**Suitability of Amon Wasteway for Salmonid Production**

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***Final Draft***

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**Executive Summary**

Amon Wasteway is a major irrigation return flow facility for the Kennewick Division of the Yakima Reclamation Project, servicing thousands of water users within 20,201 acres (USGS, 1978). Fish (including salmon and trout) have been found in the wasteway, and questions have arisen regarding the wasteway's ability to produce salmonids.

The purpose of our study was to provide resource managers with an objective and quantitative accounting of Amon Wasteway's ability to produce significant numbers of salmonids, with an emphasis on available habitat and fish presence during summer flow conditions.

To do this we reviewed available information and conducted our own independent study of habitat conditions and fish presence in the wasteway. We found relatively few biological studies documenting habitat conditions or aquatic species sampling in the wasteway, so it was necessary to supplement our review with unpublished data and information gathered during interviews with local biologists and researchers who had knowledge of the wasteway.

Our review revealed that Amon Wasteway does seasonally support a limited number of salmonids, but the wasteway's capacity to produce salmonids in significant abundance and to sustain them throughout their life-cycle was still in question. Available information about fish assemblages indicated that predator and warm water fish species, mainly smallmouth and largemouth bass dominate the assemblages of the wasteway.

After conducting habitat surveys and fish sampling in the wasteway, we discovered several important factors which appear to limit salmonid carrying capacity. The most significant of these factors were warm water temperatures and an abundance of fine sediments. Both of these habitat characteristics are controlled by local climatic and geologic conditions.

Given that the two primary limiting factors for salmonid carrying capacity are outside management control, one would expect limited gains from attempts to alter the wasteway in order to increase salmonid production.

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## Introduction

Since the late 1800's through the 1950's, a network of canals, pumping plants, and laterals were developed to distribute irrigation water to agricultural lands within the Kennewick Irrigation District (KID). The Kennewick division is part of the Yakima Reclamation Project, a federal (Bureau of Reclamation) irrigation project located in the Yakima River Basin of central Washington State. The Kennewick division provides irrigation water to 20,201 acres of agricultural and municipal land in the Project. Along with the water distribution system, a network of drains and wasteways was needed to convey irrigation return flows and irrigated agricultural drainage back to the Yakima River.

Water that is diverted, but not used consumptively by plants or lost to evaporation, is considered irrigation return flow. Generally, irrigation practices have led to return flows accounting for as much as 50% of the water that is diverted (Lentz, 1974), although improved water conservation measures seek to improve the proportion of return flow relative to diverted flow. Thus, the drainage network of the Yakima Reclamation Project is nearly as extensive as the delivery network, and some of the drains carry significant amounts of flow, particularly during the irrigation season.

Amon Wasteway (USGS, 1978) [1] is a major irrigation return flow facility for the Kennewick Division of the Yakima Reclamation Project. The KID operates and maintains project facilities, including canals, drains, pumping stations, and Amon Wasteway. The wasteway carries spills of excess water from the main canal and delivers water to about 1,500 water users in the district, all via the Gage Pumps. The wasteway also carries storm water runoff from the City of Richland and the City of Kennewick. Almost all of the flow from the east branch is from releases from the Kennewick Irrigation District's main canal. Nearly all of the flow from the west branch of the Amon Wasteway returns from groundwater inputs likely influenced by irrigation in the Badger Canyon area (USGS, 1986). Refer to appendix 7 for a detailed map of the KID.

Currently, the Yakima Basin Joint Board, the Yakima River Basin Coalition and the Bureau of Reclamation is involved in Endangered Species Act (ESA) consultation for the operation and maintenance of the Yakima Project, including all Reclamation facilities operated by the irrigation divisions, including the Kennewick division. The resulting Biological Assessment (BA) will provide a detailed description of operations and maintenance of Amon Wasteway and a description of fish resources and habitat conditions. This research provides information for the BA.

There are ongoing efforts by the KID under their Water Conservation Plan to improve water distribution systems that may ultimately result in little to no water releases into Amon Wasteway. Future climate change predictions have also stimulated discussions about water conservation measures. Generally the KID may spill water to the Amon Wasteway or convey water to the Gage Pumps during the periods of early April to late October, annually. Given

[1] The term Amon Wasteway (legal use) is used rather than Amon Creek, based on the 1978 USGS Badger MTN topographic map and further clarified in the Yakima Basin Steelhead Recovery Plan, page 26 (Conley et al. 2009) and as labeled on the Kennewick Division Construction Documents in 1955 (Revell, 2010).

probable changes in water operations, it appears likely that Amon Wasteway discharge will decrease in the future as irrigation water use becomes more efficient.

In recent years there has been some controversy about the history of Amon Wasteway, and whether it is a natural stream or a manmade irrigation drain. Historical evidence indicates that the wasteway is manmade and was established in 1957 (Early, 2001). Mistaking the wasteway for a natural watercourse is understandable since portions of the wasteway flow down a natural topographic canyon to its confluence with the Yakima River. Furthermore, irrigation water has been supplied to the area by KID since 1957 and trees and other vegetation have been established around the wasteway creating a riparian corridor, and aquatic invertebrate and vertebrate species inhabit the waterway. None of this vegetation is present in historic pre irrigation Farm Service Agency aerial photos (Revell, 2009).

In 2005, Smith et al. studied the hydrology and geology of Amon Wasteway through a project funded by the Yakima Basin Joint Board. With a drainage area of 62 square miles, the study found that the natural runoff of the wasteway drainage would range from 250-500 acre-feet per year, or less than 0.51 cubic feet per if the discharge was on a continual flow basis (Smith et al. 2005). The flows would have likely occurred as snow melt and storm events. The ephemeral streambed would have been dry for most of the year. The results of Smith's hydrology models have been supported by research done by KID and aerial photographs of the area prior to irrigation development (Revell, 2009). This information leads us to conclude that the Amon drainage did not have sufficient flow to provide fish habitat under natural, pre-irrigation conditions.

Currently, there is open access for aquatic species to travel between the Yakima River and the lower reaches of Amon Wasteway. Fish, including salmonids, have been documented in the wasteway, but until now it was not known which, if any, species were able to maintain self-sustaining populations. Reports of a limited number of rainbow trout/steelhead (*Oncorhynchus mykiss*), coho salmon (*Oncorhynchus kisutch*) and fall Chinook salmon (*Oncorhynchus tshawytscha*) sighted or collected in the wasteway (Meadow Springs Country Club, 2003) have elevated public interest in understanding the wasteway's capacity to produce salmonids.

The potential for fish use has important implications for the Bureau of Reclamation, Yakima Project ESA consultation, as well as local fisheries and water resource management. The purpose of our study was to provide managers with an objective and quantitative account of Amon Wasteway's ability to produce significant numbers of salmonids, with an emphasis on available habitat and fish presence during summer flow conditions. Further, the studies' purpose was to present the best science on the issue of habitat quality within Amon Wasteway.

**Review of Available Information**

This section summarizes available biotic and abiotic information about Amon Wasteway. Findings are presented by topic. It was necessary to draw on literature and data from outside the Yakima Basin when appropriate in order to thoroughly explore issues that were important to our understanding of how salmonids might respond to habitat conditions in Amon Wasteway.

**Historical Context**

Historical photos of Amon Wasteway document its pre-irrigation condition influences (Figure 1). Prior to establishment of the wasteway, the area lacked riparian vegetation and appears to be completely dry at the time of the photograph taken in 1950. Some postulate that the local geology indicates the Yakima River's course once followed Badger Canyon and the Amon Wasteway drainage, but the Missoula floods blocked access to the canyon with alluvial sediments which set the Yakima River in its current channel (Shaw, 2008).

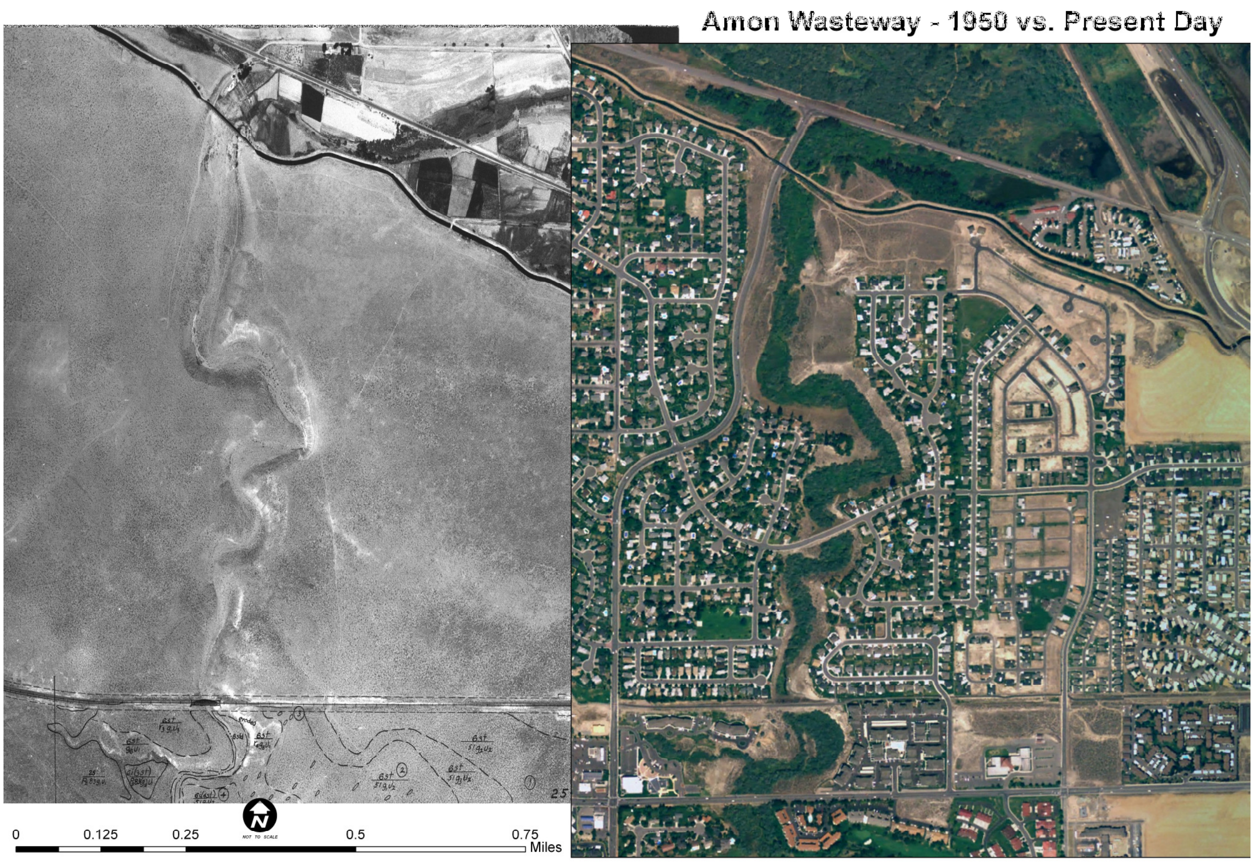


**Figure 1. Aerial photos from 1950 versus 2008 of Amon Wasteway (Revell, 2009).**

In the 1970s irrigation return flows caused flooding in the Yakima Delta area administered by the Corps of Engineers. To prevent excessive mosquito production, an overflow channel was constructed to carry excess waters to the Yakima River. The overflow channel has since become the main channel for the Amon Wasteway through the Yakima River Delta (McKern 2009).

**Flow**

It has been hypothesized that flows may be supplied to the West Fork of Amon Wasteway through underground sources in the sediments coupled with irrigation drainage (Reidel, 2008). The West Fork is denoted as the East Badger Drain on KID right of way maps (Revell, 2010). Witty and Monk (2005) found that water flows in the wasteway fluctuate daily, weekly and seasonally, especially during the irrigation season. As mentioned in the introduction Smith et al. (2005) presented natural stream flow estimates for several drainages within the lower Yakima River and concluded that with an area of 62 square miles natural runoff of the Amon drainage would range from 250-500 acre-feet per year, or 0.51 cubic feet per second per day of discharge (Table 1). Thus, it appears that the vast majority of current discharge from Amon Wasteway is derived from irrigation return flows.

**Table 1. Calculated Natural Flow Contributed From Runoff**

| Drainage | Watershed (mi2) | Precipitation | Discharge Estimates |
|---|---|---|---|
| E.F. Amon Wasteway | 26.66 | 7.58 | .23cfs/day |
| W.F. Amon Wasteway | 31.80 | 7.58 | .28 cfs/day |
| | | | .51 cfs/day Total |

*Data from the Western Regional Climate Center (www.wrcc.dri.edu) and from Smith et al., 2005. Discharge estimates were calculated based on mean annual runoff.

**Temperature**

Salmonids are cold water fish, with few species capable of tolerating temperatures greater than 24°C for an extended period of time. We deduced from the scientific literature that density declines as the maximum weekly average temperature (MWAT) exceeds approximately 16°C, with essentially all fish having to seek out thermal refugia in order to persist at temperatures >23°C (Sutton et al. 2007; Belchik 2003; Wheeler and Brown 2003; Baltz et al. 1987). Eaton et al. (1995) compiled data on fish presence and temperatures from throughout the United States and concluded that salmonids formed the coldest preference guild for common fish species, and that observation of coho salmon, Chinook salmon, rainbow trout, and cutthroat trout in habitat with MWAT above 23-24°C was extremely rare. Huff et al (2005) found that the thermal niche (± one SD of mean occurrence) used by salmonids in Oregon streams extended up to 16.5°C for cutthroat trout, 16.9°C for coho salmon and 19.7°C for rainbow trout (average 7-day maximum temperature). There is some variation in temperature tolerances across species and between populations; however, the upper limit is consistently between 21°C and 23°C with most species and life histories preferring temperatures between 10°C and 16°C.

A considerable body of literature documents salmonid avoidance of warm water habitats. In the Klamath River Basin, Sutton et al. (2007) noted significant movements by juvenile salmonids into cool water refugia as daytime main-stem Klamath River temperatures reached 22-23°C. Belchik (2003) concluded that all, or nearly all, juvenile salmonids utilize thermal refugia on the Klamath River during periods of the day when temperatures are highest, and that the main stem may not sustain juvenile salmonids without these refugia. Wheeler and Brown (2003) reported that coho in the Mattole River Basin were not found in locations where temperatures exceeded 20°C (summer maximum) unless a thermal refuge was present. Similarly, Baltz et al. (1987) found from underwater observation at a cool-water confluence to the Sacramento River that rainbow trout held their preferred position as temperatures rose past 17°C, but moved to 18°C water when river temperatures warmed above 20°C.

