GeoEngineers

February 25, 2009

MWH Americas, Inc.
2553 130th Avenue NE
Bellevue, Washington 98005

Attention: Bill Cutting

Subject: Summary Letter
Hydraulic Analysis
Proposed Additions/Modifications at
WDFW Voights Creek Fish Hatchery
Pierce County, Washington
File No. 3730-099-01

INTRODUCTION

GeoEngineers, Inc. is pleased to present this summary letter regarding our zero rise hydraulic analysis for the proposed modifications to the Washington Department of Fish and Wildlife (WDFW) Voights Creek Fish Hatchery located in Pierce County, Washington. Our services for this project were completed in general accordance with our mutual services agreement with MWH Americas, Inc.

The purpose of our hydraulic analysis was to evaluate the hydraulic and floodplain impacts related to proposed improvements at the WDFW Voights Creek Fish Hatchery. The project site is located within the Deep and Fast Flowing area of the Carbon River Floodplain as defined by Pierce County regulations. As such, the project is required to evaluate the potential for the proposed improvements to increase the Carbon River Flood surface elevations by more than 0.001 ft, per chapter 18E.70 of the Pierce County Code of Regulations (Pierce County, 1986). A meeting with WDFW, Pierce County, and the consulting team occurred on November 7, 2008 to discuss general project guidelines and specific requirements related to the hydraulic analysis and on February 18, 2009 to discuss preliminary results from the hydraulic analysis.

SITE LOCATION

This project is under the jurisdiction of Pierce County and is located approximately 2 miles south west of Orting, Washington along SR162E. The project is located within the left overbank of the Carbon River and along Voights Creek approximately 0.4 miles upstream of the its confluence with the Carbon River. The project site is within Section 33 of Township 19 North, Range 5 East of the Washington, Willamette Meridian. Figure 1 is a location map of the project site. The Washington Department of Transportation (WSDOT) has recently completed improvements to SR 162 E in the vicinity of the project location.

RIVER CHANNEL AND FLOODPLAIN

The project site is not currently within a Special Flood Hazard Area (SFHA) as defined by National Flood Insurance Program (NFIP). However, the existing hatchery experienced significant flooding in 2005, 2006, 2007 and January 2009. In addition, the project site is located within the Carbon River floodplain

1101 S Fawcett Ave
Suite 200
Tacoma, WA 98402
telephone 253.383.4940
facsimile 253.383.4923
website www.geoengineers.com

and a Zone AE region as determined by Northwest Hydraulic Consultants (NHC) in 2005 as part of the "Flood Insurance Mapping Study for the Carbon River Mile 8.4 to the Puyallup River" (2005 FIS). The 100-yr floodplain width, as shown in the 2005 FIS, varies between approximately 1,500 and 3,000 ft in the vicinity of project location. The approval status and associated timing of the FEMA map update for the Carbon River in the vicinity of the project location, related to the 2005 FIS, is uncertain. For the purposes of the study the 2005 FIS and associated mapping have been treated as effective information.

