Duck Creek Restoration Assessment Report

Mendenhall River Watershed in Juneau, Alaska

Prepared for: Juneau Watershed Partnership
June 2007

Production of this document was made possible through a 2006 Alaska Clean Water Actions (ACWA) grant from the Alaska Department of Environmental Conservation.

Purpose and Needs Statement

Duck Creek, located in the Mendenhall Valley in Juneau, Alaska, has experienced dramatic development in the last 50 years resulting in a decline in water quality and loss of fish habitat and populations. During the 1990s government agencies recognized this loss and the Alaska Department of Environmental Conservation listed this stream on its Alaska Clean Water Action list of impaired waterbodies. Numerous restoration projects were conducted in the following decade and a water quality monitoring plan was implemented. This report serves to identify the restoration projects that have been conducted and, based on current water quality data, assess the restoration progress on Duck Creek. Based on these findings and the results of current hydrologic studies new recommendations will be identified for future efforts on this creek.

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1. Introduction

Duck Creek is a small, clearwater stream located 13 miles northwest of downtown Juneau, Alaska in the heavily developed Mendenhall Valley (Figure 1). Duck Creek is one of five waterbodies draining the Mendenhall Valley including Jordan Creek, Mendenhall River, Montana Creek, and Pederson Hill Creek. Historically Duck Creek had numerous beaver ponds and supported spawning habitat for thousands of pink salmon (Koski, 1999). Modifications to Duck Creek as a result of urbanization include channel relocation, gravel mining, streambank encroachment, and road crossings. Natural processes affecting this stream include isostatic rebound as a result of relatively recent deglaciation and decreased availability of groundwater recharge. Over time the combination of urbanization and natural events has degraded the water quality of and fish habitat in this stream and caused pollutant levels to exceed state standards.

In 1999 the State of Alaska Department of Environmental Conservation (ADEC) identified Duck Creek as an impaired waterbody and listed it on their 303(d) list for dissolved oxygen, iron, turbidity, debris, and fecal coliform, thus nominating it as a priority stream for protection or restoration on the Alaska Clean Water Actions list. This report will evaluate progress towards reducing pollutant loads and improving fish habitat on Duck Creek by:

1. identifying recovery actions taken to date;
2. evaluating factors impacting reduced stream flow in Duck Creek; and
3. identifying future actions needed to restore water quality.

1.1. Evolution of the Mendenhall Valley

1.1.1. Natural History

The Mendenhall Valley formed around 1750 when the Mendenhall Glacier began retreating from its most advanced position of the last 13,000 years (Carstensen, 1995). Prior to the formation of the Mendenhall River, meltwater from the retreating glacier drained through the east side of the valley in the vicinity of present-day Duck and Jordan Creeks (Barnwell and Boning, 1968). In 1750 the glacier pulled away from its terminal moraine and meltwater began flowing west of these two streams to form the Mendenhall River. At this time, elevation of the valley floor was 5 to 10 feet lower than in 1995 (Carstensen, 1995).

As the Mendenhall Glacier continued to retreat, the subglacial Mendenhall Lake emerged around 1910. Formation of the lake allowed some of the sediment that would otherwise have been carried off by the Mendenhall River to settle out, increasing the river's ability to downcut. Eventually, the Mendenhall River became the only glacier-fed drainage in the valley and source water for Duck and Jordan Creeks was limited to groundwater and storm runoff resulting in clearwater flows that historically supported major salmon runs including an estimated 10,000 chums in Duck Creek (Koski and Lorenz, 1999).

With the weight of the glacier removed from the valley floor, isostatic rebound had initiated at a rate of ~.6"/year (Hicks and Shofnos, 1965) and continues to rise at this rate according to sea level changes shown by Coast and Geodetic Survey data collected via continuously monitored tidal gauges.

By the mid to late 1800s vegetation in the eastern part of Mendenhall Valley consisted of late-succession stage spruce forests. Today, only small portions of the original forest and wetlands of the Duck Creek Watershed remain and are, for the most part, isolated from the main channel, decreasing their ability to filter and buffer the stream (Adamus, 1987). In place of this natural land cover, impervious surfaces such as pavement and roads cover nearly 50% of the Mendenhall Valley. As a

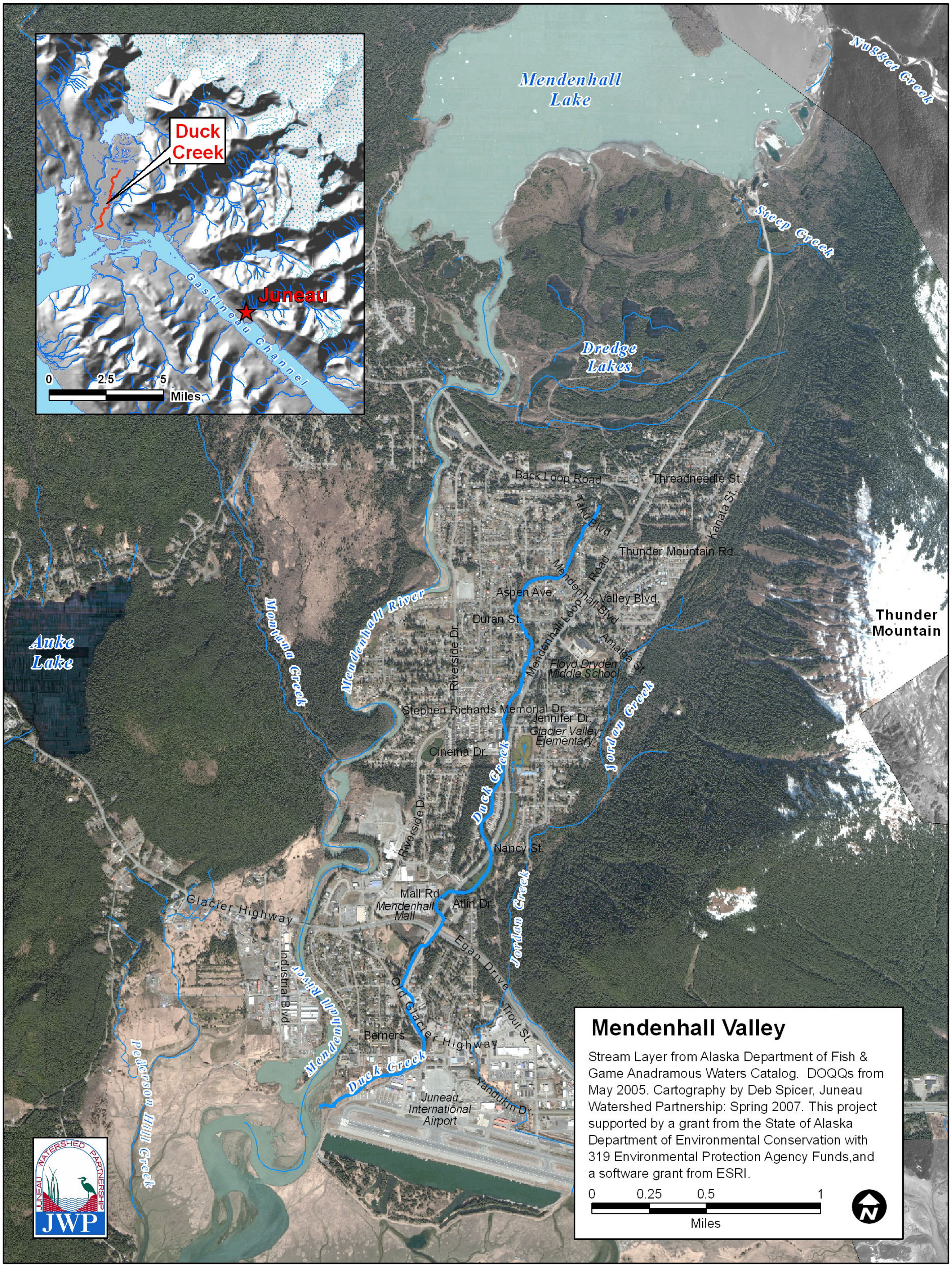

Figure1. Mendenhall Valley Base Map

result of development it is likely that Duck Creek has the smallest percent of remnant natural habitat of any watershed in Southeast Alaska (Figure 2).