Numerous fish species assemblage studies have confirmed consistent patterns in salmonid temperature preference. Reeves et al. (1987) showed the competitive advantage for maintaining a stream territory switched from juvenile steelhead to redside shiners when the stream temperature regime shifted from 12-15°C to 19-22°C. Similarly, Torgersen et al. (2006) found the crossover temperature at which fish assemblages in the John Day Basin, Oregon switched from cold-water to cool-water species occurred at 20-22°C (MWAT). This crossover corresponds with the thermal transition zone recorded by Taniguchi et al. (1998) for trout and non-trout assemblages in the Rocky Mountains. These findings were further corroborated by Torgersen et al. (2007) who found that longitudinal patterns in fish assemblages in the Crooked River, Oregon shifted from predominantly rainbow trout and whitefish to northern pike minnow and cyprinids as the seven-day average of daily maximum temperatures increased from 15°C to >21°C.

Salmonid temperature preference is controlled by metabolic requirements, and metabolic function, as characterized by growth, is optimized between 10°C and 16°C (Poole et al. 2001; Brett et al. 1982). Evidence indicates that the final preferred temperature for fish, given a choice, agrees closely with the temperature that results in their maximum growth (Magnuson et al. 1979). Accordingly, peak densities are likely to be sustained as long as the temperature and food regime enable fish to achieve optimum growth. Several studies of fish assemblages in streams spread over a broad geographic area showed salmon and trout were consistently found at highest densities where stream temperatures in summer were near their physiological optimum of 12°C to 16°C (Huff et al. 2005; Ott and Marret 2003; Waite and Carpenter 2000), and Brett et al. (1982) demonstrated that growth drops to zero between 21-24°C when ration levels are 60% to 80% of maximum.

Higher food availability has been shown to increase temperature tolerance in juvenile salmonids (Brett 1952), and it is likely that elevated food resources would result in higher rearing densities. Maroinvertebrate indices of abundance and community condition in Amon

Wasteway ranked slightly above other reference sites in the Yakima Basin and within the range of indices for other low elevation streams in the Columbia Basin ecoregion (Early, 2001). This suggests that food abundance does not greatly exceed levels available in comparable waterways; thus, we do not have evidence to support hypotheses about potential abnormalities in temperature tolerance of salmonids in the wasteway due to dramatically increased food supply.

Temperature and salmonid density appear to be negatively correlated, such that higher temperatures within the tolerance range typically support fewer individuals. This is consistent with our understanding that salmonids rearing in warmer habitats require greater quantities of food per individual. Field studies in southwest Oregon streams showed that rearing densities of juvenile salmonids decreased linearly as temperatures exceeded 17° C (Frissell, 1992). Likewise, Stuart et al. (2007) observed precipitous, curvilinear declines in rainbow trout density in streams throughout the Crooked River Basin, Oregon as maximum daily water temperatures increased between 20°C and 30°C.

We evaluated an independent data set to examine changes in salmonid density (fish/$m^2$) in response to stream temperature. Juvenile coho data was assembled from 178 sampling sites located within various coastal streams throughout Northern California and Oregon. Rainbow trout and whitefish data were compiled from studies in the Crooked River Basin, Oregon. General stream locations, sampling years, and data sources are provided in Table 2. We standardized the data by converting density estimates to a relative percentage of the maximum density observed in each dataset. Data were selected based on criteria that fish sampling and temperature monitoring locations were less than 1 mile apart, and that surveys were conducted in the summer. The choice of temperature metric has a considerable influence on expected upper thresholds since the duration of exposure is an important component of these metrics. For example, increasing exposure time reduces temperature tolerance limits for fish in laboratory studies. For consistency, we chose MWAT (maximum weekly average temperature) as our standard temperature metric for comparison between datasets.

The analysis suggests that juvenile coho rearing densities were highest at MWATs between 14°C and 16°C (Figure 2). The highest MWAT at which coho were observed was 23.4°C, although most fish were found in pools with MWAT less than 21°C. Rainbow trout and mountain whitefish also showed similar temperature preferences, with the highest densities observed in sites with MWAT below 15°C (Figure 3). Relative densities of rainbow trout and whitefish at MWATs greater than 20.5°C were less than 3% of the maximum densities observed.

**Table 2. Summary of sources for juvenile coho salmon, rainbow trout, and mountain whitefish density across a variety of stream temperature conditions**

| Stream or region | Source | Species | Years sampled |
|---|---|---|---|
| Clackamas R | Cramer Fish Sciences (2006 snorkel survey) | Coho | 2006 |
| N CA Coast | Willey_2004[a] | Coho | 1998 |
| OR Coast | ODEQ (A. Borinsenko, pers. comm.) | Coho | 2004, 2006 |
| OR Coast | ODFW (Dave Jepsen, pers. comm.)[b] | Coho | 2003-2006 |
| Sixes R | Frissell_1992[c] | Coho | unknown |
| WF Smith R | EPA (Joe Ebersole pers. comm.) | Coho | 2002-2005 |
| Tillamook R | Bio-Surveys, LLC. (Steve Trask, pers. comm.) | Coho | 2006 |
| Crooked R | USGS (Christian Torgersen, pers. comm.) | Rainbow Trout | 2004 |
| Crooked R | USGS (Christian Torgersen, pers. comm.) | Whitefish | 2004 |

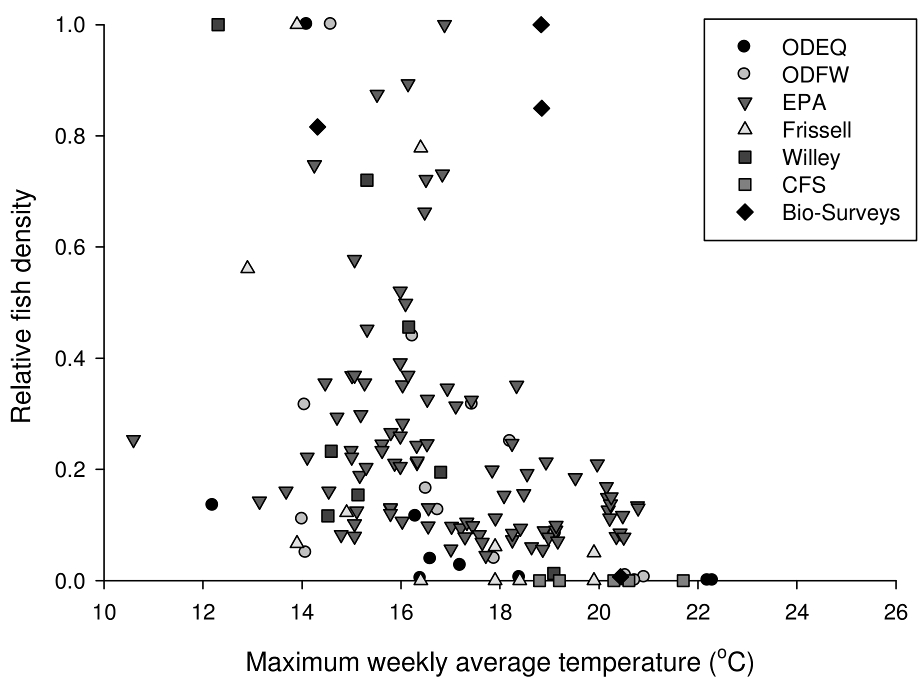


**Figure 2. Relationship between relative density of juvenile coho salmon and maximum weekly average temperature (°C) from 178 sites along the Oregon and Northern California coast.**

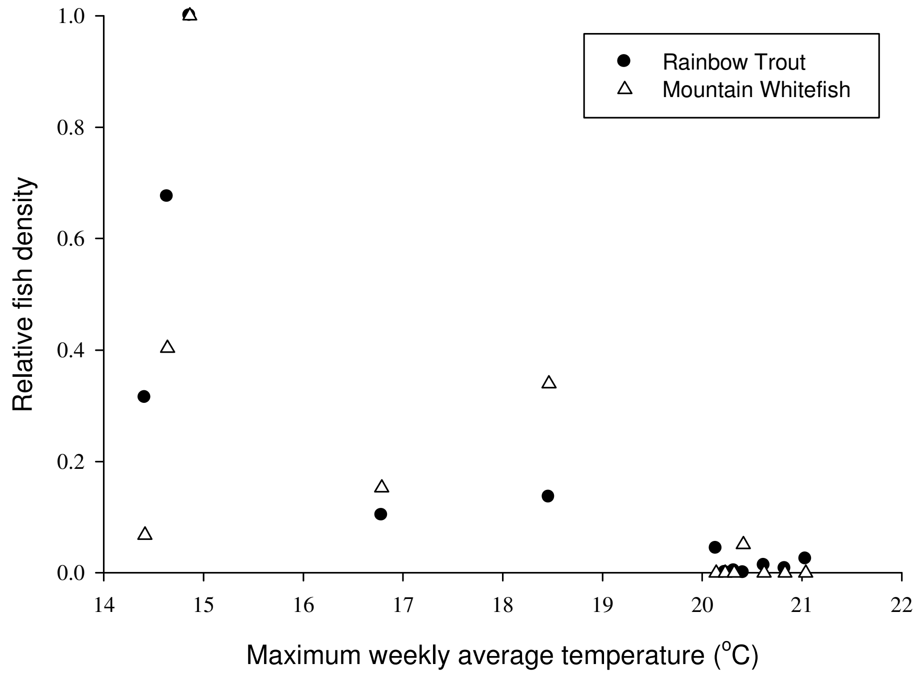


**Figure 3. Relationship between relative density of salmonids and maximum weekly average temperature (°C) in the Lower Crooked River, Oregon.**

Some have hypothesized that Amon Wasteway may provide a thermal refuge for salmonids in the lower main stem Yakima River. Appel (2009) suggests that water entering the Yakima River from irrigation drains from Prosser Dam down to the mouth, may offer thermal refugia. The input of Amon Wasteway offered one potential cooler (23°C vs 25°C and higher) water pocket in the summer and possibly warmer water inputs in the winter at the confluence with the Yakima Delta (Appel 2009). Paul Hoffarth, WDFW has deployed water temperature probes throughout Amon Wasteway in different seasons of the year and supplied this general synopsis, "Irrigation wastewater and the golf course have major influences on water temperatures and flow. The golf course cools the water in the west fork above the confluence in the winter months and warms it in the spring and summer. Water temperatures at the confluence may be similar during the summer. Water temperatures tend to cool as they move downstream." The term cool should not be misunderstood since continuous temperature monitoring data provided by WDFW demonstrates that the main stem of the wasteway exceeded 23°C for a significant amount of time during 2007. Similarly, Witty and Monk (2005) concluded that high water temperatures in the wasteway, in addition to turbidity, would not support the primary constituent elements (PCEs) needed to provide critical habitat for steelhead.

**Water Quality**
A limited amount of water quality monitoring has been conducted in the wasteway. Early (2002) studied water quality and macroinvertebrate communities and concluded that some

attributes of the wasteway's water quality are better than other drainages in the lower Yakima Basin, namely the Spring Creek Wasteway and Satus Creek below the Dry Creek confluence. The wasteway rated higher in both macroinvertebrates community indices and in water quality than the nearby Yakima River. However, others have documented high levels of turbidity in the wasteway (Witty and Monk, 2005). There are several ongoing efforts to study water quality in Amon including a continuation of Early's research through another master's degree student at Washington State University and a study conducted by a volunteer, Alexandra Amonette from the Tapteal Greenway Association, with funding form the Washington Department of Fish and Wildlife Aquatic Lands Enhancement Account (Littleton, 2009 and Amonette, 2009). Amonette (2009) concluded that water quality in the main stem of Amon Wasteway was suitable for salmonids between November and April.

**Spawning Habitat Conditions**
Blair (2005) provides a comparison of coho salmon habitat suitability indexes within the irrigation and non-irrigation season in Amon Wasteway. He concludes that instream and riparian habitats in some portions of the wasteway, considering substrates, water velocities and depths, were suitable for spawning adult coho salmon. More specifically, the Delta (much of the area below Columbia Park Trail), West Fork and East Fork reaches were deemed inadequate for spawning, but the section of the wasteway that roughly parallels Leslie Road appears to be more likely to support spawning coho. This section is also where most of the spawning coho salmon have been found in surveys (Hoffarth, 2009 personal communication). Blair (2005) also suggested that the reach running through the Meadow Springs Golf Course may provide suitable habitat for spawning coho.

**Salmonid Monitoring Surveys**
Fish sampling has been conducted on a number of occasions, but none of this data is available in written reports, in part because the surveys are typically small in scope and are not organized as part of a systematic effort to study fish abundance or assemblage in the wasteway. To our knowledge there have been two types of salmonid surveys in the wasteway: spawner/redd surveys and electrofishing. Coho spawning surveys have been completed in Amon Wasteway by the WDFW and by Yakima Basin Joint Board biologists, Pat Monk and David Child (Table 3). WDFW has also conducted two electrofishing surveys one in 2001 (Table 4 and another in 2005 (Table 5). A limited number of salmonids were collected along with a variety of other species including smallmouth bass, bluegill and mosquitofish (Table 4 and Table 5). Refer to the appendices for maps prepared by the WDFW showing the locations of the surveys. Evidence of salmonid densities was corroborated by Monk and Witty (2005) who noted a lack of salmonids during habitat surveys in the wasteway.