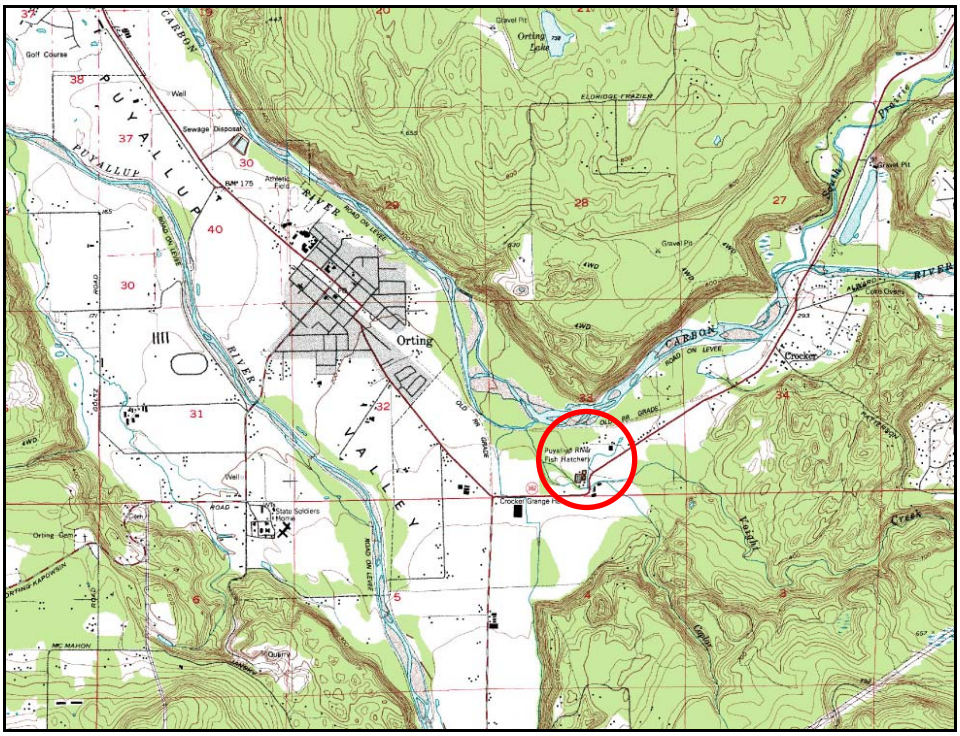


Figure 1 - Project Location

The flooding source for the project site is the Carbon River, caused by a significant flow split into the left overbank of the Carbon River upstream of the project location. Due to hydraulic separation from the main channel caused by levees, a separate hydraulic model was created by NHC, to model the split flow path within the left overbank of the Carbon River Floodplain. The split flow hydraulic model, referred to here as the Voights Creek split flow model, does not explicitly account for impacts, and characteristics representative of floods originating from Voights Creek, and is, therefore, only representative of flooding risk associated with the Carbon River.

The project reach begins approximately 500 feet upstream and extends 800 feet downstream of existing hatchery facilities. Within the split flow reach from the Carbon River, the Voights Creek channel has a slightly sinuous plan form within the project reach. The channel bed has an average slope of 0.2% and is composed of sand, gravel, and small to medium cobbles. The channel width varies between 65 and 100 ft. Channel banks are well established with moderate to thick vegetation, but exhibit some signs of bank instability and have been armored with concrete rubble riprap in places. The banks, where not eroding, are well established with grasses, willows, Himalayan blackberry, and deciduous tree species.

FIELD RECONNAISSANCE

A field reconnaissance of the project reach was conducted on February 2, 2009 by the GeoEngineers project staff on the Voights Creek channel and Carbon River split flow path in the vicinity of the project location. During the field reconnaissance general hydraulic characteristics of the project reach were observed, channel and floodplain roughness characterized, evidence of hydraulic controls investigated, and details pertinent to adequately characterizing the SR162 E Bridge were obtained. Photographs obtained during the field reconnaissance of Voights Creek channel and WDFW hatchery facilities are shown in **Figures 2** and **3**.

Figure 2 – Looking downstream from near SW corner of west pond. Dense brush line both banks and small boulder size riprap lines right bank.

METHODS

GENERAL APPROACH

The hydraulic analysis of flooding in the vicinity of the Voights Creek Hatchery was carried out using the U.S. Army Corps of Engineers HEC-RAS v.4.0 computer software. The analysis was conducted for the 10-, 50, 100- and 500-yr discharge for both the existing and proposed conditions, and performed in a steady state (discharge does not vary with time) and sub-critical regime (Froude < 1.0). When run in a sub-critical regime HEC-RAS computes reach hydraulics beginning at the downstream extent of the model and progresses to the upstream extent of the model using the standard step backwater computation method. All references to elevations within this report are reported in NGVD 29. The conversion between NAVD 88 and NGVD 29 in the vicinity of the project reach is approximately 3.49 ft.

Figure 3 – Looking Downstream just south of the building labeled Garage. Photo shows recently deposited cobble and gravel along right bank. Boulder size riprap, large trees and dense brush line the left bank.

DUPLICATE EFFECTIVE MODEL

NHC submitted the "Flood Insurance Mapping Study for the Carbon River Mile 8.4 to the Puyallup River" to Pierce County and FEMA in 2005. The 2005 FIS has been approved by Pierce County and is currently undergoing the FEMA review and approval process. The 2005 Carbon River FIS model extends from the confluence with the Puyallup River upstream through the City of Orting to RM 8.4 and mapped 100-year floodplain, 500-year floodplain, and 1 ft floodway through the study reach. Both the Carbon River and flooding in the vicinity of Voights Creek, due to split flow from the Carbon River, were studied using detailed methods. While the 2005 FIS has not been adopted by FEMA as the effective study, it has been essentially treated as such for this analysis. The duplicate effective (DE) model was created by shortening the 2005 FIS Voights Creek floodplain model, created by NHC, to extend approximately 300 ft upstream and 1,200 ft downstream of the project site and between section VE and VF. The results from the duplicate effective model are shown in Table 1.

