

Appendix F

Addendum to Hydrologic and
Hydraulic Analysis of Kunzler
Ranch Gravel Extraction
Project



SWANSON HYDROLOGY + GEOMORPHOLOGY



Addendum 1

Addendum to Hydrologic and Hydraulic Analysis of Kunzler Ranch Gravel Extraction Project

prepared for Granite Construction Company

Prepared by Matt Weld, C.E.

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OCTOBER 2008

I. Project Understanding

Citing concerns with long term maintenance of “engineered” flow control structures on off-channel terrace mines, and the lack of deep coldwater refugia for salmonids along the main branch of the Russian River, NOAA Fisheries has requested that Granite analyze the feasibility of alternative reclamation plans that would provide increased connectivity between the Russian River and the proposed Kunzler Terrace Mine. Specifically, NOAA Fisheries has requested that Granite analyze the engineering feasibility and potential benefits to salmonid habitat of lowering a portion of the bank of the Russian River to create a stable connection channel with the mine pond at an elevation that would be inundated approximately 100 days per year, on average.

Swanson Hydrology and Geomorphology (SH+G) has been retained by Granite to identify alternative reclamation plan configurations and to evaluate their feasibility with regard to:

1. Pond-river connection design, hydraulic performance, flood control, and stability;
2. Maintenance and natural lifecycle of the connection channel; and
3. Compatibility with the currently proposed mining and reclamation plan.

This report was prepared as an addendum to the Hydrologic and Hydraulic Analysis of Kunzler Ranch Gravel Extraction Project (SH+G, 2007), and will address items 1 through 3 listed above.

II. Alternative Reclamation Plan Configurations

Option 1: The plan described in the Hydrologic and Hydraulic Analysis of Kunzler Ranch Gravel Extraction Project (Hydraulic Report) will be referred to as Option 1. This option has the terrace mine set back from the top of bank by a minimum of 250 feet along the Russian River and 150 feet along Ackerman Creek. Floodplain enhancement features are proposed to Ackerman Creek and a segment of the Russian River frontages to improve habitat for salmonids. An “engineered” flow control structure (weir & fuse plug) is proposed along Ackerman Creek to convey flood waters into the pond in a controlled manner. The weir and fuse plug are set at an elevation to provide a connection between the terrace mine and Ackerman Creek at floods exceeding the 20-year event. The goal of the engineered weir and fuse plug is to provide structural protection of the pond while maximizing isolation from the river in order to reduce the likelihood of fish capture within the mine pond. Further details are provided in the Hydraulic Report.

Option 2: Option 2 provides a single connection channel from the mine pond to the Russian River at the downstream extent of the pond. The connection channel will be designed to provide a hydraulic connection for approximately 100 days/year to provide access to an area of refuge for salmonids. This option includes the floodplain enhancement features along Ackerman Creek and the Russian River, as described in Option 1, but omits the fuse plug and weir.

Option 3: Option 3 lowers the bank height within the setback area along the Russian River in addition to a connection channel from the mine pond to the Russian River at the downstream extent of the terrace mine. As in Option 2, the connection channel will be designed to provide a hydraulic connection for approximately 100 days/year to provide access to an area of refuge for salmonids. This option includes the floodplain enhancement features along Ackerman Creek and the Russian River, as described in Option 1, but omits the fuse plug and weir.

Conceptual plans for Options 2 and 3 are presented in **Appendix A**. Refer to the Hydraulic Report for detailed plans of Option 1.

III. Hydrologic Analysis

Additional hydrologic analysis was required to evaluate the proposed reclamation plan alternatives (Options 2 & 3). Annual exceedence flows and 2-year peak flow calculations were required to determine bench elevations and pond connection channel inverts, respectively. Additionally, 100-year flood hydrographs calculated in the previous Hydraulic Report had to be adjusted to better represent the lower range of flows that would first inundate the proposed connection channel in options 2 and 3. Hydrologic methods used for developing annual exceedence, 2-year peak flows, and adjusted flood hydrographs are described in detail below.

Annual Exceedence Flows

The 27.4% exceedence probability flows (flows which are exceeded approximately 100 days/year) were calculated from the mean daily flow record for the USGS gage on the Russian River near Hopland (gage #11462500). Gage data used in the analysis contained mean daily flow records from October 1939 to July 2008. The record flows were reduced by the ratio of the project site drainage areas to the gage drainage area (A_{site}/A_{gage}) to obtain the design flows for the site. USGS gage #11461000 (Russian River near Ukiah) is located closer to the site, but does not include releases from Lake Mendocino and was therefore not used in the analysis. Exceedence flows used in the hydraulic analysis are presented below in **Table 1**.

Table 1. 27.4% Annual Exceedence Flows (flow that is exceeded 100 days/year).			
Russian River Near Hopland Gage (D.A. = 362 sq.mi.)	Russian River upstream of Ackerman Creek (D.A. = 215 sq.mi.)	Russian River downstream of Ackerman Creek (D.A. = 236.7 sq.mi.)	Ackerman Creek at confluence with Russian River (D.A. = 21.7 sq.mi.)
476 cfs	283 cfs	311 cfs	28 cfs

*D.A. = Drainage Area

2-year Peak Discharges

The 2-year peak flow for the Russian River adjacent to the project site was calculated using a Log Pearson Type III flood frequency analysis of annual peak flows recorded at the Hopland gage. The gage record includes 68 annual peak flows recorded from 1940 to 2007. The calculated 2-year peak flow at the gage site was then reduced by the ratio of the project site drainage area to the gage drainage area (A_{site}/A_{gage}) to estimate the 2-year peak flow for the project site.

The 2-year peak flow for Ackerman Creek at the confluence of the Russian River was calculated using the Regional Regression equations developed by the USGS for the North Coast Region (Waananen & Crippen, 1977). Details are provided in **Appendix B**. Parameters used in the equation include the drainage area, the mean annual precipitation, and average of altitudes along the main channel at 10 percent and 85 percent of the distance from the project site to the divide.

The results of this analysis are presented in **Table 2**.

Table 2. 2-year Peak Flows			
Hopland Gage (D.A. = 362 sq.mi.)	Russian River upstream of Ackerman Creek (D.A. = 215 sq.mi.)	Russian River downstream of Ackerman Creek (D.A. = 236.7 sq.mi.)	Ackerman Creek at confluence with Russian River (D.A. = 21.7 sq.mi.)
16,035 cfs	9,524 cfs	10,485 cfs	1,473 cfs

*D.A. = Drainage Area

100-year Flood Hydrographs

A combined 100-year flood hydrograph was developed for the Russian River and Ackerman Creek and used for analysis of the Option 1 reclamation plan configuration, as described in the Hydraulic Report. This hydrograph was extrapolated to include lower flows so that the hydraulic modeling results would include water surfaces below the 27.4% exceedence elevations. The resulting hydrographs are presented in **Figure 1**.

IV. Hydraulic Analysis

Hydraulic analysis of the project site required the use of both steady-state and unsteady (time varied) analysis. These analyses were performed using HEC-RAS Version 4.0 Beta (USACE, 2006b). Steady-state analysis was used to determine the optimal elevation for the connection channel for options 2 and 3, and the 2-year terrace bench elevations along the Russian River for option 3. Unsteady analysis was used to evaluate the hydraulics of the pond connection channel and the resulting water surface elevations within the mine pond, Russian River, and Ackerman Creek, throughout the 100-year hydrograph. The unsteady model also provided data necessary to evaluate hydraulic forces occurring within the

connection channel to estimate erosion and/or sedimentation potential during the rising and falling limb of the 100-year design hydrograph.