**Table 3. Summary of redd surveys for Amon Wasteway (adapted from Hoffarth, 2008, 2009 with 2007 and 2008 data provided by Pat Monk and David Child *unpublished surveys*) *not surveyed in 2002, 2003, and 2004.**

| Year | Redds | Coho Observed |
|---|---|---|
| 2009 | 16 | 0 |
| 2008 | 4 | 2 |
| 2007 | 1 | 0 |
| 2006 | 47 | 3 |
| 2005 | 0 | 0 |
| 2001* | 0 | 7 |

**Table 4. Fish surveyed at 3 sites selected for presence/absence fish surveys in Amon Wasteway, July 18th, 2001 (adapted from files provided by Paul Hoffarth).**

| Site | Common Name | Fork Length (mm) |
|---|---|---|
| 1 | coho | NM |
| | coho | NM |
| | coho | NM |
| | Chinook | NM |
| | largemouth bass | NM |
| | largemouth bass | NM |
| | largemouth bass | NM |
| | smallmouth bass | NM |
| | whitefish | NM |
| | whitefish | NM |
| | whitefish | NM |
| 2 | largemouth bass | NM |
| | largemouth bass | NM |
| 3 | mosquitofish (many) | NM |
| | speckled dace (many) | NM |

*NM = Not Measured

**Table 5. Fish species collected in Amon Wasteway on July 26, 2005 (adapted from a technical memo provided by Paul Hoffarth dated July 27th, 2005).**

| Site | Common Name | Mean Length (mm) |
|---|---|---|
| 1 | sculpin | 89 |
| | sculpin | 89 |
| | mosquitofish | 40 |
| 2 | rainbow trout | 310 |
| | largemouth bass (15) | 102 |
| | smallmouth bass | 166 |
| | smallmouth bass | 166 |
| | smallmouth bass | 166 |
| | bluegill sunfish | 57 |
| | bluegill sunfish | 57 |
| | pumpkinseed sunfish | 92 |
| | pumpkinseed sunfish | 92 |
| | mosquitofish | 30 |
| | mosquitofish | 30 |
| | mosquitofish | 30 |
| 3 | rainbow trout | 270 |
| | largemouth bass | 62 |
| | largemouth bass | 62 |
| | brown bullhead | 149 |

**Study Methods: 2009 Data Collection and Analysis**

Amon Wasteway is located in the city of Kennewick and Richland, Washington near the mouth of the Yakima River (Figure 4). The upper reaches (East and West Forks) of the wasteway originate in agricultural lands comprised primarily of small farms and ranches, as well as large fruit orchards. The East and West Forks of the wasteway converge at the Meadow Springs Country Club and flow through the golf course and a series of residential developments until reaching the Yakima River delta.

To evaluate the wasteway's capacity to produce salmonids, we collected field data and modeled fish carrying capacity. Field data collection included three primary components: stream habitat surveys, fish sampling, and water quality monitoring. Habitat and fish sampling data were compared to values from the scientific literature to assess Amon Wasteway's suitability for salmonids. Modeled estimates of fish rearing density were also used to evaluate the potential of the wasteway to produce significant numbers of rainbow trout/steelhead and coho salmon.

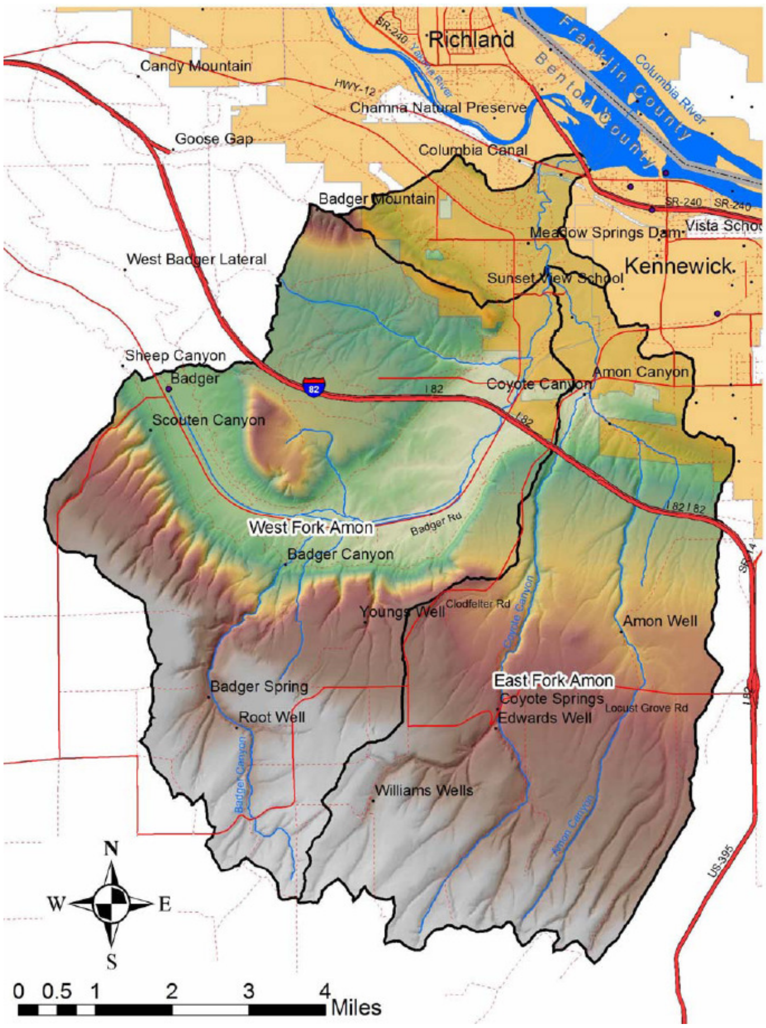

**Figure 4. Amon Wasteway drainage area (Smith et al. 2005).**

## Habitat Survey Data Collection

Field surveys were conducted in three sampling reaches approximately 150 to 200 meters in length (Figure 5). Sample reaches were chosen to represent major shifts in gradient, geomorphology and habitat conditions. Data collection followed the methods of Cramer and Ackerman (2009a), which is similar to the Oregon Department of Fish and Wildlife Stream Habitat Survey Protocol (Moore et al. 2002). Surveys were conducted in March and July to monitor any major habitat shifts between non-irrigation and irrigation seasons.

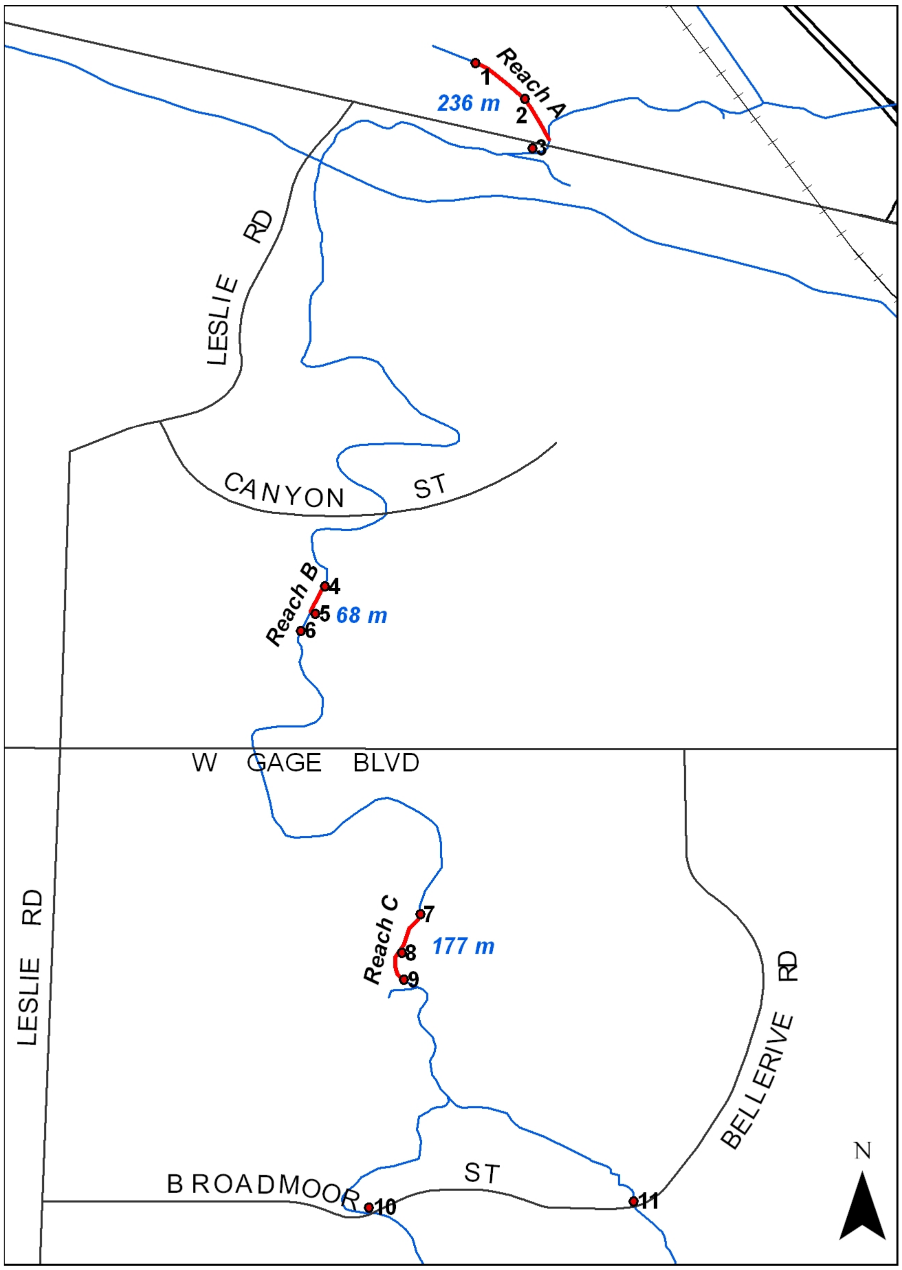


**Figure 5. Amon Wasteway habitat survey reaches (A, B, C) and temperature monitoring sites (1-11).**

Mesohabitat units such as pools, riffles, and glides were surveyed. Habitat features were described by the following variables:

- Total length of each channel unit
- Average width of each channel unit
- Maximum depth in pools
- Average depth in riffles and glides
- Classification of substrate, by proportion, into each of the following substrate classes: fines, gravel, cobble, boulder, bedrock
- Wood complexity index and count

Other useful information was noted such as flow, bankfull width, riparian vegetation, and the presence of fish passage barriers. In each reach, three temperature loggers were deployed for the term of the project from February – October. Water flow volume (cubic feet per second), dissolved oxygen (mg/l and % saturation), pH (units), salinity (*‰*), turbidity (NTUs) and conductivity (uS) were taken at the midpoint of each reach during the spring, pre irrigation season and during the summer when the wasteway was heavily influenced by irrigation return flows.

**Electrofishing Methods**

Field biologists used a backpack electrofisher and dip nets to thoroughly sweep the entire length of each sample reach, expending approximately one hour of sampling effort in each reach. Fish were individually identified according to species and measured before being released back into the wasteway. Single-pass backpack electrofishing in small streams is known to provide a reliable index of fish abundance (Carter et al. 1998 and Douglas et al. 2005). Thus, this methodology was expected to provide a reasonable estimate of relative abundance of fish in Amon Wasteway. The work was performed in cooperation with the WDFW under their scientific permitting.

**Temperature Monitoring**

In total, 11 temperature loggers (HOBOs) were deployed throughout the wasteway. (Figure 5). Temperature data was collected on an hourly time step between February 12 and October 20, 2009. Three loggers were deployed in each sample reach, as well as one in the East Fork and one in the West Fork, upstream of the confluence.

Water quality samples were taken during the winter, spring and summer of 2009 at the midpoint of each sampling reach to monitor water quality during the pre-irrigation season and during the summer when the wasteway was heavily influenced by irrigation return flows. Variables measured included flow volume (cubic feet per second), dissolved oxygen (mg/l and % saturation), pH (units), salinity, turbidity and conductivity (uS).

**Salmonid Capacity Estimation**

Stream habitat survey data was used to populate coho salmon and rainbow trout/steelhead carrying capacity models according to the methods of Nickelson (2008) and Cramer and Ackerman (2009b). Models were used to estimate fish rearing density per square meter of wetted channel width. Resulting rearing density estimates were scaled to account for temperature effects in a manner consistent with Nickelson (2008) and Arendt et al. (2008). The following is a detailed explanation of methods used to account for temperature effects. Please refer to source materials for a description of the conceptual basis and analytical framework for the carrying capacity models used to predict baseline fish density estimates.

After conducting an extensive review of available scientific literature and published and unpublished data, we concluded that salmonid density declines as MWAT increases above 16°C, with few fish capable of persisting when MWAT exceeds 23°C. To model the effect of temperature on salmonid rearing densities in Amon Wasteway, we used a logistic function that passes through values of 0.95 at MWAT = 16°C and 0.05 at MWAT = 23°C for rainbow trout/steelhead, and values of 0.95 at MWAT = 16°C and 0.05 at MWAT = 21°C for coho salmon (Figure 6). These temperature thresholds appear conservative when compared to available data on thermal tolerance limits for juvenile coho salmon and O. mykiss (Poole et al. 2001; Eaton et al. 1995; Frisell 1992; Sutton et al. 2007; Torgersen et al. 2007; Torgersen et al. 2006), and the resulting functions exceed the relative densities observed in nearly all data compiled during our independent evaluation of salmonid rearing densities. The functions were used directly to scale the habitat-based estimates of rainbow trout/steelhead and coho rearing density and were given by:

$$D_{Temp,i} = \frac{1}{1+e^{-\beta_0-\beta_1 T_i}},$$

where Dtemp,i = temperature-dependent percent of maximum density in reach i, Ti = MWAT °C for reach i, β0 = 16.40 (rainbow trout) and 21.79 (coho salmon), and β1 = negative 0.84 (rainbow trout) and -1.18 (coho salmon).

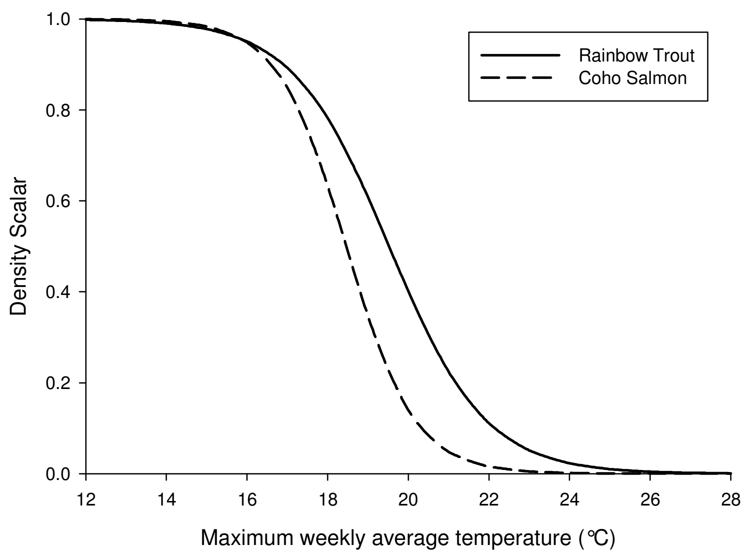


**Figure 6. Logistic functions used to predict temperature effects on coho salmon and rainbow trout/steelhead rearing densities in Amon Wasteway. The rainbow trout/steelhead function passes through values of 0.95 at 16°C and 0.05 at 23°C. The coho salmon function passes through values of 0.95 at 16°C and 0.05 at 21°C.**

## Results

### Habitat Surveys

The three sample reaches were comprised of pools, riffles and glides. Cascades, rapids and other mesohabitat types were not observed. In total, 38% of the stream area surveyed was riffle, 38% was glide and 24% was pool habitat. The majority of the pool habitat was found in the lower reach (Amon A) near the Yakima River delta. Amon B was primarily riffle habitat and Amon C (golf course reach) was mostly glide habitat (Figure 7).

