TETRA TECH

MEMORANDUM

TNC – Fisher Slough Final Design and Permitting
Subject: Inverted Siphon – Construction Feasibility

To: Jenny Baker (TNC)
Dave Olson (DD3)
Brian Olson (DD17)
Bob Boudinot
Skagit County

From: David Cline (Tetra Tech)
Jon Olmsted (Tetra Tech)
John Plump (Tetra Tech INCA)
Mike Carney (Tetra Tech INCA)
Rod DenHerder (URS)
Marty McCabe (URS)

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Introduction

This technical memorandum addresses construction feasibility of the inverted siphon using open trench construction methods. The recommended method of construction was revised after investigation of trenchless, pipe-jacking costs were evaluated, and deemed beyond project financial resources. During presentation of the revised approach at the 90% design review meeting, the question was presented to the design team if open trench construction was feasible at the site given the bridge, soils, and Fisher Slough flow and environmental constraints. The following memorandum summarizes how the open trench construction method would be implemented, and confirm that it is feasible.

Open Trench Construction Plan Review

The open trench construction plan review involves the following general investigative elements:

- OSHA Excavation and Trenching Requirements
- General Excavation Construction Plan
- Temporary Excavation Cut Slope Geometry
- Bridge Protective Measures
- Fisher Slough Diversion Dam & By-pass Structure
- Dewatering Operations
- Pipe bedding and settlement design
- Determination of construction feasibility

Each of these design and construction items is presented herein. A schematic of the preliminary plan (to be finalized by the construction contractor) is provided in **Attachment A** for reference.

OSHA Trench Excavation Requirements

The OSHA Technical Manual (OSHA, 1990) was reviewed to perform a preliminary evaluation of excavation and shoring protective measures that will likely be necessary for the inverted siphon installation. The construction contractor will be required to adhere to these standards during final planning, design and implementation of the project.

OSHA excavation and trenching definitions are pertinent as they apply to the type of excavation occurring for the project installation.

"Excavation" means any man-made cut, cavity, trench, or depression in an earth surface, formed by earth removal.

"Trench (Trench excavation)" means a narrow excavation (in relation to its length) made below the surface of the ground. In general, the depth is greater than the width, but the width of a trench (measured at the bottom) is not greater than 15 feet (4.6 m). If forms or other structures are installed or constructed in an excavation so as to reduce the dimension measured from the forms or structure to the side of the excavation to 15 feet (4.6 m) or less (measured at the bottom of the excavation), the excavation is also considered to be a trench.

The current preliminary installation plan uses excavation as defined by OSHA, with wet conditions that will require special pumping and protective / shoring measures.

The requirements by OSHA for a safe excavation area include the following elements that will need to be fully addressed in the final inverted siphon construction plan to be submitted by the construction contractor, and approved by The Nature Conservancy and their consulting engineer.

Specific Excavation Requirements (CFR 1926.651)

- Surface encumbrance removal or protection
- Underground installation and utility locates
- Excavation area access, ingress and egress
- Traffic exposure
- Falling load exposure
- Excavation area warning system for mobile equipment
- Hazardous atmospheres
- Protection from water accumulation hazards
- Stability of adjacent structures
- Protection from loose rock or soil
- Daily Inspections
- Fall protection

Requirements for Protective Systems (CFR 1926.652)

- Protection of Employees in Excavations

- Cave-in protection
- Sloping and benching systems
- Support and protective systems
- Materials and equipment
- Installation and removal of support systems
- Sloping and benching work area limits and protections
- Shield and protection systems

Each of these requirements will be addressed in the final plan. The following preliminary plan has been developed in accordance with OSHA standards.

General Excavation Construction Plan
The general trench construction plan and elements include the following:

- Open cut excavation through both levees and Fisher Slough
- Installation of protective bank stability and shoring measures, primarily for the Pioneer Highway Bridge side of the cut
- Installation and operation of Fisher Slough diversion dam and by-pass pipe to downstream of floodgates
- Installation and operation of dewatering system comprised of well points, pump hose and detention basin

Temporary Excavation Cut Slope Configurations
The excavation of the trench will use temporary cut slopes that run through the levees and Fisher Slough, behind a water diversion and isolation system.

