Appendix F
Chief Joseph Dam
Hatchery Water Supply Report

Chief Joseph Dam
Hatchery Program
MASTER PLAN

U.S. Army Corps
of Engineers
Seattle District

Chief Joseph Dam
Columbia River, Washington
Hatchery Water Supply Study

April 2004

TABLE OF CONTENTS

1. EXECUTIVE SUMMARY

2. INTRODUCTION

3. WATER SOURCES AND CONVEYANCE

4. GROUNDWATER

5. HYDRAULIC ANALYSIS

6. STRUCTURAL REQUIREMENTS

7. WATER QUALITY DATA

8. COST ESTIMATE

9. CONCLUSIONS

1. EXECUTIVE SUMMARY

1.1. The Colville Tribes and Bonneville Power Administration (BPA) requested the services of the Corps to perform a limited reconnaissance study to evaluate and recommend potential water sources for a planned fish hatchery (BPA Intergovernmental Contract No. 16123). This reconnaissance study was conducted to determine if there are water sources that can be developed and conveyed to the Colville Tribes fish hatchery, provide sufficient quantity and quality of water in a secure manner that does not pose a risk to dam safety and at minimal cost to the Government.

1.2. The Colville Tribes hatchery consultants determined the amount of water required from each potential source to satisfy the total flow and temperature. Sources identified include the reservoir, relief tunnel, and nearby well sites. Hatchery water requirements were originally identified the as 22 cfs from the relief tunnel drainage system, 25 to 30 cfs from the reservoir by way of the irrigation inlets, and 6 cfs from wells for summer/fall Chinook. The relief tunnel and well water is of particular importance because it is 6 months out of phase in temperature with the reservoir water. Subsequent hatchery design has identified the maximum flow requirement for temperature averaging as 35.1 cfs combined from the relief tunnel and wells and 42.2 cfs from the reservoir if spring Chinook are added. The hatchery design is ongoing and the flow requirements are subject to further revision.

1.3. The water supply study determined the potential to supply 20 cfs from the relief tunnel by enlarging the existing relief tunnel sump and installing a 450 HP pump and the potential to supply 45 cfs from the reservoir by opening the irrigation inlet and outlet on the upstream and downstream faces of the dam and installing a 30-inch diameter metal pipe with an emergency gate valve, trash rack, fish screen, and stoplogs.

1.4. Conveyance of the relief tunnel water to the hatchery site will require a 20-inch diameter metal pipe and conveyance of the reservoir water will require a 30-inch diameter metal pipe. The pipes must be buried for seismic and security considerations and would run approximately 300 feet through the riprap on the embankment and 2,400 feet under the existing road. This will require demolition and repaving the road and excavating pipe trench 8-feet deep by 11-feet wide.

1.5. The preliminary construction cost estimate for the modifications to the relief tunnel sump, opening the irrigation inlet, and the pipelines to the Head Box at the hatchery is $3,074,000.

1.6. A potential well field site is identified in the study upstream of the dam seepage blanket in the vicinity of the State Park and golf course approximately 2 miles from the dam. From available information potential well field sites at the hatchery do not look promising and a well field in the vicinity of the relief tunnel is precluded by dam safety considerations.

1.7. Testing of water samples from the relief tunnel and the reservoir forebay at the elevation of the irrigation indicates generally good water quality at the relief tunnel and forebay locations with no exceedances of either Washington Department of Fish and Wildlife (WDFW) or Washington Department of Ecology (WDOE) criteria. The parameters monitored show little difference between the relief tunnel and the forebay samples. Water quality samples will be collected at the relief tunnel, forebay, and hatchery well site in the spring and summer to determine if any seasonal variations in water quality exist for these source waters. The test results will be added to this study as supplements.

1.8. A further and more detailed investigation will be needed in the next phase of design to confirm the assumptions and cost estimates developed in this study and to address dam safety issues. In view of the more certain potential to supply additional water from the reservoir and the uncertainty on the location and yield from a well field in the area, it is recommended that the next phase of deign also investigate mechanical heating and cooling of additional water from the reservoir to achieve the desired temperatures for rearing fish.

2. INTRODUCTION

2.1. Background

2.1.1. The Colville Tribes proposed to the Northwest Power Planning Council (NPCC) and Bonneville Power Administration (BPA) that a fish hatchery be constructed near Chief Joseph Dam to mitigate the loss of tribal salmon fisheries caused by the construction of Federal hydropower dams. On April 30, 2003 the BPA approved funding for preparation of a Step 1 Master Plan for the project, now titled the Chief Joseph Dam Hatchery Project, with funding of subsequent steps contingent upon approval of the Master Plan.

2.2. Project Description

2.2.1. The Colville Tribes and BPA requested the services of the Corps to perform a limited reconnaissance study to evaluate and recommend feasible water sources for a planned fish hatchery (BPA Intergovernmental Contract No. 16123). This reconnaissance study was conducted to determine if there are water sources that can be developed and conveyed to the Colville Tribes fish hatchery, provide sufficient quantity and quality of water in a secure manner that does not pose a risk to dam safety and at minimal cost to the Government. The Corps study will evaluate several water sources associated with the Chief Joseph Dam and determine if they are technically and economically feasible and supply the quantity and quality of water required. The study will include preliminary cost estimates to develop the water sources. The Corps will conduct reviews of existing information, perform the necessary engineering evaluations, evaluate potential costs and recommend possible water sources to the Colville Tribes.

2.3. Specific Objectives and Tasks

2.3.1. The following outlines the tasks that need to be conducted in order to evaluate and recommend water sources for the hatchery.

2.3.1.1. **OBJECTIVE 1**: Evaluate Potential Water Sources. Evaluate several potential water sources for the fish hatchery, these include but not limited to, relief tunnel and the irrigation diversion intake on the right bank. Determine the engineering feasibility of water conveyance of each of these sources. In addition, compare to the constraining factors to determine whether it is a viable source.

2.3.1.2. **OBJECTIVE 2**: Evaluate Water Quality. Evaluate the water quality of each of the potential water sources identified in Objective 1. This will include review of existing data collected by the Corps and the Colville Tribes or their consultants and additional water quality sampling and testing in the winter, spring and summer.

2.3.1.3. **OBJECTIVE 3**: Prepare Report. Prepare a water supply study that presents the results of this work and recommend possible water sources. The study will also recommend possible methods of water conveyance from the source to the hatchery and include “conceptual” sketches at a 10% design level.

2.4. Hatchery Water Supply Requirements

2.4.1. At the project kick off meeting, John McKern of Fish Passage Solutions, a consultant to the Colville Tribes, identified the hatchery water requirements as 22 cfs from the relief tunnel drainage system, 25 to 30 cfs from the reservoir by way of the irrigation inlets, and 6 cfs from wells for summer/fall Chinook. The relief tunnel and well water is of particular importance because it is 6 months out of phase in temperature with the reservoir water. Tetra Tech KCM, the consultant to the Colville Tribes for the hatchery design, subsequently identified the maximum flow requirement for temperature averaging as 35.1 cfs combined from the relief tunnel and wells and 42.2 cfs from the reservoir if spring Chinook are included. The hatchery design is ongoing and the flow requirements are subject to further revision.

3. WATER SOURCES AND CONVEYANCE

3.1. Review Existing Information

3.1.1. A site visit was conducted to the Chief Joseph Dam on Tuesday, 12 January 2004. This visit was conducted to observe the actual site conditions of the right bank abutment in relation to the development of a water supply source from the right bank or the dam for a proposed fish hatchery. This hatchery would be located on the right bank approximately 3,500 feet downstream of the dam. The Coleville Tribes will operate the fish hatchery. The construction of the hatchery on the right bank is desired by the Tribe since their Reservation lands are on the north side of the Columbia River. The Federal Government owns the parcel of land in question.

3.1.2. Summer/fall Chinook flow requirements for the hatchery were identified as 22 cfs from the relief tunnel, 25 to 30 cfs from the reservoir, and 6 cfs from wells. If spring Chinook are included, 35.1 cfs combined from the relief tunnel and wells and 42.2 cfs from the reservoir are the maximum required flows for temperature averaging.

3.2. Development of Alternatives

3.2.1. Right Bank Water Sources. Consultants for the Coleville Tribes have identified possible water sources for the hatchery as the relief tunnel, irrigation inlet, and right bank abutment. Water from the relief tunnel is desired for hatchery operations since this water displays temperature variations, which are six months out of phase with the temperature of the surface water. Therefore, the relief tunnel water will be warm in the winter and cool in the summer relative to the river or reservoir water. Similarly, water extracted from the right bank by means of groundwater wells would also produce water with these temperature variations. The reservoir water is desired for rearing of juvenile fish in the hatchery. Reservoir water is suitable for rearing fish when mixed with waters from the relief tunnel to achieve desired temperatures. The hatchery design proposes several open tanks for rearing fish and a fish ladder at the river for capturing adult fish. In addition to the hatchery water requirements, five hundred seventy-five cfs will be supplied from the river via low head pumps for adequate attraction flow at the fish ladder.

3.2.1.1. <u>Relief Tunnel.</u> The relief tunnel extends over one thousand feet from the northwest end of Monolith 1 into right abutment. Access to the tunnel is by way of galleries in the interior of the dam. The tunnel is designed to reduce pore pressure in the soil of the right abutment. Water drains into the tunnel through wells located in the floor of the tunnel. These wells are of wood stave construction. Outflow from the tunnel was originally 95 cfs. The current outflow is 22 cfs. The tunnel drains into a sump, which connects to a four feet diameter conduit. This conduit exits the dam through the spray wall north of spill bay number one. The elevation of the bottom of the sump is 777 feet. The tunnel is typically flooded with water since the elevation of the tail water is typically above the elevation of the relief tunnel outlet at elevation 783 feet.

3.2.1.1.1. The collection of water from the relief tunnel will difficult. A valve or gate will may need to be installed in the four feet diameter culvert to prevent the mixing of the tunnel water with river water. Extraction of water from the sump will require the installation of pumps and piping to transport the water through access galleries to the surface where it may drain by gravity to the proposed hatchery site. The rise in elevation required will be at least 175 feet if the water is pumped to the top of the dam through the existing dam galleries. Alternatively, the relief tunnel water could be pumped via a pressure pipe from the sump to the hatchery along the existing road alignment.

3.2.1.1.2. The sump may be intercepted by a bore hole using directional drilling methods. The bore hole could be drilled from the surface at the west end of the parking area at the north end of the dam to install a vertical well to the sump. Alternatively, an inclined bore hole could be installed from the paved access road to the toe of the dam on the right bank to the bottom of the sump. The water in the vertical well would need to be lifted about 170 feet to the surface and could drain by gravity to the hatchery. The water produced from the inclined well would need to be raised 93 feet to reach the elevation of the Head Box for the proposed hatchery, which is at elevation 870 feet.

3.2.1.1.3. The wells in the tunnel may require future cleaning and maintenance, which may include the cleaning of the wells with weak acids to remove encrusting or biological fouling materials. The working and wash water for this operation would not be suitable for hatchery use. Residual traces of cleaning chemical could remain in the tunnel water for a period of time after maintenance. Low concentrations of these chemicals could impact fish development. The hatchery would need to have a redundant water source to allow well maintenance.

3.2.1.2. <u>Irrigation Inlet</u>. The irrigation inlet would require a new gate and construction of internal walls and decking before use. Water from the inlet would flow through an open channel or closed pipe to the hatchery site. The elevation of the outlet is 920 feet. The water from the inlet would drop 50 feet over a distance of 2,700 feet to the proposed hatchery Head Box Control Structure at elevation 870. The inlet has two openings that are 4 feet wide and 5 feet high.

3.2.1.2.1. An open channel could be constructed along the slope of the right bank. This slope is composed of gravels and sands and has experienced erosion and stability problems in the past due to surface water running down this slope. An access road would need to be constructed from the existing road to the outlet of the irrigation inlet. This road could be placed on top of the existing rip rap on the abutment slope. The base of the channel would need to be supported by bracing or piles across the face of the slope in order for the channel to have an average slope of 2.0%. The excavation of the channel into the slope is not recommended due to stability issues. Construction of the channel and possible leakage during operation could be detrimental to the stability of the right bank slope. Alternatively, water from the inlet could flow through a pressurized water pipe to the site. The pipe could follow the existing access road and be anchored to the ground along the existing road to the toe of the dam on the right bank.

3.2.1.3. <u>Right Bank Well Field</u>. A well field could be installed in the right bank to provide water to the hatchery. These wells would be vertical wells and a sufficient number of wells would need to be installed to provide the required hatchery flows. The wells could possibly improve the stability of the right bank abutment by the removal of seepage water and a resulting reduction of the pore pressure at the north end of the dam.

3.2.1.3.1. The number of wells will need to be determined. Groundwater will need to be pumped to the surface and collected in a large holding tank from which it would drain by gravity through a pipe line to the hatchery.

3.2.1.4. Inclined Wells. Inclined wells could be drilled into the right abutment from the existing road to the toe of the dam on the right bank. These wells would pass under the relief tunnel and terminate on the poolside of the dam. The wells would be constructed to take advantage of the higher hydrostatic pressure on the upstream side of the dam to produce flow of water from the wells.

3.2.1.4.1. The number of wells and screen lengths will need to be determined to ensure adequate water supply. The amount of reduction in pore pressure in the right bank due to the installation of the wells will need to be evaluated to determine if the wells assist in improving the stability of the right bank abutment. Drilling will require special equipment and set up and highly experienced personnel to install large diameter wells under differential hydrostatic pressure. Improper drilling or installation methods could pose a hazard of opening a pathway for water to flow around the dam. This flow of water could result in the erosion of soil from the right bank and seriously impact the stability of the right bank and dam structure. Uncontrolled piping of water and sediment could result in catastrophic failure of the right bank and extensive downstream flooding.

3.2.1.5. Horizontal Wells. Horizontal wells could be installed to provide water for the hatchery. The collars for these wells would be on the upstream side of the dam. These wells could be installed in bore holes that would pass under the relief tunnel but would not exit the face of the right bank. The wells could be screened in the area of the relief tunnel or other locations to assist in the reduction of pore pressure in the abutment. Large capacity pumps will be required to pump groundwater to the surface from these wells, where the water would be collected in a large holding tank. The water would then drain by gravity to the hatchery.

3.2.1.6. Vertical Wells at Hatchery Site. Vertical wells may be installed in the vicinity of the hatchery site. Two vertical wells are present under the power line that traverses the site. These wells are reported to produce 40 gallons per minute (gpm) and 60 gpm. The wells are currently used to provide irrigation water to the open area surrounding the visitor center. These wells were reported to produce water with elevated levels of E-coli bacteria. The bacteria may have entered the wells due to high pump rates, which pulled river water into the wells.

3.2.1.7. Wells at Hatchery: Wells installed at the hatchery site may not produce sufficient water for the hatchery needs. Contamination and temperature of the water are of concern. The actual water use requirements for the hatchery will need to be determined as well as the option for the recycling or recovery of water used in the hatchery. If a large quantity of water is not required on a continuous basis, then a large holding tank may be constructed at the site. This tank could store water for demand needs and be slowly refilled by pumping of wells installed at the site.

3.2.1.8. Horizontal Infiltration Gallery. A horizontal infiltration gallery could be installed at the proposed hatchery site. The fill and alluvial material that underlies the site is estimated to be at least thirty feet thick from the surface to the top of the anticipated groundwater table. Therefore, parallel horizontal wells could be installed to create an infiltration gallery, which could provide a higher amount of water with less drawdown relative to vertical wells.

3.2.1.9. Reservoir Water. Water could be pumped or transferred by a siphon to the hatchery site directly from the reservoir. Reservoir water alone is not desired for hatchery rearing, but it will be mixed with relief tunnel and well water to insure the best temperature for fish. Water treatment equipment such as ultraviolet systems could be installed to eliminate harmful organisms before use, and fish will be regularly inspected in the hatchery and provided with treatment should disease outbreaks occur.

3.2.1.10. River Water. River water could be used for attraction water for the fish ladder. The amount of water required for the operation of the ladder is 75 cfs at the top of the ladder and at least 500 cfs at the outlet. Several large pumps could be installed directly upstream of the ladder outlet. These pumps could lift water from the river to provide the 500 cfs for the outlet attraction flow. These pumps could also provide the 75 cfs required at the top of the ladder. The river water would not be used for the hatchery operations.

3.2.2. Contamination Issues. Groundwater obtained from the right bank could be contaminated with pesticides or other agricultural related chemicals. Several apple orchards are at the top of the right bank. Irrigation water from these orchards could carry these contaminants to the water table. Routine ultraviolet treatment systems would not eliminate these contaminants. The groundwater that may be obtained from the right bank should be tested before selection as a water source. This testing should be performed as soon as possible before design efforts proceed. The presence of detrimental contaminants could eliminate groundwater from the right bank as a water source for the hatchery. Numerous piezometers are in the right bank. The collection of groundwater samples from these instruments is not recommended due to possible introduction of contamination during installation or monitoring. The installation of new groundwater monitoring wells constructed to EPA standards is recommended for the sampling of the right bank groundwater.

3.2.2.1. Water Temperature. The temperature of reservoir water could be raised or lowered to the desired ranges for use. The water would need to be cooled in the summer and warmed in the winter. Heat pump systems or evaporative cooling systems could be installed to perform this task.

3.2.3. Left Bank Water Sources. Several potential water sources could be developed on the left bank. These sources are from groundwater and reservoir water upstream of the powerhouse and administration building and from the penstock lay down area, which is downstream of the dam.

3.2.3.1. Powerhouse Water Source. An extensive area of fill is to the south of the powerhouse on the southern shore of the reservoir. This fill was placed as part of the construction of the dam. Numerous wells could be installed in the fill to provide water to a holding tank. A water line could be constructed from this tank to the hatchery. The water line would need to run along the bridge crossing the river to reach the right bank. The quantity or quality of water that could be produced from the fill is not known.

3.2.3.2.. <u>Vertical Wells or Horizontal Infiltration Gallery at Penstock Lay Down Area.</u> Vertical wells or a horizontal infiltration gallery could be installed at the penstock lay down area. These wells could provide water to the hatchery on the right bank by a pipeline under the existing roadway bridge or directly to the hatchery if the hatchery were constructed on the left bank at the lay down area.

3.2.3.3. <u>Reservoir Water.</u> Reservoir water could be obtained from the west end of the concrete cut off wall for the powerhouse pool. An irrigation port is in this wall and provides water for irrigation to the penstock lay down area. This port could be modified to produce a higher flow. The water would need to flow through a pipeline along the bridge crossing the river to reach the right bank hatchery site. Water treatment equipment such as ultraviolet systems could be installed to eliminate harmful organisms before use.

3.2.3.4. <u>Groundwater</u>. A perennial spring is to the west the administration building. This spring flows year round and suggests a reliable groundwater source that may be present in this area of the left bank. Numerous wells could be installed in the vicinity of the spring and provide water via a pipeline under the bridge to the right bank hatchery site.

3.2.3.5. <u>Municipal Water</u>. The visitor site on the right bank is provided with water by a two-inch diameter pipeline. The source for this water is the powerhouse, which is also used to supply water to the administration building. Depending on the frequency of use, this water source could be used in its existing condition to supply water to a large holding tank at the right bank hatchery site. This option would not be viable if water usage by the hatchery requires continuous flow.

3.2.4 <u>Alternative Hatchery Location</u>**.** The hatchery could be located on the left bank at the pen stock lay down area. This site is a flat area composed of fill that is on the south side of the river. Alternatively, the hatchery could be sited on the extensive area of fill behind the powerhouse. A fish ladder should need to be constructed from the hatchery to the downstream side of the dam. This site should be considered since this location will require the minimal amount of behavioral screen to be placed in the reservoir to direct fish to the hatchery and fish ladder for downstream migration. A final option would be to site the hatchery at a location downstream of the dam where an available and desired water source is available. This water source would not be associated with the dam or its operations.

3.3. Evaluation of Recommended Alternatives

3.3.1.<u> Relief tunnel</u>. The relief tunnel extends over one thousand feet from the northwest end of Monolith 1 into the right abutment. Access to the tunnel is by way of galleries in the interior of the dam. The tunnel is designed to reduce pore pressure in the soil of the right abutment. Water drains into the tunnel through wells located in the floor of the tunnel. These wells are of wood stave construction. Outflow from the tunnel was originally 95 cfs. The current outflow is 22 cfs.

The tunnel drains into a sump, which connects to a four feet diameter culvert. This culvert exits the dam through the spray wall north of spill bay number one. The elevation of the bottom of the sump is 777 feet. The tunnel is typically flooded with river water since the elevation of the tail water is above the elevation of the tunnel outlet.

3.3.1.1. This water source alternative was selected by the Coleville Tribes due to water temperature characteristics and assumed quality. The temperature from the water in the right bank is approximately 6 months out of phase with the temperature of the Columbia River and this temperature difference is considered to be beneficial for the rearing of fish. Therefore, water provided from the relief tunnel would be warm in the winter and cool water would be obtained from the tunnel in the summer relative to the river water. The quality of the relief tunnel water is assumed to be good due to the filtering effects of the granular media through which the water flows to the relief tunnel. This filtration is assumed to remove parasitic organisms that could be detrimental to the health of juvenile fish.

3.3.1.2. Obtaining water from the relief tunnel will impact Chief Joseph Dam and possible dam safety impacts will have to be carefully investigated during the next phase of design.

3.3.1.2.1. Structural modifications to the dam would be required to access the relief tunnel. The existing sump and part of the relief tunnel would have to be demolished and a new larger sump and weir installed. These modifications could impact the operation and safety of Chief Joseph Dam. For example, a gate or valve may be required to prevent river water from entering the relief tunnel sump. Pumps would be required to remove the water from the sump and lift this water to a pipeline that would be connected to the fish hatchery. Since the rate of pumping would most likely be less than the flow generated by the relief tunnel, a concern is that failure of a check gate could result in water becoming trapped in the tunnel and reduce drainage from the right bank. This drainage is necessary for the safety of the right bank abutment and slope. Therefore, the possibility exists that the safety of the right bank could be jeopardized if water is obtained from the relief tunnel.

3.3.1.2.2. The quantity of water from the tunnel cannot be guaranteed. The flow from the tunnel has decreased in the past from 95 cfs. Therefore, it is possible that the current flow rate of 22 cfs may decrease in the future and not be sufficient for hatchery needs.

3.3.1.2.3. The quality of water may be impacted by agricultural waste from orchards that are up gradient of the relief tunnel. Testing of water samples from the relief tunnel in February 2004 for this study indicates good water quality. Additional samples from the relief tunnel will be tested in the spring and summer to determine the existence of seasonal variations in water quality.

3.3.1.2.4. Chief Joseph Dam operation will require periodic inspection and maintenance of the tunnel. Such activities may impact the uninterrupted delivery of water to the hatchery. Project operations and safety will take precedence over hatchery needs.

3.3.1.3. The rehabilitation of the existing wells in the relief tunnel may provide additional yield of groundwater into the tunnel assuming that the reduction of flow from the wells was not due to other causes. Rehabilitation will require performing down hole camera surveys of the wells to determine the current conditions of the well screens. These screens are composed of wood staves held together by wire. The well yield may have been diminished due to the encrustation of minerals on the screen or biofouling of the well interior and surrounding filter pack and formation by iron reducing bacteria. In this event, the wells will require cleaning using weak acidic solutions and water jetting. It is possible that the well screens may have deteriorated or collapsed. In this case, a new well screen will need to be installed to replace the wood stave screen. The existing well screens could be removed and replaced with new steel or plastic well screens.

3.3.1.4. A test of the increase in well yield should be conducted prior to committing to the rehabilitation or replacement of all the wells in the relief tunnel. Such a test would involve at least three wells that would be cleaned and monitored for increased production. The rehabilitation or replacement of the well screens will not prevent future maintenance and cleaning efforts that may impact the quality of the water produced from the relief tunnel. In addition, such efforts may have marginal impact on well production, since the reduction in well flows may have been related to reductions in seepage flowing through the right abutment due to the seepage blanket rather than deteriorating well performance. Well screen replacement, though possible, will be difficult due to the limited working space in the relief tunnel, need for special equipment for well screen extraction and placement, and difficult access to the tunnel through the dam structure.

3.3.1.5. Access to the sump during construction could be achieved by a vertical shaft through the existing random and impervious fill. The shaft could be made a permanent feature for maintenance access to the pump.

3.3.2. <u>Irrigation Inlet</u>. The irrigation inlet is in Monolith No. 2 on the right side of the dam. This inlet was built during the initial dam construction but was never used. The irrigation inlet will require a new gate and construction of internal walls and decking before use. Water from the inlet will flow through a closed pipe to the hatchery site. The elevation of the outlet is 920 feet. The water from the inlet would drop 50 feet over a distance of 2,700 feet to the Hatchery Head Box at elevation 870. The inlet has two openings that are 4 feet wide and 5 feet high. The pipeline to the fish hatchery must be underground for seismic and security considerations to connect the inlet. This pipeline would be placed in a trench that would traverse the right bank slope (See Figure 1).

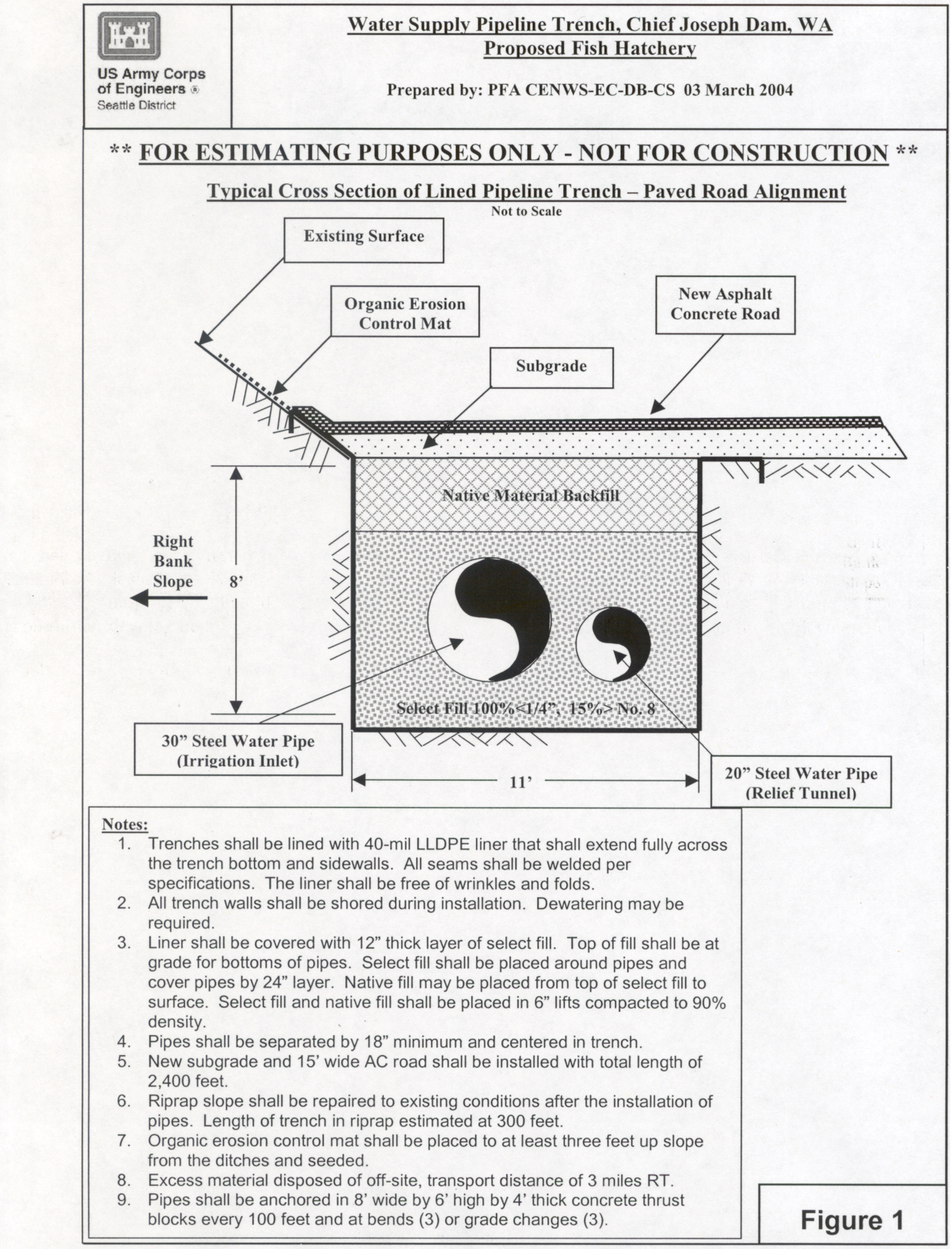
3.3.2.1. This water source is possible but the following concerns must be addressed. The right bank is composed of material that is easily eroded. In addition, the increase in the moisture in the soils that compose the right bank could result in a decrease in slope stability. Any pipeline constructed in the right bank must be free of leaks and placed in a lined trench that is well drained. Monitoring instruments, such as open standpipe, will be required along the alignment of the pipe to allow testing for the presence of pipe leakage or the presence of water in the trench due to infiltration of precipitation.