Substrate composition varied somewhat between reaches. The amount of fines (sand and organic matter) was extremely high in Reaches A and B while Reach C was comprised of gravel and cobble (Figure 8). It is noteworthy that as much as 5-10% of the substrate in some habitat units was covered with freshwater clam shells (Corpicula sp.).

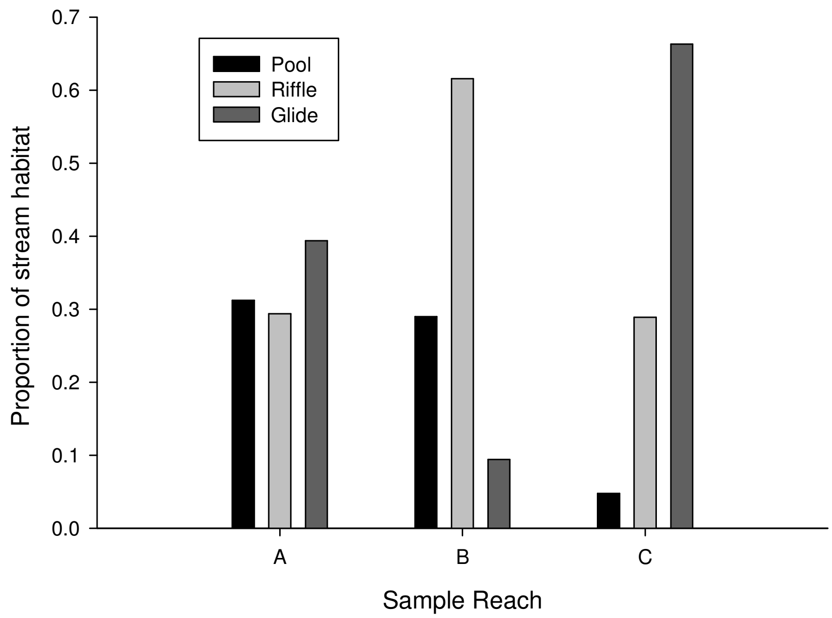


**Figure 7. Mesohabitat composition of Amon Wasteway sample reaches.**

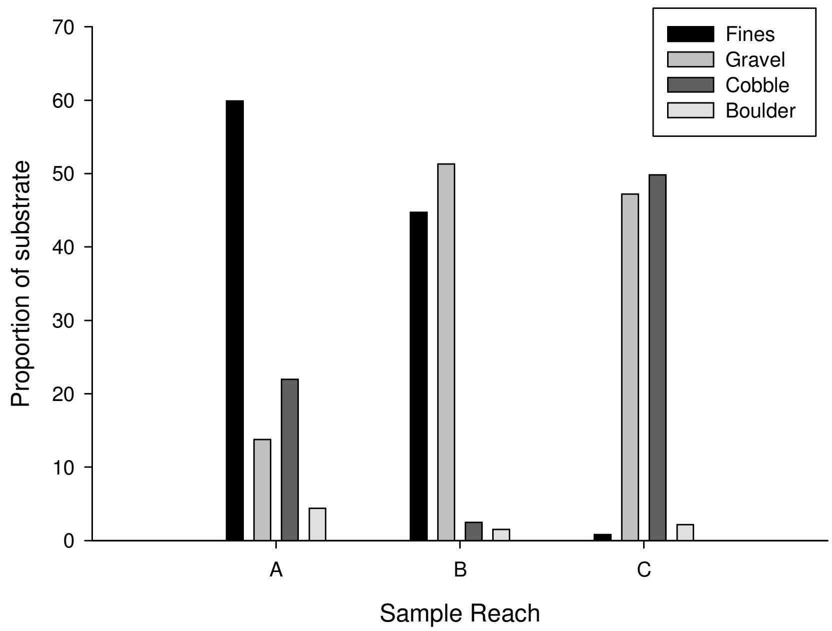


**Figure 8. Substrate composition of Amon Wasteway sample reaches.**

The amount of large wood in the wasteway was low. When scored on a scale of 1-5 (low-high), of the 17 mesohabitat units surveyed in the wasteway, 12 received a score of 1, two received a score 2, and one received a 3 (see Appendix 2 for wood complexity index description). In total, we counted 17 pieces of large woody debris (LWD) in the wetted channel. Not all of the wood counted was providing cover for fish, and this was taken into account when rating cannel unit wood complexity. Most of the wood was located in Reach A, and a significant portion of surveyed pool habitat was also located in this reach. We surveyed two large deep pools in Reach A with LWD and thick overhead cover; however, the substrate in these pools was comprised almost entirely of fine sediment and water clarity in the summer was impaired due to suspended fines.

**Water Quality**

Table 6 provides data collected during the three water quality sampling events. Dissolved oxygen (DO) readings were compromised for Reaches B and C during our summer surveys. However, temperature conditions and DO readings from Reach A suggest that oxygen concentrations in the wasteway may have been quite low during July. Salinity, pH and conductivity were within the expected range for freshwater habitat. A report that is forthcoming from Alex Amonette will help answer many of the water quality suitability questions that remain within the wasteway.

**Table 6. Amon Wasteway Water Quality Data (2009)**

| Location | Sample Date | Time | Temp °C | DO (mg/l) | DO Sat% | pH | Turbidity | Salinity | Conductivity (uS) |
|---|---|---|---|---|---|---|---|---|---|
| Reach A | 2/12 | 1053 | 8.5 | 11.40 | 92.9 | 8.42 | clear | 0.1 | 761 |
| | 3/12 | 0930 | 5.1 | 11.44 | 88.6 | 8.60 | clear | 0 | 93 |
| | 7/9 | 0900 | 18.3 | 5.64 | 92.9 | 8.59 | turbid | 0 | 397 |
| Reach B | 2/12 | 1346 | 9.7 | NA | NA | 7.66 | clear | 0.1 | 720 |
| | 3/12 | 1024 | 7.6 | 11.05 | 91.5 | 8.48 | clear | 0.1 | 766 |
| | 7/9 | 1109 | 19.8 | NA | NA | 8.44 | clear | 0 | 411 |
| Reach C | 2/12 | 1520 | 9.1 | NA | NA | 8.88 | clear | 0.1 | 705 |
| | 3/12 | 1115 | 8.0 | 11.64 | 97.6 | 8.44 | clear | 0 | 105 |
| | 7/9 | 1230 | 20.9 | NA | NA | 8.10 | clear | 0 | 383 |

**Water Temperature**

Water temperature conditions were very similar between the three sampling reaches. From July through September, average daily water temperatures varied between reaches by less than 1ºC. The lack of significant change between reaches indicates that water temperatures throughout the entire sampling area are at, or near dynamic equilibrium with meteorological conditions. The slight cooling observed between Reach C and A can be attributed to localized changes in stream attributes, such as width, depth, and vegetation cover. Due to similarities between temperature conditions in the three sampling reaches, mean daily averages were combined for the three reaches to generate our primary results (Figure 9). Detailed plots of individual, reach-specific temperature data are provided in Figure 10. Maximum seven-day average temperatures exceeded 20ºC from June 23 through September 1 and peeked in early August at 23.75ºC (Figure 10). From June 28—September 3, average daily temperature exceeded 21ºC 47 times, with a maximum average daily temperature of 24.87ºC. Instantaneous maximum temperatures reached 27.09ºC, 27.36ºC, and 27.70ºC in Reaches A, B and C respectively.

During the summer irrigation season, discharge from the East Fork of the wasteway is many times the volume of the West Fork (East Badger Drain). Therefore, temperatures recorded in Reach C are primarily driven by water temperatures from the East Fork. It has been theorized that the golf course ponds may increase temperatures in the West Fork. Indeed, the temperature logger (10) we placed in the West Fork of Amon, upstream of the Country Club, recorded temperatures as much as 5ºC cooler in the summer compared to logger 9 located just below the confluence. We were not able to directly test hypotheses related to temperature effects of the golf course ponds because not all of our temperature loggers were recovered, but the proximity of logger 9 to the confluence of the East and West Forks should have allowed us to detect any significant cooling effect associated with either branch. However, recorded temperatures were highest near the confluence (logger 9) suggesting that the West Fork likely warms significantly as it passes through the Country Club ponds located on the southern end of the golf course. Whether by a combination of factors, or solely as a result of accretions from the East Fork, temperatures in Amon Wasteway are at or near equilibrium with air temperatures below the confluence of the East and West Forks, and continue to be at equilibrium until reaching the Yakima delta.

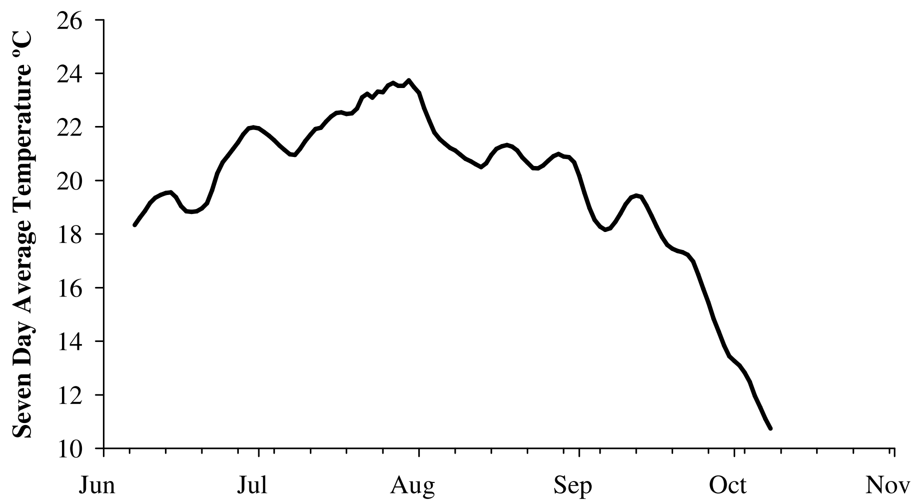


**Figure 9. Water Temperature conditions in Amon Wasteway, 2009. Seven-day moving average temperatures calculated by combining values for three sample reaches (A,B,C) spread throughout the wasteway.**

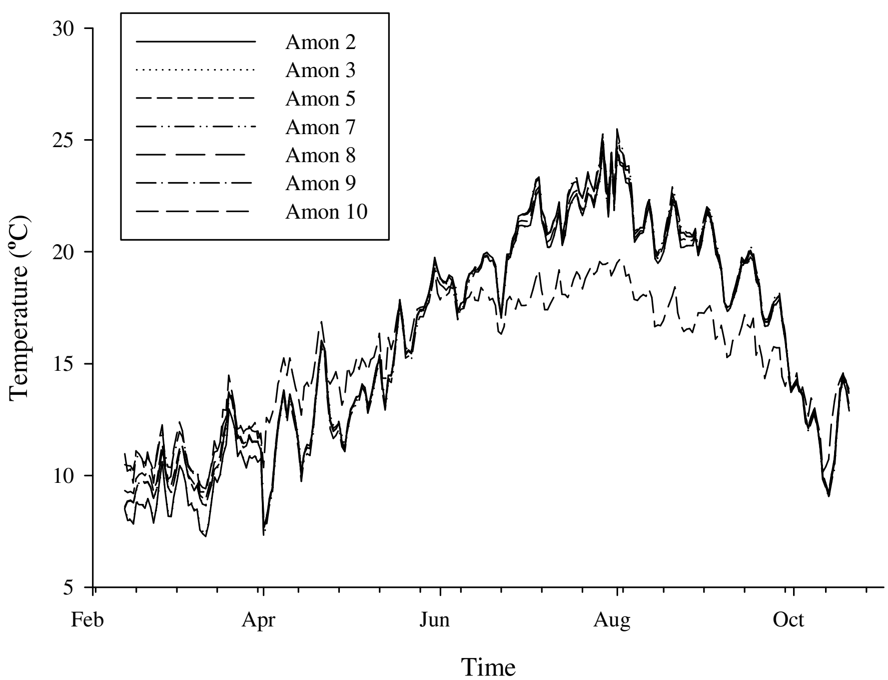


**Figure 10. Average daily temperatures recorded by the seven recovered temperature loggers in Amon Wasteway.**

**Electrofishing Surveys**

In total, four salmonids were captured, two rainbow trout and two coho, during our July 2009 electrofishing surveys in Amon Wasteway (Table 7). Paul Hoffarth with the WDFW assisted us during the survey. Species with higher temperature tolerance such as smallmouth bass, sunfish, speckled dace and peamouth were the most abundant species. The number of salmonids captured per 100-meters of stream surveyed were 0.00, 1.44, and 1.16 for Reaches A, B, and C respectively.

**Table 7. Species and size of fish captured in Amon Wasteway during July 2009 electrofishing surveys**

| Reach | Common Name | Fork Length (mm) |
|---|---|---|
| A | peamouth chub | 120 |
| | peamouth chub | 129 |
| | peamouth chub | 126 |
| | peamouth chub | 114 |
| | peamouth chub | 117 |
| | pumpkinseed sunfish | 64 |
| | smallmouth bass | 175 |
| | smallmouth bass | 234 |
| | smallmouth bass | 202 |
| | smallmouth bass | 173 |
| B | bridgelip sucker | 258 |
| | coho | 101 |
| | rainbow trout | 198 |
| | smallmouth bass | 199 |
| C | coho | 125 |
| | mosquitofish | 29 |
| | rainbow trout | 300 |
| | speckled dace | 44 |
| | speckled dace | 50 |
| | speckled dace | 43 |

**Salmonid Capacity Estimates**

Modeled estimates of coho salmon and *O. mykiss* density in our sample reaches were extremely low (Table 8). In total, we estimated a combined coho salmon and rainbow trout/steelhead rearing capacity of 9.5 fish across 2660 square meters of stream habitat surveyed. The habitat conditions that appear to be primarily responsible for low salmonid densities in the wasteway include warm summer water temperatures, excessive levels of fine sediments, lack of large woody debris, and a scarcity of pool habitat in some areas. The most influential of these habitat variables was summer water temperature, which was at or above the uppermost extent of the tolerance range for both coho salmon and rainbow trout/steelhead in all three sampling reaches. Low density predictions were consistent with low abundances observed during electrofishing surveys.

