Environmental Memo

Nelson Dam Replacement

Ramblers' Park Reach

Naches River

Yakima County Water Resources Division

Yakima County Public Works

In Cooperation with

City of Yakima Public Works Department

Water ~~and~~ / Irrigation Division

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1. HISTORICAL BACKGROUND

In the Yakima River Basin, the first recorded irrigation diversions were by Chief Kamiakin and Catholic Priests at the St. Joseph Mission on Ahtanum Creek. The second diversion was at the Nelson Homestead, located downstream from the current Nelson Dam.

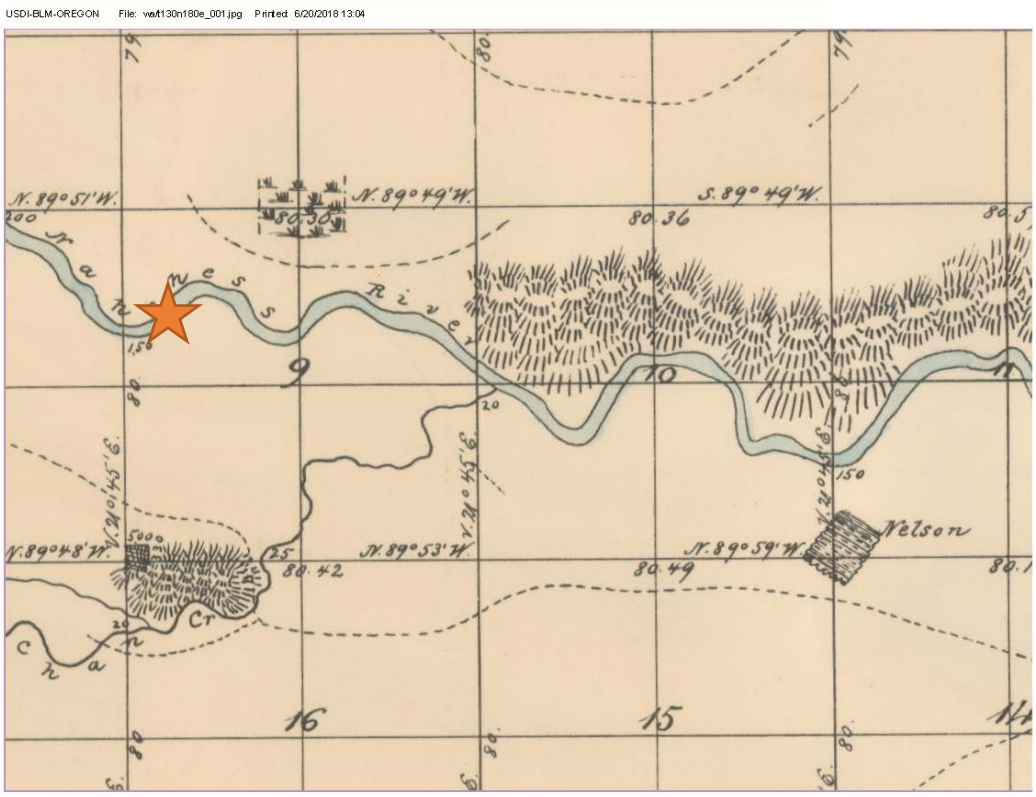

Figure 1 - 1865 General Land Office Cadastral Survey showing Nelson Homestead, Naches River, unnamed stream meandering in SW of Section 9 is Cowiche Creek, orange star indicates approximate current location of Nelson Dam.

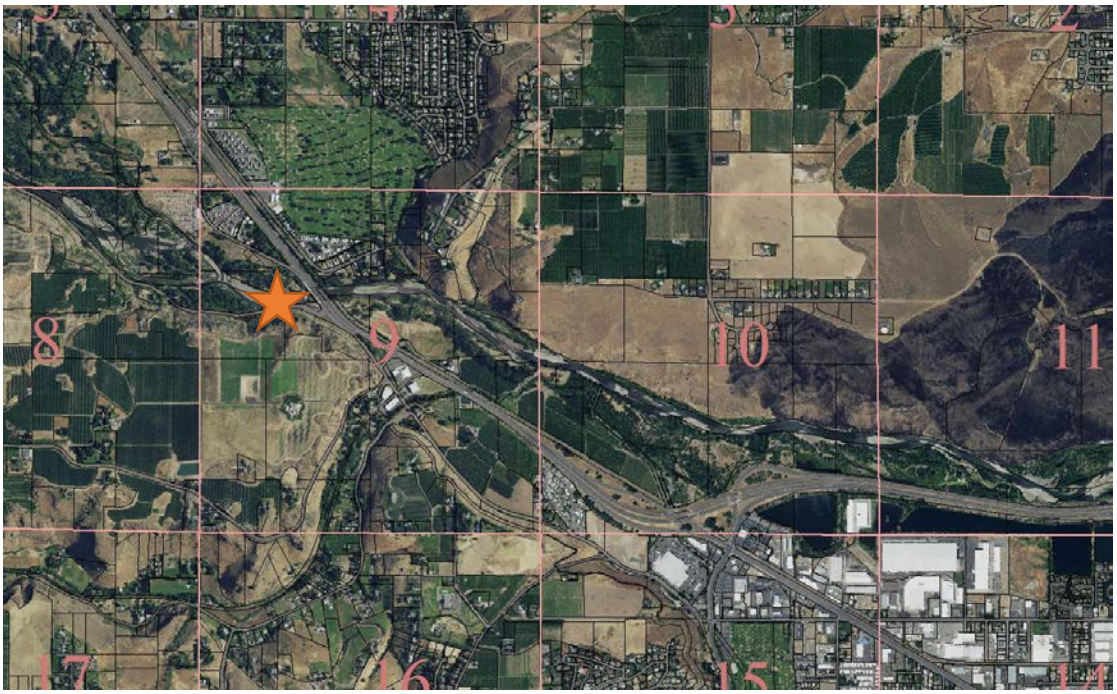

Figure 2 – 2017 Orthophoto of lower Naches River, same extent as map above.

The original diversion was located in the numerous side channels that existed just downstream of the Cowiche Creek confluence. These spring fed channels provided a year-round supply of water to the Nelson Farm. Over time, the Nelson ditch was combined with other diversions and moved upstream, the first cooperative irrigation ditch associations in the basin – the Union and Schanno ditches, now the Old Union and New Schanno ditches – started in these same channels just downstream. Collectively these irrigation diversions and their related infrastructure are the oldest of their kind in the Yakima Basin, old enough to make evident the changes in channel process which have been caused by those diversion structures, related levees, as well as highways and urbanization. The proposed replacement of Nelson Dam with another structure should be viewed in the context of these changes in riverine processes and the multiple types of infrastructure and multiple agencies which manage that infrastructure.

The earliest USGS maps from 1906 show that the Naches Cowiche Canal Company ditch begins at the current Nelson Dam Location, and the current structure serves the Naches Cowiche to this day. Given the priority date of the Naches Cowiche water right as 1880, there has likely been some type of irrigation diversion at this location since that time. The dam also serves the City of Yakima, with a majority of the water diverted at this location having a priority date of 1896 and 1878, a significant combined irrigation diversion, having near the current diversion quantity of over 60 cubic feet per second (cfs), has existed at this location since at least 1906.

Geologic and topographic conditions in the vicinity on the Naches River and floodplain were favorable at this location for the establishment of both the early road and irrigation diversion structure. More than two million years ago, an andesitic lava flow erupted in the Cascade Mountains and flowed down the channel of the current Tieton River and into the floodplain of the Naches River, flowing across the top of the alluvial gravels and halting at the current location of

Cowiche Creek, just downstream of the dam, where the lava flow came into contact with older, uplifted basalts. Ongoing uplifting of the basalt ridge on the north side of the valley keeps the river' south bank hard against those Tieton Andesites, a gentle curve above Nelson Dam concentrates flows on the south side of the channel (see Figure 10)

Figure 3. Undated photo (likely prior to 1930) of second Pacific State Highway 5 bridge, this bridge remained in use until 2007.

Other infrastructure in existence by the early 1900's was Powerhouse Road, then called the Naches Highway. It was constructed as a county Road, the original wooden bridge was damaged in the 1910 Flood and replaced just downstream with a bridge that continued in use until 2007. The Naches Highway later became incorporated into Pacific State Highway 5/Inland Empire Highway in the 1920's, and then becoming Powerhouse Road (reverting to the County) in the 1950's when US 12 was constructed north and just downstream of the Powerhouse Road and Nelson Dam. Downstream of the diversion, the Railroad Bridge had been constructed in 1895, it was apparently salvaged by the NPRR from another location in Iowa and constructed on this site. It is worth noting that old photos of the NPRR bridge show the western (upstream) approach was originally a trestle structure approximately 450 feet long, constructed over the gravel bar that existed at that location. Only after US 12 was constructed and that portion of floodplain cut off by the road prism of US 12, was the western approach converted to compacted fill.

The oldest air photos available are from 1927, showing the arched diversion dam, Powerhouse Road, and the Railroad. We know that the 1933 flood severely damaged the road and the Nelson Dam, the 1947 photos show a linear diversion dam just downstream from the location shown in 1927, indicating a replacement of Nelson Dam sometime between the two photos. Another change on visible in the 1947 photos is the presence of an armored levee, shown more clearly in the map below, generated two years later in a report to the State Department of Conservation (predecessor to Ecology) reporting flood damage and repair.