Proposed Option 2 and 3 Models

To create the Options 2 and 3 HEC RAS models, the Option 1 HEC RAS model (described in the Hydraulic Report) was modified by removing the Ackerman Creek weir and fuse plug, adding the connection channel geometry (Option 2 and 3), and lowering the elevation of the setback area along the Russian River (Option 3, only). (**Appendix A**).

The pond was modeled in HEC-RAS by connecting a “storage area” to the Russian River via a lateral structure (**Figure 2**). The available pond storage volume (473 acre-ft) was calculated based on water surfaces within the pond ranging from the estimated winter low water surface elevation (592 feet) and the elevation at which floodwater would overtop the rim of the setback area and return to the Russian River (611 feet) for Options 1 and 2. This volume is approximate and would be slightly less for Option 3. However, to be conservative with respect to the hydraulic forces, the greater pond volume was used in the hydraulic modeling of both Options 2 and 3. Interior slopes of the terrace mine were assumed to be 2.5H:1V along the Russian River and Ackerman Creek and 2H:1V for the remainder of the pond.

The connection channel was modeled as a lateral structure with side slopes of 4 horizontal to 1 vertical, and a discharge coefficient of 2.6, and with several width combinations to evaluate the hydraulic stresses on the channel during the rising and falling limbs of the design hydrograph.

Seepage rates and related impacts on water storage were found to be negligible in the hydraulic modeling of Option 1 and would remain unchanged for Options 2 and 3.

V. Hydraulic Results

27.4% Annual Exceedence Flow

The HEC RAS model calculated a water surface elevation of 592.3 for the 27.4% annual exceedence flow at the lower portion of the pond along the Russian River. A connection channel with an invert at this elevation would connect the pond to the Russian River for approximately 100 days per year, as suggested by NOAA fisheries. The resulting water surface profile is shown in **Figure 3**.

2-year Peak Flow

Water surface elevations along the Russian River range from approximately 604 feet to 607 feet for the 2-year peak flow event (**Figure 3**). Option 3 would lower the top of bank of the setback area along the Russian River to roughly match these elevations (**Appendix A**).

100-year Flow

Option 2

Hydraulic modeling results for connection channels with base widths of 20 feet and 80 feet are presented in **Table 3** below.

Table 3. Option 2 Hydraulic Results		
Pond Connection Channel Base Width	Max. Velocity Within Pond Connection Channel	Max Water Surface Difference Across Channel
20 ft	4.9 ft/s	1.5 ft
80 ft	2.9 ft/s	0.3 ft

Maximum velocities within the connection channel during the 100-year design flood were calculated to be between 3 ft/s and 5 ft/s for the 20 ft and 80 ft base widths, respectively. Increasing the base width of the connection channel to over 80 feet would provide a greater reduction in velocities, but would increase the risk of siltation of the connection channel invert. Velocities in the range of 3-5 feet per second would be capable of preventing fine silts from settling within the channel, while still keeping erosive forces in the range that could be treated with bio-mechanical means.

The Option 2 design would not require the construction of the engineered weir and fuse plug to dissipate hydraulic forces. During the rising limb of the 100-year hydrograph, the calculated maximum difference between the water surface elevations of the pond and the Russian River was 1.5 ft for a 20 ft base width connection channel and 0.3 ft for an 80 ft base width, respectively. This greatly diminished head differential, relative to Option 1, results in a far more stable configuration, eliminating the need for the weir and fuse plug.

Overtopping of the channel banks would initially occur near the confluence of Ackerman Creek where the maximum elevation of the right over-bank area is 613.0 feet (**Figure 4**). At the time of overtopping, the pond is filled to the elevation of the Russian River at the connection channel, which is just 2.4 feet below the top of bank along the Ackerman Creek. The improved connectivity of the pond created by the connection channel allows the pond water surface to quickly adjust to changing river stages, thereby minimizing the potential for erosion of the pond wall and eliminating the need for an engineered flow structure.

Option 3

Hydraulic results for base widths of 20 and 80 feet are presented in **Table 4** below.

Table 4. Option 3 Hydraulic Results		
Pit Connection Channel Base Width	Max. Velocity Within Pit Connection Channel	Max Water Surface Difference Across Channel
20 ft	4.9 ft/s	1.6 ft
80 ft	2.9 ft/s	0.3 ft

For Option 3, velocities and water surface differences are similar to those calculated for Option 2.

Overtopping of the channel banks would first occur along the Russian River where the top of bank has been lowered to match the 2-year water surface elevation. Overtopping of the channel banks along Ackerman Creek will not occur during the 100-year design flow (**Figure 5**). As with Option 2, an engineered weir and fuse plug is unnecessary in Option 3 due to the increased stability provided by the pond-river connection channel.

VI. Observation and Natural Lifecycle of the Connection Channel

Options 2 and 3 would require periodic observation to determine whether any long-term maintenance of the pond-river connection channel would be required.

The connection channel is designed with a base width of 20-30 feet to operate with a self-flushing velocity under the design flood event. However, some siltation and or debris clogging may occur as a natural process during smaller events. Over time, these deposits may increase the connection channel's base elevation and decrease the connectivity of the pond with the Russian River. If periodic observation shows that sediment and debris are altering the geometry of the connection channel, an analysis would be required to determine whether these changes would be detrimental to the goals of the reclamation, or whether they could be allowed to continue as part of the pond's natural re-incorporation into the landscape.

VII. Design Recommendations

For either Option 2 or 3, it is recommended that the pond-river connection be set at a base elevation of 592.3 feet to satisfy NOAA Fisheries' recommendation that the pond be connected to the Russian River for approximately 100 days per year. The pond-river connection should be constructed with a base width of 20 to 30 feet to provide velocities capable of preventing fine silts from settling within the channel, yet still within the realm that could be handled by bio-mechanical treatments to prevent erosion. Some use of vegetated rock slope protection is recommended at the outlet of the connection channel (adjoining Russian River) to protect against anticipated flow separation and eddy currents.

In addition to the above, if Option 3 is selected, the bank elevation along the Russian River should be lowered to an elevation of 604 to 607 feet to match the 2-year peak flow event.

VIII. Conclusion

Hydraulic modeling of has revealed that the alternatives incorporating a pond-river connection (Options 2 and 3) are hydraulically more stable than Option 1 and would eliminate the need for an engineered weir and fuseplug along Ackerman Creek. The hydraulic analysis shows no adverse flooding impacts under any of the alternatives (**Figure 6**). Additionally, reclamation design Options 2 & 3 would eliminate the need for long-term maintenance requirements if the pond were allowed to incorporate into the natural landscape.

The proposed reclamation alternatives are feasible with respect to hydraulic performance, flood control, and pond stability, and are compatible with the currently proposed mining plan.

