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1. INTRODUCTION.

The evaluation was prepared according to Section 404(b)(1) of the Clean Water Act in accordance with guidelines promulgated by the Environmental Protection Agency (EPA) (40CFR 230) for the evaluation of the discharge of dredged fill material into waters of the United States.

1.1 LOCATION.

The project is located in Southwest Washington, just west of the City of Shelton in Mason County (approximately 20 miles northwest of Olympia, Washington). The existing dam is located at river mile 2.3 on Goldsborough Creek. Downstream of the project area, the creek runs through the City of Shelton and empties into Oakland Bay. Oakland Bay is a saltwater body that connects with Puget Sound. Upstream of the project the creek flows freely through forested areas, draining approximately 51.4 square miles of high quality habitat.

1.2 PROJECT HISTORY.

The existing Goldsborough Creek Dam actually consists of four structures or steps. The primary structure is a fourteen-foot timber wall dam constructed in 1921. The structure was built to provide hydroelectric power to the City of Shelton, which operated the project in this capacity for several years. Rainier Pulp and Paper Company purchased and modified the dam in the 1930's, adding a 30-inch-diameter wood-stave pipeline to use the structure as an intake and diversion facility to provide water for cooling, fire protection, and for use in boilers at the mill site. Sometime during the 1930's, the structure was also widened to approximately 100 feet. It is likely that this widening contributed to extensive erosion downstream. The dam has a horizontal timber and plywood spillway supported by timber piles. The spillway discharges onto a shallow, concrete rimmed pool and rock step approximately 15 feet high and then into a pool. A steel sheet pile weir controls the pool elevation, from which the water flows downstream. Apparently the original dam structure had a fishway on the left bank, however because of severe erosion downstream this fishway became impassable. When the dam was modified in the 1930's a new fishway was also constructed. But erosion continued downstream again making the fishway impassable. This erosion also led to the construction of the additional structures that are now part of the four "step" dam. The three smaller "steps" range in height from 3 feet to 6 feet and consist of various materials. The concrete falls, rock face and sheet pile weirs were installed over time to arrest severe degradation of the channel below the dam. Although the existing fish ladder is operational, most species continue to be either partially or completely blocked from passage upstream. The streambed drops a total 35 feet over a distance of 100 feet at the dam.

Simpson Timber Company (the current owner) purchased full title to the site and structure and water rights in the early 1950's. After 1985, the water appropriated from the Creek was used primarily for fire protection. Sediment has accumulated over the years in the head pond of the dam, leaving no storage capacity to moderate high creek flows. Although this was not the intended use of the reservoir, the pool capacity likely helped reduce flood impacts around the reservoir. Severe flooding in 1996 destroyed the wood stave pipeline that carried the water to the mill, and since then, the dam has served no useful purpose. Although Simpson has maintained the structure over the years, including rehabilitation in 1997, the present dam serves no useful purpose and blocks fish passage. The condition of the existing structure is poor: the pilings that support a portion of the dam have significantly deteriorated, and there are large seeps on the downstream side of the wall and erosion of the soil that buttresses the timber.

1.3 NEED FOR RESTORATION.

The degraded project area is really only a small part of an otherwise healthy watershed. But under the existing without project condition the dam is a bottleneck that prevents use of the watershed by some of the Northwest's most important species. Five species of anadromous salmonids (coho, chinook and chum salmon, steelhead, and cutthroat trout) inhabit the lower part of the creek. Only two species can sometimes ascend the existing steep, eroded fish passage facilities. Past surveys have estimated that a few hundred coho per year have ascended the existing fish ladder, and it is assumed that steelhead can also jump high enough to pass the dam. Chum salmon are unable to jump high enough to use the present facility, and cutthroat trout are too small to manage this passage. Chinook have been seen below the dam, but not above it. Although they have the physical ability to ascend the present ladder, they apparently avoid it at least at times due to behavioral characteristics.

No detailed studies of juvenile salmon and trout downstream migration have been completed to date; though the Squaxin Tribe began a pilot study for assessing outmigrant studies in April 1999. Most likely, juvenile salmonids experience mortalities as a result of physical abrasion as they carry over the falls immediately below the concrete basin. Additional mortalities probably also occur as fish smash into the large rocks and concrete debris at the base of the falls.

Downstream of the dam, streambed degradation has noticeably extended many hundreds of feet and channelized the stream. Salmon and trout spawning habitat has been severely degraded in the channelized reach because of the loss of quantity and quality of spawning gravel.

Upstream of the dam wetlands and other habitat features have high value for biological use. Special habitat features including snags, down logs, and open water contribute to high habitat values. The backwater channels associated with many of the wetlands provide winter rearing habitat for juvenile fish and refuge from seasonal high flows following large storm events. The plentiful amount of instream large woody debris recruited from floodplain wetland areas also provides excellent habitat. Without the proposed restoration the high value habitat areas would continue to be under-utilized by key anadromous fish species.

The habitat features throughout much of the downstream 1,000 feet project area stream reach have been seriously degraded primarily due to erosion. The stream bank through much of this reach is very steep and void of vegetation. Habitat features such as pools and off-channel rearing areas are also lacking.

Northwest salmonid stocks have been declining for decades, and many are now reaching critically low levels. Puget Sound Chinook salmon have been listed as threatened under the Endangered Species Act and coho and coastal cutthroat trout are candidate species for listing. Goldsborough Creek, with its extensive wetlands and marshy areas, is especially suitable spawning and rearing habitat for coho. It is one of the few streams in south Puget Sound that is still in relatively good shape: the watershed is primarily managed for timber harvest, with no towns or cities above Shelton, and the Simpson Timber Company is presently preparing a Habitat Conservation Plan (HCP) to help insure that stream habitat will be preserved for the next 50 years. The stream is a lowland stream fed mostly by groundwater, so it has a unique capability to maintain both high and low flows and is less vulnerable than many streams to flashy floods or devastating droughts.

Providing upstream passage of spawning anadromous fish also provides a critical link in aquatic food webs in the Pacific Northwest. Pacific salmon are considered a “keystone” species upon which producers and consumers from the bottom to the top of the food chain depend on (Wilson and Halupka 1995). Rearing in the rich-ocean environment, adult salmon return to nutrient poor streams with a wealth of ocean nutrients, enriching the food web from primary producers to top carnivores. At the top, at least 22 species of wildlife, including black bear, mink, river otter, and bald eagle, feed on salmon carcasses (Cederholm *et al*. 1989). At the base of the food web, salmon carcasses provide a significant, if not major amount of nitrogen to streamside vegetation as well as large amounts of carbon and nitrogen to aquatic insects and other macroinvertebrates (Bilby et al. 1996). Juvenile salmon also utilize spawned-out salmon carcasses directly as a food source. Bilby et al. (1998) witnessed increased densities, increased body weight, and improved condition factor of juvenile coho and steelhead in stream reaches supplemented by the addition of salmon carcasses from a nearby hatchery. Sixty to 96 percent of the food material in the stomachs of juvenile steelhead and coho consisted of carcass flesh and eggs.

2.0 PROPOSED PROJECT.

2.1 METHOD OF EXCAVATION AND DISCHARGE.

The areas within the earthwork limits will be cleared of trees and vegetation. Excavated material from upstream of the dam site that is determined to be satisfactory for use as fill will be used to fill in the channel downstream of the dam. The excavated material will be placed in lifts and compacted. The channel will be excavated/filled to a depth of 2 feet below the profile grade shown on figure 4 to allow placement of select gravel and cobble material as the final bed surface. Approximately 26,000 cubic yards (cy) of material will need to be excavated upstream. Import of fill material will be required for the gravel and cobble bed material and approximately 5,000 cubic yards of channel fill material. The channel fill material will consist of a pit run sand and gravel that can be obtained locally. Excavation methods will be the decision of the contractor, but may include using hydraulic excavators loading off-road dump trucks that will haul the material downstream where it will be dumped and rough graded with a dozer. A compactor would follow the dozer after each new lift is placed. Alternatively, scrapers may be used to excavate, haul, and place the material. This method would use a dozer for rough grading and a compactor. All excavating and hauling should stay within the project footprint. The haul roads would be kept within the 40-foot channel bottom width. Only short sections of new access roads will be required to allow ingress and egress from the channel, most likely near the upstream end. Existing access roads may require upgrading or widening.

2.2 TIMING OF EXCAVATION AND DISCHARGE.

In water work is expected to begin June 15th, 2000. In water work is expected to take 12 weeks and the project should be out of the water by the end of August. If construction cannot begin by mid June, the project construction will likely be phased with all in water work being conducted in the summer of 2001.

2.3 PROJECTED LIFE OF THE PROPOSED PROJECT.

It is difficult to determine what would be the physical project life of the habitat restoration project, however, with proper maintenance by the sponsor it is believed that the project life would be at least 50 years.

3. ALTERNATIVES.

The Corps and other entities have considered a wide variety of dam removal and restoration strategies in the area since 1990. The full array of alternatives, including the without-project condition, are discussed below. Each of the alternatives went through a preliminary screening at which point it was determined whether or not further study was warranted. Following the description of each of these alternatives, a rationale is provided as to why it was not considered further. With the exception of the dam removal/grade control alternative, the other alternatives had serious flaws that did not warrant further detailed evaluation during the feasibility phase. The feasibility phase focused detailed effort on the restoration strategy that included removing the dam and using grade control structures to stabilize the stream. Following hydraulic, design and environmental studies the design team developed three alternatives that met the technical criteria to varying degrees. These alternatives are called "the final array of alternatives." Once these alternatives were identified, a 10% design and cost estimate was completed to assist in evaluation. The design team then scored each of the alternatives on how well they met the established technical criteria. This ranking was one tool used to help select a preferred plan. In addition to ranking by criteria, the corps quantified outputs for each of the final alternatives. These outputs were used in combination with the 10% design costs to conduct cost-effectiveness and incremental cost analysis for the final alternatives, and served as a second tool to select a preferred plan.

3.1 NO ACTION ALTERNATIVE.

If the dam is left alone, it will fail. As there is little or no storage available behind the dam, the mode of failure is not expected to be catastrophic, at least not initially. Stored sediments would eventually be conveyed downstream. With the hard point in the river removed, head cutting would proceed, and would perhaps have some effect on the structure of the salmonid habitat upstream. Dam debris could also create a logjam below the dam, which could fail in time. Flooding around the left abutment, along the railroad grade, would continue at higher level events, exacerbating erosion around the structure.

The no action option, which by its nature would result in dam failure, is not a viable option because of the potentially serious impacts to downstream areas. Leaving the structure in place does not provide any restoration for fish passage. Once the dam fails under this alternative, the system would take years to stabilize the channel and result in negative socio-economic and environmental conditions. This alternative did not meet the completeness or acceptable general planning criteria and was eliminated from detailed consideration.

Simpson Timber has performed maintenance on the structure in the past and would be expected to continue to do so. The aim of the maintenance under the current condition is to prevent failure. This option would be expected to continue to increase in price as the structure continues to degrade. A variety of measures have been examined with respect to the repair and stabilization of the dam structure. Dames & Moore (1991) recommended construction of a sheet pile wall, but without provision for improved or alternative fish passage. Problems with this measure include inadequate knowledge of subsurface conditions and potential difficulties driving sheet piles in known soil formations; ongoing maintenance of the dam; and inadequate provision for fish passage. This measure does nothing to restore the stream; it only preserves a structure of questionable utilitarian value. Simpson Timber has estimated the cost of the alternative at approximately $50,000 per year or a present value of $679,000 over a 50-year evaluation period. This alternative is not complete, there are no improvements for fish passage, and maintenance expenditures would continue to be required to prevent any liability issues for the owner.

3.2 REMOVE DAM ALTERNATIVE.

Dam removal would serve to eliminate uncertainty related to the effects of dam failure, however, in the absence of grade control, headcutting would proceed, and fish would not be able to pass the nickpoint. Thus the stream would continue to be a block to fish passage. The cost of removing the dam has been estimated at $145,000 in October 1999 prices. No costs have been estimated to address the eventual headcutting and other impacts associated with not stabilizing the channel. Due to the instability and uncertainty of the consequences of this alternative for fish passage and downstream impacts, it is not an acceptable restoration option and was eliminated from consideration.

3.3 REPAIR AND STABILIZE DAM STRUCTURE AND REHABILITATE/MODIFY EXISTING FISH LADDER.

This alternative would not only continue maintenance and rehabilitation on the dam structure but also incorporate improvements in the existing fish ladder. The existing fish ladder is impassable to many species largely because of the significant vertical drop across the structure. Under this option the ladder would likely have to be largely rebuilt over a much longer reach of the river to be passable to the targeted species. Even if this were to be accomplished, the majority of the creek would still present a blockage to both up and downstream migration. This option would not restore a natural gradient to the creek, maintenance of the structure would continue to be required, and the costs to rebuild a ladder that only passes a small portion of the flow does not appear to be a cost-effective solution. Costs have not been estimated for this alternative but would be expected to be substantially more than the $679,000 for the no action option. This alternative was eliminated from consideration because it is not a complete solution to addressing the problem or restoration needs.

3.4 MOVE CHANNEL ALTERNATIVE.

Golder Associates (1996) indicated that an old riverine channel may exist on the north side of the dam site, and that the stream has been directed into its present entrenched position by human activity. A detailed investigation during the feasibility phase was not conducted to determine whether or not such a north bank channel exists, whether it might be feasibly constructed, and whether a reasonable grade and natural geometry could be identified in order to bypass the existing dam site. The negative aspects of this alternative include the significant area and amount of disturbance involved initially. This plan would also not address removal of the deteriorating structure and would involve significant real estate costs. This option had questionable effectiveness, because of the many unknown factors. Unknown factors included engineering feasibility, especially related to geotechnical issues. The expected success of restoration would be lower than the other alternatives. If other options proved infeasible, the design team would have conducted further investigation on this option

3.5 REMOVE DAM AND REPLACE WITH GRADE CONTROL STRUCTURES.

Removing the existing dam and replacing with Grade Control Structures was the preferred alternative for the Preliminary Restoration Plan. Under this type of restoration strategy the dam and associated maintenance costs would be eliminated, but most importantly, removing the dam provides the best opportunity to provide for fish passage through controlling the grade in the project reach. As mentioned above, in the absence of grade control, head cutting would proceed, and fish would not be able to pass the nickpoint. Grade control measures could be accomplished through a variety of measures. The alternative that was presented in the PRP included removing the dam, using cut and fill sections above and below the dam respectively and placement of steel sheet pile weirs. This type of restoration strategy best met the general planning criteria of completeness, effectiveness, and acceptability. Different alternatives utilizing this concept were evaluated in detail during the feasibility phase.

A full dam removal with grade control/sediment retaining weir alternative was first proposed by Summit Technology (1996). Their proposal consisted of removing the dam and constructing 37 weirs along the reach to control the grade. Parametrix (October 1997) refined this approach, and their design was the recommended plan for the reconnaissance report (PRP). This plan consisted of two weir groups above and below the existing dam structure. The four weirs upstream were placed at 20-foot intervals, while the five weirs downstream were to be at 10-foot intervals. Channel improvements would affect a 3,000-foot reach of the creek. Below the existing dam site, the channel would have a 1% gradient. Above the dam site, channel improvements would extend upstream to the existing railroad bridge structure, providing a 1.25% channel gradient. The amount of excavation was estimated at 20,000 c.y. and the amount of fill required was 62,000 c.y. The potential drawbacks to this proposal as presented by Parametrix were the high costs ($3.6 million dollars) and degree of in-channel disturbance required for construction. None the less, the Parametrix plan showed much merit and this type of approach became the focus of the Corps feasibility study.

The design team focused their effort on developing different configurations under the general dam removal with grade control alternative that better met the technical criteria established by the group. Several key design considerations for this type of restoration approach are presented below.