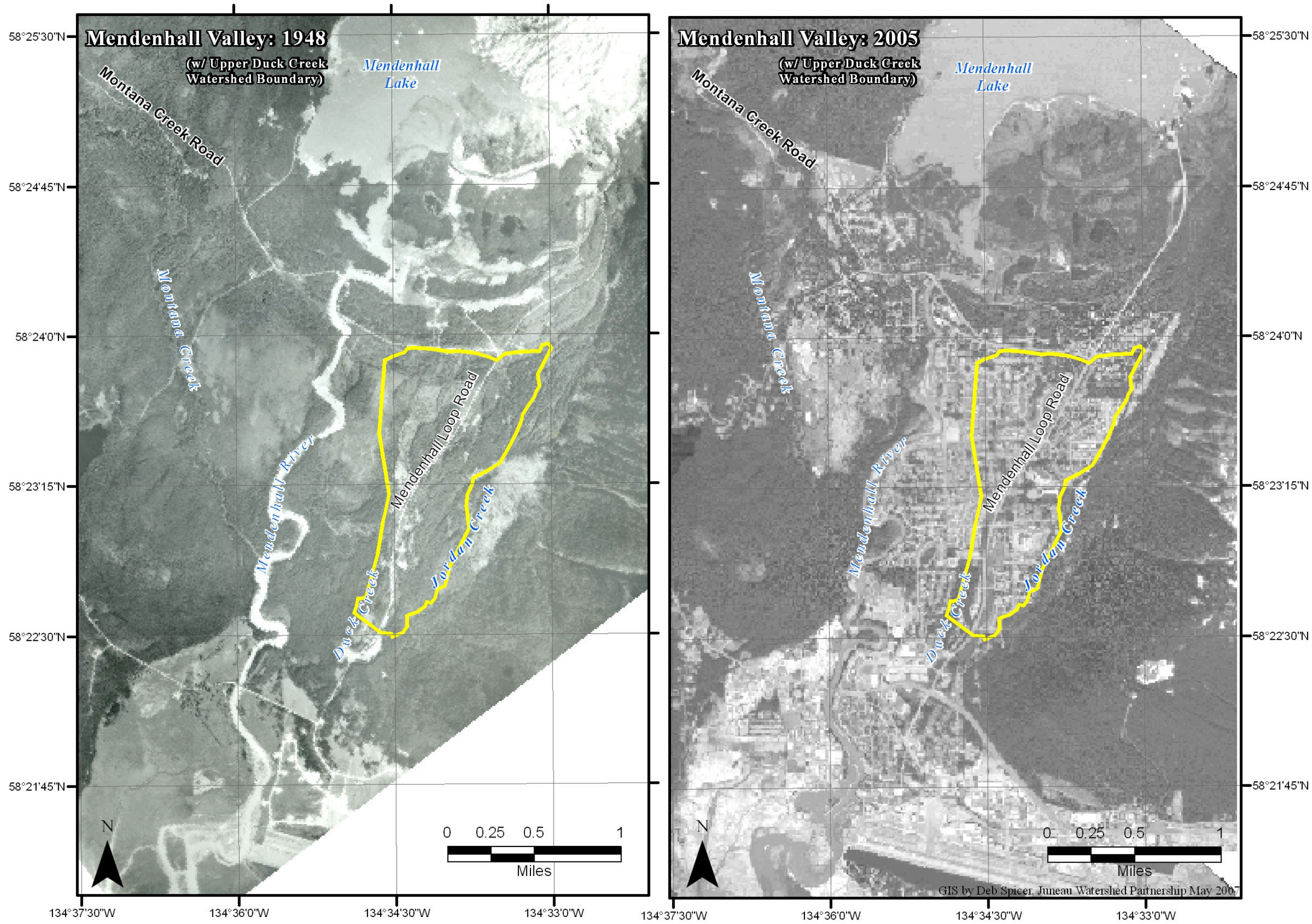

Figure 2. Mendenhall Valley Development: 1948 and 2005

1.1.2. Development Trends

Development trends in the Mendenhall Valley have been well documented by many researchers including: Fryxell, 2006; Koski & Lorenz, 1999; Carstensen, 1995; and the U.S. Army Corps, 2001.

In 1885 the first homesteader in the area, Daniel Foster, staked a 160-acre homestead near the mouth of the stream he eventually named “Duck Creek”. Fifteen years later the first road was constructed in the Mendenhall Valley to provide access to the hydroelectric plant on Nugget Creek and to harvest ice for cold storage (Koski and Lorenz, 1999). This development was quickly followed by the establishment of a 320 acre ranch operated by the Knudsen family at the mouth of Duck and Jordan Creeks, and the construction of a second dirt road by the AJ mine that followed Jordan Creek and met the route of present day Mendenhall Loop Road near Cinema Drive. By the 1920s local fur farms were harvesting Duck Creek’s salmon runs to feed their animals.

By the 1930s the Army airstrip at present day Juneau International Airport was in use and Duck Creek was diverted into the Mendenhall River. In the late 1930s the Kendlers (who purchased the Knudsen ranch to operate a dairy farm) cleared 30 acres of spruce forest on Duck Creek (including some specimens with trunks 5-6 feet across) to grow Kentucky bluegrass, timothy, rye, and clover for hay. In 1953 the Kendlers replaced their cattle farm on Duck Creek with the first commercial potato farm in

Southeast Alaska (Carstensen, 1995). Additional logging occurred around the Glacier Valley school site in the middle part of the 20th century.

Development pressures in the Mendenhall Valley became more aggressive during the 1960s when the first tract homes were constructed. With increased development came a need for gravel which was readily available in the glacial outwash materials from the historic flows in the Duck and Jordan Creek basins. Much of the middle section of Duck Creek was dredged for its well-sorted gravels resulting in the formation of long, linear ponds near Nancy Street (Figure 3).

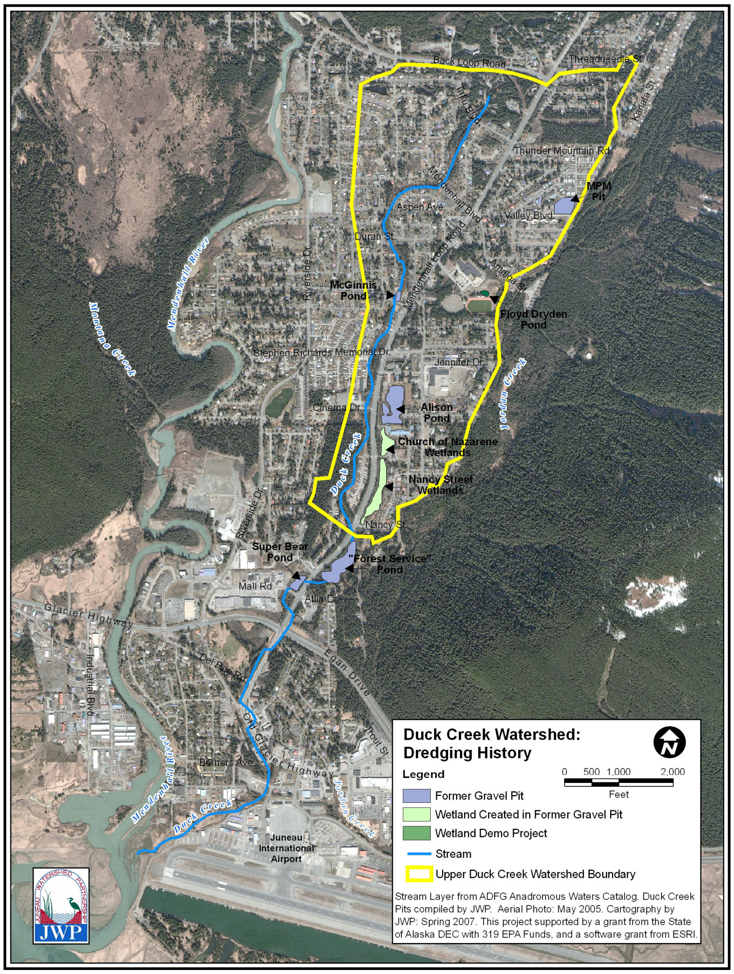

Figure 3. Duck Creek Watershed: Dredging History.

Immediately south of Mendenhall Lake is a complex of mostly groundwater-fed ponds known as Dredge Lakes. Some of the ponds are naturally occurring kettle ponds that formed in shallow depressions in glacial drift deposits formed from the melting glacial water during the retreat of the Mendenhall Glacier. In the 1960s additional ponds were dredged for gravel causing water to be rerouted away from the upper portions of the Duck Creek Watershed north of present-day Back Loop Road. With the development of the Mendenhaven Subdivision at the upper end of the watershed, the once braided channels of Duck Creek's headwaters were replaced with a single muddy ditch. At the lower end, near the airport, the stream flowed unprotected through a large borrow pit.

From 1962-1995 the number of public road crossings (excluding driveways and intermittent ditch-tributaries) on the Duck Creek system increased from 18-39. At that time, many of the culverts placed under the roads were inadequately sized and/ or perched. Thick iron flocculate impeded desired dissolved oxygen levels and encouraged undesirable algal growth. Natural ponds in the upper reaches eventually filled in with sediment from polluted streamside drainage (Adamus, 1987). The stream experienced exaggerated flooding due to increased stormwater runoff and dewatering events during annual low flows. In 1984 the lower reaches of Duck Creek from Berners Avenue to Glacier Highway were channelized. By 1989 over 60% of the wetlands in Duck Creek Watershed were filled (U.S. Corps, 2001), and more have been filled since. These wetlands functioned as filters for the watershed's high levels of dissolved iron through fixation and precipitation by the roots of certain aquatic plants. (U.S. Army Corps, 2001).