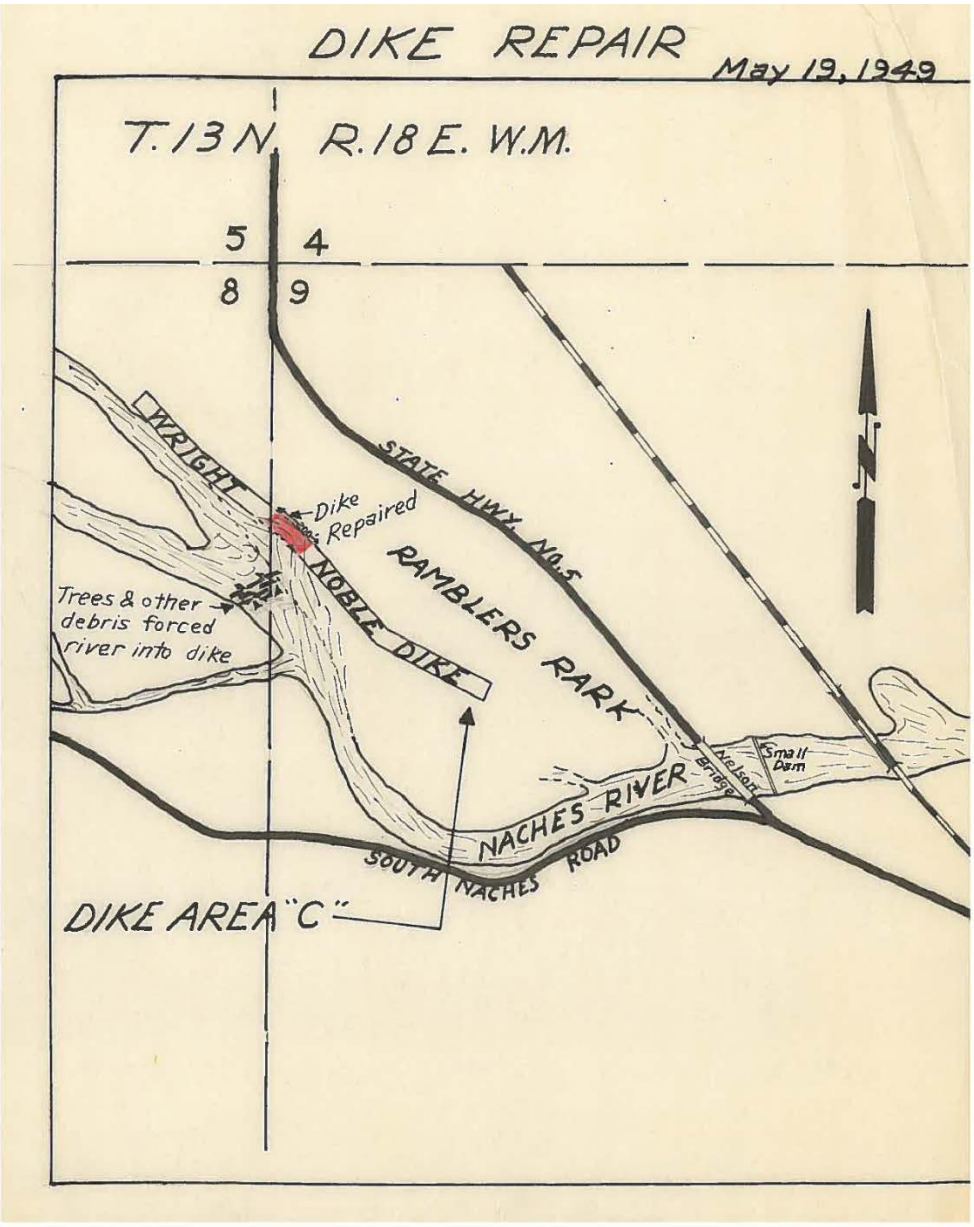

Figure 4 – 1949 Sketch of infrastructure at Nelson Dam. South Naches Road is located on a shelf cut into the Tieton Andesite. Most of State Highway No. 5 lies in a very active floodplain and regularly was flooded due to its location, the narrow bridge constriction, and the raised water surface elevation as a result of Nelson Dam.

2. ALTERED RIVERINE PROCESSES AND CONSEQUENCES

According to studies performed by Golder (2004) for the City of Yakima, it is about this timeframe, that the changes in riverine processes associated with Nelson Dam and transportation infrastructure first became problematic for infrastructure managers. The major effect of this infrastructure was to interrupt sediment transported by the Naches River, causing the bed of the river upstream of the dam/Naches Bridge to rise as sediment accumulated over time, with large accumulations of sediment associated with large peak flows and long duration flood events such as 1933 (still the flood of record), 1948 (long duration spring flood), 1971, 1974, 1996, and 1997. This resulted in the construction of the levee system to reduce the frequency of flooding of the road, and adjacent land uses which by the 1930's included the 'Rambler's Park" Camp (primarily migrant labor), hotel, store, gas stations, tavern etc.

The Wright Noble levee as shown in Figure 4 above in turn created another constriction (between the levee and the Tieton Andesite valley wall) on the river, which raises the water surface elevation upstream during high flows – 17,000 cfs or approximately 10-year frequency or higher. This in turn further interrupts sediment transport, causing large amounts of material to accumulate upstream of the narrowest constriction point in the levee, you can see this aggradation in plan view in Figure 4 as the braided nature of the channel upstream of the angled change of alignment in the levee.

The sediment accumulation upstream leads to:

1. **Relatively Expensive Emergency Efforts to Extend the Levee Upstream During or Immediately After a Flood Event as the Levee is Flanked by Floodwaters:**
   The Wright Noble levee above is approximately 1,000 feet in length. By the end of the 1996 flood, emergency repairs to the "Rambler's Park" levee had increased levee length to over 3,000 feet.

2. **Frequent Levee Failure During Minor Flood Events:**
   During larger floods when the levee constriction causes a large pool of slower moving water to form upstream, coarse and fine sediment settles out in that pool. The greatest depth of sediment deposition is at the lower end of the pool. As floodwaters recede gravel bar is left in the river with a relatively steep scarp at the lower end of the gravel bar, this scarp can be from 5 to 10 feet high and span most of the channel width. Depending on how fast the flows recede from a given flood event, the river will begin to cut a new channel at some location along that scarp, usually this occurs at the next flood (1 or 2 years later) when the river first reaches bank full flow again, but can happen in the same flood if the flood duration is very long. When this occurs, at about 7000 cfs or approximately a 2 year discharge, a narrow channel with a very steep slope and high velocity – i.e a water jet - develops. If this jet is directed at the levee, it causes erosion of the channel/loss of the levee toe in a small area, and then proceeds to undercut the levee prism itself, eventually causing the levee to collapse in 250 to 350-foot sections, similar in terms of position (upstream of the narrow point) and length of failure shown in Figure 4. The only known repairs to that structure were the 1949 repair (the year after the very long duration 1948 flood), and after enrollment in the Corps of Engineers levee maintenance program in 1971, 1972, 1974, 1975, and

1977 repairs, two separate repairs in 1996, one in 2006, and the last failure and collapse in 2012. That last failure ultimately resulted in setting back of the lower portion of the levee in 2013.

Figure 5 - May 2012 Ramblers' Park levee undercut and collapse at 2 year flow, the year after 2011 approximately 15 year peak flow. In foreground in 1996 failure, car in background is parked just upstream from 2006 failure.

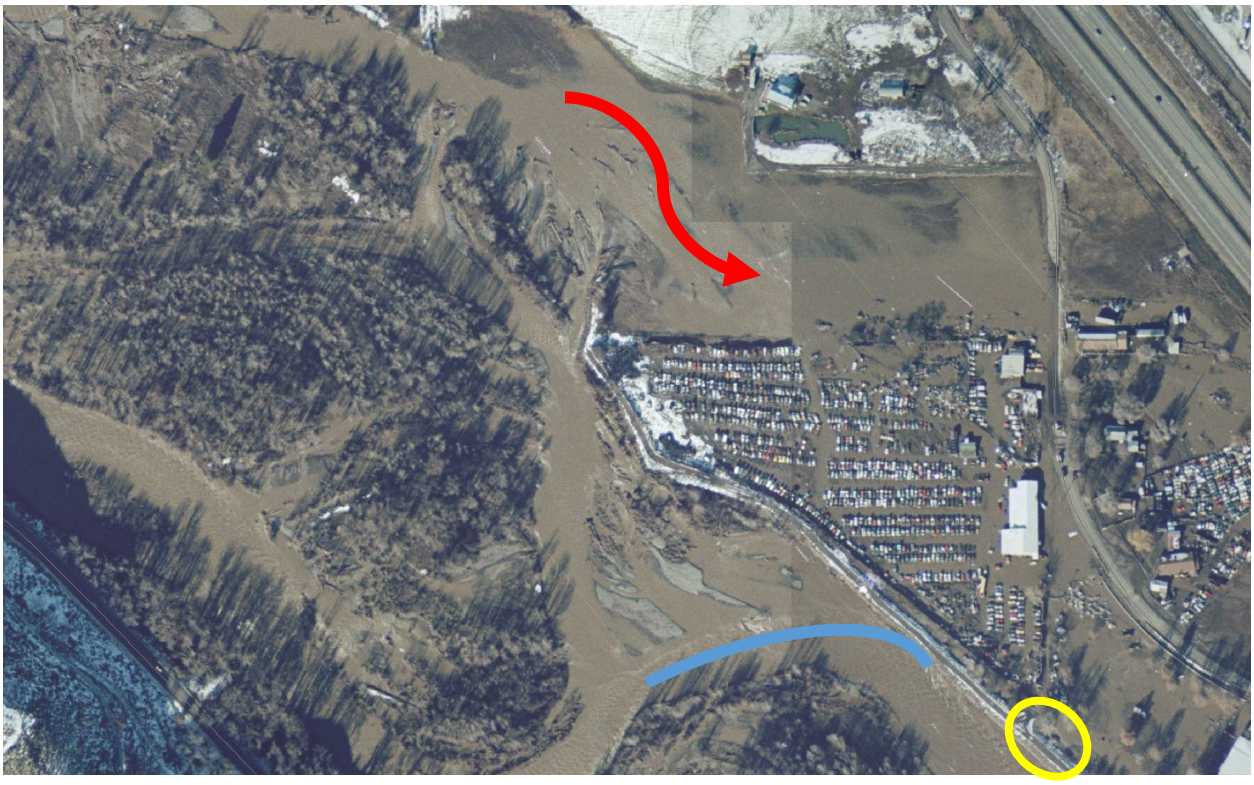

Figure 6 – 1996 Flood 2 days after 50-year peak flow, river is at about 25-year flow in photo. Red arrow shows flanking path upstream of Ramblers' Park levee, Corps and County extended the levee 450 feet upstream in the ensuing weeks. Just above the blue line in the development of the "jet" as the flow falls, area where the "jet" hits the levee would fail and collapse 3 days later. Yellow circle is second failure, approximately a month later as the "jet" reformed downstream. Note also the fresh gravels depositing upstream of the blue line, along the red line and continuing upstream off the photo.