ADDENDUM 1
HYDROLOGIC AND HYDRAULIC ANALYSIS OF
KUNZLER RANCH GRAVEL EXTRACTION PROJECT

FIGURES

100-yr Flood Hydrographs

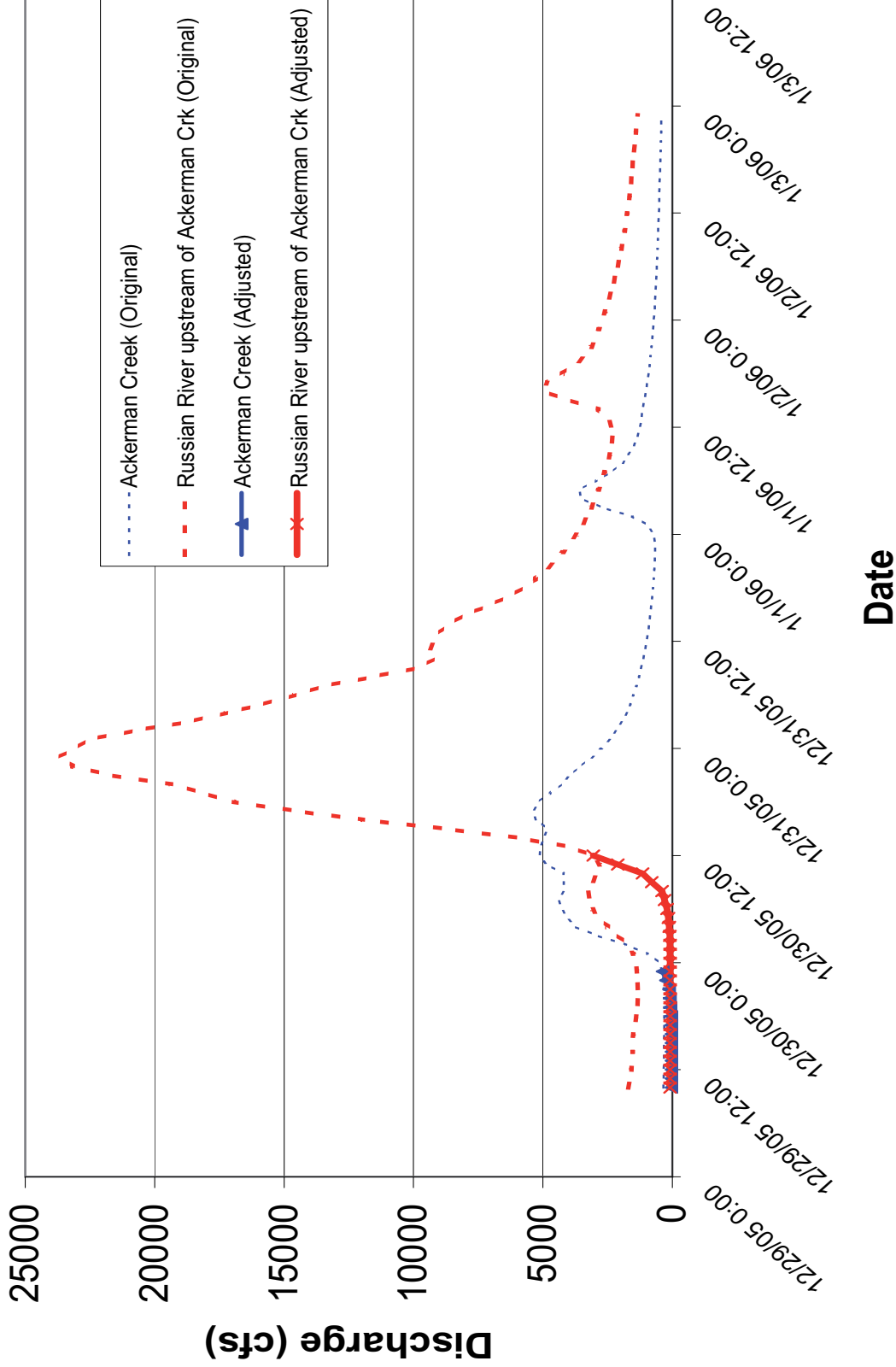


FIGURE 1: The 100-year design hydrographs were adjusted to include lower flows on the rising limb. Low flows were visually fit based on the slope of hydrographs calculated for modeling of Option 1 in the Hydrologic and Hydraulic Analysis of Kunzler ranch Gravel Extraction Project (SH+G, 2007).

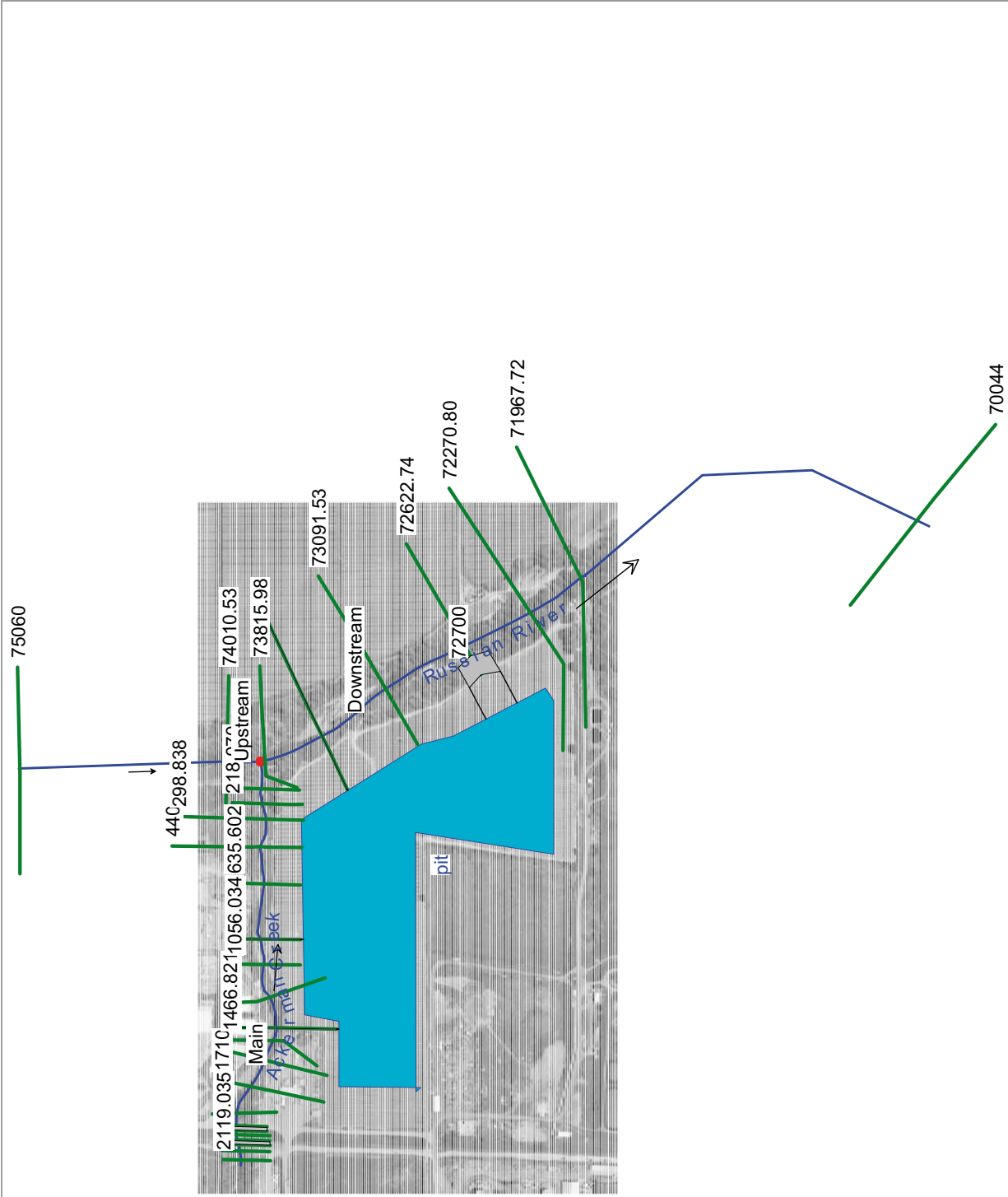


FIGURE 2: Plan view depicting Options 2 and 3 HEC-RAS cross section locations. Numbers represent river stations used in the HEC-RAS hydraulic model. Blue area represents extents of the proposed gravel pit mine. Photo coverage does not extend to the full extent of the hydraulic model.