3.3.3. Right Bank Well Field. A water supply well field may be installed on the right abutment. This well field would consist of vertical wells drilled upstream of the impermeable seepage blanket. The wells would obtain water from the seepage flowing around the right abutment of the dam. Electric pumps would lift water from the wells to a large holding tank. A pipeline would extend from the holding tank to the hatchery.

3.3.3.1. The construction of a well field near the relief tunnel, whether vertical, inclined, or horizontal, could impact the safety of the structure and is not recommended. The amount of water required for hatchery operations could result in a large area of depressed water levels in the well field due to water extraction. This depressed water table in close proximity to the dam structure would increase the hydraulic gradient between the reservoir and the right bank through the impermeable seepage blanket, thereby increasing the possibility of the piping of fines from the blanket and aquifer into the extraction wells. In addition, high seepage velocities could develop between the dam structure and the adjacent fill material resulting in the erosion of fines from the fill. This piping of fines from the fill material could seriously impact the safety of the dam.

3.3.3.2. The installation of a well field in the right bank remains a viable option if the location of the well field is moved to directly north of the proposed hatchery, to the golf course or State Park upstream of the impermeable seepage blanket on the right bank. The subsurface geology and the presence of water bearing strata capable of providing the required hatchery flows will determine the feasibility, size, and design of the well field(s). In addition, the quality of the water extracted from the possible well field sites may be contaminated with agricultural wastes and will require sampling and testing.

3.3.4. Left Bank Water Sources. Possible water sources on the left bank are not considered practical due to their distance from the proposed hatchery site, possible interference with future dam expansion, and need for large pipelines to carry the requested amount of water for hatchery operations.



US Army Corps
of Engineers ®
Seattle District

Water Supply Pipeline Trench, Chief Joseph Dam, WA
Proposed Fish Hatchery

Prepared by: PFA CENWS-EC-DB-CS 03 March 2004

**** FOR ESTIMATING PURPOSES ONLY - NOT FOR CONSTRUCTION ****

Typical Cross Section of Lined Pipeline Trench – Paved Road Alignment
Not to Scale

Notes:

1. Trenches shall be lined with 40-mil LLDPE liner that shall extend fully across the trench bottom and sidewalls. All seams shall be welded per specifications. The liner shall be free of wrinkles and folds.
2. All trench walls shall be shored during installation. Dewatering may be required.
3. Liner shall be covered with 12" thick layer of select fill. Top of fill shall be at grade for bottoms of pipes. Select fill shall be placed around pipes and cover pipes by 24" layer. Native fill may be placed from top of select fill to surface. Select fill and native fill shall be placed in 6" lifts compacted to 90% density.
4. Pipes shall be separated by 18" minimum and centered in trench.
5. New subgrade and 15' wide AC road shall be installed with total length of 2,400 feet.
6. Riprap slope shall be repaired to existing conditions after the installation of pipes. Length of trench in riprap estimated at 300 feet.
7. Organic erosion control mat shall be placed to at least three feet up slope from the ditches and seeded.
8. Excess material disposed of off-site, transport distance of 3 miles RT.
9. Pipes shall be anchored in 8' wide by 6' high by 4' thick concrete thrust blocks every 100 feet and at bends (3) or grade changes (3).

Figure 1

4. GROUNDWATER

4.1. Introduction

4.1.1. The feasibility of obtaining water for the hatchery from a right bank well field was investigated. Two general locations were considered: north of or at the hatchery site, and upstream of the seepage blanket. The area around or immediately north of the hatchery site does not appear suitable to provide sufficient water. Further north there is better potential but land ownership in this area is not known. State Park land upstream of the seepage blanket is probably the most suitable area for a well field. However, a test well would have to be installed and pumped to determine if a well field is feasible. It is estimated that at most an 11/2-mile by 2000 foot area in the park would be suitable for well installation.

4.2. Hatchery Site or North of Hatchery Site

4.2.1. A water supply well field does not appear to be a viable possibility at the hatchery site or immediately north of the proposed site. Several test wells have been drilled in this area and had very poor water production. A test well was drilled slightly northeast of the hatchery site in 1986 (by the “Colville Tribal Fish Hatchery”). This well encountered shallow bedrock at 106 feet and only produced 5 gpm during a test. The Corps has drilled at least two test wells in this general area (1988 and 1990) and both had poor test production. Shallow wells in this area, that tap the superficial, perched, aquifer are producing on the order of 50 gpm. It is unlikely that a well field could be installed in the proposed hatchery area that could produce anywhere close to the hatchery water requirements. The only likely location for wells would be well north of the hatchery site along Jack Wells Road. This area is probably located in a former river channel, and is likely to have good water potential, with enough room for a sizable well field. However, property status and water rights in this area are unknown. The extent of contamination from agricultural activities here is also unknown. It is known that the city of Bridgeport drilled a well at the mouth of this valley that produced 500 gpm in a 1950 test.

4.3. Upstream of Seepage Blanket (State Park or Golf Course)

4.3.1. The best potential for groundwater would appear to be the permeable gravel aquifer located beneath impermeable till. This material ranges from 30 to 100 feet thick, and extends for at least 2000 feet shoreward from the reservoir. The upstream extent of this aquifer is not fully defined, but is believed to extend to the upstream park boundary. The presence of these gravels is the reason for the installation of the impervious seepage blanket and the relief tunnel. Because of dam safety concerns, any wells will have to be installed upstream of the seepage blanket. This means that the wells would have to be installed on State Park property approximately 2 miles upstream of the dam or 2 _ miles upstream of the hatchery Head Box.

4.3.2. It is certain that such a well field could supply some portion of the required water, However, several steps would need to be taken to determine the quantity of water potentially available from this source.

4.3.3. First, the exact downriver boundary of the potential well field needs to be defined. The initial discussions concerned the main 2,500-foot impervious blanket that extends upstream to the vicinity of piezometer 170. However, there is also an additional seepage blanket that extends 1,500 feet upstream from the primary blanket. This 3-foot thick blanket of silty fine sand was installed in 1957 in an attempt to reduce seepage at the time of its construction, and extends upstream to the vicinity of piezometer 296. If wells would have to be installed upstream of this secondary blanket because of dam safety concerns, this would significantly reduce the available size of the well field. The upstream limits of the well field would be dictated by property boundaries, and the possible slope stability constraints on the upstream end (increased probability of slumping at upstream end of park). Based on park boundaries and downstream aquifer mapping, there is at most an1 1/2 mile by 2000 foot area where wells could be installed within the park.

4.3.4. Second, more information is needed about aquifer parameters to determine minimum well spacing and anticipated yields. Although it's possible to estimate well performance and aquifer characteristics based on historical data, this is only available for an area downstream of the seepage blanket, where recharge to the aquifer has purposely been modified with the blanket to reduce right bank seepage. The only way to determine the necessary information for the unmodified aquifer upstream of the seepage blanket would be to drill a test well and conduct a pumping test. If the test well was located reasonably close to the network of piezometers, they might be used as observation wells for the test. Data from such a test would provide the information needed to determine well spacing and ultimately a better estimate for how much water could be produced from a right bank well field.

4.3.5. Without some actual aquifer testing, it's difficult to confirm that a well field located upstream of the seepage blanket could produce all or most of the ground water needed for the hatchery. It is interesting to note, though, that a well tested in the state park in 1967 was capable of producing 1400 gpm.

5. HYDRAULIC ANALYSIS

5.1. Introduction

5.1.1. This analysis looked at various options for supplying water to the proposed Colville Tribes Fish Hatchery near Chief Joseph Dam. The hatchery needs 45 cfs from the reservoir behind the dam and another 35 cfs from ground water for both summer/fall and spring Chinook. The different sources of water provide variations in temperature needed for hatchery operations. Two possible ways to tap these sources include wells and/or the drainage tunnel (known as the relief tunnel) on the right side of the dam and the irrigation diversion structure that was built into the right side of the dam. Comments made regarding these options are from a hydraulic standpoint.

5.2. Review of Existing Information

5.2.1. Various documents, maps and drawings were reviewed to aid in this analysis. Information gathered includes:

5.2.1.1. Relief Tunnel Data: The relief tunnel is an 8-foot tall, 5-foot wide, 1000-foot long drainage tunnel that extends into the right embankment of Chief Joseph Dam. The purpose of the structure is to prevent excessive pore-water pressure from developing in the right embankment material. The main tunnel empties into a 10.5-ft long by 4.5-ft wide by 4.5-ft deep sump. From the sump, the water is discharged through a 4-ft diameter conduit into the stilling basin. It appears the relief tunnel currently generates, on average, 22 to 25 cfs of flow. Evidently this flow was up around 90 cfs back in the 1960’s, but has declined in the past. Plate 1, at the end of this section, includes a plot of hourly relief tunnel flow readings between 2000 up through 2003. This plot indicates that there are times when the flow does drop down to the 15 to 17 cfs range.

5.2.1.2. Irrigation Diversion Structure: This structure was built into the dam to supply irrigation water at some point in the future. It consists of two 4-ft wide by 5-ft height passages through the right side of the dam with inverts at elevation 920 feet. This structure has provisions for a stop log closure and a trashrack. The intake side is sealed with concrete while the outlet side is sealed with bricks. It is unclear at this point exactly how this structure was intended to be used.

5.3. Development of Supply Options

5.3.1. Pumping from Relief Tunnel Sump: From a hydraulic standpoint this appears to be feasible. Some assumptions made for this analysis include:

- Delivery point to hatchery is elevation 870 feet
- Full sump elevation is 782 feet
- Flow from tunnel is always a constant 25 cfs
- Steel pipe material is used
- A centrifugal-type pump is used

- The design river tailwater elevation is 795 feet

5.3.1.1. With these assumptions, it appears that from a hydraulic standpoint, a system could be constructed. Assuming a design discharge of 25 cfs, and making some assumptions as to system hydraulic head losses, the system would include a properly sized centrifugal-type pump and a 22-inch diameter welded steel discharge pipe. The pump would be designed to run continuously, therefore making a holding tank at the delivery point unnecessary. At the delivery point there would be a gate valve. To avoid cavitation problems, the pump would need to be located at an elevation that is not too far above the sump water surface elevation. Ideally there would be enough room in the sump access chamber. For one of the pumps looked at in this analysis, the estimated maximum vertical distance above the sump water surface was about 24 feet or around elevation 806-feet. This pump had a 30-inch diameter suction tube. Based on standard sump design methods, the existing sump appears to be too small to support pumping at this rate. Calculations indicate that, for the design flow, the sump should measure about 22-feet long, 7.5-feet wide, and 9.5-feet deep. In order to prevent vortexing and other undesirable hydraulic conditions, the sump should always maintain a water depth of at least 6-feet. Ideally, the incoming water velocity would be 1 ft/sec or less. Sump designs were made using guidelines from U.S. Army Corps of Engineers publication EM-1110-2-3105.

5.3.1.2. Figure 1 shows a basic schematic of the system and Figure 2 shows a cross-sectional view of the sump and needed modifications to the sump and the chamber ceiling.

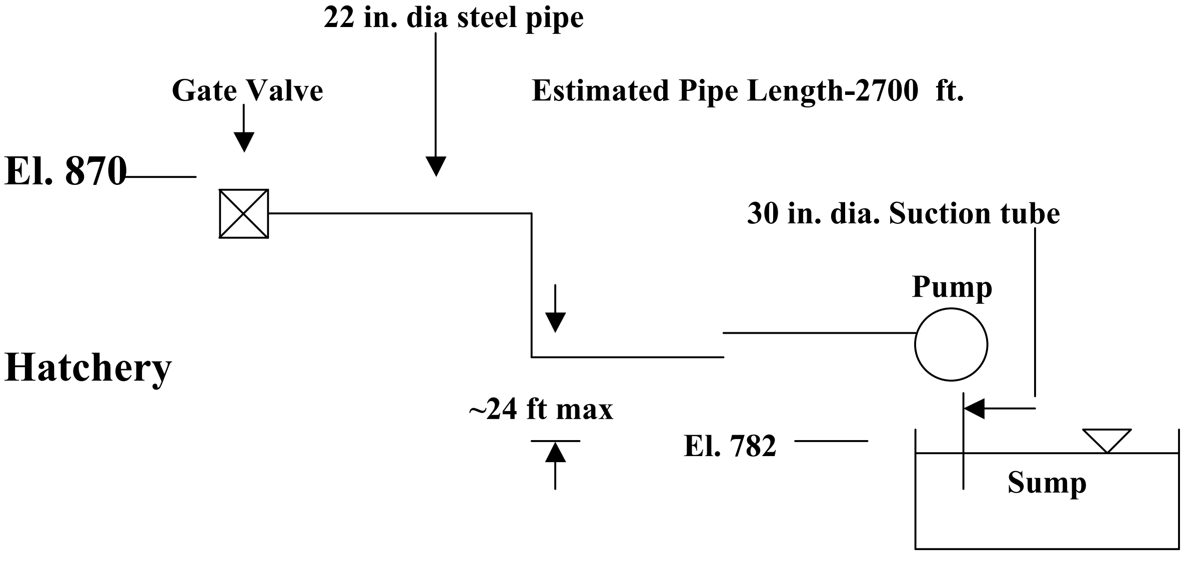


Figure 1. Conceptual Relief Tunnel Pump Schematic

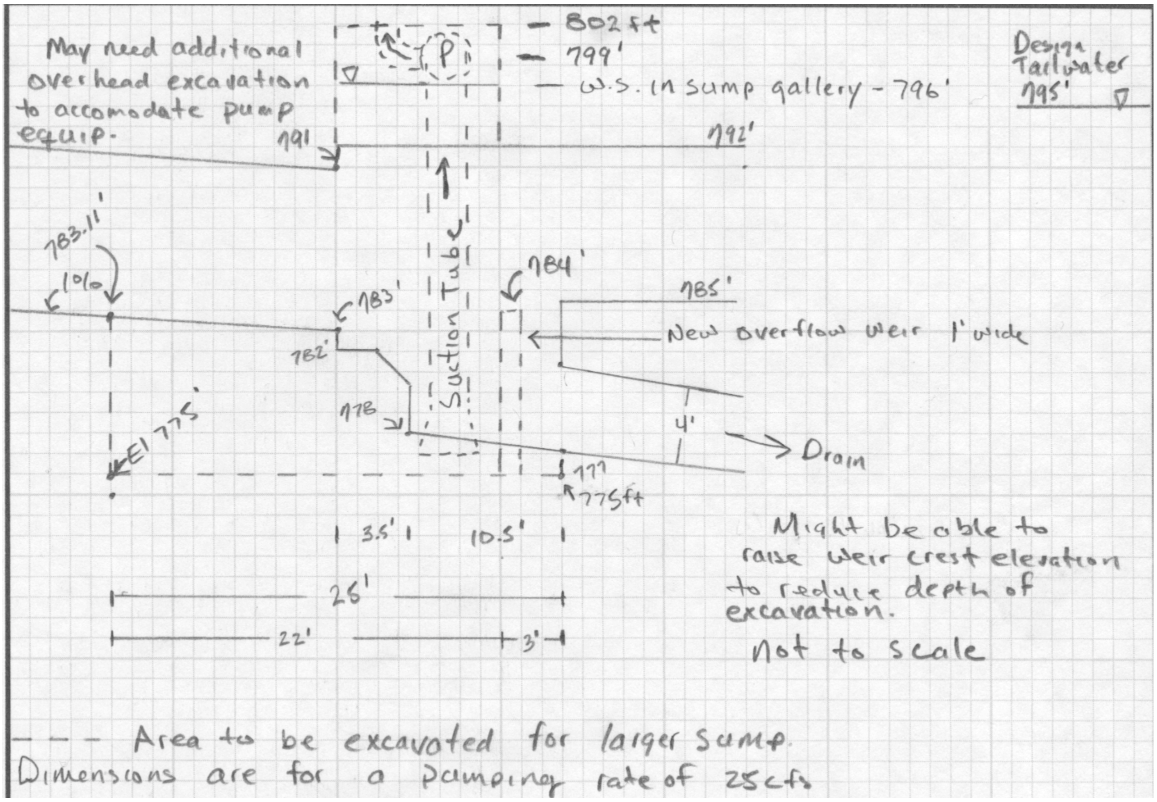


Figure 2. Conceptual Sump Cross Section for Pumping 25 cfs

5.3.1.3. In addition to the increased sump dimensions, Figure 2 shows other sump chamber modifications that include raising part of the sump chamber ceiling to keep pumping equipment in the dry up to the design tailwater elevation and construction of a weir to always insure the sump is always at a minimum elevation of 784 during low tailwater conditions. Under this configuration, as tailwater elevations exceed 795, the area in the chamber where the pump and motor are located would start to become inundated with water and equipment damage could be expected. When comparing Figures 1and 2 it might be noticed that the sump water surfaces differ by two feet. This is because the first step was to estimate system head losses and the sump water surface was initially chosen to be at 782. As the sump modifications were developed the elevation was changed to 784. This difference is not a factor at this point in the conceptual designs.

5.3.1.4. The velocity of the inflow to the sump is also of concern. Ideally, this value should be something on the order of 1 ft/sec or less. Plate 1 indicates that the velocity is closer to 4 ft/sec most of the time. Other structural measures may be needed to make the system function correctly. This may be addressed by raising the elevation of the weir to create a backwater that extends farther into the relief tunnel. Other disciplines would need to weigh in on problems (for example right abutment drainage might be impacted) that could arise (possibly hinder the drainage of the right abutment) from permanently having the relief tunnel flooded to some elevation.

5.3.1.5. The main hydraulic issue other than the size of the sump involves pumping at the maximum relief tunnel flow. Pumping at the maximum relief tunnel flow would be problematic if slight variations in relief tunnel flow occur. During periods of low tailwater, the sump could easily be pumped dry, causing pump and supply problems, and during periods of high tailwater elevations (above about elevation 784-785-when the sump chamber would start to flood above the sump) river water could be sucked into the sump due to a lower water surface in the chamber then that in the river. This would cause the pump to supply a mixture of relief tunnel water and river water. It is felt that it would be preferable to pump at some rate that is less than the relief tunnel flow, probably about 20 cfs based on what is known at this point.

5.3.1.6. The chance of river water entering the sump should also be looked at, even if the relief tunnel is pumped at a rate lower than the flow rate of the relief tunnel. There might be instances where the tailwater elevation could temporarily exceed that of the sump chamber, causing the flow to switch from chamber-to-tailwater to tailwater-to-chamber, causing river water infiltration. The proposed flow deflectors on the spillway may also have some affect on this issue. This could be alleviated with the installation of a one-way valve in the 4-foot drainpipe. There would be some issues to consider with installation of this valve as well. There would be additional installation and O&M costs as well as issues regarding valve failure/plugging and associated sump chamber/relief tunnel flooding.

5.3.1.7. The current pump capacity of the sump in its current configuration is about 10 to 14 cfs. Due to the presence of the 4-foot drain at the end of the sump, the installation of a weir structure similar to that in Figure 2 would be needed to insure that the sump is always full of water. This weir would take up space and further cut down pumping capacity. The other issues discussed above, such as the tailwater elevation, still would apply.

5.3.1.8. In the event that an unconventional sump design was needed, it is possible that a physical model study would be required to verify correct operation.

5.3.2. Constructing a Well Field to Supply Groundwater

5.3.2.1. This option would require wells be drilled in the area on the right side of the dam. These wells would be tapping groundwater that would most likely have similar characteristics as the relief tunnel water. At this point in the conceptual design, the wells would pump into a nearby storage tank that would in turn supply the hatchery. Conveyance between the storage tank and hatchery would be accomplished via a 24-inch welded steel pipe. The pipe size was arrived at based on estimates of length, number of bends, valves, etc. Based on the available mapping, the hatchery delivery point was assumed to be elevation 870, and the minimum tank water surface was assumed to be 1035.

5.3.2.2. Based on the estimate of well yields (150 gpm), about 100 wells would be needed to supply the total ground water requirement of 35cfs for both summer/fall and spring Chinook. In addition, a storage tank 30-feet in diameter and 20-feet tall would be required. This amount of storage would require the well pumps to be running about 90% of the time. If this value needs to be lower, the capacity of the tank would need to be larger. Figure 3 shows a schematic of the system.

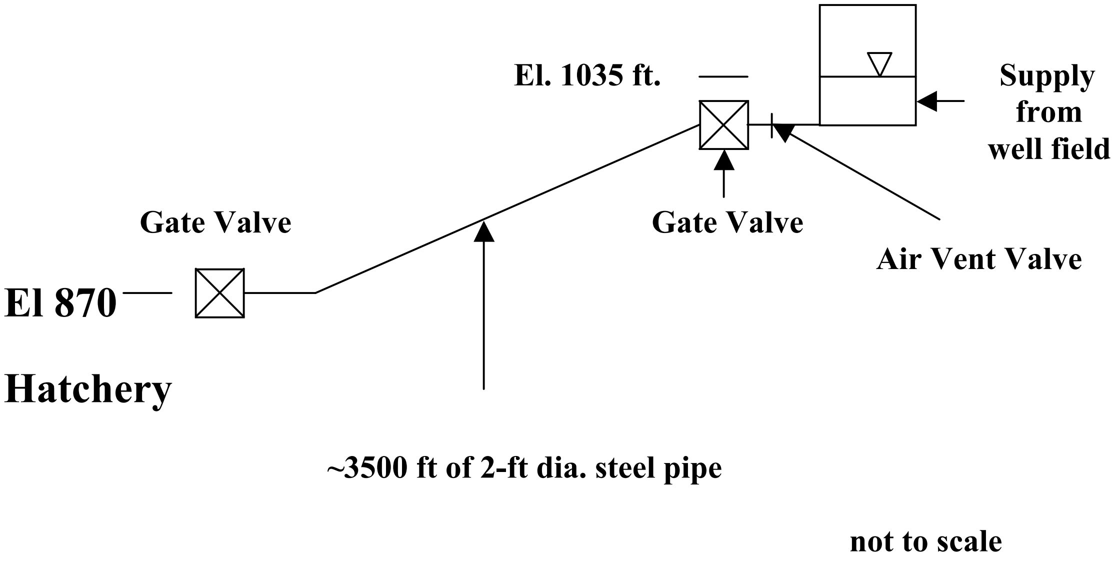


Figure 3. Well Field Supply System Schematic

5.3.2.3. More data on the volume of water that could be expected from wells is needed to further develop this option. Depending on the cost of various components of the two options for harvesting groundwater (wells and relief tunnel), it might make sense to use a combination of the two options to provide the needed supply.

5.3.3. Irrigation Diversion Structure

5.3.3.1. Chief Joseph Dam has a feature built into the right side of the structure that evidently was to be used as a diversion for agricultural water at some point. Project drawings do indicate provisions (but no designs) for a stop log type closure gate on the upstream side as well as a trash rack. The diversion has two inlets and outlets measuring four feet wide by five feet tall. The sill elevation is at elevation 920 feet. From the drawings it appears that the inlet entrances are radiused to minimize entrance head losses. Currently the inlets and outlets are plugged with concrete.

5.3.3.2. The hatchery would require a 45 cfs supply of forebay water. Again, assuming a delivery point elevation of 870 feet, and using the Chief Joseph minimum operating pool of 930 feet (60 feet of head), calculations indicate that a 30-inch diameter (assumed steel for calculations) would supply the required 45 cfs under minimum pool conditions. Using this scheme, one of the inlets and outlets would be opened, and the required pipe placed through the dam and the space between the outside of the pipe and the inlet would be sealed. The pipe system would continue on to the hatchery delivery point and terminate with a gate valve. A trash rack would need to be fabricated as well as a stop log system. For safety purposes a gate valve and an air vent valve (to prevent low pressures that could occur under some conditions) would also be installed near the intake end of the pipe. The system would be operated with the upstream gate valve in the fully opened position with flow to the hatchery controlled by the downstream gate valve. Figure 4 shows a schematic diagram of the system using the irrigation diversion.

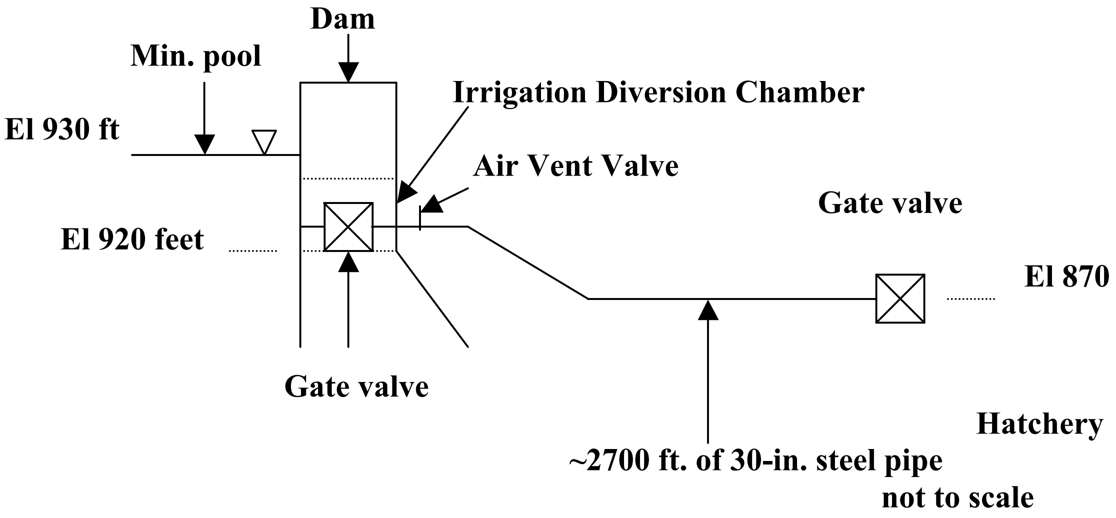


Figure 4. Irrigation Diversion Schematic

5.4. Recommendations

5.4.1. Groundwater Supply

5.4.1.1. In light of the lack of well field information, at this point the best option for supplying groundwater appears to be pumping 20-22 cfs from the relief tunnel (the exact value to be determined after analysis of relief tunnel flows) and supplying the balance from wells. This lower pumping rate would help alleviate the problems with the sump being pumped dry (and resulting supply problem) and with intrusion of river water. Figure 5 shows a conceptual sump chamber cross-section and Figure 6 shows the plan view of the sump. Due to the lower volume being pumped, theses two figures show a smaller sump than that shown in Figure 2. The sump would measure 18-feet long by 6-feet wide by 7 feet deep, compared to 22-feet long by 7.5-feet wide by 9-feet deep. As with the concept shown in Figure 2, it would require three additional feet of length for the weir structure and the weir overflow well. The volume of material to be removed for the sump shown in Figures 5 and 6 would be about 417 cubic feet compared to 1287 cubic feet for the version shown in Figure 2. As pumping rates are reduced so is the required sump size. The diameter of the supply pipeline would also be slightly reduced due to the lower pumping rate. Preliminary calculations indicate that a 20-inch diameter steel pipe would be required as opposed to a 22-inch diameter pipe for a 25 cfs pumping rate.