3. **Ongoing Sediment Accumulation Upstream:**
   As sediment deposits in the channel and floodplain upstream of the Ramblers' Park levee, not all of that sediment is later remobilized and transferred downstream. In a situation such as the 1948 flood - several months of sediment transport flow, and then no major floods occurring for more than a decade - much of the sediment is colonized by vegetation and becomes a permanent rise in floodplain and channel elevation. This rise, in turn, creates a reduction in slope or gradient of the channel, and since slope is proportional to stream power and the ability of the stream to transport sediment, that reduction in slope increases sediment deposition upstream of the sediment that was deposited upstream of the levee. If that sediment then is colonized by vegetation, the deposition moves farther and farther upstream over time. As the channel and the floodplain next to the channel rises, the river may also avulse (change course dramatically during a flood event) as is beginning to occur in Figure 6 above, increasing risk to public and private structures.

   A good measure of this increased risk is to note the changes in calculated flood height and the extent of floodways and floodplains as the National Flood Insurance Rate Maps (FIRMs) are updated. The original FIRMs for Yakima County were developed in 1984,

based largely on 1979 topography and some surveyed cross sections, the updated 2009 FIRMS were based on LIDAR topography from 2005, verified by surveyed cross sections. Both models used the same estimated 100-year flow, 27,700 cubic feet per second. The only difference in methodology was a difference in methodology for mapping the floodway downstream of Nelson Dam. The original maps did not have a floodway mapped, the updated maps did. For the most part, in comparing the two datasets, the expansion and contraction of the floodplain matches known changes in the channel and floodplain between 1979 and 2005, expanding where the channel and floodplain have risen, such as at Ramblers' Park, and contracting where the channel has incised, such as in areas 12 miles upstream, just downstream from the confluence of the Tieton and Naches Rivers. The graphics below compare the old and updated FIRMS for the Gleed/Ramblers' Park areas.

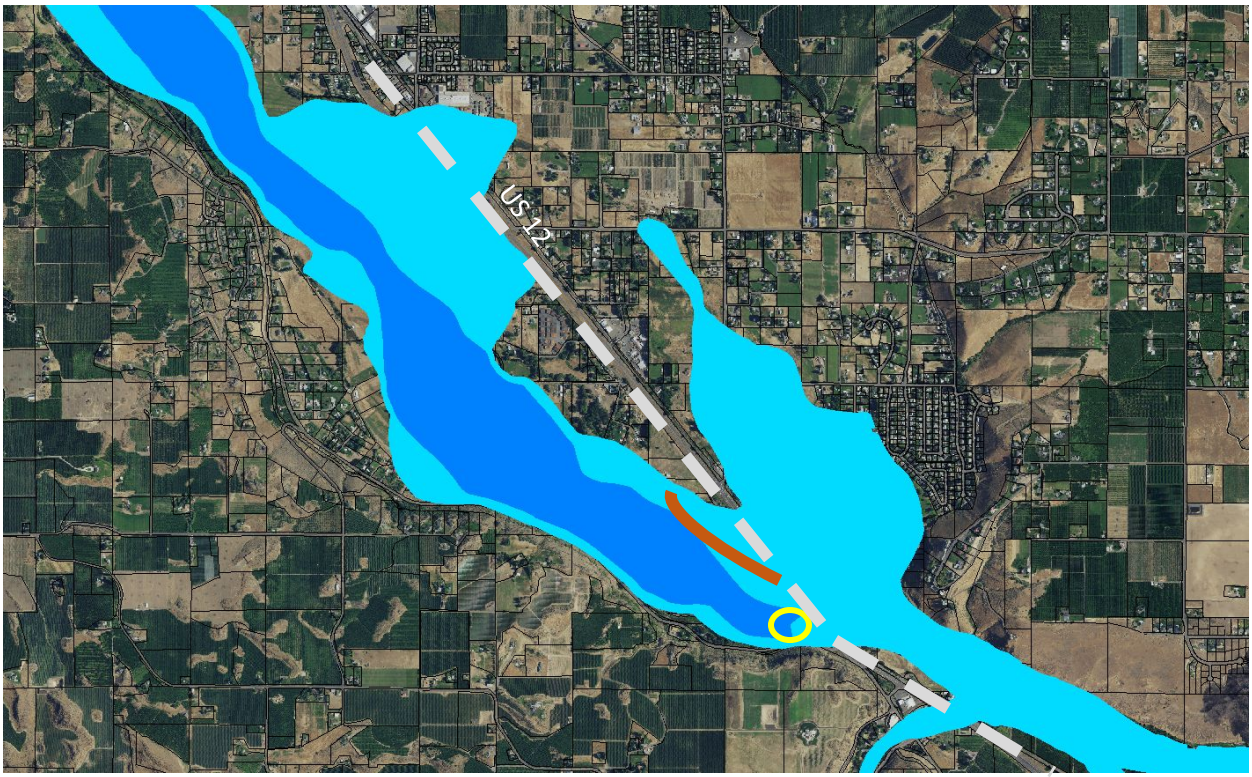

Figure 7 – Original Flood Insurance Rate Map which was in effect from 1984 to 2008. Dark Blue is Floodway, Light Blue is Floodplain, Orange line is extent of Ramblers' Park levee when the hydraulic model for the map was developed, and Yellow Circle is location of Nelson Dam.

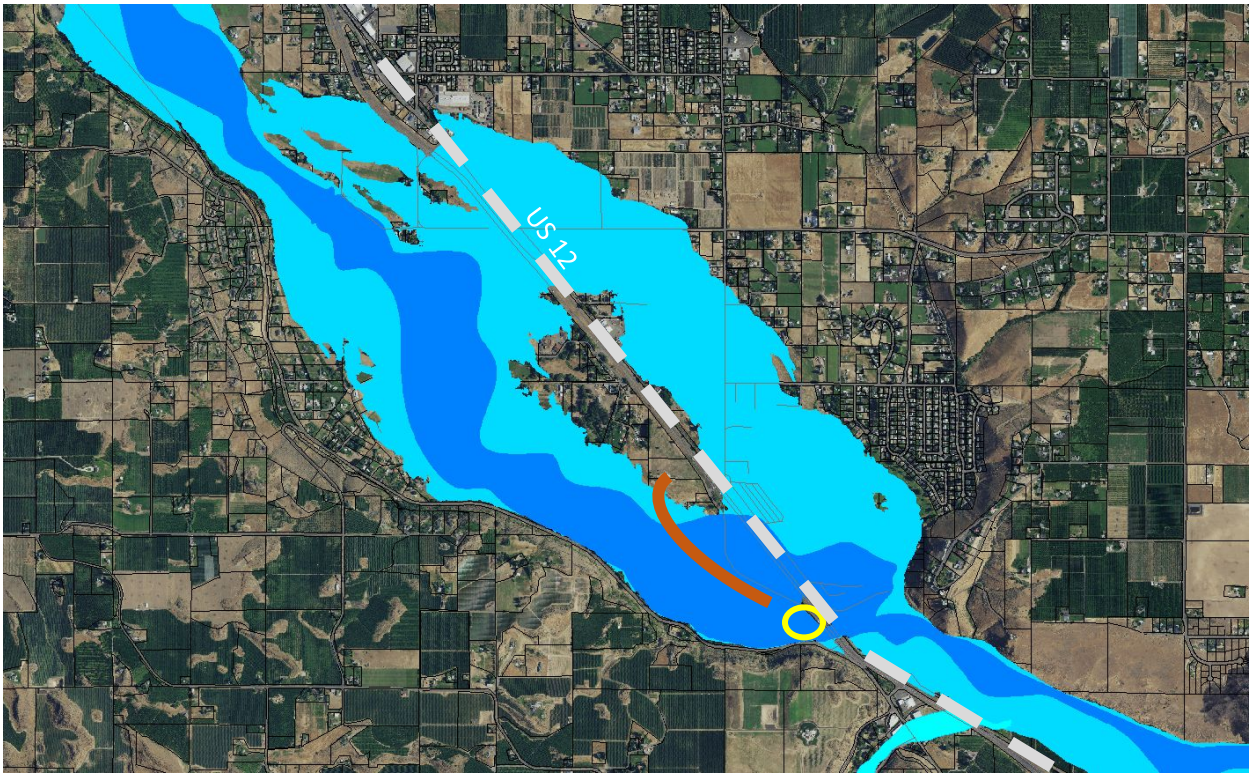

Figure 8 – Flood Insurance Rate Map in effect since 2009. Dark Blue is Floodway, Light Blue is Floodplain, Orange line is extent of Ramblers' Park levee when the hydraulic model for the map was developed, and Yellow Circle is location of Nelson Dam.

As noted above, in comparing the two maps the change in the extent of floodway downstream of Nelson dam was due to a change to a "detailed study area" which mapped a floodplain. The methodology for the overall floodplain width in that area was the same. As you can see the extent of the floodway in the area of the Ramblers' Park levee is much larger, even with the longer levee. This is because the modeled elevation of the water surface at the 100 Year flow is three to five feet higher in this area on the updated map, that elevation overtops the levee. This rise in water surface elevation at Ramblers' Park also causes the Naches River to flow across US 12 to a depth of a little over 4 feet in the updated hydraulic model, while in the original model there was only shallow backwater flooding on the highway as well as downstream of the highway. Water surface elevations are also much higher approximately 1.5 miles upstream of the dam, and also shift from a shallow backwater across US 12 in the original model, to the river flowing eastward across US 12, causing a dramatic increase in the extent of the floodplain northeast of the highway in the updated maps. These altered riverine processes also effect the river and riverine infrastructure at and below Nelson Dam.

At Nelson Dam the variability of sediment loads that occur due to periodic interruption of sediment transport during larger floods, and the increase in sediment transport as that flood recedes or in the next minor flood (potentially) years later creates unique challenges to maintaining upstream and downstream fish passage at the current facility. The fish passage facilities at Nelson are so-called Phase II facilities (compliant with early '90s fish passage best practices) and that maintenance is funded by the Bonneville Power Administration, who provides funds for this structure and other large irrigation diversions in the basin to the Bureau of Reclamation, which has the legal responsibility to

maintain passage at large diversions facilities such as Nelson Dam. Washington State Department of Fish and Wildlife performs for more or less routine maintenance of the fish ladder and Naches Cowiche screens, larger periodic maintenance of sediment accumulation or channel shape and the City of Yakima Screen is performed by Reclamation.