Kunzler Ranch Gravel Extraction Project

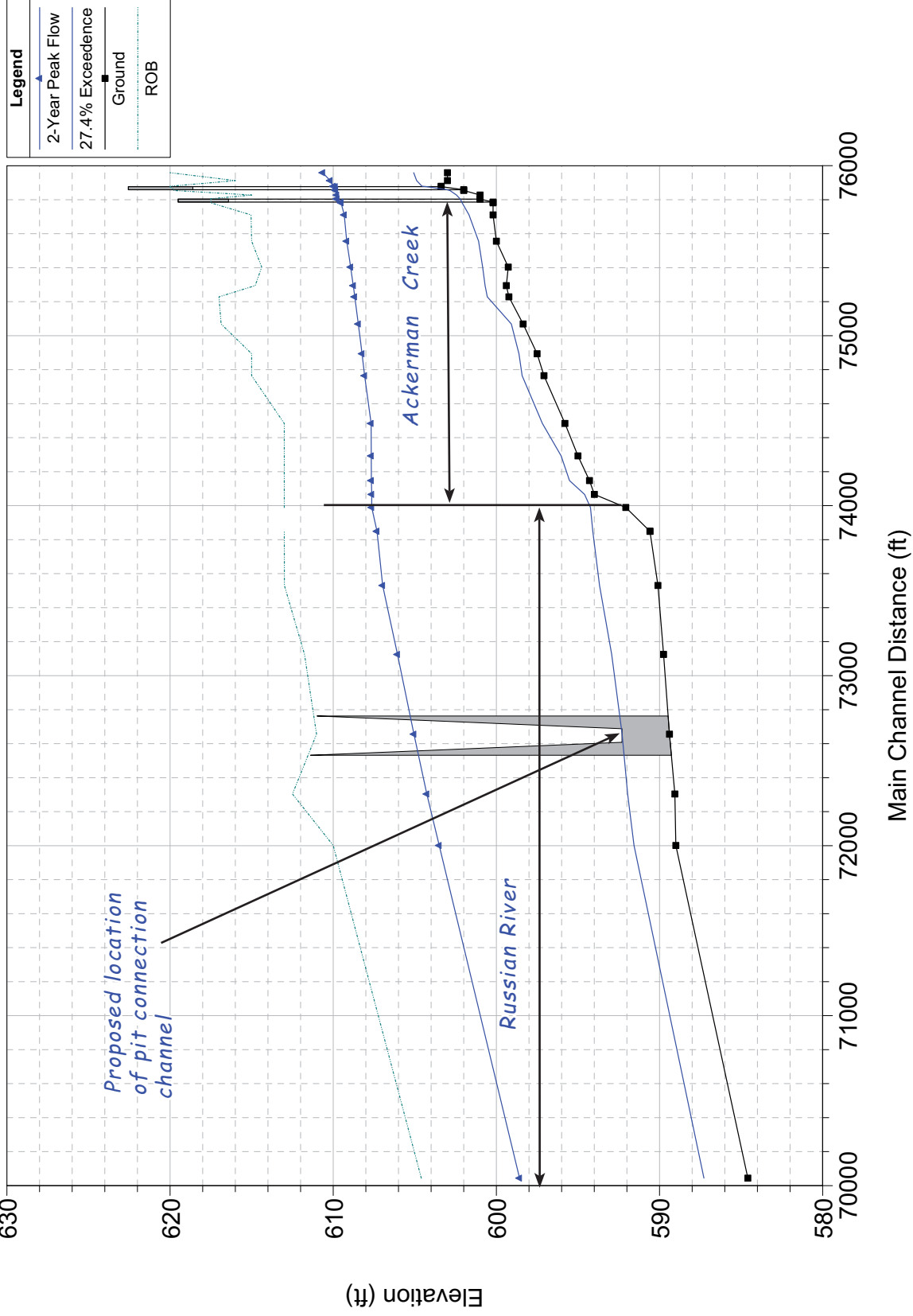


FIGURE 3: Water surface profiles for the 2-year and the 27.4% annual exceedance events. The proposed pit connection channel inverts would be set to approximately 592.3 feet for Options 2 and 3. Option 3 would also lower the top of bank along the Russian River to match the 2-year peak flow water surface profile adjacent to the pit.