CORRECTED EFFECTIVE/EXISTING CONDITIONS MODEL

The corrected effective (CE) model and existing conditions (EC) reflects additional cross sections, new and more detailed topographic information, and refines the hydraulics model between section VE and VF. For the purposes of this analysis the CE and EC model are identical and referred as the existing conditions (EC) model.

Table 1 - DE Model Results for 100-yr Profile

FIS River Station	Section Label	Hatchery Analysis River Station	WSEL (ft-NGVD29)
3	VF	12562	229.170
2.1	VE	11088	227.510

Cross Sections

The duplicate effective model utilized 2 cross section locations to model flood events related to Carbon River flood flows within the project reach. Twelve (12) additional cross sections were added to the EC model resulting in 14 total cross section locations. Cross section stationing in the DE model was based on river miles from the confluence from Puyallup River. Due to the relatively short length of the project reach, the stationing, as part of this study, was changed to river feet from the confluence from Puyallup River. Cross Section 2.1 and 3.0 from the 2005 FIS were re-labeled 11088 and 12562, respectively. The new cross sections were located at river station (RS) 11575, 11702, 11771, 11852, 12063, 12171, 12201, 12270, 12308, 12364, 12401, and 12506 (Section Label A-L). Cross sections were added to more accurately reflect the existing conditions at the hatchery and evaluate the impact of the proposed improvements on flood elevations.

Cross section interpolation was not utilized within the EC model. A sensitivity analysis was performed to determine whether interpolation would remove normal HEC-RAS conveyance ratio warnings and increase computational resolution of the model. Results from the model using interpolated sections and the EC model were not significantly different and interpolation was determined not necessary.

Roughness

Manning's n values within the DE model for the main channel and overbanks range between 0.05 to 0.075 and 0.05 to 0.15, respectively. Field reconnaissance of the project reach suggested that the Manning's n values within the EC should be adjusted to more accurately reflect effects from vegetation along the channel banks, floodplain, and the existing hatchery facilities. Manning's n values within the EC model for the main channel (top of bank to top of bank) was set to 0.045. Manning's n values within the EC model for overbanks range between 0.02 to 0.015 with 0.02, 0.03, 0.15 representing the hatchery facilities, maintained pasture, and forested regions, respectively. Manning's n values were set in accordance with field observations and in conjunction with standard references (Chow 1959, Barnes 1967). Field observations indicated moderate to heavily vegetated channel banks within a moderately incised channel and sparsely vegetated to well maintained pastures in the overbank regions throughout the majority of the project reach. These conditions results in a relatively high main channel roughness value and a low overbank roughness value in certain locations. Manning's n values were applied to each cross section using the horizontal variation in n values HEC-RAS method.

Hydraulic Structures

The hydraulic effect from the SR162 E Bridge, located 500 ft upstream of the hatchery site, was not incorporated into the EC model. The hydraulic effects from the historic SR162 E roadway alignment embankment were incorporated into the EC model by representing the roadway embankment in RS 12401and 12506. Since all models were run in a sub-critical regime, resulting in a downstream to

upstream computation of the water surface and energy grade profile, the hydraulic effects from the current SR162 E Bridge on the hydraulics at the hatchery site are considered negligible.

Ineffective Flow

Ineffective flow settings were utilized in the EC model to represent conveyance shadowing from existing hatchery facilitates. A contraction and expansion ratio of 1:1 and 1.5:1, respectively, was employed to determine the stationing of ineffective flow regions. Ineffective flow settings were also utilized to represent existing fence locations at the hatchery facilities.

Boundary Conditions

The downstream starting water-surface elevation and discharge values for the EC model was set to exactly match results from the 2005 FIS study. Discharge values and boundary conditions used for the study are shown in **Table 2**.

Table 2 – EC Model Boundary Conditions

Recurrence Interval (yrs)	Discharge (cfs)	WSEL at RS 11088 (ft-NGVD29)
500	16204	228.770
100	11605	227.510
50	10715	227.230
10	6640	226.070

Channel Survey and Topography

Survey of the river channel and topographic mapping adjacent to Voights Creek was performed by Washington Department of Fish and Wildlife land surveyors in February, 2008. Survey data was provided in NAVD 29. Additional vertical and horizontal data was obtained from the aerial mapping provided with the 2005 FIS workmaps. The aerial mapping data was created by Triathlon, Inc. from aerial photographs taken 1998. Aerial mapping data was provided in NAVD 29. The conversion to from NGVD 29 to NAVD 88 was taken to be 3.49 ft, as was used by 2005 FIS.