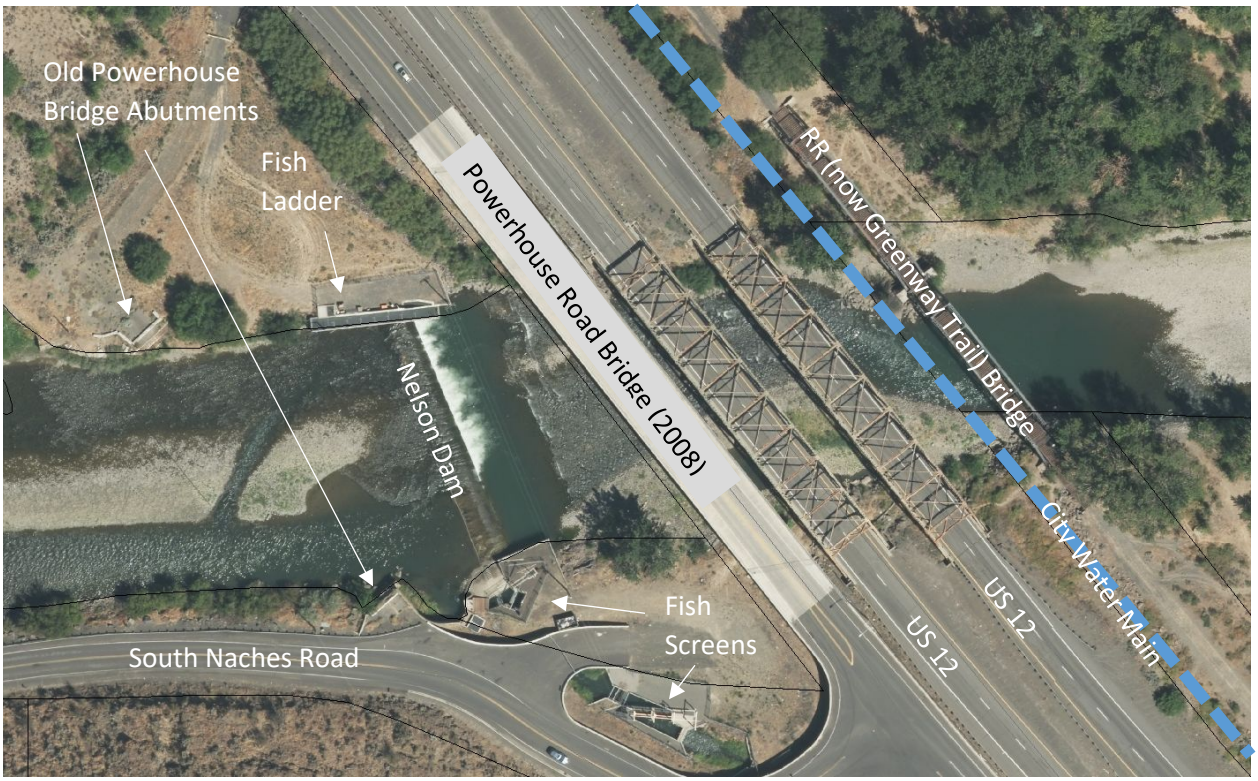

Figure 9 – Aerial view of Nelson Dam vicinity with infrastructure labeled. The photo was taken during the very low flow of summer 2015. Note that the river tends to hug the Tieton Andesite wall near S. Naches Road, which provides good flow to the irrigation diversions and fish screens, but poor flow to the fish ladder. Note channel cut across bar to improve flow to the ladder.

Figure 10 – Fish Ladder Entrance at Nelson Dam, 2018

Upstream fish passage at the dam is provided by a fish ladder constructed when the dam was last reconstructed in 1985, there was no passage structure prior to that time. As shown in Figure 9 sediment tends to accumulate just upstream of the dam, especially on the inside of the river bend near the fish ladder. This can cause the ladder exit ladder to be plugged, or for sediment to enter the ladder and fill the pools in the ladder during sediment transport events. Downstream of the ladder, sediment can accumulate near or in the ladder entrance, plugging the entrance and/or changing the attraction flow to the ladder. Management of this structure to maintain fish passage has included closing the upper ladder entrance during sediment transport events (typically in the spring when the ESA-listed Steelhead are migrating) and excavation of the channel at the upstream exit, excavation of material from the pools in the channel itself, and excavation of sediment near the downstream ladder entrance.

Fish Passage Effectiveness

Depending on sediment conditions in the channel, the dam itself may or may not be passable for large, upstream migrating fish in any given year. Typically, the fall from the plunge pool to the water surface above the ladder is 2-3 feet. If there has been a sediment starvation event/large long duration flood, the plunge pool and downstream channel can be much lower in elevation, creating an impassable 5 to 7-foot difference in water surface elevations. When that impassable condition exists, and the fish ladder is plugged, the dam can be a full fish passage barrier. Such an event occurred in the fall of 2011, the spring flood was followed by consistent high flows well into the end of August, which prevented both maintenance of the fish ladder, also prevented the development of a large water surface

difference at the dam over the summer due to backwater from the bridges downstream. During the fall Coho migration, which began in late October when flows are at their lowest, the dam was impassable. Coho accumulated at the dam, which provided opportunity for poaching the fish with weighted treble hooks, and also caused unusually high concentrations of spawning in the less suitable habitats of Cowiche Creek/Fruitvale Diversion channel downstream. This situation required the stationing of a Washington State Patrol officer at the dam to discourage poaching and the application by Reclamation for emergency permits to perform ladder maintenance outside of the normal "fish window", as passage at this facility is ultimately Reclamation's responsibility.

Farther downstream, the current fish screens at the irrigation diversions are designed to keep migrating fish, primarily juvenile salmonids, from being entrained into the City of Yakima and Naches-Cowiche Canal Company irrigation systems. As the fish are screened out in the forebay of those facilities, there is a fish bypass pipe that carries fish from the forebay back to the river. The pipe terminates in the river underneath the new Powerhouse Road bridge, near the central bridge pier. The construction of the bridge likely exacerbated the already less than ideal channel stability conditions in the vicinity of the fish bypass. As discussed above the configuration of the dam and levee results in a large variability in sediment transport conditions, which in turn causes the bed elevation downstream of the dam to fluctuate within and between years. Before bridge construction, and certainly after the bridge was constructed, this could lead to the fish bypass discharge being suspended above the channel bed and exposed to damage from bedload, or completely buried by sediment which prevented outmigration from the forebay and likely greatly increased mortality as fish we trapped next to the rotating screen drums. In order to resolve this problem, Reclamation began a program of armoring the outfall with riprap to protect the discharge. These structures failed annually. Reclamation then constructed a series of "ecology block" structures, with the last structure reinforced with steel strapping having stayed in place since 2010.

Figure 11 – Fish bypass discharge pipe location beneath Powerhouse Road Bridge. "Ecology Block" structure and racked woody material shown. (downstream US 12 bridge is sheathed in plastic for painting)

The structure shown in Figure 11 has a hydraulic and sediment transport effect of its own as can be seen in Figure 10. This structure tends to reduce water conveyance thorough this section of the bridge, forcing it to the north and forming a bar on the south bank, with the trickle of water flowing from the bypass pipe flowing across the bar and downstream. The bypass pipe was located in this area because it was thought that the dominant channel location would be on the south side, below the channel that runs along the andesite wall below S. Naches Road. This loss of conveyance capacity and resultant bar formation also encourages sediment to accumulate on the downstream side of the dam, plugging the fish ladder entrance. Maintenance of that entrance by sediment removal must be balanced with the need to not over-excavate the sediment and destabilize the "Ecology block" structure which protects the fish bypass discharge.

The accumulation of sediment upstream of the dam and levee can be expected to result in sediment starvation downstream of the dam and levee. Just as Figure 4 shows the existence of the Wright Noble levee and the need to repair after the 1948 flood, infrastructure managers downstream of the dam were also having to respond to sediment starvation.

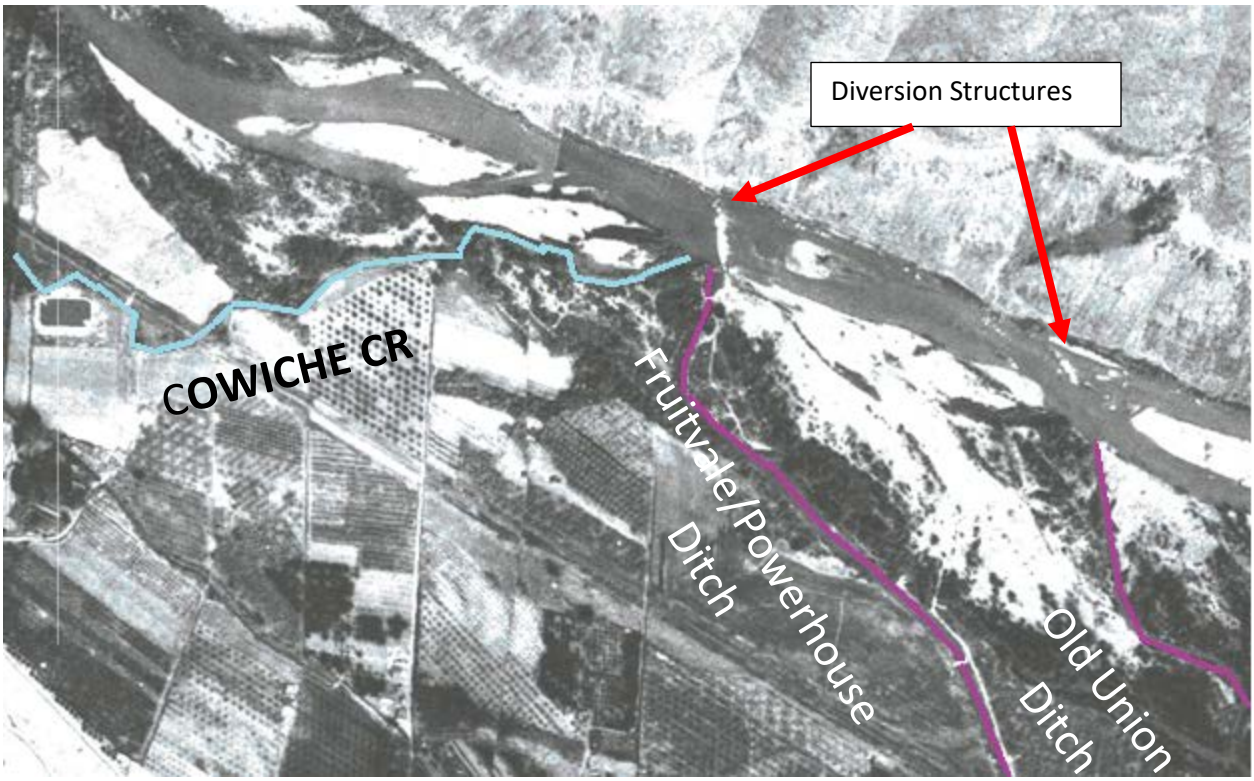

Figure 12 - 1927 Aerial Photo, Cowiche Creek, Naches River, Fruitvale and Old Union Ditches.

