FUTURE MEANDER BEND MIGRATION AND FLOODPLAIN DEVELOPMENT PATTERNS NEAR RIVER MILES 241 TO 235, SACRAMENTO RIVER

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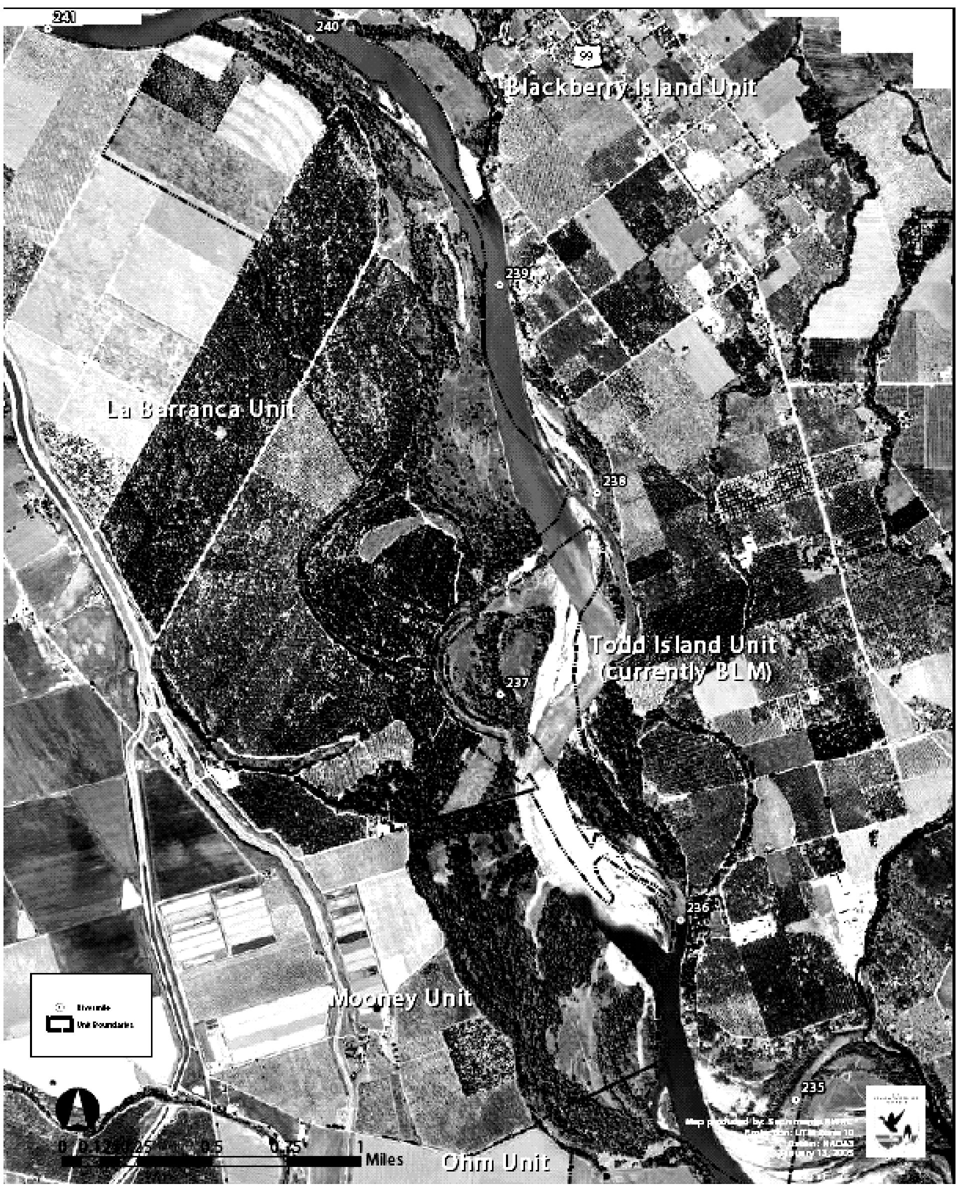

REPORT FOR RIVER PARTNERS
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Contents

1.0 Introduction

The Sacramento River near RM 240, which is the current location of the La Barranca unit of the Sacramento River National Wildlife Refuge, has experienced lateral and downstream meander migration in the last century. The reach in the vicinity of the La Barranca unit has evolved in shape through natural processes of river meander migration. The unit is located on the west side of the river. Channel migration in this area has been quite limited.

