Homework-6: Rewilding the Colorado River

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Glen Canyon Dam Rewilding Proposal

SECTION 1(Introduction, Proposal, & Attribution Statement):

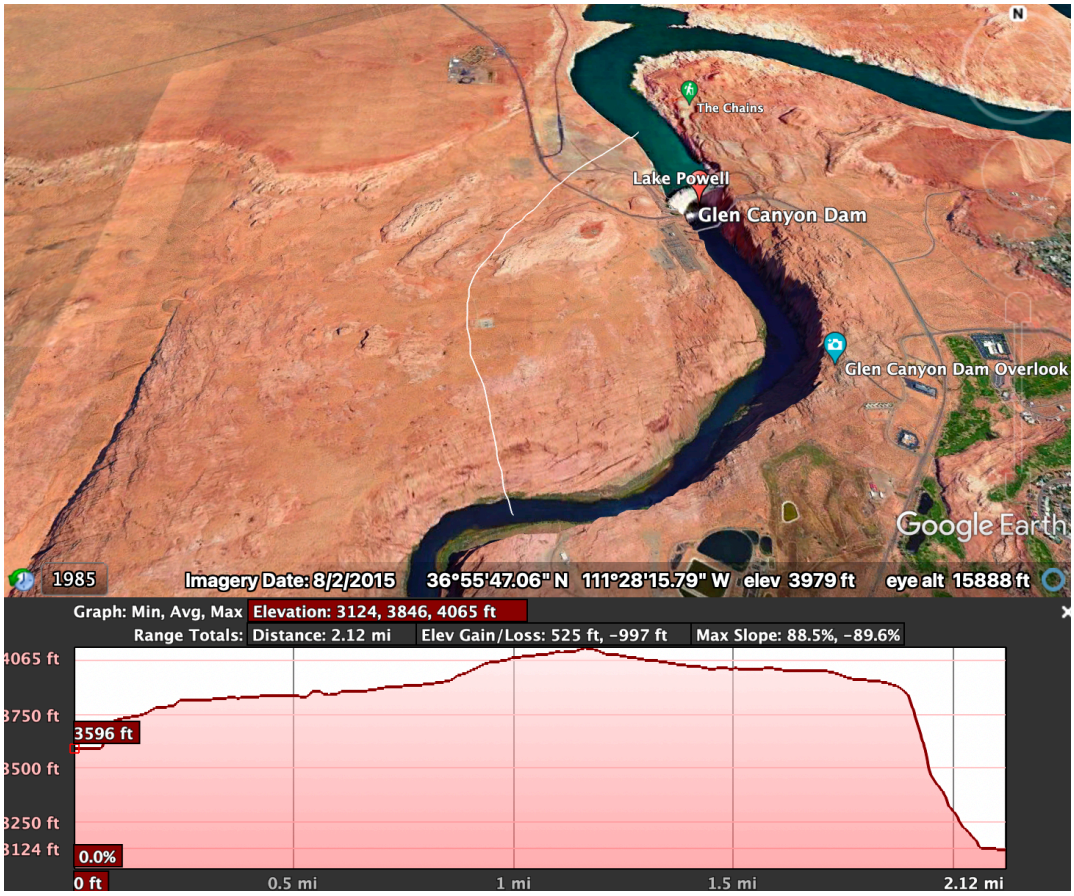
-Context:

Glen Canyon Dam on the Colorado River in Northern Arizona was designed to be a storage reservoir. The intention behind this dam was to store excess water. However, the hydrology situation along the Colorado river has changed since its construction in 1966. In more recent times, more and more water has been pulled from the Colorado river. As a result, Lake Powell (the reservoir formed by the Glen Canyon dam) and Lake Mead are only at 27% and 30% capacity respectively. Hydrology predictions going forward predict no change to this new status quo. This change in situation has nullified much of the utility of Glen Canyon Dam, leading to efforts to remove the dam and 'Rewild' the Colorado River. However, many factors influence the plausibility of removing this dam. Cost, safety, sediment impacts, recreation, hydropower, fish migration, and habitat restoration will all be explored in more depth in the final section of this proposal.