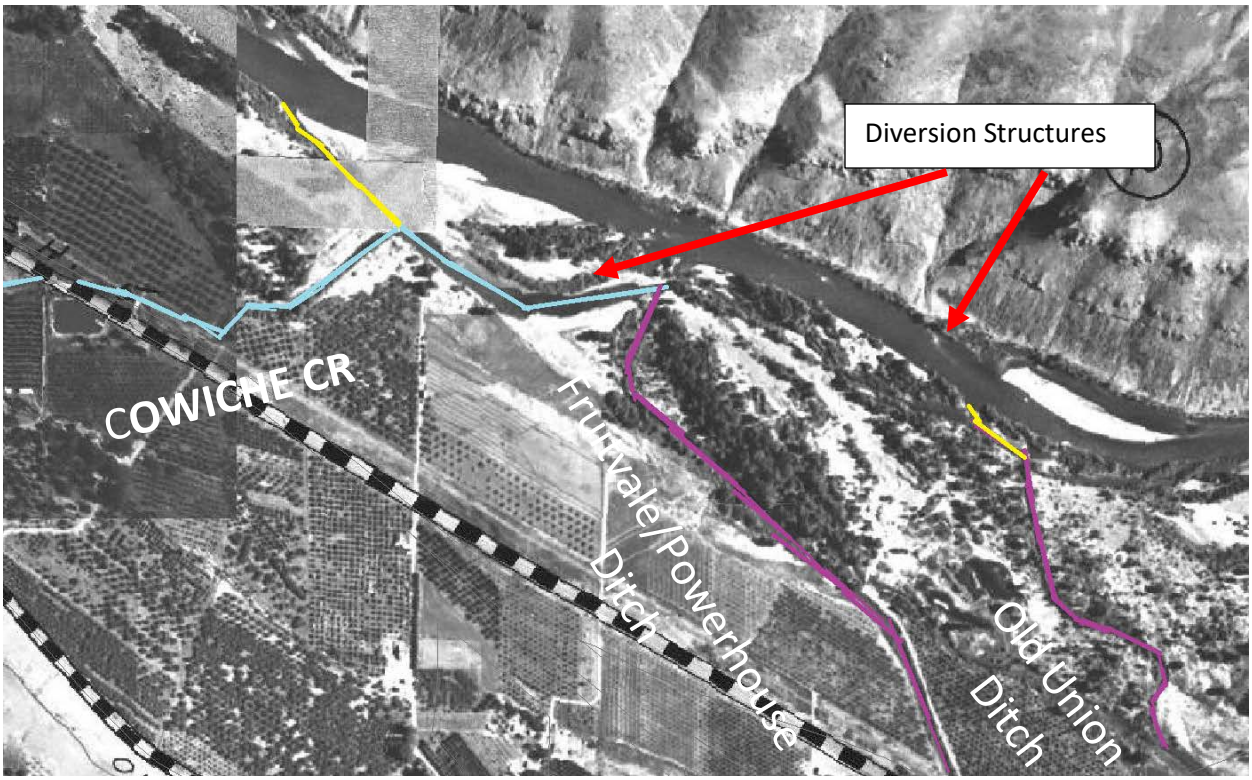

Figure 13 – 1947 Aerial Photo, Cowiche Creek, Naches River, Fruitvale and Old Union Ditches.

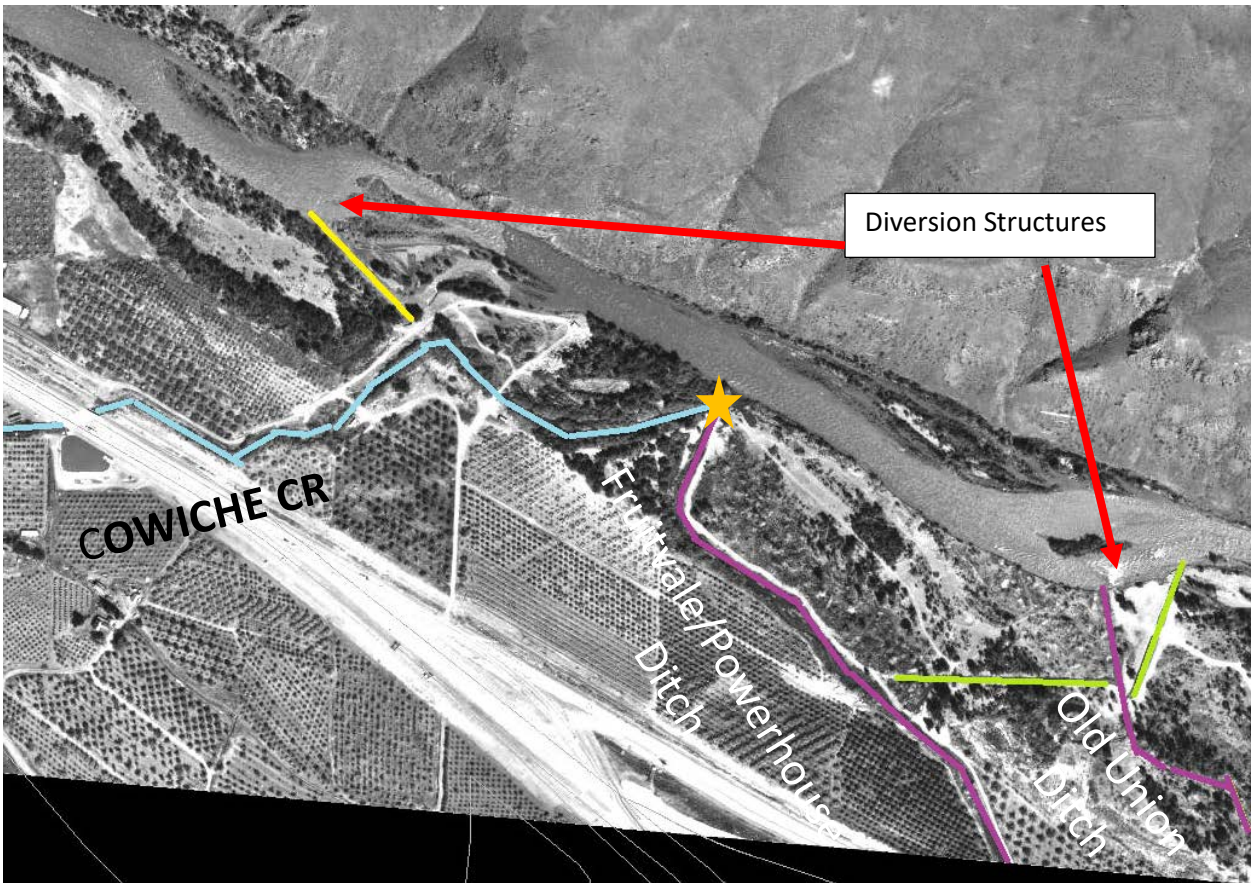

Figure 14 – 1971 Aerial Photo, Cowiche Creek, Naches River, Fruitvale and Old Union Ditches.

Downstream Sediment Effects

The figures above show the efforts of the infrastructure managers to cope with ongoing lowering of the channel and institutional change around them. In the 1927 photo, the Fruitvale ditch appears and is a consolidation of previously existing diversions and a new diversion for power generation from which Powerhouse Road got its name. The two in-river diversion structures are clearly visible, and Cowiche Creek, its course already heavily modified by the irrigation and the railroad flows into the Naches River just upstream of the Fruitvale Diversion. By 1947, the Fruitvale was no longer used for power, and largely owned and controlled by the City of Yakima. The Naches river diversion weir is gone, replaced with a diversion dam at the very bottom of the Cowiche Creek channel, with the entire mouth heavily modified including a constructed connection (shown in yellow) from the Naches River to Cowiche Creek. Similarly, Old Union has also tied into a side channel and moved its point of diversion upstream as well. By 1971, the facilities and infrastructure are much as they exist today. The City has constructed a series of levees on the bar at the confluence, constricting the river to raise the upstream water level, in later years the City would once again construct a large weir in the river even further upstream. Too small to be seen on the photo is another diversion dam (orange star on Figure 14) constructed at the diversion point on Cowiche to raise the water surface and backwater flow into the Fruitvale Ditch. This dam is equipped with an Alaskan Steep Pass/Denil Fishway to provide fish passage over this low head dam. The ditches are equipped with fish screens, and fish bypass returns (shown in green) flow from the Fruitvale screens to the Old Union inlet, and from the Old Union Screens back

to the river. The Old Union has constructed a new, higher dam just downstream of their diversion. These interconnections of the Naches flowing into the Cowiche, and thence into the Fruitvale, and from there to the Old Union create several false attraction flow paths for species such as Steelhead and Spring Chinook which migrate during the irrigation season.

Figure 15 – Dam and Fishway at Cowiche Creek mouth.

The Alaska Steep Pass Fishways generally require frequent (weekly) maintenance in the form of maintaining upstream and downstream water surface elevations to maintain fish passage velocities required for passage. City of Yakima staff checks the dam for blockage or material buildup, WDFW does not currently make regular weekly visits to the fishway to ensure upstream passage is maintained.

The modification of the Cowiche Creek channel for irrigation diversion, in combination with modification of the channel at the US 12 and Railroad Crossings, and the construction of private and public levees in this lower reach does not allow the channel to respond to changes in the elevation of the Naches River or natural channel processes such as channel migration. This type of artificial confinement only allows response of the channel in a vertical direction by channel rise, or infrequently by concentrating energy against a levee and causing levee collapse. These predictable responses to vertical and lateral confinement have been evident during the winters of 2016 and 2017 as relatively minor flood events exceeded channel capacity upstream of US 12, and flowed overland into the City of Yakima, closing 40th Avenue and the 40th Avenue interchange of US 12, and in 2017, causing severe damage over several days of flooding as waters penetrated well into the City of Yakima.

Figure 16 – Old Union Diversion in 2018.

Finally, as the channel in the downstream portion of this reach continues to lower, the Old Union Irrigation Company continues an annual battle to maintain the flow of water to their point of diversion. The photo above shows the upstream end of a constructed side channel that is heads 800 feet upstream of their diversion point and check dam structure, which requires annual excavation and armoring to keep up with the declining bed elevation. The diversion works also includes another 600-foot-long constructed side channel downstream pf the check dam to take excess flow and the fish bypass flows back to the Naches River. This maintenance causes significant amounts of disturbance each spring and is a very large maintenance load for a small and underfunded private irrigation company.