5.4.1.2. The elevation of the weir crest is important to the amount of excavation required. There are several factors (discussed below) that would determine this value for a final design. If the crest could be located at a higher elevation, the amount of vertical excavation would be less as long as the required amount of pump intake submergence is met. While raising the weir crest would reduce the amount of excavation, it also would back water up into the relief tunnel. It would need to be determined what affect this would have on relief tunnel performance.

5.4.1.3. Finally, depending on cost, difficulty, logistics, etc. of excavating the sump, it is possible that a sump could be designed that incorporates smaller dimensions than discussed above but provides satisfactory performance for the same pumping rate. To arrive at an “unconventional” design would require reviewing details of other sumps that have been constructed, working with a pump manufacturer(s) and possibly a physical model study. Depending on the other, non-hydraulic issues identified by other disciplines, this added effort might make a lot of sense.

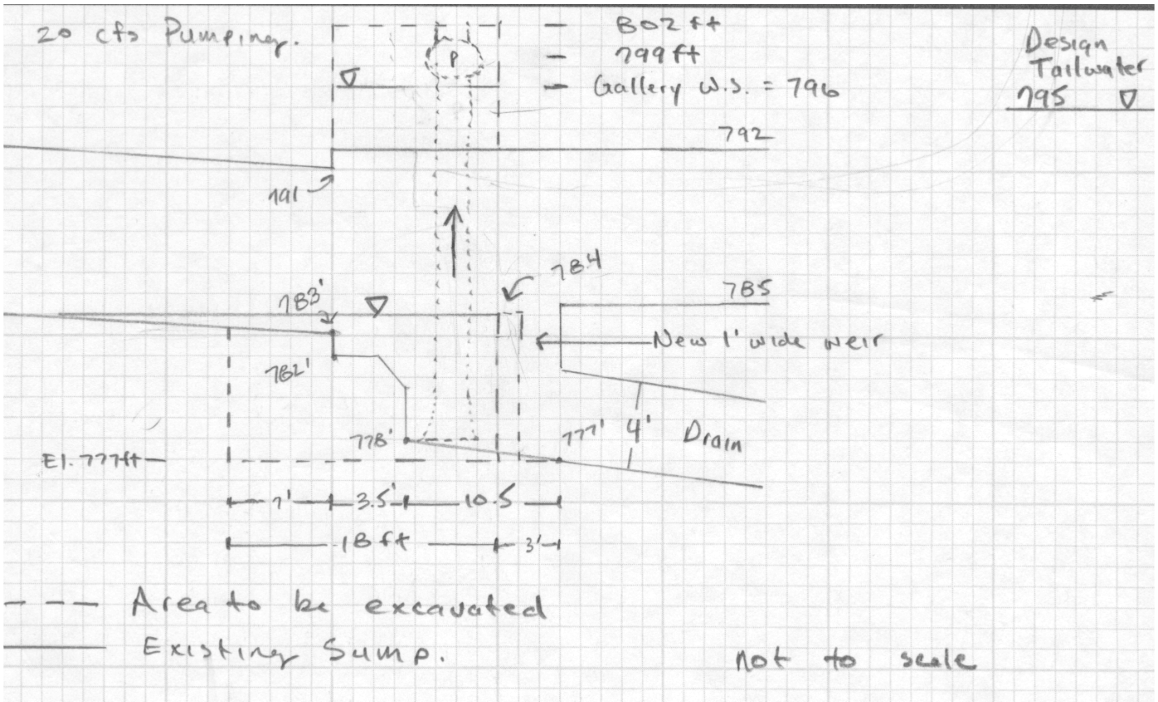


Figure 5. Proposed Conceptual Sump Chamber Cross Section

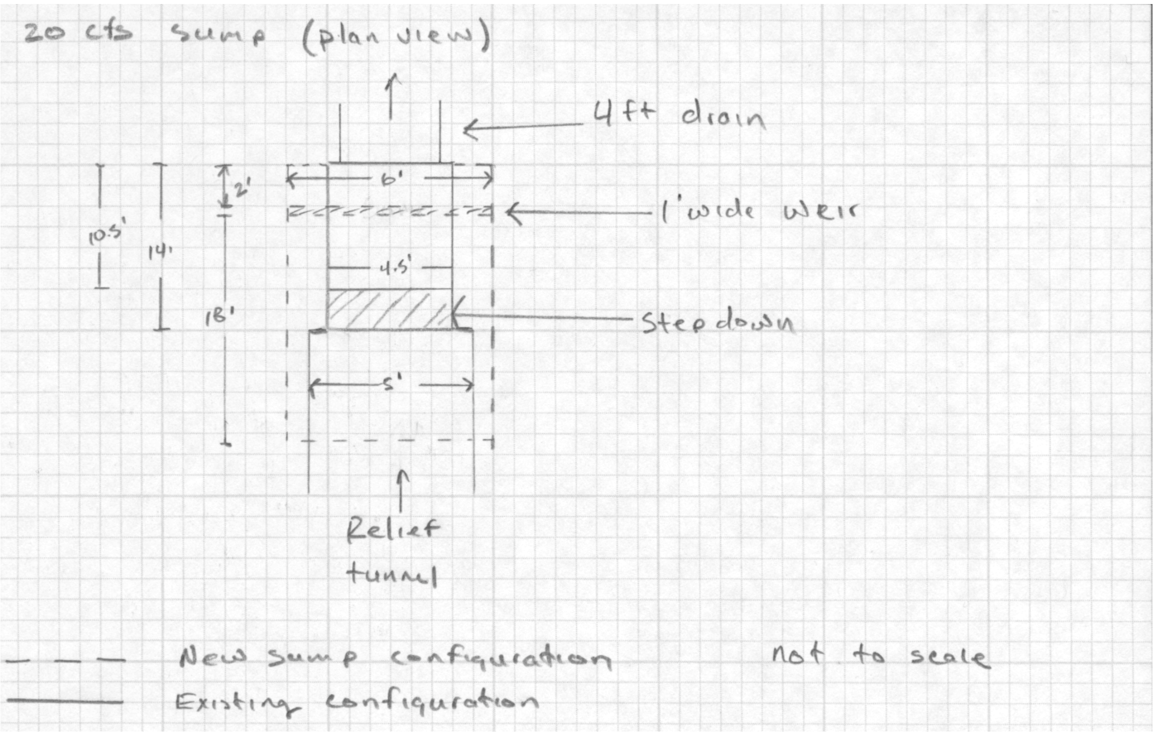


Figure 6. Proposed Conceptual Sump Chamber Plan

5.4.1.4. Some considerations for further development of this concept:

5.4.1.4.1. Pumping Equipment**:** To this point this option was developed using a conventional, centrifugal-type pump with a motor that would need to operate in the dry. This created the need to elevate the sump chamber ceiling to provide this dry area during high tailwater conditions. An investigation into motors designed to run in either the wet or the dry might yield one that would work in this case and reduce or eliminate the distance the ceiling needs to be raised. A quick call to a pump manufacturer found a submersible motor that did not produce the required horsepower for this application. Possibly, a suitable unit could be found or the sump could be configured to use two smaller pumping units. More investigation into the difficulty of raising the ceiling, pumping equipment availability and sump modification needs to be done.

5.4.1.4.2. Relief Tunnel Flow: An investigation into flow variation of the relief tunnel needs to be undertaken to arrive at a pumping rate that will be hydraulically stable.

5.4.1.4.3. Stability of Tailwater: The amount of variation in the tailwater elevation due to surging, wave action, flow deflector installation and spillway influences for a given flow needs to be evaluated. The results will influence sump weir crest elevation and influence the decision to install a one-way flow valve in the 4-foot drain.

5.4.1.4.4. One-way Flow Valve Installation: In addition to the tailwater issue, factors that need to be evaluated to determine one-way flow valve suitability are O&M, valve failure and debris blockage. Blockage or failure could flood the sump chamber, relief tunnel, and access gallery. This could in turn cause damage to pumping equipment and possibly abutment stability problems if the relief tunnel could not effectively reduce pore water pressures due to flooding. During periods of high tailwater it would be practically impossible to access the valve for repairs. From a hydraulic standpoint, it appears that this valve would not be necessary. The flow from the relief tunnel should almost always (if not always) maintain an equilibrium sump/tailwater head differential (sump water surface being higher than tailwater) such that flow would be from the sump to the tailwater, resulting in the sump almost always containing relief tunnel water only. Surging and other factors that cause the tailwater to rapidly rise could possibly allow a small amount of river water to enter the sump chamber for a brief time until the equilibrium head differential is restored. After a more detailed hydraulic analysis, if there is still concern about tailwater intrusion, temperature and conductivity data loggers could be placed in the sump for a period of time (probably when spill is likely to occur) to detect the presence of river water.

5.4.1.4.5. Flow Regime of Relief Tunnel: The velocity of the flow entering the sump needs to be analyzed to insure suitable sump operation. Ideally this should be 1 ft/sec or less. Plate 1 seems to indicate that the velocity is higher than 1 ft/sec. Raising the elevation of the sump weir might also be a means to reduce incoming velocities. Other disciplines would need to provide input as to the ramifications of doing this. Whether the flow is sub critical or super critical also needs to be determined. If it is supercritical, a hydraulic jump might form at the interface of the tunnel flow and the backwater created by the new weir. If this happens, then a determination needs to be made as to what measures, if any, are required.

5.4.1.4.6. Design Tailwater Elevation: This value needs to be looked at to determine if it is realistic for design. If pumping equipment is used that would be damaged by flooding of the chamber, then it is important to determine a ceiling elevation that represents the amount of risk that is acceptable in this respect. The costs associated with raising the ceiling and/or damaged equipment would need to be looked at. A tailwater elevation exceedance analysis would be needed to make this determination.

5.4.1.4.7. Reliability: Thus far this concept has been developed using just one pump. Would some redundancy, such as a backup pump need to be incorporated?

5.4.2. Reservoir Water Supply

5.4.2.1. At this point, modifying the irrigation diversion chamber seems to be the best option for supplying reservoir water. Initially a pumping/siphon system was looked at, but due to the simplicity and reliability of a gravity system it was not developed. A pumping/siphon system would require an intake structure capable of working with pool elevations down to elevation 930 (this is the minimum operating pool) to always guarantee operation. For a true siphon, the maximum elevation differential between the reservoir surface and the maximum pipe elevation is about 28 feet. For full pool conditions this requirement would probably be met but for the lower elevations a pump assist system would likely be needed to make up any head differential in excess of 28 feet. Even though it would be a rare occurrence that the pool would get this low (depending on the routing of the pipeline, it is possible that such a system would be able to operate in siphon mode most of the time), an assumption was made that the system would always be functional. Even if a system were to operate only as a siphon, some type of pumping system would be required to prime it. Also, since the intake structure would be placed in the reservoir, upstream of the dam, a longer pipeline (and excavation) would be required for a pumping/siphon system than for the irrigation diversion. From a hydraulic standpoint the diversion structure appears to be a good option for supplying reservoir water at this point.

5.4.2.2. With all options, more hatchery design information would be helpful. Hydraulic systems within the hatchery (head losses, supply-duration requirements, delivery points, etc) may have an impact on the assumptions made to develop these options at this stage and could have a bearing on further development.

5.4.2.3. It should be noted that these hydraulic designs are very conceptual at this stage. Assumptions and estimates (pipe materials, number of bends, certain elevations, constructability, etc.) were made. As the designs evolve, aspects of them could change.

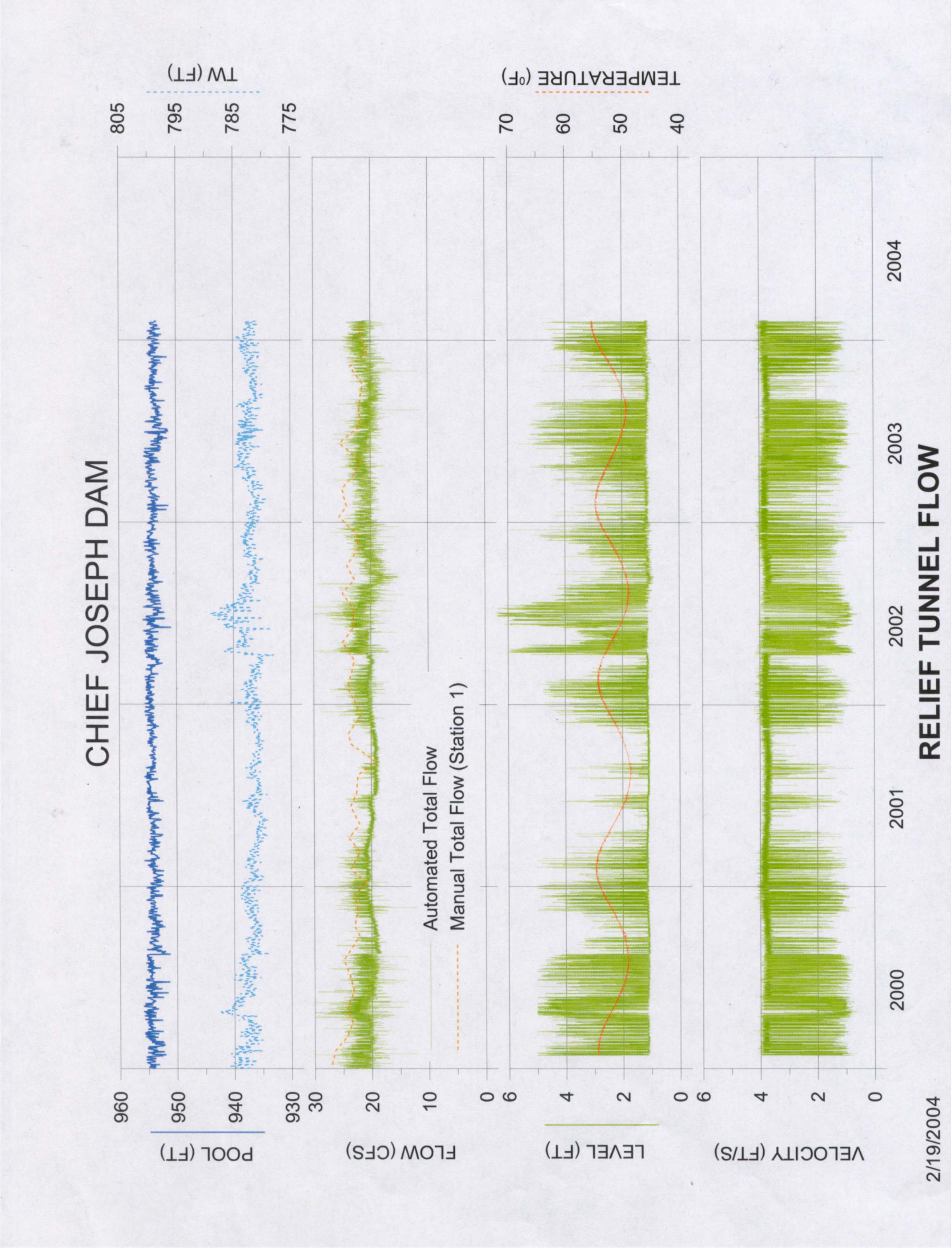


Plate 1. Relief Tunnel Flow Plot (2000-2003)

6. STRUCTURAL REQUIREMENTS

6.1. Dam Intake Diversion Structure

6.1.1. When the dam was constructed provisions were made in Monolith 2 to provide for an irrigation intake. This passage way through the dam can now be used to provide for water from the upstream pool to pass in a pipe through the dam to the downstream area for a proposed fish hatchery water supply on the right bank. An intake opening from the upstream pool, a room for mechanical equipment and an exit through the downstream face of the dam with trashrack and stop log guides at the sides of the upstream opening, were formed when the dam was constructed.

6.1.2. At present the upstream intake is blocked by a 1-foot thick reinforced concrete wall and the downstream passage is closed with an 8-inch thick concrete block wall. A portion of these walls will have to be removed so that a 30-inch diameter metal pipe can pass through them to transport the water.

6.1.3. The existing room in Monolith 2 is available for mechanical equipment and this proposed design calls for a 30-inch gate valve to be installed in the 30-inch diameter metal pipe. The metal pipe invert elevation will be at approximately 920.0 feet. The Chief Joseph normal pool is at elevation 956.0 feet. The room entrance doorway sill is at elevation 930.5 feet. At this elevation, a grating floor will be installed with a metal stairway leading down to a platform from which a person will stand and can turn the wheel to open and close the gate valve (See Figure 1).

6.1.4. A trashrack will have to be designed, fabricated and installed within the existing metal guides. The trashrack will be designed to be 3 feet above the maximum pool. This could be done without a cofferdam.

6.1.5. Stoplogs shall be designed, fabricated and can be installed within the existing stoplog metal guides. The stoplogs can be used as an emergency stoppage of water flow in the pipe and for stoppage of water to inspect, repair and maintain the gate valve and pipe inside the dam.

6.1.6. A fish screen approximately 5-feet high by 4-feet wide will be installed at the inlet between the stoplogs and the entrance of the pipe to prevent small fish from being trapped and injured going through and hitting the interior of the pipe at high velocities.

6.1.7. The 30 inch metal pipe will have an elbow at it's exit at the downstream face of the dam and will be trenched in the rock fill and attached to the dam concrete surface with metal straps. The pipe will continue through the rock fill to the right bank lower roadway at elevation 843 feet and then will continue in an 8-feet deep by 11-feet wide trench excavated beneath the roadway. The pipe will be anchored in concrete thrust blocks every 100-feet and at bends or grade changes. The pipe line ends at the Hatchery Head Box Control Structure at approximately elevation 870 feet.

6.2. Relief Tunnel Structure

6.2.1. The existing Relief Tunnel extends from the base of Monolith 1 in a Northwest direction for 1,020 feet. The inside of the tunnel is 8 feet high by 5 feet wide. The ceiling concrete is 3 feet thick, concrete walls 1 foot 8 inches and concrete floor 3 feet thick for the first 180 feet from the sump and then the ceiling, walls and floor are 2 feet, 1 foot 6 inches and 2 feet respectfully for the remainder of the tunnel.

6.2.2. Relief wells exist beneath the relief tunnel and the water from the downstream right bank passes into the relief wells and up into the relief tunnel. The water then travels down the relief tunnel into a sump at one end of the tunnel. An existing 4 foot diameter drain hole in the concrete starts at the sump and exits at the surface base of Monolith 5 with an I.E. of 765.0 into the downstream pool. In order for the Hatchery water to be from the relief tunnel and not from the downstream pool, a flap gate shall be installed at the end of the 4 foot diameter drain hole. When the upstream pool at Wells Dam, the next downstream dam, is high, the flap gate closes to prevent water from Chief Joseph's downstream pool from backing up into the relief tunnel. Back flow from the downstream pool into the relief tunnel is believed to be a transient phenomenon, and the new sump may function satisfactorily without the gate.

6.2.3. A new sump room will be required. Currently the sump is about 10.5 feet long, 4.5 feet wide and 4.5 feet deep (See Figure 2). The new sump room needs to be 18 feet long by 6 feet wide by 7 feet deep. In order to build this room approximately 21 feet of existing tunnel and sump floor slab has to be removed and replaced with a new floor approximately 7 feet deep and 6 feet wide. Also approximately 7 feet of one relief tunnel wall has to be removed and replaced by a new wall which will widen the interior of the room to 6 feet. The ceiling of the existing tunnel would remain but an extension of 1 feet of new ceiling would have to be added on to make the room 6 feet wide by 18 feet long. Approximately 11 feet of the ceiling over the existing sump would be removed and a new raised ceiling constructed to accommodate the pump chamber. A new overflow weir will be added in the sump room between the bottom of the pump intake and the entrance to the 4 foot diameter drain outlet. In order to construct the new sump and pump chamber, a large portion of impervious and random fill would have to be removed and replaced or a shaft would have to be excavated through the fill. The shaft could be made a permanent feature for access to the pump.

U.S. ARMY CORPS OF ENGINEERS OFFICE SYMBOL:

PROJECT: Chief Joseph Dam Hatchery Water Supply

COMPUTED BY: MCR

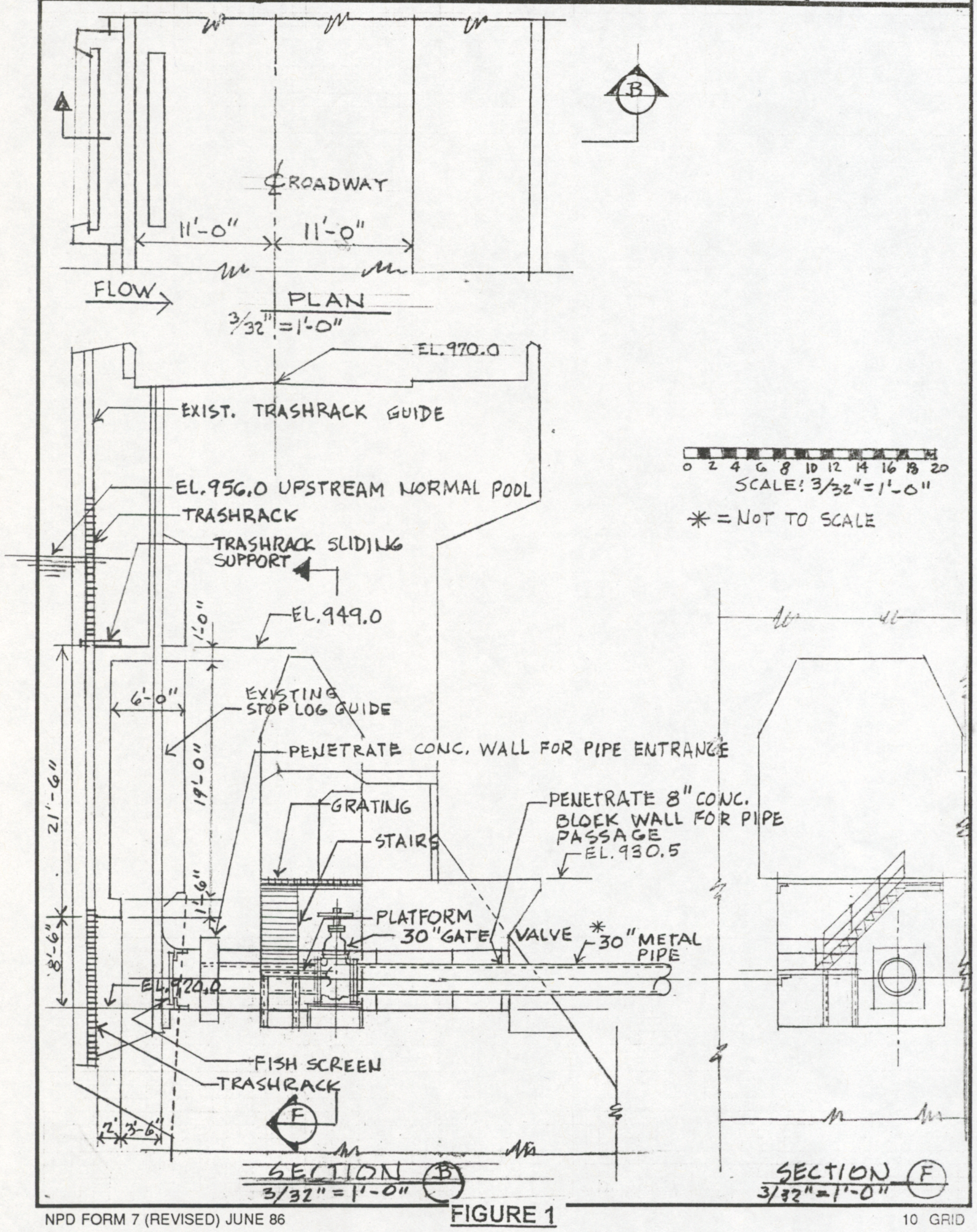
DATE: FEB. '04

SHT. 1 OF 3

SUBJECT: Irrigation Intake at Dam 10% Design

CHECKED BY:

PART:



NPD FORM 7 (REVISED) JUNE 86

FIGURE 1

10 GRID

RELIEF TUNNEL SUMP AND DRAIN

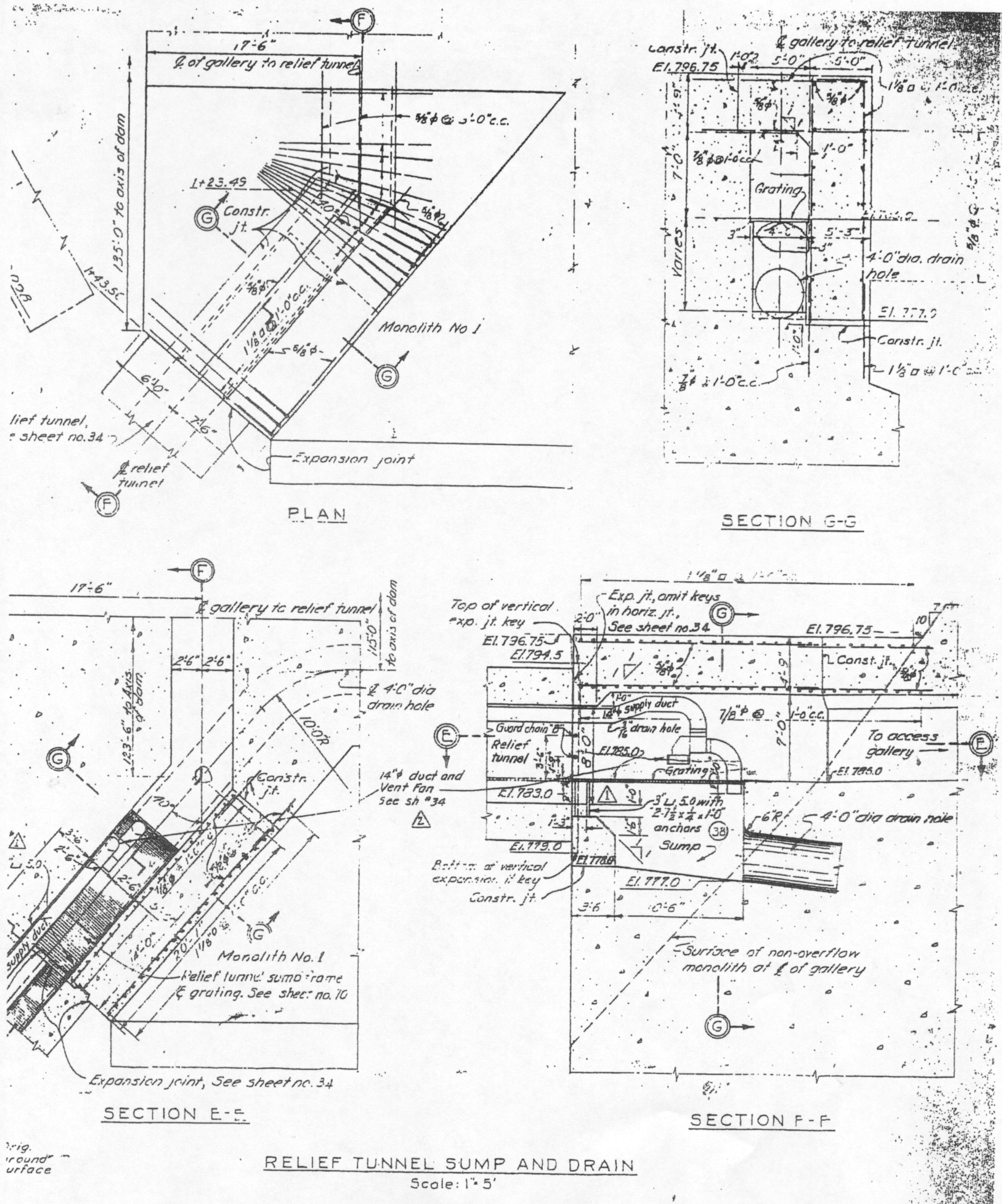


FIGURE 2

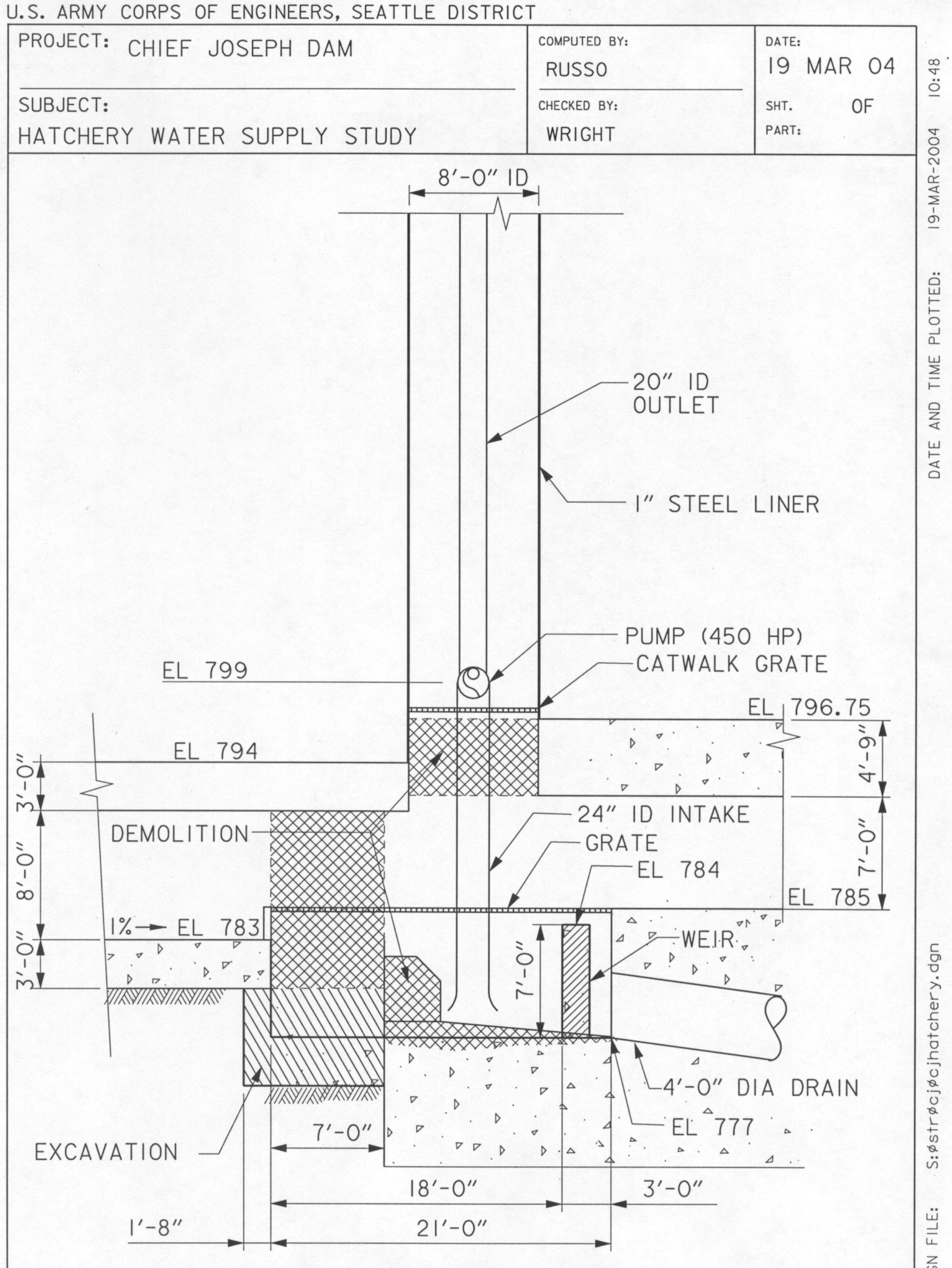

U.S. ARMY CORPS OF ENGINEERS, SEATTLE DISTRICT
PROJECT: CHIEF JOSEPH DAM
SUBJECT:
HATCHERY WATER SUPPLY STUDY
COMPUTED BY:
RUSSO
CHECKED BY:
WRIGHT
DATE:
19 MAR 04
SHT. OF
PART:
DATE AND TIME PLOTTED: 19-MAR-2004 10:48
DESIGN FILE: S:ø0strøcjøcjhatchery.dgn
8'-0" ID
20" ID
OUTLET
1" STEEL LINER
PUMP (450 HP)
CATWALK GRATE
EL 799
EL 796.75
EL 794
4'-9"
7'-0"
24" ID INTAKE
GRATE
EL 784
EL 785
DEMOLITION
3'-0"
8'-0"
3'-0"
1% EL 783
WEIR
7'-0"
4'-0" DIA DRAIN
EL 777
EXCAVATION
7'-0"
18'-0"
3'-0"
1'-8"
21'-0"

FIGURE 3

7. Water Quality Data

7.1. Introduction

7.1.1. The Seattle District Corps of Engineers Hydrology and Hydraulics Section (COE) is conducting a baseline water quality assessment of fish hatchery water sources at Chief Joseph Dam during the 2004 water year. Potential sources of water identified for this study include the relief tunnel, the irrigation inlet structure located near the right bank in the forebay, and the orientation water system wells located along the right bank at the hatchery site. The fish hatchery would utilize one or more of these sources of water during the entire year to meet the quantity and quality of water needed for hatchery operations.

7.1.2. The quality of the proposed hatchery source water is important because water quality can determine the success or failure of fish hatchery operations. Physical and chemical characteristics of the source waters must be properly analyzed and evaluated in order to select a suitable water source. Historical sampling conducted in 1989 and 1990 at the relief tunnel and hatchery site wells detected mercury at concentrations exceeding Washington State Department of Fish and Wildlife (WDFW) recommended water quality criteria for aquaculture programs. Recent sampling conducted in 2003 detected mercury at concentrations well below WDFW recommended criteria but did detect nitrite at concentrations exceeding the WDFW recommended criteria. Consequently, the Colville Tribes expressed concerns about the quality of the relief tunnel and orientation water system wells water for hatchery operations. To address these concerns, the COE designed a water study to quantify more precisely the water quality of all potential water sources for the fish hatchery.

7.2. Purpose and Scope

7.2.1. The purpose of the study is to characterize the quality of the relief tunnel, hatchery site wells and forebay waters during the winter, spring, summer, and fall to determine if these waters are of sufficient quality for use at a fish hatchery. The objective of the monitoring program is to determine existing water quality conditions of possible hatchery source waters during a water year. These objectives will be met using data collection and analysis methods to evaluate surface water quality and ground water quality at Chief Joseph Dam.

7.2.2. This study is currently being conducted during 2004 and has not been completed. Data were collected on February 3, 2003 from one (1) station in the relief tunnel and one (1) station in the forebay. Data were not collected at the hatchery site well during the February sampling event because the well was decommissioned for the winter and was not operational. Therefore, the data presented in this section are preliminary and represent only one sampling event out of a possible four sampling events. It is anticipated that additional samples, including the hatchery site well, will be collected in the spring and/or summer.

7.3. Methods

7.3.1. Site Characterization

7.3.1.1. Chief Joseph Dam is located at river mile 545 on the Columbia River in Washington, about 51 miles downstream of Grand Coulee Dam (Figure 1). The dam is a concrete gravity dam, 230 feet high, with 19 spillway bays which abut the right bank. The general location of the irrigation inlet structure, the relief tunnel, and the hatchery site wells are shown in Figure 2.

7.3.1.2. The irrigation inlet structure is located on the face of the dam near the right bank at a depth of about 30 feet below the forebay water surface under normal pool conditions. The relief tunnel extends over 1,000 feet from the northwest end of the spillway into the right abutment. Access to the tunnel is by way of galleries in the interior of the dam. The tunnel captures water seeping from the forebay through the right bank and towards the right abutment. Water drains into the tunnel via wood stave wells located in the floor of the tunnel, flows down the tunnel into a sump located near the foot of the gallery stairs, and ultimately drains to the Columbia River via a 4-foot conduit. The hatchery site wells are located on the right bank of the river about 3,500 feet downstream of the dam near the site of the proposed fish hatchery. These wells are located at a distance from the river of about 50 feet and an elevation above the river of about 20 feet.

7.3.2. Data Collection

7.3.2.1. Sampling procedures were conducted according to the *Preliminary Scope of Work: Water Quality Sampling at Chief Joseph Dam for the Colville Tribes Fish Hatchery* (USCOE 2003), and generally followed Puget Sound Estuary Program (PSEP) protocols (U.S. EPA 1990). Water quality parameters monitored in the relief tunnel and forebay are shown in Table 1. Sampling locations are presented in Figure 2. As previously noted, water quality was not monitored at the hatchery site wells because they were not operational during the sampling event. Prior to the sampling event, all sampling equipment was thoroughly cleaned and decontaminated following PSEP protocols. The equipment was scrubbed with a brush and detergent (1 percent Liquinox), thoroughly rinsed with deionized water, rinsed with a 10 percent Nitric Acid solution, and given a final rinse with deionized water.

7.3.2.2. Surface water grab samples were collected from the center of the channel in the relief tunnel and from a depth of 30 feet in the forebay by field technicians wearing new vinyl gloves. Relief tunnel samples were collected by submerging laboratory-cleaned, prelabled sample containers below the water surface to a depth of about 1 foot. Forebay samples were collected from a depth of 30 feet by submerging a cleaned and decontaminated 2.2 liter (L) polycarbonate (Lexan) van-dorn style sampler with ultra-clean seals to depth and filling. All sample containers were rinsed 3 times prior to filling, capped, and immediately placed on ice in a cooler. Measurements of field parameters (See Table 1) were performed by submerging a Hydrolab DataSonde 4

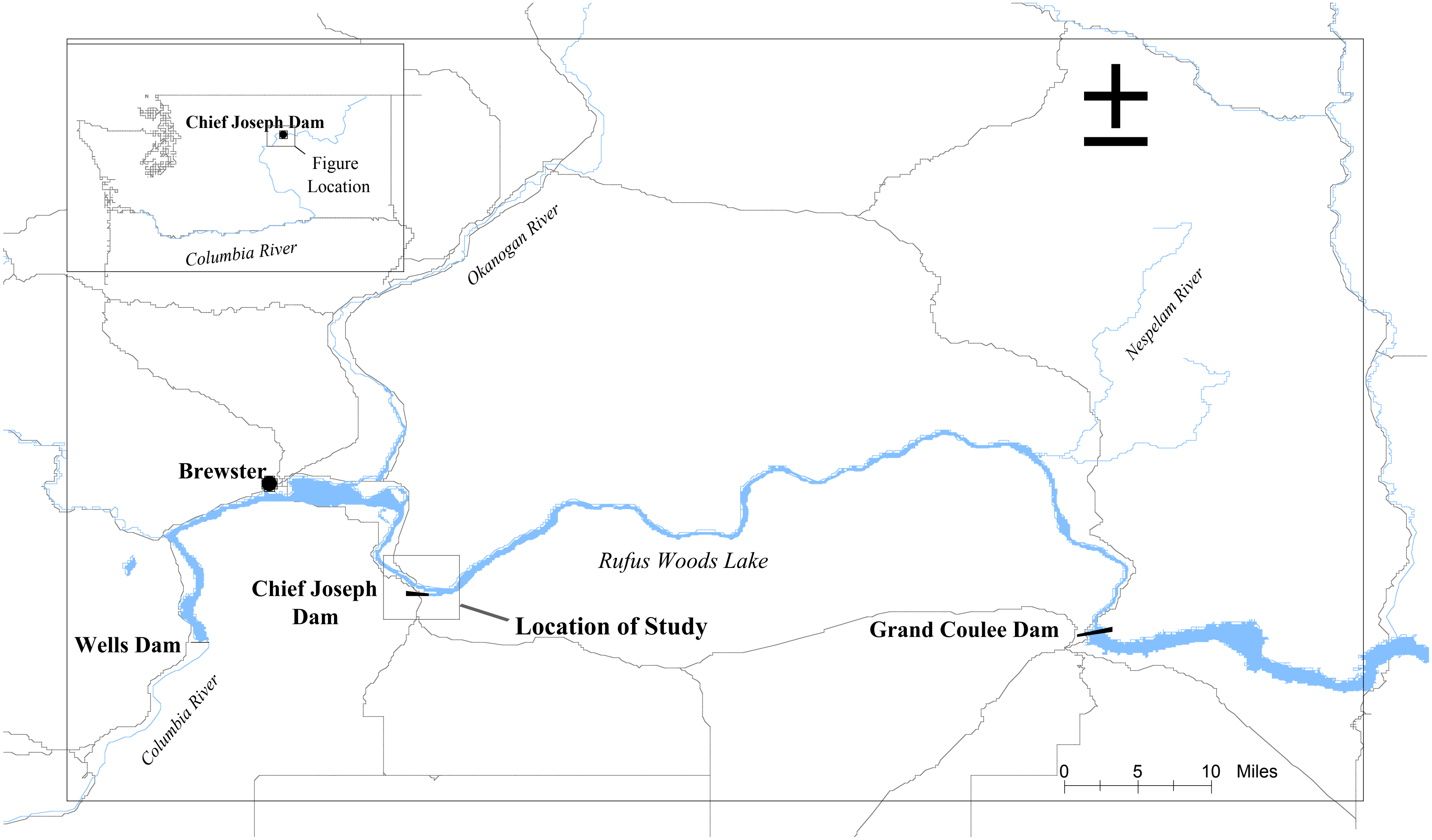


Figure 1. **Location of the study.**

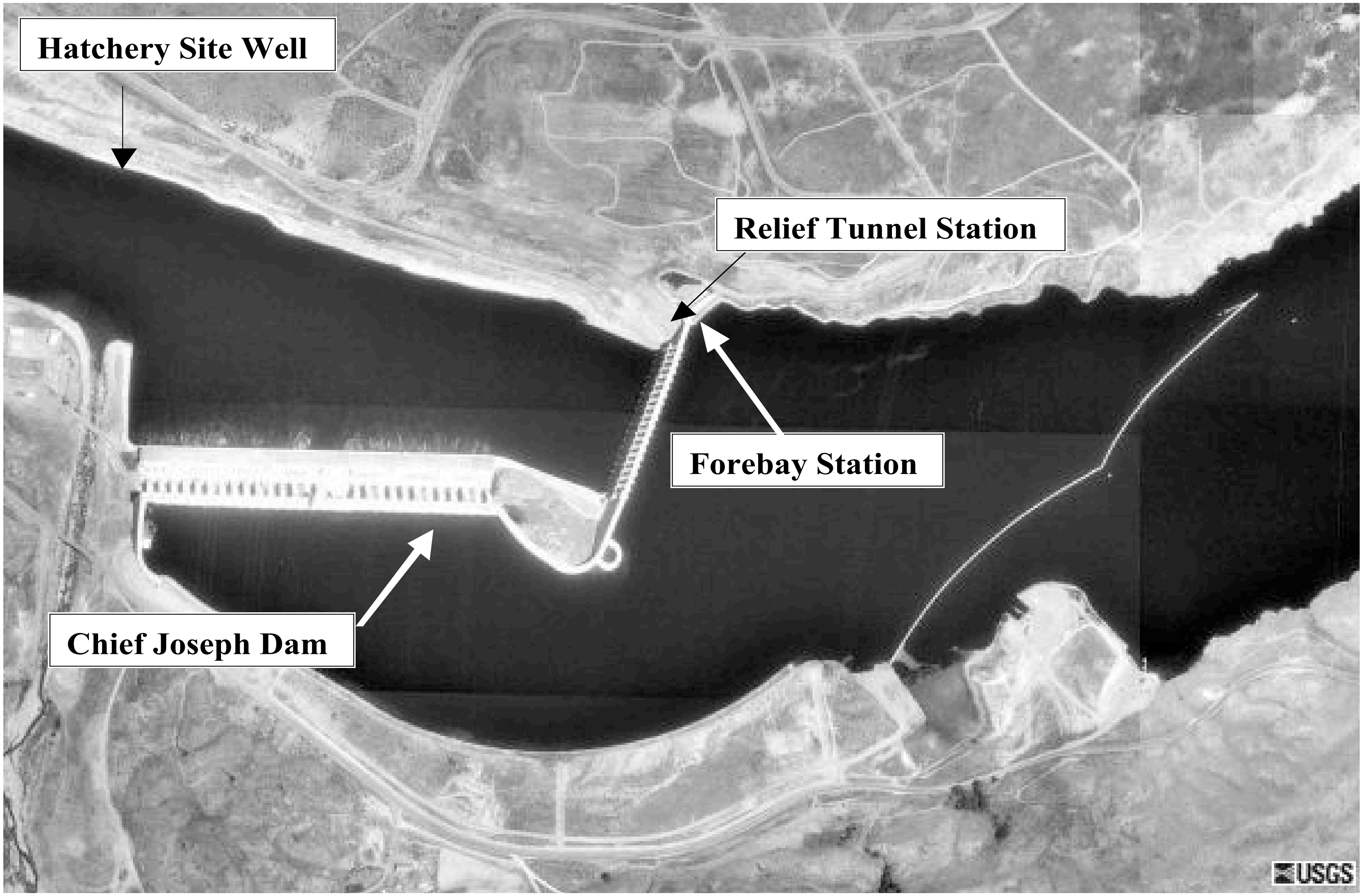


Figure 2. Location of the water quality sampling stations.

Table 1. Methods and detection limits for water quality analyses.

	Matrix	Method Number [a]	Detection Limit/Unit
Field Parameters			
Temperature	Water	SM 2550-B	0.1°C
pH	Water	SM 4500-H	–
Conductivity	Water	SM 2510-B	1 µS/cm
Turbidity	Water	SM 2130-B	0.1 NTU
Dissolved Oxygen	Water	SM 4500-O-G	0.1 mg/L
Laboratory Parameters			
Total Phosphorus	Water	AM 4500PB	0.010 mg/L
Total Nitrogen	Water	EPA 351.2	0.100 mg/L
Nitrate+Nitrite	Water	EPA 353.2	0.010 mg/L
Nitrite	Water	EPA 354.1	0.010 mg/L
Ammonia	Water	EPA 350.1	0.010 mg/L
Alkalinity	Water	EPA 310.1	1.00 mg/L
Hardness	Water	SM182340B	1.00 mg/L
Calcium	Water	EPA 6010	0.100 mg/L
Magnesium	Water	EPA 6010	0.100 mg/L
Potassium	Water	EPA 6010	0.700 mg/L
Sodium	Water	EPA 6010	0.500 mg/L
Sulfate	Water	EPA 300	1.00 mg/L
Chloride	Water	EPA 300	0.50 mg/L
Fluoride	Water	EPA 300	0.100 mg/L
Aluminum	Water	EPA 200.8	0.020 mg/L
Arsenic	Water	EPA 200.8	0.002 mg/L
Barium	Water	EPA 200.8	0.005 mg/L
Cadmium	Water	EPA 200.8	0.0002 mg/L
Chromium	Water	EPA 200.8	0.0020 mg/L
Copper	Water	EPA 200.8	0.0010 mg/L
Iron	Water	EPA 200.8	0.020 mg/L
Lead	Water	EPA 200.8	0.0010 mg/L
Manganese	Water	EPA 200.8	0.005 mg/L
Mercury	Water	EPA 1631B	0.0020 µg/L
Nickel	Water	EPA 200.8	0.0020 mg/L
Selenium	Water	EPA 200.8	0.0030 mg/L
Silver	Water	EPA 200.8	0.0010 mg/L
Zinc	Water	EPA 200.8	0.005 mg/L
Total Dissolved Solids	Water	EPA 160.1	5.00 mg/L
Pesticide/PCB	Water	EPA 8081/8082	0.005 µg/L to 0.1 µg/L

[a] SM method numbers are from APHA et al. (1992); EPA method numbers are from U.S. EPA (1983, 1984).

mg/L	Milligrams per liter
µS/cm	Microsiemens per centimeter
NTU	Nephelometric turbidity unit

multiprobe directly into the forebay water or from a sample withdrawn from the relief tunnel. Equipment used for field measurements was calibrated prior to the sampling event. One set of field duplicates was collected at the forebay station to assess both environmental and analytical variability. All samples were transported to the laboratory within 24 hours, where they were analyzed for the parameters shown in Table 1.

7.3.3. Quality Assurance Procedures

7.3.3.1. Quality assurance of water quality samples followed procedures set forth in the *Preliminary Scope of Work: Water Quality Sampling at Chief Joseph Dam for the Colville Tribes Fish Hatchery* (USCOE 2003). Data were validated according to the sampling and analysis plan, and quality control data provided by the laboratory were combined with results of field duplicates to check the precision and accuracy of the data. Data validation results are presented in Attachment A at the end of this report. Values qualified as estimates were used in the evaluation, and none of the values were rejected.

7.3.4. Water Quality Criteria

7.3.4.1. The Washington Department of Ecology (WDOE) and the Colville Tribes determine surface water quality criteria for the Columbia River at Chief Joseph Dam in Washington. The WDOE has classified the Columbia River above and below Chief Joseph Dam as a Salmon and Trout spawning non-core rearing and migration aquatic life use water body, while the CCT has classified the Columbia River as a Class I water body above Chief Joseph Dam and a Class II water body below the dam. These criteria are designed for the protection of aquatic life in fresh surface waters of the state of Washington and the Colville Reservation. However, at the time of this report, water quality criteria for regulating source waters intended for aquaculture do not exist for the state of Washington. In lieu of aquaculture specific criteria, WDFW has compiled a list of recommended water quality criteria for source waters intended for aquaculture uses as shown in Table 2. For comparative purposes, WDOE surface water chronic criteria are also shown in Table 2.

7.3.5. Historical Data

7.3.5.1. Historical water quality data for the relief tunnel, forebay, and hatchery site well are presented in Table 3. Data collected in 1977 by Koch and Cochran (1977) from the relief tunnel and forebay are limited and represent only field parameters and conventionals. Relief tunnel samples were collected near the lower end of the tunnel, while forebay samples were collected from the surface about 50 feet upstream of the dam. Data collected by the COE between 1989 and 2003 represent the most complete data set for these water sources. Samples from the relief tunnel, forebay, and hatchery site well were analyzed for field parameters, conventionals, metals and bacteria. Relief tunnel samples were collected near the lower end of the tunnel about 15 feet upstream of the sump while forebay samples were collected from the surface about 50 feet upstream of the dam.

Table 2. Washington State Department of Fish and Wildlife Recommended Water Quality Criteria for Aquaculture and Ecology Chronic Criteria.

		WDFW Recommended Values		
Parameter	**Units**	**Piper Values [a]**	**U.S. EPA Values [a]**	**WDOE Values [b]**
Alkalinity (as $CaCO_3$)	mg/L	10 – 40	At least 20	□
Aluminum	mg/L	< 0.01	□	□
Ammonia (as NH_3)	mg/L	0.0125	0.02	0.028[c]
Arsenic	mg/L	< 0.05	□	0.19
Barium	mg/L	< 5.0	□	□
Cadmium (Alk > 100 mg/L)	mg/L	< 0.0004	0.0004	0.0009[b]
Cadmium (Alk < 100 mg/L)	mg/L	□	0.003	□
Calcium Carbonate	mg/L	4 – 160	□	□
Carbon Dioxide	mg/L	0 – 10	□	□
Chloride	mg/L	< 4.0	□	230
Chlorine	mg/L	< 0.03	0.003	0.011
Chromium	mg/L	< 0.03	0.03	0.1483[b]
Copper (Alk > 100 mg/L)	mg/L	< 0.006	0.006	0.0094[b]
Copper (Alk < 100 mg/L)	mg/L	□	0.03	□
Fluoride	mg/L	< 0.5	□	□
Hardness	mg/L	10 – 400	□	□
Hydrogen Cyanide	mg/L	< 0.01	□	0.0052
Hydrogen Sulfate	mg/L	< 0.0001	0.002	□
Iron	mg/L	< 0.15	□	□
Lead	mg/L	< 0.03	0.03	0.0020[b]
Manganese	mg/L	< 0.01	□	□
Mercury	µg/L	< 0.2	0.2	0.012
Nickel	mg/L	< 0.01	□	0.1302[b]
Nitrate	mg/L	0 – 3	□	□
Nitrite	mg/L	< 0.1	□	□
Nitrogen	% sat	< 100	□	110
PCBs	mg/L	< 0.002	0.002	0.00014
pH	units	6.5 – 8.0	6.0 – 9.0	6.5-8.5
Potassium	mg/L	< 5.0	□	□
Salinity	ppt	< 5.0	□	□
Selenium	mg/L	< 0.01	□	0.005[d]
Settleable Solids	mg/L	< 80	< 80	□
Silver	mg/L	< 0.003	□	0.0024[b]
Sodium	mg/L	< 75	□	□
Sulfate	mg/L	< 50	□	□
Total Dissolved Solids	mg/L	10 – 1000	□	□
Total Suspended Solids	mg/L	< 80	< 80	□
Uranium	mg/L	< 0.1	□	□
Vanadium	mg/L	< 0.1	□	□
Zinc	mg/L	< 0.03	□	0.0865

a Sources: Piper et al (1982) and U.S. EPA (1973).
b Dissolved metals chronic criteria for waters with an average hardness of 80 mg/L, except Silver, which is an acute criteria.
c. Based on a typical pH value of 7.8 and a water temperature of 10°C.
d. Total recoverable fraction.

Table 3. Summary of historical water data collected in the relief tunnel, forebay and hatchery well at Chief Joseph Dam.

	Historical Data	**Historical Data**	**Historical Data**	**Historical Data**	**Historical Data**	**Historical Data**	**Historical Data**	**Historical Data**	**Historical Data**
	Relief Tunnel (1/19/1977)[1]	Relief Tunnel (4/14/1989)[2]	Relief Tunnel (5/26/1989)[2]	Relief Tunnel (1/29/2003)[2]	Relief Tunnel (5/13/2003)[2]	Forebay (1/19/1977)[1]	Forebay (1/29/2003)[2]	Forebay (5/13/2003)[2]	Hatchery Well (9/19/1990)[2]
Field Parameters									
Temperature (°C)	_	_	_	_	_	_	_	_	_
PH	87.7	_	_	_	_	7.67	_	_	_
Conductivity (µS/cm)	162	170	_	161	_	141	138	_	270
Turbidity (NTU)	□	0.4	_	< 0.5	_	□	< 0.5	_	0.2
Conventionals/Bacteria									
Nitrate+Nitrite (mg/L)	□	_	_	0.32	_	□	0.4	_	_
Nitrate (mg/L)	0.75	0.3	_	0.16	_	0.49	0.21	_	2.5
Nitrite (mg/L)	_	_	_	**0.16**	_	□	**0.19**	_	_
Alkalinity (mg/L)	_	_	_	_	_	□	_	_	_
Hardness (mg/L)	88.5	80	_	72.9	_	72.7	67.2	_	120
Calcium (mg/L)	22.3	_	_	21	_	20.2	19.5	_	_
Magnesium (mg/L)	5.3	_	_	4.97	_	4.3	4.5	_	_
Potassium (mg/L)	1.5	_	_	_	_	0.65	_	_	_
Sodium (mg/L)	2.4	< 5	_	2.18	_	1.5	1.46	_	< 10
Sulfate (mg/L)	9.8	_	_	8.4	_	11.5	8.9	_	_
Chloride (mg/L)	0.5	< 5	_	< 0.5	_	0.5	< 0.5	_	< 5
Fluoride (mg/L)	_	< 0.2	_	0.15	_	□	0.12	_	< 0.2
Total Dissolved Solids (mg/L)	86.1	_	_	64	_	75	382	_	_
Total Coliform Bacteria (#/100mL)	_	_	_	< 2	_	_	< 2	_	_
Fecal Coliform Bacteria (#/100mL)	_	_	_	< 2	_	_	< 2	_	_

Table 3. Summary of historical water data collected in the relief tunnel, forebay and well at Chief Joseph Dam (Continued).