**Table 8. Estimated coho and *O. mykiss* parr carrying capacity in sampling Reaches A, B, and C of Amon Wasteway. Baseline coho estimates were derived according to the methods of Nickelson (2008), and *O. mykiss* estimates were derived according to the methods of Cramer and Ackerman (2008b). Baseline estimates were adjusted to account for temperature effects.**

| | Density (fish/m$^2$) | | | Combined |
|---|---|---|---|---|
| Reach | O. mykiss | Coho | Habitat Area (m2) | Carrying Capacity |
| A | 0.0018 | 0.0024 | 1294 | 5.44 |
| B | 0.0025 | 0.0018 | 690 | 2.92 |
| C | 0.0007 | 0.0011 | 677 | 1.16 |

**Discussion and Conclusions**

After conducting a thorough literature review and an independent evaluation of habitat conditions and fish presence in Amon Wasteway, we conclude that Amon Wasteway, below the East and West-Fork confluence, does not appear to be well suited for salmonid production, particularly during the summer and fall. Observed salmonid abundance and modeled densities were extremely low relative to salmonid producing streams elsewhere in the Yakima Basin. For example, trout densities in several different sites throughout Taneum Creek, a high priority watershed for salmonid restoration activities located within an agricultural area in the upper Yakima Basin, averaged between 0.13 and 0.56 fish/$m^2$ over the years 1998-2008 (Gabriel Temple, pers. comm.). This is approximately 80 to 350 times the predicted density of trout in Amon Wasteway. During 2009 summer electrofishing surveys in Amon Wasteway we captured an average of 1.4 salmonids per hour. For relative comparison, similar surveys conducted in small streams throughout the Upper Yakima Basin during 2004-2008 produced on average over 57 trout per hour (Gabriel Temple, pers. comm.).

There are a number of reasons why Amon Wasteway appears to have very low capacity to produce salmonids. In general, the wasteway provides poor habitat because of its geomorphic properties and regional climatic conditions. The wasteway exists within a geologic area characterized by plentiful fine silts, clays, and sands that do not provide suitable stream substrate for salmonids. Sedimentary deposits of glaciofluvial (glacial or riverine), lacustrine (lake), and eolian (wind blown) origin, and basalts of volcanic origin are the two principal formations found in the lower Yakima Basin (Molenaar 1985). The distribution of these sediments is an important driver of geomorphic conditions in Amon Wasteway. The land irrigated by the KID, the source of nearly all of Amon's flow volume, lies on the west side of the Yakima River at higher elevations than the river floodplain (Smith et al. 2005). Thus, the origin of sedimentary deposits in the KID are primarily lacustrine and eolian. These areas contain wind deposited loess and fine silts and sands deposited during the Missoula Floods (Molenaar 1985). In contrast, most soils in the river floodplain lying to the west of the Yakima River in the vicinity of Toppenish and Wapato are cobbles, gravels, and sands of glaciofluvial origin.

Cramer Fish Sciences (Romey and Cramer 2001) found salmonid habitat conditions in drains flowing through basalt dominated zones, namely Spring, Snipes, and Corral Creek Wasteways, all had suitable substrate, gradient, and other habitat conditions which could support salmonids. Habitat conditions in Sulphur, Granger, and Moxee drains were found to be generally unsuitable for salmonids. High levels of substrate embeddedness and low gradients were the primary factors diminishing habitat suitability in the Sulphur, Granger, and Moxee drains (Romey and Cramer 2001). Their findings are corroborated by the results of our habitat surveys, which showed that salmonids are unlikely to be successful in Amon Wasteway for similar reasons.

In addition to regional geology, climate conditions have a significant impact on Amon Wasteway's capacity to produce salmonids. The waterway exists in the lowest precipitation zone of the Yakima Basin. Mean annual precipitation in Kennewick is less than 10 inches, and the Rattlesnake Hills to the east receives about 15 inches of precipitation annually. Lack of sufficient precipitation to naturally sustain fish-bearing streams in this area is evidenced by the fact that there are no perennial streams flowing from the hills, east of Amon, to the Yakima or Columbia Rivers (Molenaar 1985).

The arid landscape surrounding Amon is also hot. A significant body of literature validates the conclusion that a stream's fish species assemblage is strongly correlated to its thermal regime (Wehrly et al. 2003; Huff et al. 2005; Ott and Maret 2003; Torgersen et al. 2007), underscoring the importance of temperature as a constraint to salmonid production in Amon Wasteway. The wasteway's temperature regime is a function of its location within the lower Yakima Basin watershed. Given regional meteorological conditions (>90ºC average of daily maximum air temperatures July-August) and sources of flow, we would expect the wasteway to be better suited for warm water species, and warm water species were indeed most abundant in our electrofishing surveys. Furthermore, predicted shifts in meteorological conditions due to climate changes will likely further impair Amon Wasteway's ability to offer an adequate thermal regime for salmonids.

Results from our habitat surveys in Amon Wasteway confirm our assertions that this irrigation drain is unlikely to provide suitable salmonid habitat. Relative to other small streams in the Yakima Basin, substrate conditions in Amon Wasteway are inadequate for significant levels of salmonid production because of the high concentrations of fine sediments. Figure 11 depicts substrate conditions in Taneum Creek, which are better suited for salmonid production relative to substrate conditions in Amon Wasteway. The large proportion of cobble in Taneum Creek is ideal for juvenile trout, which use substrate interstices as velocity refugia and cover from predators (Cramer and Ackerman 2008a).

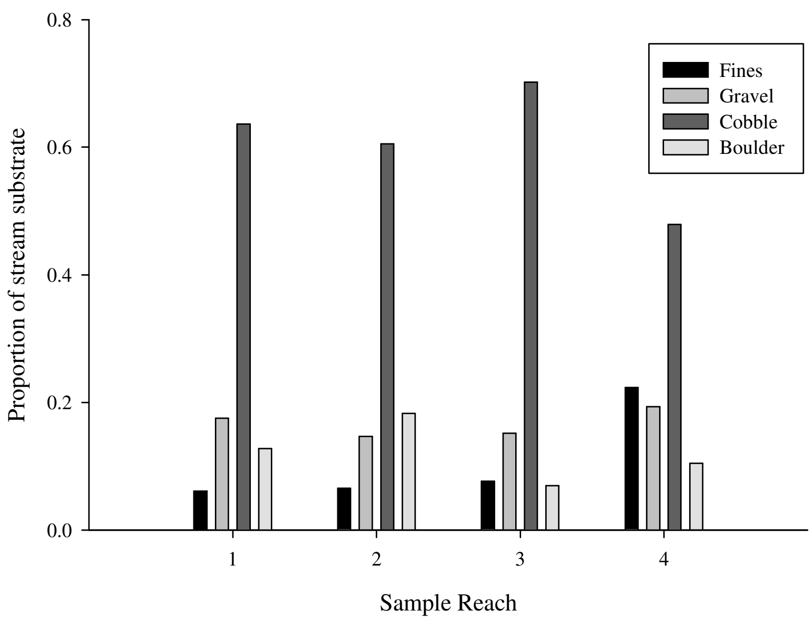


**Figure 11. Substrate conditions in four 100-meter sites in Taneum Creek (Data collected through coordination with Washington Department of Fish and Wildlife).**

Amon Wasteway has a significant amount of glide habitat, characterized by laminar flow and low habitat complexity, which is not ideal for rearing salmonids. The amount of rearing potential in salmonid streams is closely tied to the amount of available riffle habitat, because salmonids are drift feeders and riffles produce most of the drift. Pool habitat is also crucial because deeper water with less velocity is necessary for holding during inactive periods. Furthermore, pools often contain structure, such as large wood, which can be used for cover from birds and other predators. Pool-riffle interfaces commonly have the highest salmonid densities because these areas provide ideal feeding opportunities while minimizing energy consumption. Figure 12 provides mesohabitat composition observed in four 100-meter sites surveyed in Taneum Creek. Taneum Creek provides a reasonable comparison to Amon Wasteway because of its location within the Yakima Basin and similarity in summer discharge.

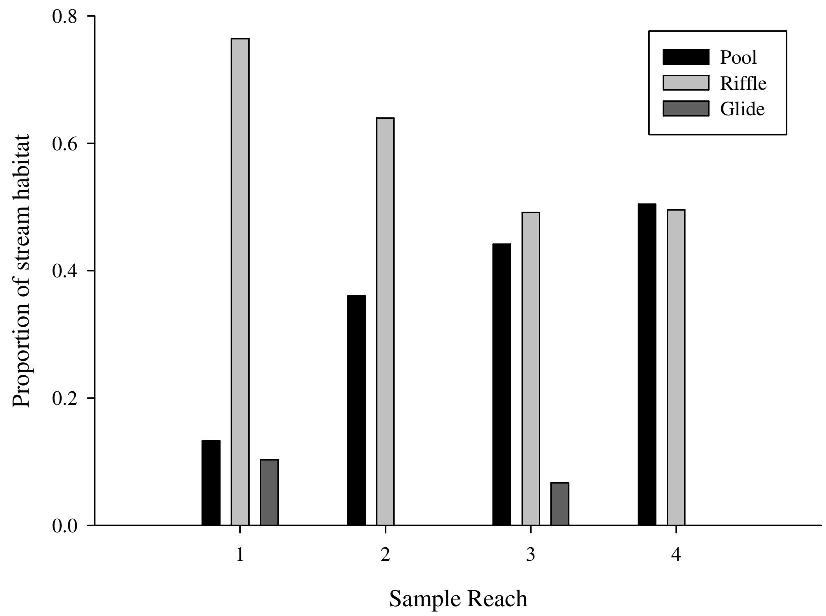


**Figure 12. Mesohabitat composition from four 100-meter sites in Taneum Creek (Data collected through coordination with Washington Department of Fish and Wildlife).**

The most significant habitat constraint for salmonid production in Amon Wasteway is water temperature. Average daily temperatures exceed 21ºC throughout most of the summer, and seven-day average temperatures exceeded 22ºC for several weeks in 2009. Amon's temperature regime is reflected in the wasteway's fish assemblage, which appears to be predominantly warm water species, most of which prey on juvenile salmonids (Table 8). This corresponds to the results of other electrofishing efforts discussed in the literature review (Table 4 and 5). In contrast to Amon Wasteway, Taneum Creek had an MWAT of 18ºC (Figure 13) and did not exceed 19º C daily average temperatures during the period of record (2005-06). As a result of this temperature regime, fish sampled in Taneum Creek are primarily cold water species.

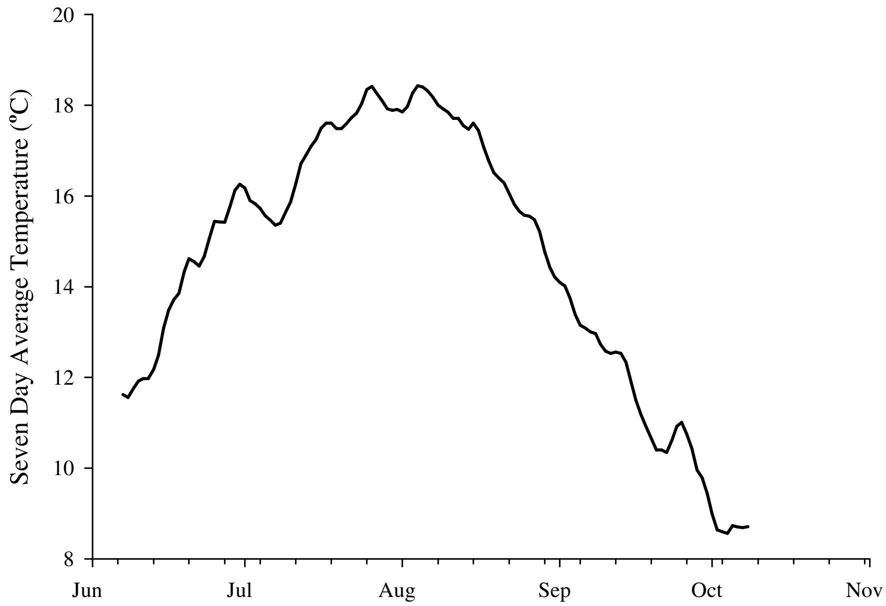


**Figure 13. Seven-day average temperatures in Taneum Creek at Brain Ranch gauge, 2005. Data provided by James Kardouni, Washington Department of Ecology.**

A limited number of adult coho salmon have been recently documented in Amon Wasteway, and there is increasing local interest in understanding whether the wasteway can sustain significant numbers of salmon. As described above, available scientific evidence suggests not. Why then would coho spawn in habitat that becomes unsuitable for their offspring? Coho spawning occurs in the late fall when temperatures are cooler and the wasteway's water quality conditions are improved. The majority of redds counted during surveys were located in lower portions of the wasteway near Leslie Road. Coho prefer low gradient, tributary habitats (Lestelle 2007), which makes this the most likely portion of the wasteway to attract adult spawners.

Due to the apparent summer rearing constraints in Amon Wasteway, some have hypothesized that coho in the wasteway might have adopted a life-history strategy in which juveniles migrate downstream and over-summer in the main stem Yakima and Columbia Rivers. We explored this possibility and conclude that juveniles attempting to rear in sections of the lower Yakima and mid-Columbia River are unlikely to survive. Summer temperature conditions in these mainstem habitats are hostile to rearing salmonids. For example, on July 31, 2009 midday temperature in the mainstem Yakima River, adjacent to the Amon inlet was 27ºC, while the mouth of Amon Wasteway was 22.5ºC (Marcie Appel pers. comm.). Summer temperatures in the mainstem Columbia River below the Yakima confluence are cooler, but still frequently exceed 21ºC. We are not aware of evidence to suggest that juvenile coho successfully over-summer in the mainstem Yakima or mid-Columbia Rivers, and temperature conditions appear limiting.