Results

The results from the EC model is are summarized in **Tables 3**. Profile and cross-section plots from the HEC-RAS model and more detailed output information can be provided upon request.

PROPOSED CONDITIONS MODEL

The proposed conditions (PC) model was created by modifying the existing conditions model to reflect proposed improvements to the Voights Creek hatchery. Existing conditions cross sections were modified to reflect cut/fill regions, removal of existing structures, additions of new structures, changes in Manning's n values due to the proposed changes (paving, landscaping, etc.), and changes to the conveyance shadow related to the existing and proposed structures. All other model parameters are identical to the EC model. Drawings detailing the specific improvements to the hatchery are included within the **Appendix**.

Table 3 - EC Model Results for 100-yr Profile

FIS River Station	Section Label	Hatchery Analysis River Station	WSEL (ft-NGVD29)
3	VF	12562	228.524
	L	12506	228.337
	K	12401	227.979
	J	12364	227.990
	I	12308	227.737
	H	12270	227.664
	G	12201	227.698
	F	12171	227.649
	E	12063	227.608
	D	11852	227.606
	C	11771	227.608
	B	11702	227.600
	A	11575	227.588
2.1	VE	11088	227.510

The proposed improvements will include the following elements:

- Replacing the existing earthen adult holding pond with two new parallel concrete ponds in roughly the same location (Top Elevation = 230 ft);
- Constructing a new fish ladder connecting Voights Creek to the new adult holding ponds;
- Stream bank restoration adjacent to the fish ladder to improve aesthetic and habitat values;
- Constructing a dedicated spawning shed adjacent to the new adult holding ponds;
- Constructing a new pump station to serve the new adult holding ponds;
- Creating a new stormwater bio-infiltration swale at the site of the existing pollution abatement pond to protect water quality;
- Constructing a new pollution abatement pond (Top Elevation = 230 ft);
- Removing the existing 1917 residence;
- Removing the material stockpile near proposed pollution abatement pond.
- Installing two new stormwater detention rain gardens within the footprints of the existing adult holding pond, which is to be replaced, and 1917 residence, which is to be removed.
- Replacing the two rearing ponds with two new 42-ft by 140-ft rearing ponds in approximately the same location (Top Elevation = 230 ft); and
- Comprehensive landscaping throughout the site using native species.

Results

The results from the PC model are summarized in **Tables 4**. Comparison between EC and PC model results indicates the proposed improvements will cause a rise in excess of the 0.001 ft tolerance at five sections. The maximum amount of rise computed is 0.167 ft at RS 12506. With an exception to the five sections where a rise is expected to occur, the PC model results generally match or are slightly lower than the EC model. The PC model results also indicate a slight reduction in the energy grade elevation (0.001-0.01 ft) from RS 11088 to 12270 and a slight increase (0.10 ft) at RS 12308 and above. Profile and cross-section plots from the HEC-RAS model and more detailed output information can be provided upon request.

Table 4 – PC Model Results and Comparison with EC Results

			WSEL		
FIS River Station	**Section Label**	**Hatchery Analysis River Station**	**Existing Conditions, EC**	**Proposed Conditions, PC**	**Difference (ft)**
			(ft-NGVD29)	(ft-NGVD29)	
3	**VF**	**12562**	**228.524**	**228.651**	**0.127**
	L	**12506**	**228.337**	**228.504**	**0.167**
	K	**12401**	**227.979**	**227.985**	**0.006**
	J	12364	227.990	227.978	-0.012
	I	12308	227.737	227.693	-0.044
	H	**12270**	**227.664**	**227.668**	**0.004**
	G	12201	227.698	227.687	-0.011
	F	12171	227.649	227.645	-0.004
	E	12063	227.608	227.607	-0.001
	D	**11852**	**227.606**	**227.607**	**0.001**
	C	11771	227.608	227.606	-0.002
	B	11702	227.600	227.598	-0.002
	A	11575	227.588	227.588	0.000
2.1	VE	11088	227.510	227.510	0.000

PROPOSED CONDITIONS ALTERNATIVE MODEL

The proposed conditions alternative (PC_ALT) model reflects changes to the PC geometry and represents efforts to eliminate or minimize impacts to the 100-yr EC WSEL related to the proposed improvements at the Voights Creek hatchery. Cross sections were modified by GeoEngineers to reflect changes to cut/fill regions, locations of new structures, and changes to the conveyance shadow related to the existing and proposed structures. All other model parameters are identical to the EC and PC model.