Excavation of the trench will likely use a temporary cut slope of 2H: 1V, to a depth 1ft below the pipe inverts, with a 15ft bottom width. The assumed 2H: 1V cut slope is flatter than all slopes specified in the OSHA manual (Type C Soil Slopes of 1.5H: 1V – poorest identified soil slope), and therefore considered a conservative estimate for excavated areas and offsets from the excavation area.

Using the 2H: 1V slope cuts, the western side of the temporary excavation area daylights at the edge of Pioneer Hwy and the bridge, specifically in the taller levee section area of the cut. It is likely that temporary sheet pile or soldier pile shoring will be necessary along the levee sections to provide embankment stability and protect the bridge.

For the Slough area, the trench excavation daylights at the bottom of the channel, with a ~27ft offset from the nearest bridge pile and deck of the bridge.

The contractor will likely determine a method that incorporates localized shoring near the levee and bridge areas, and possibly open cut slopes along the Slough. One potential design option would be to incorporate the shoring measures into the new inverted siphon inlet/outlet headwall and wingwall sections, to remain in place as part of the overall structure.

On the east side of the pipes, the excavation area is free to daylight without affecting other infrastructure. The only potential conflict or impact is the diversion by-pass dam that will be installed as part of the project. The contractor will determine if the proposed ~26ft offsets are adequate, or if changing position of the dam is necessary.

Overall, the cut slopes and offsets to the bridge are feasible, and will not likely affect the bridge infrastructure.

Bridge Protective Measures

The OSHA manual specifies a number of possible protective bank stabilization and shoring measures that can be used to provide stable slopes and protect employees from soil slumping or caving. Typical measures include the following:

- Excavation slopes
- Benching
- Shoring

It is likely for the inverted siphon installation, that each type of measure will be necessary in some form or another in the excavated area. For feasibility, it was assumed that protective shoring (sheet or soldier piles) would be used in combination with 2H: 1V excavated slopes. This provides a minimum offset of ~27ft from the top of trench to the Pioneer Highway bridge piers, and 54ft offset from the bridge piers to the bottom of the trench. This is considered adequate offset for protection of the bridge piers and superstructure. The piers are not exposed or in conflict with construction alignments or activities. The method of pile installation will be limited. Vibratory pile installations will not be allowed to protect the bridge.

Monitoring of the bridge will be performed daily during construction. Monitoring will include survey of bridge corner elevations and positions to assess settlement and deformation or changes in position. Daily monitoring during construction will be provided to The Nature Conservancy and Skagit County. Changes greater than 0.1 inch in either settlement or lateral deformation will be flagged for stoppage of construction to inspect and correct shoring measures and implement contingencies if necessary.

Construction contingencies should be set aside to make corrective changes in shoring and protective measures during construction, and possibly additional bridge shoring as a last resort and worst case scenario contingency item.

Fisher Slough Diversion Dam and By-Pass Structure

A diversion dam and by-pass structure will need to be installed during construction. The structure will likely be comprised of a dam built from sand bags, aggregate bags, porta-dam or hydraulic geomembrane dam to check the water and isolate the excavation area.

Water will then be pumped from the upstream side of the dam, downstream past the floodgates. It is recommended to keep the floodgates completely closed during the inverted siphon excavation and installation operations. Pump operations would need to accommodate discharge from the Fisher Slough Tributary system. The estimated summer time high flow rates from Fisher Slough tributaries are estimated at 5cfs to 8cfs. This estimate was determined by documentation of shallow depths of flow 0.1ft deep over the Big Ditch culvert crossing, and application of a broad crested weir equation.

A block net and fish removal activities will be necessary for the operation of the pump system. The system will need to be manned and operated 24/7 during the installation of the pipes in case of pump shut down. If not physically manned, then the contractor will need to have equipment that provides notification if shut down occurs.

A preliminary ~26ft offset for the diversion dam is shown on the plan, and meets excavation temporary cut slope and work area minimum distance offset requirements. The position of the dam and cut slope areas can be changed and lengthened as necessary, as there is little infrastructure to protect on the east side of the pipes. The one additional item that should be evaluated by the contractor is the possible loading on the slope from heavy equipment and the additional weight of dammed water. These loads could require additional shoring and stabilization measures.

The diversion dam and by-pass structure will be installed and operational during the in-water work window from Aug. 1 – Oct. 15, 2010.

Construction installation of this type of diversion by-pass structure is feasible in this environment and situation.