3. PLANNING PROCESSES AND RECOMMENDATIONS

The area of Nelson Dam, including the reaches for 3 miles upstream, downstream to the confluence of the Naches and Yakima Rivers, and lower Cowiche Creek have been the focus of several planning efforts due to the large amount of riverine infrastructure, the high maintenance cost/history of damage to that infrastructure, and its location adjacent to the City of Yakima and within the Yakima Urban Growth Area. The most relevant planning processes for the purposes of this memo are the Comprehensive Flood Hazard Management Plan (CFHMP) processes; planning processes directly related to Salmon Recovery and Endangered Species Act Recovery Plans; and Engineering analyses associated with the construction of the new Powerhouse Road Bridge, the updated FIRMS, and condition/poor fish passage performance of Nelson Dam.

CFHMPs - The crossing of US 12 just below Nelson Dam marks the boundary of the Upper Naches CFHMP and the Lower Yakima CFHMP. The first CFHMP to be completed (1998) was

the Upper Yakima which placed much more focus on the Gap to Gap reach of the Yakima River and did not examine this reach in much depth. The Upper Yakima did recommend the establishment of the Yakima Countywide Flood Control Zone District and that recommendation was acted on in 2000, with staff hired in 2001. The Lower Naches CFHMP was finished in 2006, and the recommended actions for Ramblers' Park are the highest ranked structural recommendations in the plan. These recommendations include buyout of vulnerable properties, moving Powerhouse Road upland as far as possible, and setting back the Rambler's Park Levee as much as possible. After the formation of the Flood Control Zone District, the FCZD undertook to amend the Upper Yakima CFHMP; during that same time the Washington State Legislature passed the Salmon Recovery Act (RCW 77.85); and WSDOT, Yakima County, and the City of Yakima were all proposing fairly significant infrastructure modifications in this reach. To coordinate infrastructure and Salmon Recovery planning in this reach, the Lower Naches River Coordination Partnership Plan was developed by the Washington State Department of Fish and Wildlife, Yakima County Flood Control Zone District, and the City of Yakima. Out of that document came the first fairly specific recommendations relating to the proposed Powerhouse Road Bridge, Nelson Dam Replacement and consolidation of the Fruitvale and Old Union at Nelson Dam, restoration of lower Cowiche Creek and other actions in the reach. That document, in its entirety was incorporated into the Upper Yakima CFHMP amendment, approved by WDFW and Ecology, and adopted as policy guidance by Yakima County and the City of Yakima. That document also helped to spur development of related fish passage restoration plans and projects in the remainder of Cowiche Creek which were implemented over the next decade.

With the recent flood events in 2016 and 2017, the City of Yakima, Yakima County Flood Control Zone District and Washington State Department of Transportation have developed an amendment to the Upper Yakima CFHMP specific to lower Cowiche Creek. This amendment has been approved by the City and County and has been forwarded to the Department of Ecology for approval, expected in early 2019.

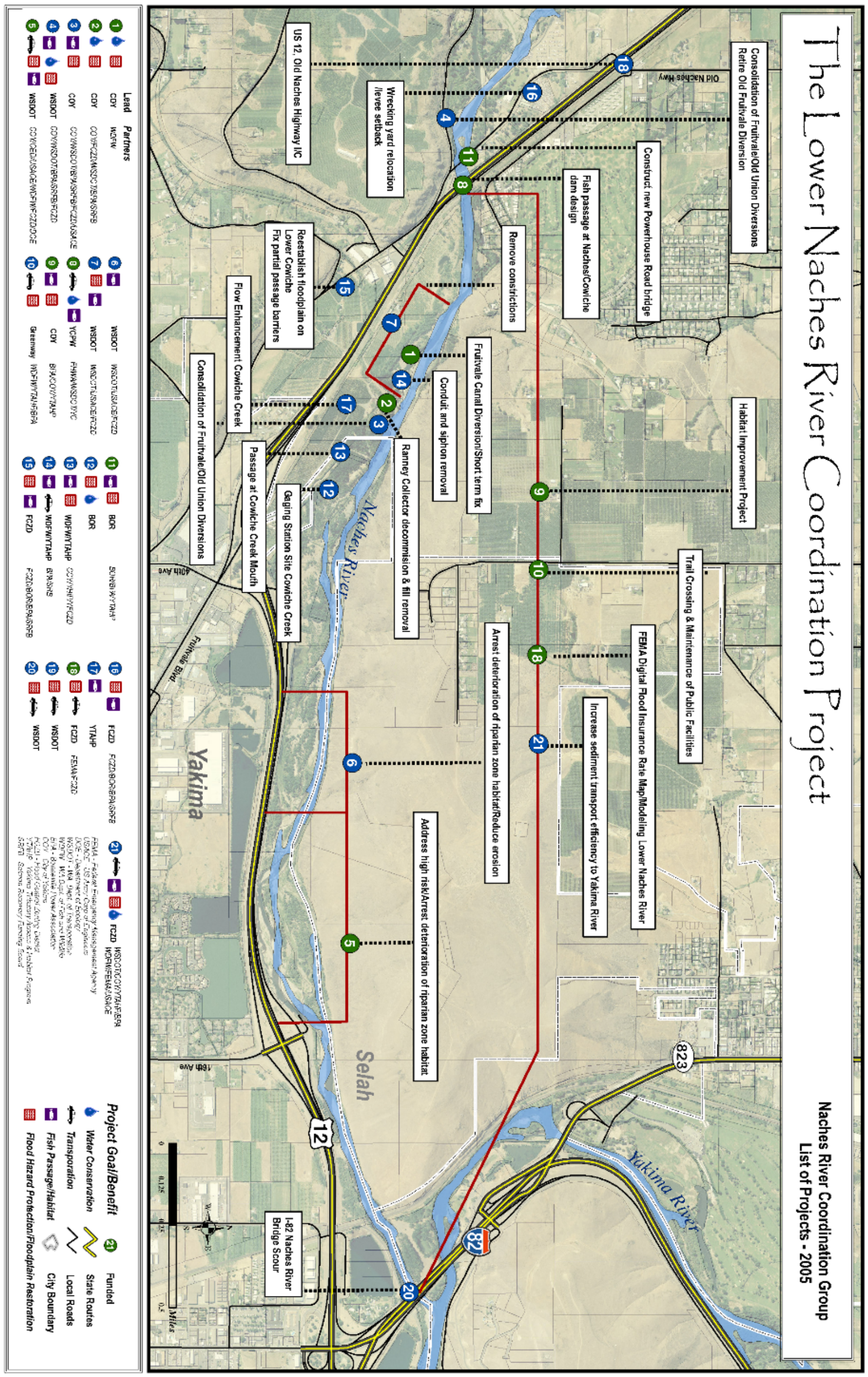

Figure 17 – The Lower Naches River Coordination Project.

Salmon Recovery Plans - Already mentioned was habitat restoration planning under the Washington State Salmon Recovery Act, which was followed by development of the Yakima Sub-Basin Plan for Northwest Power Planning Council (now Northwest Power and Conservation Council), and the ESA Salmon Recovery Plan for the Yakima Basin. Both of those efforts were led by Yakima County. Recommendations in those documents were for larger scale floodplain restoration efforts that would have watershed or reach-scale effects, and specifically the restoration of cold side channel habitat such as those that existed at the site of the original Nelson diversion back in 1859.

Site Specific Studies - Powerhouse Road Bridge was replaced in 2008 as a component of a larger project to improve freight (fruit truck) mobility and safety in this area. The hydraulic and hydrologic analysis used to design the bridge recognized its location in relative to other pieces of infrastructure upstream and downstream and was the first hydraulic analysis to identify that the estimated water surface elevations of the 100-year flood were much higher than those shown on the FIRMS. The degree to which the new bridge could reduce those flood elevations was limited as the presence of Nelson Dam and fish ladder downstream of the old Powerhouse Road bridge prevented the removal of that bridge's abutment and a portion of the road approach to the bridge as that would likely destabilize the foundation of the fish ladder downstream and cause failure of the dam. Likewise, the US 12 bridges downstream began to backwater at approximately the 50-year flows, so regardless of the length of the new bridge, hydraulic and sediment transport conditions in the vicinity of the new bridge were fixed in place by this adjacent infrastructure.

National Flood Insurance Program (NFIP) map update - The development of the hydraulic model for updating the Flood Insurance Rate Maps was undertaken by the Flood Control Zone District in cooperation with the Federal Emergency Management Agency. This development occurred simultaneously with the latter stages of the Lower Naches CFHMP, and the model construction and analysis was geared to not only look at the 100-year discharge but to characterize the hydraulic conditions in the river and floodplain and evaluate some of the proposed actions in the CFHMP. This analysis first indicated that the Ramblers park levee was overtopped at less than the 50-year flood, and toward the upper end of the levee, accumulation of gravel in the channel was so severe that the gravel bars in the river were higher than the levee crest. This analysis also included a visualization of a 100-year flood, from normal base flow to the peak and back down again, that (along with the modeled cross sections) showed how the hydraulics in the reach changed as flows changed and identified of flow thresholds where constrictions began to backwater. Also, this analysis resulted the dramatic expansion of the size of the mapped and regulated 100-year floodplain and floodway with associated land use effects, as well as the risk to infrastructure of the modeled overflow paths across US 12. All of these results added up to the conclusion that aggradation upstream of the dam and levee, and degradation downstream, were ongoing processes, and unless changes to infrastructure were made, there was every reason to believe that flood hazard would continue to increase in the Ramblers Park area and several miles upstream. The related conclusion that these changes in riverine processes were causing ongoing habitat degradation over a several miles of the river was upstream and downstream of Ramblers' Park was confirmed by that analysis.