The specific modifications to proposed improvements include the following elements:

- Moving and rotating the adult holding pond between raceway and hatchery office building (Top Elevation=230 ft)

- Moving the pump house for the adult holding pond behind the existing raceway and proposed parallel concrete ponds.
- Moving the proposed parallel concrete ponds 18 ft to the northwest (Top Elevation = 230 ft);

Results

The results from the PC_ALT model are summarized in **Table 5**. Comparison between EC and PC_ALT model results indicates the proposed improvements will cause a rise in excess of the 0.001 ft tolerance at five sections. The maximum amount of rise computed is 0.025ft at RS 12506. With an exception to the five sections where a rise is expected to occur, the PC_ALT model results generally match or are slightly lower than the EC model. The PC_ALT model results also indicate a slight reduction in the energy grade elevation (0.001-0.01 ft) from RS 11088 to 12201 and an increase (0.02 ft) at RS 12270 and above. While the PC_ALT model reflects a rise in excess of 0.001 ft, the alternative conditions does reduce the maximum and average impact to the base flood profile from the original proposed conditions. Profile and cross-section plots from the HEC-RAS model and more detailed output information can be provided upon request.

Table 5 – PC_ALT Model Results and Comparison with EC Results

			WSEL		
FIS River Station	**Section Label**	**Hatchery Analysis River Station**	**Existing Conditions, EC (ft-NGVD29)**	**Proposed Conditions Alternative, PC_ALT (ft-NGVD29)**	**Difference (ft)**
3	**VF**	**12562**	**228.524**	**228.390**	**0.018**
	L	**12506**	**228.337**	**228.121**	**0.025**
	K	**12401**	**227.979**	**227.981**	**0.014**
	J	12364	227.990	227.970	-0.012
	I	**12308**	**227.737**	**227.737**	**0.002**
	H	12270	227.664	227.657	-0.006
	G	12201	227.698	227.678	-0.018
	F	12171	227.649	227.643	-0.003
	E	12063	227.608	227.606	-0.001
	D	**11852**	**227.606**	**227.606**	**0.001**
	C	11771	227.608	227.604	-0.002
	B	11702	227.600	227.596	-0.002
	A	11575	227.588	227.586	0.000
2.1	VE	11088	227.510	227.510	0.000

SUMMARY

Based on our hydraulic evaluation of the flood flows from the Carbon River in the vicinity of Voights Creek, we conclude that improvements proposed for the WDFW Voights Creek Hatchery will create a rise (>0.001 ft) in the base flood elevations at five sections within the deep and fast flowing area of the Carbon River floodplain as defined by Pierce County.

While the results of the proposed condition and proposed alternative indicate the improvements to the Voights Creek Hatchery will cause a rise (>0.001 ft) in the base flood elevations, GeoEngineers is pursuing options with WDFW with the goal of eliminating a rise in excess of 0.001 ft and minimizing any impact to adjacent property owners. For more information on these efforts please refer to the letter titled "Addendum to Summary Letter" by GeoEngineers and dated February 25, 2009.

REFERENCES

Barnes, H.H. 1967. Roughness Characteristics of Natural Channel. U.S. Geological Survey, Water Supply Paper 1849, Washington D.C.

Brunner G.W. 2008. HEC-RAS River Analysis System Hydraulic Reference Manual, U.S. Army Corps of Engineers' Hydraulic Engineering Center; Davis, CA.

Chow, V.T. 1959. Open Channel Hydraulics, McGraw-Hill Book Company, NY.

NHC. 2005. Flood Insurance Mapping Study for the Carbon River Mile 8.4 to the Puyallup River. Seattle, WA.

Pierce County Planning and Land Services. 1986. Pierce Code of Regulations. Pierce County, Washington

It was a pleasure to work with you on this project. If you have any questions regarding this summary letter, please contact us.

Sincerely,

GeoEngineers, Inc.