In 1987 the City and Borough of Juneau (CBJ) hired Adamus Resources, Inc. to evaluate the functions and values of all wetlands throughout the CBJ in an effort to identify locations for industrial and residential growth without violating existing laws or compromising local environmental integrity (Adamus, 1987). Each watershed was evaluated on an individual basis and compared to other watersheds in CBJ. Through detailed habitat surveys and winter population estimates it was determined that Duck Creek had the lowest percent cover of overhanging vegetation and shade, the least undercut banks, the highest percent cover of aquatic plants, and the deepest soft sediment deposits per reach of any stream in the study (Adamus, 1987).

The health of a watershed has been directly related to the percent of impervious cover (Scheuler, 1994), as it increases the rate that water and any pollution or impurities are deposited into a stream and removes natural filters such as wetlands and riparian vegetation. The presence of impervious surfaces greatly contributes to nonpoint source pollution and has been recognized as an indicator of urban/suburban stream quality. It has been calculated that 32% of the eastern portion of the Mendenhall Valley is covered by impervious surfaces (Carstensen, 1999). According to Scheuler (1994) watersheds containing >25% impervious surfaces are classified as non-supporting streams and have a highly unstable flow and poor biological condition, consistent with the findings in Duck Creek.

Cumulative impacts from development became more noticeable in the late 1980s and early 1990s as salmon populations dwindled, iron floc became more prevalent, and the stream began experiencing regular periods of low flow. Duck Creek's location in the center of the Mendenhall Valley residential and business area makes it particularly vulnerable to urban runoff and, as a result, Duck Creek has higher levels of heavy metals and hydrocarbons (U.S. Corps, 2001).

2. Water Quality

2.1. TMDLs/ Impairments

The Federal Clean Water Act (CWA) of 1977 was passed to regulate the discharge of pollutants into the waters of the United States with the intent to maintain and restore the chemical, physical, and biological integrity of the nation's waters. Under Section 305(b) of the CWA, the states are mandated to establish water quality standards and criteria for its protection. Water quality standards establish beneficial uses for each waterbody. Designated uses for Alaska's freshwater sources include water supply, recreation, and growth and propagation of fish, shellfish, other aquatic life, and wildlife. The criteria developed for protection of water quality is established as the amount of an identified pollutant that can be assimilated by a waterbody without impairing its designated use. In addition, states are mandated to provide water quality assessments of receiving waters and to identify and prioritize these water quality limited water bodies. Subsequently, Section 303(d) of the CWA requires states to develop waste load allocations, called Total Maximum Daily Loads (TMDLs) among the various sources of pollutants that are impairing the water body. A TMDL defines the degree of pollution control needed to maintain compliance with state water quality standards and defines the amount of pollutant input that can occur and still have the water body fully supporting its designated beneficial uses (EPA, 2000).

Duck Creek is in the ADEC Alaska Clean Waters Action (ACWA) Waterbody Recovery Track, with water quality being a primary concern. It is currently in Category 4a on Alaska's 2002/2003 Integrated Water Quality Monitoring and Assessment Report, for dissolved gas (low dissolved oxygen), residues, toxic and other deleterious organic and inorganic substances, fecal coliform bacteria, and turbidity. TMDLs have been completed for all these parameters. Diversion of flow is high in the watershed which could reduce streamflow and negatively impact aquatic life.

Duck Creek is one of eleven streams in southeast Alaska listed in 2007 by ADEC as impaired from runoff from non-point source pollution. This stream is included on the impaired water body list and is in need of recovery due to water quality concerns with sediment, residues (debris), turbidity, dissolved gas (low dissolved oxygen), fecal coliform, metals, petroleum aromatic hydrocarbons (PAHs), altered flows, and habitat modifications since 1994. These impairments have resulted in significant declines in salmon returns. In a draft water quality assessment for Duck Creek completed by ADEC in 1995, ADEC identified the stream as being water-quality-limited for all criteria listed above except PAHs for which they determined the data to be insufficient. Various past reports have identified restoration needs and/or recommended actions. A compilation of these recommendations is listed in Appendix A.

2.1.1. Alaska Water Quality Standards for Sediment, Debris, Turbidity, Dissolved Oxygen, and Fecal Coliform (from Duck Creek's TMDLs)

Sediment: *The percent accumulation of fine sediment in the range of 0.1 mm to 4.0 mm in the gravel bed of waters used by anadromous or resident fish for spawning may not be increased more than 5% by weight above natural conditions (as shown from grain size accumulation graph). In no case may the 0.1 mm to 4.0 mm fine sediment range in those gravel beds exceed a maximum of 30% by weight (as shown from grain size accumulation graph)… In all other surface water no sediment loads (suspended or deposited) that can cause adverse effects on aquatic animal or plant life, their reproduction or habitat may be present.*

Debris: *May not, alone or in combination with other substances or wastes, make the water unfit or unsafe for the use, or cause acute or chronic problem levels as determined by bioassay or other appropriate methods. May not, alone or in combination with other substances, cause a film, sheen or discoloration on the surface of the water or adjoining shorelines, or cause leaching of toxic or deleterious substances, or cause a sludge, solid or emulsion to be deposited beneath or upon the surface of the water, within the water column, on the bottom, or upon adjoining shorelines. The numeric target for Duck Creek's debris TMDL is zero, with no debris or solid waste allowed in Duck Creek or along its corridor.*

Turbidity: *May not exceed 5 nephelometric turbidity units (NTU) above natural conditions when the natural turbidity is 50 NTU or less, and may not have more than 10% increase in turbidity when the natural turbidity is more than 50 NTU, not to exceed a maximum increase of 15 NTU.*

Dissolved Oxygen: *Dissolved oxygen (D.O.) must be greater than 7 mg/L in waters used by anadromous and resident fish. In no case may D.O. be less than 5 mg/L to a depth of 20 cm in the interstitial waters of gravel used by anadromous or resident fish for spawning. For waters not used by anadromous or resident fish, D.O. must be greater than or equal to 5 mg/L. In no case may D.O. be greater than 17mg/L. The concentration of D.O. may not exceed 110% of saturation at any point of sample collection.*

Fecal Coliform: *In a 30-day geometric mean of 20 FC/100mL, with no more than 10 percent of the samples exceeding 40FC/100mL.*

2.1.2. Stream Flow

Low flow is potentially the greatest limiting factor of successful recovery actions on Duck Creek. Numerous channel relocations combined with the dramatic increase in the percentage of impervious surfaces in the watershed have contributed to low flows on Duck Creek. The Mendenhall Valley is naturally flat resulting in a low gradient for local streams and, for Duck Creek in particular, the streambed permeability may be naturally too high (Koski and Lorenz, 1999). Several reaches of the stream dry up each year and many juvenile salmon become stranded and die. Low flows also contribute to increased sediment and iron floc leading to reduced oxygen levels. Low flows are one of the most limiting factors for salmonids reproduction due to low or no fish passage, and inadequate dissolved oxygen levels (Bethers et al, 1995; Host and Neal, 2004) which lead to increased infiltration by iron sediment.

Low flows occur both in the summer and winter months and correspond to the periods when precipitation is lowest from June-August and December- March. Peak flow is between September and December. Peak flow data is available from the USGS website located on the World Wide Web at: http://nwis.waterdata.usgs.gov/ak/nwis/discharge.

A U.S. Geological Survey streamflow gage (USGS 15053200) located below Nancy Street recorded streamflow from the period 1994-2003. The mean annual flow for this period was 4.08 cfs. In 1998 a survey of hydrologic conditions was conducted on Duck Creek to provide baseline information prior to restoration activities and additional development. A detailed discussion of low flow, groundwater monitoring, and identification of reaches that go dry in the spring were included in the survey (Beilharz, 1998). Depth to groundwater was monitored in 14 wells from May –August 1997 and again in the winter of 1998. Results of the survey indicate that the water table is 3-8 feet below the surface of the stream in the area between (former) Egan Way and Glacier Highway during the driest times indicating that flows cannot be restored to the channel just by deepening the channel to access groundwater. In addition, the reaches that experience no flow are permeable and allow the surface water to flow directly into the ground, possibly due to existence of old residual glacial outwash channels, but more likely a result of ditching, channel relocation and, possibly, a lowering of the water table as a result of isostatic rebound.