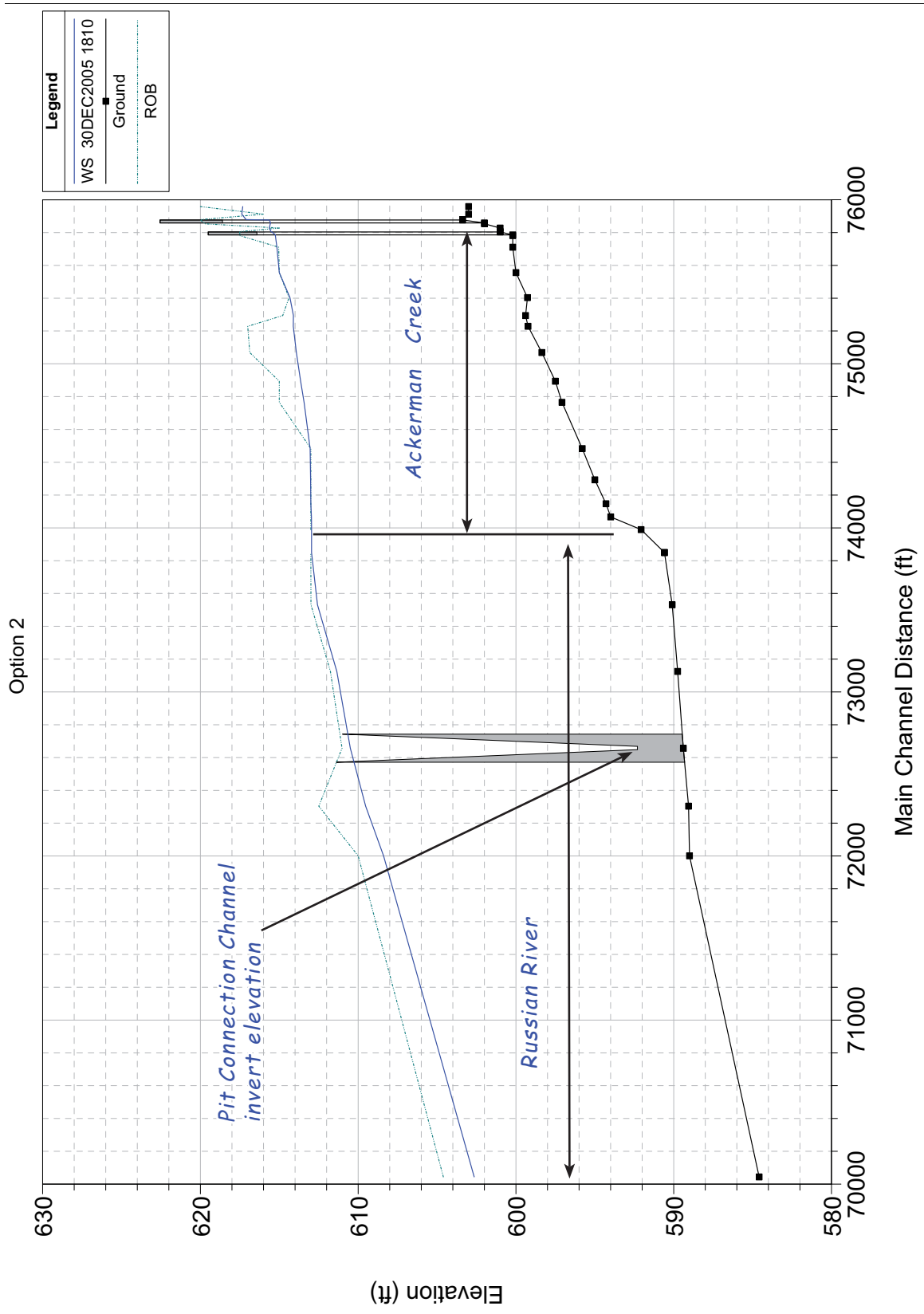


FIGURE 4: Option 2 water surface profile for the 100-year flood event when the flow in Ackerman Creek has just overtopped the right bank and the water surface elevation within the pit is approximately equal to the water surface elevation in the Russian River at the pit connection channel. The difference in these water surfaces is approximately 2.5 feet.

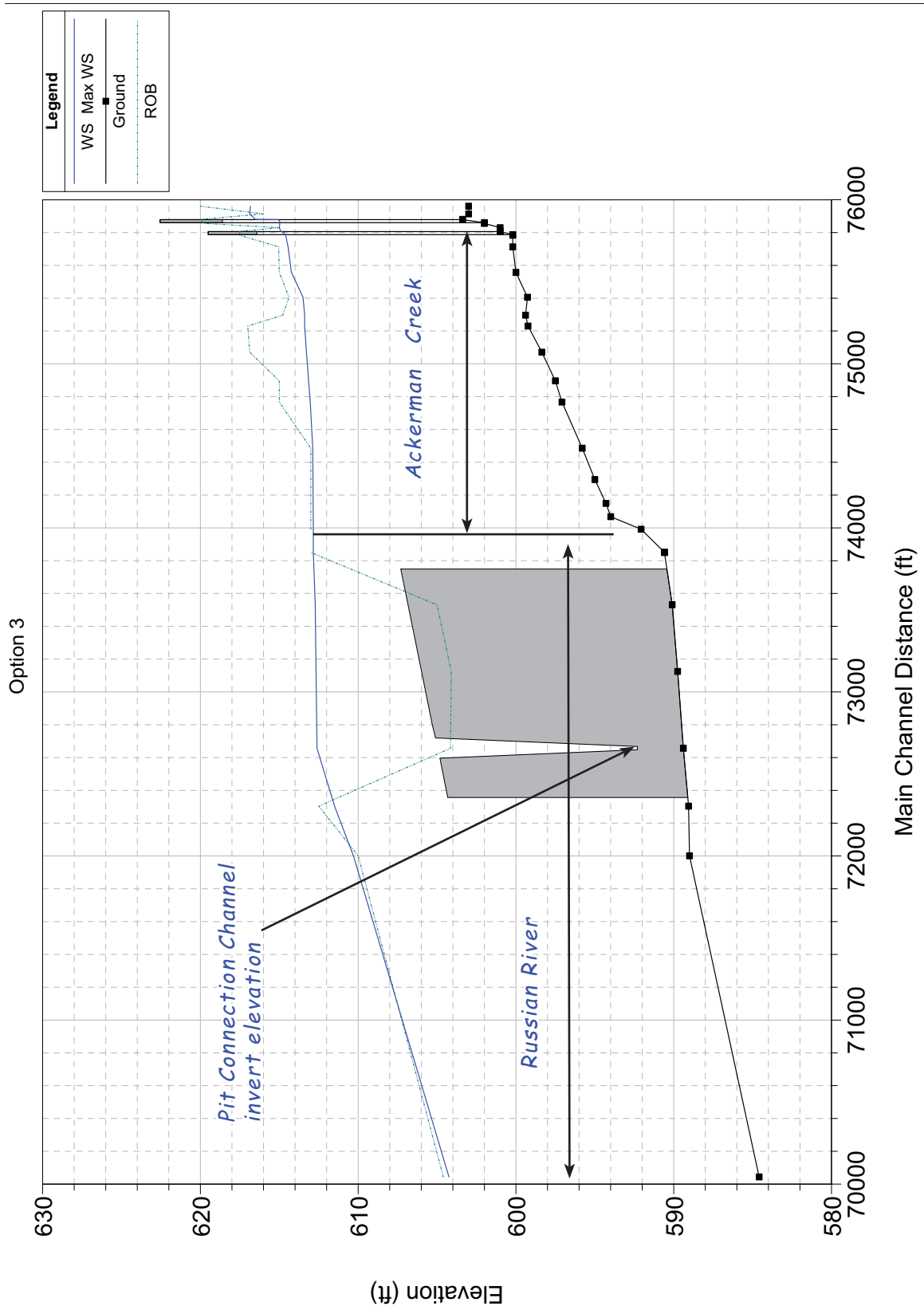


FIGURE 5: Option 3 peak water surface profile for the 100-year flood event. The flow in Ackerman Creek has not overtopped the right bank. The top of the grey structure represents the proposed top of bank along the Russian River.