R. Leif Embertson, PE
River Engineer

Jeffrey J. Fealko, PE
Project Manager

Mary Ann Reinhart, LG, LEG
Associate – Fluvial Geomorphologist & Geologist

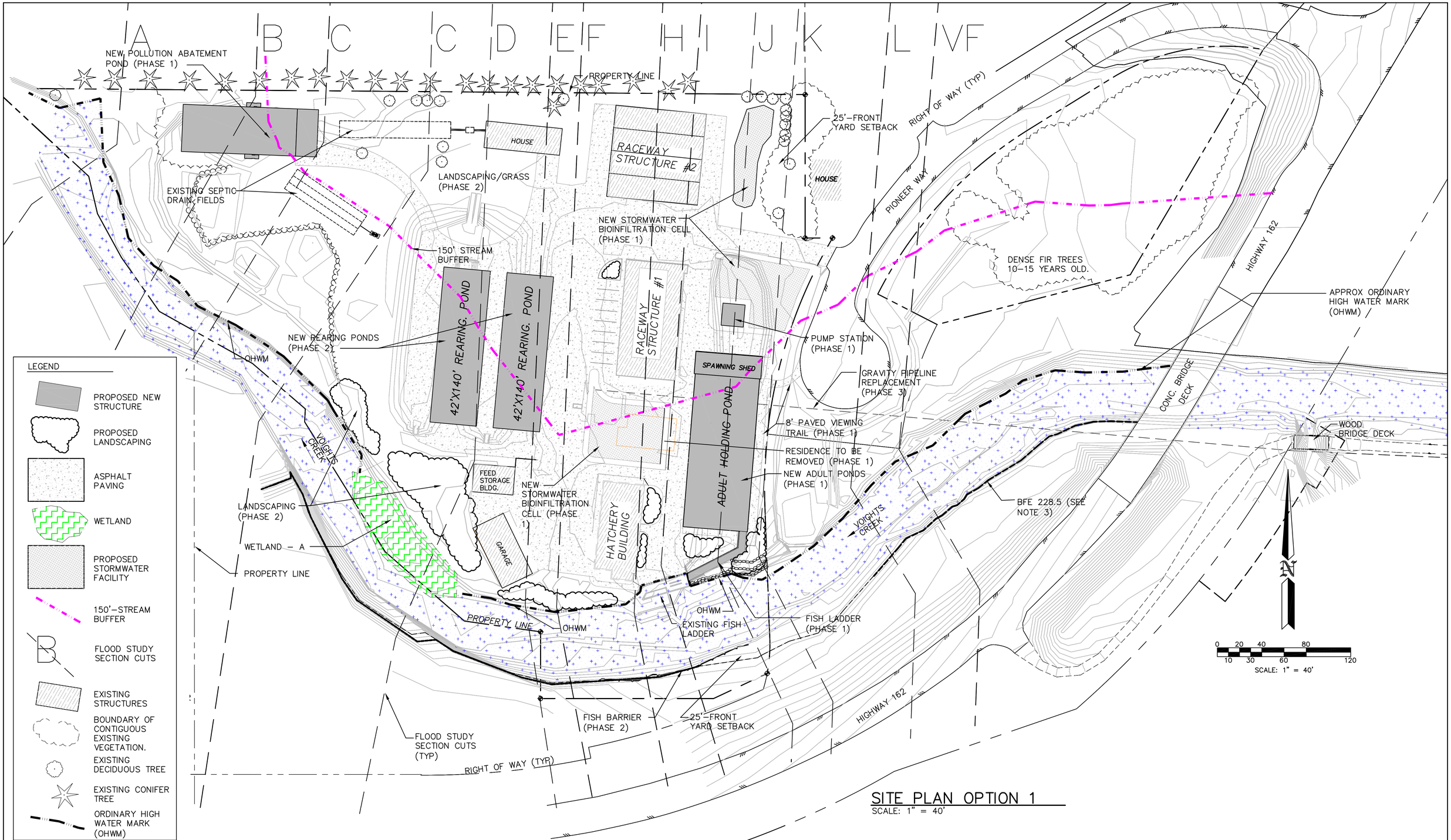
RLE:MAR:ims
BELL:\3\3730099_Boise\01\Finals\3730099_LR D1.doc

Disclaimer: Any electronic form, facsimile or hard copy of the original document (email, text, table, and/or figure), if provided, and any attachments are only a copy of the original document. The original document is stored by GeoEngineers, Inc. and will serve as the official document of record.