Isostatic rebound has been identified as a likely contributor to declining stream flows and may be a factor in observed changes to habitat access and quality (Fryxell, 2006; Neal, 2005a). These low stream flows are an important limiting factor for fisheries, particularly during winter, as they reduce or even eliminate fish rearing habitat by isolating pools, decreasing depth and volume, stranding fish, and limiting or preventing access to habitat during critical life stages (Fryxell, 2006). Neal (2007) has recognized a relationship between uplift and channel incision and points out that channel incision rates are strikingly similar to rates of decline in water table elevations: 0.03m/year for incision compared to 0.03m/year for decline in water table elevation. Neal hypothesizes that it is likely that the Mendenhall River is functioning as a localized base level for groundwater discharge as groundwater elevations appear to be rising and falling in relation to river stage, which is decreasing due to increased channel incision by the Mendenhall River. Carstensen (1995) also recognized the possibility of the Mendenhall River pirating water from the Duck Creek Watershed. Data indicate that as flow stage elevations increase in the late spring and summer for the Mendenhall River, groundwater elevations also increase. Elevations decline in October and November as cooler temperatures decrease glacial melt waters even though precipitation increases. Stage heights for both surface and groundwater are lowest during late winter and early spring as glacial melt water and precipitation contributions are minimal. This aquifer is also the primary source of flow for Jordan and Duck Creek Watersheds.

Hydrologic processes in the Mendenhall Valley are further complicated by a seasonal migration of the boundary between the upper Duck and Jordan watersheds (Beilharz, 1998). However, during the times when the Duck Creek Watershed groundwater is low and the Thunder Mountain fans are well-charged, Duck Creek might benefit from aquifers that usually provide flow to Jordan Creek.

2.1.3. Sediment

Urban non-point source runoff is the main source of the sediment/turbidity, hydrocarbon, and heavy metals concerns in Duck Creek, and contributes to low dissolved oxygen. Other sources of pollution resulting in impairment are sewage, landfills, nutrient introduction from fertilizers, yard waste, wildlife, and pets (Koski and Lorenz, 1999). Non-natural sediment loads are derived from surface runoff from disturbed ground at construction and utility installation sites, and from winter road maintenance activities. These elevated sediment loads can be introduced during both high precipitation periods due to surface runoff or from street maintenance and snow plowing. Although petroleum by-products and heavy metals may be introduced directly into a stream by surface runoff they may also be picked up and transported by sediment and soil particles. As a result, these pollutants can be introduced during street maintenance practices such as snow being plowed directly into the stream (Koski and Lorenz, 1999; TEAM Tsunami, 2005).

The primary source for most heavy metals in the Mendenhall Valley is synthetic rubber (i.e. tires), paint, or brake dust (Koski and Lorenz, 1999; TEAM Tsunami, 2005). PAHs are derived from roads, parking lots, private vehicle oil changes, and spills of heating oil, leaky fuel tanks, and illegal dumping of petroleum based products. PAHs are not only toxic to people but have also been found to have lethal consequences on the eggs of coho and chum salmon eggs when the concentrations were as little as 15 ppb (Koski and Lorenz, 1999).

2.1.4. Debris

Debris is an on-going problem in all urban streams throughout the CBJ. The major effects of debris and solid waste on uses of Duck Creek identified in the 2000 TMDL include: negative impacts on recreational uses, creation of nuisance conditions that may attract undesirable wildlife species, and potential adverse effects on resident fish populations and their habitat. Debris in Duck Creek can clog culverts, altering flow patterns leading to potential flooding and limiting fish migration.

Figure 4. An engine that has been dumped into Duck Creek next to Super Bear, May 2007.

The primary sources of debris in Duck Creek are littering and inadequate storage of garbage at residential and commercial properties, but occasional deliberate "dumping" is also a concern (Figure 3). Ongoing education and outreach to teach residents to secure their garbage from ravens and bears can help reduce debris accumulation, but regular community clean ups are necessary. The Juneau Watershed Partnership's (JWP) Adopt-a-Stream program encourages groups to adopt a section of Duck Creek to regularly clean up. JWP coordinates with Litter Free, Inc.'s annual spring community clean up to pick up the winter's accumulation of trash, and then hosts another stream clean up in the fall to specifically target local streams.

2.1.5. Turbidity

Turbidity is an optical measure of water related to light transmission and is a measure of the total amount of light-scattering particles in a water sample (EPA, 1999). Due to various data limitations on Duck Creek at the time the TMDL for turbidity was developed, it was not possible to establish a relationship between turbidity and total suspended solids (TSS) or suspended sediment concentration (SSC) using local data. For the purposes of the Duck Creek TMDL, a 1:1 ratio was assumed although it was recognized that this may result in an underestimate of the amount of sediment in Duck Creek. In addition to watershed related (runoff) sources, groundwater-discharged iron that precipitates as iron floc has been identified as the primary concern of impairment for this TMDL. Therefore, turbidity issues on Duck Creek may be directly related to flow.

2.1.6. Dissolved Oxygen/ Iron

The inflow of low D.O. and iron-rich groundwater into Duck Creek has substantially increased since development first began in the Mendenhall Valley in the 1940s. Three main factors, ground disturbance, isostatic rebound, and the loss of wetlands, combined with the presence of a naturally-occurring layer of glaciomarine deposits that is high in iron, contribute to this increase.

Section 2.1.2 discussed how isostatic rebound has largely eliminated surface flow to both Jordan and Duck Creeks, decreasing overall flow and increasing the dependability of groundwater recharge for the viability of these streams. In the past flows were strong enough to flush out any iron that entered the stream preventing it from accumulating the way it does today (Figure 4).

Land disturbances such as excavation during development increase groundwater exposure to surface oxidation and further disrupt surface and groundwater flow paths to Duck Creek, which subsequently increases the likelihood of groundwater becoming exposed to D.O. and forming a floc that accumulates on the substrate. Overall development and increased urban runoff also contribute to lower D.O. from the accumulation of more nutrients and deicing chemicals, as they require large amounts of oxygen for their breakdown (Koski and Lorenz, 1999).

Figure 5. Iron floc in a ditch near Short Court that flows into Duck Creek.

The loss of wetlands in the Duck Creek Watershed has also contributed to increased iron floc. Numerous wetlands in the watershed were comprised of plants capable of oxidizing the iron at the root rhizosphere, preventing the iron from entering the stream. When groundwater flowed through these wetlands the iron and sulfides were oxidized within them resulting in the discharge of water with substantially lower iron and sulfate contents (Koski and Lorenz, 1999).

Groundwater in the Mendenhall Valley is the primary source of the D.O. impairment in Duck Creek due to the high content of dissolved ferrous iron and sulfides, the naturally low oxygen content of the groundwater discharging into it, and in-stream alterations (Hood, et al., 2005; TEAM Tsunami, 2005; E.P.A. 2001, Koski and Lorenz, 1999). The high iron and sulfide contents are the products of solution that occurs as the area's groundwater flows through the Mendenhall Valley's underlying glaciomarine deposits. These two products are very unstable under surface conditions and, as a result, they oxidize very quickly once the groundwater discharges into the stream and large amounts of oxygen are consumed (Hood et al., 2005). This oxidation produces the ubiquitous iron floc which covers much of the bottom of Duck Creek and clogs the interstitial spaces between gravels, drastically reducing productive habitat for fish and aquatic insects. D.O. levels in these conditions are typically less than 2.0 mg/L and have been found to be as low as 0.61 mg/L (E.P.A. 2005; Koski and Lorenz, 1999). State water quality criteria requires D.O. levels greater than 7 mg/L for water used by anadromous and resident fish while D.O. levels within spawning gravels must be at least 5.0 mg/L (E.P.A., 2001). Iron floc provides an energy source for iron-fixing bacteria. This combination of dissolved iron and the action of the bacteria results in a chemical reduction that lowers the concentrations of D.O. (U.S. Corps, 2001) resulting in a nearly sterile stream in many reaches.

2.1.7. Fecal Coliform

Most exceedances of the fecal coliform water quality standard in Duck Creek occur with high flows, indicating the origin to be nonpoint sources associated with storm water runoff (EPA, 2000a). Data from the 2000 TMDL identify ponds located between Taku Boulevard and Nancy Street as potential sources of fecal coliform. This area attracts numerous wild ducks and is a popular place for residents to walk their dogs. Without a point source of fecal coliform in this watershed, it may be possible that the underlying issue with the fecal coliform problem is a lack of flow to flush these bacteria out of the stream, causing the bacteria to accumulate to levels that exceed the state standard.

3. Fish and Fish Habitat

Historically, Duck Creek was reported to have runs of up to 10,000 chum salmon, and as recently as 1966 the coho escapement was 500 fish (Bethers, 1995). Beginning in the late 1980s iron sediment was discoloring the water too much to be able to count spawners. Based on the most recent data from 2001, the chum run was extinct, the coho run was less than 20 fish, and the once notable trout fishing was and remains closed (U.S. Corps, 2001).

Nearly all the issues that affect water quality affect fish habitat. However, the water quality itself affects fish habitat along with seasonal loss of stream flow and loss of riparian zone functions.

