ATTACHMENT B

Small Communities Flood Risk Reduction Program – Hydraulic Analysis for the Communities of Rio Oso and Nicolaus

MBK ENGINEERS

Water Resources ◆ Flood Control ◆ Water Rights

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M E M O R A N D U M

DATE: August 30, 2019

TO: SCFRR Rio Oso & Nicolaus Study Team

FROM: Don Trieu, P.E., Patrick Ho, P.E. MBK Engineers

SUBJECT: Small Communities Flood Risk Reduction Program – Hydraulic Analysis for the Communities of Rio Oso and Nicolaus

1. PURPOSE

The purpose of the Small Community Flood Risk Reduction (SCFRR) Program is to invest in qualifying projects that would reduce flood risk for small communities. Rio Oso and Nicolaus are in process of identifying structural and nonstructural flood risk reduction projects that would qualify for SCFRR program funding.

The project team requested that MBK Engineers (MBK) analyze potential flood risks to these communities using best available data at the time of this study. Historically, the Feather River south levees near Nicolaus breached during the flood of December 1955 and there remains potential risk at this location. As part of this study, flood control levees protecting these communities were hypothetically breached and flood depth maps are attached to inform the project team on characterizing existing risk and developing potential flood risk reduction alternatives.

2. HYDRAULIC MODEL

Flood risk to Rio Oso and Nicolaus could potentially be derived from levee breaches along the Bear and Feather River. After levees are breached, floodwater flows overland and fills the basin. This dynamic is better captured and understood using a two-dimensional (2D) model. The Central Valley Floodplain Evaluation Delineation (CVFED) Sacramento River basin, HEC-RAS model is an integrated one-dimensional (1D) and two-dimensional (2D) hydraulic model. This model simulates the Sacramento River and tributaries such as the Feather and Bear Rivers. This model was modified to include a 2D flow area in the basin around Rio Oso and Nicolaus. This will provide more informative flood depth calculations. The hydraulic model was developed

using HEC-RAS version 5.06. The basins with improved spatial representation for this study is shown in Figure 1. The model is simulated using a representative 1-in-100 year flood event. This hydrology is from a Central Valley Hydrology Study (CVHS) selection prepared for the Sacramento General Re-evaluation Report.

3. CHARACTERIZING EXISTING FLOOD RISK

3.1 Hydraulic Analysis

Using best available data and techniques, flood depths are calculated and mapped by following guidelines from Federal Emergency Management Agency (FEMA) levee analysis and mapping procedures. Levees protecting Rio Oso and Nicolaus are non-accredited levees and flood mapping of areas protected by these levees will require a comprehensive critical section-by-section breach analysis per FEMA guidelines. In this analysis, two locations were selected as critical sections that may produce the largest floodplain and greatest flood depths. These are a levee section along the south Feather River at Highway 99 and a levee section along the south Bear River levees above Highway 70.

During the December 1955 flood, the levees along the south Feather River at Highway 99 breached and flooded the basin. This breach is revisited in this analysis because the location potentially draws the largest flood volume as it brings flows from the Feather and the Bear Rivers. The breach on the south Bear River levees at Highway 70 is a point of higher elevation in the basin. This location has the potential to generate higher water surface elevations provided that flood volume is sufficient, and it also would affect more properties along the path of a breached flood wave. Both these scenarios will provide a representative baseline for formulating flood risk reduction alternatives.

Levee breaches are assumed to occur as the water surface elevation (WSE) reaches a height against where the Federal/State project levee design criteria would be exceeded. This height is measured from the top-of-levee to a vertical distance downwards identified as the levee reduction height (URS, 2011). The levee reduction height is determined through geotechnical assessment and is a concept derived from the Non-Urban Levee Evaluation (NULE) program. Once the levees fail, the levee structure is assumed to completely wash out the levee towards the dry-side toe elevation. This breach is assumed to fully form in two hours. Table 1 shows the parameters selected for each levee breach.