The design team concluded it would be most efficient and effective to leave a portion of the existing structure in place. This would not only reduce the amount of fill and cut quantities, but leaving the concrete base of the existing structure in place could serve as an added check point to reduce any potential headcutting or erosions.

- **Fixed channel bed**. The channel bed must be fixed for dam removal to be a success in terms of restoring channel geometry, arresting head cutting, and providing reliable fish passage. The primary purpose of fixing the bed is to insure safety of the project and to reduce impacts outside the project area. Preventing the channel from headcutting and creating long-term sediment releases, channel instability, flood capacity reductions downstream, and habitat degradation upstream and downstream was an important consideration through the project planning. A steppened channel created by dam removal would not be a stable alluvial channel. It would continue to headcut upstream for a considerable distance. Likewise, it cannot be stabilized solely by debris without substantial risk over time because a debris stabilized channel requires the continual recruitment of new, but mature, woody debris which cannot be guaranteed at this site. Stored material can be utilized as backfill. Depending on the type of bed material used, an impervious channel lining might be required.

- **The project start and end points**. Establishing the upstream invert of project restoration is important in reducing the risk of undesirable sedimentation impacts. The potential of increased sedimentation could arise if water surface profiles were to change substantially above the rail road trestle, which is at roughly station 124+00. Each alternative would involve fixing the upstream grade to the existing invert at station 126+00 in order to prevent alteration in the sediment transport load entering the project reach. Alteration could result in headcutting and a greater sediment load in the stream than under existing conditions, thus increasing the likelihood of downstream impacts. The stream gradient currently flattens out above this point. All the alternatives have a weir or grade control element upstream of the railroad trestle in the vicinity of 126+00. The primary consideration at the downstream end was to avoid unnecessary impacts to existing habitat. Further the channel naturally widens out at approximately station 108+00. Based on field investigations, the team identified station 106+00 as a natural end point.

- **Total project footprint**. Based on the above considerations the total project footprint totals 2000 feet in length, a substantial reduction from the 3000 feet impact area of the reconnaissance level alternative.

- **The overall channel gradient**. Balancing sections of free flowing sections at a more natural gradient (.5%) with steeper reaches that would be stable. Provided that the weirs are constructed properly with minimum disturbance to the clay banks and appropriate bank protection elsewhere, the restored channel reach should stabilize in a short period of time. This may be up to five years depending on the alternative.

- **Material of grade control structures**. Grade control structures could be constructed from steel or vinyl sheet-pile weirs, boulders or logs. Sheet-pile weirs provided the greatest flexibility in designing the channel to optimize passage conditions over a broad range of flows. Boulder weirs were also considered a viable option that would result in a more natural looking stream. Log weirs were initially considered, but were thought to have less flexibility in design over a variety of flows. The expected physical life of log weirs was also thought to be substantially lower than for steel, vinyl or boulders. Further, the required armoring to stabilize log structures reduced their attractiveness. For these reasons, log weirs were not considered in the three final alternatives.

- **Channel cross-sections**. A trapezoidal cross-section with a 40 feet bottom width, 3H:1V side slopes to nine feet horizontal on each side, with 10H:1V side slopes to the intersection of existing topography. Channel geometry is based on interpretation of existing channel properties in the vicinity of the project reach and iterative gradually varied flow modeling.

Three different options were developed, each meeting the established criteria to differing degrees and incorporating the above design considerations. Each of these options includes removing the timber wall portion, the spillway, and fish ladder of the existing dam and using cut and fill above and below the dam respectively to arrive at a stable grade. A natural grade for this type of stream is between 0.3% and 0.7%. To arrive at this grade without grade control structures, the overall project length would need to be on the order of 6,000 feet. This was considered unacceptable not only because of the large quantities of fill required, but also because of the tremendous impact to the existing relatively pristine habitat conditions outside the immediate vicinity of the dam. Further, and more importantly, this type of approach would introduce flooding problems in the project area that would need to be addressed. In order to reduce these impacts, and to meet the 90% fish passage reliability criterion, steeper sections were incorporated into the design at various intervals generally not exceeding 3.75%. The steeper reaches need to have drops small enough to provide for fish passage, but stable enough to withstand high flows without significant stream degradation or impacts downstream. In between the steeper sections, the gradient would be reduced to the more natural gradient of 0.5%. Conceptual Designs were developed for the final three alternatives.

3.5.1 Concentrated Weirs.

The sheet pile weir design is essentially a fish way, which uses the entire width of the stream as steps for the ascent and descent of fish. The sheet pile weir design also serves the grade control function, which is required in order to provide a passageway to the basin above the dam site. A concentrated weir alternative was considered as a means of reducing the project impact area. The spacing between the steel sheetpile grade control weirs is 20 feet for a total of approximately 45 weirs. The gradient through the steep reach would be 3.75%. This gradient was considered an upper limit to provide for structural safety in channel design. Upstream and downstream of the concentrated weirs the grade would be between .5% and .7%. Each of the weirs would have an approximate 40 feet bottom width, and 3H:1V side slopes to contain high flows, followed by 10H:1V slopes to tie into high ground. In addition to the two-stage channel, each weir will have a 6'wide low flow notch. The low flow notch will provide a water depth of 1' during low flow periods. The low flow period was defined as the 95% daily average discharge exceedence, by month, during the time of upstream migration. The project length of the concentrated weirs is approximately 800 feet. A buried stone grade control element would be placed at section 126+00 and 107+00 to ensure stability.

Achieving successful upstream fish passage through the Goldsborough project site requires that hydraulic conditions cannot exceed the physical abilities of the target species. Although a variety of anadromous fish are found in Goldsborough Creek, chum salmon are the weakest swimmers among the salmonid species. Chum salmon have an estimated upper limit of darting or burst speed of 10.6 fps (Orsborn and Powers 1985), and are generally considered to be poor leapers (Salo 1991). A fish moving at burst speed can only maintain that high rate of activity for 1-20 seconds before becoming fatigued. If when attempting to negotiate a barrier a fish becomes fatigued, the fish will fall back and rest for up to 3.2 hours before re-challenging the barrier. The most significant uncertainty regarding successful fish passage of concentrated weirs is whether the fish would make the effort to make the sustained ascent. If a fish becomes fatigued, it may fallback downstream until it reaches an acceptable holding area. Chum salmon may successfully pass individual weirs, but the concentrated series of up to 45 weirs lowers the likelihood that fish can successfully pass through the steepened reach.

One of the merits of the Concentrated Weir alternative is that it minimizes the project reach that would be impacted by construction. This consideration is perhaps best reflected in criterion 2. This alternative was thought to have the least effect on the wetlands upstream of the dam and the channel downstream. However, in minimizing the project footprint, the alternative raised significant concerns on whether fish would be able ascend such a large number of jumps without adequate resting areas, this is reflected in the score for criteria 1 and 4. The alternative somewhat surprisingly scored higher on fish passage than the Boulder Cascade. The reason for this is likely because of the shape of the weirs, especially the low flow notch. Of the three alternatives considered, the concentrated weir scored the lowest in terms of mimicking natural conditions. The gradient through the weir section, at 3.75%, was a concern for some members of the design team in terms of structural stability. However, based on the expected velocities through the project reach, it appears reasonable that this alternative could be designed to accommodate these flows.

3.5.2 Boulder Cascade Alternative.

Rather than using exposed weirs to control the grade through the stream reach, incorporating boulder drop structures at spaced intervals was considered. Conceptually, the boulder channel alternative is designed to emulate natural step-pool morphology as described by Grant (1990). The boulder channel would basically look and function like a series of cascades or rapids. Boulders would be aligned across the channel in rib-like fashion, with a riprap bed to resist displacement of the boulders. Design elements consist of rapid slope, free flowing reach slope, rapid spacing, bed armor size, boulder size, and longitudinal and transverse spacing.

A buried weir would be placed at the upstream end of each boulder cascade. The buried weir is required to prevent failure of the entire system. If one cascade were to fail by unraveling, the next cascades upstream would also likely fail in series. Each boulder group is approximately 100 feet in length and in a trapezoidal shape with a 40 feet bottom width and 3H: 1V side slopes and 10H: 1V side sloped thereafter to the intersection with the existing bank. In between the boulder groups the gradient would be roughly 0.5% to allow natural stream process to take place, and would provide for resting areas for migrating fish. Over time the boulder drop structures would disperse somewhat, while the buried weir would ensure against unraveling of the channel slope. The overall project length of this alternative is 2000 feet. This type of design has been used where smaller elevation drops were required.

There is a high level of uncertainty of successful fish passage when incorporating a series (11) of boulder cascade structures. Cascades can present fish with high velocities, high turbulence, and orientation difficulties that may prevent a fish from effectively using all of its swimming power (Powers and Orsborn 1985). Under low flow conditions, large bodied fish such as chinook or chum salmon may require a near-continuous thread of deep water to assure passage within a cascade group. Over time, and after repeated exposure to high winter flows, boulders will move around within a cascade group. Changes in the channel thalweg or the depth or shape of local scour pools within a cascade may present additional passage difficulties. An additional fish passage risk is that the boulders would disperse leaving the weir at the top of the cascade as a barrier with no opportunity for a scour pool to develop in the middle of the cascade. Because of uncertainty on how the project would function, maintenance and rehabilitation costs would also be higher.

The merits of the Boulder Cascade alternative are that it best mimics natural channel conditions, as evidenced by the scores under criterion 3. One of the weaknesses of Boulder Channel is the substantially lower reliability in assuring fish passage under criteria 1 and 4. There was also concern among the design team in how the alternative would function following a flood event in terms of rehabilitation costs and structural integrity as reflected in criterion 6. The ability of this alternative to adequately dissipate energy in the project reach was viewed as less reliable. The score for criterion 7 reflects this concern, which would be reflected in adverse impacts outside the project reach.

3.5.3 Selected Alternative Weir Group Alternative.

Rather than concentrating the drop in one reach of the river, the concept of using groups (4-5) of weirs with free flowing sections in between the groups was the basis for the third alternative. The space between weir groups acts as an energy dissipating reach and provides a flexibility in the design in case of extreme flows, debris jams or other perturbations exceed the design criteria. This alternative would have a somewhat larger impact area than the concentrated weir but as a trade-off would provide a higher likelihood of providing fish passage during a greater variety of fish flows. Grouping the weirs provides a more stable alternative compared to concentrated weirs. The space between weir groups acts as an energy dissipating reach and provides a flexibility in the design in case extreme flows, debris jams or other perturbations exceed the design criteria. The space between the weir groups also provides a variety of resting habitats to allow fish to recover after passing through the downstream group of weirs.

Design elements consist of determining the elevation drop between individual weirs, the number of weirs per weir group, longitudinal spacing between individual weirs, longitudinal spacing between weir groups, cross-sectional properties, low-flow notch geometry, and armor size. The maximum allowable elevation drop between individual weirs was specified to be 1 foot by the design team. Each of the weirs will provide for a two-stage channel in addition to a 6 foot-wide low flow notch. The low flow notch will provide a water depth of one foot during low flow periods. The provision of the low flow notch will increase the likelihood that chum salmon can swim through the notch rather than having to leap to ascend the weir. The design team also agreed to the suggestion by the fisheries experts that no more than 5 weirs be used in any one weir group.

These guidelines, in conjunction with site constraints and with emphasis on maintaining a slope of 0.5% in free flowing reaches between weir groups, helped to establish the alternative layout as follows: weir groups will consist of 4 to 5 sheet pile weirs in series, with 35-foot spacing between individual weirs at a maximum one foot elevation drop. Free flowing sections are a minimum of 100 feet in length at 0.5% channel bottom slope. The length of the free-flowing sections is up to 275 feet above the existing dam. Trapezoidal channel section as prescribed previously is retained for this section. The resultant 33-weir alternative, in seven groups, has an average channel slope of 2.3%, and the overall project length is less than 2,000 feet. As in the Concentrated Weir alternative, the individual weirs have a ‘dog-leg’ pattern.

The Weir Group alternative scored lower than the Boulder Cascade alternative in its ability to mimic natural conditions. Incorporating adequate spacing between the weir groups resulted in a higher score in mimicking natural conditions than the concentrated weirs. The spacing between the weir groups also helped increase this alternatives ability to ensure fish passage when compared to the concentrated weirs. This alternatives ability to mitigate (avoid, minimize, mitigate) wetland and other impacts was slightly lower than the concentrated weir alternative. Overall, the Weir Group alternative scored higher than the other alternatives on 6 out of the 9 criteria. There was strong concurrence among the design team that this alternative provided the most optimal design to:

- Provide passage for adult and juvenile resident and migratory fish (criterion 1)
- Ensure fish passage standards would be complied with 90% of the time
- Ensure surface structures would safeguard against catastrophic failure
- Provide for fish passage following a reasonable flood event.
- Minimize the potential for impacts downstream of the project
- Provide successful and safe downstream passage to resident and migratory fish.

Based on this evaluation technique the Weir Group Alternative is the recommended plan as it best meets all of the technical criteria. The design team scoring was used as one tool to select a recommended plan. The other tool is a cost-effectiveness analysis and incremental cost analysis (CEA/ICA). This evaluation more explicitly considers alternative costs in relation to expected outputs, and is requirement for all Corps of Engineers restoration projects. This evaluation selected the weir group alternative.

4.0 POTENTIAL IMPACTS ON PHYSICAL AND CHEMICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM.

4.1 SUBSTRATE.

A SAM model was used to evaluate the potential effects of the project on the substrate. The SAM Sediment Hydraulic Design Package is an integrated system of programs developed through the Corps Flood Damage Reduction and Stream Restoration Research Program to aid engineers in analyses associated with designing, operating and maintaining flood control channels and stream restoration projects (Copeland, et. al., 1997). SAM combines hydraulic information and the bed material gradation to compute the sediment transport capacity for a given cross section, and a given discharge, for a single point in time. A number of sediment transport functions are available for this calculation. The sediment transport capacity is combined with a flow duration curve to compute the total sediment passing the cross section or over some period of time, i.e. one year.

The results provide a number of significant findings:

(1) The hydraulics of the stream result in very low yields for the larger sizes within the armor layer and thus confirm that it is relatively stable. For example, during high fish flows in the supply reach, the model shows that sediments with a diameter greater than 30 mm are not moved in any appreciable amount. As a result, the subsurface layer (with the finer gradation) is generally not available for transport.

(2) Grain sizes that constitute the bulk of the fish gradation (12 – 50 mm) are relatively abundant in gravel bars in the supply reach and will be transported throughout the project.

(3) In the without-project condition, reaches 4 and 5 have a lower transport capacity than the supply reach and are thus potentially aggradational.

(4) The with-project reaches (reach 4 and reach 5) have a higher transport capacity than the supply reach (reach 6) and will thus transport the incoming sediment with little or no aggradation. Since the bed and banks of the with-project reaches will be protected, they will not significantly degrade and thus and will not contribute a

significant amount of sediment. As a result, reaches 4 and 5 simply function as pass-through reaches for the upstream supply.

(5) The sediment transport capacity of the downstream reaches is unaffected by the proposed project alternatives.

(6) The reach immediately downstream of the project (reach 3) has a greater capacity than the supply reach (reach 6) and will thus effectively transport all of the incoming supply.

It is important to note that the calculated yields represent the potential sediment transport capacity for each reach and are based on a model that does not account for changes in cross section or the gradation. The upstream watershed yield and the fact that the streambed is frequently well armored limit the actual sediment transport through the system. The importance of the findings in this analysis are limited to the relative transport capacities on a reach to reach basis.

4.2 SUSPENDED PARTICULATES/TURBIDITY.

After the dam is removed, sediment will not be catastrophically released. Rather, it will be released over a period of time when major storms pass through the area and erosion continues to remove sediment. A short-term burst of sediment that has already been in transport by the stream will not have long-term effects.