Due to low/no flows during the spring smolt migration, low D.O. levels, too much sediment resulting in poor spawning and incubation conditions, and lack of large woody debris necessary to form backwater pools, Duck Creek can no longer provide viable habitat for salmonids.

Although anadromous fish populations are currently nonexistent in Duck Creek, the stream continues to provide overwintering habitat for coho salmon migrating out of other local streams and the Mendenhall Wetlands. In 2001 approximately 2,000-4,000 of these cohos migrated out of Duck Creek in the spring as smolts (U.S. Army COE, 2001). With the increasing occurrence of low flows in the spring timed with the out migration of overwintering salmon, many of these fish are becoming stranded and are dying before they make their way back to the ocean.

4. Historic Recovery Actions

4.1. Restoration Projects

Numerous reports have identified water quality issues and provided recommendations to restore Duck Creek including ADFG (1994), R&M Engineering (1996), Beilharz (1998), Koski and Lorenz (1999), and the U.S. Corps of Engineers (2001). These recommendations have been compiled in Appendix A.

In 1993 concerned citizens joined together to form the Duck Creek Advisory Group to coordinate, plan, initiate, and carry out activities to restore Duck Creek's water quality, fish habitat, and estuarine wetlands and developed the Duck Creek Watershed Management Plan to provide a science-based restoration plan (Koski and Lorenz, 1999).

In 2001 the Alaska District, U.S. Army Corps of Engineers and CBJ proposed to restore the aquatic ecosystem on Duck Creek. The Alaska District conducted this project under the authority of Section 206 of the Water Resources Development Act of 1996 which provided cost sharing opportunities for state, local, and tribal governments for the improvement of habitat quality for fish and wildlife resources.

Based on recommendations from these various reports and management/ recovery plans, numerous recovery actions have been implemented on Duck Creek including culvert replacements, streambank stabilizations, revegetation projects, wetland creations, community clean ups, and habitat enhancements. More studies have been conducted and restoration actions have been implemented on Duck Creek than in any other watershed in the Juneau Borough to date. These projects have been identified and mapped in Figure 5 and are listed in Appendix B.

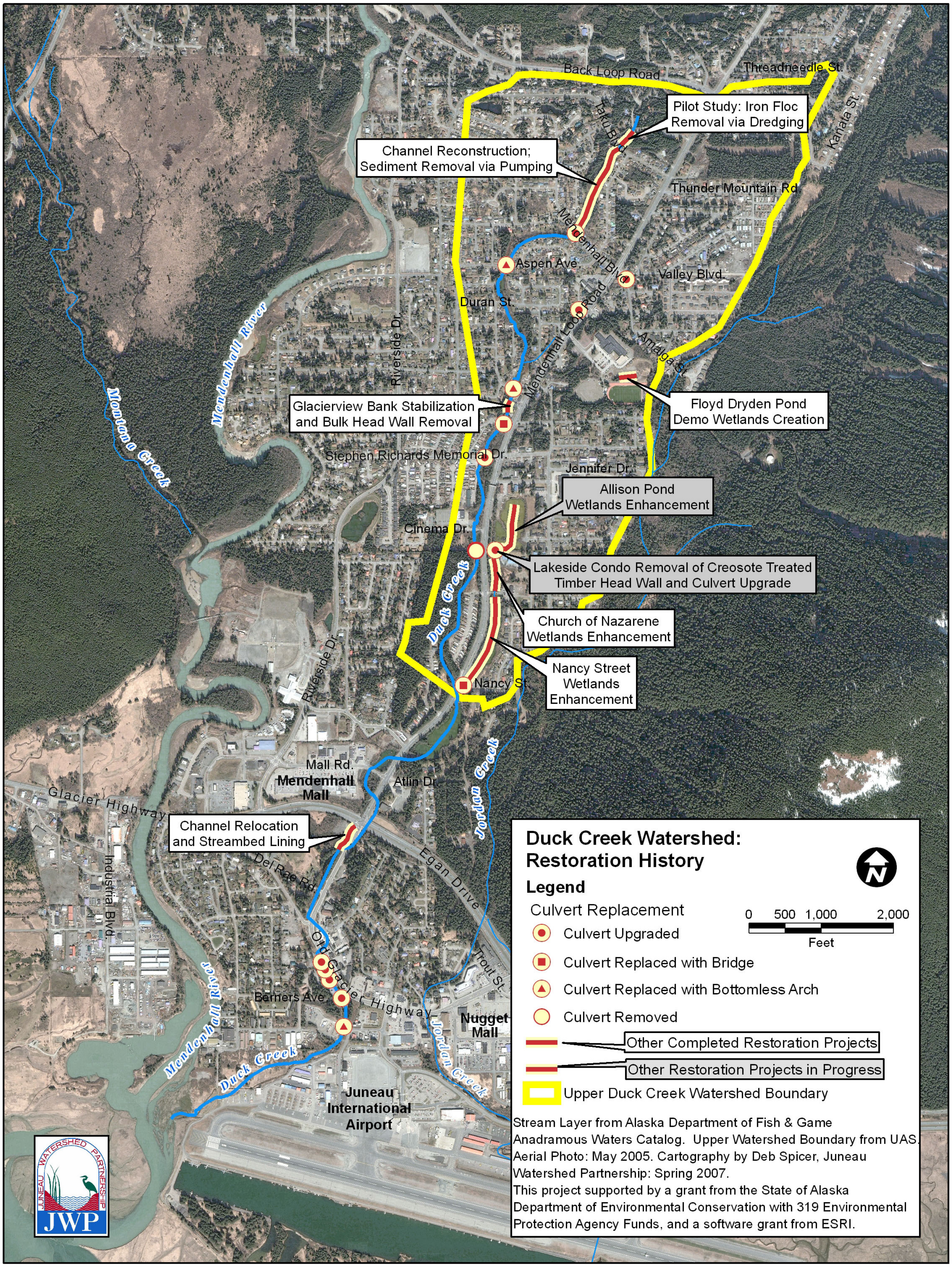

Figure 6. Duck Creek Watershed: Restoration History

4.2. Historic Water Quality Data

Between 1993-1999 little water quality data had been collected on Duck Creek, but no analysis of groundwater-stream flow interactions had been conducted. Koski and Lorenz (1999) compiled and published water quality data available at the time of their publication.

Data sources used for the TMDL included:

Fecal Coliform

- 1992-1993 Alaska Water Watch Water Quality Monitoring (JYS students)
- 1994-1998 USGS Water Quality Sampling and Flow Gage Monitoring
- 1994-1995 and 1998 ADEC Water Quality Monitoring

Debris

- Best judgment for debris totals

Turbidity

- 1992-1993 Alaska Water Watch Water Quality Monitoring (JYS students)
- 1994-1998 USGS Water Quality Sampling and Flow Gage Monitoring

Dissolved Oxygen and Iron

- 1992-1993 Alaska Water Watch Water Quality Monitoring (JYS students)
- 1994-1995 ADEC Water Quality Monitoring
- 1994-1997 NMFS Sampling
- 1996 USGS Water Quality Monitoring
- 1994-1998 USGS Flow Gage Monitoring
- 1997 USDA Forest Service Iron Sampling
- 1999 Groundwater Monitoring

4.3 Current Water Quality Data

The University of Alaska Southeast (UAS) has been monitoring Duck Creek water quality since 2004 through ADEC grants funded with 319 EPA funds acquired by JWP (formerly Mendenhall Watershed Partnership). Results from the 2006 final report indicate:

> *Duck Creek continues to suffer from low in-stream flow, except for during large precipitation events. Bimonthly discharge measurements between January and June, 2006, did not exceed 2.1 cfs. Dissolved oxygen levels continue to regularly fall below state standards for aquatic life. On some dates, temperatures observed at DC-B and DC-C exceed the 13^{o}C limit for egg and fry incubation and spawning, and the 15^{o}C limit for migration routes and rearing areas. pH values were centered near and at times below (especially at site DC-B) the state water quality standard of 6.5 for aquatic life, at least during the morning sampling events conducted for this study (variations in pH are expected based on time of day and amount of sunlight). Large amounts of iron floc were noted at all sites, with particularly high amounts at DC-A, where the streambed is thickly coated in floc that easily resuspend if disturbed. Construction of wetland habitat and channelization of the stream above Nancy Street (DC-B) is expected to improve fish and wildlife habitat, reduce turbidity and iron levels, and raise pH and D.O. in the future; however, short-term impacts of the construction included major surges in turbidity and TSS immediately downstream of the construction area. Salt application to roads in the Mendenhall Valley appears to have detectable impacts on Duck Creek, particularly at the lowermost site, where*

zero to low flows exacerbate the problem with low dilution potential. While the effects of salting included sharp rises in Na, Mg, and Cl levels in the stream, the concentrations of Cl (max. 200 mg/L) did not violate the EPA secondary drinking water standard (250 mg/L) nor the acute freshwater criterion (860 mg/L) but approached the chronic freshwater criterion (230 mg/L). (Nagorski et al, 2006)

5. Summary

The Mendenhall Valley is a geologically young system and current natural processes are still shaping it. The relatively recent retreat of the Mendenhall Glacier and resultant land-surface uplift, the formation of the Mendenhall River, and urban development all occurred simultaneously. This increased the complexity of the hydrology in this system and challenges our current understanding of the relationships between surface water in Duck and Jordan Creeks, the Mendenhall River, and groundwater. In addition to these natural processes, human impacts such as nonpoint pollution from development, changes to groundwater recharge processes, the filling of wetlands, and vegetation removal further altered the watersheds in the valley and hindered the ability of the streams to function properly and to recover on their own.

