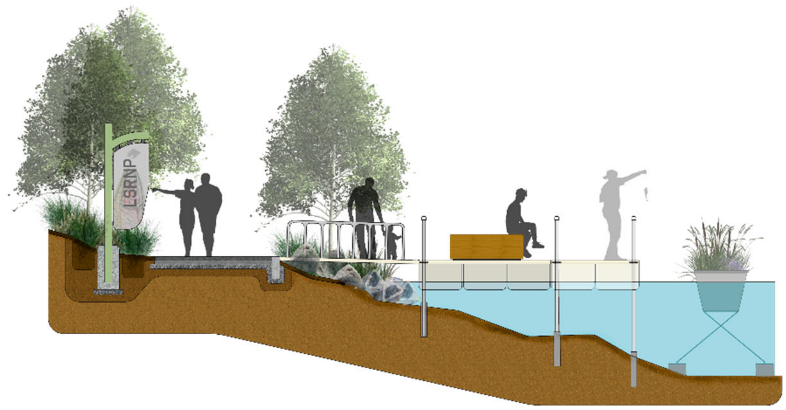
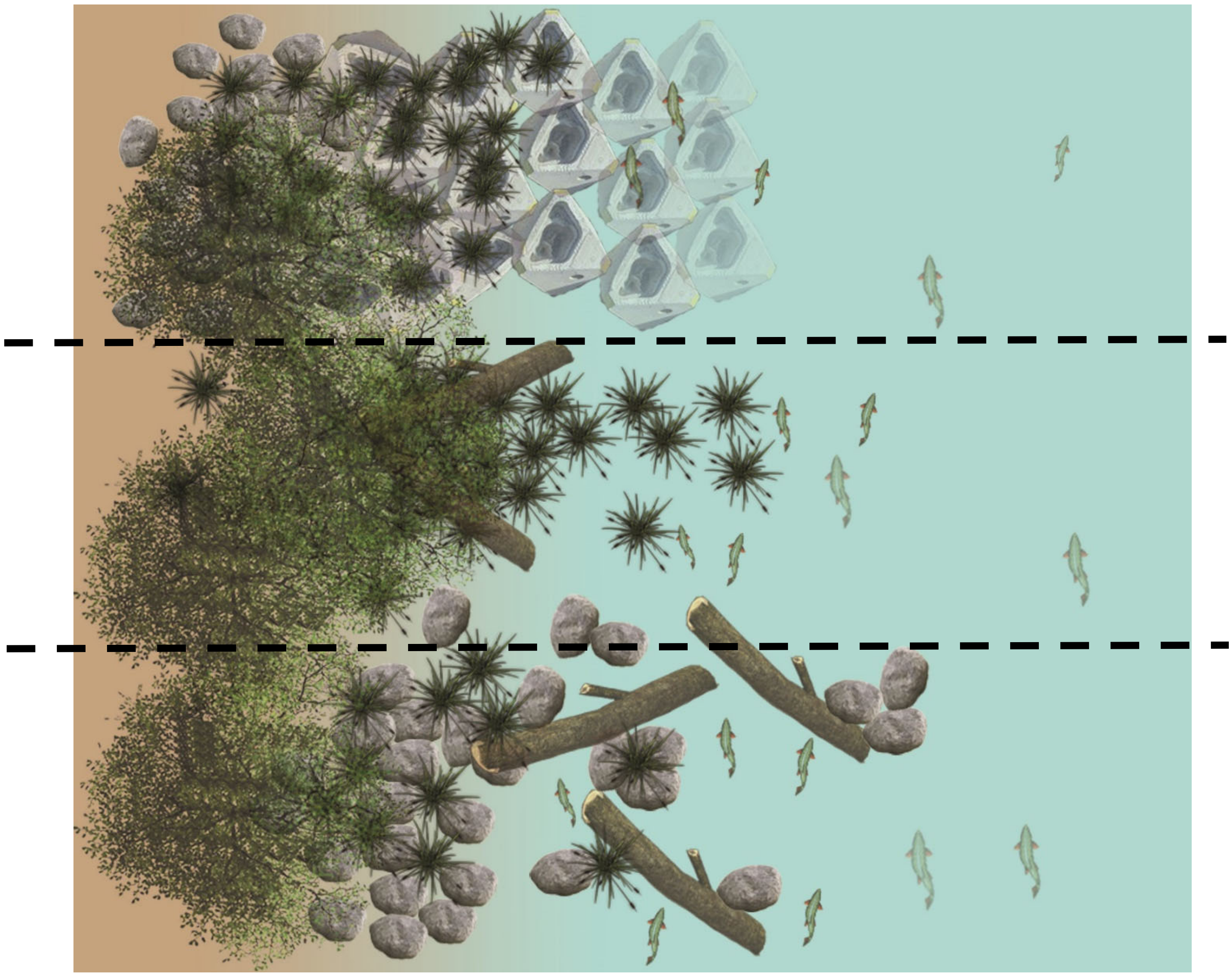