Downstream deposition of sediment will be a function of the amount and timing of the sediment release from behind the dam. The amount of sediment behind the dam that is released to the stream is limited by the size of the material and by the limits of mass wasting processes that bring sediment to the stream.

4.3 WATER QUALITY.

Water quality and flow in Goldsborough Creek are expected to change little. Because the project area is in a relatively small area in comparison to the remainder of the watershed, flow stability will not be altered. The stream will continue to transport fine sediment throughout its length, through Shelton into Oakland Bay.

Potential point and non-point sources of water pollution will not be affected by this project. Some canopy cover in the project area will be lost during project construction. Though replanting will occur, it may take several years for the canopy to return to pre-project conditions. This loss may contribute to slight temperature increases during warm temperature and low flow conditions within the project reach.

There will be some construction impacts on water quality at several stages during the construction process. Large pulses of sedimentation following diversion of the stream back into the restored stream bed will result in short term turbidity until the water slows sufficiently to allow settlement, potentially lowering dissolved oxygen concentrations for short durations. Localized shifting of sediments will continue sporadically as the new stream heals and adjusts. Floods during the winter and spring following construction will continue to mobilize sediments in the project area, potentially contributing to small increases in turbidity over that normally seen during flood events. Sedimentation impacts will be controlled through best management and conservation practices during construction. They should be temporary and of short duration. Water quality will be monitored in the project area and downstream during construction to detect any unacceptably high water quality impacts.

4.4 CURRENT PATTERNS AND WATER CIRCULATION.

The hydraulic impacts of any of the proposed alternatives were viewed from the perspective of changes from the existing condition. The intent of the hydraulic evaluation was to ascertain any changed conditions in water surface profiles.

There are three potential areas of concern related to the performance of the recommended plan; sedimentation, flood conveyance, and erosion. Substantial efforts have been made to reduce any possibility of impacts outside of the project area. The flood conveyance through the project reach is equal to the existing condition. Specifying a 40 foot wide channel cross-section, with appropriate side-slopes and tying into high ground ensures flood flows will be contained. Conveyance in the vicinity of the railroad trestle will be increased to prevent flood flows from diverting down the railroad grade and back into the stream in the vicinity of the fish ladder. Any potential sedimentation impacts that could occur as a result of implementing the recommended plan have been minimized by setting the upstream channel invert above the railroad trestle at the level of the existing bed. Finally, the potential for any increased erosion, through changes in channel depth or velocity, have been minimized in the project design. Increased velocities are expected through the project reach, however the hydraulic model indicates that the water surface profile of the preferred plan matches the existing condition profile downstream of the last weir groups, indicating that the weir groups are able to dissipate sufficient energy so that the existing channel controls flow conditions. In other words, implementing the preferred plan should not alter hydraulic conditions below the last element of the project. As such it is not expected that the project as designed will exacerbate existing instabilities downstream of the project reach.

Also, due in part to the increases in velocity in the project reach, bank protection is required intermittently through the project footprint to reduce erosion potential. Bank protection is also required to ensure the integrity of the grade control features.

4.5 NORMAL WATER FLUCTUATIONS AND CLIMATOLOGY.

The Goldsborough Creek basin resides entirely within the East Olympic/Cascade Foothill climatological division (NOAA designation). The climate in this region is somewhat cooler and wetter than that of Seattle. Summers are typically cool and dry with mild, rainy winters interrupted by frigid cold snaps. National Climactic Data Center (NCDC) data and statistics (Hydrosphere, 1998a) for Shelton during the 50 year period 1948-1997 are provided below:

<u>Precipitation (Rainfall)</u>

Maximum Annual: 81.7 inches in 1950.
Average Annual: 64.4 inches.
Minimum Annual: 40.7 inches in 1952.

Maximum Monthly Average: December, 11.06 inches.
Maximum Monthly: 23.86 inches, January 1953.
Minimum Monthly Average: July, 0.95 inches.
Minimum Month: 0.00 inches, September 1991.
Maximum Day: 4.84 inches, 19 November 1962.

<u>Precipitation (Snow)</u>

Maximum Annual: 32.9 inches in 1969.
Average Annual: 9.04 inches.
Minimum Annual: 0.00 inches in 1990.
Maximum Month: 32.8 inches in January 1969.
Maximum Day: 12.8 inches, 25 January 1962.

<u>Temperature</u>

Average Annual: 53.6 F.
Maximum Daily Average, by Month: August, 64.7 F.
Minimum Daily Average, by Month: January, 38.7 F.
Maximum: 104 F, 9 August 1981.
Minimum: -2.0 F, 31 January 1950.

Tides

Tides at Oakland Bay, which is connected to Puget Sound by Hammersly Inlet, exhibit semi-diurnal fluctuations; that is, each lunar day (24 hours 50 minutes) two flood tides and two ebb tides occur. Each peak and ebb then occurs approximately 50 minutes later than the day previous. Semi-diurnal tides are the norm in Washington coastal areas, although diurnal tide fluctuations do exist, depending primarily on geographic location and phase of the lunar cycle.

The mean tide range at Shelton is 10.60 feet, mean higher high water is 7.25 feet NGVD and mean tide is 0.95 feet NGVD, referenced to the current tidal epoch.

The maximum observed tide of record in Oakland Bay occurred 15 December 1977 during a low pressure storm over the Puget Sound region. This event caused flooding in the powerhouse and Mill No. 4 to a depth of two feet at the Simpson Timber Company plant. That tidal flood event has been characterized as greater than 100-year event (Nelson, 1978). The 10-yr and 100-yr tidal elevations for Oakland Bay based on NOAA observations at the Elliott Bay tide gage for the period of record 1898-1995 and adjusted to Oakland Bay at Shelton are 10.2 feet and 10.7 feet, respectively, NGVD datum.

The tide (specifically, the water surface elevation at Oakland Bay) represents a downstream boundary condition for the hydraulic models used in this study. Hydraulic modeling for this study suggests that tides in Oakland Bay effect water surface elevations in Goldsborough Creek from the mouth up to the vicinity of the 7th Street bridge.

Past Flood Events

Flooding in Shelton is caused by major floods on Goldsborough Creek or by extreme tides in Oakland Bay or by combinations of both. Shelton has experienced flooding from Shelton Creek as well, but the threat of flooding from Shelton Creek has been greatly diminished by the US Army Corps of Engineers project which diverts excess Shelton Creek flows into Goldsborough Creek. While a complete record of damaging floods on Goldsborough Creek is not available, evidence indicates that flooding occurred in 1935, 1951, 1972, 1997, and probably in 1933 as well (USACOE, 1983).

Riverine flood events in small, lowland river basins in the Puget Sound region are generally caused by two different types of climactic triggers: 1) prolonged periods of sustained rainfall, and 2)substantial snowfall followed by sustained warm winds and heavy rains. The following excerpt from the Mason County Journal dated 22 January 1933 describes well the second type of flooding event, which has been repeatedly manifested over time, most recently during the 1996-97 Holiday Storm Event[1]:

> *Steady rains which have pounded down for 40 consecutive hours on the 19 inches of snow which fell in Shelton and more out in the county during the recent cold snap have swollen every river and stream in the county to the point where they have burst their banks and inundated the surrounding county.*

Streamflow Records

[1]For a description of the 27 Dec 1996 – 4 Jan 1997 Holiday Storm Event, see: USACOE (1997) "Post Event Report: Winter Storm of 1996-97. Federal Disaster DR 1159, Western Washington Summary." US Army Corps of Engineers, Seattle District, for the Federal Emergency Management Agency, Region X.

The USGS has maintained two streamflow gages on Goldsborough Creek in the past. Streamflow records for these gages on Goldsborough Creek are available as shown below in Table 1. USGS streamgaging program on goldsborough creek. There are currently no USGS gages on the creek.

Table 1. USGS streamgaging program on goldsborough creek.

	Goldsborough Creek near Shelton USGS No. 12076500	**Goldsborough Creek at Shelton USGS No. 12077000**
Period of Record	July 1951-Sept. 1971	a) Dec. 1942-Sept. 1943 a) June 1951- Sept. 1951 b) 1972-1977
Type of Record	Water Stage Recorder	a) Water Stage Recorder b) Crest Stage Recorder
Drainage Area	39.3 mi^2	55 mi^2 (includes area attributable to Shelton Ck. flood diversion).
Location		
Latitude	N 47 12’50”	N 47 12’30”
Longitude	W 123 10’50”	W 123 06’00”

The drainage area at the dam site is approximately 44 square miles.

The recurrence interval of the annual peak discharge is the inverse of the probability. For example, the 50 year recurrence interval event, or ‘50-year flood’, is that discharge which has a probability of 2% of being met or exceeded once in any given year. The 50-year discharge is approximately 1800 cfs based on the 21 year period of record at the location of the former usgs gage, which was located near the present day matlock road crossing of goldsborough creek.

Goldsborough Creek is a unique stream. It is the largest drainage in the West Sound Basin (Puget Sound Task Force, 1970). It resides in a geographic area which is somewhat unique; indeed, an inspection of topographic maps of west Puget Sound reveal that there are no other drainages comparable in size and topography. The primarily flat land comprising the drainage basin behaves much like the hump on a camel’s back, storing water and releasing it in sustained fashion. This behavior is prevalent with respect to both flood event discharge and late spring to early fall streamflow.

Table 2 below shows the two highest peak flow events for the period of record, with associated maximum one, three, and seven day average daily discharges for gage number 12076500. Both events were approximately 13-year peak floods.

Table 2. USGS gage #12076500 peak and associated daily discharges of record.

	20 January 1968 Event	**21 February 1961 Event**
Peak Discharge (cfs)	1430	1420
1 Day Avg. Discharge (cfs)	1360	1230
3 Day Avg. Discharge (cfs)	1336	1095
7 Day Avg. Discharge (cfs)	900	864
Percent of 1 Day to Peak	95%	87%
Percent of 3 Day to Peak	93%	77%
Percent of 7 Day to Peak	63%	61%

The high percentages of 1, 7, and particularly 3 day average flows to peak discharge shown in Table 2 demonstrate the ability of the basin to provide sustained and high flows during flood events. This is most probably resultant of the flat topography of the basin, as well as the very high percentage of soils in the basin which are categorized as ‘low runoff’ type soils.

Both the sustained high and low flows suggest the prominence of the soils and their groundwater contribution to the stream’s dependable hydrologic character and overall stable channel properties.

4.6 SALINITY GRADIENTS.

In this project the salinity gradients will not be effected.

5.0 POTENTIAL IMPACTS ON BIOLOGICAL CHARACTERISTICS OF THE AQUATIC ECOSYSTEM.

5.1 THREATENED AND ENDANGERED SPECIES.

Threatened and Endangered Species impacts have been addressed in Biological Assessments sent to the U.S. Fish and Wildlife Service and the National Marine Fisheries Services.

5.2 AQUATIC FOOD WEB.

Dam removal and restoration of the stream grade would result in returns of fish to the river throughout the year, optimize use of all accessible portions of the watershed, produce much greater numbers of fish, and restore ecosystem processes. Wildlife prey would be provided by fish carcasses, juveniles, and eggs. Removal of the dam would allow nutrients and bedload (sand, gravel, and cobble) to pass naturally downstream.

5.3 FISH AND WILDLIFE.

5.3.1 Habitat.

Channel reconstruction will include alternating pool and riffle sections at a more natural stream gradient. The incorporation of habitat enhancement features such as log jams, deflector logs, overhanging logs, and gravel bars, together with large woody debris included in the stream bands, will provide considerable improvements in the rearing and refuge habitat for young salmonids and resident fish.

Reconstruction of the stream channel will also provide stability to the channel habitat that does not currently exist. The source of erosion caused by the drop at the dam will be removed. Construction of a more natural stream gradient will also provide a more stable channel structure than the existing conditions. Reconstruction of the stream channel will also provide more natural migration and rearing habitat for outmigrating salmonids.

5.3.2 Anadromous Fish.

Populations of salmon in the Pacific Northwest have declined precipitously over the past several decades (Nehlsen et al. 1991). Small streams like Goldsborough Creek have the capacity to buffer the declines in larger systems and support the efforts of the federal and state agencies to preserve and recover wild salmonid stocks.

Small streams like Goldsborough Creek are preferred by coho salmon for spawning, and typically exhibit low levels of primary production because of a combination of heavy shading, variable discharge, and low water temperatures (Bilby and Bisson 1992). In addition to the direct and indirect effects upon the aquatic biota, this project will restore natural stream processes to Goldsborough Creek. Natural fluvial processes will eventually restore the stream gradient and allow sediment to move downstream more efficiently. Over time, the downstream channel will benefit from the increased transport of sand and gravel and the substrate composition, channel meander, and riffle/pool sequence should approach the upstream condition. This will improve the currently poor salmonid habitat quality in this segment. Finally, the increased sediment transport should improve conditions in the estuary. Simpson Timber Company is no longer dredging the mouth of Goldsborough Creek, and an increase in the sediment supply will help restore the delta and increase the estuarine intertidal habitat available for rearing salmonids and migratory birds.

The Goldsborough Creek Dam is the primary bottleneck to salmonid upstream rearing and spawning habitats. Without a project to either remove the dam or significantly modify the fishway, the bottleneck would remain and continue to prevent most salmonids from accessing the upper watershed. This habitat is particularly limited in southern Puget Sound and the condition of Goldsborough Creek is better than most other streams in the area. Downstream passage for juvenile and resident fish will also improve through dam removal. The face of the dam, which includes a concrete basin, concrete and rock debris, metal sheetpile, and exposed clay banks, likely results in the mortality or decreased condition of juveniles migrating out of the system (Fraser 1993).

5.3.3 Resident Fish.

Considering the currently degraded conditions of the project reach, there will be little impact to the resident fish population during construction. After diversion of the stream flow into the bypass pipe, as many fish as possible will be collected in the dewatered section. Fish could be trapped in numerous pools in this section. Resident fish will be placed upstream a minimum of one mile to avoid the project area and downstream sedimentation.

A significant increase in anadromous fish above the dam could affect the current population of resident trout. The upper watershed has always had some level of salmonid use, including natural spawning and extensive hatchery supplementation using coho fry. The proposed project would result in an incremental increase of primarily coho fry above the dam.

An increase in cutthroat trout smolt numbers in eastern Hood Canal streams coincided with declines in coho salmon abundance (Johnson *et al.* 1999). This suggests that the interactions between the two species may have reduced the abundance of cutthroat trout. There has also been some evidence that cutthroat trout are relegated to riffles by the more dominant coho salmon (Glova 1986), although other authors have found that cutthroat trout select the shallower and faster waters in riffles even though coho salmon are not present (Sabo and Pauley 1999). When coho salmon fry are present they can dominate cutthroat trout fry because juvenile coho salmon emerge from redds earlier and are larger in size (Laufle *et al.* 1986). Yet, adult cutthroat trout will readily prey on coho salmon fry or other small fish.

Anadromous salmonids historically occurred in the upper watershed. Additional nutrients and elevated primary productivity levels resulting from increased adult carcass densities will partially offset the detrimental effects to resident fisheries associated with the increased abundance of juvenile anadromous salmonids.

5.3.4 Fish Passage.

In the long term, this project will restore natural river processes and improve fish passage. The plan would provide unobstructed fish passage, restore a healthy creek bed for fish use, and protect and enhance riparian and wetland habitat upstream and adjacent to the creek.

Removal of the dam will most likely improve downstream passage conditions for young anadromous salmon.

5.3.5 Short Term Impacts (Construction).

Removal of the dam and reconstruction of the stream will require approximately two to six months, depending upon the construction schedule, to complete. During this period, the creek will be diverted into a pipe for the length of the project area, and will provide little or no fish habitat along the length of the diversion.

The construction period will follow the spring high-flow period, so it will avoid impacts to the young salmon migrating downstream during the spring. Most of the construction (all in-water work) will occur prior to the adults arriving in the fall. There is some potential that upstream migrants, particularly early chinook and chum, will arrive in Goldsborough Creek prior to completion of the stream restoration.