Several studies have been conducted and restoration activities have been implemented to address human-induced issues on Duck Creek however, current water quality data indicate that it still does not meet Alaska State standards for D.O., temperature, and pH. Iron floc and salt are still present in the stream.

6. Discussion

Small streams throughout Southeast Alaska provide important wildlife habitat for numerous species ranging from birds to mammals to insects to fish including the rearing and spawning of wild, native salmon. It is believed that streams less than 20 feet wide produce more than 80% of the coho salmon, 60% of the pink salmon, and 90% of the Dolly Varden trout populations throughout the region (Koski and Lorenz, 1999).

Southeast Alaska is relatively undeveloped, but streams in Juneau have suffered similar impacts to streams in larger urban areas in the lower 48 as a result of increased impermeable surfaces and stormwater runoff. Addressing these issues requires a collaborative effort from all stakeholders in a watershed. It is necessary for the community to decide the relative importance of issues such as free-flowing streams with salmon and trout, health concerns, and flood risks and to take actions based on these decisions. It is easier and more cost-effective to protect a stream than to restore a stream.

The CBJ Comprehensive Plan (2007) recognizes the ecological, recreational, and scenic values of streams as well as the floodway and floodplain values of stream corridors. Adamus (1987) identifies non-renewable uses for Duck Creek such as development for residential and/or commercial usage, for drainage containment or as a greenbelt (preferable publicly owned) to provide open space amidst urban construction. Numerous benefits of open spaces and recreational attractions have been identified including increased outdoor exercise reducing health care costs; increased tourism; and business relocation and expansion to take advantage of this outdoor amenity (Hamilton Conservation Authority, 2003). Proximity to a waterbody is often used as a marketing tool in real estate. A 1991 study by the American Housing Survey conducted by the Department of Housing and Urban Development and the Department of Commerce determined that the value of a home located within 300 feet of a waterbody is 27.8% higher than the value of a similar home located away from water (National Association of Homebuilders, 1993). The EPA recommends that the beautification of areas adjacent to waterways and detention ponds should be integral to development plans as it increases property value while enhancing the quality of life (EPA, 1995).

As demonstrated here, numerous restoration projects have been implemented on Duck Creek but water quality and fish habitat remain impaired. Urbanization has long been a force in the decline of this stream, but it is believed that natural processes also play a role in the low flow problem on Duck Creek. If the water table in the Mendenhall Valley has already begun to drop and is expected to continue in this way, is it reasonable to alter other natural systems to defy the implications of this to "save" Duck Creek at the expense of other systems? Is it worth sacrificing one stream (i.e. diverting flow from another system such as Jordan Creek) to save another?

It can be argued that development in the Mendenhall Valley has had a larger impact than the natural processes, but perhaps at this point we should refer to Duck Creek as an example of what not to do and why planning in the form of stream setbacks and stormwater management should be implemented prior to development. Watershed management works best when there is opportunity for planning, protection and prevention. At this point in the development of our country, natural resource management often involves restoration, but Alaska still maintains undeveloped watersheds that provide opportunities for planning watershed management. With limited available funding and reductions in federal budgets, it is prudent to prioritize efforts for stream restoration and to grasp opportunities to conserve intact watersheds.

In the past 10 years, the community perception of Duck Creek has changed and the value of the stream for its fish populations is being reconsidered. Various individuals, agencies, and organizations have commented that the efforts on Duck Creek should be redirected to improving aesthetics, stormwater management, and developing a recreational greenbelt along this corridor. Recent wetland enhancement projects on gravel pits at Nancy Street and the Church of the Nazarene demonstrate the success of these projects in beautifying the watershed, providing open space (and in the case of the Nancy Street wetlands, a recreational opportunity through the development of a trail), and improving habitat for wildlife. The wetland enhancement and trail development near Nancy Street have been accepted by many neighbors and community members who expressed that the reclamation was an improvement to their neighborhood (CBJ Engineering, 2006). Future water sampling may determine that these wetland creations are also improving water quality, but the immediate benefits are tangible by relaxing on the new bench that was constructed next to the wetlands and watching the dragonflies fly by during a June afternoon.

Although Duck Creek no longer provides viable fish habitat, it should continue to be valued and enhanced for wildlife habitat, aesthetics and recreational opportunities. These can be enhanced by constructing more wetlands similar to the Nancy Street wetlands enhancement project and by encouraging CBJ to acquire the corridor along the stream to develop a greenbelt and trail to connect with other trails in the Mendenhall Valley.

It is questionable as to what extent funds should continue to be allocated to restoring fish habitat and water quality on Duck Creek when numerous other streams in CBJ merit protection or recovery actions. Other waterways in CBJ that provide viable fish habitat worth investing in include Sawmill Creek, Cowee Creek, Peterson Creek (out the road), Montana Creek, Auke Lake, Steep Creek, Jordan Creek, Fish Creek, and Peterson Creek (on Douglas Island), just to name a few.

7. Conclusions

It is impossible to restore Duck Creek to its pre-development condition. The hydrologic characteristics of the watershed have been permanently altered and development prevents the creek from being restored to its original channel. Although it may not be possible to correct habitat modifications made to Duck Creek, this stream still functions for stormwater removal, provides open space and wildlife habitat, and has potential to be an aesthetically pleasing recreational greenway corridor through the center of the Mendenhall Valley.

Songbirds, shorebirds, waterfowl, raptors, insects, and common mammals such as porcupine, river otters, squirrels, voles, mice, black bear, black-tailed deer, and mink continue to use the Duck Creek corridor as residents or migrants, particularly in the lower reaches where the stream is adjacent to the Mendenhall Wetlands and is used for rearing and spawning by other marine species such as eulachon, sandlance, capelin, herring, salmon, and Dungeness crab. Although Duck Creek may not provide viable fish habitat, the watershed should still be considered as habitat for other wildlife.

Despite its water quality impairments and lack of fish habitat, Duck Creek is still valuable to the community as an educational and recreational resource. The creek corridor is used and could be enhanced further as a greenway and trail corridor to connect the Mendenhall River trail system with the proposed Thunder Mountain trail on the east side of the valley. Local schools and UAS recognize the values of Duck Creek as an outdoor laboratory to conduct water quality monitoring and to study aquatic ecology.

Although Duck Creek may not support viable anadromous fish populations again, improvements to water quality and wetland development will benefit the entire ecosystem as a whole and improve the quality of the community living in the watershed.

References

Adamus Resource Assessment, Inc. 1987. Juneau wetlands: functions and values. Prepared for City and Borough of Juneau, Alaska Department of Community Development.

ADEC. 2007. ACWA priority waters index. <http://www.dec.state.ak.us/water/acwa/app_d_08_acwa_priority_waters_actions.xls> May 10, 2007.

Barnwell, W.W. and C.W. Boning. 1968. Water resources and surficial geology of the Mendenhall Valley, Alaska. U.S. Geological Survey Hydrologic Investigations Atlas HA-259.

Beilharz, M. 1998. Duck Creek hydrology baseline conditions. Prepared for National Marine Fisheries Service, Auke Bay Laboratory. U.S.D.A. Forest Service. Juneau Ranger District, Tongass National Forest.

Bethers, M., K. Munk, and C. Seifert. 1995. Juneau fish habitat assessment. Alaska Department of Fish and Game. Douglas, Alaska.

Carstensen, R. 1995. Duck Creek water watch report. *Two Centuries on Duck Creek.* Discovery Foundation. Juneau, Alaska.

CBJ. 2007. Annoted 2007 Draft CBJ comprehensive plan, dated February 20, 2007. http://www.juneau.org/plancomm/TXT2006-00003_042407.php

CBJ. 2006. Nancy Street wetland enhancement: Assessment of design and construction. Engineering Department. Juneau, Alaska.

EPA. 1995. Economic benefits of runoff controls. Office of Wetlands, Oceans and Watersheds (4503F). EPA 841-S-95-002.

EPA. 1999. TMDL for turbidity in the waters of Duck Creek in Mendenhall Valley, Alaska. Alaska Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska.