	Historical Data Relief Tunnel (1/19/1977)[1]	**Historical Data** Relief Tunnel (4/14/1989)[2]	**Historical Data** Relief Tunnel (5/26/1989)[2]	**Historical Data** Relief Tunnel (1/29/2003)[2]	**Historical Data** Relief Tunnel (5/13/2003)[2]	**Historical Data** Forebay (1/19/1977)[1]	**Historical Data** Forebay (1/29/2003)[2]	**Historical Data** Forebay (5/13/2003)[2]	**Historical Data** Hatchery Well (9/19/1990)[2]
Dissolved Metals									
Arsenic (mg/L)	□	< 0.010	_	< 0.002	_	□	< 0.002	_	< 0.010
Barium (mg/L)	□	< 0.250	_	0.014	_	□	0.043	_	< 0.250
Cadmium (mg/L)	□	< 0.002	_	< 0.0003	_	□	< 0.0003	_	< 0.002
Chromium (mg/L)	□	< 0.010	_	< 0.0047	_	□	< 0.0047	_	< 0.010
Copper (mg/L)	□	< 0.250	_	< 0.002	_	□	< 0.002	_	< 0.250
Iron (mg/L)	□	< 0.100	_	0.0124	_	□	0.013	_	< 0.100
Lead (mg/L)	□	< 0.002	_	< 0.0005	_	□	< 0.0005	_	< 0.002
Manganese (mg/L)	□	<0.010	_	< 0.002	_	□	< 0.002	_	<0.010
Mercury (µg/L)	□	**0.6**	**0.6**	**< 0.3**	0.000171	□	**< 0.3**	0.000365	**0.5**
Nickel (mg/L)	□	_	_	< 0.010	_	□	< 0.010	_	_
Selenium (mg/L)	□	< 0.005	_	< 0.005	_	□	< 0.005	_	< 0.005
Silver (mg/L)	□	< 0.010	_	< 0.0047	_	□	< 0.0047	_	< 0.010
Zinc (mg/L)	□	< 0.250	_	< 0.020	_	□	< 0.020	_	< 0.250

1.	Source: Koch and Cochran (1977)
2.	Source: USCOE (2004)
mg/L	Milligrams per liter
µg/L	Micrograms per liter
□S/cm	Microsiemens per centimeter
NTU	Nephelometric turbidity unit
<	Analyte not detected at specified detection limit
□	Not analyzed/not available
0.001	Value Exceeds Washington State Department of Fish and Wildlife Recommended Criteria for Aquaculture (Piper et al. 1982; U.S. EPA 1973)

7.3.5.2. Little difference in water quality for the relief tunnel, forebay, and hatchery site well was observed between samples collected in 1977, 1989, 1990, and 2003 except for mercury. Mercury was detected in the relief tunnel and hatchery site well in 1989 and 1990 at concentrations exceeding both the WDFW recommended criteria and the WDOE chronic criteria. Sampling at both sites on January 29, 2003 had a mercury detection limit above the WDFW and WDOE criteria, so re-sampling occurred on May 13, 2003 using a lower detection limit. The May 13, 2003 samples detected mercury in the relief tunnel and forebay at concentrations well below the WDFW and WDOE criteria. The WDFW criteria for nitrite was exceeded in the relief tunnel and forebay samples on January 29, 2003, with forebay nitrite concentrations (0.19 mg/L) slightly greater that relief tunnel concentrations (0.16 mg/L). Nitrate concentrations were relatively low. No other exceedances of the WDFW or WDOE water quality criteria were observed from the historical data.

7.4. Results and Discussion

7.4.1. Water quality results are shown in Table 4. In general, water quality at the relief tunnel and forebay locations were good with no exceedances of either the WDFW recommended criteria for aquaculture or the WDOE chronic criteria. Field parameters monitored include temperature, conductivity, pH, dissolved oxygen, and turbidity. These parameters show little difference between the relief tunnel sample and the forebay sample except for conductivity and dissolved oxygen. Relief tunnel water had a higher conductivity and lower dissolved oxygen concentration than the forebay, likely reflecting the influence of chemical interactions between the surface water and the overlying soil and bedrock along the right bank. Temperature was not recorded in the relief tunnel.

7.4.2. Conventional parameters data indicate that the relief tunnel water quality is similar in quality to the forebay water, with only minor differences. Slightly greater alkalinity, hardness, calcium, potassium, sodium, and total dissolved solids concentrations in the relief tunnel suggest that chemical interactions between the forebay water seeping into the right bank and the overlying soil and bedrock may be occurring. The overall similarity in water quality between the relief tunnel and forebay suggest that the major source of water to the relief tunnel is the forebay. However, the slightly greater concentrations of several major ions together with the observed differences in conductivity and dissolved oxygen could also indicate that another source of water, possibly ground water derived from local precipitation, is influencing the relief tunnel water quality.

7.4.3. Four forms of nitrogen were sampled, total kjeldhal nitrogen (TKN), nitrate + nitrite-nitrogen ($NO_3 + NO_2$), nitrite (NO_2), and ammonia nitrogen ($NH_4^+ + NH_3$). The dissolved inorganic forms of nitrogen, ammonia and nitrate + nitrite are all readily available for plant growth. Total kjeldhal nitrogen includes ammonia plus organic nitrogen, while nitrate + nitrite-nitrogen represents total oxidized nitrogen, with nitrite being an intermediate state between ammonia and nitrate. Nitrate is an essential plant nutrient, while nitrite can be a plant nutrient but is toxic to animal life and is generally rapidly oxidized to nitrate in oxygenated waters.

Table 4. Summary of current water data collected in the relief tunnel, forebay and hatchery well at Chief Joseph Dam.

	CHJRT Relief Tunnel (2/3/2004)	**CHJFB** Forebay (2/3/2004)
Field Parameters		
Temperature (°C)	□	2.7
PH	7.7	7.8
Conductivity (µS/cm)	157	135
Turbidity (NTU)	0.3	1.0
Dissolved Oxygen (mg/L)	6.9	10.5
Conventionals		
Total Phosphorus (mg/L)	0.031	0.016
Total Kjeldahl N (mg/L)	< 0.2	< 0.2
Nitrate+Nitrite (mg/L)	0.14	0.15
Nitrate (mg/L)	0.14	0.15
Nitrite (mg/L)	< 0.01	< 0.01
Ammonia (mg/L)	0.017	< 0.01
Alkalinity (mg/L)	74	63
Hardness (mg/L)	66	67
Calcium (mg/L)	19.0	18.7
Magnesium (mg/L)	4.61	4.86
Potassium (mg/L)	1.4	0.7
Sodium (mg/L)	2.3	1.8
Sulfate (mg/L)	8.9	9.6
Chloride (mg/L)	0.9	1.0
Fluoride (mg/L)	< 0.1	< 0.1
Total Dissolved Solids (mg/L)	99	68
Dissolved Metals		
Aluminum (mg/L)	< 0.02	< 0.02
Arsenic (mg/L)	0.0011	0.0004
Barium (mg/L)	0.015	0.025
Cadmium (mg/L)	< 0.0002	< 0.0002
Chromium (mg/L)	< 0.0005	< 0.0005
Copper (mg/L)	< 0.0005	0.0006
Iron (mg/L)	< 0.02	< 0.02
Lead (mg/L)	< 0.001	< 0.001
Manganese (mg/L)	< 0.001	< 0.001
Mercury (µg/L)	0.000118 E	0.000256 E
Nickel (mg/L)	0.0005	0.0007
Selenium (mg/L)	< 0.005	< 0.005
Silver (mg/L)	< 0.0005	< 0.0005
Zinc (mg/L)	< 0.006	< 0.006

Table 4. Summary of current water data collected in the relief tunnel, forebay and hatchery well at Chief Joseph Dam (Continued).

	CHJRT Relief Tunnel (2/3/2004)	**CHJFB** Forebay (2/3/2004)
PCBs (µg/L)		
Aroclor 1016	< 0.1	< 0.1
Aroclor 1242	< 0.1	< 0.1
Aroclor 1248	< 0.1	< 0.1
Aroclor 1254	< 0.1	< 0.1
Aroclor 1260	< 0.1	< 0.1
Aroclor1221	< 0.1	< 0.1
Aroclor 1232	< 0.1	< 0.1
Pesticides (µg/L)		
alpha-BHC	< 0.0062 E	< 0.0052 E
beta-BHC	< 0.0062 E	< 0.0052 E
delta-BHC	< 0.0062 E	< 0.0052 E
gamma-BHC (Lindane)	< 0.0062 E	< 0.0052 E
Heptachlor	< 0.0062 E	< 0.0052 E
Aldrin	< 0.0062 E	< 0.0052 E
Heptachlor Epoxide	< 0.0062 E	< 0.0052 E
Endosulfan I	< 0.0062 E	< 0.0052 E
Dieldrin	< 0.012 E	< 0.010 E
4,4'-DDE	< 0.012 E	< 0.010 E
Endrin	< 0.012 E	< 0.010 E
Endosulfan II	< 0.012 E	< 0.010 E
4,4'-DDD	< 0.012 E	< 0.010 E
Endosulfan Sulfate	< 0.012 E	< 0.010 E
4,4'-DDT	< 0.012 E	< 0.010 E
Methoxychlor	< 0.062 E	< 0.052 E
Endrin Ketone	< 0.012 E	< 0.010 E
Endrin Aldehyde	< 0.012 E	< 0.010 E
gamma Chlordane	< 0.0062 E	< 0.0052 E
alpha Chlordane	< 0.0062 E	< 0.0052 E
Toxaphene	< 0.62 E	< 0.52 E

mg/L	Milligrams per liter
µg/L	Micrograms per liter
□S/cm	Microsiemens per centimeter
NTU	Nephelometric turbidity unit
E	Estimated value
<	Analyte not detected at specified detection limit
□	Not analyzed/not available
0.001	Value Exceeds Washington State Department of Fish and Wildlife Recommended Criteria for Aquaculture.

7.4.4. Ammonia nitrogen is largely produced by the deamination of organic nitrogen-containing compounds and is a plant nutrient that is often utilized before nitrate. Ammonia is generally reported as the combined ionized (NH_4^+ -ammonium) and unionized (NH_3-ammonia) forms of ammonia. However, only the unionized form of ammonia (NH_3) is toxic to freshwater life and this form of ammonia has water quality criteria established (See Table 2). Equations can be used to estimate the concentration of unionized ammonia fraction from measured values of the pH and temperature of the water.

7.4.5. Nitrate concentrations were similar between the relief tunnel and forebay, while ammonia was only detected in the relief tunnel at very low concentrations (0.017 mg/L). Using an average unionized ammonia percentage of 1.8 percent in pH 8.0 water at 10 °C (APHA 1992), the calculated unionized ammonia is 0.00003 mg/L, which is well below WDFW and WDOE criteria. In general, chronic ammonia toxicity is not a problem in pH 8.0 water at 10 °C when ammonia-nitrogen concentrations are less than about 2 mg/L (EPA 2002). The greater ammonia concentrations and the slightly lower nitrate concentrations in the relief tunnel versus the forebay may be due to oxidation-reduction conditions in the ground water favoring the presence of ammonia. Nitrite was not detected in the relief tunnel or forebay samples.

7.4.6. Dissolved metals did not exceed the WDFW recommended criteria for aquaculture or the WDOE chronic criteria during the sampling event. Concentrations were below the laboratory detection limits for all metals except barium and mercury, which were detected at very low concentrations in the relief tunnel and forebay. Mercury concentrations in the relief tunnel (0.000118 µg/L) were similar to concentrations detected on May 13, 2003 (0.000171 µg/L) and well below concentrations detected in 1989 (0.6 µg/L). Similarly, concentrations in the forebay (0.000256 µg/L) were similar to concentrations detected on May 13, 2003 (0.000365 µg/L). These data suggest that mercury concentrations in the relief tunnel water may not be a water quality concern for the fish hatchery. However, it is recommended that additional samples be collected during the spring and summer to determine if any seasonal variations in mercury concentrations occur in the relief tunnel and forebay.

7.4.7. Polychlorinated biphenyls (PCBs) were not detected at the relief tunnel and forebay on the sampling date at the laboratory detection limits shown in Table 4. These detection limits are below the WDFW recommended criteria for aquaculture but are greater the WDOE chronic criteria. Therefore, exceedances of the WDOE chronic criteria may have occurred in non-detected samples.

7.4.8. Chlorinated pesticides were not detected at the relief tunnel and forebay on the sampling date at the laboratory detection limits shown in Table 4. There are no WDFW recommended criteria for pesticides. However, these detection limits are below the WDOE chronic criteria, resulting in no exceedances of the WDOE chronic criteria.

7.5. Conclusions

7.5.1. Water quality samples collected from the relief tunnel and forebay during the February 3, 2004 sampling event were characterized by good water quality with no exceedances of the

WDFW recommended criteria for aquaculture or the WDOE chronic criteria for surface waters. It should be noted that the detection limits for PCBs and some pesticides exceeded the WDOE criteria suggesting that exceedances may have occurred in non-detected samples. Historical exceedances of mercury and nitrate measured in the relief tunnel were not seen for the current sampling event. Water quality samples were not collected from the hatchery site well during the February sampling event due to the well being non-operational during the winter months.

7.5.2. It is recommended that water quality samples be collected at the relief tunnel, forebay, and hatchery well site in the spring and summer to determine if any seasonal variations in water quality exist for these source waters. Because mercury and nitrate were historically detected in these source waters at concentrations exceeding the WDFW recommended criteria for aquaculture, it is advised to sample water quality more than one time before concluding that these source waters are acceptable for the fish hatchery. In addition, the hatchery well site should be sampled in the spring and summer to determine the existing water quality conditions of this potential hatchery source water.

7.6. References

APHA, AWWA, WEF. 1992. Standard methods for the examination of water and wastewater. 18th edition. Edited by A.E. Greenberg, American Public Health Association; A.D. Eaton, American Water Works Association; and L.S. Clesceri, Water Environment Federation.

U.S. EPA. 2002. National recommended water quality criteria: 2002. EPA-822-R-02-047. U.S. Environmental Protection Agency, Office of Water, Science, and Technology, Washington D.C.

Piper, R.G., McElwain, I.B., Orme, L.E., McCraren, J.P., Fowler, L.G., and J.R. Leonard. 1982. Fish hatchery management. U.S. Fish and Wildlife Service.

U.S. EPA. 1973. Suggested water chemistry limits conducive to optimum health of warm and cold water fishes.

Koch, D.L. and G. F. Cochran. 1977. Feasibility report of a fish hatchery on the Colville Indian Reservation at Chief Joseph Dam Bridgeport, Washington. March 1, 1977, Reno, Nevada.

U.S. EPA. 1983. Methods for chemical analysis of water and wastes. EPA-600/4-79-020. U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, Ohio.

U.S. EPA. 1984. Guidelines Establishing Test Procedures for the Analysis of Pollutants under the Clean Water Act; Final Rule and Interim Final Rule. U.S. Environmental Protection Agency. CFR Part 136. Friday, October 26, 1984.

U.S. EPA. 1990. Recommended protocols for measuring conventional water quality variables and metals in fresh water of the Puget Sound region. Puget Sound Estuary Program U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, Washington.

U.S. EPA. 1996. Recommended protocols for measuring selected environmental variables in Puget Sound. U.S. Environmental Protection Agency, Region 10, Office of Puget Sound, Seattle, Washington.

U.S. COE. 2003. Preliminary scope of work: Water quality sampling at Chief Joseph Dam for the Colville Tribe fish hatchery. United States Army Corps of Engineers, Seattle District, Seattle, Washington.

Attachment A

7.7. Quality Assurance Report

7.7.1. This report presents results from the quality assurance review of data collected for the Libby Dam Ground Water Quality Monitoring Project. Data assessment procedures used in this quality assurance review are based on the following eight control elements:

Completeness
Methodology
Holding times
Detection limit
Blanks
Duplicates
Matrix spikes
Control samples.

7.7.2. No major problems were associated with the data collected in connection with this project. The following sections provide specific details for each of the quality control elements reviewed and any resultant corrective action required.

7.7.3. Completeness

7.7.3.1. Completeness was assessed by comparing valid sample data values with total number of sample values. Because the number of valid sample data divided by the total number of samples was greater than the quality assurance objective of 95 percent, no corrective actions were required to address problems related to completeness.

7.7.4. Methodology

7.7.4.1. Methodology was assessed by examining field notebooks, sampling data sheets, and laboratory reports for deviations from the monitoring plan and quality assurance plan. Subsequent to this review, it was concluded that there were no significant deviations in methodology that required corrective action.

7.7.5. Holding Times

7.7.5.1. Holding times were assessed by comparing analytical dates to sample collection dates. Corrective action was implemented for all values that exceeded the maximum holding times required by U.S. EPA. Holding time problems were encountered for pesticide samples collected on 2/3/04 from all sites because the samples were extracted beyond the required 7-day holding time. Data qualified as an estimate (E).

7.7.6. Blanks

7.7.6.1. Preparation blanks, which are composed of reagent water that is prepared as a sample, were analyzed with collected samples, and the results were reported in each laboratory report. If a blank value exceeded the detection limit, corrective actions were to be implemented for the associated samples. Mercury was detected in the method blank, resulting in sample values that were less than 5 times the detected blank being considered estimates (E).

7.7.7. Detection Limits

7.7.7.1. Laboratory data were reported with a method detection limit (MDL) and a reporting detection limit (RDL). The laboratory MDL represents the minimum concentration of a constituent that can be detected. All data values that were below the MDL were qualified as below detection with a < symbol next to the reported detection limit.

7.7.8. Duplicates

7.7.8.1. Laboratory duplicates are two aliquots of a sample processed concurrently and identically. Corrective action was implemented for all laboratory duplicates with a relative percent difference (RPD) greater than 20 percent. No duplicate problems were encountered.

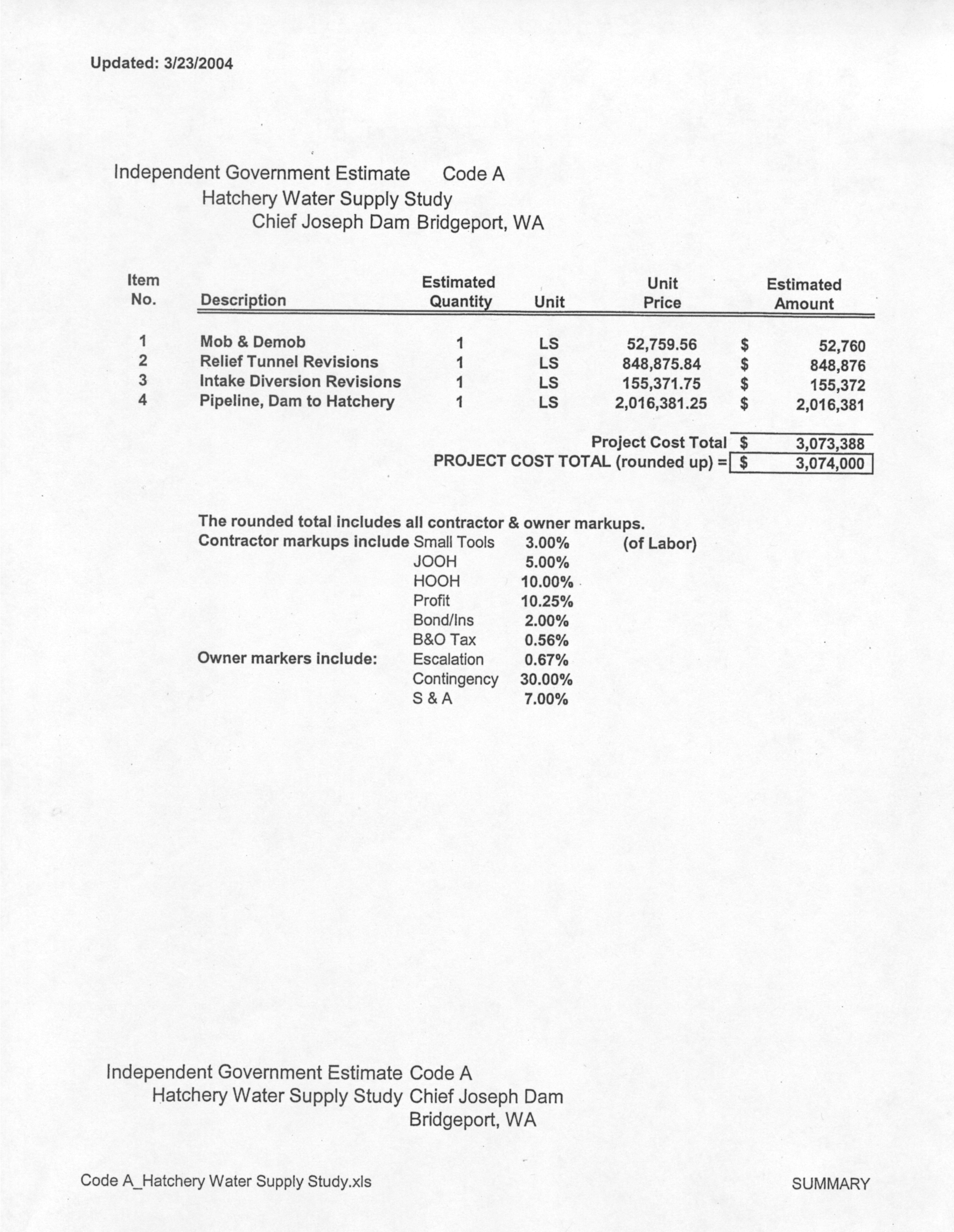
7.7.9. Matrix Spikes

7.7.9.1. Matrix spikes are used as an indicator of matrix effects on sample recovery and precision. If a percent recovery from a matrix spike was not within 80 to 120 percent for conventionals and metals or a pre-determined laboratory range for organics, corrective actions were implemented where necessary. No matrix spike problems were encountered.

7.7.10. Control Samples

7.7.10.1. Control samples refer to check standards, blank spikes, or standard reference materials. If the percent recovery for a control standard was not within 80 to 120 percent for conventionals and metals, and a pre-determined laboratory range for organics, corrective actions were implemented, where necessary. All control sample recoveries were within acceptable limits.

8. Cost Estimate



Updated: 3/23/2004

Independent Government Estimate Code A
Hatchery Water Supply Study
Chief Joseph Dam Bridgeport, WA

Item No.	Description	Estimated Quantity	Unit	Unit Price		Estimated Amount
1	**Mob & Demob**	1	LS	52,759.56	$	52,760
2	**Relief Tunnel Revisions**	1	LS	848,875.84	$	848,876
3	**Intake Diversion Revisions**	1	LS	155,371.75	$	155,372
4	**Pipeline, Dam to Hatchery**	1	LS	2,016,381.25	$	2,016,381
				Project Cost Total	$	3,073,388
				PROJECT COST TOTAL (rounded up) =	$	3,074,000

The rounded total includes all contractor & owner markups.

Contractor markups include	Small Tools	3.00%	(of Labor)
	JOOH	5.00%	
	HOOH	10.00%	
	Profit	10.25%	
	Bond/Ins	2.00%	
	B&O Tax	0.56%	
Owner markers include:	Escalation	0.67%	
	Contingency	30.00%	
	S & A	7.00%	

Independent Government Estimate Code A
Hatchery Water Supply Study Chief Joseph Dam
Bridgeport, WA

Code A_Hatchery Water Supply Study.xls SUMMARY

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Title Page

Hatchery Water Supply Project
A 25% contingency is used for this initial budgetary estimate.

Estimated by	Cost Engineering Unit, CENWS-EC-CO-CA
Designed by	U.S. Army Corps of Engineers, Seattle District
Prepared by	Timothy F. Sullivan, P.E.
Preparation Date	3/23/2004
Effective Date of Pricing	9/30/2005
Estimated Construction Time	120 Days

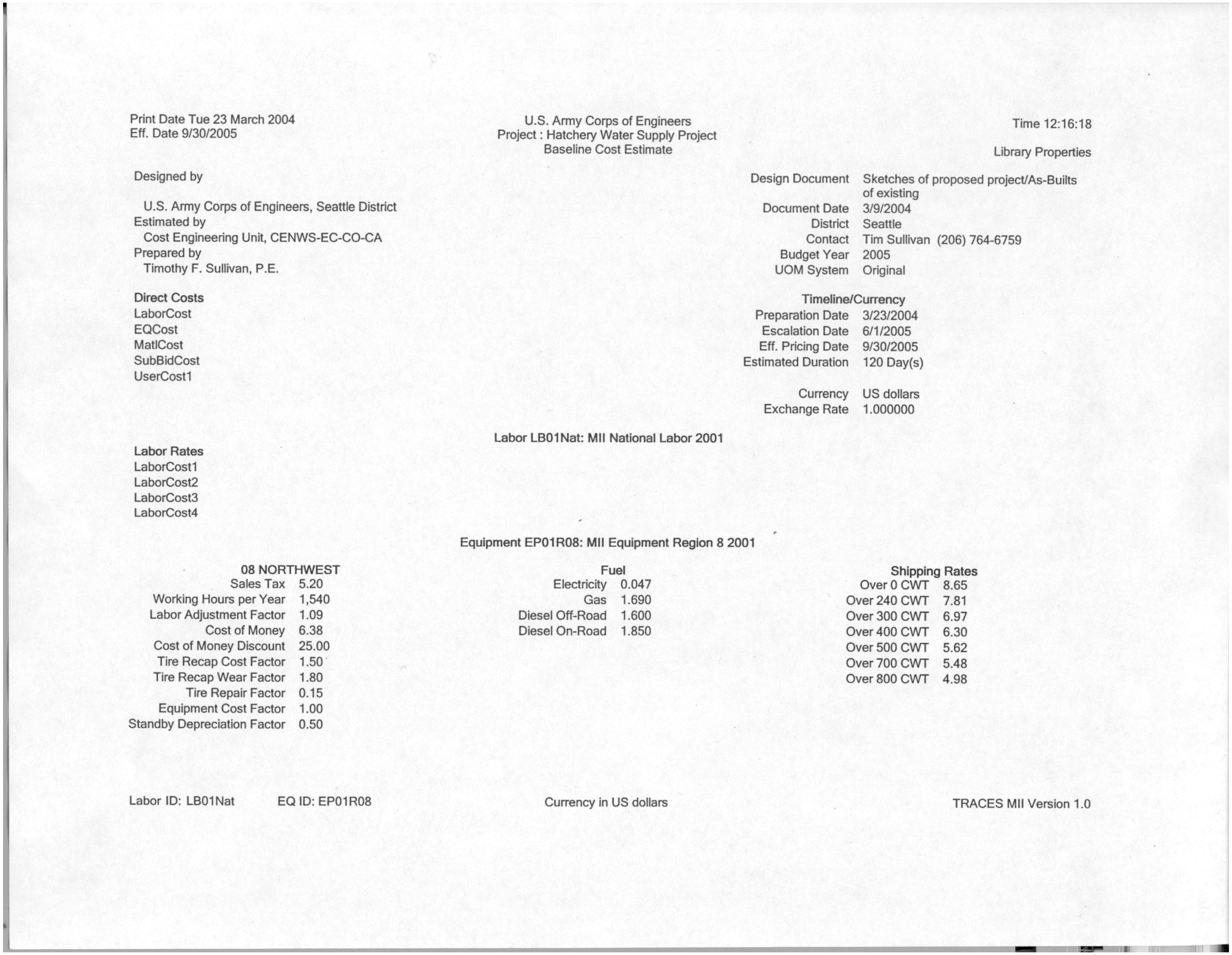
This report is not copyrighted, but the information contained herein is For Official Use Only.

Labor ID: LB01Nat

EQ ID: EP01R08

Currency in US dollars

TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Library Properties

Designed by
U.S. Army Corps of Engineers, Seattle District
Estimated by
Cost Engineering Unit, CENWS-EC-CO-CA
Prepared by
Timothy F. Sullivan, P.E.

