The impacts of dams on the hydrologic regime

Environment, Nature

The earliest remains of dams that archaeologists have unearthed date back to around 5000 A. D. They were constructed as part of a domestic water supply system for the ancient town of Jawa in Jordan. Over the next few millennia, the building of dams for water retention spread throughout the Mediterranean, the Middle East, Southern Asia, China, and Central America. Later, as technologies increased and industrialization took hold in Europe, dam mechanisms advanced to incorporate watermills. With the advent of the water turbine in 1832 and developments in electrical engineering, the first hydropower plant began running in Wisconsin in 1882 (IRN n. pag.). Over the next few decades, while structural engineering techniques improved, dams multiplied in size, strength, and numbers worldwide.

Today, although the construction of new dams is halting (albeit with less vigor in underdeveloped countries) (de Villiers 146; Pielou 206), they are still being built around the globe for a multitude of social and economical reasons: flood control, hydroelectric power production, river navigation, irrigation, human consumption, industrial use, emergency water reservation, tourism, and flat-water recreation (e. g., NPDP n. pag.; Trout Unlimited 11). For all the benefits that dams provide, however, there are adverse effects and concerns that arise from manipulating theenvironmentin such an unnatural manner.

Impacts of Dams on the Hydrologic Regime

Dams are ultimately created as a water reservoir. This impounding of water impedes the circulation of a river and subsequently changes the hydrology and ecology of the river system and its contiguous environments.

Behind a dam, the rise in water level submerges the landscape; often displacing people and engorging culturally valuable ruins. Furthermore, biodiversity of the region is constrained by the destruction of vegetation and loss or extinction of wildlife (Power et al. 887-895). In essence, both the aquatic and land-based ecosystems are damaged by the advent of a dam (Pielou 209).

Upstream of the barricade, the once flowing water that housed the riverine habitat becomes still, oxygen depleted, deepens into darkness, temperature stratified, and susceptible to enhanced evaporation which adjusts the entire hydrologic cycle (e. g., Pielou 207, 210; Ocean Planet n. pag.; Leopold 157). Moreover, drowned vegetation in the stagnant water is subject to rotting and may thereby pollute the atmosphere and reservoir with methane and carbon dioxide (Leopold 158; Pielou 208).

Another change in the water chemistry that alters many river-based systems is the inclusion of heavy metals (and minerals) such as methyl mercury due to reactions between the reservoir bed and the standing water (Pielou 114, 207). If undetected, these toxins may bioaccumulate by moving through the trophic levels of thefoodweb, eventually reaching humans.

Aside from the changes in the chemical constituencies of the water, a dam will also physically augment the river by modifying the shape of the channel. This is primarily due to the retention of sediments behind the dam wall. Water that was once entrained with silts has the increased erosive power to degrade the riverbanks downstream while upstream, the deposition process is shallowing and narrowing the river reaches (e. g., Moffat 1116; Pielou

210). These alterations in channel shape can also shift the elevation of the groundwater table and can amplify the severity of the floods that the dams may have been built to prevent (de Villiers 155-56; PCFFA n. pag.).

The silting process, though, can have other effects on riverine environments. With the deprivation of sediments, valuable nutrients are withheld from the floodplains and the delta of the river. Ultimately, agricultural land suffers from fertility loss and coastlines recede (e. g., DRIIA n. pag.; Pielou 212). In addition to the above noted deterioration of wetland environs, major fish spawning andnursinggrounds are harmed by the lack of continual silt and gravel replenishment (e. g., Chambers n. pag.).

Fish species, nevertheless, are not simply affected by the decreased deposition that occurs below a dam. These, and other aquatic based biota adapted to the natural pulsations of seasonal flooding, can be strained by the regulation of stream flow afforded by a dam (Pielou 145; Leopold 156). Furthermore, moderating the flow may actually retard the entire regime of the river by delaying spring break-up (Pielou 212).

Apart from the precipitous effects on the hydrologic cycle and river-based ecosystems thus far noted, there are an extensive number of further reasons to remove a dam. Briefly, a few of these are (Ocean Planet n. pag.; Pielou 208-09; Trout Unlimited 17; Leopold 156):

ƒx the restoration of anadromous fish migration and subsequent reliant fisheries ƒx ameliorate conditions associated with damming which promote epidemics such as bilharzia and milaria

ƒx damming has accelerated the rate of earth¡s rotation, displaced the axis of the earth, changed the shape of earth¡s magnetic field, increased the occurrence of seismic events, and influenced sea level changes

ƒx dam removal has been shown to improve recreation, tourism, and aesthetics to the associated riverside communities

ƒx amend the river and groundwater quality

Yet for all of the reasons that a dam may be removed, it is often economic and, in part, safety purposes that prompts the decommissioning of a dam. Whether the reservoir has filled with silt, wear-and-tear has taken its toll, or the dam has become obsolete, the benefit of removal may outweigh the cost of maintaining dam operation (PCFFA n. pag.).

Consequences Associated with Dam Removal: ACase Studyof the Elwha River

Early in the 20th century, two hydroelectric dams were built on the Elwha River within the Olympic Peninsula of Washington State. The Elwha Dam, the first to be constructed (1910), created the Lake Aldwell reservoir 4. 9 miles from the mouth of the Elwha river [fig. 1]. Respectively, 8. 5 miles upstream, Lake Mills is contained by the Glines Canyon Dam (1926). Despite their continued success as a viable resource for Bonneville Power Administration (Meyer n. pag.), the existence and utilization of the Elwha and Glines Canyon dams causes detrimental besetment for the ecosystem and native anadromous fish populations of the Elwha River basin (U. S. Dept. of the Interior, 1995, n. pag.). Thus, per restitution stipulations, the 1992 Elwha River Ecosystem and Fisheries Restoration Act (the Elwha Act) authorized the Secretary of the Interior to appropriate the two dams (e. g., Winter n. pag.). Measures to remove the dams will be undertaken as sanctioned from the Environmental Impact Assessment (EIS) that followed in 1995.