In spite of the survival constraints that restrict recruitment, it is not surprising that a few coho spawners are observed in the wasteway each year. Salmon commonly “stray” and spawn in non-natal areas. There are numerous potential causes of this behavior. The most likely cause in this case is that flows in Amon Wasteway are derived from water withdrawn from the Yakima River, higher in the basin. Salmon rely on their sense of smell and the chemical signature of the water to find their natal stream (Hasler et al. 1978); thus, diverted water from the upper Yakima River may attract fish homing to sites in other parts of the basin, particularly fish of hatchery origin, which are known to have higher rates of straying than wild fish (Lister et al. 1981; Ford et al. 2009). Evidence of adult coho being attracted to irrigation return flows is not a phenomenon unique to Amon Wasteway. For example, it has been hypothesized that adult coho salmon are attracted to Sulphur Creek Wasteway, because it contains water conveyed directly from the upper Yakima River, which is unique in its chemical constituents (Monk, 2001).

Given consistently low numbers of adult coho observed annually (less than 10), poor salmonid habitat conditions, and extremely low abundance of rearing juveniles observed in Amon Wasteway, the most logical conclusion is that adult coho documented in Amon Wasteway are strays from other populations in the Yakima Basin and mid-Columbia River region and, therefore, do not constitute a self-sustaining population.

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**Appendix 1.** Habitat Survey Measurement Protocol

***Delineation into Geomorphic Unit Types***

Channel geomorphic units are relatively homogeneous lengths of the stream that are classified by channel bed form, flow characteristics, and water surface slope. With some exceptions, channel geomorphic units are defined to be at least as long as the active channel is wide. Individual units are formed by the interaction of discharge and sediment load with the channel resistance (roughness characteristics such as bedrock, boulders, and large woody debris). Channel units are defined (in priority order) based on characteristics of (1) bedform, (2) gradient, and (3) substrate.

It should be noted that the unit types listed below do not necessarily describe all units that may be encountered in a stream, but describe all of the unit types likely to produce juvenile salmonids. Other unit types such as isolated pools, dry channel units, culverts, or steps are unlikely to produce salmonids and typically make up only a very small portion of a stream.

When a stream diverges into multiple channels, each of the channels should be surveyed.

Pools

A section of stream channel where water is impounded within a closed topographical depression. Pools are typically created when fluvial processes such as scour associated with a channel obstruction form depressions in the channel bed. The scour forms a depression which acts as a basin that would continue to hold water if there was no flow. Some pools are created by impoundments such as a debris flow, a log jam, or a beaver dam.

Glides

An area with generally uniform depth and flow with no surface turbulence. Low gradient; 0-1 % slope. Glides may have some small scour areas but are distinguished from pools by their overall homogeneity and lack of structure. Generally deeper than riffles with few major flow obstructions and low habitat complexity. There is a general lack of consensus regarding the definition of glides (Hawkins et al. 1993).

Riffles

Fast, turbulent, shallow flow over submerged or partially submerged gravel and cobble substrates. Generally broad, uniform cross section. Low gradient; usually 0.5-2.0% slope, rarely up to 6%. Some riffles may contain numerous sub-unit sized pools or pocket water created by scour associated with small boulders, wood, or stream bed dunes and ridges. In these instances, sub-unit sized pools comprise 20% or more of the total unit area.

Rapid

Swift, turbulent flow including chutes and some hydraulic jumps swirling around boulders. Exposed substrate composed of individual boulders, boulder clusters, and partial bars. Moderate gradient; usually 2.0-4.0% slope, occasionally 7.0-8.0%. Rapids over bedrock may appear as swift, turbulent, "sheeting" flow over smooth bedrock. Sometimes called chutes. Little or no exposed substrate. Moderate to steep gradient; 2.0-30.0% slope.

Cascade

Much of the exposed substrate composed of boulders organized into clusters, partial bars, or step-pool sequences. Fast, turbulent, flow; many hydraulic jumps, strong chutes, and eddies; 30-80% white water. High gradient; usually 3.5-10.0% slope, sometimes greater. Cascades over bedrock are similar except that structure is derived from sequence of bedrock steps. Slope 3.5% or greater.

Backwater

Pool found along channel margins; created by eddies around obstructions such as boulders, root wads, or woody debris. Part of active channel at most flows; scoured at high flow. Substrate typically sand, gravel, and cobble.

Beaver Pond

Pool formed by a beaver dam.

***Geomorphic Unit Length***

Total length of each unit in meters.

***Geomorphic Unit Width***

Average width of wetted channel in meters. Average width should be estimated by observing the wetted width in at least three locations along the longitudinal axis of the unit, and then averaging. We prefer width measurements approximately every 10-12 meters for each unit to ensure an accurate average width measurement.

***Maximum Depth in Pools***

Maximum depth should be recorded in pools in meters. It is also adviseable that maximum depth be recorded in backwater units and beaver ponds, though these measurements are currently not needed for the UCM.

***Average Depth in Riffles***

Average depth in meters should be recorded in riffles. It is also advisable that average depth be recorded in glides, rapids and cascades, but the model can be run without depth data for these select units. Depth measurements should be taken in conjunction with each width measurement.

***Substrate Classification***

Percent distribution by streambed area of substrate material in six size classes: fines (<2mm), gravel (pea to baseball; 2-64mm), cobble (baseball to bowling ball; 64-256mm), boulders, and bedrock. Estimate distribution relative to the total area of the habitat unit (wetted area). Round off each class to nearest 5 percent.

***Wood Complexity***

Each pool and glide should have a wood complexity rating assigned. Wood complexity is rated on a 1-5 scale as defined below. Other measures (counts) of LWD availability are also adviseable, though currently there are no means to incorporate these data into the UCM. Future use of these data in the UCM are possible.

**Table 9. Wood complexity rating definitions.**

| Wood Complexity Rating | Definition |
|---|---|
| 1 | Wood debris absent or very low |
| 2 | Wood present, but contributes little to habitat complexity. Small pieces creating little cover. |
| 3 | Wood present as combination of single pieces and small accumulations. Providing cover and some complex habitat at low to moderate discharge. |
| 4 | Wood present with medium and large pieces comprising accumulations and debris jams that incorporate smaller root wads and branches. Good cover for fish over most flow levels. |
| 5 | Wood present as large single pieces, accumulations, and jams that trap large amounts of additional material and create a variety of cover and refuge habitats. Woody debris providing excellent persistent and complex habitat. Complex flow patterns will exist at all discharge levels. |

***Alkalinity and Turbidity***

Measures of alkalinity (mg/L $CaCO_3$) and turbidity (NTU) at low flow are needed to parameterize the UCM. Ideally, these values would be available for each reach surveyed. However, this is typically not the case in which instance it is desired to have several measurements available from various locations within the watershed so as to provide a representative estimate of the value for the entire basin. Previously, S.P. Cramer & Associates has undertaken analysis to estimate low flow values for these parameters if measurements were only available from other times of the year. Also, when no data are available within the watershed of interest, data from nearby representative watersheds may be used.

***Other Useful Stream Survey Information***

Other data may be collected that are not directly needed to parameterize the UCM, but may be useful in post modeling analysis, or to estimate capacity where no habitat survey data are available. These include active channel width, flow, gradient, and potential barriers.

**Appendix 2.** Amon Wasteway Habitat Composition at Reaches A, B, and C

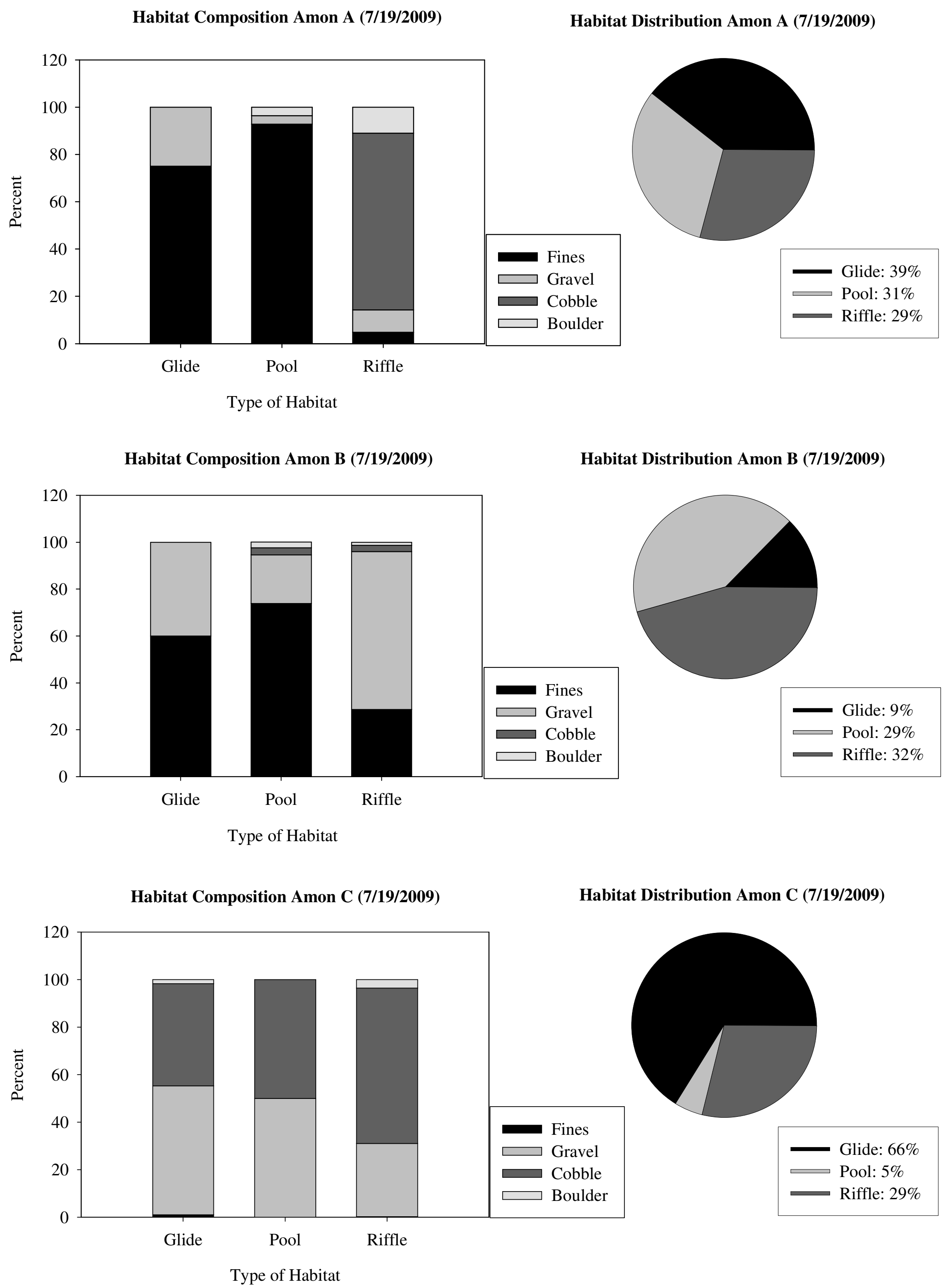



**Figure 14. Amon Wasteway Habitat Composition at Reaches A, B, and C**

**Appendix 3.** Survey Flow Information

**Table 10. Amon Wasteway flow from surveys**

| **Observed Flow* in Amon Wasteway During Surveys** | | | |
|---|---|---|---|
| **Date** | **Amon A** | **Amon B** | **Amon C** |
| 2/12/2009 | 6.29 | 9.74 | 5.13 |
| 3/11/2009 | 6.96 | 8.25 | 5.65 |
| 7/9/2009 | 19.78 | 24.42 | 30.03 |
| 8/18/2009 | 25.18 | 30.86 | 30.85 |

*flows are calculated in cubic feet per second (cfs) and were based on wading discharge measurements by the researchers

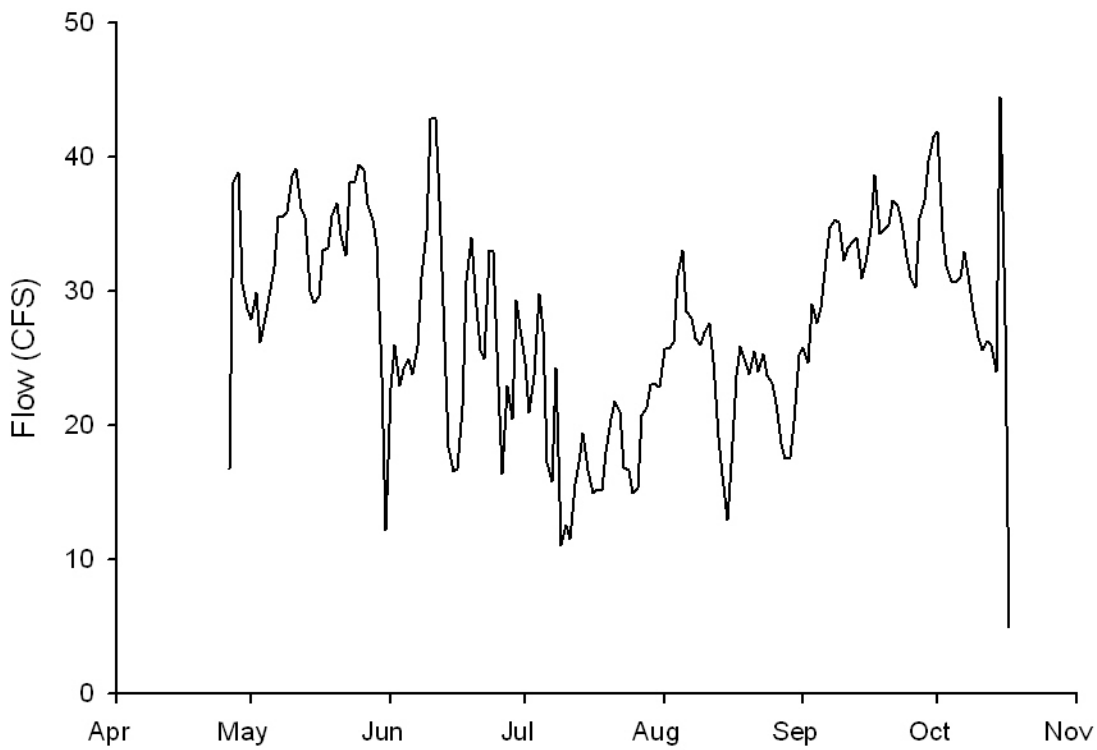
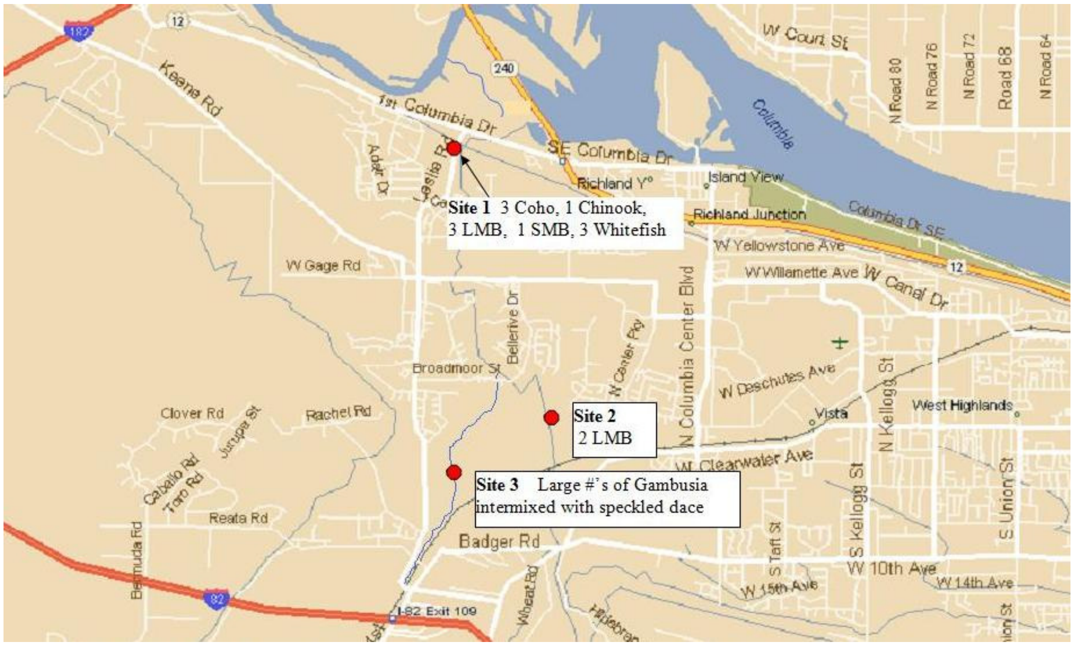