Table 1. Levee Breach Parameters

Location	Width (ft.)	Dry-Side Levee Toe Elevation	Formation Time (hrs)	Breach Trigger Elevation (NAVD 88-FT)
Feather River above Highway 99	600	33.0	2	45.0
Bear River above Highway 70	525	38.5	2	49.0

3.2 Discussion and Results

Flood protection structures and facilities protecting the communities of Rio Oso and Nicolaus are managed and maintained by Reclamation District (RD) 1001. RD 1001 maintains 6 levee units. Floodwaters resulting from breaches on the Bear or Feather River will overland flow southwesterly and impound behind Levee Units 4, 5, and 6 (Figure 2). Major features within the basin that can impede flows include embankments supporting the Highway 99 and Highway 70 infrastructures. Maximum flood depths as a result of these scenarios are mapped in Figure 3 and Figure 4.

3.2.a Feather River Levee Breach above Highway 99

In the event of the Feather River above Highway 99 breach scenario, floodwater flows southwesterly and fills Reclamation District (RD) 1001. Once flood depth in the basin exceeds crown elevations of Highway 99, floodwater back northeasterly towards Highway 70 towards Rio Oso. Flood depths in this scenario reaches greater than 20 feet in lower lying areas and floodwaters overtop the north Natomas Cross Canal levees, which then flows back into the Sacramento River from the Natomas Cross Canal.

3.2.b Bear River Levee Breach above Highway 70

In the event of the Bear River above Highway 70 breach, floodwaters overtop Highway 70 and flows southwesterly towards RD 1001. Similar to the Feather River levee breach, floodwater fills RD 1001 to portions of the floodplain bounded by Highway 99 to the northeast. The flood source from this breach is not solely from the Bear River watershed. The breach opening size has the potential to divert most of the Bear River and in addition, draw water from the Feather River and into this basin.

Another pertinent feature to point out is public infrastructure development within the basin that can affect flow dynamics. The hydraulic model uses CVFED topography. In this model, floodwater overtops at a depressed location at Highway 70 and Rio Oso Road. The topographic survey used in the hydraulic model was collected before construction of the Highway 70 Bypass Project. The Highway 70 Bypass Project raised the Highway crown elevation between 0.5 and 1.4 feet (DOT, 2011) at Rio Oso Road. Per the As-Built Plans, Highway 70 crown elevations between from Cornelius Avenue to about Kempton Road were largely matched, therefore it is likely a similar flow pattern overtopping Highway 70 still exists today. However, it is pertinent that future analyses requiring FEMA mapping consider a topographic model that includes Highway 70, as it exists today.

4. NON-STRUCTURAL FLOOD RISK REDUCTION

4.1 Hydraulic Analysis

Based on the analysis in Section 3, the largest flood damage to properties in the basin could be caused by a breach on the Feather River levees at Highway 99. As part of a non-structural flood risk reduction alternative, relief cuts were analyzed at a levee location on the Feather River near Verona (Figure 5) to explore flood-fighting the breach on the Feather River at Highway 99. Excavation depths at the relief cut location will be limited by the water surface

elevation on the Feather River, which is the receiving water. In the breach analysis at Highway 99, the stage reached approximately 40 feet on the water side of the relief cut location. The top-of-levee elevations at this location is approximately 50 feet. Therefore, relief-cut depth dimensions with 10 feet (50 feet – 40 feet) of depth is simulated on our relief-cut scenarios. Three relief-cuts were explored, and their parameters are tabulated as follows:

Table 2. Assumptions of Relief-Cuts Analyzed

Location	Width x Depth (ft x ft)	Final Relief Cut Crest Elevation (NAVD 88)	Approximate Time Available to Construct Cut After Breach Occurs (hours)
Feather River near Verona	100	40	24
	500	40	24
	1,000	40	24

4.2 Discussion and Results

By performing relief-cuts, lower portions of the RD 1001 basin will observe reductions in maximum stage while the upper portions near Rio Oso and Nicolaus will observe reduction in inundated lands. The flood stage reductions in the lower portions of the basin provided by each relief-cut is tabulated in **Table *3***. The flood stage reduction is outflow constrained as the inflow from the breach at Highway 99 far exceeds outflow capacity at the relief-cut. While relief-cuts are outflow constrained, there are reductions in the acres of lands as a result of performing relief-cuts. **Table *3*** quantifies and Figure 5 illustrates the reduction in flooded lands as a result of each relief cut.