EPA. 2000a. TMDL for fecal coliform bacteria in the waters of Duck Creek in Mendenhall Valley, Alaska. Alaska Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska.

EPA. 2000b. TMDL for debris in the waters of Duck Creek in Mendenhall Valley, Alaska. Alaska Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska.

EPA. 2001. TMDL for dissolved oxygen and iron in the waters of Duck Creek in Mendenhall Valley, Alaska. Alaska Department of Environmental Conservation, 410 Willoughby Avenue, Suite 303, Juneau, Alaska.

Ferlauto & Associates. Inc. 2001. Mendenhall Watershed action strategy. Prepared for Mendenhall Watershed Partnership. Juneau, Alaska.

Fryxell, J. 2006. Draft Mendenhall Watershed assessment. Juneau Ranger District, Tongass National Forest. USDA Forest Service, Region 10, Alaska.

Hamilton Conservation Authority. 2003. A Conservation Strategy. Healthy Streams…Healthy Communities.
http://www.protectingwater.ca/protectingWater/uploads/HCA%20Conservation%20Strategy.pdf

Hicks S.D. and W. Shofnos. 1965. The determination of land emergence from sea-level observations in southeast Alaska. Journal of Geophysical Resources. 70:3315-3320.

Host, R.H. and E.G. Neal. 2004. Baseline Characteristics of Jordan Creek, Juneau, Alaska. U.S. Geological Survey Open File Report 2004-1220.

Koski, K and M. Lorenz. 1999. Duck Creek Watershed management plan. Prepared for the Duck Creek Advisory Group and the 319 Program of the Clean Water Act.

Nagorski, S., E. Hood, L. Hoferkamp. 2006. Watershed protection and recovery for Duck Creek, Juneau, AK. FY 2006 Final Report. Project #ACWA-06-09.

National Association of Homebuilders. 1993. Housing economics. National Association of Homebuilders. Washington, D.C.

Neal, E.G. 2007. Personal Communication.

R&M Engineering. 1996. Mendenhall Valley drainage study. Prepared for the City and Borough of Juneau. Contract no. E89-130.

Schueler, T. 1994. The importance of imperviousness. Watershed Protection Techniques, 1: 100-111.

Strecker, E., M. Lorenz. 1994. Duck Creek Watershed action plan. Alaska Department of Fish and Game. Douglas, Alaska.

Team Tsunami: Brooks, W., C. Craig, J. Fanning, B. Rohm, C. Good, Coach. 2001. Natural and human history of the Mendenhall Watershed near Juneau, Alaska: A plan for managing the watershed. Juneau-Douglas High School, Juneau, Alaska.

U.S. Army Corps of Engineers, Alaska District. 2001. Aquatic ecosystem restoration Duck Creek, Juneau, Alaska. Environmental Assessment and Finding of No Significant Impact.

Appendix A. Previously Published Recommendations for the Restoration of Duck Creek

Strecker and Lorenz, 1994

Implement Best Management Practices (BMPs) including:

- Educational programs for residences and businesses
- Establish new development controls/standards
- Structural controls
- Illegal dumping/ illicit connection detection and elimination programs
- Highway runoff BMPs
    - Structural retrofit controls could be considered, along with evaluations and altering maintenance and de-icing activities to reduce pollutants
- Ensuring compliance with NPDES regulations
    - The airport and other industries can be checked to make sure they have obtained a permit and are complying with permit conditions
- Flow augmentation
- Stream restoration
    - Restore riparian vegetation in open areas
    - Regrade selected portions of the stream so that the creek is lowered to shallow groundwater levels.

R&M Engineering, 1996

Improve numerous inadequate culverts and ditches with inadequate grade that were contributing to flooding.

Beilharz, 1998

- Improve the stormdrain system to alleviate flooding as recommended by R&M Engineering (1996); stormdrain system should be designed to augment flow.
- Prevent hydrocarbons by designing new developments with urban stormwater controls and retrofitting key areas with urban stormwater treatment systems such as settling ponds, oil traps, or oil skimmers.
- Prevent sediment by:
    - Requiring BMPs for sediment control at construction sites; enforce permit stipulations
    - Look at size and gradient of gravel applied in the winter
    - put snow fences at road crossings
    - educated public to push snow away from the creek
    - in some areas restoration of the channel shape and gradient may increase velocity allowing fine sediments to be flushed out of the steam.
- Restore flow to the channel by:
    - Adding water the maintain streamflow during the desired times without and channel modifications.
        - Transport water from Dredge Lakes area;
        - Utilize water from the east edge of Thunder Mountain;
        - Reconstruct a pipe to carry water from Nugget Creek
    - Modify the channel do the flow is less dependent on groundwater.
    - Modify the channel and augment flow.

- Remediate high concentrations of dissolved iron:
    - Prevent additional iron from entering the stream by developing an understanding of where the groundwater has high concentrations of iron and treat it prior to entering the stream.
    - Treat incoming water where the concentrations of iron are the highest and are already entering the stream by:
        - Use iron precipitating or binding material that can be placed at seep areas in the mainstream (above Duran and below Berners Ave.).
        - If ponds are contributing, fill the ponds to above the groundwater inflow depth and establish vegetation.
- Improve culvert sizing and placement to restore aquatic habitat, channel morphology, and flow.

Koski and Lorenz, 1999

- Enforcement
    - Enforce existing ordinances that protect watershed functions- Local, State, and Federal
    - Enforce policies supporting land-use activities and BMPs that protect watershed functions
    - Inform, educate, and develop a community conservation ethic to limit the need for enforcement
- Management
    - Develop more local expertise on integrating watershed protection BMPs into local situations
    - Establish partnerships to produce broadly beneficial solutions to watershed issues
    - Explore alternative means of wetland management (e.g., mitigation banking, conservation easements)
    - Adopt BMPs based on functional standards (e.g., vegetated surface treatment areas are more efficient and less costly to maintain than structural sediment and oil/water separators)
    - Implement proactive management policies for developing issues (e.g., stormwater treatment)
    - Decrease pollution from management activities (e.g., snow management, transportation, utilities)
    - Maintain specific drainage boundaries and protect stream flow
    - Develop construction standards that limit water quality problems from low dissolved oxygen and iron pollution through less exposure of groundwater
    - Use standards for stream crossings that provide for channel maintenance and fish passage, rather than simply flow routing
    - Provide incentives for development that minimizes land-use (e.g., cluster development, infilling, redevelopment)
    - Require new development to integrate stormwater management into construction
    - Develop policies and incentives to reduce traffic and parking demands
    - Limit use of garden chemicals
    - Require runoff from impervious areas (e.g., roofs, roads) and disturbed soils to be routed to treatment areas
    - Utilize landscaping areas as treatment areas (lawns, flower beds, medians, etc.) as stormwater treatment areas

    - Manage riparian areas to benefit water quality, fish habitat, flood attenuation, and aesthetics
    - Consider aesthetics in management and development
- Restoration
    - Create wetlands in borrow pits to function as stormwater treatment systems
    - Develop adequate riparian setbacks along stream channels and untreated drainages to filter pollutants
    - Reduce levels of dissolved iron from discharging groundwater by capping such areas with organize fill, planting with riparian/aquatic plants, mechanically aerating water at the source, or increasing flow volume to dilute and mobilize iron floc
    - Augment flow in the mainstem of Duck Creek
    - Line sections of the stream channel that go dry with impervious material
    - Replace stream crossings that are poorly designed for flood capacity or fish passage
    - Fence areas or develop riparian buffers where snow is customarily plowed into stream channels or untreated drainage areas
    - Restore channel form and substrate in salmon spawning areas.

Koski and Lorenz (1999) recommend the following for improving stream flow:
1. Channel water from Nugget Creek into Duck Creek (Koski and Lorenz (1999) preferred alternative);
2. Channel water from Dredge Lakes into Duck Creek;
3. Access and utilize groundwater from the east edge of Thunder Mountain through existing wells or diversions and route it to Duck Creek;
4. Tap into springs or former stream channels adjacent to Duck Creek and pump groundwater from them into Duck Creek; or
5. Divert Jordan Creek into Duck Creek in the vicinity of Nancy Street.

Koski and Lorenz (1999) recommend the following for controlling levels of dissolved iron:
1. Cap sources of iron with organic fill;
2. Plant aquatic and/or riparian plants;
3. Aerate the water mechanically at the source (Koski and Lorenz (1999) preferred alternative);
4. Construct a gallery of aeration pipes in the streambed and floodplain upstream of Taku Blvd. to precipitate the iron and trap it below the surface; or
5. Increase stream flow.

Koski and Lorenz (1999) recommend the following for revegetating the riparian zone:
1. Acquire/ establish additional greenbelt areas along the stream;
2. Thin dense stands of vegetation in existing greenbelts to promote growth of larger trees;
3. Plant vegetation along reaches exposed to road sanding and plowing;
4. Construct snow fences to protect vegetation; and
5. Place woody debris (e.g., tree boles, root wads) in selected stream reaches for instream habitat.