Dewatering Operations

The excavated trench areas will be dewatered using well-point or groundwater pump installations. The dewatering discharge will be pumped out of the excavated area to a detention, and infiltration area, likely to the south on Smith A property and return to Big Ditch. There is a possibility of using the newly excavated Big Ditch channel as a detention and infiltration basin. Preliminary estimates of groundwater flow rates are fairly low and considered well within construction feasibility for installation and operation of a groundwater pumping or well point system.

Pipe Bedding & Settlement Design

During design review, there was an issue and concern regarding pipe stability due to possible liquefaction and settlement of the pipe during a seismic event. It is estimated that 4” to 6” of settlement could occur during a seismic induced liquefaction event. Buoyancy is not an issue, as the amount of soil cover over the pipes, especially in the levee areas, is significant and counteracts any potential buoyancy.

The options available for pipe settlement design were either to install piles affixed to the pipes that would prevent settlement, or allow for some settlement as part of the pipe design using standard pipe bedding methods. The pile option was originally considered in the design, but is more costly than the pipe bedding alternative.

The current plan is to use pipe bedding material, 1 ¼ inch minus crushed rock, placed 1ft below the pipe invert, and embed the pipe 1/3 the total diameter of the pipe. The placement of a geotextile fabric beneath the pipe bedding material (although difficult) will ultimately improve the workability of the area and reduce the wet and muddy conditions. The bedding material will be compacted which will provide a stable working surface for equipment and laborers during pipe installation. Use of the geotextiles and compacted bedding material will be more stable both during construction and reduce settlement potential in the long term.

A 6 inch sleeve has been added to the headwall to allow for settlement along the pipe. That way, if settlement does occur, the pipe will not pull out from the headwall and leak. It is allowed to slip within the sleeve. The additional 6" will provide a total lateral pull out length of 1.5ft (headwall is 1.0ft thick).

Determination of Construction Feasibility

A preliminary construction plan for the inverted siphon construction has been developed, and reviewed for feasibility. It is the opinion of the design team that the open cut excavation is feasible, and the least cost solution for the project.

References

Occupational Safety & Health Administration, 1990. Excavation Standard (29 CFR 1926, Subpart P)

Attachment A – Preliminary Inverted Siphon Construction Plan

PRELIMINARY WATER CONTROL PLAN TO CLOSE FLOODGATES DURING CONSTRUCTION. FINAL PLAN TO BE PROVIDED BY CONTRACTOR

STABILIZE AND PROTECT POWER POLES (TYP)

PIONEER HIGHWAY BRIDGE (EXISTING)

BIG DITCH OHW=6.0'

INVERTED SIPHON OUTLET EL -4.58

EXCAVATION CUT LINE WITHOUT SHORING ALTERNATIVE

BIG DITCH OHW=6.0'

JUNGQUIST ACCESS SEE DETAIL

80.2'

60.0'

WELL-POINT AND PUMP (TYP.). ACTUAL LOCATION TO BE DETERMINED BY CONTRACTOR

SHORING ALTERNATIVE

2:1 CUT SLOPE

20+00

22+00

BIG DITCH REALIGN

H-PILES (TYP)

BIG DITCH ALIGNMENT

FLOW

SEDIMENT SILL

CONCRETE SEDIMENT BASIN

NEW SOUTH LEVEE ALIGNMENT

HOSE TO DETENTION POND. CONTRACTOR TO LOCATE.

SCALE: HOR: 1"=40'
VER: 1"=40'

FISHER SLOUGH

FISHER OHW 12.0'

INVERTED SIPHON INLET SEE DETAIL (S2)