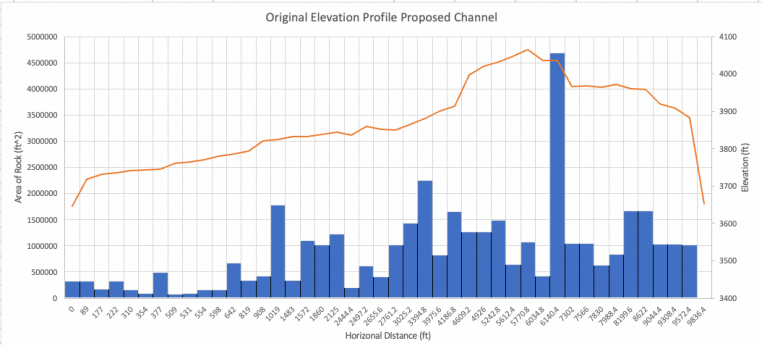
-Technical description of proposed approach:

Our team's proposed solution to the hydrological effects of Glen Canyon Dam is to create a new channel through which the Colorado River can be redirected and return to a more natural state. This new channel would be about 1.9 miles long and 100 feet wide. Potentially, the Colorado River could erode itself to its natural longitudinal profile with the creation of a knickpoint at the mouth of the manmade channel as we allow the river to reach a steady state with reduced human interference.

Below, our team included a map of our proposed channel and a graph depicting its elevation profile and cross-sectional area which gave us a rough estimate of the amount of material that would be removed for the creation of this channel. Over 250 million cubic feet of surrounding rock would need to be removed, however our team believes it would be beneficial in the long run to abandon the Glen Canyon Dam and its impacts on the Colorado River.



horixontal distance (ft)	elevation (ft)	horizontal distance (ft)	fixed distance (ft)	area under curve
354	3646	354	0	324494
443	3719	443	89	327272
531	3731	531	177	167895
576	3736	576	222	328768
664	3742	664	310	164648
708	3744	708	354	86112
731	3746	731	377	494472
863	3761	863	509	82742
885	3765	885	531	86595
908	3771	908	554	165924
952	3780	952	598	166320
996	3786	996	642	670122
1173	3794	1173	819	337666
1262	3821	1262	908	424131
1373	3824	1373	1019	1774336
1837	3832	1837	1483	341048
1926	3832	1926	1572	1103616
2214	3838	2214	1860	1017070
2479	3844	2479	2125	1227773.6
0.53	3837	2798.4	2444.4	202593.6
0.54	3860	2851.2	2497.2	611424
0.57	3852	3009.6	2655.6	406771.2
0.59	3849	3115.2	2761.2	1016136
0.64	3865	3379.2	3025.2	1428504
0.71	3881	3748.8	3394.8	2254084.8
0.82	3901	4329.6	3975.6	823891.2
0.86	3913	4540.8	4186.8	1652851.2
0.94	3997	4963.2	4609.2	1266249.6
1	4020	5280	4926	1273536
1.06	4033	5596.8	5242.8	1490596.8
1.13	4047	5966.4	5612.4	641044.8
1.16	4065	6124.8	5770.8	1073160
1.21	4036	6388.8	6034.8	426201.6
1.23	4036	6494.4	6140.4	4688217.6
1.45	3967	7656	7302	1047288
1.5	3969	7920	7566	1047816
1.55	3965	8184	7830	628056
1.58	3972	8342.4	7988.4	838886.4
1.62	3961	8553.6	8199.6	1673126.4
1.7	3958	8976	8622	1671859.2
1.78	3919	9398.4	9044.4	1034616
1.83	3909	9662.4	9308.4	1031976
1.88	3882	9926.4	9572.4	1024848
1.93	3652	10190.4	9836.4	



total area under curve (ft^2)	rectangle under curve (not removed)
38544739	35863514.4 ft^2

proposed removal area (ft^2)
2681225

-Budget:

For budgeting, see Section 2 “Cost effectiveness” & sources [1], [2], and [3]. Source 3 outlines the difficulties associated with developing cost estimates on similar endeavors. 1 and 2 are critical in developing a context for the proposed strategy and grounding it in reality instead of relying on speculation.

-Attribution Statement:

This proposal was written by Karen Pederson, Charles Crosby, Crockett Stultz, & Nina Botvin. Context, Budget, attribution statement, citations 1-3, and Cost Effectiveness were written and researched by Charles Crosby. Karen Pederson constructed the technical description/approach, developed models in excel, and explored sediment flow and hydropower. Crockett Stultz developed comprehensive reports on Fish Migration and Habitat restoration. Nina Botvin developed all sections regarding public safety and impacts on recreational activities in the dam area.