Design Document	Sketches of proposed project/As-Builts of existing
Document Date	3/9/2004
District	Seattle
Contact	Tim Sullivan (206) 764-6759
Budget Year	2005
UOM System	Original

Direct Costs
LaborCost
EQCost
MatlCost
SubBidCost
UserCost1

Timeline/Currency

Preparation Date	3/23/2004
Escalation Date	6/1/2005
Eff. Pricing Date	9/30/2005
Estimated Duration	120 Day(s)
Currency	US dollars
Exchange Rate	1.000000

Labor LB01Nat: MII National Labor 2001

Labor Rates
LaborCost1
LaborCost2
LaborCost3
LaborCost4

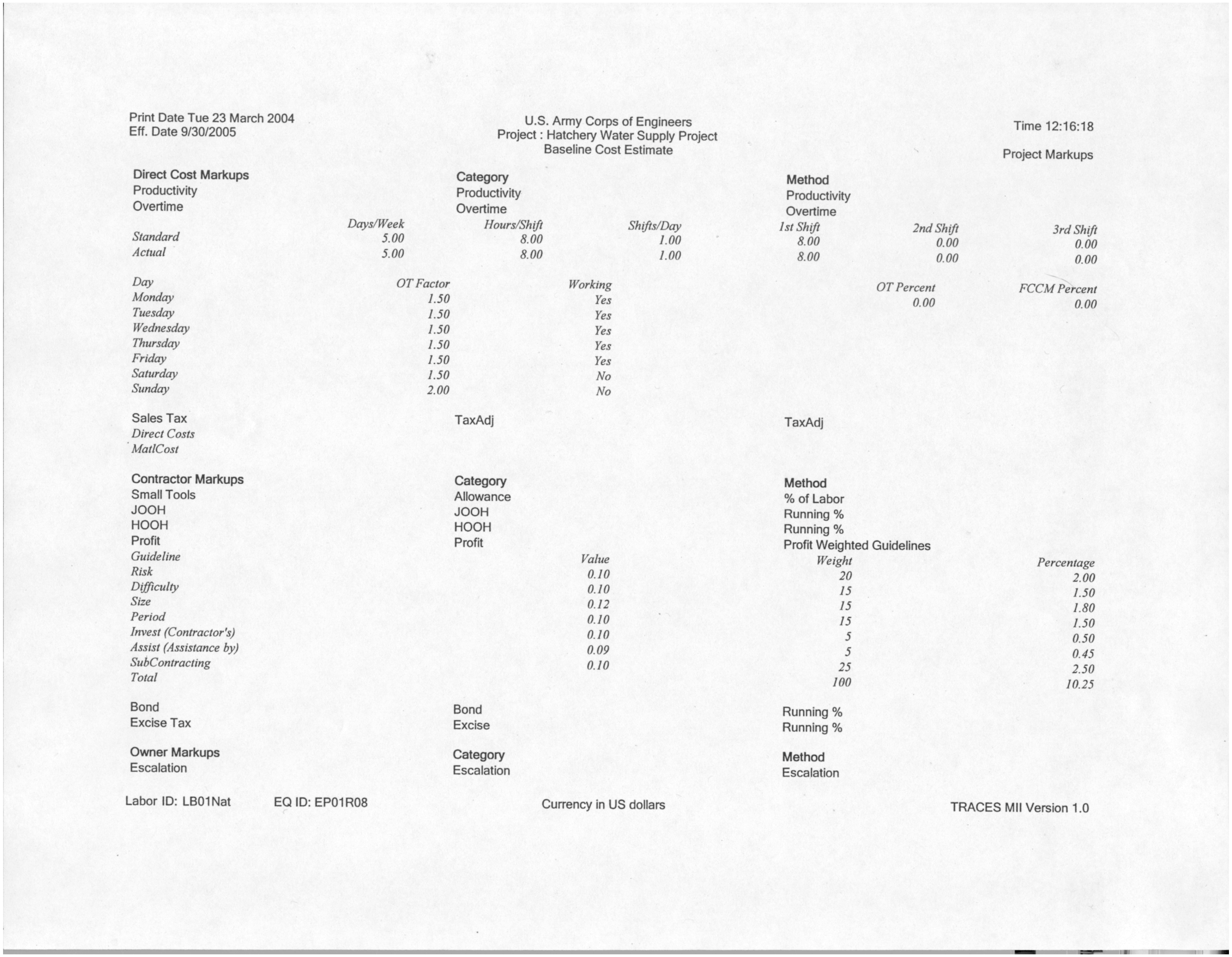
Equipment EP01R08: MII Equipment Region 8 2001

08 NORTHWEST	
Sales Tax	5.20
Working Hours per Year	1,540
Labor Adjustment Factor	1.09
Cost of Money	6.38
Cost of Money Discount	25.00
Tire Recap Cost Factor	1.50
Tire Recap Wear Factor	1.80
Tire Repair Factor	0.15
Equipment Cost Factor	1.00
Standby Depreciation Factor	0.50

Fuel	
Electricity	0.047
Gas	1.690
Diesel Off-Road	1.600
Diesel On-Road	1.850

Shipping Rates	
Over 0 CWT	8.65
Over 240 CWT	7.81
Over 300 CWT	6.97
Over 400 CWT	6.30
Over 500 CWT	5.62
Over 700 CWT	5.48
Over 800 CWT	4.98

Labor ID: LB01Nat   EQ ID: EP01R08   Currency in US dollars   TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Project Markups

Direct Cost Markups	**Category**	**Method**
Productivity	Productivity	Productivity
Overtime	Overtime	Overtime

	Days/Week	*Hours/Shift*	*Shifts/Day*	*1st Shift*	*2nd Shift*	*3rd Shift*
Standard	*5.00*	*8.00*	*1.00*	*8.00*	*0.00*	*0.00*
Actual	*5.00*	*8.00*	*1.00*	*8.00*	*0.00*	*0.00*

Day	*OT Factor*	*Working*
Monday	*1.50*	*Yes*
Tuesday	*1.50*	*Yes*
Wednesday	*1.50*	*Yes*
Thursday	*1.50*	*Yes*
Friday	*1.50*	*Yes*
Saturday	*1.50*	*No*
Sunday	*2.00*	*No*

OT Percent	*FCCM Percent*
0.00	*0.00*

Sales Tax	TaxAdj	TaxAdj
Direct Costs		
MatlCost		

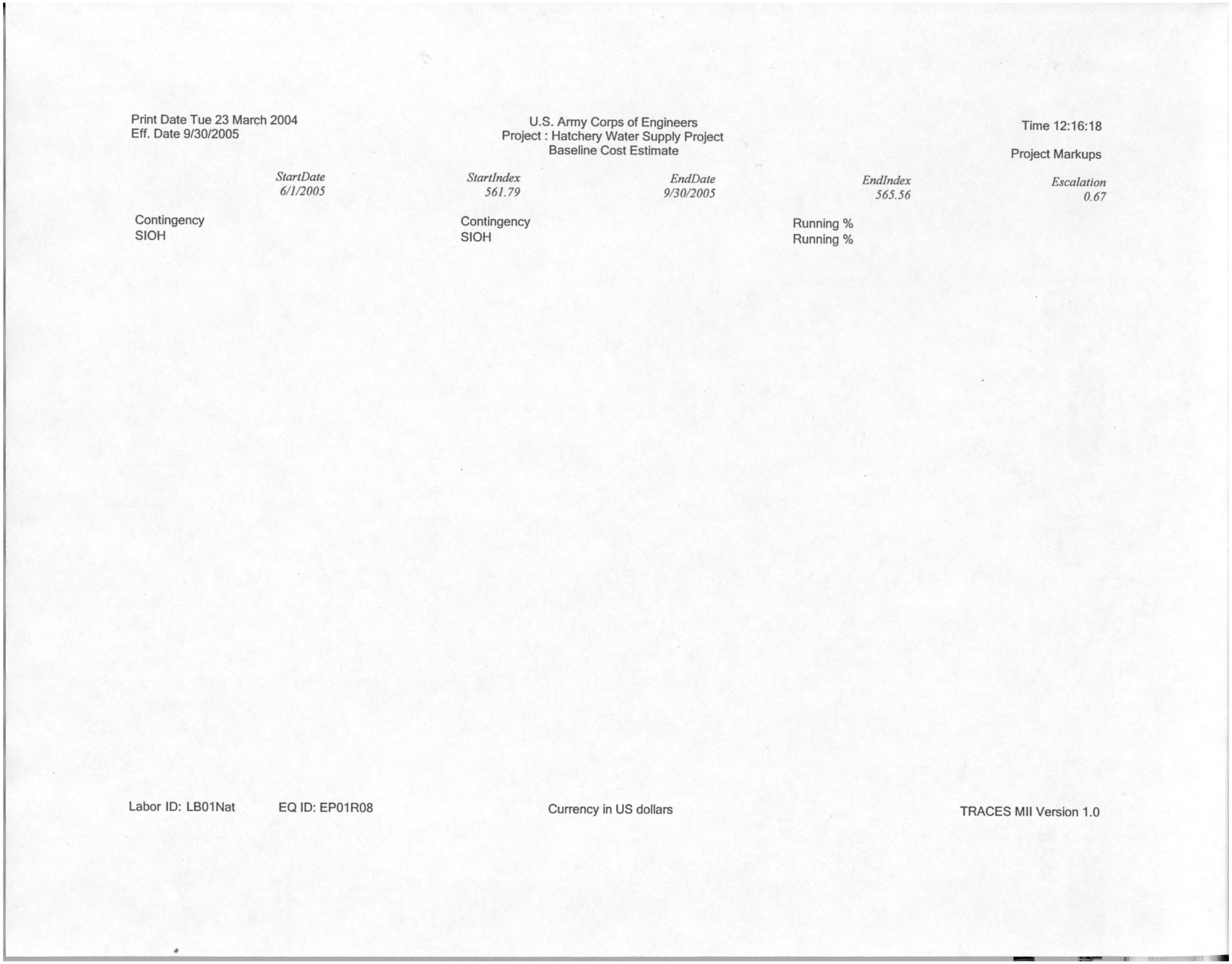
Contractor Markups	**Category**	**Method**
Small Tools	Allowance	% of Labor
JOOH	JOOH	Running %
HOOH	HOOH	Running %
Profit	Profit	Profit Weighted Guidelines

Guideline	*Value*	*Weight*	*Percentage*
Risk	*0.10*	*20*	*2.00*
Difficulty	*0.10*	*15*	*1.50*
Size	*0.12*	*15*	*1.80*
Period	*0.10*	*15*	*1.50*
Invest (Contractor's)	*0.10*	*5*	*0.50*
Assist (Assistance by)	*0.09*	*5*	*0.45*
SubContracting	*0.10*	*25*	*2.50*
Total		*100*	*10.25*

Bond	Bond	Running %
Excise Tax	Excise	Running %

Owner Markups	**Category**	**Method**
Escalation	Escalation	Escalation

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

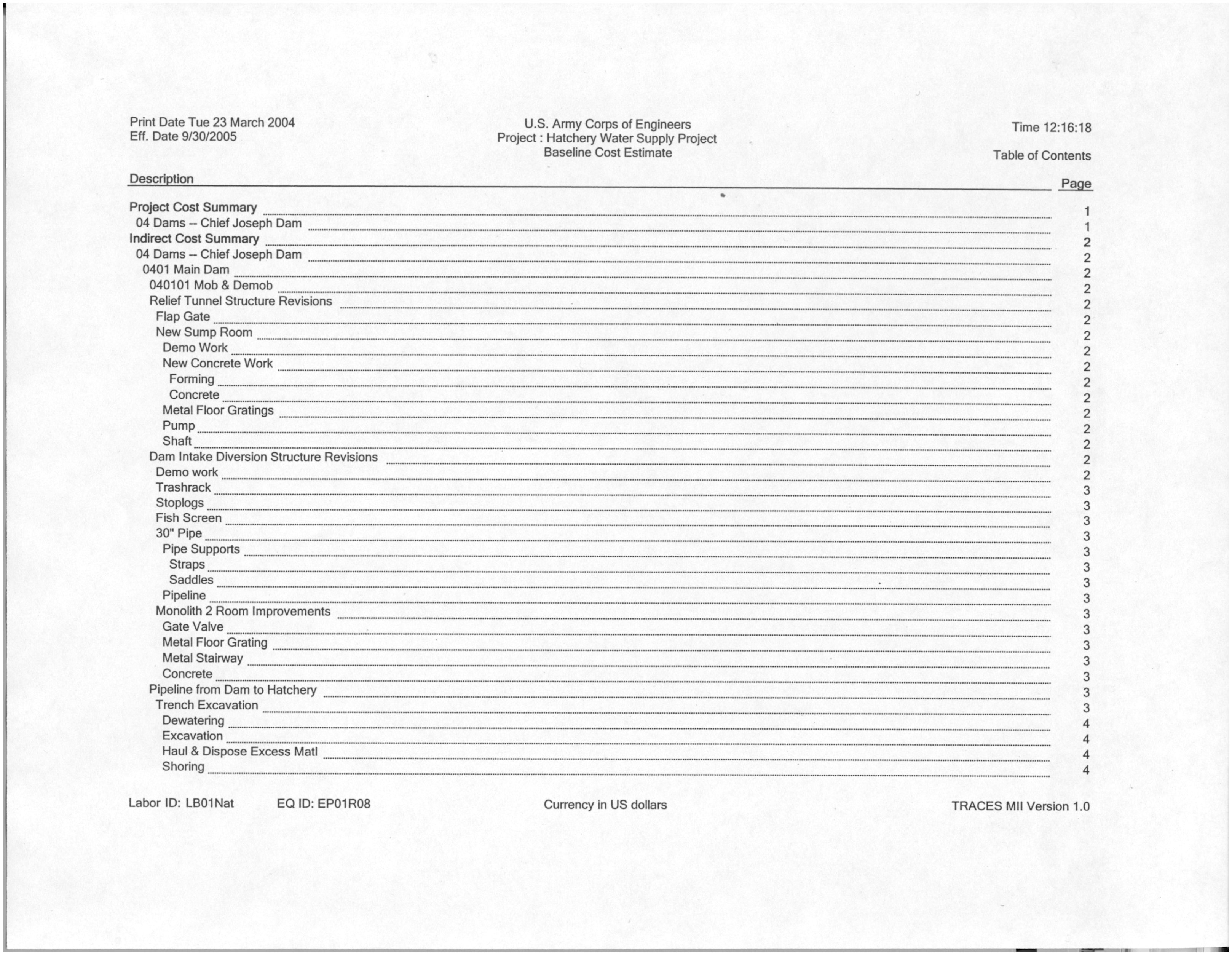
Time 12:16:18

Project Markups

StartDate	*StartIndex*	*EndDate*	*EndIndex*	*Escalation*
6/1/2005	*561.79*	*9/30/2005*	*565.56*	*0.67*

Contingency	Contingency	Running %
SIOH	SIOH	Running %

Labor ID: LB01Nat   EQ ID: EP01R08   Currency in US dollars   TRACES MII Version 1.0



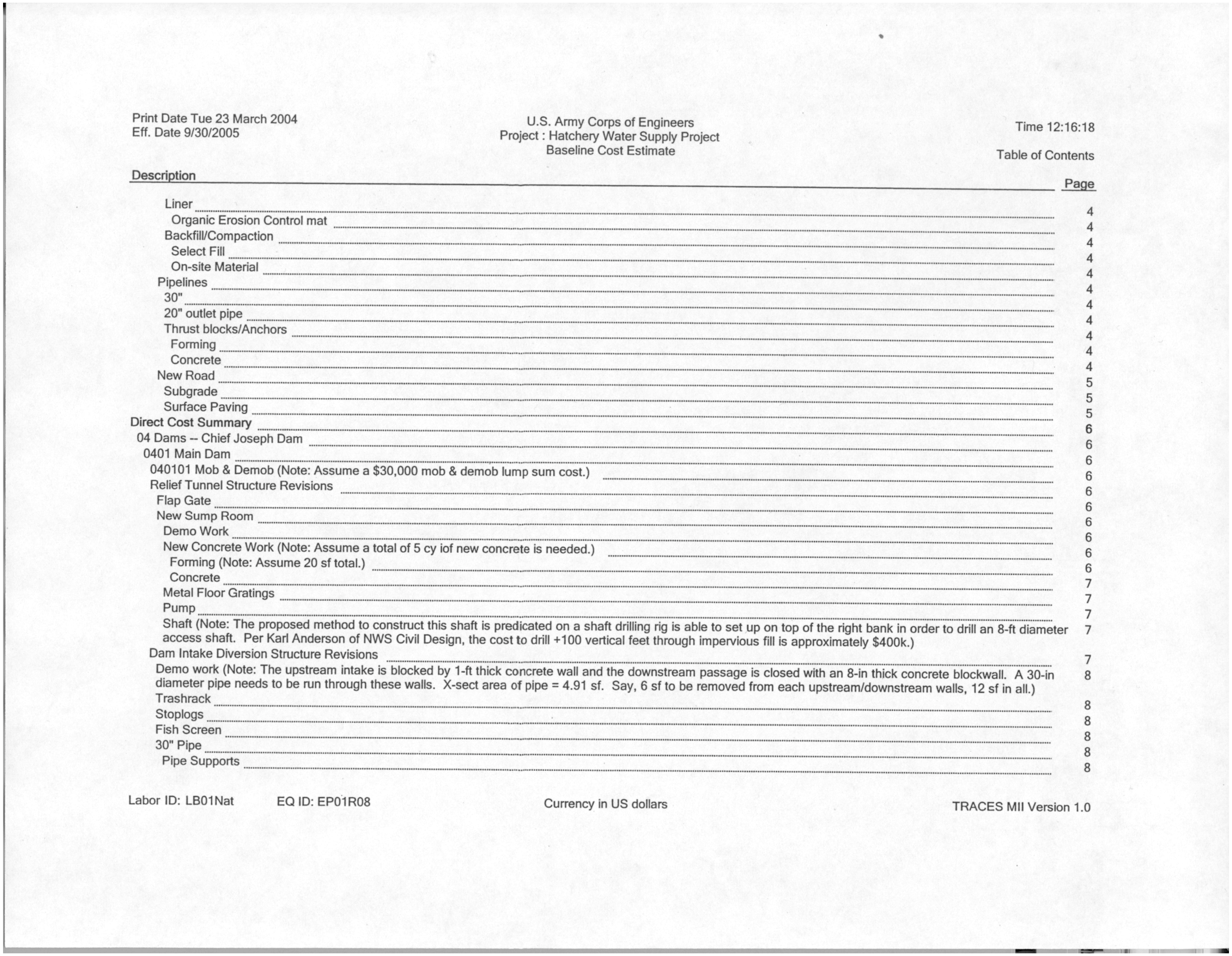
Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18
Table of Contents

Description — Page

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Table of Contents

Labor ID: LB01Nat   EQ ID: EP01R08   Currency in US dollars   TRACES MII Version 1.0

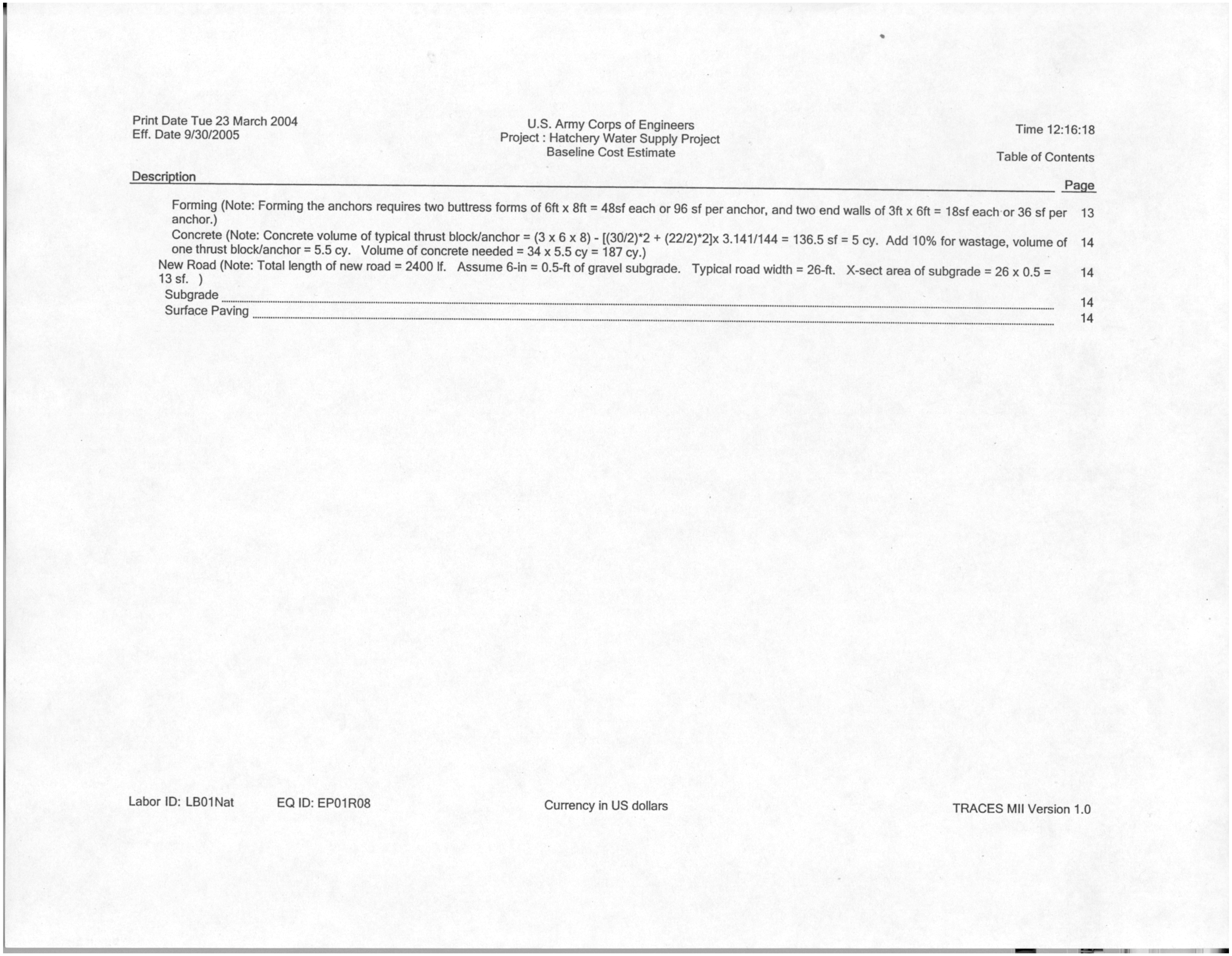
Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Table of Contents

Labor ID: LB01Nat   EQ ID: EP01R08   Currency in US dollars   TRACES MII Version 1.0



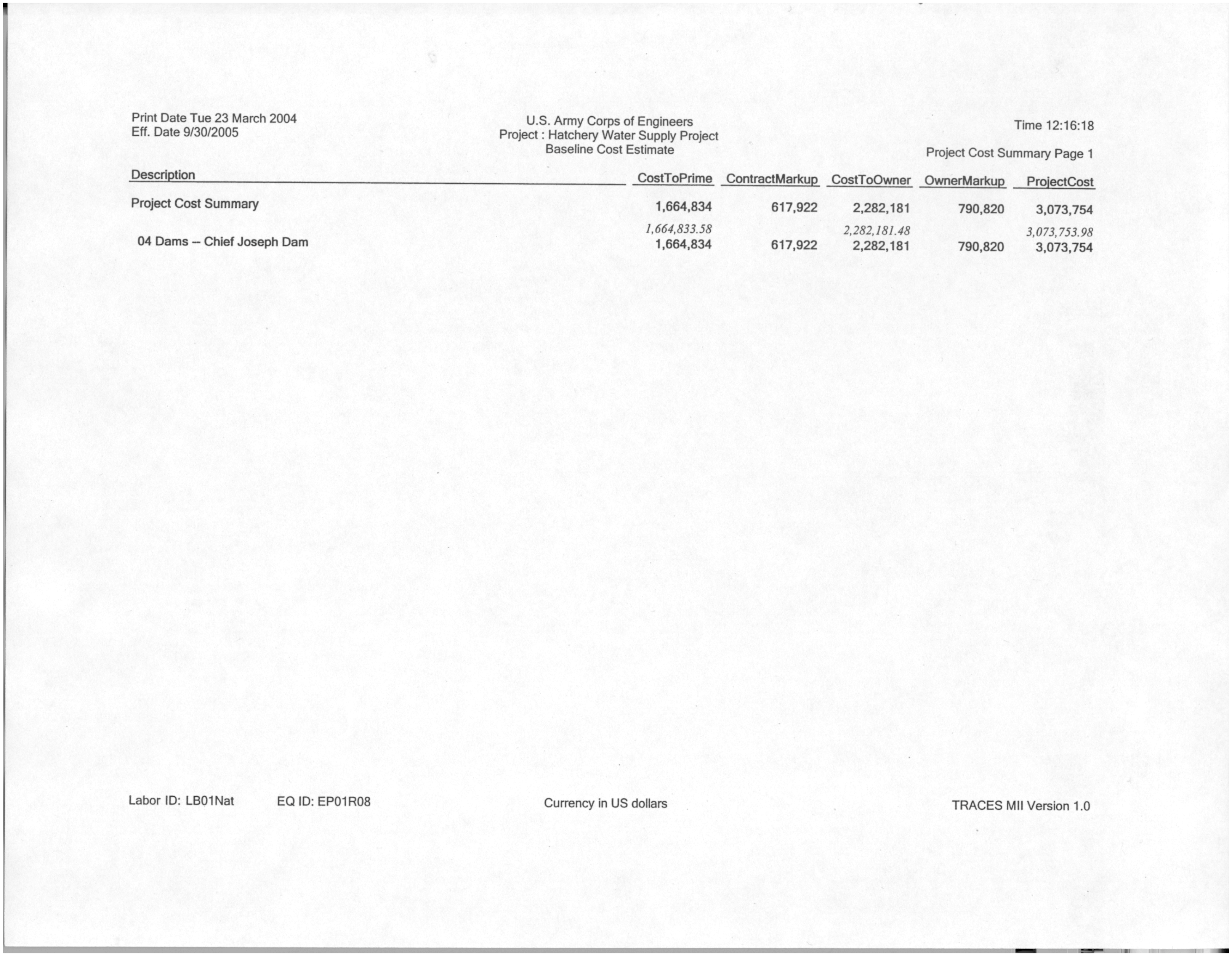
Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Table of Contents

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Project Cost Summary Page 1

Description	CostToPrime	ContractMarkup	CostToOwner	OwnerMarkup	ProjectCost
Project Cost Summary	1,664,834	617,922	2,282,181	790,820	3,073,754
	1,664,833.58		*2,282,181.48*		*3,073,753.98*
04 Dams -- Chief Joseph Dam	1,664,834	617,922	2,282,181	790,820	3,073,754

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Indirect Cost Summary Page 2

Description	CostToPrime	JOOH	HOOH	Profit	Bond	CostToOwner
Indirect Cost Summary	1,664,834	87,379	183,501	206,894	44,507	2,282,181
04 Dams -- Chief Joseph Dam	*1,664,833.58* 1,664,834	87,379	183,501	206,894	44,507	*2,282,181.48* 2,282,181
0401 Main Dam	*1,664,833.58* 1,664,834	87,379	183,501	206,894	44,507	*2,282,181.48* 2,282,181
040101 Mob & Demob	*30,000.00* 30,000	1,500	3,150	3,552	764	*39,183.87* 39,184
Relief Tunnel Structure Revisions	*482,289.41* 482,289	24,135	50,682	57,144	12,292	*630,447.71* 630,448
Flap Gate	*4,079.76* 4,080	209	439	494	106	*5,455.16* 5,455
New Sump Room	*478,209.65* 478,210	23,926	50,243	56,650	12,186	*624,992.55* 624,993
Demo Work	*939.40* 939	57	119	134	29	*1,476.20* 1,476
New Concrete Work	*608.25* 608	32	67	76	16	*837.15* 837
Forming	*139.40* 139	8	16	18	4	*203.60* 204
Concrete	*468.85* 469	24	51	58	12	*633.55* 634
Metal Floor Gratings	*1,662.00* 1,662	87	182	206	44	*2,268.00* 2,268
Pump	*75,000.00* 75,000	3,750	7,875	8,879	1,910	*97,959.66* 97,960
Shaft	*400,000.00* 400,000	20,000	42,000	47,355	10,187	*522,451.54* 522,452
Dam Intake Diversion Structure Revisions	*84,462.57* 84,463	4,417	9,277	10,462	2,251	*115,392.18* 115,392
Demo work	*18.48* 18	1	2	3	1	*29.04* 29