PRELIMINARY - SHEET PILE CUTOFF OR OTHER DIVERSION STRUCTURE. FINAL PLAN TO BE PROVIDED BY CONTRACTOR

PRELIMINARY TRIBUTARY BY-PASS PUMP AND PIPE W/ FISH SCREEN ON INTAKE. FINAL PLAN TO BE PROVIDED BY CONTRACTOR

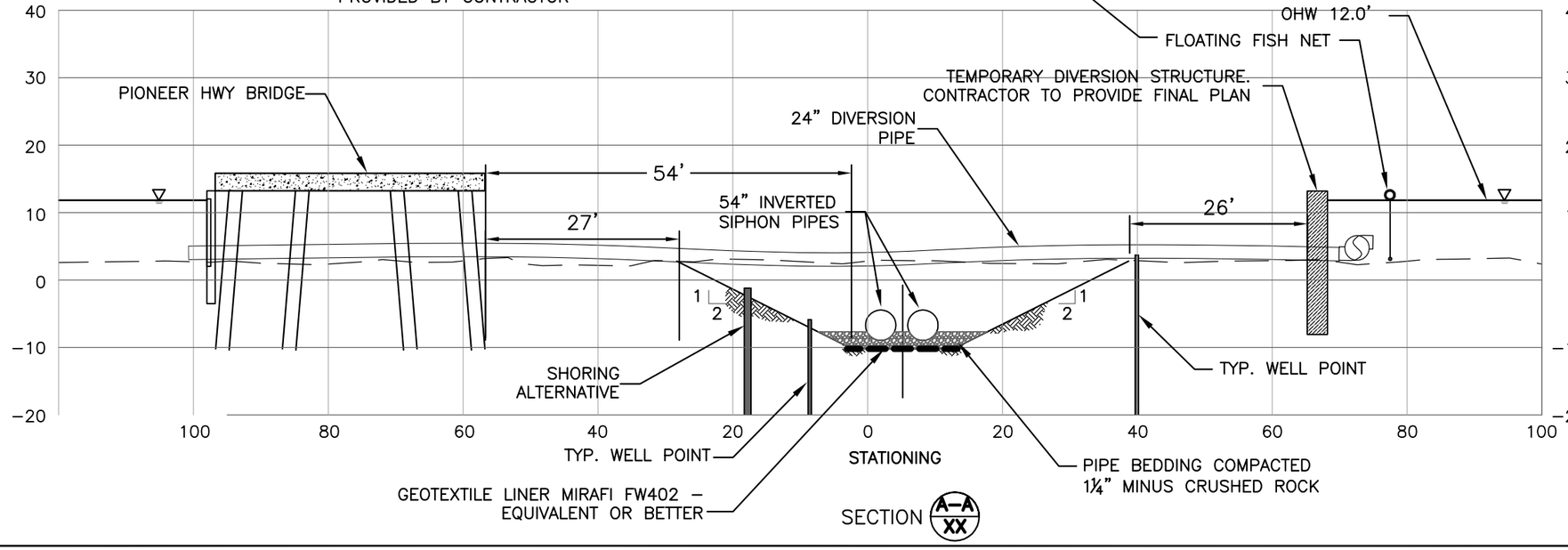
40 0 40
SCALE IN FEET

LEGEND

- EXISTING GROUND
- PROPOSED CHANNEL INVERT
- SIPHON STRUCTURE AND PIPE
- FLOW DIRECTION ARROW

CONSTRUCTION NOTES:

1. THIS IS A PRELIMINARY PLAN ONLY. NOT FOR CONSTRUCTION.
2. CONTRACTOR REQUIRED TO SUBMIT FINAL PLAN FOR APPROVAL.
3. TRENCH CONSTRUCTION WITH WATER DIVERSION IS THE PROPOSED CONSTRUCTION METHOD FOR PROJECT PERMITS. OTHER CONSTRUCTION METHODS, SUCH AS TRENCHLESS PIPE JACKING, ALLOWED. CONTRACTOR TO PROVIDE PROPOSAL FOR CHANGES IN CONSTRUCTION METHODS.
4. CONSTRUCTION PLAN SHALL INCLUDE INFORMATION REGARDING DIVERSION PLANS, SCHEDULES, DETENTION AND SEDIMENTATION FACILILITIES, AND PROTECTIVE MEASURES FOR FISH.



SECTION A-A (XX)

20 0 20
SCALE IN FEET

DAVID R. CLINE
STATE OF WASHINGTON
39326
REGISTERED
PROFESSIONAL ENGINEER
EXPIRES

NOT FOR CONSTRUCTION

Date SEPT 2009
Designed D. CLINE
Drawn J. OLMSTED
Checked
Approved
Title

THE NATURE CONSERVANCY
FISHER SLOUGH RESTORATION PROJECT
PRELIMINARY INVERTED SIPHON CONSTRUCTION PLAN
SKAGIT COUNTY, WASHINGTON

TETRA TECH
1420 Fifth Avenue, Suite 550
Seattle, Washington 98101
206-728-9655 Fax: 206-728-9670

File Name

Drawing No. XX

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