SECTION 2(Consideration points):

-Cost Effectiveness:

Dam removals as well as excavation are both costly endeavors that are difficult to develop estimates on without extensive professional advising. However, based on our chosen pathway to excavate, which has an area (Length x Depth) of 2,681,225 ft^2 , in tandem with the proposed width of 100 ft, about 268,122,500 ft^3 of sandstone would need to be removed. Slightly more stone would also need to be removed in order to create a gradient such that the water would naturally flow through this man mad river. This could ultimately prove a very costly endeavor because the removed material must also be disposed of. However, there is a course of action that could offset costs and ensure that no material is wasted. The removed sandstone could be processed into sandstone tiling and sold at a cheap rate. Stoneline Group suggests that sandstone tiling should be one half inch or greater in thickness [1]. To grant room for error, it will be assumed that each slab produced is 1 inch thick and covers an area of 1 ft^2. This would result in as much as 3,217,470,000 ft^2 of sandstone tiling that could be sold on the open market or directly to distributors. 1-inch-thick sandstone tiling is sold to consumers on soiltoppers.net at 5 to 8 dollars per ft^2 [2]. Once again, using a much more conservative estimate of 1 dollar per ft^2 could help to offset the project costs by as much as 3 billion dollars. Realistically, not every square foot is made into a perfect slab, so the actual outcome would be somewhat lower. Additionally, a substantial portion of that sum would be going back into the project just to cover the cost of removing and processing the sandstone in such a way that would allow it to be used as tiling. Critically though, because rewilding the Colorado river is not meant to be ran as a business, even just breaking even or reducing costs on excavation/removal would be a huge victory for the environment and environmentalists because it would allow funds to be diverted into other critical projects. Unfortunately, developing an estimate on the true cost of completing such a project is extremely in depth and requires consideration of many points and even professional involvement.[4] Property rights, mining cost, and processing costs are not always open sources. Cost analysis may require professional assessments and quotes that could even then prove to be inaccurate once the project is under way. There are also variations to this plan of action that could help to influence costs. If selling the tiling is not doable, the

tiling could be donated to those in need to develop press and draw in more donations to the Rewilding cause. Worst case scenario, if the lithology is not suited for being made into tiling, lower cost excavation using explosives and other less costly means may be used to complete the project at the minimum cost.

-Public Safety:

Although there are no direct public safety concerns regarding the Glen Canyon Dam, there are plenty of indirect concerns with the dam still functioning today. The main concern is that the dam's lifespan was estimated at 85 to 100 years of peak performance [1]. Being built in 1966, the dam is halfway through its peak performance era. This means that if the dam were to be left as is, the already prevalent risk of floods would increase at a rapid rate, with failure on the horizon. If this dam were to fail, releasing all the water and sediment that has been building up over the last 56 years, there would be catastrophic consequences to the surrounding neighborhoods, and those who live miles downstream of this dam. As mentioned, flooding is already occurring at frequent intervals within the lakes due to the amount of sediment buildup and failure to function properly as a dam. When discussing public safety regarding the Glen Canyon Dam, the main concern is both small scale and larger scale flooding and preventing that from occurring in the future. By rewilding the Colorado River and negating the dam as a main stressor for residents near and downstream of the dam, public safety would increase, getting rid of the probability of dam failure or malfunction.

There is one main concern when it comes to getting rid of the dam all together: with so many neighborhoods and residential communities downstream, with the release of the water in the dam, there is a probability that people may need to relocate or give up their current homes for fear of the new water levels of the Colorado River taking over their residential area. Although it may be difficult to have people relocate in order to get rid of the dam, it would be more necessary as a preventative measure than as an emergency plan, considering the dam breaking instead of a controlled release.