Table 3. Reduction in Stage and Inundated Lands Provided by Relief Cuts

Location	Width x Depth (ft x ft)	Approximate Stage Reduction (feet)	Reduction in Inundated Lands (acres)
No Relief Cut	0 x 0	0	0
Feather River near Verona	100 x 10	0.1’	757
	500 x 10	0.3’	1,767
	1,000 x 10	0.6’	2,779

REFERENCES

1. (URS, 2011). Geotechnical Assessment Report North NULE Project Study Area Volume 4 of 6: Appendix E, URS 2011.
2. (MBK, 2018). *Sacramento General Re-evaluation Report CVHS Selection.* MBK Engineers. December 2018.
3. (DOT, 2011). State of California, Department of Transportation, Project Plans for Construction on State Highway in Sutter and Yuba Counties near Nicolaus from 70/99 Separation to 1.0 KM North of Feather River Blvd., Caltrans 2011.

DRAFT

Olivehurst
Reeds Creek
Yuba County
Dry Creek
Wheatland
2066
0784
2103
0817
0823
0803
1500
1000
1600
Bear River
Feather River
Coon Creek
Sutter County
Placer County
Pleasant Grove Creek
Curry Creek
Steelhead Creek
Sacramento River
Sacramento River
Yolo County
Sacramento County
SMF
N
65
70
99
113

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

Legend

- Project Levee
- 2D Model Extents

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Rio Oso & Nicolaus 2D Model Extents
Figure 1

0 5,280
Scale in Feet

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Olivehurst
Reeds Creek
Yuba County
Dry Creek
Wheatland
2066
0784
0817
2103
0823
0803
1500
1001
1000
1600
Bear River
Feather River
Coon Creek
Sutter County
Placer County
Yolo County
Sacramento County
Pleasant Grove Creek
Curry Creek
Steelhead Creek
Sacramento River
Sacramento River
Dry Creek
SMF

Levee Unit 3
Levee Unit 4
Levee Unit 5
Levee Unit 6

N

65 70 99 113

Legend
Project Levee
Levee Unit Demarcation

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Reclamation District 1001 - Levee Units
Figure 2

0 5,280
Scale in Feet

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Legend

Project Levee

Flood Depth (ft.)

0 - 3

3 - 5

5 - 10

10 - 15

15 - 20

>20

N

2066

Feather River

0784

Yuba County

Dry Creek

0817

Bear River

0823

0803

1500

Feather River at HWY 99 Breach

Sutter County

Coon Creek

1001

1000

Pleasant Grove Creek

Curry Creek

Sacramento River

Yolo County

1600

Steelhead Creek

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure 3 - Maximum Flood Depth Map from Breach on Feather River at Highway 99

0 5,280
Scale in Feet

R:\Working\Ho\4173 Rio Oso SCFRR\ArcMap\Maximum Flood Depth Map - Breach 1.mxd 8/28/2019

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Legend

Hypothetical Levee Failure Location

Project Levee

Flood Depth (ft.)

0 - 3

3 - 5

5 - 10

10 - 15

15 - 20

>20

N

Bear River at HWY 70 Breach

Yuba County

Sutter County

Yolo County

0784

0817

0803

1500

1001

1000

1600

Dry Creek

Bear River

Feather River

Coon Creek

Pleasant Grove Creek

Curry Creek

Steamboat Creek

Sacramento River

Sacramento River

70

99

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community

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Figure 4 - Maximum Flood Depth Map from Breach on Bear River at Highway 70

0 5,280

Scale in Feet

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DRAFT

Legend

Relief-Cut Location

Project Levee

Flood Extent

1000' Relief-Cut

500' Relief-Cut

100' Relief-Cut

Without-Relief Cut

N

2066

Feather River

0784

Yuba County

0817

Dry Creek

Bear River

113

70

Rio Oso

99

Sutter

Yuba

0823

0803

Coon Creek

Feather River at Highway 99 Breach

1500

Sutter County

River Oaks Golf Club

1001

Pleasant Grove

Pleasant Grove Creek

1000

Curry Creek

Relief-Cut Location

Sacramento River

Yolo

Sacramento River

Yolo County

1600

Source: Esri, DigitalGlobe, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community, Esri, HERE, Garmin, © OpenStreetMap contributors, and the GIS user community

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Figure 5 - Reduction of Inundated Areas as a Result of Relief Cuts

0 5,280
Scale in Feet

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