River meander migration is related to the channel planform shape, flow characteristics, bank erosion potential, and other factors (Johannesson and Parker 1989). The history of river meander migration from 1904 to 1997 at this site suggests that the river is currently very stable having not migrated laterally in the past roughly 100 years. This report describes historic channel locations and modeling, where the future migration of the river is simulated

2.0 Historical channels and erosion resistant areas

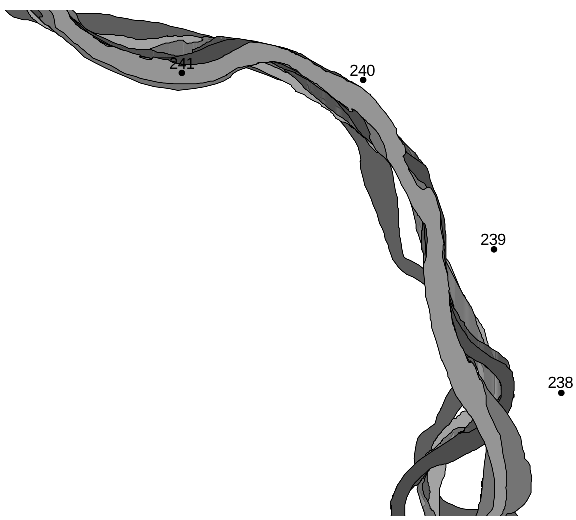

Figure 1 Study reach with the locations of the historical channels between 1904 and 1997. Oldest age channels are pictured on the bottom, with newer channels layered on top. Numbers indicate River Mile.

Figure 1 shows the study reach with the river channels between 1904 and 1997. The river in the vicinity of River Mile 239 to 240 has not moved significantly in the past century. This has been partially due to the fact that the channel has been constrained by non-erodible areas on the eastern bank (Figure 2).

The depositional unit primarily responsible for limiting channel migration in the study reach is the Modesto Formations (Q_m) (Figure 2). Another erosion-resistant formation is the Riverbank formation (Q_r), located to the west of the site. These terrace deposits typically consist of 1 to 3 m of dark gray to red fine sand and silt overlying 1.5-2 m of poorly sorted gravel (CDWR 1994). The Modesto formation is younger than the Riverbank formation, and contains the youngest terrace with a pedogenic B-horizon (CDWR 1994). This unit is usually less than 2.5 m thick and is composed of gravel, sand, silt, and clay (CDWR 1994). The Riverbank and Modesto formations are generally erosion-resistant; when exposed on bends, these formations can inhibit bank erosion and channel migration (Fischer 1994). In the study reach, the east side of the river in the vicinity of RM 194 (Figures 1 and 2) is constrained by the Modesto formation (Figure 2). Other geologic units (Q_{mb}, $Q_{hms,\ and}$ Q_{hm}) represent fluvial deposits in the 100-yr meander belt, meander point bar scrolls, and the historical meander belt respectively. The erosion potential described by this geologic

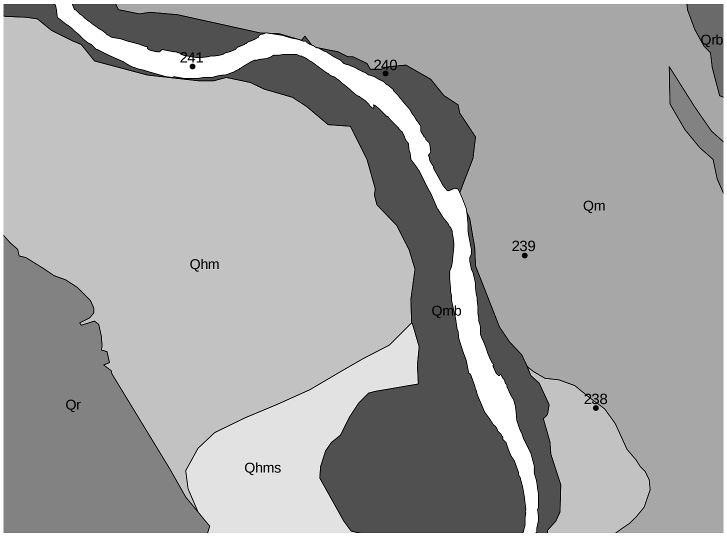

Figure 2 GIS geology layer. (California Department of Water Resources, 1995)

information, in connection with model calibration, was used to develop an erosion-potential grid to predict future migration potential.