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

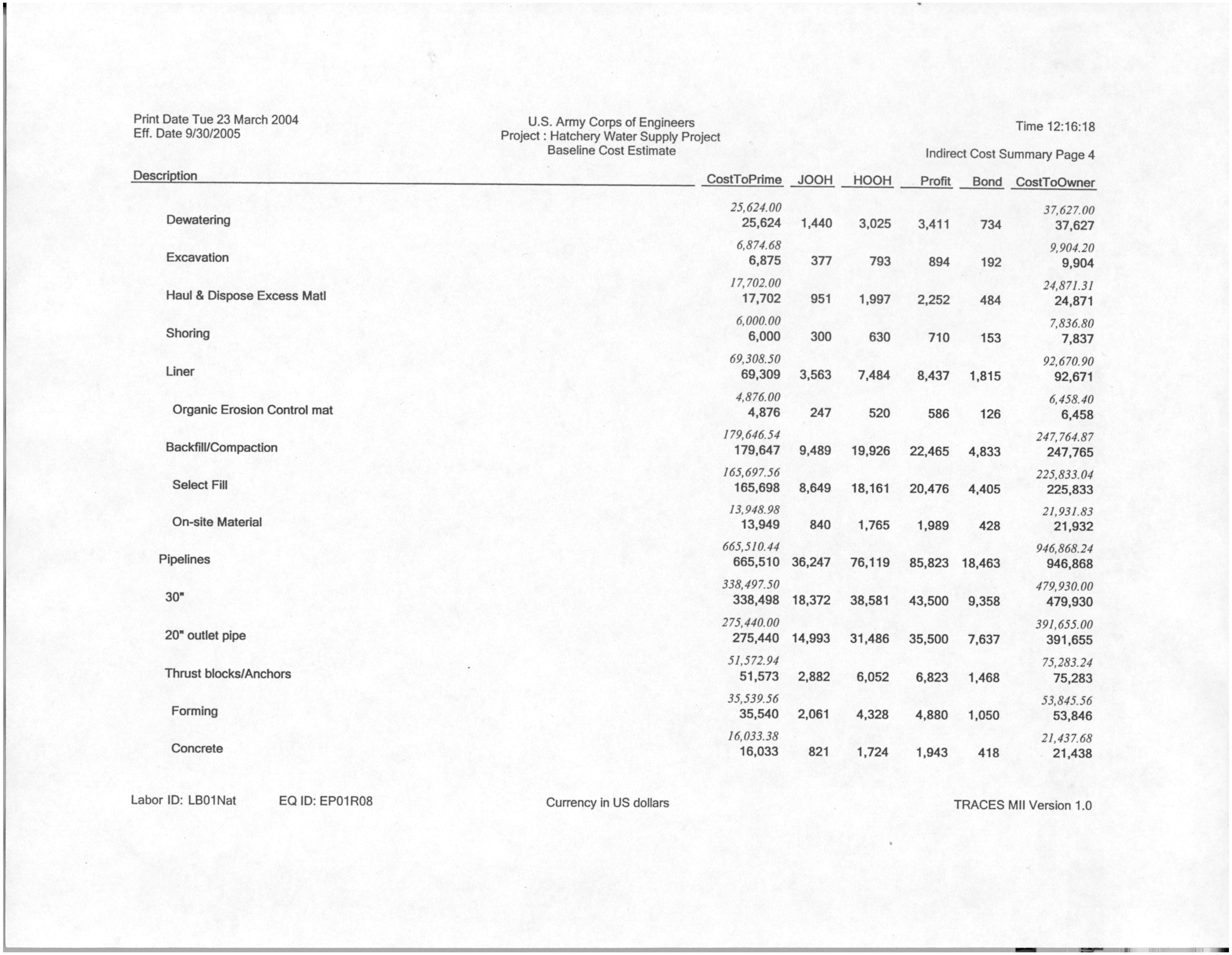
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Indirect Cost Summary Page 3

Description	CostToPrime	JOOH	HOOH	Profit	Bond	CostToOwner
Trashrack	*10,000.00* 10,000	500	1,050	1,184	255	*13,061.29* 13,061
Stoplogs	*10,000.00* 10,000	500	1,050	1,184	255	*13,061.29* 13,061
Fish Screen	*4,437.90* 4,438	225	472	533	115	*5,875.80* 5,876
30" Pipe	*33,939.68* 33,940	1,864	3,914	4,414	950	*48,685.96* 48,686
Pipe Supports	*9,321.68* 9,322	528	1,108	1,250	269	*13,781.96* 13,782
Straps	*2,138.00* 2,138	121	254	287	62	*3,161.00* 3,161
Saddles	*7,183.68* 7,184	407	854	963	207	*10,620.96* 10,621
Pipeline	*24,618.00* 24,618	1,336	2,806	3,164	681	*34,904.00* 34,904
Monolith 2 Room Improvements	*26,066.51* 26,067	1,327	2,789	3,144	675	*34,678.80* 34,679
Gate Valve	*22,950.19* 22,950	1,164	2,445	2,757	593	*30,411.87* 30,412
Metal Floor Grating	*1,108.00* 1,108	58	122	137	29	*1,512.00* 1,512
Metal Stairway	*1,859.78* 1,860	97	204	230	49	*2,532.79* 2,533
Concrete	*148.54* 149	8	18	20	4	*222.14* 222
Pipeline from Dam to Hatchery	*1,068,081.60* 1,068,082	57,327	120,392	135,736	29,200	*1,497,157.72* 1,497,158
Trench Excavation	*305,155.72* 305,156	16,120	33,855	38,169	8,211	*420,675.08* 420,675

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

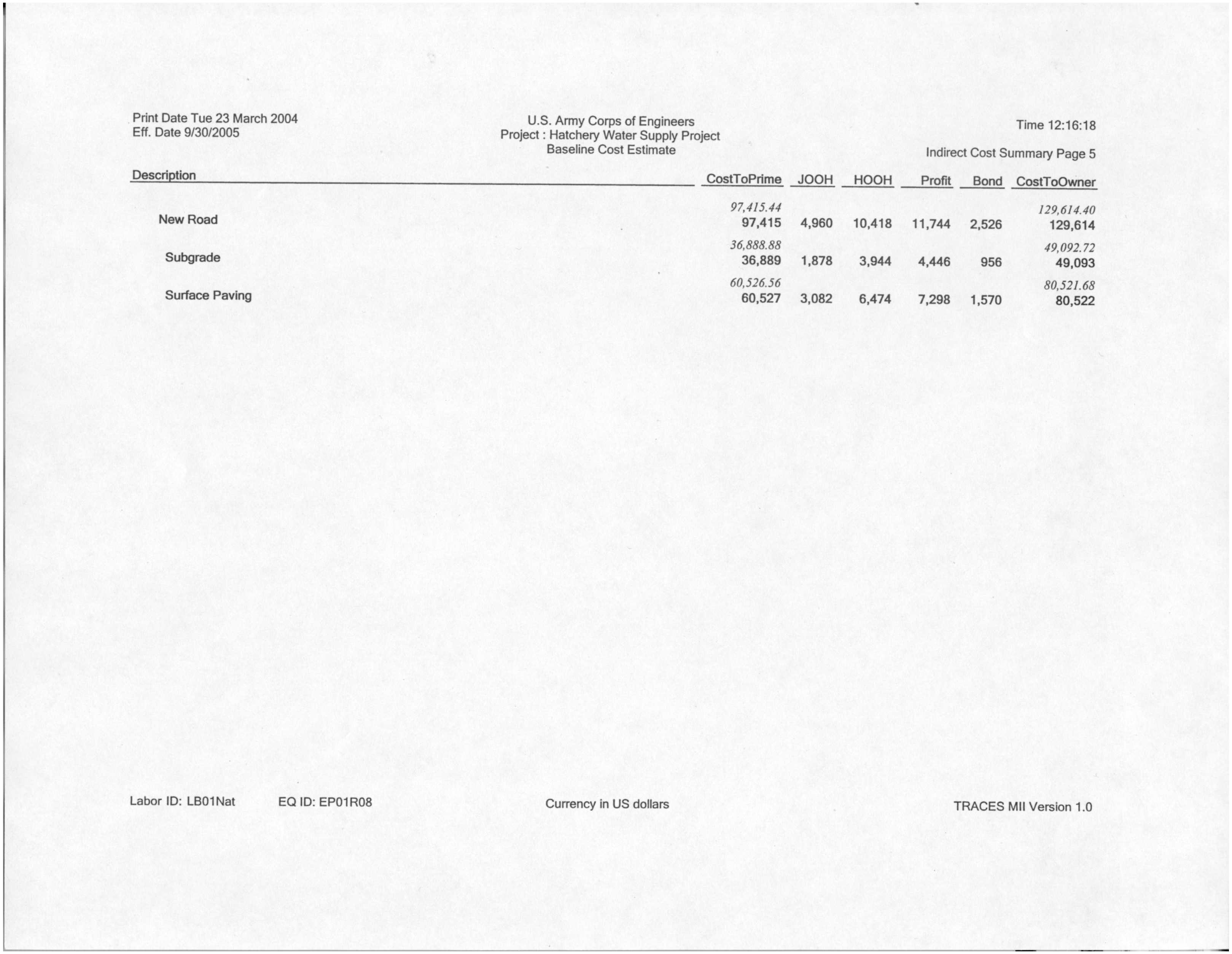
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Indirect Cost Summary Page 4

Description	CostToPrime	JOOH	HOOH	Profit	Bond	CostToOwner
Dewatering	25,624.00 25,624	1,440	3,025	3,411	734	37,627.00 37,627
Excavation	6,874.68 6,875	377	793	894	192	9,904.20 9,904
Haul & Dispose Excess Matl	17,702.00 17,702	951	1,997	2,252	484	24,871.31 24,871
Shoring	6,000.00 6,000	300	630	710	153	7,836.80 7,837
Liner	69,308.50 69,309	3,563	7,484	8,437	1,815	92,670.90 92,671
Organic Erosion Control mat	4,876.00 4,876	247	520	586	126	6,458.40 6,458
Backfill/Compaction	179,646.54 179,647	9,489	19,926	22,465	4,833	247,764.87 247,765
Select Fill	165,697.56 165,698	8,649	18,161	20,476	4,405	225,833.04 225,833
On-site Material	13,948.98 13,949	840	1,765	1,989	428	21,931.83 21,932
Pipelines	665,510.44 665,510	36,247	76,119	85,823	18,463	946,868.24 946,868
30"	338,497.50 338,498	18,372	38,581	43,500	9,358	479,930.00 479,930
20" outlet pipe	275,440.00 275,440	14,993	31,486	35,500	7,637	391,655.00 391,655
Thrust blocks/Anchors	51,572.94 51,573	2,882	6,052	6,823	1,468	75,283.24 75,283
Forming	35,539.56 35,540	2,061	4,328	4,880	1,050	53,845.56 53,846
Concrete	16,033.38 16,033	821	1,724	1,943	418	21,437.68 21,438

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Indirect Cost Summary Page 5

Description	CostToPrime	JOOH	HOOH	Profit	Bond	CostToOwner
New Road	*97,415.44* 97,415	4,960	10,418	11,744	2,526	*129,614.40* 129,614
Subgrade	*36,888.88* 36,889	1,878	3,944	4,446	956	*49,092.72* 49,093
Surface Paving	*60,526.56* 60,527	3,082	6,474	7,298	1,570	*80,521.68* 80,522

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

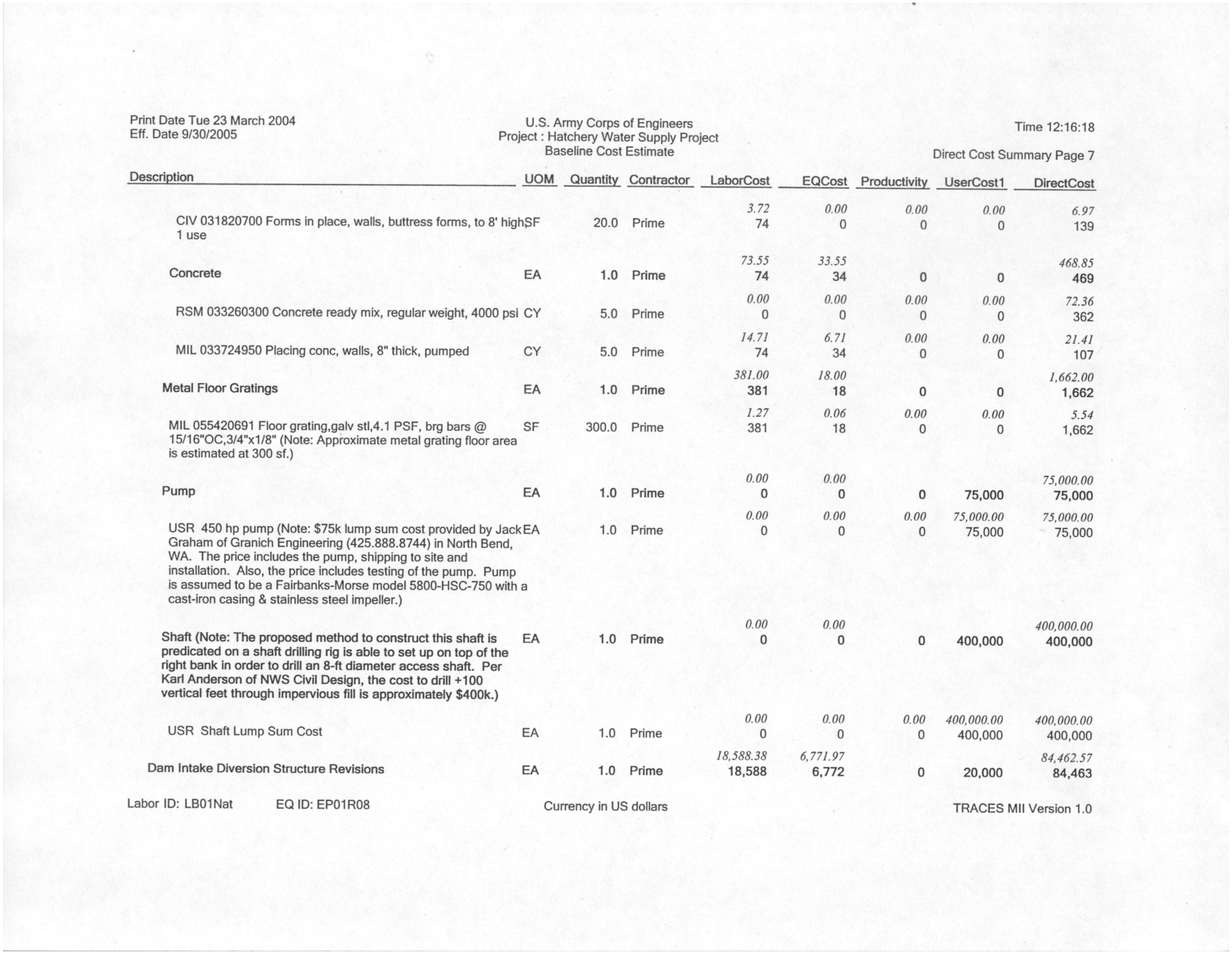
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 6

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
Direct Cost Summary				381,810	195,021	0	525,000	1,664,834
04 Dams -- Chief Joseph Dam	EA	1.0	Prime	*381,809.80* 381,810	*195,020.51* 195,021	0	525,000	*1,664,833.58* 1,664,834
0401 Main Dam	EA	1.0	Prime	*381,809.80* 381,810	*195,020.51* 195,021	0	525,000	*1,664,833.58* 1,664,834
040101 Mob & Demob (Note: Assume a $30,000 mob & demob lump sum cost.)	EA	1.0	Prime	*0.00* 0	*0.00* 0	0	30,000	*30,000.00* 30,000
USR Mob & Demob lump sum	EA	1.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*30,000.00* 30,000	*30,000.00* 30,000
Relief Tunnel Structure Revisions	EA	1.0	Prime	*1,836.05* 1,836	*130.85* 131	0	475,000	*482,289.41* 482,289
Flap Gate	EA	1.0	Prime	*447.00* 447	*0.00* 0	0	0	*4,079.76* 4,080
CIV 027180800 Valves, iron body, mud valve, 36" size, flanged	EA	1.0	Prime	*447.00* 447	*0.00* 0	*0.00* 0	*0.00* 0	*4,079.76* 4,080
New Sump Room	EA	1.0	Prime	*1,389.05* 1,389	*130.85* 131	0	475,000	*478,209.65* 478,210
Demo Work	EA	1.0	Prime	*860.10* 860	*79.30* 79	0	0	*939.40* 939
AF 020462345 Site dml, conc, air eqpt, to 6" thick, rod reinf (Note: proximate volume difference between new & existing sump room = 756 cf - 202.5 cf = 553.5 cf. Assume approx 10% more in overexcavation to = 610 cf. If a 1-ft thickness is used, then this equates to 610 sf.)	SF	610.0	Prime	*1.41* 860	*0.13* 79	*0.00* 0	*0.00* 0	*1.54* 939
New Concrete Work (Note: Assume a total of 5 cy iof new concrete is needed.)	EA	1.0	Prime	*147.95* 148	*33.55* 34	0	0	*608.25* 608
Forming (Note: Assume 20 sf total.)	EA	1.0	Prime	*74.40* 74	*0.00* 0	0	0	*139.40* 139

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

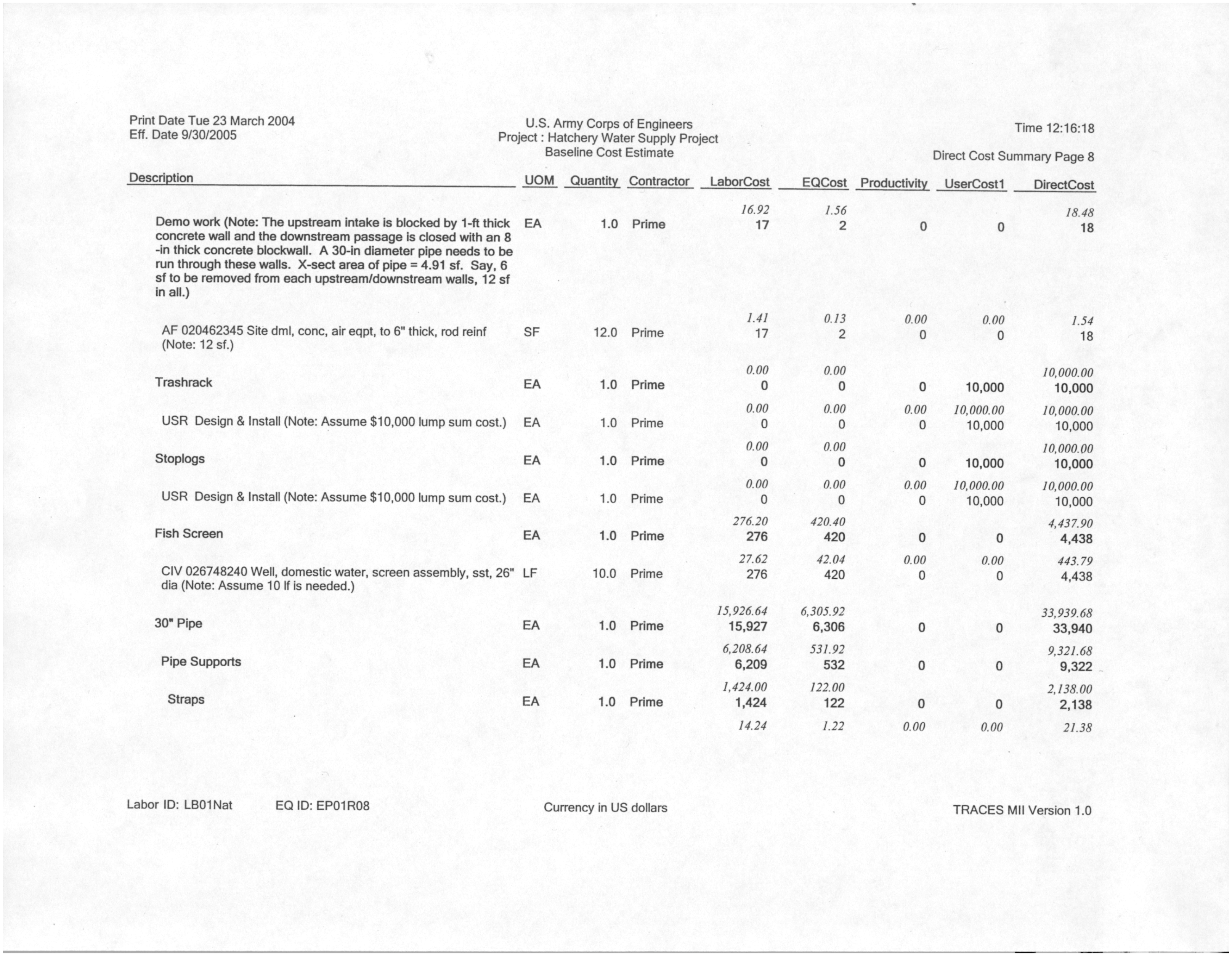
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 7

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
CIV 031820700 Forms in place, walls, buttress forms, to 8' high, 1 use	SF	20.0	Prime	*3.72* 74	*0.00* 0	*0.00* 0	*0.00* 0	*6.97* 139
Concrete	EA	1.0	Prime	*73.55* 74	*33.55* 34	0	0	*468.85* 469
RSM 033260300 Concrete ready mix, regular weight, 4000 psi	CY	5.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*0.00* 0	*72.36* 362
MIL 033724950 Placing conc, walls, 8" thick, pumped	CY	5.0	Prime	*14.71* 74	*6.71* 34	*0.00* 0	*0.00* 0	*21.41* 107
Metal Floor Gratings	EA	1.0	Prime	*381.00* 381	*18.00* 18	0	0	*1,662.00* 1,662
MIL 055420691 Floor grating,galv stl,4.1 PSF, brg bars @ 15/16"OC,3/4"x1/8" (Note: Approximate metal grating floor area is estimated at 300 sf.)	SF	300.0	Prime	*1.27* 381	*0.06* 18	*0.00* 0	*0.00* 0	*5.54* 1,662
Pump	EA	1.0	Prime	*0.00* 0	*0.00* 0	0	75,000	*75,000.00* 75,000
USR 450 hp pump (Note: $75k lump sum cost provided by Jack Graham of Granich Engineering (425.888.8744) in North Bend, WA. The price includes the pump, shipping to site and installation. Also, the price includes testing of the pump. Pump is assumed to be a Fairbanks-Morse model 5800-HSC-750 with a cast-iron casing & stainless steel impeller.)	EA	1.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*75,000.00* 75,000	*75,000.00* 75,000
Shaft (Note: The proposed method to construct this shaft is predicated on a shaft drilling rig is able to set up on top of the right bank in order to drill an 8-ft diameter access shaft. Per Karl Anderson of NWS Civil Design, the cost to drill +100 vertical feet through impervious fill is approximately $400k.)	EA	1.0	Prime	*0.00* 0	*0.00* 0	0	400,000	*400,000.00* 400,000
USR Shaft Lump Sum Cost	EA	1.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*400,000.00* 400,000	*400,000.00* 400,000
Dam Intake Diversion Structure Revisions	EA	1.0	Prime	*18,588.38* 18,588	*6,771.97* 6,772	0	20,000	*84,462.57* 84,463

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 8

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
Demo work (Note: The upstream intake is blocked by 1-ft thick concrete wall and the downstream passage is closed with an 8 -in thick concrete blockwall. A 30-in diameter pipe needs to be run through these walls. X-sect area of pipe = 4.91 sf. Say, 6 sf to be removed from each upstream/downstream walls, 12 sf in all.)	EA	1.0	Prime	*16.92* 17	*1.56* 2	0	0	*18.48* 18
AF 020462345 Site dml, conc, air eqpt, to 6" thick, rod reinf (Note: 12 sf.)	SF	12.0	Prime	*1.41* 17	*0.13* 2	*0.00* 0	*0.00* 0	*1.54* 18
Trashrack	EA	1.0	Prime	*0.00* 0	*0.00* 0	0	10,000	*10,000.00* 10,000
USR Design & Install (Note: Assume $10,000 lump sum cost.)	EA	1.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*10,000.00* 10,000	*10,000.00* 10,000
Stoplogs	EA	1.0	Prime	*0.00* 0	*0.00* 0	0	10,000	*10,000.00* 10,000
USR Design & Install (Note: Assume $10,000 lump sum cost.)	EA	1.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*10,000.00* 10,000	*10,000.00* 10,000
Fish Screen	EA	1.0	Prime	*276.20* 276	*420.40* 420	0	0	*4,437.90* 4,438
CIV 026748240 Well, domestic water, screen assembly, sst, 26" dia (Note: Assume 10 lf is needed.)	LF	10.0	Prime	*27.62* 276	*42.04* 420	*0.00* 0	*0.00* 0	*443.79* 4,438
30" Pipe	EA	1.0	Prime	*15,926.64* 15,927	*6,305.92* 6,306	0	0	*33,939.68* 33,940
Pipe Supports	EA	1.0	Prime	*6,208.64* 6,209	*531.92* 532	0	0	*9,321.68* 9,322
Straps	EA	1.0	Prime	*1,424.00* 1,424	*122.00* 122	0	0	*2,138.00* 2,138
				14.24	*1.22*	*0.00*	*0.00*	*21.38*

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

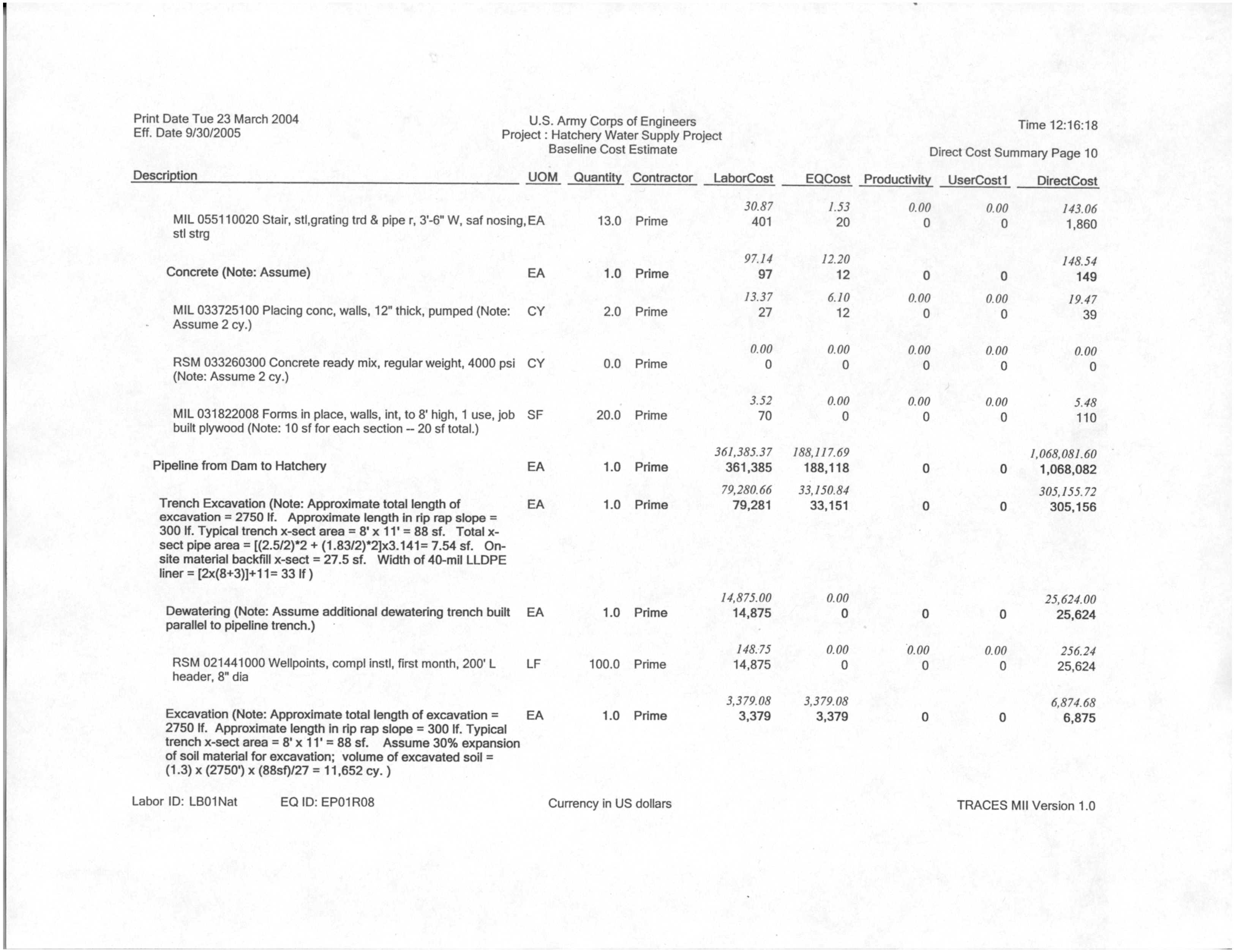
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 9