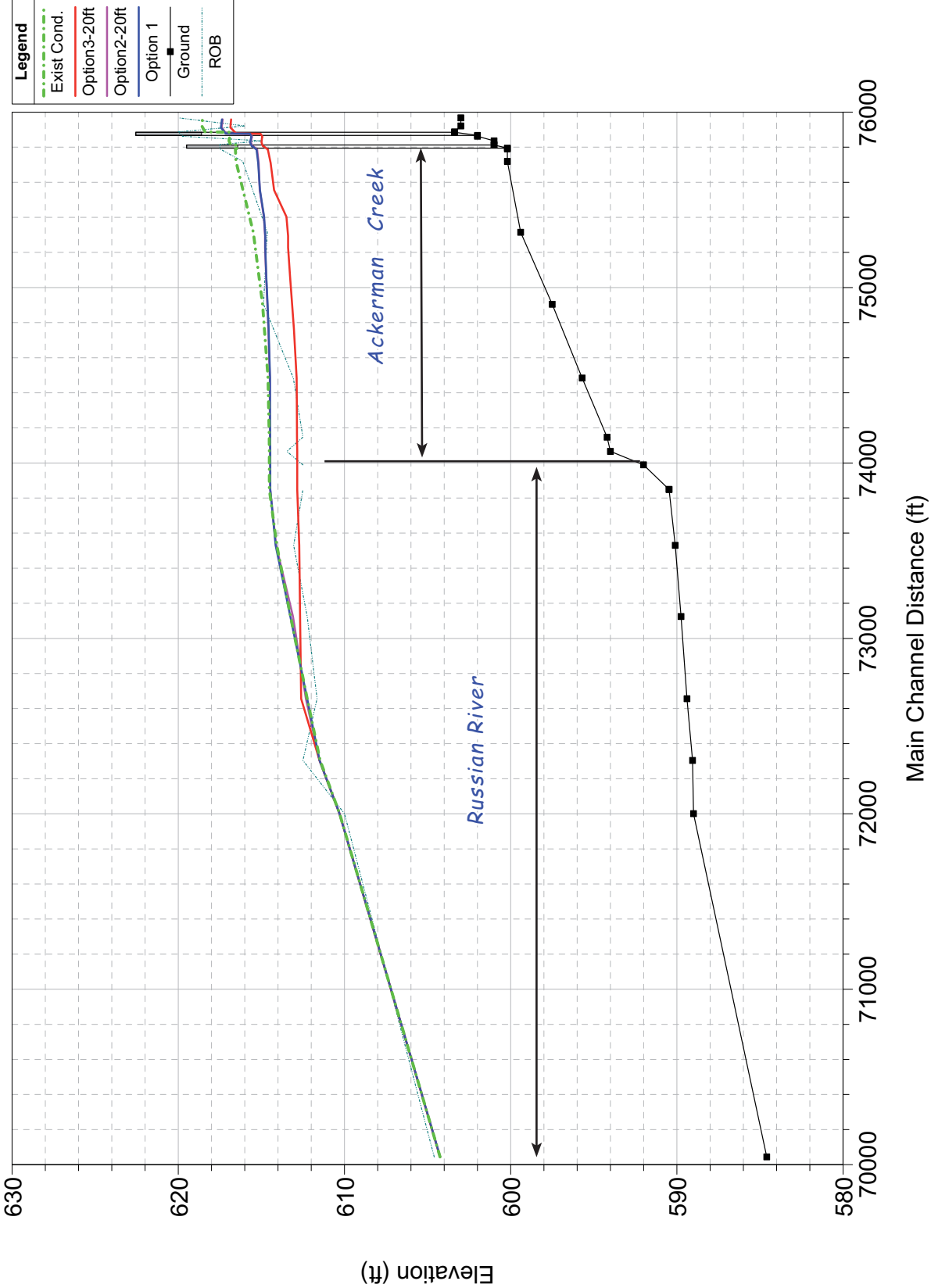


FIGURE 6: Water surface profiles depicting existing and proposed reclamation plan alternatives for the 100-year flood event.

ADDENDUM 1
HYDROLOGIC AND HYDRAULIC ANALYSIS OF
KUNZLER RANCH GRAVEL EXTRACTION PROJECT

APPENDIX A

GRADING SUMMARY

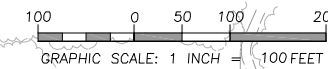
NATIVE CUT	55,000 CY
NATIVE FILL	0 CY
NET CUT	55,000 CY

THE ABOVE QUANTITIES ARE APPROXIMATE IN-PLACE VOLUMES CALCULATED FROM THE EXISTING GROUND TO THE PROPOSED FINISH GRADE. EXISTING GROUND IS DEFINED BY THE TOPOGRAPHIC CONTOURS AND/OR SPOT ELEVATIONS ON THE PLAN. PROPOSED FINISH GRADE IS DEFINED AS THE DESIGN SURFACE ELEVATION OF EARTH TO BE CONSTRUCTED.

THE ABOVE QUANTITIES ARE FOR PERMITTING PURPOSES ONLY AND HAVE NOT BEEN FACTORED TO INCLUDE ALLOWANCES FOR BULKING, CLEARING AND GRUBBING, SUBSIDENCE, SHRINKAGE, OVER EXCAVATION, AND RECOMPACTION, UNDERGROUND UTILITY AND SUBSTRUCTURE SPOILS AND CONSTRUCTION METHODS.

TOP OF PIT GRADING OFFSET APPROXIMATE 250' FROM TOP OF BANK ALONG RUSSIAN RIVER, TYP. REFER TO MINING AND RECLAMATION PLAN.

RUSSIAN RIVER PIT CONNECTION CHANNEL INVERT SET TO PROVIDE CONNECTION FOR FLOWS EXCEEDING THE 27.4% ANNUAL EXCEEDENCE OF MEAN DAILY FLOWS. BASE EL. 592.3



SHTG ENGINEERING
 500 SEABRIGHT AVE., SUITE 202
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 (831)-427-0288
 A Division of Swanson Hydrology + Geomorphology