GeoEngineers

Appendix

Flood Study Options and Water Surface Summary



SITE PLAN OPTION 1

SCALE: 1" = 40'

USER: swradford

FILE: \\Usea5s01\BU20801\Projects\WDFW\Voights Creek Renovation - Ph 1\07 Design Phase\7.7 Drawings\PermittingSchematicSiteDesign\MODEL\VCH Phase1_2_RevisedSiteDesign.dwg

MWH

WASHINGTON STATE DEPARTMENT OF FISH AND WILDLIFE

SYM	DATE	REVISION DESCRIPTION	BY

APPROVED AND RELEASED FOR CONSTRUCTION

CHIEF ENGINEER ..... DATE: .....

PROGRAM ..... DATE: .....

0 — 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

DESIGNED BY S. RADFORD
CHECKED BY C. CUTTING
DRAWN BY S. RADFORD
DATE JANUARY 2009

VOIGHTS CREEK HATCHERY

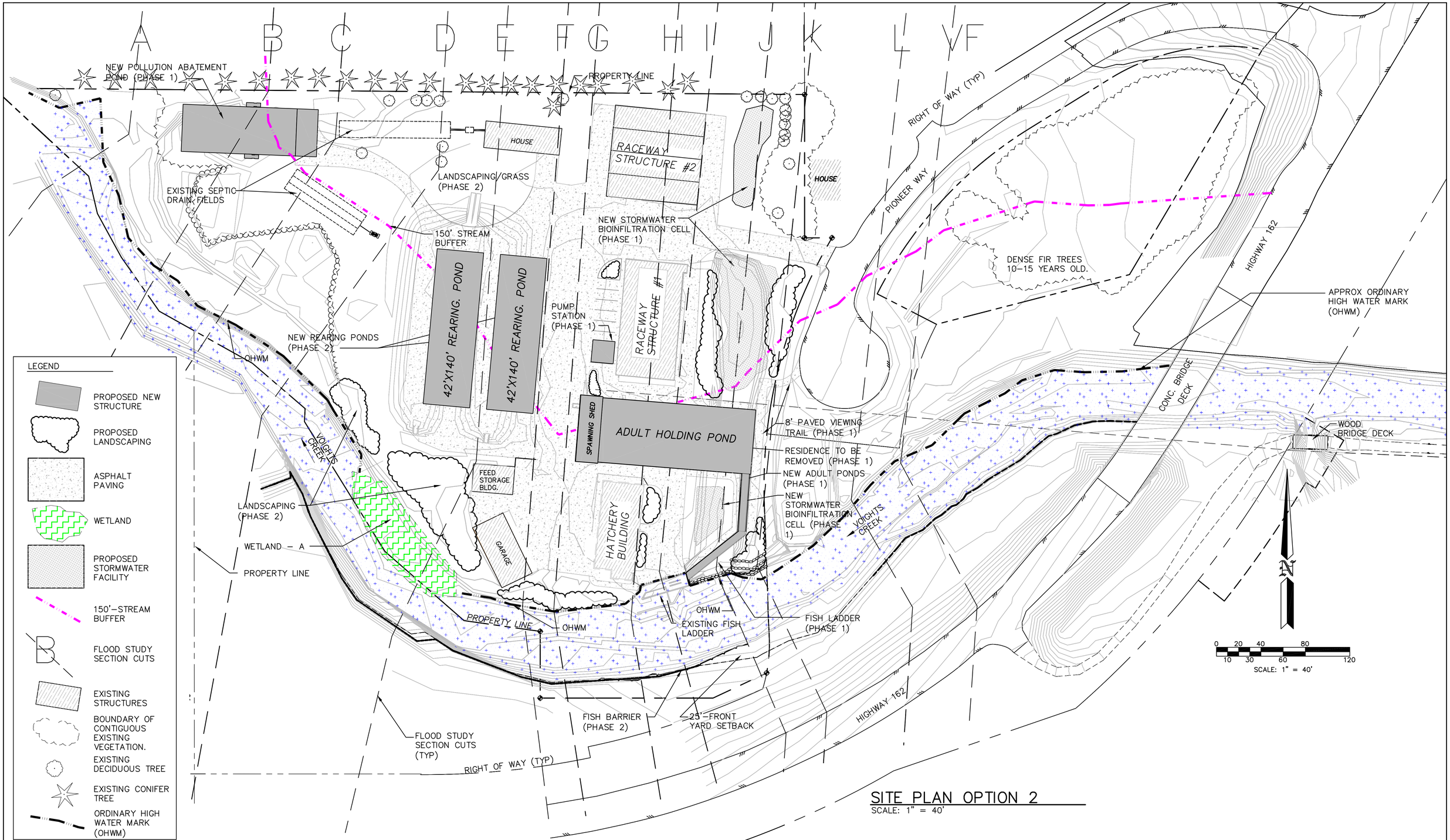
HATCHERY RENOVATION

FLOOD STUDY – ZERO RISE ANALYSIS

SITE OPTION 1

PROJECT NO. PE: H8:08-1

SHEET 1 OF 2



SITE PLAN OPTION 2

SCALE: 1" = 40'

