The Post Dam Hydrology of the Mid-Columbia Basin

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The Dams

The dams and the irrigation systems changed everything. Beginning in the 1930's with the construction of Grand Coulee Dam and continuing into the 1960's many of these rivers became lakes or technically "pools" behind one of the largest dam systems in the world. Indeed, in the MCB, only the Hanford Reach, a short, 30 some mile, stretch of the Columbia River just north of the Tri-Cities (Richland, Pasco and Kennewick), remains free flowing. But even the Hanford Reach does not reflect the diversity of flow that occurred on the Columbia. The upstream dams provide sufficient storage capacity to damp the seasonal river heights.

The Dams filled each of its own basins and naturally the river rose up and spread out until the steeper hillsides prevent much more widening. I believe all the Snake and Columbia River dams are "run-of-the-river" dams in that they can vary the water level by only 4 or 5 feet. Hence the seasonal variation in water height has decreased from upwards of 20 feet, and possibly more, to an average of a few feet. Today, there are far fewer flat or modestly sloped areas that can flood and the land compatible for wetlands and riparian habitats has been greatly diminished. The US ACE retains a flood easement for the majority of Columbia Park in Kennewick for "just in case the shit hits the fan" but nothing like the 1948 flood of Kennewick and the necessity to build the Miracle Mile dike in Richland has occurred since. Our riparian areas, that were once miles wide, have been pushed against the steepest hillsides and eradicated in many places with steep basalt or clay cliffs or narrowed to a hundred feet and often much less.

In addition, the constancy of water levels leaves many shoreline areas stagnant. Small back-channels, inlets and backwashes create permanent quiescent pools that never get flushed out or conversely dry out. These areas, as we will see are problematic as habitat of toxic blue-green algae. Constant water levels are also ideal for aquatic plants such as the invasive Milfoil. These tend to grow in water between approximately 3' to 20' and create by themselves a mass that further impedes water flow. Today these plants begin growth in the spring and by August can create an impermeable barrier for small water craft.

In one late August paddle from Hood Part to the take-out at Casey Pond, I encountered weeds so thick that my trolling motor became fouled and I had to grunt paddle through a couple of miles of thick Milfoil. It was back breaking work and I already have a broken my back.

Pre-dam water levels would cause these stagnant areas and these near shore Milfoil nurseries to become dried out yearly and especially in the late summer and early fall would have desiccated their root systems and dried out over-wintering spores from algae. One wonders if dam water heights could be manipulated to dewater these near-shoreline, stagnate areas.

The dams also slowed the water flow and this may contribute to water warming. But O'Connor suggest that warming air temperatures especially prevalent in the last two decades have resulted in the observe 4-5 degree increase in water temperatures. This is consistent with the general heat budget of river systems where solar radiation is the dominant contributor to rising water temperatures. The dams, by slowing water flow rates, do not apparently cause this temperature increase. However the solar budget is proportionally dependent on total irradiated area and the formation of wide pools behind each dam significantly increase the total area.

In addition, O'Connor probably used temperature data taken from mid-stream flows. For the stagnant shoreline areas caused by the dams, solar radiation could result in a significant increase in water temperature. Do we blame the dams or climate change for increased temperatures in these near shore ecosystems?

The Columbia Basin Irrigation Project

Today the hydrology of the MCB is dominated by the various irrigation systems made possible by the construction of the dams. The major irrigation system is the Columbia Basin Irrigation Project (CBIP) and is shown appropriately as the green area in Fig. 1. There are other irrigation projects in the MCB region, but the CBIP is the largest and hydrologically most important irrigation system. And I would like to emphasize the size of these irrigation projects relative to the normal pre-dam hydrology. Most crops need about 3-4 acre-feet per year which is the equivalent of roughly 40 inches of rain per year. That is about what Seattle, Washington gets in a year. The CBIP irrigates 671,000 acres at about 3 to 4 acre-ft per year for a minimum of 2,013,000 acre-ft per year. The CBIP, as just one irrigation system, uses about 3-4% of the Columbia River Water. The CBIP is in essence a brand-new river system comparable in size to some of the smaller tributaries of the Columbia.

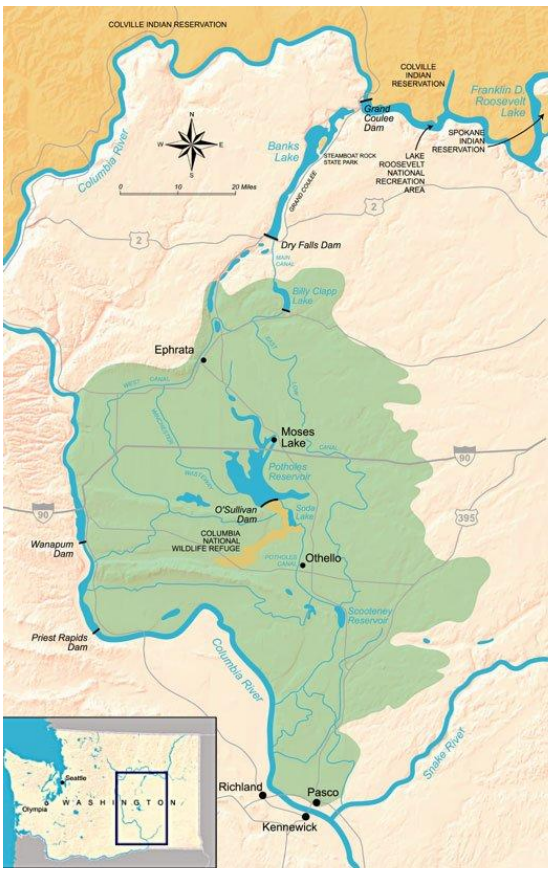

Figure 1. The Columbia Basin Irrigation Project

By US-Bureau of Reclamation. - http://www.usbr.gov/pn/project/columbia_index.html,

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So where does the water come from, where does it go and how does it impact the local hydrology. Banks Lake was originally a dry coulee and its original purpose was as a storage system for Grand Coulee Dam power generation. Water was pumped up to Banks Lake during high flows and then released back into the Columbia to generate power at low water flows. Banks Lake is one of the original pumped hydro storage systems that seem to be all the rage these days. (Science never changes it just gets better.)