-Sediment Flow:

A major consideration of the impacts of dam construction and removal is the sediment buildup resulting from blockage of the natural river's transport rates. Because Glen Canyon Dam is among the largest dams in the United States, it is expected for there to be a massive sediment buildup within the dam's reservoir. Annually, about 100 million tons of sediment fills this reservoir [8]. Leaving the dam in this state will continue to negatively impact the surrounding stream channel. Aside from the ecological impacts, which is discussed later in this analysis, the finer-grained sediment trapped nearest to the dam often limits hydropower and water storage capacity, ultimately deprecating the value of a dam the longer sediment is allowed to build. Another impact is the filtration of particle size that results from a sudden drop in velocity as the water meets the dam's reservoir; results of dam removal for this issue proved to be promising in the case of the Woolen Mills Dam in Wisconsin, which saw an increase in larger rock clasts further downstream [5]. This allowed for the ecology of the region to recover to a more natural state. In its current condition, Glen Canyon Dam is causing drastic changes to the river channel through its blockage of sediment flow, and it is for this reason conservationists are calling for its removal.

By simply removing the dam, however, this creates an issue of the sudden influx of sediment drastically altering the ecological system within the river. Our proposed solution of new channel formation could potentially mitigate the effects of the sediment blockage while preventing the shock to the channel that would come with removal. The sediment within the current reservoir would remain behind the dam as the water is redirected, however over time it is possible the new channel would erode away the buildup as it transports more material without the hinderance of a dam.

-Recreation:

The Glen Canyon Dam and surrounding area is known for a variety of recreational activities: boating, swimming, fishing, back-country backpacking and four-wheel drive trips. With these activities in mind, and the current state of the dam and lakes, it is imperative that the financial resource of recreation be maintained, while also considering the overall risk of the dam itself. With the lake levels dropping quickly, the lakes have become less of a source for fishing, swimming, and boating as they have been in years past; therefore, recreation as a source of income has also begun dropping drastically over the years. In order to maintain this resource with the dam being removed, activities like boating, backpacking, and fishing can still be considered in the grand scheme of things, simply in a different way. Instead of utilizing lakes for such activities, the Colorado Rover offers the same kind of sport. On top of that, the number of fish in the area would increase, allowing fishing, specifically fly fishing, to take more of a forefront. Additionally, activities such as white-water rafting could come into effect due to rapids and the natural flow of the river. The addition of new recreation would not be a financial burden, instead, it would promote the opportunity for new businesses to arise. The current condition of the lakes offers little to no recreation; therefore, with this new initiative of rewilding the river, the opportunity for recreation in and around that area would increase.

-Hydropower:

One compelling argument for keeping the dam is its capacity to produce hydroelectric power. In an increasingly “greener” energy-focused world, many would argue for the benefits of a renewable source of energy like hydroelectric power. Glen Canyon Dam produces nearly five billion kilowatt-hours of hydroelectric power annually [7]. By comparison, the entire United States consumes nearly 4000 billion kilowatt-hours of energy per year. This power is distributed across 7 western states and takes up a large portion of the total energy supplies to this region. A study done on the effects of removing this dam estimated 16 million dollars of total increased cost to energy consumers in the western region of the US, which would cause an increased price of about 8 cents per month of their electric bill for residential consumers [6]. Although this is not a huge price difference, a potentially more impactful drawback to discontinuing Glen Canyon power production would be a need for more non-renewable energy sources to make up for the lost energy. It is difficult to predict the effects of this change, however, there are possible solutions to these problems, like water energy turbines which do not disrupt the channel’s flow as much. Although the hydroelectric power supplied by Glen Canyon is a major factor in considering how to approach this situation there still are many positive results from the discontinuation of the dam.

Fish Migration:

Migratory fish are defined as a fish that needs to travel from feeding grounds to spawning grounds to survive and reproduce. These fish are key transporters of nutrients and oxygen for organisms both in and around the river. Dams represent a literal concrete block that a fish are incapable of passing. While fish ladders are installed on most modern dams and allow fish to get around/over dams, they are not one hundred percent effective, and many fish are still left stuck behind a dam. Other alternatives to getting migratory fish around dams includes loading them into tanks and trucking them around the dams but this solution can have a high fatality rate on fish. As cases like Washingtons Olympic Peninsulas' Elwha River shows, removing dams can have massive positive effects on migratory fish populations in a short amount of time.