Fig. 1. Map of the Elwha River, Clallam County, Olympic Peninsula, Washington.

(Olympic National Park n. pag.)

In an effort to remove the dams in a ¡§safe, environmentally sound and cost effective manner¡ (U. S. Dept. of the Interior, Apr. 1996, n. pag.), various procedural alternatives are being considered prior to the implementation of the scheduled 2004 deconstruction. Under the River Erosion alternative, which is the proposed action, the Elwha and Glines Canyon dams would be incrementally removed in succession over a two year period with the controlled regulation of natural sediment erosion (e. g., U. S. Dept. of the Interior, Aug. 1996, n. pag.). A dredge and slurry system, a further method of sediment disposal, is an action alternative that has also been analyzed by the Environmental Impact Statement (EIS) Team (e. g., U. S. Dept. of the Interior, Apr. 1996, n. pag.).

Between the inauguration of the Elwha River dams and 1994, it is estimated that 17. 7 million cubic yards of sediments has become trapped in the Lake Aldwell and Lake Mills reservoirs (U. S. Dept. of the Interior, Aug. 1996, n.

pag.). Of that total deposition, some 4. 8 to 5. 6 million cubic yards of fine-grained alluvium (silts and clays less than 0. 075 m in diameter) and 1. 2 to 2. 6 million cubic yards of coarse grained sediments (sands, gravels, and cobbles greater than 0. 075 mm in diameter) will be reintroduced into the Elwha River system through the proposed action (U. S. Dept. of the Interior, Apr. 1996, n. pag.; U. S. Dept. of the Interior, Aug. 1996, n. pag.).

In comparison, approximately 6. 9 million cubic yards of the fine-grained sediments stand to be directly pumped via a pipeline into the Strait of Juan de Fuca if the dredge and Slurry alternative is undertaken (U. S. Dept. of the Interior, Aug. 1996, n. pag.). Incremental removal of the dams will be the primary regulation on the rate of sediment withdrawal and will partially effect the resulting term of biological and physical impacts felt on downstream reaches of the Elwha River (U. S. Dept. of the Interior, Aug. 1996, n. pag.).

An increase of alluvium transport will renew the natural sediment distribution and hydrological flow patterns to their pre-dam character while new channels and wetland habitats will be created in the freshly drained areas (Foster Wheeler 17). Aggradation of stream load materials will be most prominent in the low-lying and less circulating shoals, including a revitalization of the Ediz Hook [fig. 1] and estuarine beaches (U. S. Dept. of the Interior, Aug. 1996, n. pag.). In response to these raised river beds, water elevations are expected to rise, thereby threatening the resources that fall within the 100-year floodplain (U. S. Dept. of the Interior, Apr. 1996, n. pag.).

Surface water quality is likely to be hampered for two to six years after dam abstraction as turbidity, suspended sediments and dissolved solids flow through the system. Furthermore, water temperatures, dissolved oxygen concentrations, and pH levels will be affected for the interim of dam removal (U. S. Dept. of the Interior, Apr. 1996, n. pag.). Turbidity, in turn, will be the chief cause of groundwater contamination by infiltration into underlying foundations or well and septic systems (removal (U. S. Dept. of the Interior, Apr. 1996, n. pag.).

The implementation of either the Proposed Action or Dredge and Slurry alternatives will also impact the native anadromous (indigenious?) and resident populations on the Elwha River. The high sediment regimes, especially those of the River Erosion Alternative (the proposed action), will encumber the migrating fish over the deconstruction process.

However in the long term, runs will improve with the staged delayed of dam destruction, fisheries management (including the supplementation fish stocks through hatchery intervention), unrestricted passage up the full stretch of the Elwha River, and the formation of quality spawning grounds and rearing habitats from the released sediments (U. S. Dept. of the Interior, Aug. 1996, n. pag.). (steph, this last paragraph seems akward) Moreover, apart from the obvious economic profits of salmon run restoration, the heightened decomposition of dead fish after spawning will significantly enrich nutrients cycling through the riparian area (Munn et al. n. pag.).

Magnified numbers of anadromous fish will, too, eventually increase the biotic diversity down the length of the Elwha Basin. In the future wildlife will be drawn to the decaying remains of dead fish and their young even though the immediate disturbances during the removal period may ward off certain animals (U. S. Dept. of the Interior, Apr. 1996, n. pag.). Vegetation and marine organisms will benefit from the circulation of organic remains; those primarily adapted to sandy substrates will flourish after the initial strain of post-dam sediment conditions (Winter, 2000, n. pag.; U. S. Dept. of the Interior, Aug. 1996, n. pag.).

Prospective temporary consequences to the environment will also include air, traffic, and noisepollutionin conjunction with dam destruction and debris conveyance (U. S. Dept. of the Interior, Apr. 1996, n. pag.).

This Elwha River case study exemplifies the foremost probable impacts on the hydrologic cycle and the environmental ecosystems which it encompasses. Successful removal of a dam can, in the end, rehabilitate a region to its natural state. Recovery, however, is not without adverse consequences to the existing regimes and full restoration may take many years.