Evaluation of Fish Passage at Nelson Dam - The need for this evaluation resulted from the recommendations in the Lower Naches River Coordination Partnership Plan (also included in the Upper Yakima CFHMP) to evaluate the potential for consolidation of the Fruitvale and Old Union diversions at Nelson Dam, as well as the increasing difficulty in maintaining upstream and downstream fish passage at Nelson Dam, and the effects of management actions, such as the "Ecology Block" structure, on flood conveyance. In 2010 the City of Yakima, North Yakima Conservation District, the Bureau of Reclamation, WDFW, and the Flood Control Zone District partnered to hire the Bureau of Reclamation's Denver Technical Services Center to undertake an analysis of those two issues – expansion of diversion capacity for consolidation and modification to that facility to improve passage. The report concluded that modifying the structure to increase diversion capacity was feasible, but that improving fish passage, especially the fish bypass from the screens could not be assured due to the chronic channel instability for a substantial distance downstream of the dam. The plan estimated the cost to improve passage efficiency at $1.5 million, with no guarantee of success from year to year. This study also cited back to a study from 2000 that evaluated the structural stability of the dam. That study found that most of the energy-dissipating dentated baffles at the base of the dam had been eroded away, and areas beneath the dam had been eroded away. Discussion of the report raised the worst-case scenario that if a major flood occurred and the dam partially or fully failed, it was the desire of all the partners that the facility be replaced in-kind. In order to prevent that occurrence, a design for a new dam needed to be developed and ideally constructed.

4. RELATED PAST AND FUTURE ACTIONS

Over time, actions based on the recommendations from plans above have been implemented. This section discusses those actions.

Lower Naches River Coordination Partnership Plan – Actions that have been implemented from this plan include:

WSDOT Chronic Environmental Deficiency Project (2006) – while the WSDOT in-river work for this project occurs a half mile below this reach at the 16th Avenue interchange, this project included the removal of a large amount of levee material and old fill on the "island" shown in Figure 15 at the confluence of Cowiche Creek and the artificial channel. This project anticipated that someday, after the recommendation for the diversion to be consolidated at Nelson Dam, these structures could be fully removed.

City of Yakima Application to move Point of Diversion for Fruitvale and Old Union – the City applied for these permits in 2011 and received them in 2016. This action also required a SEPA analysis that described a future series of actions to accomplish the consolidation and the environmental benefits that would accrue. This SEPA will be amended as a portion of the permitting process for Nelson Dam.

Land Transfers, Purchases and Dedications (2006-2012) – There was an emphasis on land acquisition in this plan and the CFHMP as much of this area lies within the City of Yakima or the Urban Growth Area. Any action to restore floodplain and riverine processes in this reach would be much more difficult to implement if use changed from agriculture and open space to urban uses.

The plan recommended securing agricultural easements on existing ag land to retain those ag uses; the purchase of several parcels of private land by FCZD and transfer of parcels owned by WSDOT to FCZD which would then dedicate those parcels to public purposes of flood hazard reduction, habitat enhancement and public recreation; and the future dedication of land at the Fruitvale diversion owned by the City to those same purposes. These recommendations have largely been implemented and the vast majority of property in the reach below Nelson Dam to the confluence with the Yakima River is in public ownership. Those portions of the Squire-Ingham orchards have been constrained by conservations easements that retain agriculture, protect the riparian zone along the river, and allow for realignment and restoration of Cowiche Creek north of US 12. In Ramblers Park itself, these same recommendations have been implemented to purchase lands in association with the construction of the new Powerhouse Road Bridge and setback of the Ramblers' Park Levee (discussed below).

Powerhouse Road Bridge (2008) –The design for this bridge attempted to maximize conveyance through the bridge and across the floodplain where possible. The bridge is constructed with the western abutment being a pier, which would allow for extension of the bridge if and when the US 12 bridges downstream are replaced and lengthened. Because the abutments of the old bridge had to be retained to protect the fish ladder at Nelson Dam, maximizing floodplain width and conveyance was limited to how the floodplain was re-contoured once the former road alignment of powerhouse was abandoned, the removal of all of the adjacent residential structures on lots purchased for the project, and allowing for floods above the 50 year return interval to inundate the road and maintain a flow route between the new bridge and the US 12 bridges, which was a major flow path in the 1996 flood. The project was able to implement the recommendation to move Powerhouse Road away from the River when possible with the realignment of over 1000 feet of road away from the river. Even with those actions, the new, much wider bridge opening only resulted in 0.4 feet of decrease in the Base Flood Elevation upstream of the new bridge. Major improvement in reduction of the Base Flood Elevation is dependent on the reconfiguration of adjacent infrastructure such as Nelson Dam.

Lower Yakima CFHMP – Prior to the CFHMP, Yakima County had taken some actions to purchase property in Ramblers Park after the 1996 flood with the purchase of several residential properties near the US 12 bridges and the Ramblers Park Tavern. After completion of the Lower Naches Partnership Plan and the Lower Yakima CFHMP, the FCZD attempted to purchase the Wells property consisting of 3 parcels totaling 12 acres which lay between the Naches River and Powerhouse Road from Nelson Dam Upstream, upon which was the lowest portion of the Ramblers' Park Levee and the Wells Residence. The County was able to purchase the most downstream 4 acres, but the high appraised value of the residence prevented purchase of the other two parcels. In 2006, the lowest 300 feet of the Ramblers' Park levee collapsed and was repaired since the FCZD lacked the real estate interests needed to set the levee back.

DHI Ramblers Park Hydraulics Report 2011 – with an emphasis on beginning to look at the effects of modifications to the Ramblers Park Levee and Nelson Dam, the FCZD contracted with Danish Hydraulic Institute (the contractor for the FIRM update) to evaluate different scenarios for reconfiguration of both the levee and dam. This report showed that the Base Flood Elevations upstream of the dam were really controlled by the topography of the floodplain and channel, and (since the levees were overtopped by the 100 Year flood and the US 12 bridges constricted the river

at the 50 year flood) removal of the levee, the old Powerhouse Bridge Abutments and the dam did not have much of an immediate effect on flood heights. Scenarios which modeled the effect of lowering the channel upstream of the dam did have some effect, but the distance that the channel had aggraded was so far upstream, and so much was trapped in the riparian zone, that any reasonable level of removal (i.e. less than 500,000 cubic yards) would not yield a large benefit in flood reduction. The most effective configuration of infrastructure modeled in the scenarios was to remove not only the dam and abutments, but to lower the floodplain in the vicinity of the dam and gain flood conveyance width. While this study did not include sediment transport analysis, the steepness of the local water surface slopes generated by that scenario also indicated that type of action would begin a regrade/sediment evacuation process upstream of the dam even a fairly low flood flows.

Lower Ramblers Park Levee Setback (2012) – with the sudden collapse of the levee at a relatively low flow during the Spring 2012 runoff - shown in Figure 5 – the adjacent landowner, the County and the Corps of Engineers agreed that the best course was to purchase the remaining property, relocate the residence and belongings in accordance with State and Federal Law, and implement the CFHMP recommendation to set back or remove the Ramblers' Park Levee. With financial assistance from the Department of Ecology's Flood Control Assistance Account Program and the Corps of Engineers acceptance, design, and implementation of a non-structural (setback) alternative to repairing the levee in place, that recommendation – setting the lowest 1200 feet of the levee back to the edge of the Powerhouse Road Right of Way - was implemented in the summer of 2013.

Upper Ramblers Park Levee Setback (2013-2018) – In 2013 Yakima County applied for and received a Floodplains by Design Grant from Ecology for design of Nelson Dam and implementation of a proposal to reconfigure the Weber Wrecking Yard and setback the remainder of the Ramblers' Park Levee. This project is scheduled to be completed in the fall of 2018 and will set the levee back between 400 and 800 feet, substantially widening the current constriction and reducing the backwater/interruption of sediment transport significantly.

City of Yakima Nelson Dam Alternative Report, Nelson Bypass Channel Design Project (2015-17) With the successful award of the Floodplains by Design Grant to FCZD, the City of Yakima and the FCZD entered into agreement to begin designs for Nelson Dam. The City retained HDR Engineering to evaluate the diversion structure with special emphasis on fish passage and screening, irrigation water conveyance facilities, and eventually documentation of the alternative development process that the City and FCZD took with their cooperators. The City funded these efforts and will fund the eventual construction of the facilities with a municipal bond. Early analysis of existing irrigation conveyance capacity by HDR lead to the conclusion that the project would also need to include the construction of at least one new 32-inch pipeline to convey the additional water (from the consolidation of the Fruitvale and Old Union) from the dam into the city, even when additional capacity available in the Naches-Cowiche canal was used. The FCZD hire Northwest Hydraulic Consultants (NHC) to develop preliminary designs for the dam, and to construct a physical scale model of a selected alternative. Both sets of analysis were performed concurrently with meetings of the partners or stakeholders in the project including the Yakama Nation, WDFW, NOAA, USFWS, North Yakima Conservation District, WSDOT, the Yakima Basin Fish and Wildlife Recovery Board and recreational and conservation interest to help set the goals for the project and guide the scope of the consultants. This process is thoroughly documented in the HDR and NHC reports. The resultant

recommendations for the Nelson Dam was to allow for removal of the abutments and creation of approach channels in the left overbank floodplain, similar to the scenario in the DHI study. Dam width goes from the current 180 feet to over 480 feet of crest length greatly reducing the backwater effect associated with the dam. The structure also includes 3 separate fish passage channels to allow for fish migration at a variety of flows, especially higher spring runoff flows when both Steelhead and Spring Chinook are migrating.