Figure #9. River Shoreline Perspective

Figure #10. Aquatic Habitat Diagram



10. DESIGN CONCLUSIONS & REFLECTION

10.1 Site Performance

Whilst analyzing performance data, the proper site summary and analysis would be the SITES v2 landscape architectural site design performance summary. This will collect qualitative data and a ranking system to gather and add up the sum for site performance. The performance summary and data is shown below along with a designed perspective that relates to site management, performance, since ecological restoration is part of that effort. For this project, since it consists of mostly conceptual design, the SITES v2 performance data summary remains to be a proposal and for reference purposes only.

SITES v2 Points Analysis

Limit development on farmland – Required

Protect floodplain functions - Required

Conserve aquatic ecosystems – Required

Conserve habitats for threatened and endangered species – Required

Redevelop degraded sites – 3-6

Engage users and stakeholders – 3

Restore aquatic ecosystems – 4-6

Conserve healthy soils and appropriate vegetation – 4-6

Conserve and use native plants – 3-6

Conserve and restore native plant communities – 4-6

Optimize biomass – 1-6

Design for adaptability and disassembly – 3-4

Reuse salvaged materials and plants – 3-4

Use recycled content materials – 2-4

Use regional materials – 3-5

Protect and maintain cultural and historic places – 2-3

Provide optimum site accessibility, safety, and wayfinding – 2

Encourage fuel efficient and multi-modal transportation – 4

Support local economy – 3

Maximum total points = 68 points

10.2 Management + Success

With regards to further management of the project, there must be a call for a dedicated plan for making sure the ecological restorations continue to thrive for years to come after implementation, being as much of a crucial component as design. Management along the river corridor may call for a dedicated organization of its own, similar to many current programs that are going on today that focus on maintaining landscapes. Management processes include but are not limited to addressing seasonal changes that occur which come with changing water levels along the river corridor, preventing the growth of invasive species along the corridor, and continuous restoration of the riparian areas that may be vulnerable at first, along with general facilities maintenance. The future success of this project can be compromised without careful attention to the reinvigorated landscape that the design portion of this project calls for.

Figure #11. Restoration in Action

10.3 Reflection

Some conclusions to the overall sign design are listed below, noting what makes this project successful in the long and short term:

- A nurturing habitat and landscape to promote regrowth of native life, including anadromous fish species.
- A regional destination promoting recreational and educational opportunities, also reminding us of the dams and further growth since their proposed removal.
- Project to potentially be used as a set of design guidelines, aiming to be a replicable answer for future dam removal.

REFERENCES

Blumm, M. C., & Erickson, A. B. (2012). DAM REMOVAL IN THE PACIFIC NORTHWEST: LESSONS FOR THE NATION. *Environmental Law*, *42*(4), 1043–1100. http://www.jstor.org/stable/43267821

This journal article discusses the large-scale bounce back of environmental remediation, specifically in the Pacific Northwest of the United States. Many species of river organisms have been reinvigorated to very immensely intolerant species like salmon. Yet, although there are many efforts to remove dams in this region, there is a lack of a large-scale comprehensive plan of action. The article walks through fundamental ways to remove a dam and restore surrounding ecology, then explaining different case studies of this process, then finally what will happen to similar processes in the future.