**Table 15. Amon Wasteway flow during irrigation season spill and operations, measured at the Gage Pumps in water year 2002 (Weatherly, 2010).**

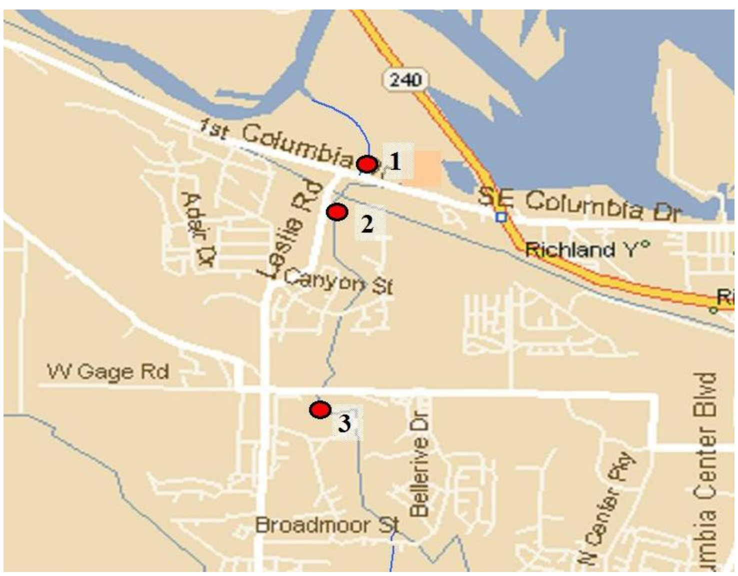
**Appendix 4.** Amon Wasteway Temperature Monitoring Sites


**Figure 16. Amon Wasteway temperature monitoring sites (1-11) (Google Earth 2009).**
*The Google 2009 map denotes a "Meadow Springs Reservoir" inaccurately.

**Appendix 5.** Maps of WDFW electrofishing site locations along Amon Wasteway in 2001 and in 2005.




**Map 1. Survey sites selected for presence/absence fish survey in Amon Wasteway, July 18th, 2001 (provided by Hoffarth, 2009).**




**Map 2. Survey sites selected for presence/absence fish survey in Amon Wasteway, July 25th, 2005 (provided by Hoffarth, 2009).**

**Appendix 6.** Yakima Basin Biologist's Review Period and Comments

A draft of the Amon Wasteway Salmonid Suitability Report was circulated to Yakima Basin biologist's on 1/5/2009. We incorporated pertinent suggestions and edits into the report. We also received numerous comments about wasteway management; such issues were not addressed in this scientific report, but as a courtesy to those with policy concerns, we forwarded all comments to the Kennewick Irrigation District.

The following is an accounting of comments received:

- Joel Hubble, Biologist with the Bureau of Reclamation provided emailed comments on 1/7/2010.
- Alex Conley, Executive Director of the Yakima Basin Fish and Wildlife Recovery Board provided email comments on 1/14/2010 and an attached document which focused mainly on the management of Amon Wasteway.
- Pat Monk, Biologist with the US Fish and Wildlife Service provided written comments on a print out of the report. He met with me and explained his suggestions on 1/20/2010.
- Scott Kline, Biologist with the Bureau of Reclamation provided emailed comment document on 1/21/2010.
- Paul LaRiviere, Biologist with the Washington Department of Fish and Wildlife provided emailed comments on 1/22/2010. The letter contains the consolidated comments and suggestions from Paul LaRiveire, John Easterbrooks, Perry Harvester, Eric Bartrand and Paul Hoffarth with the WDFW.
- Dale Bambrick, Eastern Washington Branch Chief with the National Marine Fisheries Service provided verbal comments on 1/25/2010.
- Jeff Thomas, Biologist with the US Fish and Wildlife Service provided verbal comments on 1/25/2010.
- Dave Fast, Senior Scientist with the Yakama Nation's, Yakima/Klickitat Fisheries Program provided emailed comments on 1/25/2010.

**Joel Hubble's Comments**

Joel Hubble provided several edits to the text and asked if this research was done as a prelude to installing a fish barrier, similar to the one installed at the Sulphur Creek Wasteway. We responded that as researchers we provide the results of the study and don't have to make the management decisions on what happens next. The study will initiate discussions with various interests and some agreements generated for management.

**Alex Conley's Comments**

David,
Thanks for the opportunity to review your draft report titled "Suitability of Amon Wasteway for Salmonid Production." The attached comments are mine alone, and are not a formal

statement of the Yakima Basin Fish and Wildlife Recovery Board. The first section offers some general comments about this report in relation to the broader discussion about the Amon drainage; the second section gives more detailed comments on specific elements of the report.

There is good some good stuff here, and there are also a number of claims that seem to overreach the evidence that is available in this report. If this were my report, I'd edit it to focus on cleanly on the specific things I have data to support, and convert many of the more speculative statements that are made from assertions to hypotheses/areas of further study- otherwise you risk having those that disagree with you on specific assertions discarding all the findings in a knee-jerk response against the report as a whole. If you do want to keep these assertions in the report, I'd want to see more specific data and analysis that supports them, as noted in my comments.

I hope these notes are useful- do feel free to get in touch with me if you have any questions.

Alex Conley, Executive Director
Yakima Basin Fish & Wildlife Recovery Board
1110 W. Lincoln Ave
Yakima, WA 98902

**GENERAL COMMENTS:**

A) **Do we have agreement that the Amon system did not sustain consistent flows prior to irrigation development?** I don't need any more convincing myself, but if some still assert otherwise, I'd like to see all the evidence on both sides assemble so we can try to get agreement there. Clearing up that issue makes all subsequent discussions easier. I did poke around the 1917 USGS map and the 1860-72 land survey notes, which appear to support the assessment made in this report (details below).

B) **This report provides a lot of data that the accessible portions of the mainstem and East Branch are currently crappy places to be a salmonid in July.** This is an important thing to know, and is the most valuable part of the report. However it has little bearing on the regulatory concerns that have made management of this waterway such a contentious issue. WDFW is interested in fish-bearing waters, not only waters that support productive salmonid rearing in all seasons. The Corps of Engineers regulatory authorities that the Districts are rightfully concerned about are all based in the Clean Water Act, and have little relation to the fish assemblages supported. The regulatory side of the ESA simply wants to know whether or not steelhead are harmed- if one swam up the drain into my bathtub, I'd still be liable for take. I assume KID and the Bureau are working hard to cover any take in Amon via the Yakima Project Biop process, so in the long haul I'd hope that's a non-issue. ESA-designated Critical habitat is a non-issue as Amon was excluded from designated critical habitat. The recovery side of the ESA has pretty clearly acknowledged that recovery of steelhead in the Yakima is not dependent on steelhead production from the Amon system, so no one should be afraid they'll be forced into anything as part of steelhead recovery. Coho are not listed, and as a reintroduced population, are pretty darn unlikely to be listed in the future. Unless Amon proved to be a major population sink at a basin level (unlikely), there are few implications to the presence- whether or not successful- of coho in the system. The same thorny bureaucratic issues- and non-issues- remain, whatever the summer habitat conditions.

C) **The implications of the fact that it is a crappy place to be a salmonid in summer are not clear.** So if it doesn't change the regulatory picture, what do we gain from knowing that it's a crappy place to be a salmonid in summer? This report argues in essence, that that is why it would be stupid to manage Amon for salmonid production, but the argument, as presented, is pretty weak, and is based on some rather speculative statements (eg that there is nothing that could be done to change temperature and flow conditions, and that there are no successful life histories that would rear elsewhere (eg move to the Columbia)). If I were in your shoes and committed to making this argument I'd work to really tighten up these claims. I can already hear Amon advocates making the opposite argument- that the data in this report only further highlight the need to get passage into the cooler W branch, and potentially, to try to address the temperature affects of routing the W branch through the gold course ponds. Both arguments have their merits and issues- it'd take an honest assessment of the potential-or lack there of- for habitat improvements to get real answers. This report simple asserts that it's all a function of climate and geology, which is only half true.

D) **So what does this leave me thinking, given my role in the basin?**

As was made clear in the recovery planning process, habitat work in Amon Creek is not a high priority for steelhead recovery at the population level. While steelhead production in Amon could feasibly make a minor contribution to meeting recovery goals (note that it could also feasibly act as a population sink), there are many other areas where we would expect a far greater-and more certain-contribution to recovery goals. Those are the areas where we as a recovery board are actively advocating for recovery actions.

I do understand that there are a lot of local interests that want to do habitat work in Amon, and the other way that we might engage is if another Amon project is proposed through the SRFB process. To be successful in that process, any Amon proposal would have to show the support of all the major stakeholders (KID, WDFW, Reclamation, Meadow Springs Golf Course, Tapteal, etc-this is where the last proposal fell apart) and show that it could resolve the legitimate concerns about water temperature and quality raised in this report. I can, as a perennial optimist, imagine a compromise solution that might meet these bars, perhaps by:

1) opening passage into the better temps in the W branch,

2) rerouting the W branch out of some or all of the ponds to reduce the warming instream, and give the golf-course the ability to fill the ponds from a diversion on the W branch but cut them off as needed to manage moss, and perhaps even to enable put and take fisheries (kids would love that).

3) Creating legal agreements that address KID and reclamation concerns about regulatory impacts, and explicitly note that KID is working to reduce or eliminate spill.[2]

4) Possibly installing a fish barrier at some point in the E branch if needed to reduce concerns about direct impacts of spill on fish.

5) And of course, getting the USGS to officially name it Amon Dreek (or is that too much like Solomon suggesting cutting the baby in half?)

I'm not advocating for this as a solution- just acting as devil's advocate to both sides based on what I've learned from spending time in both the SRFB and recovery planning processes on these issues. Any such compromise solution would be a lot of work, and would not be guaranteed to address all the issues. Even if it made a compelling case, how such a proposal would fare in the SRFB process would depend on how competitive that year's pot is, but if everything else were in place, there are other funding sources that aren't as specifically tied to steelhead recovery goals. If a project can't show that it has all parties aboard and can significantly improve the marginal conditions in the system documented in this report, I can't see it being viable. If that's the case, it'd be nice to see people agree to disagree here, and put our energies into other areas with more immediate positive outcomes for all parties.

## SPECIFIC COMMENTS ON THE REPORT:

### Executive summary

The report states:

*The most significant of these factors were warm water temperatures and an abundance of fine sediments. Both of these habitat characteristics are controlled by local climatic and geologic conditions. Given that the two primary limiting factors for salmonid carrying capacity are outside management control, one would expect limited gains from attempts to alter the wasteway in order to increase salmonid production.*

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[2] I know that KID is concerned that active management for fish would lead to being required to provide water for instream flows, and thus conflict with their efforts to reduce spill. KID should be lauded for its desire to tighten up its system, and my guess based on what it in this report and others, is that this would improve conditions in the Amon system (less flow, but of better quality, as long as the groundwater return flows continue).

This is a bold assertion given that the drivers of temperature and sediment were not empirically assessed in this study.

Re temperature, the report makes clear that there is substantial warming of the waters coming out of the West Fork as they pass through the (artificial) golf course ponds. This could feasibly be reduced by rerouting the West fork to bypass these ponds; likewise reducing warmer flows out of the East fork could reduce temperatures below the confluence. To say that temperature is a function of climate and geology alone is to tell only half the story.

Re the fine sediment load, it is my understanding that the system saw a major influx of fine sediment in the canal break in 1998, which deposited sediment 4' deep in the golf course ponds. It would be interesting to see relative turbidities from the East and West branch. Given that the West branch is in essence an (artificial) springbrook, I wouldn't expect much turbidity there. In the East branch, I suspect turbidities would be a function of bank erosion and canal releases. Again, to say that sediment conditions are outside of management control seems inaccurate.