3.0 Future Predictions

3.1 Introduction

Unconstrained meander bends tend to migrate naturally across the landscape (Brice 1984, Hooke 1984). Bend migration tends to follow patterns that can be described by mechanical laws of fluid flow and by other methods (Brice 1974, Hooke 1984, Ikeda and Parker 1989). When such meander bend migration occurs, an individual bend tends to move, unless constrained, both downstream and cross-stream. In other words, a bend will tend to migrate continuously downstream. At the same time, because of the cross-stream component of migration, a bend will tend to migrate cross-stream. As the bend migrates, it also changes shape.

One approach to understanding the future channel movement near the site is to model its future migration. As Larsen et al. 2002 recently did for a longer reach of the river downstream from this site, this report describes simulated channel migration using a channel migration model that is based on mathematical algorithms physics-based relationships for flow and sediment transport – the main physical processes responsible for channel migration (Larsen and Greco 2002). “Unlike empirically-based models, which tend to focus on local conditions, the physically-based numerical model integrates the effects of local morphology and upstream conditions.”[1]

3.2 Methods

Heterogeneous Erodibility Surface

A heterogeneous erosion surface was created using a geographic information system (GIS) and imported into the river meander migration model. The spatial erodibility surface was developed from the GIS data by using a geology layer (Figure 2). The geology surface dataset was obtained from the California Department of Water Resources (CDWR 1995). All geology surface types were assumed to be erodible, except for Q_r (Riverbank formation) and Q_m (Modesto formation), which represent non-erodible areas based on their soil properties, sometimes called areas of geologic constraint. The dataset was converted to a 30 m grid based on erodibility potential. A map representing how certain geology types erode at different rates was derived from this GIS dataset. This erodibility surface was used as the basis for the migration scenario.

[1] Larsen et al. 2002.

Migration Modeling

Following the procedures of Larsen et al. (2002), "A steady flow of 80,000 cfs is used in the analysis, which approximates the calculated two-year return interval." Slope, channel top width, and area of flow within the designated channel come from HEC-RAS output. Average depth is calculated using channel area and channel top width ($^{(area)}/_{(top\ width)}$). The overall slope for the study reach is calculated based on HEC-RAS model information. The slope used for the study reach was 0.00042 m/m. The following input parameters for the meander migration model for predictive modeling were calculated using the output of HEC-RAS:

- Slope: 0.00042 m/m
- Top width: 235 m (ft)
- Average depth: 5.4 m

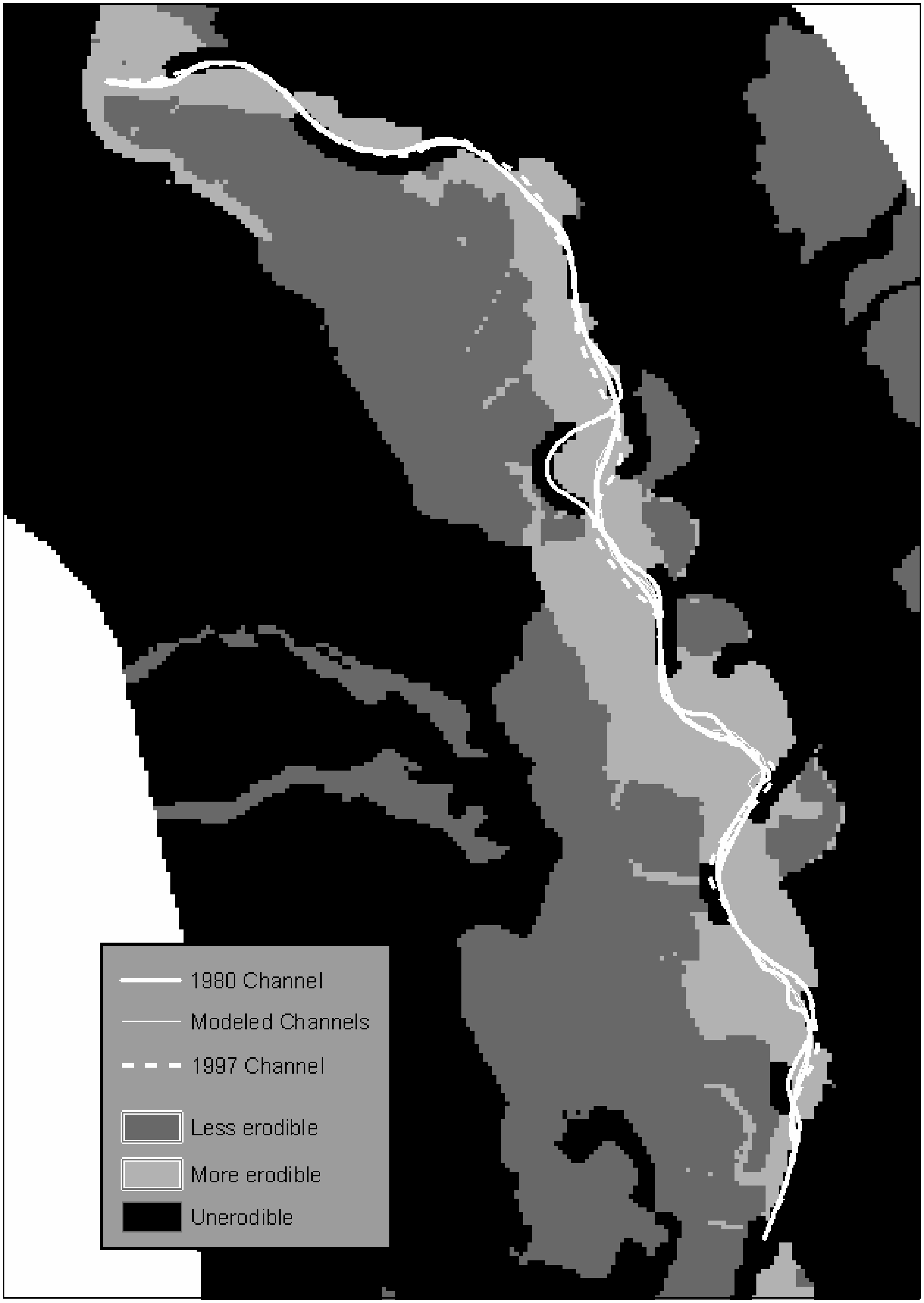

Figure 3 Sacramento River near the La Barranca unit. The initial observed channel location was in 1980, and the final observed channel location was in 1997. The calibrated simulated migration shows good agreement with the observed migration.

3.3 Model Calibration

"Calibration of the meander migration model is required because the exact erodibility of the sediments within the study reach in not known. Calibration allows calculation of an erodibility field by running the model on historic channel data. Calibration also allows fine-tuning of the model to local conditions by adjusting the coefficient of friction."[2]

Figure 3 shows the calibration of modeling. To calibrate, we used the observed locations of the channel in 1980 and in 1997. We adjusted bank erodibility near the channel until the 1997 modeled channel matched the observed 1997 channel location, as shown in Figure 3. In our calibration, we simulated the effect of the bank constraints. These conditions were then used for model predictions.

The calibration results show reasonable agreement (Figure 3). Based on this calibration, we expect the overall direction and pattern of the predictions to be valid, although the timing and distances of movement could be better estimated with more extensive model calibration and validation.

[2] Larsen et al. 2002.