POFF, N. L., & HART, D. D. (2002). How Dams Vary and Why It Matters for the Emerging Science of Dam Removal: An ecological classification of dams is needed to characterize how the tremendous variation in the size, operational mode, age, and number of dams in a river basin influences the potential for restoring regulated rivers via dam removal. *BioScience*, *52*(8), 659–668. https://doi.org/10.1641/0006-3568(2002)052[0659:hdvawi]2.0.co;2

The text in this scholarly journal article explains the fundamentals and original intents of design/implementation of a dam, and also the consequences that arise from them. Although there are plenty of long-term environmental consequences and uncertainties with the construction of dams, they do reduce flood hazards and allow for production on agricultural lands.

The journal article also addresses why there is a growing need for their removal. There is no simple answer or way to weigh out the pros and cons, with the possible need for a more streamlined process in the future, because communities lack so much holistic knowledge. This article break it down by walking through very local effects, surrounding landscape effects, and their operations, along with some statistics about classifications.

Baxter, R. M. (1977). Environmental Effects of Dams and Impoundments. *Annual Review of Ecology and Systematics*, *8*, 255–283. http://www.jstor.org/stable/2096729

This journal article discusses the role of the construction of dams and other hydraulic structures like impoundments with controlled release. Sometimes providing plenty of uses with the standing bodies of water created artificially behind them. The text also walks through the history and original uses an reasons for creating dams, and even how dams are created in nature with beavers creating smaller, but similar structures that many times have relatively positive outcomes for local ecology. Although these great structures can be engineering marvels, there is an overall lack of environmental planning surrounding this issues according to the journal article.

Stanley, E. H., & Doyle, M. W. (2003). Trading off: The Ecological Effects of Dam Removal. *Frontiers in Ecology and the Environment*, *1*(1), 15–22. https://doi.org/10.2307/3867960

> In this journal article, it is shown that the process of dam removals is gaining much momentum and credibility, especially ones that are dilapidated physically and according to the article are not quite practical environmentally and even economically. As humans, we actually have very little overall knowledge of total effects of these structures, where pushing for more repairs of dams seems like the quick fix. Dam removal will also become quite a bit more frequent in the future due to fast-paced aging of the United States' infrastructure.

Poff, N. L., Allan, J. D., Palmer, M. A., Hart, D. D., Richter, B. D., Arthington, A. H., Rogers, K. H., Meyer, J. L., & Stanford, J. A. (2003). River Flows and Water Wars: Emerging Science for Environmental Decision Making. *Frontiers in Ecology and the Environment*, *1*(6), 298–306. https://doi.org/10.2307/3868090

> In this article, supporting claims made in other journal articles the ecology feasibility of riparian ecosystems is uncertain by alterations made from human interactions. Although conceptually, rivers can be managed through models on paper yet professionals still sometimes fall short on clearly defining direct needs of the local ecosystem, with missing policy and management guidelines according to the article. Although the overall temperament of this article was bleak, it shows that many stakeholders are performing large river experiments in many different areas of the world. Much funding may be potentially needed from private and public sectors to advance the professional management of water.

<u>Case Studies</u>

Final Blast Removes the Copco No. 2 Dam from the Klamath River - Active NorCal

On the Klamath, Dam Removal May Come Too Late to Save the Salmon - Yale E360

Dam and reservoir removal projects: a mix of social-ecological trends and cost-cutting attitudes | Scientific Reports (nature.com)

Elwha River ecology bursts with new life following dam removals in Washington (revitalization.org)

Elwha River dam removal historic, but not explosive | KNKX Public Radio

Boardman River Project Enters Final Phase - Dredging Today

A River Reborn - Conservation Resource Alliance (rivercare.org)

Showcasing the Michigan DNR: Boardman River dam-removal project moving forward - Gr8LakesCamper

Clark Fork River – America's Most Endangered Rivers® of 2023

Milltown Dam Removal & Clean Up Project - Clark Fork Coalition