**p. 1-2:**

Re the historic nature of the drainage, it'd be nice to include all of Scott's aerial photos as an appendix to this report, for those that haven't seen them. They make a pretty compelling case that the drainage was intermittent at best before irrigation development. I've also taken a look at the 1917 USGS map (http://kaga.wsulibs.wsu.edu/zoom/zoom.php?map=topo054) which shows an intermittent drainage with the only springs noted as 'wells' much higher up in the drainage. The GLO surveys and associated notes from the original land survey are also online (http://www.blm.gov/or/landrecords/survey/yNoteView1_2.php?R0019WA0213002430). The maps only indicate streams much higher in the watershed, each clearly marked dry in summer, and petering out to nothingness on the maps. I worked through a chunk of the survey notes (yes, handwritten, from 1860-72) to track where they crossed parts of Amon, Badger and Coyote drainages. At section line crossings above and below the confluence and near the mouth, no mention of any water- just reference to a grassy bottom. Higher up, references to ravines, some with dry brooks (early July survey), but no springs until many miles up the forks. Doing a tighter job of mapping out these surveys would be great for someone with a historical bent- a few days work? Generally if there was water, these notes would reflect it. Everything I saw was consistent with intermittent reaches and springs tucked in spots higher in the watershed, with more ephemeral[3] reaches lower down with the defined but often dry channel typical of a desert wash, and an alluvial fan at the end of the canyon. No reason to expect enough flow to support salmonids. Sounds a lot like Cold Creek, or the poignantly named Dry Creek that drain Hanford and the Firing Center. I know some have asserted there was more flow in Amon; if there's any evidence (water right claims, survey notes, oral histories, etc) it'd be good to see.

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[3] Here I'm using the definition of intermittent as a stream with consistent but seasonal flows, and ephemeral as a stream that only flows in response to specific precipitation events.

Even given the historic nature of the area, I don't understand the odd reluctance to admit to any term other than wasteway. After all, no one balks at calling Cold Creek or Dry Creek by those names, despite their ephemeral nature, and the word 'creek' has no regulatory import. I don't really care what we call it, but comments like "Mistaking the wasteway for a natural stream is understandable since portions of the wasteway flow down a natural topographic canyon to its confluence with the Yakima River," imply that this is an artificial drainage. It is not; it is a natural set of stream channels that went from intermittent/ephemeral to perennial with the development of the irrigation system.

P 3- Move the historical context info into the intro, or move the history from the intro down here- right now the structure is repetitive.

P4- reference to the Smith study repeats p 2 cite exactly- remove one or the other to keep report concise.

P4-8 Can't the basic info on temperature tolerances be summarized in 1-2 paragraphs? This seems like a lot of verbiage on a point that is widely accepted. The use of coastal OR/CA coho temperature tolerance data strike me as odd. Is there no info on arid interior fish (hmm, maybe we can import some of those Steens Mt redband…)? The modeling seems perhaps more complex than is needed to prove the basic point (temperatures above 18 deg C start to negatively affect fish, with increasingly negative affects up to the upper threshold in the 22-24 deg range).

P12 1st paragraph and maybe 2nd too should be blended into the introduction. So should figure 4.

Edit for clarity? "To evaluate the wasteway's capacity to produce salmonids, we ~~employed methods of~~ collected field data ~~collection~~ and modeled fish carrying capacity ~~modeling~~.

P14 Section titled "Electrofishing Data Analysis" should be titled "Electrofishing Methods" as it does not describe data analysis at all.

P15 Might consider combining this page with the earlier temperature discussion so it flows better (to me for this paper (not headed to a journal) keeping to the standard outline is less important than readability.

P18 Both here and on p8 you note that with the exception of the golf course reach of the W fork, temperatures cool as you move downstream. How does this jive with you assertion here that water and air temperatures are at equilibrium? Generally downstream cooling would be an indicator of groundwater input to the stream. It'd be good to see some more analyses of air/water temp relationships if you are going to make this assertion. The last sentence on the page seems a particularly strong assertion to make based on little analysis. Note that this page also implies that if one were to want to manage for cooler temperatures, eliminating the warming effect of routing the West branch through the pond and reducing spill down the East branch could significantly cool the stream below the confluence. It also highlight why, for those who really want to see salmon & steelhead in Amon, it makes so much sense to get passage into the west fork, which looks like it has surprisingly good temperature conditions for rearing.

P22 Para 1: I'd suggest changing the statement that "we conclude that the wasteway does not appear to be well suited for salmonid production," to "we conclude that the mainstem and east fork do not appear to be well suited for rearing salmonid during summer and early fall". As noted above, the W fork looks like it may be better…, and your claims are about summer rearing. The report would benefit from a better discussion of current and potential fish life history/seasonal use patterns. It is certainly feasible that steelhead or coho could spawn in Amon, and have left the system in early summer to rear down in the Columbia; with steelhead, spawning in streams that are bone dry by August is not uncommon, and can be productive as long as rearing areas are within reach of parr. Don't worry, I know that's speculative, and I'm also willing to entertain the contrary hypothesis that a place like Amon can be a population sink if it attracts spawners but does not allow for juvenile survival. But you do need to at least address the possibilities of diverse life histories that might make use of parts of Amon without rearing through the summer there.

Para 2: The claims about sediment and geology are pretty speculative; either get a more developed site-specific geomorphic assessment or cut the discussion out or way down.

P22-23 The climate discussion is again general- the paragraph spaning the pages could be blended back into the history section of the intro- I'm certainly not going to argue against the conclusion that this area was dry pre-irrigation. The statement that "we would predict that this area, absent significant sources of cool ground water, would be better suited for warm water species" means little when this report and other assessments of Amon make pretty clear that there is at least 5-10 cfs of cool groundwater entering into the W branch (that it is almost certainly subsurface return flow doesn't change the fact that it is cool ground water).

P23-24 The comparison with Taneum Creek seems bizarre; if I were searching for an analogue for this odd combination of wasteway and artificial spring brook in the basin, it'd probably be some of the highly altered floodplain springbrooks (Nelson Springs, etc)

P25 Again, are there coho life histories that would allow them to avoid rearing in the mainstem and E fork (e.g. downstream parr movements, or movement up into the W fork if passage existed?) If not, and if the assertion of false attraction is real, there is a real risk that this represents a population sink for coho (I'd assume not for steelhead since likely migration would be before spill occurs). If that is significant enough to b a concern (and the relatively low numbers of redds say it probably isn't), it'd point to reducing spill (KID's long term goal anyway), improving rearing conditions, or keeping fish out.

**Pat Monk's comments**

ii Pat asked if temperatures could be influenced by limiting surface spills from canals and restricting flow to groundwater sources

P 1 Pat suggested that a KID service area map would be helpful, showing the wasteway if possible

P 1 Pat suggested we add a sentence or two on the operations of the wasteway

P 2 Pat commented that Figure 1 could go after the Revell 2009 citation

P 4 Pat thought we should quote directly from Smith et al. 2005 and possibly infuse some of the comparable ephemeral flow information from the report on Cold Creek.

P 4 Pat asked how much density declines with water temperature

P 5 & 6 Pat commented that some of the discussion about food supply seems irrelevant

P 6 Pat commented that the information presented about temperature and salmonid densities being negatively correlated was good

P 8 Pat commented that we should present some of the WDFW data and let the reader see how you reached this conclusion, a similar comment with the Witty and Monk reference.

P 15 Pat asked where are the scales for the habitat based estimates in the report.

P 15 Regarding the equation used to calculate salmonid densities Pat commented that this is a reasonable approach, but I'm not sure what you are using for baseline capacity density. i.e. What are you applying this scale to?

P 19 in regards to Figure 10, Pat commented that we might add a horizontal line indicating a known temperature constraint. We might also compare these findings to Taylor Ditch (David Child's Master's thesis).

P 20 Pat commented that we should say how many days, how many meters per reach, etc. for the electrofishing surveys

P 21 Pat asked if Table 8 is based on the model provided earlier or what's the baseline

P 22 Pat shared that there are density estimates from Spring/Snipes and Sulphur Creek Wasteways if helpful for comparison

**Scott Kline's comments**

First, let me be clear from the get go that I am not a proponent of trying to improve fish passage or habitat in Amon Creek. On the other hand, if there are salmonids in there, I don't want to do anything to try to oust them out of there either. Conditions have developed that allows at least some salmonids to survive there. The Yakima Basin needs every inch of tributary habitat it can get.

That said…

Page ii, executive summary, second to last paragraph: You state that water temp and fine sediments are controlled by local climate and geologic conditions. That's true if we left it alone. Those habitat conditions certainly could be altered for the better if we wanted to. Perhaps a disclaimer could be inserted in the sentence "Both of these habitat characteristics, without man-made interference, are controlled by local climatic and geologic conditions."

Page 1, Introduction, first paragraph: you state that as much as 50% of water is diverted comes back as return flow and reference a 1974 paper. Is this outdated? Haven't practices improved since then so that the proportion of return flow relative to diverted flow is lower now?

Page 4, Flow, first paragraph. The information about the range of acre feet per year and equivalent discharge per day appears to be repeated unnecessarily from the introduction.

Page 9, water quality, first paragraph: the sentence about water quality being suitable for salmonids between November and April seems to have been blown off. There are many places in a river where salmonids seek refuge at appropriate times of the year, but not all times of the year, and that's a good thing. The following statement makes it sound like a tributary is worthless at providing habitat unless it provides habitat all year, which is not true.

Page 12, Methods: This is apparently the beginning of your "independent study". I think a clearer heading would be nice hear to let the reader now that all the following is part of the independent study and the previous data was from existing information.

Page 13, Figure 5. Reach A is appears to largely be a small tributary to the amon wasteway mainstem. Perhaps some background or descriptive information about this tributary would be useful to the reader to understand why you chose to sample a tiny and perhaps unrepresentative tributary to the subject water way.

Page 18, Water Temperature, first paragraph: you state "The lack of change between reaches indicates that water temperatures throughout the entire sampling area are at, or near equilibrium with air temperature." It sounds like you are saying that average water temperature is equal to the air temperature in this reach, which I'm sure is not the case. Please clarify.

Page 20, salmonid capacity estimates: The capacity estimates should clearly state that these are only for the 3 sample areas, and are not extrapolated to the entire stream. The way it is presented makes it sound like the entire amon wasteway has 9.5 fish. In addition to clarifying that here, perhaps a statement declaring the ratio of sampled stream habitat to total amon wasteway habitat would help with the reader's understanding of the significance of these results.

There are small errors such as typos that I didn't bother mentioning here.  Keep on the lookout for those.

**Paul LaRiviere provided the comments below from the WDFW.**

State of Washington

**Department of Fish and Wildlife**

Mailing Address: District 4 Office, 2620 N. Commercial Avenue N. Pasco WA 99301, (509) 545-2057

**January 20, 2010**

David Child
DC Consulting LLC

**Subject: Comments on Amon Basin Study**

Dear David:

We appreciate the opportunity to comment on the draft study, *Suitability of Amon Wasteway for Salmonid Production*. Several Washington Department of Fish and Wildlife (WDFW) staff reviewed the report so we consolidated comments and suggestions into one response.

The study contributes to the available information and our understanding of fish life within the Amon Basin and respective tributaries. The surveys and results are similar to a number of other surveys and reports produced over the last 10 years. While our mutual interest in management of the fish and water resource may be for different reasons, your study can be used to further an agreement in principle between WDFW and Kennewick Irrigation District (KID) on how to manage the watercourse and fish resources in the Amon Basin. As we've previously indicated, we believe that irrigation interests and fish management can co-exist within the Amon Basin and are not mutually exclusive. We believe that this is in the best interest of both KID and the public.

The purpose of the study appears somewhat unclear and appears slanted towards suggesting that the production potential of the Amon Basin is so minimal as to be inconsequential, is of no value, and perhaps is unnatural compared to other tributaries of the Yakima River Basin. There appears to be some focus on the source of the flow and the proportions relative to natural or artificial sources rather than on the fish production potential of the Basin, what the limiting factors are, and what might be done to improve productivity regardless of historical origin.

There is little need for extensive study to determine that the Amon Basin was likely never a significant producer of anadromous fish. However, neither were a host of other streams within the Yakima Basin. It's the cumulative production of these types of small watersheds that is important. We wish to ensure that productive habitat is accessible wherever production can be reasonably expected to contribute positively to overall production of salmonids regardless of the origin of the flow or historical use. We agree that there is a need to better understand what habitat functions are limiting salmon production within the Amon Basin and how we might improve them, while ensuring that irrigation delivery and operational spill interests are met.

We suggest that further study is needed in the West Fork Amon Creek regarding habitat functions and values. If not for a fish passage barrier salmonids would have access to high value wetlands and better water quality in the West Fork. The West Fork should also be included in any fish production model used for population and habitat evaluations. We also suggest additional habitat and fish surveys for the entire Basin to identify the possible enhancement opportunities, but not to the detriment of KID operations.

The unique opportunity to partnership in the Amon Basin could also lead to funding irrigation infrastructure projects that reduce costs for KID but also provide an environmental benefit to the Basin. It is our interest to mutually co-manage the Amon Basin in a manner where it becomes an attractive amenity to the community that provides a small showcase for salmonid enhancement efforts in a manner that also serves the interests of irrigators.

Sincerely,

Paul LaRiviere
Instream Flow Biologist
509 545-2057

cc: Project files
Easterbrooks, WDFW Region 3 Fish Program Manager
Harvester, WDFW Region 3 Habitat Manager
Bartrand, WDFW
Hoffarth, WDFW

**Comments received from Dale Bambrick**

Dale Bambrick with the NMFS complimented the research in a discussion on 1/25/2010. He commented that he believes restoration efforts in the Amon Wasteway system should be viewed as public relations or educational projects as opposed to projects intended to meaningfully increase fish production. Funding of any future efforts there should be considered accordingly.

F. Dale Bambrick, Eastern Washington Branch Chief
304 South Water Street # 201
Ellensburg, Washington 98926

**Comments received from Jeff Thomas**

Jeff Thomas with the USFWS complimented the research in a discussion on 1/25/2010. He shared that the Amon Wasteway had limited, if any, productive potential for salmonids and should not be considered a priority for salmonid restoration projects.

Jeff A. Thomas
USFWS, Mid-Columbia Fishery Resource Office
Yakima Sub-Office
1917 Marsh Road

**Comments received from Dave Fast**

David
Thanks for the opportunity, and the reminder, to review this report.
I read through the report this afternoon and believe that you achieved your goal of an independent review and assessment of the potential for salmonid rearing and production in Amon Wasteway. The reviews were comprehensive, the study was well designed, and the results and discussion were well written and explained that the wasteway did not have much potential for production of salmonids due to high temperatures and high fine sediment content in the gravel. I also agree with your belief that habitat improvement projects in the wasteway would not correct the existing problems of temperature and sediment.
Thanks for the opportunity to review.

David E. Fast, Ph.D.
Senior Research Scientist
Yakima/Klickitat Fisheries Program

**Appendix 7.** Detailed map of the Kennewick Irrigation District service area, Amon Wasteway meets the Yakima Delta near I-182.