<u>Ferlauto, 2001</u>
- Follow the Duck Creek Plan
- Complete a demonstration project for cost-effective riparian restoration techniques.
- Partner with National Marine Fisheries Service to execute work in the riparian management plan focusing on improving the success of native species.

U.S. Corps of Engineers, 2001

- Line or seal the streambed to prevent low flows
- Improve road crossings (about 20-25 culverts) to remove artificial grade controls and improve sediment transport, fish passage, and floodwater passage.
- Control dissolved iron.
- Create wetlands.
- Treat stormwater.
- Remove fine sediments.
- Revegetated the riparian corridor.

Team Tsunami, 2001

- Conduct management at all levels in the watershed in accordance with Best Management practices in order to minimize the impact of human activity.
- Change permitting processes to protect remaining wetland areas within the developed area of the watershed.
- Perform a study to determine the cause of the increase of flow from the Mendenhall River.
- Bioengineer riparian vegetation solutions along urbanized waterways to make the most effective use of the limited riparian zone available.
- Work with landscapers to increase local use of bioengineered landscaping by individuals.
- Increase the grain size of gravel used for improving traction on roads during winter months, and implement a pre-treatment program at the city and state level for snow control.
- Divert some water into Duck Creek through either the Nugget Creek or Dredge Lake pipeline.
- Replace poorly installed culverts in Duck and Jordan Creeks with bridges or bottomless arch culverts.
- Promote and expand the city-sponsored toxic chemical collection clinics and improve enforcement of chemical-dumping violations.
- Rebuild the banks of the dredge ponds in Duck Creek, creating wetlands on the filled areas.
- Create boggy marshes in areas near Duck Creek where groundwater upwelling occurs and construct a mechanical aeration facility to reduce levels of iron flocculate in that creek.

U.S. Corps of Engineers, 2001

- Line or seal the streambed to prevent low flows
- Improve road crossings (about 20-25 culverts) to remove artificial grade controls and improve sediment transport, fish passage, and floodwater passage.
- Control dissolved iron.
- Create wetlands.
- Treat stormwater.
- Remove fine sediments.
- Revegetated the riparian corridor.

Fryxell, 2006

- Establish a central interagency database and information center to house existing data as well as future data.
- Implement a data collection program to provide long term streamflow and groundwater level data to adequately define trends in both watershed and aquatic health.

- Develop a partnership with the Glaciology Department of University of Southeast Alaska and/or Fairbanks, or University of Idaho, to implement a long term monitoring program that studies rates of uplift at selected locations in Southeast Alaska.
- Develop a project to form an understanding of the role of Pacific Decadal Oscillations in influencing salmonids fisheries within the Mendenhall Valley.
- Establish reference reaches in order to monitor changes in channel morphology in relation to changes in stream flow over time due to uplift.
- Develop and implement a well-designed long term water quality and aquatic insect monitoring program.
- Develop and support wetlands, streamflow, and riparian vegetation restoration projects.
- Inventory wetlands for health and function in non-urbanized portions of the watershed.
- Update the 1987 and 1997 City and Borough of Juneau (CBJ) wetlands surveys and the Juneau Wetlands Management plan. Updates should include updating the CBJ GIS layer and metadata, and facilitating the distribution of this information to other agencies and the public.
- Develop well-designed monitoring plans to ascertain the effectiveness of project design and restoration methods.

Appendix B. Duck Creek Restoration Projects

Duck Creek Restoration Projects			
What	**Who (Participants & Funders)**	**When**	**Why**
All non-natural debris was removed from Duck Creek.	ADFG Sport Fish Division	1989	remove debris and improve flow
Kiowa Dr. culvert upgraded with pipe arch culverts with concrete floors covered with gravel lowering the grade ~1 ft		1994-1999	flood control
El Camino culvert upgraded with pipe arch culverts with concrete floors covered with gravel lowering the grade ~1 ft		1994-1999?	flood control
Wetland Development- Church of Nazarene dredge pond	NMFS; CBJ; SAGA; Private	1997-1999	to improve water quality downstream; demonstration wetland to install storm water drainage near the East Fork of Duck Creek; fill material from storm water project was used to convert a 2-acre dredge pond into a marsh wetland; designed function was to filter out urban pollutants, suspended sediment, and iron floc that would otherwise reach the mainstem; other benefits= improved habitat for rearing salmon and waterfowl and reducing the risk of drowning in the formerly deep, steep-banked dredge pond.
Taku Blvd- Mendenhall Blvd.: sediment removal; channel reconfiguration	NMFS; SAGA	1996/98	spawning habitat; reconfigure stream channel, remove fine sediment, and increase D.O. in an area used by spawning coho; high pressure jet pumps and suction dredges used to remove fine inorganic and organic sediment from the streambed; gravel larger than 1/4 inch was screened and returned to the streambed; fine inorganic sediment was retained in large plastic totes for filling burlap sand bags for use in developing new streambanks and constricting the width of the channel
Cessna Dr. culvert replacement w/ bottomless arch; construct fish weir	USFWS; NMFS; CBJ; ADOTPF	1999	flood control; fish passage; 17 ft. wide arch- new one is upstream of original one; installed permanent concrete fish trap to monitor smolts out and adults in
Berners Ave culvert replacement	DOT; NMFS, USFWS, USFS	1998-1999	flood control; fish passage; channel morphology
Egan-Berners channel restoration/ relocation	DOT; NMFS, USFWS, USFS	1998-1999	channel morphology: relocated stream away from road & put in new bed liner to reduce low flows; needs side channel to be filled in 300-400' lower- part needs new bed liner
Floyd Dryden Pond Demo Site	MWP	1998-2000	a pond on a Duck Crk tributary was considered unsafe for children; pond is source of iron floc; pond was designed to serve as an outdoor education facility in addition to improving water quality and providing wildlife habitat; pond was filled and planted w/ aquatic plants in 1998; construct paths, board walks and dipping platforms in 1999; plant upland plants in 2000
Taku Blvd. storm drainage installation/ update	CBJ; NMFS	1998-99	update/improve storm drainage infrastructure
Experimental snow fence installed at Nancy Street Crossing			reduce sediment from winter road maintenance
Mendenhall Blvd. Culvert Replacement & storm drainage	CBJ; NMFS	2000	flood control

Duck Creek Restoration Projects (continued)			
What	**Who (Participants & Funders)**	**When**	**Why**
Meander Way reconstruction of storm drainage; curb/gutter	CBJ	2002-2003	update/improve storm drainage infrastructure
Stephen Richards culvert replacement; storm drainage and curb/gutter	CBJ; NMFS; USFWS	2003	flood control; fish passage; revegetation; arch; 1st Duck Creek restoration project; SAGA revegetated up and downstream of this area
Nancy St. Wetlands	USFWS; CBJ	2006	improve water quality and habitat
Glacier View Bank Stabilization & bulk head wall removal	NRCS; Private	2006	bank stabilization
Valley Paint Culvert Replacement	USFWS; Private	2007	improve flow/ reduce flooding potential; improve stream profile and fish passage
Stream clean ups	MWP/JWP; DEC	1999-2007	remove debris; raise community awareness regarding streams
Cinema Drive Culvert	MWP; USFWS	2003	flood control
Professional Plaza culvert replacement	DOT; NMFS, USFWS, USFS		fish passage; channel morphology
Bright Beginnings culvert replacement	Private, USFWS, MWP		fish passage; arch
Nancy St. Bridges culvert replacement	CBJ; NMFS	late 90's	flood control; fish passage; two bridges
Glacier View Condo culvert replacement with bridge- demo project	USFWS; MWP; SAGA	2000	flood control; fish passage; foot bridge; stream profile was compromised
McGinnis Arch culvert replacement	CBJ; USFWS; NRCS	2005	flood control; fish passage; improve stream profile; NRCS and USFWS cost-shared the difference between a new culvert and a fish-friendly culvert
Aspen Culvert replacement with bottomless arch	CBJ; USFWS; NRCS	2005	flood control; fish passage; improve stream profile; NRCS and USFWS cost-shared the difference between a new culvert and a fish-friendly culvert
Church of the Nazarene wetland creation	CBJ; NMFS; USFWS; Americorps; Private; DCAG		2.5 acres wetland; water quality (stormwater treatment marsh)
Iron floc control pilot study upstream of Taku Blvd	NMFS; NRCS; NFWF; Univ. Illinois; Univ. AK		monitored water quality; used flume to measure iron floc and pump to remove (project was too expensive to continue)
Allison Pond wetland creation	CBJ; Private	Potential 2007/2008	water quality and aesthetics
Lakeside Condo timber removal	NRCS; Private; CBJ	2007	remove chemical-laden timbers; improve fish passage; aesthetics