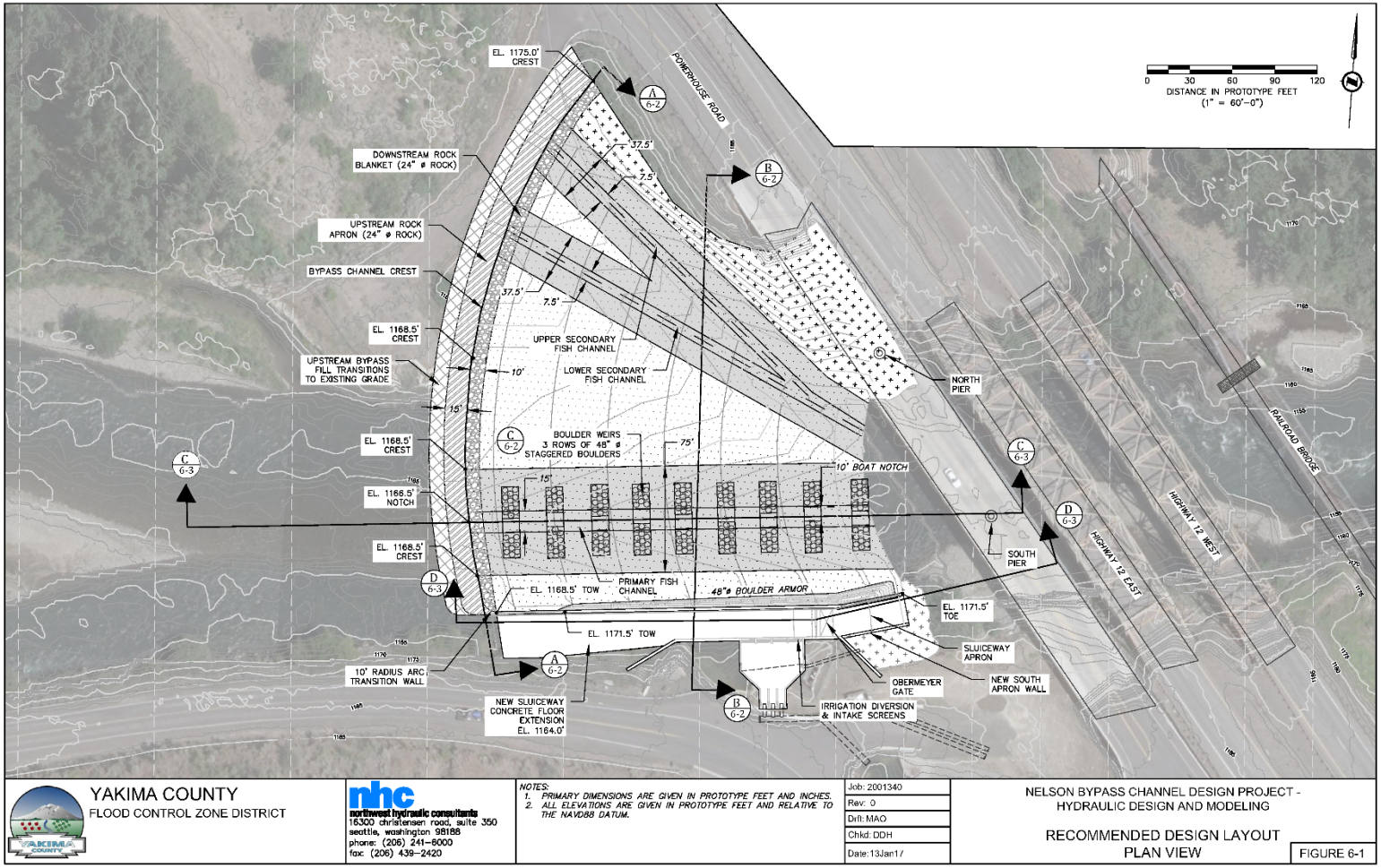

Figure 18 – Recommended configuration of Nelson Dam.

HDR's Dam Report focuses on the suitability of fish passage of the recommended structure and the design of the diversion including the flat plate fish screens, the bypass and gate structure to ensure proper submersion of the screens, and the irrigation conveyance pipe sizing and alignment shown below.

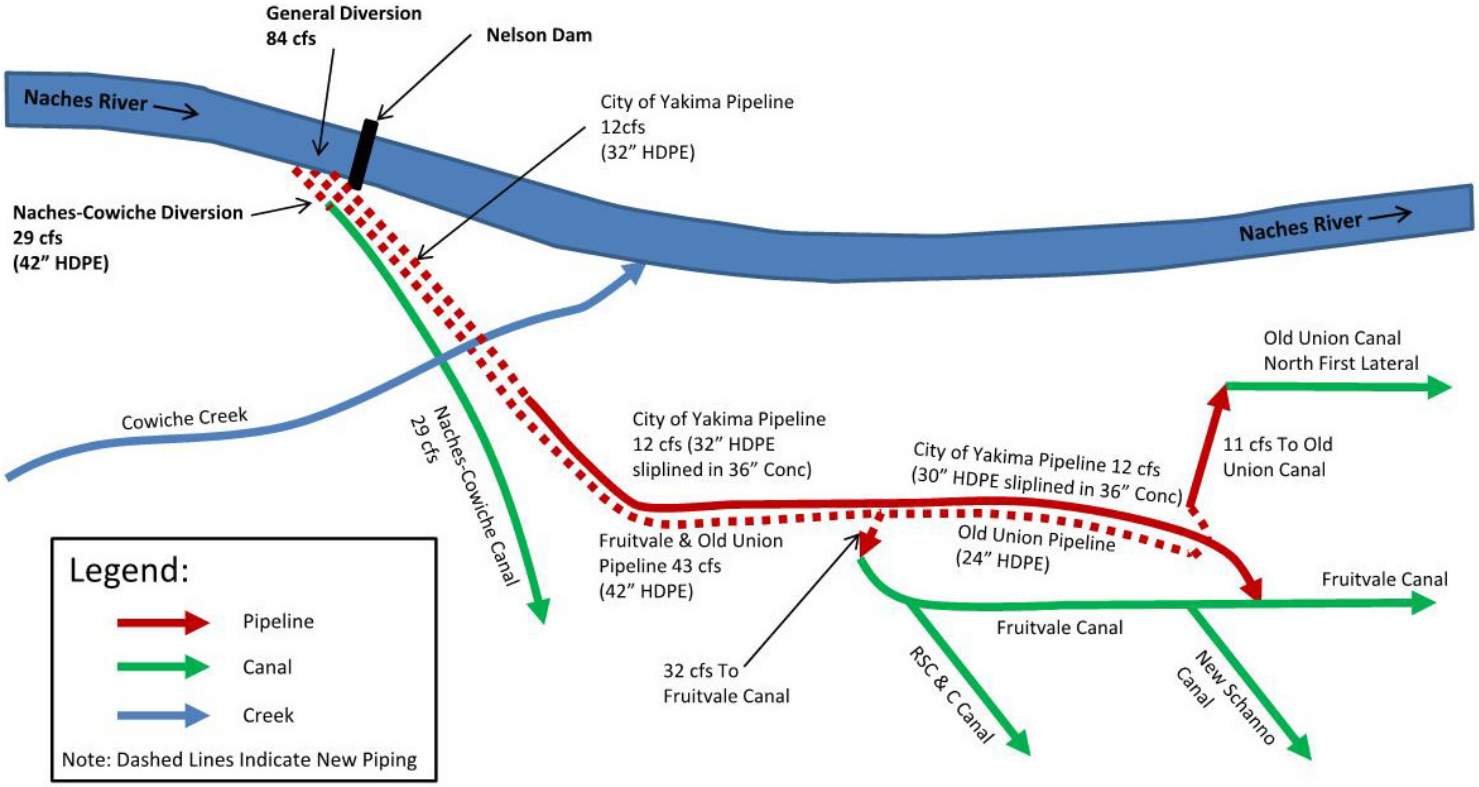

Figure 20 – Schematic of necessary pipeline improvements. Note that the project will require routing new pipelines below Cowiche Creek, likely just upstream of US 12, and the area of new piping past the 32 cfs to Fruitvale Canal will all occur in the developed portions of the City of Yakima.

Future Actions

Once completed, the proposed new dam and diversion structure will allow the removal of the Fruitvale and Old Union diversion structures, clearing the way for full restoration of lower Cowiche Creek and restoration of the high value floodplain/side channel habitats along the Naches River now occupied by those facilities. Due to the recent flood events of 2016 and 17, the City and FCZD have undertaken a process to amend the Upper Yakima CFHMP to deal with flood hazard reduction in the reach of Cowiche Creek upstream of US 12, and other recommendations to mitigate future flood damage in the City of Yakima. The addition of the flood conveyance goals for that stream reach will likely influence aspects of the restoration of Cowiche Creek and the Naches River downstream of US 12. Full implementation of the Nelson Dam will require the new pipelines under Cowiche Creek, with another pipeline – the City's drinking water supply main – needing to be lowered underneath Cowiche Creek to meet flood conveyance goals for the channel and restore natural channel dimensions.

A Recent Geomorphic Assessment of the entire reach affected by Nelson Dam was undertaken by NHC to examine degree of hazard – downstream aggradation, head cutting upstream – which may be associated with replacement of Nelson Dam with a structure such as shown in Figure 19 above. This analysis indicates that those dangers are minor, with an initial flush of sediment from the area immediately upstream of the dam producing a rise of approximately 1.5 feet in the severely incised channel (near Old Union Diversion) downstream of the dam within the first 5 years of construction. Absent other action the downstream river would slowly aggrade as sediment loads returned to normal. That scenario would leave the river channel for 2 miles upstream of the dam in a "perched" condition (likely to avulse, channel "losing" water in a reach that should be "gaining" cold water, unstable, enlarged regulatory floodplain) for the foreseeable future. In other locations in the basin, the FZCD has implemented projects to restore these normal sediment connections between channel and floodplain through the use of "pilot channels" which focus stream energy and are designed to encourage erosion and increase sediment transport locally. The FCZD has applied for and received another Floodplains by Design grant to implement a series of pilot channels in the reach upstream of the dam to encourage transport of those accumulated sediments to move downstream.

Figure 21 – Aggraded Bar, Ramblers Park 2015 (water levels very low in this extreme drought year).

Figure 22 – Aggraded Bar, Ramblers' Park 2017, after construction of 3 pilot channels in late 2015. Note increase in wetted channel area and diversity.

The constructed pilot channels in the upstream reaches would be somewhat different than those shown above, as the example above is located in the area with the highest potential energy/slope, where channel regrade would be expected in most spring runoff. There was no effort to install woody material in these channels as we did not want to encourage salmonid spawning in areas of rapid regrade. Farther upstream, Steelhead and Coho channels could be constructed with woody material, or woody material placed after the first flood, to encourage spawning or resting in those much lower gradient lower energy channels.

5. SUMMARY

The proposed replacement of Nelson Dam is a component of a large, multi-project, multi-reach, and multi-jurisdictional flood hazard reduction and habitat process restoration program. While there have been some restorative actions taken in this reach to improve floodplain function and riverine processes, much remains to be done, and with the largest single action in the near future is to replace Nelson Dam. The effect of Nelson Dam and related infrastructure have expanded to upstream and downstream reaches over time, even extending into a tributary downstream. Replacement of the dam with a structure similar to the one proposed will change the sediment transport dynamics for this same large reach and allow the retirement of related infrastructure and simultaneous processes of recovery to begin. Design of the new structure was in recognition of the context of the physical and biological conditions in the reach with an objective of restoring those physical and biological processes while maintaining the function of the riverine infrastructure

References

Hyperlinks to

Golder 2004 Consolidation Memo

Lower Naches Cooperation MOU

DHI Ramblers 2011 Task 4 Memo

Subbasin Plan

Salmon Recovery Plan for Yakima Basin

NHC Physical Model Study

NHC Ramblers Park Geomorphic Assessment

NHC Naches River Atlas

HDR City of Yakima Nelson Dam Alternatives Report.