5.3.6 Adult Salmon Collection and Trucking Upstream.

To avoid the most direct adverse construction impacts to salmonids, ideally the temporary stream bypass by pipe should only occur between June 15 and August 31, for a construction window of approximately 10 weeks. The downstream migration of smolts is completed by June 15 and the adult return of chinook and chum salmon for spawning can begin in early September. All reasonable effort will be made to require the contractor(s) to include a concentrated and intensive work schedule to complete instream work that requires flow bypass within this time frame.

After diversion of the stream flow into the bypass pipe, a concerted effort will be made to collect as many fish as possible in the dewatered section. Fish will be trapped in numerous pools in this section. Considering the size of this stream, numerous personnel and collection and transporting equipment will be required. Salmonid smolts will be placed downstream to allow them to continue their outmigration and resident fish will be placed at least a mile upstream to remove them from any effects of construction and sedimentation

If the project in-water work and temporary bypass by pipe cannot be completed in the preferred time frame, even with a concentrated and intensive work schedule, then it would preferable to initiate the work prior to June 15 rather than extend the work into September. However, based on the project schedule, it is extremely unlikely that in-water work could be initiated prior to 15 June 2000. During plans and specifications the project construction schedule will be revisited. If it appears likely that the in-water construction period required exceeds approximately 10 weeks, coordination will occur among all the project stakeholders to determine the best course of action. The options may include delaying construction one year so that the work could begin earlier the following spring, or continuing construction into September, in which case a trap and haul facility would be necessary.

If construction (in water work) is initiated prior to 15 June, the diversion structure would need to accommodate passage of outmigrating fish. No detailed evaluations have been completed as part of the feasibility phase to determine the design requirements that would need to be incorporated into the diversion structure to allow for safe passage of outmigrating fish.

It must be understood that even if the stream diversion is anticipated to be completed by August 31, unplanned delays may make this impossible. A contingency plan must be developed to mitigate this potential problem. Work progress will be carefully monitored throughout the construction period to determine if the schedule is being met. Trap and haul will be scheduled to begin August regardless of construction schedule.

The trap and haul may require that all adult salmonids be collected as close to the stream mouth as possible and trucked to upstream of the project. In this situation a net, louver, or other barrier would have to be placed across the stream upstream of the project to prevent the adults from entering the bypass pipe and spawning downstream of the project. The primary reason for this mitigation is the potential sedimentation to spawning chinook and early race of chum salmon. This sedimentation pulse could come from the new rebuilt channel section during the first flush when the flow is placed back into the new channel section and also from subsequent sediment release increases as fall stream flows increase.

However, potential problems with the trap and haul procedures will be avoided if a contingency plan is developed prior to construction. Requiring the contractor to demonstrate the capability to collect and haul adult salmon prior to beginning construction will also prevent problems with implementing the trap and haul process.

Further investigation into the potential effects of the first flush of sedimentation will continue during the permitting process. At this time WDFW has not fully evaluated from past experience and reasonable expectation if potential effects are understated or overstated. Mitigation of the potential first flush sedimentation will include gradually increasing the flow in the new channel over numerous days to use dilution to minimize downstream sedimentation.

5.3.7 Fish Collection after Channel Dewatering.

After diversion of the stream flow into the bypass pipe, a concentrated effort will be made to collect as may fish as possible in the dewatered stream. Fish will be trapped in numerous pools. The number of fish is likely to be high, based on the size of the stream and significant numbers of personnel and equipment will be required to accomplish this task. Salmonid smolts will be placed downstream to allow them to continue their out-migration.

5.8.8 Long Term Impacts.

This project is proposed as a means to remove the existing adverse impact the dam has on anadromous fish passage and fish habitat within the dam reach of Goldsborough Creek. Removal of the dam will provide an opportunity to both restore natural and better upstream migration, and to restore a normal gradient to Goldsborough Creek in the area of the dam. Restoration of natural upstream migration for anadromous fish stocks is a primary objective of the proposed project.

Removal of the dam will eliminate the need for the existing fish ladder and its approach that has been an impediment to upstream passage of salmonids. The existing ladder and its approach conditions have apparently impeded the movement of chum salmon and anadromous cutthroat, and possibly coho salmon and steelhead, to the productive areas of Goldsborough Creek upstream from the dam. Since most of the potential spawning and rearing habitat (about 14 miles) of Goldsborough Creek exists upstream of the dam, eliminating this passage impediment has the potential to substantially increase the salmonid production from Goldsborough Creek.

Stream habitat in the dam reach will also be improved by removal of the dam. The dam dominates existing channel morphology. The dam has produced a sediment-filled forebay that provides a broad shallow channel section with relatively low stream velocities. It has also led to occasional out-of-channel flows during extreme storm events. During these periods the stream has overflowed its bank at the railroad bridge, flowing down the railroad tracks to return to the creek at the fish ladder. These events have adversely affected performance of the ladder until repairs are made.

Downstream of the dam the channel has been eroded by the plunge over the dam. This erosion has removed any potential spawning or rearing habitat in the area immediately downstream of the dam. This erosion has also produced a passage impediment due to the steep drops in the hard clay bottom of the eroded stream section. This passage impediment has been partially rectified by installation of sheet pile to form a shallow pool structure in the stream. However, additional erosion has produced a three-foot drop over the sheet pile again producing a passage impediment. This existing situation would be resolved by reconstruction of the stream channel as part of dam removal.

Channel reconstruction will include alternating pool and riffle sections at a more natural stream gradient. These features, together with large woody debris included in the stream bands, will provide considerable improvements in the rearing and refuge habitat for young salmonids and resident fish.

Removal of the dam will most likely improve downstream passage conditions for young anadromous salmon. Although it is unknown to what extent the existing drop at the dam produces injury or mortality in downstream migrants, any impacts that do occur will be eliminated by removal of the dam. Reconstruction of the stream channel will provide more natural migration and rearing habitat for these young salmon.

Reconstruction of the stream channel will also provide stability to the channel habitat that does not currently exist. The source of erosion caused by the drop at the dam will be removed. Construction of a more natural stream gradient will also provide a more stable channel structure than the existing conditions.

6.0 POTENTIAL IMPACTS ON SPECIAL AQUATIC SITES.

6.1 WETLANDS.

6.1.1 Existing conditions.

Goldsborough Creek supports a number of riparian and floodplain wetlands. Within the project impact area there are four wetlands. In general the floodplain and riparian wetlands have a deciduous forested canopy with a dense to open shrub understory. The dominant tree species found in the wetlands are Oregon ash (*Fraxinus latifolia*), black cottonwood (*Populus balsamifera*), and red alder (*Alnus rubra*). The shrub understory is dominated by salmonberry (*Rubus spectabilis*), with minor components of vine maple (*Acer circinatum*), Indian Plum (*Oemleria cerasiformis*), and *cascara (Rhamnus* *purshiana*). Ground cover in other areas are commonly occupied by lady *fern (Athyrium filix-femina*), mountain wood-fern (*Dryopteris austiaca*), common touch-me-not (*Impatiens noli-tangere*), youth-on-age (*Tolmiea menziesii*), slough *sedge (Carex obnupta*), reed canary grass (*Phalaris arundinacea*), and mannagrass (*Glyceria spp*). The backwater channel and pools can contain skunk cabbage (*Lysichitum americana*), water parsley (*Oenanthe sarmentosa*), and American speedwell (*Veronica americana*).

The wetlands are ringed by mixed coniferous and deciduous forest made up of Douglas fir (*Pseudotsuga menziesii*), western hemlock (*Tsuga heterophylla*), big leaf maple *(Acer macrophyllum*), western red cedar (*Thuja plicata*), Indian Plum (*Oemleria cerasiformis*), salal (*Gaultheria shallon*), hazelnut (*Corylus cornuta*),

(*Pteridium aquilinum*), Oregon grape (*Berberis nervosa*), red huckleberry *(Vaccinium Parvifolium*) and twin flower (*Linnaea borealis*).

The soils within the wetlands reflect the alluvial processes of deposition and scour common in floodplains. When present the soil is silt loam over sand/gravel. Other substrates are represented by accreted cobble, gravel or sand bars without soil profile. Organic muck material accumulates to small degree allowed between scouring that occurs during seasonal high flows. Portions of the wetland areas have accumulated some organic matter within the soil profile indicating that those areas are out of the main floodplain scour zone.

Wetland #1

Wetland #1 is a small (0.1acre) riparian/floodplain wetland. It is approximately 900 feet downstream of the dam on the north side of the creek. Although small, this wetland is classified as a category 1 wetland based on Ecology's rating system (Ecology 1993). This small wetland provides habitats similar to the non-wetland riparian habitats along this reach of the stream. Based on direct observation the hydrologic model results this wetland periodically is flooded by high creek flows.

Wetland #2

Wetland 2 is classified as palustrine forested wetland and meets criteria established for Category 1 wetlands. This forested riparian wetland covers 1.33 acres. It is on the North side of Goldsborough Creek just upstream of the dam forebay. The wetland is confined between the Creek and small ridge that supports the railroad tracks.

The water exchange between Goldsborough Creek and wetland #2 occurs when part of the wetland is flooded periodically. Flooding from the up-stream side of the wetland will

Photograph W1. Looking from wetland #2 toward west with Goldsborough Creek in background, wetland #2 inlet areas.

occur at the 2-year and greater discharge within the Creek.

Portions of the lower wetland may flood more frequently. The evidence for this is that Goldsborough Creek water flows through the wetland often enough to prevent establishment of vegetation along a path where small gravel (one and one-half inch and smaller gravel's and sand) deposits are exposed.

Water exchange between the wetland and Goldsborough Creek is also influenced on the downstream wetland end by backwater from the forebay of the dam and fish passage structure. Wetland #2 is topographically above the summer-based flow of the stream and does not benefit from up stream water input during lower flows.

In general, wetland # 2 receives water from flooding of Goldsborough Creek, both directly inundating the wetland and from forebay channel backwater at the dam. There may also be some water movement exchange through the gravel bars and lens that separate the wetland and the creek. It is also possible the some water seeps through the gravel base of the railroad and down the north bank supplying the wetland during periods of high water.

Surface flooding from Goldsborough Creek occurs at 2 years discharges or greater. The inlet to the wetland is located in the very north end of the wetland. Inflow from the creek flows from the inlet through the wetland and exits along the southern edge of wetland #2. The invert of the wetland varies with flow and scour of the creek. At the present time it is one to two feet above low water level of the creek.

Wetland #2 was mostly created after the construction of the dam when sediment accumulated in the dam's forebay. This forested floodplain wetland was forested riparian area prior to the construction of the dam. The ecological function of this wetland is somewhat different today then it was historically since it now supports wetland as well as riparian plants and animals. Today the wetland ecological function is similar to the its pre-dam function except that it presently provides some aquatic habitat for waterfowl, aquatic insects and amphibians.

Wetland #3

Wetland # 3 also known as Beaver Marsh is located 400 feet upstream of the dam and the main channel of Goldsborough Creek. A ridge defines the wetland boarder to the southwest and northwest and the railroad to the north and northeast. The eastern edge of the wetland is confined by the west bank of Goldsborough Creek. A beaver dam retains the wetland open water at the outlet end of the wetland. The beaver dam is located at the southeast end of the wetland and is an extension of the west bank of the creek to the base of the south ridge. This dam appears to block an old oxbow channel of the creek that may have existed years before the first logging occurred in this area. Beaver activity has historically maintained the dam although, in 1999 field visits, beaver activity at this site was not observed.

Photograph W5. Open water wetland showing beaver lodge looking to the southeast toward the beaver dam.

Wetland #3 covers 2.5 acres and is classified as a possible Category I wetland (Cowardin et al. 1979). It is palustrine scrub/shrub, emergent , and open water wetland. The dominant tree species within Beaver Marsh are red alder (*Alnus rubra*) and Black cottonwood (*Populus balsamifera*). Other trees observed are Oregon *ash (Fraxinus Latifolia*), vine maple (*Acer circinatum*), western hemlock (*Tsuga heterophylla*), and western red cedar (*Thuja plicata*). Downed logs are common throughout the wetland as are grasses and sedges. A shrub dominated area lines the areas adjacent to Goldsborough Creek bank as is comprised of salmonberry (*Rubus spectabilis*) and hardhack (*Spirea douglasii*) with reed canary grass (*Phalaris arundinacea*) between the shrubs and the

Photograph W6. Open water wetland looking toward inlet at the northeast end of the wetland.

open water areas. The shallow open water areas contain emergent plant species such as small-fruited bulrush (*Scripus microcarpus*), water parley (*Oenanthe sarmentosa*), marsh forget-me-not (*Myosotis scorpioides*) and several species of sedge (*Carex* spp.). In addition, there is floating plant duckweed (*Lemna minor*) and several species of submersed pond weeds (*Potamogeton* spp.) within the open water areas. Subsoils are made-up of sand and gravel overlaid by coarse sand. The top six to 18 inches of soil is made up of dark gray gravelly sandy silt loam with a high organic content. As characteristic of hydric soils the surface horizon of the wetland soil is accumulating organic debris.

The direction of water movement within wetland # 3 is from the north to south and probably to the east through the gravel banks of Goldsborough Creek. The inflow into this wetland is from an old wood pipeline that carries water along the railroad line from the northwest. This pipeline is broken and flows through the pipe and the gravel base enters wetland #3 near the very north end of the wetland through a swale. This source of water is an active water source for the wetlands during the rainy season October through May, but appears to dry in the summer months. Based on the heights of water in wetland # 4 versus #3 it would appear that water movement from wetland #4 to wetland #3 is insignificant. Implying the conductivity of soil between wetland 3 and 4 is very low. The water elevation difference when surveyed in September between the two wetlands was

Figure W3. Ground elevations and water levels in wetland #2 , #3 and Goldsborough Creek

3.3 feet, water level in wetland #4 was 94.6 feet above mean sea level and the water level in wetland #3 was 91.3 feet above mean sea level.

Since at the same time wetland #4 was 1.4 feet above the water level is the creek. This indicates that the rate of water movement from wetland #4 to the creek and wetland #3 was slow.

The water within the wetland #3 at the central part of the wetland was 0.4 feet below the water level at the creek and 0.5 feet above the creek water level at the southern end of the wetland. The surface water level in Goldsborough Creek varied from 91.7 to 90.8 feet above mean sea level as the creek flowed from north to south along the eastern border of wetland #3. Yet the surface water elevation within the wetland was approximately 91.3 feet above mean sea level throughout.

It is probable that the silts and organic material employed by the beaver in the southern beaver dam results in a slower rate of water movement through the dam than the rate of water movement through the sediment deposits of the creek on the western bank.

Based on these observations the direct exchange of water between Goldsborough Creek and wetland #3 is limited during low flow periods. Based on the modeling direct flooding of wetland #3 by the creek will occur when the discharge is greater that the 10 year flow rate.

No direct inlet from Goldsborough Creek to wetland #3 exists at this time, except during high flow events when the waters of the creek over top the western bank of the stream and flow into the wetland. The surface inlet flow appears to be from the old railroad pipeline located at the north end of the wetland. Water also enters the wetland from the

Figure W4. Ground elevations and water levels in wetland #3 and Goldsborough Creek

surrounding ridge and steep slope draining into the wetland. The existing beaver dam at the southern boundary of wetland #3 blocks the former outlet from the wetland.

At the time of the first cutting of the forest in the area the central portion of wetland #3 supported a stand of western red cedar (*Thuja plicata*) as evidenced by the large cut stumps remaining within the wetland. The roots of the remaining stumps are at current ground level. This indicates that wetland surface has not filled with sediment and that at portions of the wetland were present before the dam was constructed. It is likely that this wetland was originally formed by an oxbow of the creek and backwater influences. The beaver occupation enhanced the wetland character and diversity as did the inflow of water from the railroad pipeline and ditch. The direct benefit to fisheries is limited since there is no direct fisheries access to the wetland resources. Occasionally, fish will get stranded in the wetland when they are carried into the wetland during periods of flooding.