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 NOT FOR CONSTRUCTION

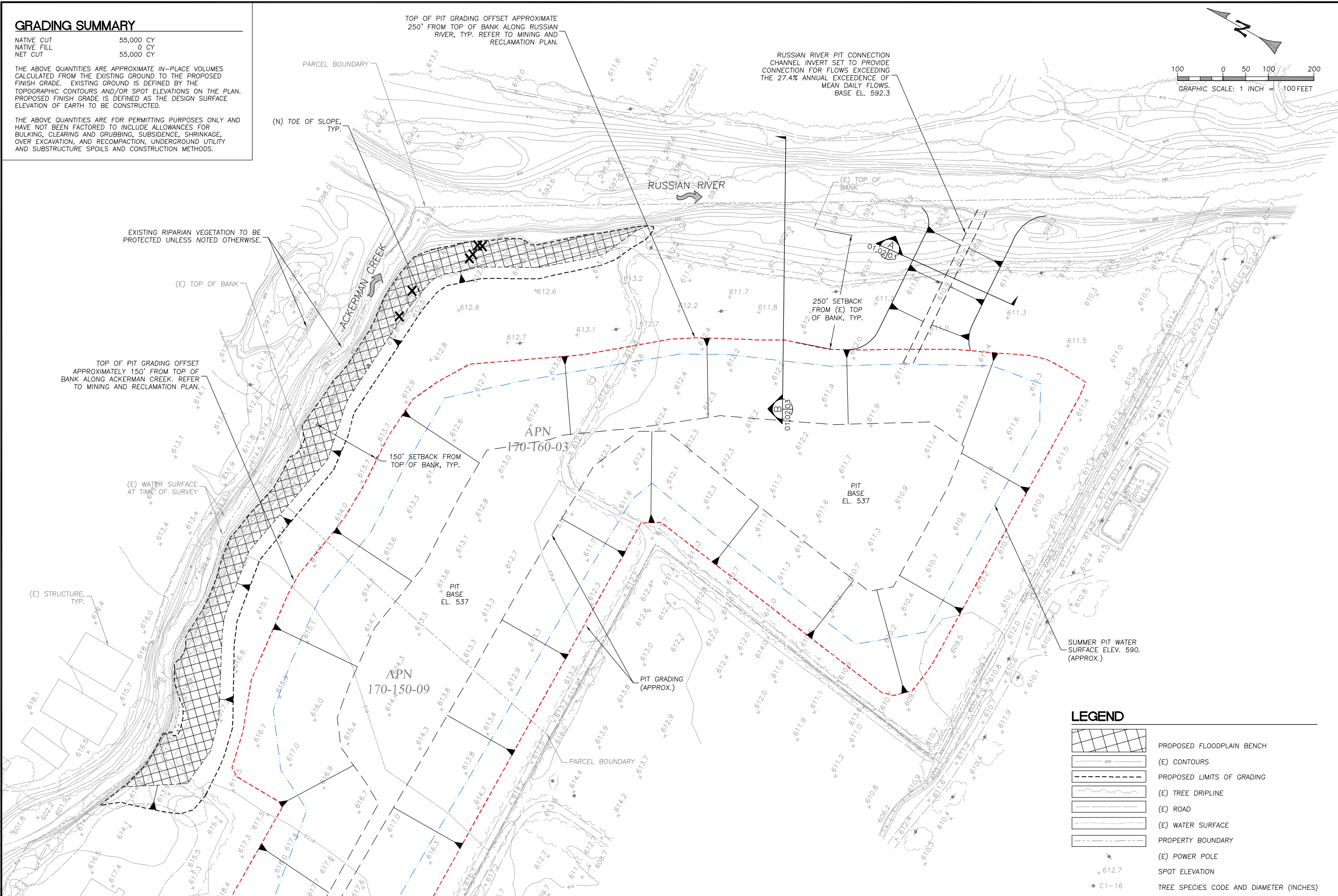
PREPARED AT THE REQUEST OF:
GRANITE CONSTRUCTION COMPANY

OPTION 2
 SITE PLAN

GRADING PLAN FOR
 KUNZLER RANCH
 TERRACE EXCAVATION
 CONCEPTUAL DESIGNS

DESIGNED BY: B.M.S.
 DRAWN BY: B.M.S.
 CHECKED BY: M.W.W.
 DATE: 09/05/08
 JOB NO.: 05-471

BAR IS ONE INCH ON ORIGINAL DRAWING. ADJUST SCALES FOR REDUCED PLOTS



LEGEND

- PROPOSED FLOODPLAIN BENCH
- (E) CONTOURS
- PROPOSED LIMITS OF GRADING
- (E) TREE DRIPLINE
- (E) ROAD
- (E) WATER SURFACE
- PROPERTY BOUNDARY
- (E) POWER POLE
- SPOT ELEVATION
- TREE SPECIES CODE AND DIAMETER (INCHES)
- TREE TO BE REMOVED

OPTION 2 SITE PLAN
 SCALE: 1"=100'

GRADING SUMMARY

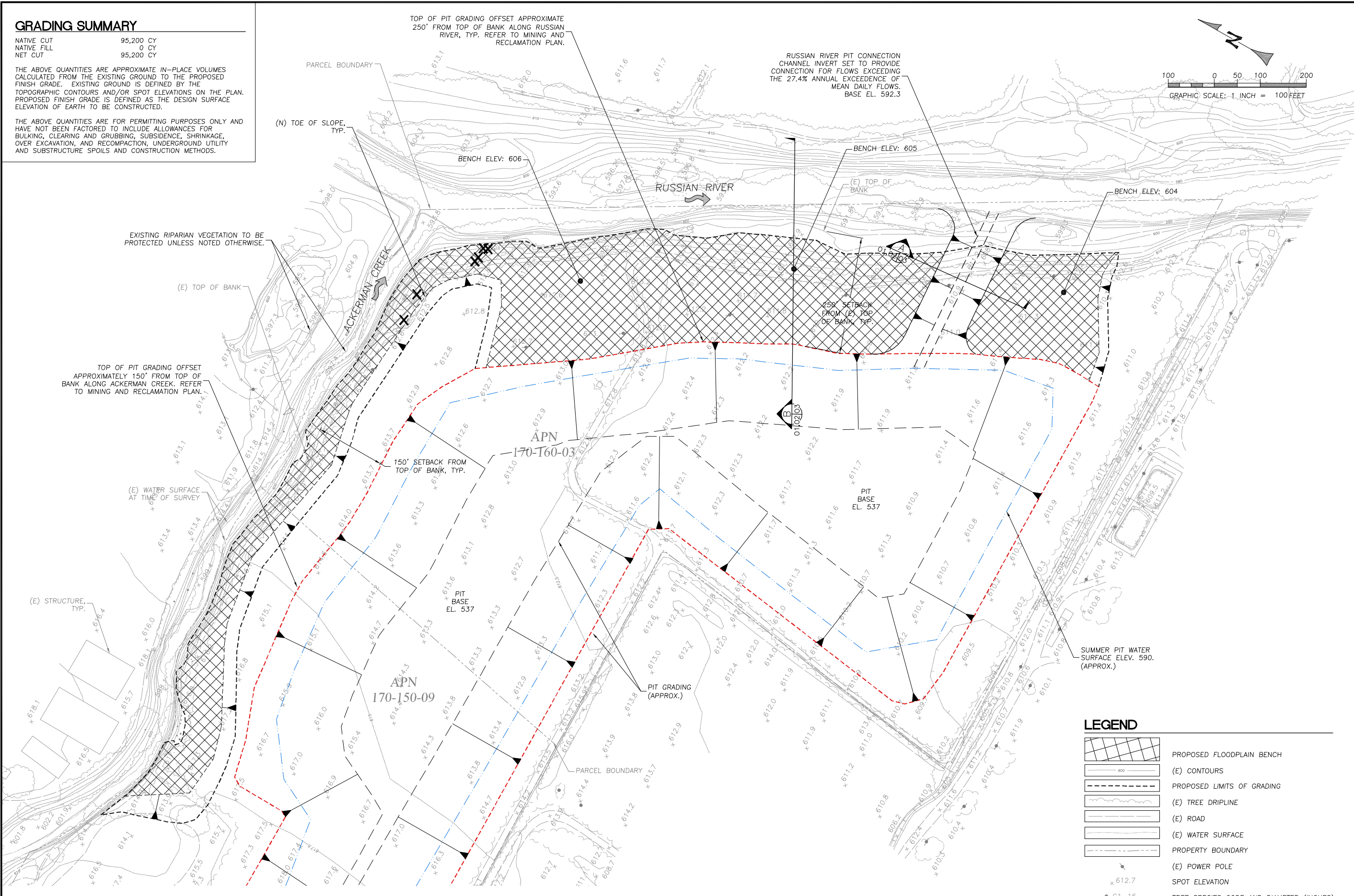
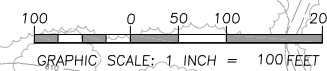
NATIVE CUT	95,200 CY
NATIVE FILL	0 CY
NET CUT	95,200 CY

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TOP OF PIT GRADING OFFSET APPROXIMATE 250' FROM TOP OF BANK ALONG RUSSIAN RIVER, TYP. REFER TO MINING AND RECLAMATION PLAN.