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
MIL 051300748 Lightweight framing, junior beam, field fabed, 7" (Note: Assume these sized beams are used to support the pipeline along the dam. An angled support made up of this material would total 10 lf each. Assume supports needed every 10 lf of pipeline (appproximately 100 lf.) 10 x 10 lf = 100 lf.)	LF	100.0	Prime	1,424	122	0	0	2,138
Saddles	**EA**	**1.0**	**Prime**	*4,784.64* **4,785**	*409.92* **410**	**0**	**0**	*7,183.68* **7,184**
MIL 051300748 Lightweight framing, junior beam, field fabed, 7" (Note: Assume these sized beams are used to support the pipeline as saddles. A saddle support made up of this material would total about 12 lf each. Assume supports needed every 100 lf of pipeline (appproximately 2750 lf.) 12 x 28 lf = 336 lf.)	LF	336.0	Prime	*14.24* 4,785	*1.22* 410	*0.00* 0	*0.00* 0	*21.38* 7,184
Pipeline	**EA**	**1.0**	**Prime**	*9,718.00* **9,718**	*5,774.00* **5,774**	**0**	**0**	*24,618.00* **24,618**
CIV 026611090 Piping, water dist, 30" dia, blk stl, pl end, welded 3/8" wall (Note: Assume 200 lf total.)	LF	200.0	Prime	*48.59* 9,718	*28.87* 5,774	*0.00* 0	*0.00* 0	*123.09* 24,618
Monolith 2 Room Improvements	**EA**	**1.0**	**Prime**	*2,368.62* **2,369**	*44.09* **44**	**0**	**0**	*26,066.51* **26,067**
Gate Valve	**EA**	**1.0**	**Prime**	*1,616.17* **1,616**	*0.00* **0**	**0**	**0**	*22,950.19* **22,950**
CIV 151943832 Valves, iron body, gate, 125 lb, OS&Y, flanged, 30"	EA	1.0	Prime	*1,616.17* 1,616	*0.00* 0	*0.00* 0	*0.00* 0	*22,950.19* 22,950
Metal Floor Grating	**EA**	**1.0**	**Prime**	*254.00* **254**	*12.00* **12**	**0**	**0**	*1,108.00* **1,108**
MIL 055420691 Floor grating,galv stl,4.1 PSF, brg bars @ 15/16"OC,3/4"x1/8" (Note: Two platforms are needed. Approximate total area = 200 sf.)	SF	200.0	Prime	*1.27* 254	*0.06* 12	*0.00* 0	*0.00* 0	*5.54* 1,108
Metal Stairway	**EA**	**1.0**	**Prime**	*401.31* **401**	*19.89* **20**	**0**	**0**	*1,859.78* **1,860**

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

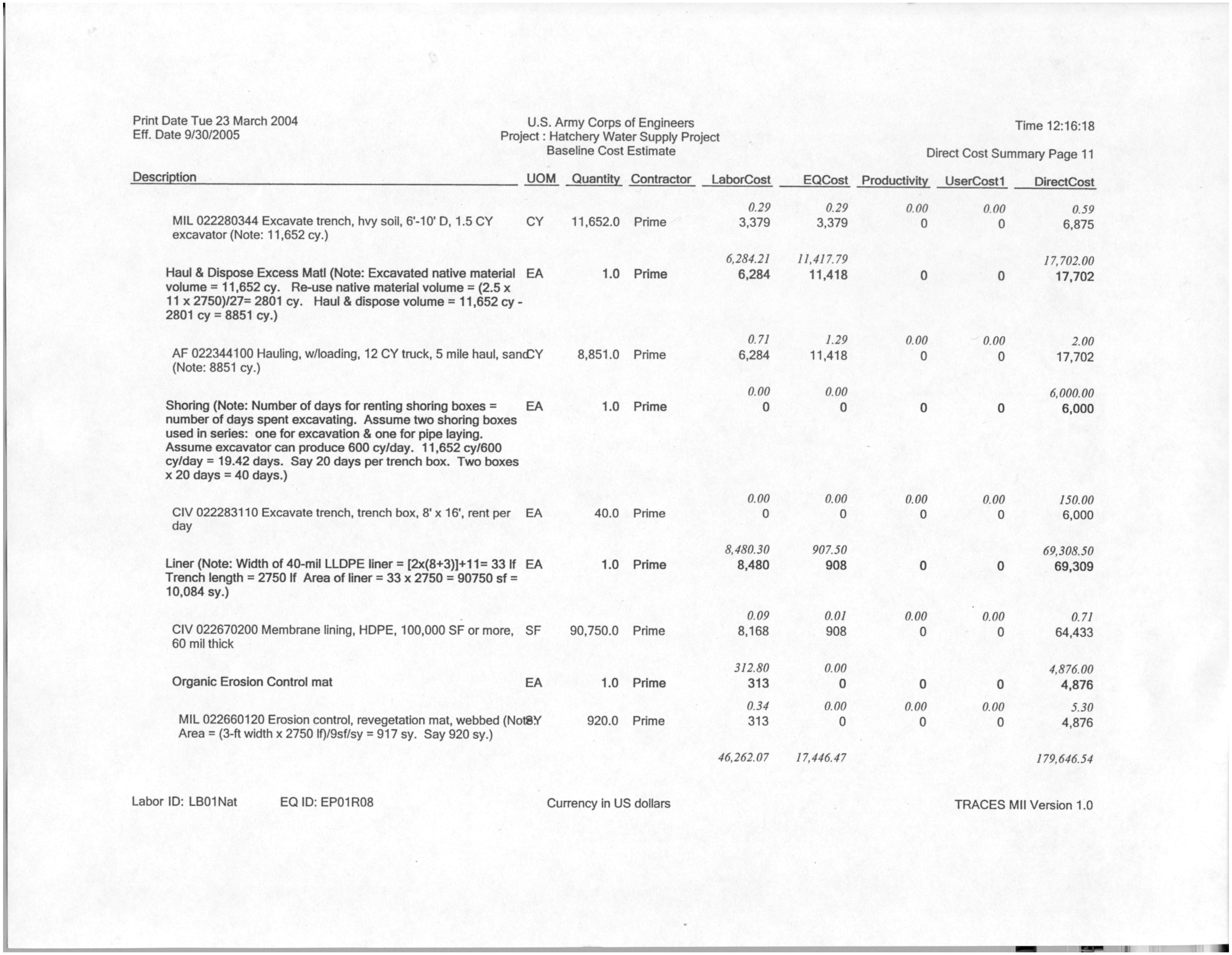
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 10

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
MIL 055110020 Stair, stl,grating trd & pipe r, 3'-6" W, saf nosing, stl strg	EA	13.0	Prime	*30.87* 401	*1.53* 20	*0.00* 0	*0.00* 0	*143.06* 1,860
Concrete (Note: Assume)	**EA**	**1.0**	**Prime**	*97.14* **97**	*12.20* **12**	**0**	**0**	*148.54* **149**
MIL 033725100 Placing conc, walls, 12" thick, pumped (Note: Assume 2 cy.)	CY	2.0	Prime	*13.37* 27	*6.10* 12	*0.00* 0	*0.00* 0	*19.47* 39
RSM 033260300 Concrete ready mix, regular weight, 4000 psi (Note: Assume 2 cy.)	CY	0.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*0.00* 0	*0.00* 0
MIL 031822008 Forms in place, walls, int, to 8' high, 1 use, job built plywood (Note: 10 sf for each section -- 20 sf total.)	SF	20.0	Prime	*3.52* 70	*0.00* 0	*0.00* 0	*0.00* 0	*5.48* 110
Pipeline from Dam to Hatchery	**EA**	**1.0**	**Prime**	*361,385.37* **361,385**	*188,117.69* **188,118**	**0**	**0**	*1,068,081.60* **1,068,082**
Trench Excavation (Note: Approximate total length of excavation = 2750 lf. Approximate length in rip rap slope = 300 lf. Typical trench x-sect area = 8' x 11' = 88 sf. Total x-sect pipe area = [(2.5/2)*2 + (1.83/2)*2]x3.141= 7.54 sf. On-site material backfill x-sect = 27.5 sf. Width of 40-mil LLDPE liner = [2x(8+3)]+11= 33 lf)	**EA**	**1.0**	**Prime**	*79,280.66* **79,281**	*33,150.84* **33,151**	**0**	**0**	*305,155.72* **305,156**
Dewatering (Note: Assume additional dewatering trench built parallel to pipeline trench.)	**EA**	**1.0**	**Prime**	*14,875.00* **14,875**	*0.00* **0**	**0**	**0**	*25,624.00* **25,624**
RSM 021441000 Wellpoints, compl instl, first month, 200' L header, 8" dia	LF	100.0	Prime	*148.75* 14,875	*0.00* 0	*0.00* 0	*0.00* 0	*256.24* 25,624
Excavation (Note: Approximate total length of excavation = 2750 lf. Approximate length in rip rap slope = 300 lf. Typical trench x-sect area = 8' x 11' = 88 sf. Assume 30% expansion of soil material for excavation; volume of excavated soil = (1.3) x (2750') x (88sf)/27 = 11,652 cy.)	**EA**	**1.0**	**Prime**	*3,379.08* **3,379**	*3,379.08* **3,379**	**0**	**0**	*6,874.68* **6,875**

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

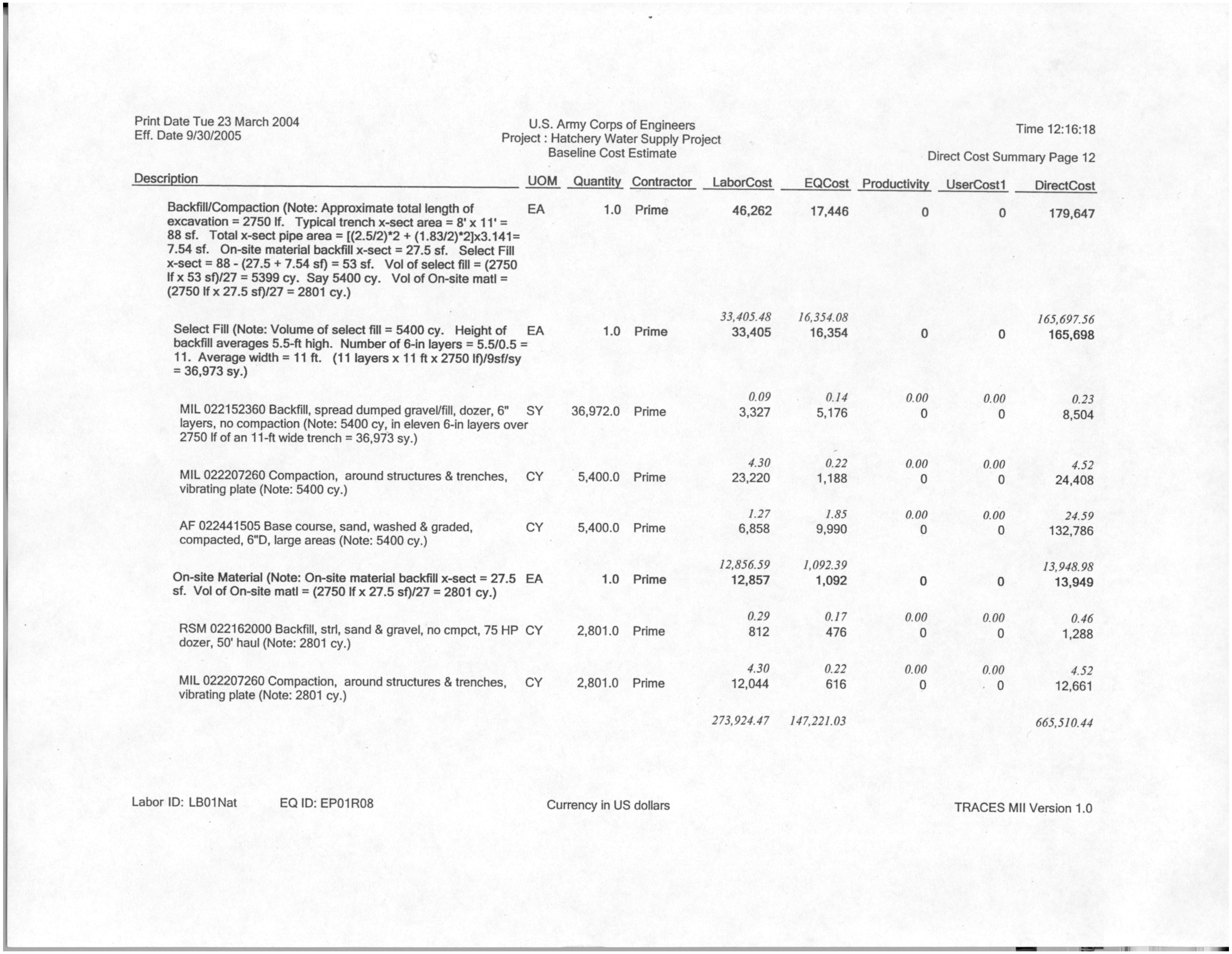
U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 11

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
MIL 022280344 Excavate trench, hvy soil, 6'-10' D, 1.5 CY excavator (Note: 11,652 cy.)	CY	11,652.0	Prime	*0.29* 3,379	*0.29* 3,379	*0.00* 0	*0.00* 0	*0.59* 6,875
Haul & Dispose Excess Matl (Note: Excavated native material volume = 11,652 cy. Re-use native material volume = (2.5 x 11 x 2750)/27= 2801 cy. Haul & dispose volume = 11,652 cy - 2801 cy = 8851 cy.)	**EA**	**1.0**	**Prime**	*6,284.21* **6,284**	*11,417.79* 11,418	**0**	**0**	*17,702.00* **17,702**
AF 022344100 Hauling, w/loading, 12 CY truck, 5 mile haul, sand (Note: 8851 cy.)	CY	8,851.0	Prime	*0.71* 6,284	*1.29* 11,418	*0.00* 0	*0.00* 0	*2.00* 17,702
Shoring (Note: Number of days for renting shoring boxes = number of days spent excavating. Assume two shoring boxes used in series: one for excavation & one for pipe laying. Assume excavator can produce 600 cy/day. 11,652 cy/600 cy/day = 19.42 days. Say 20 days per trench box. Two boxes x 20 days = 40 days.)	**EA**	**1.0**	**Prime**	*0.00* **0**	*0.00* **0**	**0**	**0**	*6,000.00* **6,000**
CIV 022283110 Excavate trench, trench box, 8' x 16', rent per day	EA	40.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*0.00* 0	*150.00* 6,000
Liner (Note: Width of 40-mil LLDPE liner = [2x(8+3)]+11= 33 lf Trench length = 2750 lf Area of liner = 33 x 2750 = 90750 sf = 10,084 sy.)	**EA**	**1.0**	**Prime**	*8,480.30* **8,480**	*907.50* **908**	**0**	**0**	*69,308.50* **69,309**
CIV 022670200 Membrane lining, HDPE, 100,000 SF or more, 60 mil thick	SF	90,750.0	Prime	*0.09* 8,168	*0.01* 908	*0.00* 0	*0.00* 0	*0.71* 64,433
Organic Erosion Control mat	**EA**	**1.0**	**Prime**	*312.80* **313**	*0.00* **0**	**0**	**0**	*4,876.00* **4,876**
MIL 022660120 Erosion control, revegetation mat, webbed (Note: Area = (3-ft width x 2750 lf)/9sf/sy = 917 sy. Say 920 sy.)	SY	920.0	Prime	*0.34* 313	*0.00* 0	*0.00* 0	*0.00* 0	*5.30* 4,876
				46,262.07	*17,446.47*			*179,646.54*

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0



Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 12

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
Backfill/Compaction (Note: Approximate total length of excavation = 2750 lf. Typical trench x-sect area = 8' x 11' = 88 sf. Total x-sect pipe area = [(2.5/2)*2 + (1.83/2)*2]x3.141= 7.54 sf. On-site material backfill x-sect = 27.5 sf. Select Fill x-sect = 88 - (27.5 + 7.54 sf) = 53 sf. Vol of select fill = (2750 lf x 53 sf)/27 = 5399 cy. Say 5400 cy. Vol of On-site matl = (2750 lf x 27.5 sf)/27 = 2801 cy.)	EA	1.0	Prime	46,262	17,446	0	0	179,647
Select Fill (Note: Volume of select fill = 5400 cy. Height of backfill averages 5.5-ft high. Number of 6-in layers = 5.5/0.5 = 11. Average width = 11 ft. (11 layers x 11 ft x 2750 lf)/9sf/sy = 36,973 sy.)	EA	1.0	Prime	*33,405.48* 33,405	*16,354.08* 16,354	0	0	*165,697.56* 165,698
MIL 022152360 Backfill, spread dumped gravel/fill, dozer, 6" layers, no compaction (Note: 5400 cy, in eleven 6-in layers over 2750 lf of an 11-ft wide trench = 36,973 sy.)	SY	36,972.0	Prime	*0.09* 3,327	*0.14* 5,176	*0.00* 0	*0.00* 0	*0.23* 8,504
MIL 022207260 Compaction, around structures & trenches, vibrating plate (Note: 5400 cy.)	CY	5,400.0	Prime	*4.30* 23,220	*0.22* 1,188	*0.00* 0	*0.00* 0	*4.52* 24,408
AF 022441505 Base course, sand, washed & graded, compacted, 6"D, large areas (Note: 5400 cy.)	CY	5,400.0	Prime	*1.27* 6,858	*1.85* 9,990	*0.00* 0	*0.00* 0	*24.59* 132,786
On-site Material (Note: On-site material backfill x-sect = 27.5 sf. Vol of On-site matl = (2750 lf x 27.5 sf)/27 = 2801 cy.)	EA	1.0	Prime	*12,856.59* 12,857	*1,092.39* 1,092	0	0	*13,948.98* 13,949
RSM 022162000 Backfill, strl, sand & gravel, no cmpct, 75 HP dozer, 50' haul (Note: 2801 cy.)	CY	2,801.0	Prime	*0.29* 812	*0.17* 476	*0.00* 0	*0.00* 0	*0.46* 1,288
MIL 022207260 Compaction, around structures & trenches, vibrating plate (Note: 2801 cy.)	CY	2,801.0	Prime	*4.30* 12,044	*0.22* 616	*0.00* 0	*0.00* 0	*4.52* 12,661
				273,924.47	*147,221.03*			*665,510.44*

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 13

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
Pipelines (Note: Approximate length of pipeline = 2750 lf. Assume 3/8" thick A53 steel, welded joints. Pipelines require anchoring every 100 lf and at three bends & three elevation changes.)	EA	1.0	Prime	**273,924**	**147,221**	0	0	665,510
30"	EA	1.0	Prime	*133,622.50* **133,623**	*79,392.50* **79,393**	0	0	*338,497.50* **338,498**
CIV 026611090 Piping, water dist, 30" dia, blk stl, pl end, welded 3/8" wall	LF	2,750.0	Prime	*48.59* 133,623	*28.87* 79,393	*0.00* 0	*0.00* 0	*123.09* 338,498
20" outlet pipe (Note: Design considerations selected a 20"diameter outlet pipe. This estimate used a 24" diameter pipe due to the Unit Cost database had either an 18" or 24" diameter pipe from which to choose.)	EA	1.0	Prime	*112,860.00* **112,860**	*67,045.00* **67,045**	0	0	*275,440.00* **275,440**
CIV 026611080 Piping, water dist, 24" dia, blk stl, pl end, welded 3/8" wall	LF	2,750.0	Prime	*41.04* 112,860	*24.38* 67,045	*0.00* 0	*0.00* 0	*100.16* 275,440
Thrust blocks/Anchors (Note: Thrust block/anchorss are designed to be 8-ft wide x 6-ft high (long) x 3-ft highthick concrete. Number of thrust blocks/anchors needed = pipeline length/100 + 3 for bends + 3 for elev changes = 2750/100 +3 + 3 = 34.)	EA	1.0	Prime	*27,441.97* **27,442**	*783.53* **784**	0	0	*51,572.94* **51,573**
Forming (Note: Forming the anchors requires two buttress forms of 6ft x 8ft = 48sf each or 96 sf per anchor, and two end walls of 3ft x 6ft = 18sf each or 36 sf per anchor.)	EA	1.0	Prime	*25,723.44* **25,723**	*0.00* **0**	0	0	*35,539.56* **35,540**
CIV 031820100 Forms in place, wall, to 10 SF, box out for opening, to 16" thk (Note: 54 anchors with 2 blockout per anchor = 108 blockouts.)	EA	108.0	Prime	*54.28* 5,862	*0.00* 0	*0.00* 0	*0.00* 0	*78.75* 8,505
CIV 031820850 Forms in place, walls, buttress forms, to 8' high 4 use (Note: 54 anchors x 96 sf per anchor = 5184 sf.)	SF	5,184.0	Prime	*2.71* 14,049	*0.00* 0	*0.00* 0	*0.00* 0	*3.79* 19,647

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 14

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
MIL 031822150 Forms in place, walls, below gr, to 8' high, 4 use job built plywood (Note: 36 sf per anchor x 54 anchors = 1944 sf.)	SF	1,944.0	Prime	*2.99* 5,813	*0.00* 0	*0.00* 0	*0.00* 0	*3.80* 7,387
Concrete (Note: Concrete volume of typical thrust block/anchor = (3 x 6 x 8) - [(30/2)*2 + (22/2)*2]x 3.141/144 = 136.5 sf = 5 cy. Add 10% for wastage, volume of one thrust block/anchor = 5.5 cy. Volume of concrete needed = 34 x 5.5 cy = 187 cy.)	EA	1.0	Prime	*1,718.53* **1,719**	*783.53* **784**	**0**	**0**	*16,033.38* **16,033**
RSM 033260300 Concrete ready mix, regular weight, 4000 psi (Note: 187 cy.)	CY	187.0	Prime	*0.00* 0	*0.00* 0	*0.00* 0	*0.00* 0	*72.36* 13,531
MIL 033722150 Placing conc, footings, deep continuous, pumped (Note: 187 cy)	CY	187.0	Prime	*9.19* 1,719	*4.19* 784	*0.00* 0	*0.00* 0	*13.38* 2,502
New Road (Note: Total length of new road = 2400 lf. Assume 6-in = 0.5-ft of gravel subgrade. Typical road width = 26-ft. X -sect area of subgrade = 26 x 0.5 = 13 sf.)	EA	1.0	Prime	*8,180.24* **8,180**	*7,745.82* **7,746**	**0**	**0**	*97,415.44* **97,415**
Subgrade	EA	1.0	Prime	*3,050.96* **3,051**	*4,368.42* **4,368**	**0**	**0**	*36,888.88* **36,889**
MIL 022440100 Base course, crushed 3/4" stone, compacted, 6"D, large areas (Note: Area = (2400 lf x 26 ft)/9 sf/sy = 6934 sy.)	SY	6,934.0	Prime	*0.21* 1,456	*0.31* 2,150	*0.00* 0	*0.00* 0	*4.77* 33,075
MIL 022430100 Base, prepare & roll sub-base, large areas over 2500 SY	SY	6,934.0	Prime	*0.23* 1,595	*0.32* 2,219	*0.00* 0	*0.00* 0	*0.55* 3,814
Surface Paving	EA	1.0	Prime	*5,129.28* **5,129**	*3,377.40* **3,377**	**0**	**0**	*60,526.56* **60,527**
RSM 025050850 Asphaltic conc pavement, highway, wearing course, 1" thick (Note: Assume 143 pcf. Volume of asphalt = 2400' x 1/12 x 26 = 5200 cf. Weight = (5200 cf x 143 pcf) /2000 = 372 tons.)	TON	372.0	Prime	*3.99* 1,484	*2.95* 1,097	*0.00* 0	*0.00* 0	*36.98* 13,757

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

Print Date Tue 23 March 2004
Eff. Date 9/30/2005

U.S. Army Corps of Engineers
Project : Hatchery Water Supply Project
Baseline Cost Estimate

Time 12:16:18

Direct Cost Summary Page 15

Description	UOM	Quantity	Contractor	LaborCost	EQCost	Productivity	UserCost1	DirectCost
MIL 025050813 Asphaltic conc pavement, highway, binder course, 4" thick (Note: Assume 143 pcf. Volume of asphalt = 2400' x 4/12 x 26 = 20,800 cf. Weight = (20,800 cf x 143 pcf) /2000 = 1487.2 tons. Say 1500 tons.)	TON	1,500.0	Prime	*2.43* 3,645	*1.52* 2,280	*0.00* 0	*0.00* 0	*31.18* 46,770

Labor ID: LB01Nat EQ ID: EP01R08 Currency in US dollars TRACES MII Version 1.0

9. CONCLUSIONS

9.1. The water supply study determined the potential to modify the existing relief tunnel sump to provide 20 cfs. This will require excavating through the random and impervious fill and constructing a permanent shaft, demolishing a portion of the existing relief tunnel and sump, constructing a new larger sump 18-feet long by 6-feet wide by 7-feet deep and a 7-feet high overflow weir, and installing a 450 HP pump. The construction cost estimate for the relief tunnel work is $849,000 plus mobilization and demobilization.

9.2. The study determined the potential to supply 45 cfs from the reservoir. This will require opening the irrigation inlet and outlet on the upstream and downstream faces of the dam, installing a 30-inch diameter metal pipe with an emergency gate valve, trash rack, fish screen, and stoplogs.

9.3. The construction cost estimate for the dam intake diversion structure is $155,000 plus mobilization and demobilization.

9.4. Conveyance of the relief tunnel water to the hatchery site will require a 20-inch diameter metal pipe and conveyance of the reservoir water will require a 30-inch diameter metal pipe. The pipes must be buried for seismic and security considerations and would run approximately 300 feet through the riprap on the embankment and 2,400 feet under the existing road. This will require demolition and repaving the road and excavating a pipe trench 8-feet deep by 11-feet wide.

9.5. The pipes will be anchored in concrete thrust blocks every 100 feet and at bends or grade changes. The construction cost estimate for the water conveyance pipelines is $2,016,000 plus mobilization and demobilization.

9.6. The total mobilization and demobilization cost is estimated at $53,000 for a total water supply project cost of $3,074,000. These costs are not related to the operation of Chief Joseph Dam for hydropower and so would have to be borne by the Fish Hatchery Project along with operation and maintenance costs of these hatchery features.

9.7. A potential well field site is identified in the study upstream of the dam seepage blanket in the vicinity of the state park or golf course approximately 2 miles from the dam. From available information potential well field sites at the hatchery do not look promising and a well field in the vicinity of the relief tunnel is precluded by dam safety considerations. Additional investigation in the next phase of design, including test wells, is needed to determine the location, potential yield, and the number and size of the wells needed to make up the balance of well water required beyond the 20 cfs from the relief tunnel.

9.8. Water quality samples were taken on 3 February 2004 from the relief tunnel and the reservoir forebay at the elevation of the irrigation inlet. In general, water quality at the relief tunnel and forebay locations were good with no exceedances of either WDFW recommended criteria for aquaculture or the WDOE chronic criteria, and the parameters monitored show little difference between the relief tunnel sample and the forebay sample. Water quality samples will be collected at the relief tunnel, forebay, and hatchery well site in the spring and summer to determine if any seasonal variations in water quality exist for these source waters. The test results will be added to this study as supplements.

9.9. Although this study determined the feasibility of supplying 20 cfs to the hatchery from the relief tunnel and 45 cfs from the reservoir, and identified a potential location for a well field to supply the balance of well water required beyond the relief tunnel supply, further and more detailed investigation will be needed in the next phase of design to confirm the assumptions and cost estimates in this study and to address dam safety issues. In view of the more certain potential to supply additional water from the reservoir and the uncertainty on the location and yield from a well field in the area, it is recommended that the next phase of design also investigate mechanical heating and cooling of additional water from the reservoir to achieve the desired temperatures for rearing fish.