The beaver dam blocks the exit from the wetland and the main wetland is isolated from the creek by the sediment berm that has built up over the years.

The function value of wetland #3 is similar at present as it was historically with the influence of the beaver dam being the factor that has increased the open water percent of the wetland area.

Wetland #4

Wetland #4 is a floodplain wetland that is supported by seasonal flooding. The inlet to this wetland is in the north to northwest end of the wetland. The inlet is a small swale that allows creek water to flow into it at moderate stream flow levels. The gravel swale inlet invert is 1 to 2 feet above water level of Goldsborough Creek during low flow conditions. The outlet to the wetland is located at the very southern end of the wetland. The outlet channel is currently 2 to 3 feet higher than the current low water level in the creek. This forested wetland covers 1.27 acres.

Photograph W7. Vegetation and character of the floodplain wetland #4

Soils within this floodplain wetland reflect the alluvial processes of deposition and scour common to floodplain wetlands in the Goldsborough Creek drainage. Due to re-occurring scouring events organic material does not have the opportunity to accumulate within this wetland. Wetland #4 meets the criteria for a Category 1 wetland according to Ecology's rating system.

6.1.2 Impacts to wetlands.

The negative impacts of dams on river fishes in North America has been well documented and the removal of a dam is generally considered extremely important action in the restoration of the ecosystem. The Goldsborough Dam removal project would restore full anadromy to the stream, allowing coho, chum, and chinook salmon, steelhead and cutthroat trout access to about 22 miles of upstream spawning and rearing habitat. The removal would also allow recovery of natural physical properties (i.e., sediment and nutrient transport, hydrology, and temperature regimes). However, there are some inherent problems associated with removing a large dam. The loss of wetlands is frequently a significant impact resulting from removing a dam.

Table 3. Wetland summary.

Wetland #	Location	Type	Dept. of Ecology Rating	Area (in acres)
1	900 ft. below dam	riparian	Category 1	<0.1
2	forebay area of dam	floodplain/ forested	Category 1	1.33
3	400 ft. upstream of dam	palustrine shrub, emergent, open water	Category 1	2.50
4	900 ft. upstream of dam	floodplain	Category 1	1.27

The Goldsborough Dam removal design team consisted of personnel from the US Army Corps of Engineers, US Fish and Wildlife Service, Washington Department of Fish and Wildlife, Squaxin Island Tribe, Mason County, and Simpson Timber. When dealing with impacts to wetlands, the design team first attempted to avoid any impacts to wetlands, when this was determined to not be possible for wetlands 2 and 3 then all effort was made to minimize the impacts. Mitigation was also looked at as an option to replace lost wetland area.

6.1.3 Avoidance.

The project was designed to avoid any impacts to Wetland 1 and Wetland 4. However, it was determined that if the dam was to be removed then impacts to Wetland 2 and Wetland 3 could not be avoided. Because of the placement of the weir groups through the current southwest corner of wetland #2, it is thought that wetland #2 may de-water as a result of the lower invert elevation of Goldsborough Creek. Although the alignment would not go through wetland #3 (we moved alignement to help avoid impacts) it is also thought that it may de-water because the invert elevation of Goldsborough Creek will be lowered approximately 10 feet. However, rather than forego the important benefits of the project, the design team looked into several alternatives to minimize impacts. Several alternatives were developed and considered by the design team and refined by the contractor Tetra Tech, Inc (See Appendix f of Final Advance Planning Report, Addendum to the July 1999 Ecosystem Restoration Report and Environmental Assessment, Revisions December, 1999).

6.1.4 Minimize impacts.

Several alternatives were looked at to minimize impacts to wetlands 2 and 3. These included piping water to wetland 3, using sheet pile to cut off subsurface flow, lowering wetland inverts to match new stream invert, deepen and line open water ponds, and expanding the abandoned creek section into a riparian /flood channel wetland habitat. Many of these alternatives were ultimately eliminated due to constraints of the project, low probability of success, and exorbitant financial costs to the project. The analysis of each alternative is presented below.

6.1.5 Pipe water to wetland three alternative.

To mitigate for the loss of flood water inflow to wetland #3 and to compensate for water loss to dewatering, water could be diverted from Goldsborough Creek under the railroad tracks near the northwest corner of wetland #4 and piped to wetland #3. Inflow volume could be set to offset the potential loss of water through the existing wetland bank to the stream channel. The cost of this alternative would be approximately $28,000 for 200 linear feet of pipe intake structure and culvert under the railroad.

However, given the sand/gravel nature of the material beneath the wetland, the wetland may readily drain to the new channel invert. As a result, maintaining an open water wetland could require significant amount of water to be transferred from upstream in the creek. If the project was successful in maintaining an open water surface in wetland #3 it would have a permanent head differential (12 feet over a distance of only 120 feet) between the wetland and the proposed channel. The resulting subsurface flow would continuously undermine the right bank and would require extensive armoring to keep it in place. US Army Corps of Engineers, Washington Department of Fish and Wildlife, and Tetra Tech engineers all felt that this would pose a serious geotechnical threat to the project. Operation and maintenance of this alternative would also be considerably high. Also, there would be a potential for fish stranding in this alternative. Thus, given the geotechnical concerns, which are relatively certain, along with potential biological concerns, this alternative was not considered feasible unless used in conjunction with the steel sheetpile

6.1.6 Steel sheetpile alternative.

Steel sheetpile could be used to cut off the subsurface flow and would thus eliminate the stability question. The cost estimate is described in more detail below. A depth of 15 feet would probably be adequate. If a depth of 20 feet were required, the cost would increase to roughly $130,000.

Table 4. Wetland 3 sheetpile and diversion alternative cost.

Wetland 3 sheetpile and diversion alternative cost

Item	Description	Unit Cost	Quantity	Cost $
Sheetpile	depth 15 ft	$308/LF	275LF	$84,700
Diversion	Intake	LS	2500	$2,500
	Pipeline	$30/LF	300LF	$9,000
Outlet	Stand Pipe	$30/LF	100LF	$3,000
Cost total				$99,200
Design costs				$35,000
Total				134,200

Due to the cost and the potential impact of installing the sheet pile, this alternative was not considered to be a feasible alternative to the state and county agencies.

6.1.7 Lower wetland inverts alternative.

To eliminate the elevation difference between the wetlands and the new stream channel and hence eliminate the potential for de-watering, lowering the wetland inverts was considered. Lowering wetland #3 would present an opportunity to enhance the present condition and functional value of the wetland. This is possible if the invert of the wetland is lowered in portion to the reduction in the creek invert and if the berm between the wetland and the creek would be notched to allow inflow of water into the wetland. This water in flow would create side channels that could be maintained by backwater influences. Also the existing beaver utilization would be potentially lost due to construction. To lower the wetland #3 approximately ten vertical feet and re-establish the wetland vegetation would cost an estimated $300,000. If the wetland was expanded into the old creek channel area the additional cost would be $90,000 giving a total cost of $390,000.

6.1.8 Deepen and line open water ponds.

In order to minimize the potential loss of open water wetland area within wetland #3 a series of ponds could be constructed within the current open water area of the existing wetland. These ponds would have to be lined with clay or another material to prevent the infiltration of water into the soil. The ponds could be located in the northwest area of the wetland where there is currently an open water wetland. The pond could be dredged to allow for more dead storage of water. This dead storage would allow the maintenance of open water during the dry season when inflow water is limited. This would also allow the remaining wetlands to develop fully as a riparian wetland. It was determined that in order to accomplish this alternative that there would possibly be quite extensive impacts to the wetlands from construction. Also there was some concern that lowering these wetlands may act as a "trap" to certain species. Since there seemed to be greater potential to impact wetlands through construction than benefits gained, this alternative was eliminated from consideration. Since this alternative was eliminated from consideration a cost estimate was not prepared. However, the cost would be considered to be quite high.

6.1.9 Expanding the abandoned creek section into a riparian /flood channel wetland habitat alternative.

In this alternative the project would divert water that is available from an adjacent swale to the abandoned stream channel. The abandoned stream channel could be contoured in such manner as to impede the immediate flow of this water so that is would saturate the soil during wet periods this would convert the creek channel into a riparian/flood channel wetland habitat. This would add approximately 0.75 acres of wetland at the site. This new wetland will in turn form a hydraulic barrier that will reduce the draining of the open water portions of wetland #3. The remaining wetland will be allowed to adjust to the new hydrologic regime. This will result in limited to partial conversion from an open water wetland to a riparian wetland. This alternative was the preferred alternative of the design team.

6.1.10 Mitigation.

The design team also looked into mitigation as a mean of replacing some of the lost functions of wetlands that may occur. A constructed wetland could be developed in Goldsborough Creek floodplains upstream of the stump wetland. This developed wetland could be designed in such away as to allow connectivity with the stump wetland and the creek to provide for more fisheries habitat within the constructed wetland and the stump wetland. It is estimated that a two for one area formula could to be applied. That yields a constructed wetland of 5 acres. The estimated cost of this wetland development would be $250,000. This alternative was not further considered after discussions with Washington Department of Ecology indicated that they considered this alternative to have too much of a risk to the naturally occurring functions of the stump wetland. Also, while this would increase habitat for fish it would not necessarily increase the amount of wetland since the stump wetland is already functioning well as a wetland. No further offsite mitigation was considered since US Army Corps of Engineers regulations (EC 1105-2-214) does not allow for mitigation on Section 206 restoration projects.

Table 5. Wetland mitigation alternatives considered.

Alternatives considered	Estimated Cost ($)	Probability of success	Benefits	Problems associated with alternative
Pipe water to wetland 3	100,000	low	maintain open water function	undermine the right bank, structurally unsound, potential for project to fail
Sheetpile alternative	$135,000-	moderate	maintain	large construction impacts

	$175,000		open water function	
Lower wetland inverts	$390,000	moderate	create side channels	loss of beaver utilization
Deepen and line open water ponds.	$150,000 ?	low	maintain open water function	construction impacts, artificial solution
Off-site wetlands alternative	$250,000	moderate	provide fish rearing habitat	fish stranding, risk to current function of wetland
Expanding creek section	$10,000	high to moderate	add 0.75 acres of wetland	small construction impacts
Mitigation	$250,000	moderate to high	yield of 5 acres of wetland	USACE regulations does not allow, WA DOE did not like site considered for mitigation

6.1.11 Conclusion.

The environmental impacts of wetlands #1 and # 4 will be temporary and no long term change in hydrology or ecological function is expected as result of the project. Wetland #3 may dewater resulting in the loss of open water habitat. The former open water area will transition into riparian wetland habitat. Wetland # 2 will be lost and the area will revert to its original character, riparian habitat. Although some wetlands may be lost as the result of the project, the design team believes that its preferred alternative will provide the best benefit at a reasonable cost. Any lost functional value of a wetland will be greatly outweighed by the benefits provided through the project. In fact, one of the results in the dam removal would be the new connectivity between Goldsborough Creek and the floodplain, this may result in increased beneficial floodplain flooding patterns. Other benefits may include groundwater recharge, and floodplain habitat forming processes. It is also thought that the dam removal will lead to substantial gains in habitat quality within only a few years. Supporting language can be found in the 404 guidelines "the benefits of the proposed alteration outweigh the damage to the wetlands resource and the proposed alteration is necessary to realize those benefits." Further, "some activities that require Department of the Army permits result in beneficial effects to the quality of the environment. The district engineer will weigh these benefits as well as environmental detriments along with other factors of the public interest." The balancing of the favorable impacts against the detrimental impacts is known as the "public interest review." In this it states "The benefits which reasonably may be expected to accrue from the proposal must be balanced against its reasonable foreseeable detriments." Further supporting language can be found in EPA's guidelines for section 404 (b) (1). where it states "when a significant ecological change in the aquatic environment . . ., the permitting authority should consider the ecosystem that will be lost as well as the environmental benefits of the new system." Per the EPA guidelines' preamble, FR page 85344, "Restoration and habitat development techniques can be used to minimize adverse impacts and compensate for destroyed habitat." "Restoration has the potential to return degraded environments to their former ecological state." "From an environmental point of view, a project involving the discharge of dredged and fill material should be designed and managed to emulate a natural ecosystem." Also, offsite mitigation was not further considered since US Army Corps of Engineers regulations (EC 1105-2-214) does not allow for mitigation on Section 206 restoration projects.

6.2 SANCTUARIES AND REFUGES.

The proposed action will have no effect on sanctuaries or refuges.

6.3 MUDFLATS.

The proposed action will have no effect on mudflats.

6.4 VEGETATED SHALLOWS.

The proposed action will have no effect on vegetated shallows.

7.0 POTENTIAL IMPACTS ON HUMAN USE CHARACTERISTICS.

7.1 MUNICIPAL AND PRIVATE WATER SUPPLIES.

The proposed action will have no effect on municipal or private water supplies.

7.2 RECREATIONAL AND COMMERCIAL FISHERIES.

The proposed action will benefit recreational and commercial fisheries for migratory salmon and trout by providing fish passage to valuable spawning and rearing areas. With dam removal, the river's historic fisheries could resume. Most of the river's stocks could take advantage of the large amounts of pristine habitat upstream of the dam and may provide harvestable surpluses. Anadromous fishing opportunities would expand from the 2 river miles currently available to the entire river. Catches would also shift away from fisheries of short duration targeted on hatchery stocks to year-round fisheries on wild stock.

7.3 WATER RELATED RECREATION.

The project would not adversely affect any water related recreation. It would most likely increase opportunities for angling.

7.4 AESTHETICS.

During the construction period there would be short-term adverse impacts to aesthetics from the construction equipment working within the site and from material and equipment stored within the staging area.

7.5 PARKS, NATIONAL AND HISTORIC MONUMENTS, NATIONAL SEASHORES, WILDERNESS AREAS, RESEARCH SITES, AND SIMILAR PRESERVES.

The proposed action will have no effect on parks, national and historic monuments, national seashores, wilderness areas, research sites, and similar preserves.

8.0 EVALUATION AND TESTING OF DISCHARGE MATERIAL

8.1 GENERAL EVALUATION OF DREDGE OR FILL MATERIAL.

The material excavated from Goldsborough Creek is expected to be clean or very low concentrations of contaminants.

8.2 EVALUATION OF CHEMICAL-BIOLOGICAL INTERACTIVE EFFECTS.

8.2.1 Exclusion of Material from Testing.

Material would be obtained from clean sources which would not require testing. Initial nourishment will be obtained from the upstream section of the project's stream bottom. This native material is natural material and is not considered contaminated. Formal testing of material is not considered necessary. Material stockpiled from other areas as part of future nourishment requirements will be specially selected and will meet minimum disposal criteria.

8.2.2 Water Column Effects.

The proposed project will have no effect on the water column.

8.2.3 Effects on Benthos.

The most common direct effect of suspended sediment on macroinvertebrates observed in experiments with fine sediments has been a pronounced increase in downstream drifting. Such increased drift has been attributed primarily to a decrease in light with consequent drift responses similar to behavioral drift in a diel periodicity. Extraordinary drift under prolonged high levels of suspended sediment may deplete benthic invertebrate populations.

Severe damage to benthic invertebrate populations can be caused by heavy sediment deposits. The affected organisms consist mainly of the insect orders Ephemeroptera, Plecoptera, and Trichoptera, (EPT), which generally are the forms most readily available to foraging fish. Virtually no research has been conducted on the effect of sediment on the meiofauna of streambeds, despite increasing appreciation of the ecological importance of these small organisms to fisheries.