It was also intended to supply the CBIP. Dry Falls Dam at the southernmost end of the lake is the start of the CBIP. It then diverges into a number of main canals with Potholes Reservoir being a major storage facility for the system. It extends southward to the northern most portions of Pasco, WA.

The irrigation system was originally built by the Bureau of Reclamation (BR) and is currently run by the three irrigation districts – The South Columbia Basin I.D., the East Columbia Basin I.D. and the Quincy Columbia Basin I.D. They are now in the process of transferring BR facilities to the various districts through the 2019 Dingle Act.

The Numbers

The average flow of the Columbia River at Grand Coulee for the 2024 year was about 85,000 cfs. This works out to be ~63 million acre-ft per year.

85,000(cf/sec)*32,400,000(sec/yr)/43560(cf/af) = 63,223,140 af/yr

This number agrees with NOAA

The CBIP irrigates 671,000 acres at about 3 to 4 acre-ft per year for a minimum of 2.0 million acre-ft per year. Thus, the CBIP uses about 3-4% of the Columbia River Water. The exact percentages on any given day depend upon snow pack melt rates, rain and temperature, crop planting times and growth rate. These estimates do not include withdrawals by other irrigation systems such as the much smaller independent Franklin Co. Irrigation system which primarily serves the Pasco residential areas.

The irrigated land is classified by the amount of water needed but this ranges from 3-4 acre-feet per acre per year or the equivalent of roughly 40 inches of rain per year which is pretty close to the average natural rainfall in Seattle, Washington.

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Irrigations impact on Hydrology

Crab Creek, for example, did not have permanent water flow prior to construction of the irrigation systems. Moses lake and the Potholes Reservoir did not exist. The Winchester wasteway did not exist. Indeed, the CBIP added hundreds of outlets or wasteways that drain a significant portion of the water pumped out of the Columbia right back into the Columbia after it passes through thousands of acres of farmland. Some of these wasteways drain from small confined underground aquifers high up on the cliffs overlooking the Columbia and some are huge concrete canals that run at more than 1,000 cfs.

Water applied through irrigation will be removed from the fields either through evapotranspiration or by percolation down through the vadose zone. Some evaporates directly into the dry air of our region and some is removed through plant transpiration. The rest that which percolates downward eventually reaches the Columbia River via canals or by lateral transport along the water table. Kahle et al. suggest that with modern crop circle irrigation they system efficiency is roughly 75% with considerable variation from region to region. This means about 25% of the water is lost though percolation through the vadose zone.

Bauer and Hanson estimate that ground waters have risen as much as 300' since the introduction of irrigation. The saturation of the ground water has caused many mud slides into the Columbia and in some areas evidence of ground creep is quite obvious and significant changes can be visually detected over a few days.

Water Quality

It is not hyperbolic to consider the CBIP one large hydroponics garden. The soil, being mostly quarzitic, does not carry many nutrients and heavy fertilization is required and is often applied directly through irrigation crop circles. The fate of the nitrates and phosphates is not clear. Farmers generally optimize fertilizer applications to maximize crop profit margins. In residential and urban areas, fertilizers are applied more haphazardly and often in great excess to create the perfect lawn. Still a significant fraction of fertilizer is not utilized by the crop and percolates down through the vadose zone and eventually out to the Columbia River. I have not been able to find studies of fertilizer use efficiency (FUE) that give actual numbers for the MCB. ChatGPT reports wheat as having a FUE of near 50% while tomatoes have a FUE of 30%. We might surmise from this that most if not a majority of applied nitrates, phosphates, and other nutrients end up in the water table and are eventually discharged to the Columbia River. We clearly need more information on the transport of chemicals through the MCB aquifers.

We conclude this section on hydrology and water quality and leave the impact on the riparian habitat zone for another major rant. However, in preview the discharge of fertilizer into the Columbia River has only recently become problematic and 2021 was the first year that we in the MCR saw animal deaths and health problems resulting from toxic algae blooms. TABs deserve a rant of their own and should probably be discussed in conjunction with local ecology.

Ecology Preview

As a preview of the description of local ecology we have described the Wetland, Riparian, Shrub-Steppe ecosystem that allows us to emphasize the importance of the near shoreline part of the ecosystem. The Shrub-Steppe is a fascinating ecosystem in itself but those of us who live here understand importance of the river and the adjacent wetlands and riparian habitats that it supports. As I have state before, without the Columbia River, the Tri-Cities would be a hell-hole for habitation.

An interactive map can found at Map of Franklin Co. and Pasco WRSS Areas that describes the South CBIP irrigation system and identifies areas of interest that are conduits for entry of irrigation flow into the Columbia. They range from large aqueducts to cliff side seepage. A full description of these areas can be found at Mid-Columbia River Wetland, Riparian and Shrub-Steppe Restoration Areas