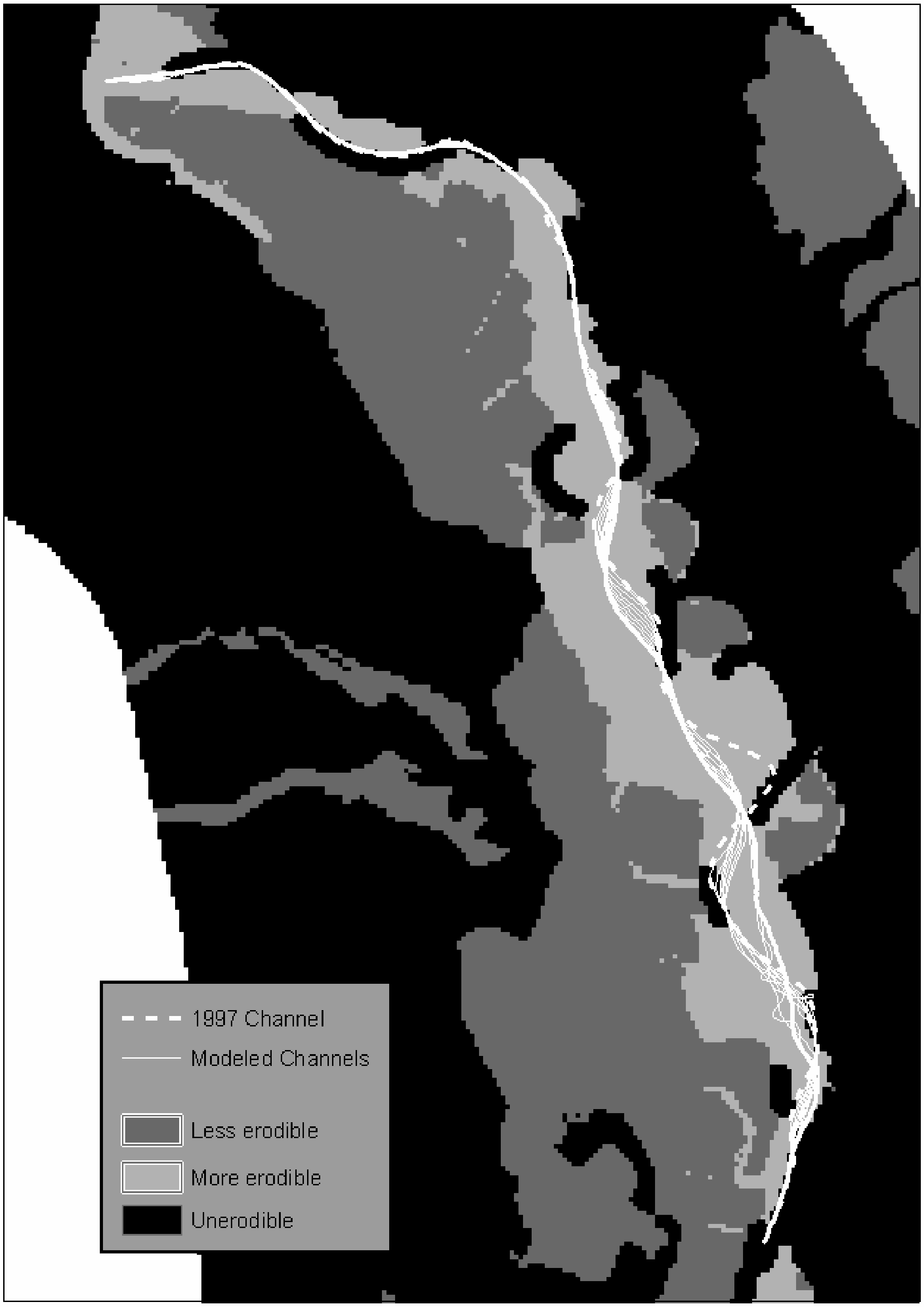

Figure 4 Prediction of migration potential 50-years into the future.

3.4 Prediction Results

Based on the input values for the hydraulic variables given above and the calibrated bank erosion values, a prediction 50 years into the future was made (Figure 4). The model included downstream river channel lengths, for ease of modeling. The river channel in the vicinity of our area of concern shows almost no potential for migration in the future.

4.0 Conclusions

Modeling the potential future migration at the site shows that the site as currently configured is likely to be highly stable in terms of planform meander migration.

5.0 Acknowledgements

Part of the research for this study was based on previous work by Eric Larsen and by student research and modeling by Evan Girvetz at UC Davis.

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