Any effect of sediment input to Goldsborough Creek is likely to be of minor consequence to benthic invertebrates since the biological effect of episodic inputs has been found generally to be temporary. Rapid recovery often results from invertebrate drift from upstream reaches. In a Ohio stream, sediments from eroding deposits of glacial lacustrine silt, although natural, simulated episodic events. The glacial silt periodically reduced benthic macrosinvertebrates up to 5 km downstream from the site (DeWalt and Olive 1988). However, after one of the glacial silt deposits was completely eroded, sediment input ceased, the stream deposits cleared, and drift from upstream quickly restored benthic populations. In British Columbia, temporary siltation from a pipeline crossing reduced local benthos populations by up to 74% but benthos recovery was rapid after construction stopped (Tsui and McCart 1981).

8.3 COMPARISON OF EXCAVATION AND DISCHARGE SITES.

Materials for the fill and revetment would be obtained from local quarries and consist of large rock, sand and gravel which would not contain toxic materials or high levels of organic soils. Following placement of the materials no further dispersion is expected, therefore no measures to control placement of these materials are considered necessary. However, some cleanup of displaced revetment rock may be undertaken to minimize impacts and ensure project function. Dispersion of nourishment materials will serve to protect existing beach profiles and will be left to natural wave action.

8.4 PHYSICAL TESTS AND EVALUATIONS.

Seventeen sediment grab samples were collected at thirteen sites within the study reach. The downstream most sample, at "Site A" is near the Railroad Avenue bridge in the City of Shelton. The upstream most sample at "Site M" is ~3600 feet upstream of the STC railroad trestle. The remaining sites are distributed along the 9000-foot reach in between. The samples were taken from bars, banks, and from the subsurface layer below the existing armor layer. Table 6 lists the locations and the D10, D50 and D90[2] for each sample. With the exception of the sample taken immediately upstream of the dam, the D50's are fairly consistent and fall within a range of 2 – 15 mm. The D50's for gradation

[2] D50 refers to the particle diameter for which 50% of the sample (by weight) is smaller. Likewise, D10 and D90 respectively refer to the sizes for 10% and 90% of the sample are smaller

curves found by Golder and Associates (1996) and Dames and Moore (1991) vary from 2.5 to 10 mm.

In addition to grab sampling, photos were taken of armored portions of the bed and bars. The photos included a tape measure or object of known length, which was used to construct a scale grid. The pebbles/cobbles within the grid were outlined and measured, and converted to weight by assuming an equivalent spherical diameter. The distribution of weights was broken into classes and gradation curves of percent finer by weight were constructed. Table 7 lists the locations of the pebble counts along with D10, D50, and D90. Since the armor layer was generally lacking in finer grain materials, the pebble counts give a fairly complete gradation for the surface material. Table 7 shows that pebble counts are also fairly consistent within the sample area. The D50's generally range from 20-40 mm on bar deposits, but are as high as 60-90 mm in the armored areas.

Table 8 shows the gradations that were chosen for use in computing the sediment transport capacity for the sublayer and the armor layer using the SAM model. The chosen "armor layer" gradation is weighted toward the larger samples that are more representative of the armor layer. Also shown is the gradation for a recommended fish gravel (Inter-Fluve, 1999). It falls between the sublayer and armor layer gradations chosen for use in the SAM model.

Table 6. Sediment grab sample gradations.

Site	Description	Sample #	D10 (mm)	D50 (mm)	D90 (mm)
A	Bar on left bank, downstream of Railroad Ave Bridge	A1s	0.7	8	35
B	Bar on right bank, upstream of Railroad Ave Bridge	B1s	0.5	7	34
C	300' downstream of downstream utility line – instream sample	C1s	0.4	2	65
D	Large sand and gravel bar on left bank, upstream of SR 101	D1s	0.9	8	28
D	Smaller bar with finer material downstream of logjam just downstream of sample D1s (upstream of SR 101)	D2s	0.5	3	16

D	Bar on left bank 50 feet downstream of Cascade pipe crossing	D3s	0.4	8	22
E	50 feet upstream of upstream utility line – approx. 6 feet above water line	E1s	0.6	3	15
F	600 feet upstream of upstream utility line at bend – instream sample	F1s	0.4	3	13
G	Upstream side of log jam – instream sample	G1s	2	15	28
H	300 feet downstream of dam – at water's edge	H1s	0.5	4	25
I	100 feet upstream of dam – instream sample	I1s	0.3	0.7	1.5
J	10 feet downstream of railroad trestle	J1s	0.8	8	24
K	2000 feet upstream of trestle – instream sample	K1s	0.7	10	30
K	2000 feet upstream of trestle sublayer below Pebble Count	K2s	0.7	11	38
L	3500 feet upstream of trestle – instream sample	L1s	0.4	4	30
L	3500 feet upstream of trestle – instream sample	L2s	0.6	5	17
M	4000 feet upstream of trestle – bar	M1s	1	14	30

Table 7. Sediment samples – pebble counts.

Site	Description	Sample #	D10 (mm)	D50 (mm)	D90 (mm)
A	Bar on left bank, downstream of Railroad Ave Bridge	A1p	28	58	78
B	Bar on right bank, upstream of Railroad Ave Bridge	B1p	22	49	75
D	Large sand and gravel bar on left bank, upstream of SR 101	D1p1 D1p2	40 15	88 25	102 33
D	Smaller bar with finer material downstream of logjam just downstream of sample 103 (upstream of SR 101)	D2p	11	18	27
D	Bar on left bank 50 feet downstream of Cascade pipe crossing	D3p1 D3p2	17 35	26 68	35 85
E	50 feet upstream of upstream utility line – approx. 6 feet above water line	E1s	35	79	100 (1)
F	600 feet upstream of upstream utility line at bend – instream sample	F1s	54	83	100

G	Upstream side of log jam – instream sample	G1s	35	68	85
H	300 feet downstream of dam – at water's edge	H1s	7	17	28
J	10 feet downstream of railroad trestle	J1s	38	77	92
K	2000 feet upstream of trestle sublayer below Pebble Count	K2s	10	68	88

(1) Estimated

Table 8. Gradation curves used in SAM.

Gradation Curve	D10 (mm)	D50 (mm)	D90 (mm)
Subsurface curve used for SAM sediment transport capacity calculations	.7	8	29
Fish gradation	6	30	75
Pebble count/armor layer curve used for SAM sediment transport capacity calculations	35	72	90

9.0 FACTUAL DETERMINATIONS.

9.1 PHYSICAL SUBSTRATE DETERMINATIONS.

The sediment analyses conducted for Goldsborough Creek extended and refined the updated hydraulic results and sediment samples collected in the field. The SAM Sediment Hydraulic Design Package is an integrated system of programs developed through the Corps Flood Damage Reduction and Stream Restoration Research Program to aid engineers in analyses associated with designing, operating and maintaining flood control channels and stream restoration projects (Copeland, et. al., 1997). SAM combines hydraulic information and the bed material gradation to compute the sediment transport capacity for a given cross section, and a given discharge, for a single point in time. A number of sediment transport functions are available for this calculation. The sediment transport capacity is combined with a flow duration curve to compute the total sediment passing the cross section or over some period of time, i.e. one year. The SAM user's manual refers to this as "yield". A better term might be "potential yield" since the SAM computes the theoretical volumetric transport capacity of a reach, with no regard to changes within the reach. The SAM does not consider that an eroding cross section will have changing hydraulics. It also does not consider that as fines are transported out of a reach, the transport capacity is less since the available material is that much coarser (i.e., the program does not simulate the armoring of the bed). In summary, the sediment yield is not based on the analysis of a changeable bed, but rather is the sum of a series of steady state sediment “potential yields” computed over the hydrograph or flow duration curve.

Hydraulic inputs to the SAM model include effective width, depth, velocity, and energy slope and are computed using either weighted-average or representative outputs from the HEC-RAS model. The sediment transport capacity module within the program combines the hydraulic parameters with the bed material gradation information to compute bed material sediment discharge rating curves by size classification. A sediment transport function that combines the Meyer Peter Muller (MPM) function for bedload with the Toffaleti function for suspended load was chosen for this analysis. The sediment discharge-rating curve is integrated with a flow duration curve (USACE, 1989) to determine the volumetric yield of sediment passing through the given reach over some period of time, e.g., one year. When the computations are made over a series of reaches within a stream or channel, the relative sediment yields for adjacent reaches can be compared. If the potential sediment yield within a particular reach is less than that provided by the reach immediately upstream, then there will be more sediment coming in than can be transported, and an aggradational reach is expected. If the sediment yield in a reach is greater than what is supplied by the upstream reach, a degradational reach is expected. If the two yields are approximately the same, the reaches are in equilibrium with respect to each other. By carrying out this comparison from upstream to downstream (with the upstream-most reach designated as a supply reach) the potential sediment yield excess or deficit on a reach by reach basis can be identified. The Goldsborough Creek study reach was divided into the following subreaches for sediment analysis.

Table 9. Sediment analysis reaches.

Reach #	Description	From	To
1	Downstream/Tidal Reach	Oakland Bay	7th Ave. Bridge

2	Through Shelton	7th Ave. Bridge	Railroad Ave. Bridge
3	SR 101 Area	Railroad Ave. Bridge	Downstream limit of project
4	Lower Project Reach	Downstream limit of project	Dam
5	Upper Project Reach	Dam	Upstream limit of project
6	Supply Reach	Upstream limit of project	Upper limit of hydraulic modeling

The hydraulic inputs to the SAM model: effective width, effective depth, effective velocity and effective energy slope are tabulated for the existing condition in Table 10 and for the project alternatives in Table 11. The equations for effective values and the HEC-RAS cross sections used are defined below

Effective Depth: DCH = SHEAR/(UWW * SLOPE)
Effective Width: WDTH = ACH/DCH
Effective Velocity: VEL = QCH/(DCH *WDITH)
Effective Slope: $ES = ((VEL * XNCH)/DCH^{2/3})^2$

Where:
ACH = QCH/VCH
SHEAR = boundary shear stress within the in channel (lb/sf)
SLOPE = slope of the energy grade line
Q = total discharge
QCH = flow in channel (cfs)
UWW = unit weight of water (lb/cf)
VCH = velocity in the channel (f/s)
XNCH = Manning's n for the channel area

The first line of discharges in each table lists a series of intervals that were read from the flow duration curve published in the feasibility report. The intervals were chosen for portions of the plotted curve that were approximately linear. The second line lists the logarithmic mean for each interval and is the value that was run through the HEC-RAS models in order to determine effective parameters.

Table 10. SAM hydraulic input – existing conditions.

Discharge – Flow Interval (cfs)	17 - 29	29 - 45	45 - 100	100 - 300	300 - 500	500 - 1000	1000 - 1400
Discharge – Log. Mean (cfs)	22	36	67	173	387	742	1241
Parameter (1)	*Reach 1- Downstream Tidal Reach, High-Tide*						
Eff. Velocity (fps)	0.09	0.14	0.26	0.67	1.48	2.74	4.27

Eff. Depth (ft)	6.25	6.25	6.25	6.25	6.32	6.50	6.91
Eff. Width (ft)	53.05	53.05	53.06	53.09	53.27	23.84	55.16
Eff. Energy Slope (ft/ft	0.000001	0.000002	0.000005	0.000035	0.000169	0.000559	0.001234
	Reach 1- Downstream Tidal Reach, Low-Tide						
Eff. Velocity (fps)	0.22	0.35	0.66	1.64	3.24	4.86	6.20
Eff. Depth (ft)	2.84	2.84	2.85	2.93	3.25	4.00	5.02
Eff. Width (ft)	42.32	42.33	42.36	42.60	43.58	45.87	49.14
Eff. Energy Slope (ft/ft	0.000011	0.000030	0.000101	0.000612	0.002105	0.003674	0.004220
	Reach 2 – Shelton						
Eff. Velocity (fps)	1.61	1.81	2.26	3.15	3.88	4.76	5.73
Eff. Depth (ft)	0.55	0.66	0.89	1.47	2.23	3.19	4.26
Eff. Width (ft)	25.20	30.10	33.20	37.30	44.70	48.90	50.80
Eff. Energy Slope (ft/ft	0.0093	0.0091	0.0095	0.0095	0.0083	0.0077	0.0076
	Reach 3 – SR 101 Area						
Eff. Velocity (fps)	1.43	1.77	2.19	3.02	3.92	4.65	5.39
Eff. Depth (ft)	0.60	0.71	0.89	1.32	1.92	2.61	3.40
Eff. Width (ft)	25.56	28.94	34.24	43.46	51.53	61.00	67.78
Eff. Energy Slope (ft/ft	0.0069	0.0086	0.0096	0.0109	0.0111	0.0104	0.0098
	Reach 4 – Lower Project Area						
Eff. Velocity (fps)	0.89	1.16	1.52	2.32	3.23	4.22	5.18
Eff. Depth (ft)	0.77	0.87	1.15	1.69	2.50	3.41	4.39
Eff. Width (ft)	32.00	35.73	38.27	44.28	48.04	51.63	53.61
Eff. Energy Slope (ft/ft	0.0023	0.0032	0.0039	0.0054	0.0062	0.0070	0.0075
	Reach 5 – Upper Project Area						
Eff. Velocity (fps)	1.08	1.37	1.72	2.42	2.64	3.03	3.21
Eff. Depth (ft)	0.62	0.70	0.80	1.32	1.44	1.93	2.26
Eff. Width (ft)	32.90	37.40	48.90	54.21	102.10	125.40	160.70
Eff. Energy Slope (ft/ft	0.0020	0.0027	0.0036	0.0036	0.0076	0.0077	0.0077
	Reach 6 – Supply Reach						
Eff. Velocity (fps)	1.17	1.45	1.88	2.72	3.42	4.27	4.99
Eff. Depth (ft)	0.54	0.67	0.88	1.20	1.74	2.40	3.02
Eff. Width (ft)	35.00	37.30	40.50	52.90	64.80	72.40	74.40
Eff. Energy Slope (ft/ft	0.0050	0.0058	0.0066	0.0093	0.0089	0.0091	0.0092

(1) Values are for "effective" parameters used in SAM input

Table 11. SAM hydraulic input – with-project conditions.

Discharge – Flow Interval (cfs)	17 - 29	29 - 45	45 – 100	100 - 300	300 - 500	500 - 1000	1000 - 1400
Discharge – Log. Mean (cfs)	22	36	67	173	387	742	1241
Parameter (1)							
	Reach 4 – Lower project Area, Feasibility Alternative						
Eff. Velocity (fps)	1.97	2.04	2.27	3.16	4.32	5.49	6.62

Eff. Depth (ft)	0.47	0.54	0.68	1.12	1.67	2.29	3.02
Eff. Width (ft)	23.72	32.66	43.45	48.95	53.66	59.03	62.11
Eff. Energy Slope (ft/ft	0.0170	0.0151	0.0138	0.0138	0.0151	0.0160	0.0161
	Reach 5 – Feasibility Alternative						
Eff. Velocity (fps)	1.49	1.61	1.87	2.68	3.67	4.74	5.88
Eff. Depth (ft)	0.51	0.59	0.76	1.28	1.89	2.65	3.56
Eff. Width (ft)	28.98	38.04	47.41	50.56	55.69	59.02	58.98
Eff. Energy Slope (ft/ft	0.0087	0.0084	0.0081	0.0083	0.0092	0.0098	0.0102
	Reach 5 – Shortened Alternative						
Eff. Velocity (fps)	1.83	1.96	2.18	3.04	4.10	5.21	6.41
Eff. Depth (ft)	0.46	0.54	0.67	1.15	1.73	2.41	3.28
Eff. Width (ft)	26.13	33.81	46.13	49.56	54.48	59.14	58.91
Eff. Energy Slope (ft/ft	0.0151	0.0138	0.0131	0.0123	0.0130	0.0134	0.0135
	Reach 5 – Upper Project Area, Refined Feasibility Plan (Shortened and Widened)						
Eff. Velocity (fps)	1.65	1.67	1.85	2.54	3.52	4.50	5.45
Eff. Depth (ft)	0.44	0.50	0.62	1.02	1.57	2.20	3.00
Eff. Width (ft)	30.63	43.34	57.96	66.91	70.16	75.11	75.77
Eff. Energy Slope (ft/ft	0.0131	0.0112	0.0103	0.0101	0.0109	0.0113	0.0110

(1) Values are for "effective" parameters used in SAM input

In each reach, the hydraulic information from the HEC-RAS models was combined with the three gradation curves listed in Table 8 and the flow duration information from the feasibility report to determine the expected yield for the subsurface layer, the armor layer, and the proposed fish gradation. The existing-conditions results are listed in Table 12 and the with-project results are listed in Table 13.