FILE: \\ussea5s01\BU20801\Projects\WDFW\Voights Creek Renovation - Ph 1\07 Design Phase\7.7 Drawings\PermittingSchematicSiteDesign\MODEL\VCH Phase1_2_RevisedFloodStudyDesign.dwg USER: swradford DATE: Feb 17,2009 - 7:16am

MWH

WASHINGTON STATE
DEPARTMENT OF FISH AND WILDLIFE

SYM	DATE	REVISION DESCRIPTION	BY

APPROVED AND RELEASED FOR CONSTRUCTION

CHIEF ENGINEER ..... DATE: .....
PROGRAM ..... DATE: .....

0 — 1"
BAR MEASURES ONE INCH ON ORIGINAL DRAWINGS

DESIGNED BY S. RADFORD
CHECKED BY C. CUTTING
DRAWN BY S. RADFORD
DATE FEBRUARY 2009

VOIGHTS CREEK HATCHERY
HATCHERY RENOVATION
FLOOD STUDY ZERO RISE ANALYSIS
SITE OPTION 2

PROJECT NO. PE: H8:08-1

SHEET 2 OF 2

Energy Grade Results for Proposed Improvements to Voights Creek Hatchery

2005 FIS		Hatchery Analysis		Water Surface Elevation*					Difference		
River Station	***Section Label***	***River Station***	***Section Label***	***DE***	***EC***	***PC***	***PC_ALT***		***EC-DC***	***PC-EC***	***PC_ALT-EC***
3	VF	12562	VF	229.170	228.524	228.651	228.542		-0.646	**0.127**	**0.018**
		12506	L		228.337	228.504	228.362			**0.167**	**0.025**
		12401	K		227.979	227.985	227.993			**0.006**	**0.014**
		12364	J		227.990	227.978	227.978			-0.012	-0.012
		12308	I		227.737	227.693	227.739			-0.044	**0.002**
		12270	H		227.664	227.668	227.658			**0.004**	-0.006
		12201	G		227.698	227.687	227.680			-0.011	-0.018
		12171	F		227.649	227.645	227.646			-0.004	-0.003
		12063	E		227.608	227.607	227.607			-0.001	-0.001
		11852	D		227.606	227.607	227.607			**0.001**	**0.001**
		11771	C		227.608	227.606	227.606			-0.002	-0.002
		11702	B		227.600	227.598	227.598			-0.002	-0.002
		11575	A		227.588	227.588	227.588			0.000	0.000
2.1	VE	11088	VE	227.510	227.510	227.510	227.510		0.000	0.000	0.000

** All Elevations Reference NGVD 29 ft vertical datum*

Energy Grade Results for Proposed Improvements to Voights Creek Hatchery

2005 FIS		Hatchery Analysis		Energy Surface Elevation*					Difference		
River Station	***Section Label***	***River Station***	***Section Label***	***DE***	***EC***	***PC***	***PC_ALT***		***EC-DC***	***PC-EC***	***PC_ALT-EC***
3	VF	12562	VF	229.349	228.834	228.928	228.848		-0.515	**0.094**	**0.014**
		12506	L		228.644	228.768	228.662			**0.124**	**0.018**
		12401	K		228.248	228.345	228.268			**0.097**	**0.020**
		12364	J		228.165	228.219	228.176			**0.054**	**0.011**
		12308	I		228.093	228.115	228.093			**0.022**	0.000
		12270	H		227.980	227.969	227.981			-0.011	**0.001**
		12201	G		227.833	227.829	227.827			-0.004	-0.006
		12171	F		227.805	227.800	227.798			-0.005	-0.007
		12063	E		227.738	227.734	227.734			-0.004	-0.004
		11852	D		227.685	227.681	227.681			-0.004	-0.004
		11771	C		227.653	227.651	227.651			-0.002	-0.002
		11702	B		227.641	227.640	227.640			-0.001	-0.001
		11575	A		227.626	227.626	227.626			0.000	0.000
2.1	VE	11088	VE	227.543	227.547	227.547	227.547		0.004	0.000	0.000

** All Elevations Reference NGVD 29 ft vertical datum*