RUSSIAN RIVER PIT CONNECTION CHANNEL INVERT SET TO PROVIDE CONNECTION FOR FLOWS EXCEEDING THE 27.4% ANNUAL EXCEEDENCE OF MEAN DAILY FLOWS. BASE EL. 592.3



LEGEND

	PROPOSED FLOODPLAIN BENCH
	(E) CONTOURS
	PROPOSED LIMITS OF GRADING
	(E) TREE DRIPLINE
	(E) ROAD
	(E) WATER SURFACE
	PROPERTY BOUNDARY
	(E) POWER POLE
	SPOT ELEVATION
	TREE SPECIES CODE AND DIAMETER (INCHES)
	TREE TO BE REMOVED

OPTION 3 SITE PLAN
 SCALE: 1"=100'

DRAFT
 NOT FOR CONSTRUCTION

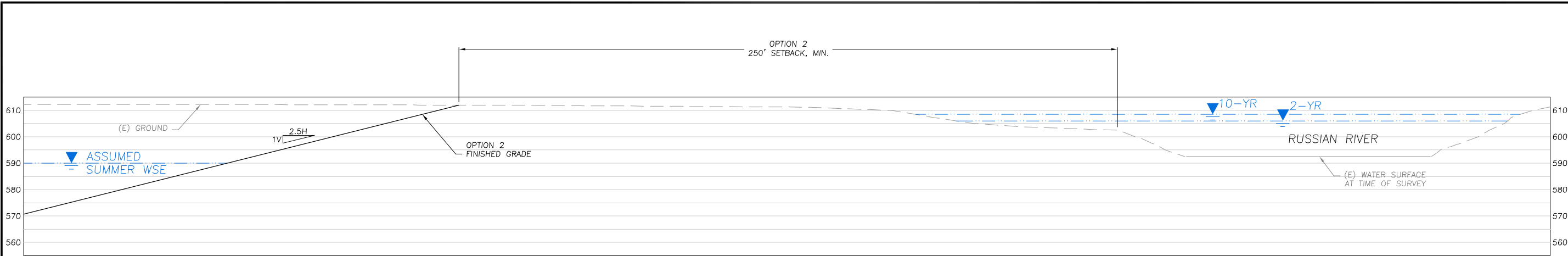
PREPARED AT THE REQUEST OF:
GRANITE CONSTRUCTION COMPANY

CONCEPTUAL SECTIONS

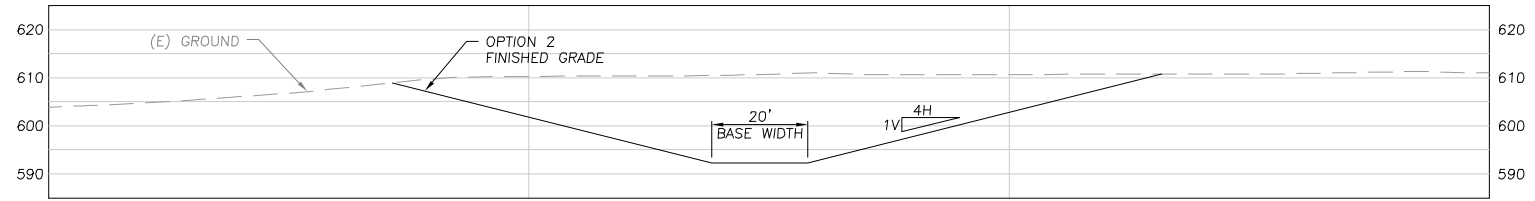
GRADING PLAN FOR
 KUNZLER RANCH
 TERRACE EXCAVATION
 CONCEPTUAL DESIGNS

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 DRAWN BY: B.M.S.
 CHECKED BY: M.W.W.
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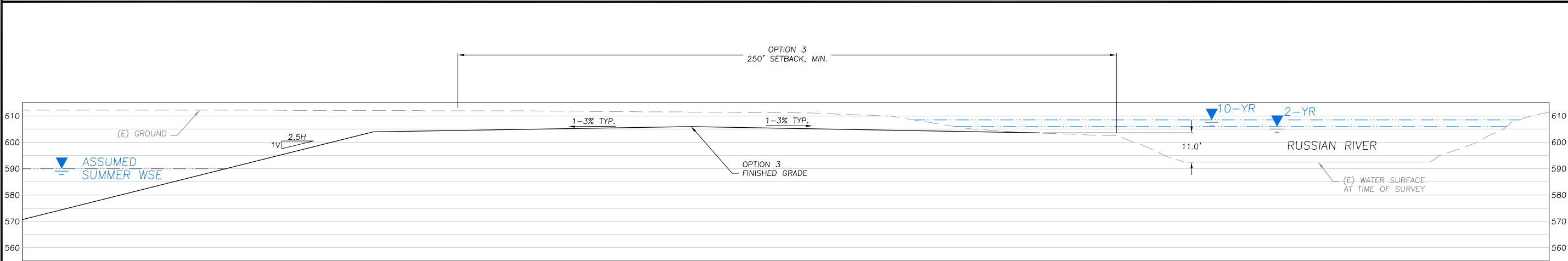
BAR IS ONE INCH ON ORIGINAL DRAWING, ADJUST SCALES FOR REDUCED PLOTS



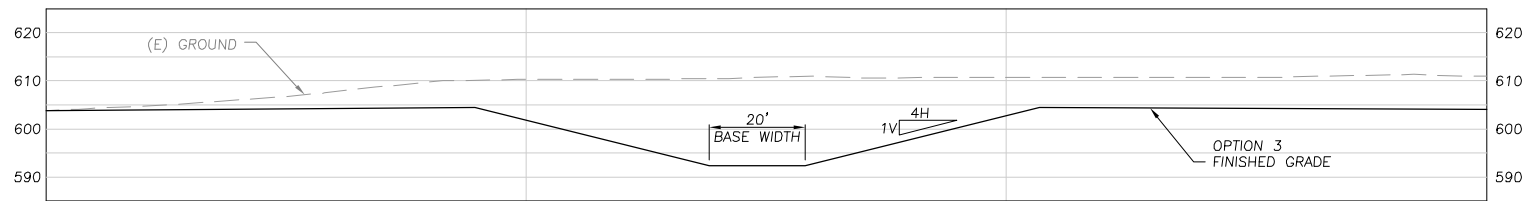
CROSS SECTION (OPTION 2) (B)
 SCALE: 1"=20' 01,02|03



RUSSIAN RIVER CONNECTION CHANNEL SECTION (OPTION 2) (A)
 SCALE: 1"=20' 01,02|03



CROSS SECTION (OPTION 3) (B)
 SCALE: 1"=20' 01,02|03



RUSSIAN RIVER CONNECTION CHANNEL SECTION (OPTION 3) (A)
 SCALE: 1"=20' 01,02|03

ADDENDUM 1
HYDROLOGIC AND HYDRAULIC ANALYSIS OF
KUNZLER RANCH GRAVEL EXTRACTION PROJECT

APPENDIX B

Appendix B

USGS Regional Regression Equation

U.S. Geological Survey Water Resources Investigations Report 77-21

North Coast Region

Q2 =	3.52	A [^]	0.90	P [^]	0.89	H [^]	-0.47
Q10 =	6.21	A [^]	0.88	P [^]	0.93	H [^]	-0.27
Q25 =	7.64	A [^]	0.87	P [^]	0.94	H [^]	-0.17
Q50 =	8.57	A [^]	0.87	P [^]	0.96	H [^]	-0.08
Q100 =	9.23	A [^]	0.87	P [^]	0.97	H [^]	0.00

where: Q = Peak discharge (cfs)

A = Area (sq. mi)

P = Mean annual precipitation

H = Altitude index, which is the average of altitudes in thousands of feet at points along the main channel at 10% and 85% of the distance from the site to the divide

Ackerman Creek Parameters

Parameter	Value	Units
Area =	21.7	sq. mi.
H _{10%} =	660	ft
H _{85%} =	2500	ft
H value =	1.6	ft
P value =	50	in

Results

Q2 =	1473	cfs
Q10 =	3130	cfs
Q25 =	4065	cfs
Q50 =	5138	cfs
Q100 =	5969	cfs