Table 12. Existing conditions sediment transport.

Reach #	Description	Annual Sediment Transport (Tons per year)		
		Sublayer (D50 = 8 mm)	Armor Layer (D50 = 75 mm)	Fish Gradation (D50 = 30 mm)
1	Downstream Reach Low Tide	34400	1020	6960
1	Downstream Reach High Tide	2400	32	210
2	Through Shelton	152100	6550	43100
3	SR 101 Area	171600	8370	52350

4	Lower Project Reach	89100	3440	23400
5	Upper Project Reach	75600	2010	14770
6	Supply Reach	136780	5600	36360

Table 13. With project conditions sediment transport.

Reach #	Description	Annual Sediment Transport (Tons per year)		
		Sublayer (D50 = 8 mm)	Armor Layer (D50 = 75 mm)	Fish Gradation (D50 = 30 mm)
COE Feasibility Alternative				
3	SR 101 Area	171600	8370	52350
4	Lower Project Reach	311800	23770	143700
5	Upper Project Reach	142850	6130	39060
6	Supply Reach	136780	5600	36360
Shortened Alignment Alternative				
3	SR 101 Area	171600	8370	52350
4	Lower Project Reach	311800	23770	143700
5	Upper Project Reach	232670	13790	81530
6	Supply Reach	136780	5600	36360
Refined Feasibility Plan (Shortened and Widened)				
3	SR 101 Area	171600	8370	52350
4	Lower Project Reach	311800	23770	143700
5	Upper Project Reach	232660	7900	50040
6	Supply Reach	136780	5600	36360

The without-project results for the sublayer sizes range from range from 34,400 to 171,600 tons per year (not including high tide results) and is roughly equivalent to the estimate of 36,000 – 100,000 tons per year given by Summit Technology (1996). The fish gradation, being larger, yields 6,960 to 52,350 tons per year, and the armor layer sizes yield only 1,020 to 8,370 tons per year. The sediment yields in the with-project reaches (reach 4 and reach 5) vary by alternative and are generally greater than those in the reaches immediately upstream and downstream. In the upper project reach (reach 5) the yields for the shortened alternative are 60% to 100% greater than the feasibility alternative. When the upper project reach is shortened and widened, the yield (in comparison to the shortened alternative) is about the same for sublayer sizes, but is roughly 40% less for the fish gradation and armor layer sizes.

The results provide a number of significant findings:

The hydraulics of the stream result in very low yields for the larger sizes within the armor layer and thus confirm that it is relatively stable. For example, during high fish flows in the supply reach, the model shows that sediments with a diameter greater than 30 mm are not moved in any appreciable amount. As a result, the subsurface layer (with the finer gradation) is generally not available for transport.

Grain sizes that constitute the bulk of the fish gradation (12 – 50 mm) are relatively abundant in gravel bars in the supply reach and will be transported throughout the project.

In the without-project condition, reaches 4 and 5 have a lower transport capacity than the supply reach and are thus potentially aggradational.

The with-project reaches (reach 4 and reach 5) have a higher transport capacity than the supply reach (reach 6) and will thus transport the incoming sediment with little or no aggradation. Since the bed and banks of the with-project reaches will be protected, they will not significantly degrade and thus and will not contribute a significant amount of sediment. As a result, reaches 4 and 5 simply function as pass-through reaches for the upstream supply.

The sediment transport capacity of the downstream reaches is unaffected by the proposed project alternatives.

The reach immediately downstream of the project (reach 3) has a greater capacity than the supply reach (reach 6) and will thus effectively transport all of the incoming supply.

It is important to note that the calculated yields represent the potential sediment transport capacity for each reach and are based on a model that does not account for changes in cross section or the gradation. The upstream watershed yield and the fact that the streambed is frequently well armored limit the actual sediment transport through the system. The findings in this analysis are limited to the relative transport capacities on a reach to reach basis.

9.2 WATER CIRCULATION, FLUCTUATIONS, AND SALINITY DETERMINATIONS.

There is a concern that the proposed weir reach, because of increased overall slope from the current condition, will increase flow velocities downstream of the weir reach, resulting in increased erosion and streambed scour. The area of concern is all of Goldsborough creek downstream of the last weir section near channel station 107.09, and in particular that reach between the last weir section and a gas pipeline located approximately 1,150 feet downstream near river station 96.00. This issue was evaluated in several ways.

The HEC-RAS model is a one-dimensional water surface profiles model which estimates water surface elevations by tracking total energy and energy losses from cross section to cross section. Surface flows can be classified as supercritical, subcritical or critical. Supercritical flow is dominated by inertial forces and is usually described as rapid flow with relatively low depth. Flow characteristics at a given cross section are governed by upstream flow conditions. Subcritical flow is dominated by gravitational forces and is described as tranquil with relatively high depth. Flow characteristics at a given cross section are governed by downstream flow conditions. Critical flow is characterized by minimal specific energy and is intermediate in depth between supercritical and subcritical. Flow characteristics at a given cross section are independent of upstream or downstream flow conditions. The flow classification for a particular cross section is indicated by the Froude number (F): $F > 1$ for supercritical flow, $F = 1$ for critical flow and $F < 1$ for subcritical flow. It is common for flow to transfer from subcritical to supercritical and back as it progresses down a natural stream channel. The HEC-RAS model will determine whether flow in a particular cross section is subcritical or supercritical based on energy balance.

Based on the HEC-RAS results, the flow between river stations 106.40 and 96.50 is tranquil in both the existing ands with-project condition, with Froude numbers less than one for every cross section and every discharge (Table 14). This indicates that gravitational, rather than inertial forces govern the hydraulic conditions, and hydraulic control operates from the downstream direction upstream. Based on the energy-balance results of the HEC-RAS model, the project will have no adverse hydraulic impact downstream of the last weir.

Table 14. Comparison of HECRAS results.

			Water Surface Elevation		Channel Velocity		Froude # (Channel)	
River Station	Return Interval	Q Total	Existing	COE Pref.	Existing	COE Pref.	Existing	COE Pref.
		(cfs)	(ft)	(ft)	(fps)	(fps)		
9650	2-year	905	51.10	51.10	5.55	5.55	0.49	0.49
	10-year	1500	52.16	52.16	7.19	7.19	0.59	0.59
	100-year	2240	53.07	53.07	8.92	8.92	0.69	0.69
9715	2-year	905	51.50	51.50	4.69	4.69	0.49	0.49
	10-year	1500	52.83	52.83	5.29	5.29	0.46	0.46
	100-year	2240	54.12	54.12	5.95	5.95	0.47	0.47
9815	2-year	905	51.82	51.82	6.50	6.50	0.67	0.67
	10-year	1500	52.99	52.99	7.57	7.57	0.69	0.69
	100-year	2240	54.16	54.16	8.56	8.56	0.69	0.69
9910	2-year	905	52.72	52.72	6.98	6.98	0.85	0.85
	10-year	1500	54.03	54.03	6.44	6.44	0.71	0.71
	100-year	2240	55.50	55.50	5.61	5.61	0.59	0.59
10010	2-year	905	53.84	53.84	5.23	5.23	0.53	0.53
	10-year	1500	54.71	54.71	6.70	6.70	0.61	0.61
	100-year	2240	56.05	56.05	6.62	6.62	0.68	0.68
10115	2-year	905	54.38	54.38	4.77	4.77	0.49	0.49
	10-year	1500	55.44	55.44	5.74	5.74	0.53	0.53
	100-year	2240	56.69	56.69	6.30	6.30	0.52	0.52
10225	2-year	905	54.79	54.79	3.76	3.76	0.32	0.32
	10-year	1500	55.92	55.92	4.92	4.92	0.38	0.38
	100-year	2240	57.12	57.12	5.90	5.90	0.43	0.43
10325	2-year	905	54.88	54.88	5.66	5.66	0.50	0.50
	10-year	1500	56.02	56.02	7.24	7.24	0.58	0.58
	100-year	2240	57.19	57.19	8.64	8.64	0.64	0.64
10435	2-year	905	55.49	55.49	4.71	4.71	0.47	0.47
	10-year	1500	56.88	56.88	5.31	5.31	0.46	0.46

	100-year	2240	58.32	58.32	5.84	5.84	0.44	0.44
10540	2-year	905	56.11	56.11	3.25	3.25	0.36	0.36
	10-year	1500	57.47	57.47	3.46	3.46	0.32	0.32
	100-year	2240	58.94	58.94	3.67	3.67	0.29	0.29
10640	2-year	905	56.58	56.58	4.91	4.91	0.54	0.54
	10-year	1500	57.74	57.74	5.35	5.35	0.49	0.49
	100-year	2240	59.10	59.10	5.52	5.52	0.43	0.43

Whereas the existing flow condition is tranquil through most of the project reach, the feasibility plan would result in a series of abrupt drops over which flow passes from subcritical to supercritical. Flow conditions at the drops is classified as critical. Supercritical flow downstream of the drops must go through a hydraulic jump to achieve a subcritical depth. The depth of flow after a hydraulic jump, referred to as the sequent depth, is not necessarily the same as the downstream depth of flow computed from the HEC-RAS model. Further, there is energy loss and flow turbulence associated with a hydraulic jump that could result in bed scour and bank erosion.

With the exception of the last weir (at Station 107.05), the sequent depth downstream of the proposed weirs is slightly more than the downstream tailwater depth calculated by HEC-RAS. This indicates that the hydraulic jumps downstream of most weirs may have a slight tendency to progress downstream. There is no hydraulic jump at the last weir because the downstream tailwater is high enough to prevent formation of supercritical (rapid) flow at that weir. Further, jumps from upstream should not progress beyond the last weir because the tailwater at the last weir, 30 feet downstream of the location of the last hydraulic jump, is 20% deeper than the depth of the last hydraulic jump.

Most of the 100-year calculated Froude numbers just before the jump are slightly more than 1.45, and all are less than 1.65. Froude numbers in this range result in weak, undular jumps, in which the water surface profile increases to the sequent depth in a series of undulations. According to “Hydraulic Design of Flood Control Channels” by the U.S. Army Corps of Engineers (1994), the height of the first wave of an undular jump is greater than the calculated sequent depth. This wave height is given by the formula:

$$a = y_1(3/2)((y_2 - y_1)/y_1)$$

Where: a = Wave height above initial depth, y_1; and,
y_2 = Sequent depth.

The calculated wave heights for the 100-year flood range from 5.9 to 6.1 feet. They are considerably higher than the tailwater at most weirs and could be expected to continue with diminishing height downstream until being dampened by high tailwater at the downstream side of the last weir.

The sequent depths for the 2-year peak range from 3.2 to 3.4 feet, and those for the high fish flows range from 2.2 to 2.4 feet. In both cases, the sequent depth and tailwater depth are nearly identical and thus indicate less opportunity for hydraulic jumps to propagate downstream and adversely affect other property. No undular wave height is calculated for the high fish flows because the supercritical Froude number at hydraulic jumps is approximately 1.9, which is outside the undular jump range.

I. Ohtsu and Y. Yasuda, in a publication entitled "Characteristics of Flow Over Drop Structure," described three possible flow conditions over a series of drops as is proposed for the Goldsborough Dam project. These conditions are:

> **Wave Train,** characterized by violent undulations traveling far downstream and potentially eroding channel banks downstream of the drop;
>
> **Plunging Condition,** characterized by a stationary wave downstream of the drop and strong, upstream-directed surface velocity, or vortex in a transition reach; and
>
> **Limited Jump,** characterized by a hydraulic jump formed on the bed below the drop.

A momentum equation was used to characterize these conditions:

$$(h_d/h_c)^3 - (k(s/h_c)^2 + 2k(s/h_c) + 2)(h_d/h_c) + 1 = 0$$

Where: h_d = Downstream (tailwater) depth;
h_c = Critical depth;
s = Drop height; and,
k = Ratio of actual pressure on face of drop to hydrostatic pressure.

The value of "k" was determined experimentally by Ohtsu and Yasuda as:

k = 1 for Wave Train condition;
k = 0.64 to 0.83 for Plunging Condition; and,
k = $0.17 - 10^b$ for Limited Jump condition, where:
b = $(-4.1/(s/h_1)^2 - 0.025) - 0.85$; and,
h_1 = Supercritical depth at the drop.

In the case of the Goldsborough Dam project, "k" for Limited Jump condition is 0.17 for the 100-year flood. From HEC-RAS results: h_d = 5 feet, h_c = 4.2 feet, and s = 1 foot. Solving for h_d using the above equation and h_c = 4.2 feet; s = 1 foot, get:

h_d = 5.6 for k = 1 (Wave Train);
h_d = 5.2 to 5.4 for 0.64 and 0.83 (Plunging Condition);
h_d = 4.5 for k = 0.17 (Limited Jump).

Since the backwater calculation gives h_d (tailwater depth) = 5 for most weirs, the Goldsborough Dam weir flow condition should be between Plunging Condition and Limited Jump. The same is true for all discharges (Table 15).

Table 15. Determination of flow condition downstream of drops (momentum method).

Discharge	Critical Depth (h_c), in Feet	Tailwater Depth (h_d), in Feet	Calculated h_d Using Ohtsu and Yasuda Momentum Equation	
500-year	4.8	5.8	Wave Train	6.2
			Plunging Condition k = 0.83	6.0
			Plunging Condition k = 0.64	5.8
			Limited Jump	5.1
100-year	4.2	5	Wave Train	5.6

			Plunging Condition k = 0.83	5.4
			Plunging Condition k = 0.64	5.2
			Limited Jump	4.5
50-year	3.9	4.7	Wave Train	5.3
			Plunging Condition k = 0.83	5.1
			Plunging Condition k = 0.64	4.9
			Limited Jump	4.3
10-year	3.2	4.0	Wave Train	4.5
			Plunging Condition k = 0.83	4.4
			Plunging Condition k = 0.64	4.2
			Limited Jump	3.5
2-year	2.3	3.1	Wave Train	3.6
			Plunging Condition k = 0.83	3.4
			Plunging Condition k = 0.64	3.2
			Limited Jump	2.6
High Fish	1.5	2.2	Wave Train	2.7
			Plunging Condition k = 0.83	2.6
			Plunging Condition k = 0.64	2.4
			Limited Jump	1.8

Table 10 shows that the flow conditions at the drops should be between limited jump and plunging condition (no calculation was made for low fish flow because all flow should fit through the notch). There should be no wave train.

According to Ohtsu and Yasuda, the transition distance for plunging condition, defined as the location where surface flow becomes level and no backward flow can be seen on the surface, can be estimated by:

$$Log_{10} (L_j/H_l) = -4.8(H_l/H_t) + 2.2$$

Where: L_j = Length of transition zone;
H_t = Total head at control section with the horizontal bed downstream of the drop as a reference level; and,
H_l = Head loss in the transition zone.