The primary migratory fish species in the Colorado river is the Colorado Pikeminnow. While not as popular or respected as other fish in the system, the pikeminnow represents a key cog in the ecosystem of the Colorado river. Known as the "white salmon" by the indigenous people who used to call the Colorado river home, the fish was once a prized food source and could grow to over 6 feet in length. Now the pikeminnow is rarely seen over 3 feet in length and was the first fish given full protection under the endangered species act in 1973, which it still has today. Once found across the entire Colorado drainage, now only two remaining wild populations remain, one in the upper Colorado river system and the Green River system in Utah and Wyoming [9]. In the areas where the Colorado Pikeminnow has gone extinct nonnative species such as channel and flathead catfish have taken over and are wreaking havoc on populations of native baitfish. With the decrease in population of bait fish, small micro-organisms and plants that help with water quality are also affected causing an overall decrease in the quality and habitability of the water in Colorado. The population of Colorado Pikeminnow began to decrease as more and more dams were constructed on the Colorado and the reaches where the species is still prevalent have small or no dams present. While removing the Glen Canyon dam will have larger and more important effects than just saving a few species of fish, the importance of the native Colorado pikeminnow cannot be overlooked and will not truly be known until it is too late.

Habitat Restoration:

The Colorado River was once a historically unpredictable and powerful river. These unpredictable flows would flood the canyon banks before they were tamed and controlled through dams like the Glen Canyon. While at first it may seem like a good thing to prevent flooding, most of these floods occurred in deep canyons where very little human infrastructure would be. The main loss of these floods being controlled is the riparian habitat in and around the river's banks. Riparian habitat not only provides habitat for many animals and insects but also helps to shade the rivers banks, keeping water more habitable for fish and other organisms. Another impact is the loss of sediment flow that causes a decrease in beaches and sandbars, which are also key habitats for other species in the ecosystem. Before the dams on the Colorado were completed cottonwoods, willows, and mesquites dominated the banks along the river. These large trees also helped to prevent erosion along the banks. There was believed to be more than 400,000 acres of riparian habitat along the river, now there are only 6,000 acres. In these 6,000 acres few of the old trees once prevalent remain, with most foliage comprised of invasive salt cedar and tamarisk, which can survive in the much drier environment. Following the major floods of 1993, many of the species that once flourished along the banks began to

show signs of returning, but with the lack of floods in years since, they have all but disappeared once again [10]. The fact that many of the native species were able to return so shortly after the flooding leaves hope and proof that by removing the dams that control the river, the river can return to its natural state.

Works Cited

[1] "Finding the Right Natural Stone Floor Tile for Your Project." stonelinegroup.com, Tile Vs. Pavers para 3. [Online]. Available: https://www.stonelinegroup.com/finding-the-right-natural-stone-floor-tile-for-your-project/. [Accessed: Nov 13, 2022]

[2] "Limestone & Sandstone." soiltoppers.net, section: Sandstone. [Online]. Available: http://www.soiltoppers.net/savannahstone [Accessed: Nov 13, 2022]

[3] "How much will it cost" MINING[DOT]COM, Section: Hurdles to Obtaining cost Data. [Online]. Available: https://www.mining.com/web/much-will-cost/ [Accessed: Nov 13, 2022]

[4] History of the River Restoration Movement". Glen Canyon Institute. Archived from the original on 2009-09-02. Retrieved 2009-05-13.

[5] A. T. Bednarek, "Undamming rivers: A review of the ecological impacts of dam removal," *Environmental Management*, vol. 27, no. 6, pp. 803–814, 2001.

[6] "The impact of the loss of electric generation at Glen Canyon Dam ..." [Online]. Available: https://www.glencanyon.org/wp-content/uploads/2018/05/GCI-Power-Study-Overview-Full.pdf. [Accessed: 14-Nov-2022].

[7] "Interior Region 7 : Upper Colorado Basin," *Glen Canyon Dam | Upper Colorado Region*. [Online]. Available: https://www.usbr.gov/uc/rm/crsp/gc/. [Accessed: 13-Nov-2022].

[8] "All Dams are Temporary – Sedimentation ." [Online]. Available: https://www.glencanyon.org/all-dams-are-temporary-sedimentation/. [Accessed: 13-Nov-2022].

[9] "Colorado Pikeminnow." *Colorado River Recovery Programs*, 2 May 2022, https://coloradoriverrecovery.org/information/fish-species/colorado-pikeminnow/.

[10] News, Deseret. "Conservation Group Critical of Glen Canyon Dam Experiment." *Deseret News*, Deseret News, 6 Mar. 2008, https://www.deseret.com/2008/3/6/20075015/conservation-group-critical-of-glen-canyon-dam-experiment.