H_l is calculated as:

$$H_l/H_t = 1 - (((1/h_d/h_c)) + 2(h_d/h_c))/(3 + 2(s/h_c))$$

Solving for H_l using H_t = 5.2 feet: H_l = 0.38. L_j is then 27 feet for the weirs of the Goldsborough Dam project. Adding 8 feet from the HEC-RAS model for the location of the transition from supercritical to subcritical flow, the total length of disturbance would be 35 feet for typical weirs. At the end of the transition reach, flow characteristics should be entirely governed by downstream flow conditions and be identical to those of the existing condition. Table 16 gives a summary of the transition length analysis for the range of design flows.

Table 16. Summary of typical plunge flow transition lengths (momentum method).

Discharge	Transition Length, in Feet[1]	Total Length of Disturbance,[2] in Feet
500-Year	27	35
100-Year	27	35
50-Year	26	34
10-Year	22	30
2-Year	17	25
High Fish	11	19

[1] Calculated by Ohtsu and Yasuda Procedure.
[2] Assumes eight feet from weir crest to beginning of transition.

Based on the momentum analysis presented by Ohtsu and Yasuda, adverse effects of the proposed project should not extend more than 35 feet below the next-to-last weir.

All three of the above methods of analysis to determine potential adverse hydraulic impacts downstream of the feasibility project indicate that there will be no significant impact downstream of the last weir for all discharges up to the 100-year. It is recommended that boulders of three to four feet diameter be placed in the middle of the stream downstream of the last weir as an added factor of safety to ensure no adverse impact over the long term.

Scour holes are expected to occur downstream of the weir drop structures. Scour hole depth was determined according to the Veronese equation.

$$D_s=1.32\ (h^{0.225} * q^{0.54})/d_{50}^{0.32}$$

where D_s = Depth of scour below the downstream tailwater surface, in meters;
h = Drop height, in meters; and
q = Unit discharge, in cubic meters per second.
d_{50} = median grain size (mm)

An alternative form of the equation that does not include grain size is given by the USBR (1987) is:

$$D_s=3.68\ (h^{0.225} * q^{0.54})$$

where D_s = Depth of scour below the downstream tailwater surface, in feet;
h = Drop height, in feet; and
q = Unit discharge, in cubic feet per second.

Table 17 provides a summary of the results of the scour depth analysis (converted to feet) given a typical drop height of 1 foot (0.305 meters), with the unit discharge computed as maximum depth multiplied by channel velocity. The table includes computations or the "sublayer" gradation, the "armor" layer gradation, and the suggested "fish gradation" using the first form of the equation; and compares those results using the second form.

Table 17. Scour hole dimensions using the veronese equation.

Return Interval	Discharge (cfs)	Scour Depth (feet) Below Downstream Channel Invert Veronese Equation			
		Sublayer (d50 = 8 mm)	Fish Gravel (d50 = 30 mm)	Armor Layer (d50 = 75 mm)	USBR (No d50)
Low Fish	22	2.8	1.7	1.1	.5
High Fish	475	5.2	2.8	1.7	2.6
2-year	905	6.3	3.3	1.9	3.4
10-year	1500	7.3	3.7	2.1	4.5
50-year	2015	8.1	4.0	2.2	5.1
100-year	2240	8.3	4.2	2.2	5.3
500-year	2800	9.0	4.4	2.3	5.6

Maximum depths for the 500-year event range from 2.3 feet given the armor layer gradation to 9.0 feet given the sublayer gradation. Depths for the high fish range from 1.7 feet to 5.2 feet.

Scour hole length was computed using four methods: hydraulic jump analysis, momentum analysis, U.S. Army Corps of Engineers scour hole dimension, and Federal Highway Administration scour hole dimension.

Froude numbers upstream of the hydraulic jumps for most weirs range from approximately 1.46 typical for the 100-year discharge to a maximum of 2.2 for high fish flows. Froude numbers below 1.7 result in weak, undular jumps, in which the water surface profile increases to the sequent depth in a series of undulations. According to "Hydraulic Design of Flood Control Channels" by the U.S. Army Corps of Engineers (1994), hydraulic jumps in this range are characterized by breaking undulations with very little energy dissipation. The length between the first and second undulations, or wave length, is estimated from Plate 52 of "Hydraulic Design of Flood Control Channels" as approximately four times the sequent depth. Froude numbers between 1.7 and 2.2 produce weak hydraulic jumps for which the jump length is given by Chow in "Open Channel Hydraulics" as approximately 4.2 times the sequent depth. For purposes of this analysis, it is assumed that the length of scour hole will be at least the jump length (or initial wave length) plus eight feet between the weir and initial location of the jump (based on HEC-RAS backwater analysis). Table 13 provides maximum estimated scour hole lengths for the high fish flows and the 2-year through 500-year peak discharges. It should be noted that for the 100-year and 500 year return periods, the jump length given is the initial wavelength. Smaller waves will continue downstream until reaching a control point such as the next downstream weir or high backwater. Since the distance between weirs is typically 35 feet, it is possible that the scour hole effect extend from weir to weir.

The momentum analysis is the same as described above under "Determination of Potential Downstream Impacts." The scour hole length is assumed to be the same as the transition length and total length of disturbance given in Table 16. These are included in Table 18 for comparison.

The U.S. Army Corps of Engineers in "Hydraulic Design of Flood Control Channels" (1994) recommends that the length of the scour hole be estimated as ten times the critical depth. The Federal Highway Administration, in "Hydraulic Design of Energy Dissipators for Culverts and Channels" (1983) recommends that the length of riprap basins at culvert outlets be at least ten times the difference between the tailwater elevation and the weir crest, plus an apron of one-half that distance.

Table 18 provides a summary of scour-hole lengths according to the different methods used. There is good agreement, particularly for the smaller discharges. The scour hole should be at least one half the distance between weirs for high-fish flows, and could extend the entire distance between weirs for discharges above the high-fish flow.

Table 18. Comparison of estimates of scour hole length for the goldsborough dam project.

Method		Scour Hole Length, in Feet (Measured from the Downstream Face of the Weir)				
	High Fish	2-Year	10-Year	50-year	100-year	500-year
Hydraulic Jump	18	25	26	29	30	33
Momentum	19	25	30	34	35	35
U.S. Army Corps of Engineers	16	24	32	39	42	48
Federal Highway Administration	18	31	45	55	59	72

In the proposed with-project condition, the 500-year event (2800 cfs) is completely conveyed under the Simpson Timber Company Railroad Bridge. Scour at the abutments is not expected since the stream will be channelized through the bridge and there will be no abutment-induced contraction. There are, however, eight sets of 1-foot diameter piers spaced at 14-foot intervals. Pier scour is computed using the Colorado State University dimensionless equation:

$$\frac{y_s}{Y_1} = 2.0 K_1 K_2 \left(\frac{a}{y1} \right)^{0.65} Fr_1^{\,0.43}$$

Where: y_s = depth of scour
y_1 = depth of flow
K_1 = pier coefficient (1.0 for round piers)
K_2 = correction for angle of attack (1.0 for straight on)
a = pier width
Fr_1 = Froude Number $(V/(gh)^{1/2})$

(Simons and Senturk, 1992)

Given an assumed pier diameter of 3-feet to account for debris loading, and $K_1 = K_2 = 1.0$, the expected scour depths are tabulated below.

Table 19. Stc railroad trestle pier scour depths.

Return Interval	Peak Discharge (cfs)	Froude #	Flow Depth (ft)	Pier Diameter (ft)	Scour Depth (ft)
Low Fish	22	0.52	1.25	3	3.67
High Fish	475	0.45	3.65	3	5.01
2-year	905	0.43	4.91	3	5.46
10-year	1500	0.43	6.27	3	5.94
50-year	2015	0.43	7.25	3	6.25
100-year	2240	0.43	7.64	3	6.37
500-year	2800	0.43	8.52	3	6.62

The depths of the existing abutments and piers is not well documented. Values of up to 40 feet have been reported but the depth to the Kitsap formation in the vicinity of the trestle on the order of 20 feet near the centerline of the channel.

The affect of pier scour depends on the bridge configuration. If the piers are resting on top of piles and pile caps, stability can be jeopardized at pile cap exposure. If the bridge has continuous piers (i.e., piers that extend below ground and use friction with the soil to provide support) the exposure allowance depends on the assumptions made at design, i.e. the amount of the burial depth the designer was counting on to provided the required support. Additional research into the pier configuration is needed. Additional invert stabilization may be necessary to insure the stability of the bridge in the with-project condition.

Salinity would not be affected.

9.3 SUSPENDED PARTICULATES/TURBIDITY.

Suspended particulates and turbidity will not be significantly increased from the proposed action.

9.4 CONTAMINANTS.

Use of existing materials and clean angular rock and gravel would not be expected to introduce contaminants into the ecosystem

9.5 AQUATIC ECOSYSTEM AND ORGANISMS DETERMINATION.

The proposed action will benefit the aquatic ecosystem.

9.6 DETERMINATION OF CUMULATIVE EFFECTS ON THE AQUATIC ECOSYSTEM.

Dam removal would result in unobstructed juvenile and adult fish passage, restoration of inundated habitat and recovery of natural physical processes (i.e., sediment and nutrient transport, hydrology, and temperature regimens) in the lower river. In contrast, dam removal and restoration of anadromous fish would result in increased returns of fish to the river, optimize use of all accessible portions of the watershed, produce much greater numbers of fish, and restore ecosystem processes. Wildlife prey would be provided by fish carcasses, juveniles, and eggs.

More natural fluvial processes will be-introduced to the stream by restoring the stream gradient and allowing sediment and nutrients to move downstream more efficiently.

Instream habitat features will be incorporated in the design to help facilitate upstream passage and recover the affected stream reach's habitat values more quickly. Over time, the downstream channel will benefit from increased transport of sand and gravel and the substrate composition, channel meander, and riffle/pool sequence should approach the upstream condition. This will improve the currently poor salmonid habitat quality in this segment. Finally, the increased sediment transport should improve conditions in the estuary.

There may be some wetlands in the project area that may be affected or altered by the project. However, the extensive wetlands upstream from the dam removal will not be altered by the project as these wetlands are beyond the area of construction and water level changes in the creek adjacent to them will not occur.

9.7 DETERMINATION OF SECONDARY EFFECTS ON THE AQUATIC ECOSYSTEM.

Channel reconstruction will include alternating pool and riffle sections at a more natural stream gradient. These features, together with large woody debris included in the stream bands, will provide considerable improvements in the rearing and refuge habitat for young salmonids and resident fish.

Removal of the dam will most likely improve downstream passage conditions for young anadromous salmon. Although it is unknown to what extent the existing drop at the dam produces injury or mortality in downstream migrants, any impacts that do occur will be eliminated by removal of the dam. Reconstruction of the stream channel will provide more natural migration and rearing habitat for these young salmon.

Reconstruction of the stream channel will also provide stability to the channel habitat that does not currently exist. The source of erosion caused by the drop at the dam will be removed. Construction of a more natural stream gradient will also provide a more stable channel structure than the existing conditions.

10.0 PROPOSED AND ALTERNATIVE ACTIONS TO MINIMIZE ADVERSE EFFECTS.

The proposed action is designed to enhance fish and wildlife habitat and not cause adverse effects. Alternative restoration actions are described in the EA, but the proposed action was determined to be the optimal alternative.

11.0 REVIEW OF CONDITIONS FOR COMPLIANCE WITH THE GUIDELINES.

11.1 AVAILABILITY OF PRACTICABLE ALTERNATIVES.

The availability of practicable alternatives are discussed in detail in the July 19999 Ecosystem Restoration Report and Environmental Assessment..

11.2 COMPLIANCE WITH PERTINENT LEGISLATION.

11.2.1 Water Quality.

The proposed discharges are in compliance with the applicable provision of sections 301, 302, 303, 306, and 307 of the Federal Clean Water Act as amended subject to the applicants compliance's with conditions of the federal water quality certification. The certification will require the state to proceed with any remedial action necessary to ensure that no undocumented violations of water quality standards occur. The certification criteria for monitoring and other conditions designed to ensure that state water quality standards are not violated are established in the laws, regulations, and standard practices of the EPA.

11.2.2 Threatened and Endangered Species.

Threatened and Endangered Species impacts have been addressed in Biological Assessments sent to the U.S. Fish and Wildlife Service and the National Marine Fisheries Services.

11.2.3 Marine Sanctuaries.

This proposed action will have no effect on marine sanctuaries.

11.2.4 Coastal Zone Management Act.

The Shoreline Management Act (SMA) is the core authority of the Washington State Coastal Zone Management Program. Under the SMA, local governments have primary administrative responsibility for the SMA. The proposed action is located within the shoreline jurisdiction of the Mason County. The Shoreline Master Program of Mason County is the county's administrative tool for determining consistency with SMA. The proposed actions will restore natural hydrologic function, improve habitat, and increase fish passage. Although these actions may moderately change the use and access of the sites, they will not change the overall character of the shoreline. They are also consistent with the Mason County's use designations.

11.2.5 National Historic Preservation Act.

In accordance with federal regulations (36 CFR Part 800.4) a report was prepared as the first step on the Section 106 process. The report provides a basis for the Washington State Historic Preservation Officer (SHPA) to evaluate the historic significance of the property against the National Register Criteria.

The dam does not appear to meet the standards for inclusion on the National Register. While the dam is associated with both Rainier Pulp and Paper Company and Simpson Timber Company, there are a number of historic places associated with the timber companies that still survive in Shelton. Some of these remain in use by Simpson. Because of their greater visibility and familiarity, these resources serve to better illustrate the important role of the lumber industry in the history of the community. The dam is not directly associated with any one individual who was significant in history. Its structural design is not unusual, and, because of many efforts over the years to stabilize it, the design and the immediate setting lack historic integrity. Finally, because of these continual modifications, the property is unlikely to yield further information important to history.

A review of environmental, historical, and ethnographic data by Larson Anthropological/Archaeological Services (LAAS) in 1997 indicated that the project area has a moderate probability for both historic and hunter-fisher-gatherer archaeological resources. The project area is on the banks of a major salmon-spawning stream and is within 1.6 miles of an ethnographically reported Sahehwamish village. In addition, historic logging has occurred since the 1880s, but most of the project area along the creek from Highway 101 to the dam is heavily disturbed by human and natural forces, leaving few intact sediments. The project area above the dam has been filled to the level of the spillway basin by sediment.

The project site is within the territory of the Sahehwamish people. The Sahehwamish primarily inhabited Hammersley Inlet, Totten Inlet, Eld Inlet, Budd Inlet, and Henderson Inlet in southwestern Puget Sound. The Sahehwamish were closely related to the Squaxin people who lived at the head of Case Inlet at North Bay. Descendants of the Sahehwamish and Squaxin people are now known as the Squaxin Islnad Tribe of the Squaxin Island Reservation.

No archaeological resources eligible for listing on the National Register of Historic Places were identified in the literature or during field reconnaissance. The heavily disturbed nature of the project area suggests that historic and hunter-fisher-gatherer resources do not occur within a 10-foot buffer on either side of Goldsborough Creek.

In the unlikely event that artifacts are discovered on the site during construction, then work would stop and notice would be given to the Office of Archeology and Histroic Preservation. In the event human remains are discovered, then notice will be given to the Mason County Medical Examiner's Office. Affected Tribes will be also notified of the finding of artifacts or human remain.

11.3 EXTENT OF DEGRADATION OF THE WATERS OF THE UNITED STATES.

The proposed action will neither cause nor contribute to degradation of the water of the United States.

11.4 STEPS TO MINIMIZE POTENTIAL ADVERSE IMPACTS ON THE AQUATIC ECOSYSTEM.

Appropriate and practicable steps such as planning for anticipated impacts, sensitivity to the environment through design and maintenance controls to minimize potential adverse impact of the proposed project on the aquatic ecosystem have been incorporated into the project design.

12.0 FINDINGS.

Based on the information provided in paragraphs 1 through 11, discharges associated with the proposed action are in compliance with the Section 404 (b)(1) guidelines.

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Date

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James M. Rigsby
Colonel, Corps of Engineers
District Engineer

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