SIMULATED CHANNEL MIGRATION (2007-2057) NEAR RIVER MILES 197 TO 191 OF THE SACRAMENTO RIVER

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EXECUTIVE SUMMARY

This report describes analyses to study the meander migration patterns 50 years into the future on the Sacramento River between River Miles (RM) 191 TO 197. Previous studies have been done to document the channel dynamics near the location of the M&T pumping plant near RM 192-3 (Larsen and Cui 2004, Larsen 2005b, a, 2006, 2008). The current report describes modeling that repeated the 2006 study that used a 2004 centerline as the starting time. The current study used a 2007 planform centerline as a starting time and simulated meander migration patterns to 50 years in the future. The details of modeling techniques, the background on the meander migration model, and key assumptions are not repeated in this report and can be found in previous reports (Larsen and Cui 2004, Larsen 2005b, a).

Because the river channel location did not significantly change at the scale of meander wave lengths between 2004 and 2007, the pattern of migration near RM 192-3 did not significantly differ from the 2006 study. The new results and a comparison with the 2006 results are reported here.

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INTRODUCTION

This report describes analyses to study the meander migration patterns 50 years into the future of the Sacramento River between River Miles (RM) 191 and 197 (Figure 1). Previous studies have documented the channel dynamics near the location of the M&T pumping plant near RM 192-3 (Larsen and Cui 2004, Larsen 2005b, a. 2006, 2008). The current report describes modeling performed to see if the changes in the channel configuration between 2004 and 2007 made a significant difference to the modeling results 50 years in the future.

In a conference call of June 19, 2008, it was agreed that Eric Larsen would "*rerun the model with the 2007 alignment changes both downstream and upstream of the Rock Toe Project to see how that would affect placement of a new pumping plant.*"

The studies done in 2004 and 2005 analyzed the meander migration dynamics 50 years into the future starting with a channel location in 1997 (using data existing at those times) and reported migration tendencies. Subsequent work used a 2004 channel centerline, and also simulated migration for 50 years into the future. A subsequent study (Larsen 2007) incorporated a variable flow algorithm (Larsen et al. 2006a, Larsen et al. 2006b, Larsen 2007) that relates yearly migration rates to the observed (or modeled) flow in that year. The current study repeated the modeling done by Larsen in 2006, but used a 2007 centerline for the beginning modeling time.

Simulation of future meander migration shows tendencies of the river dynamics at the scale of approximately a meander wavelength. Mathematical modeling of geomorphic processes such as meander migration can provide information about tendencies. Such modeling can be accurate in predicting migration patterns, but simulations are not expected to produce precise point-by-point predictions of future channel locations. Analyses results show patterns of meander migration, and can be effectively used to compare patterns at different sites. In this study, the modeling was done to evaluate the changes that might occur if a newer centerline were used.

The modeled scenarios simulate meander migration patterns from the 2007 river planform to 50 years in the future. The simulation scenarios utilize previously done calibration and use a previously developed spatially variable erosion field.

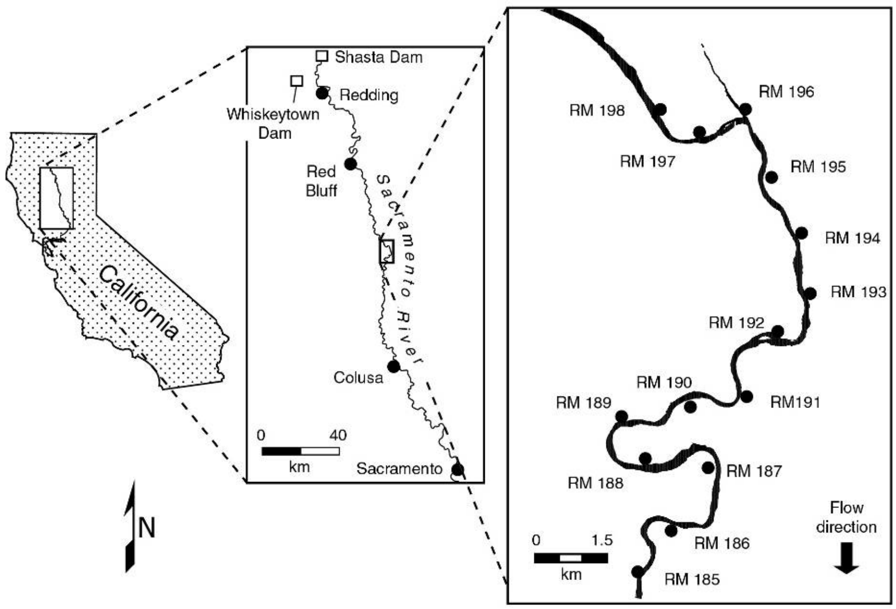

Figure 1 Location of the Sacramento River and the study reach.

METHODS

Site Description and Centerline Digitization

In the previous modeling, the simulations commenced from a 2004 channel centerline, which was taken from data existing at the time of previous reports. For the current analyses, a new channel centerline was developed and used. Aerial photographs of the channel taken in 2007 were used to digitize the banklines (Nelson 2008, Pers. Com.). From the digitized banklines, a channel centerline was determined. Figure 2 shows a comparison of the 2004 (dashed white line) and 2007 centerlines (solid white line). Channel alignments are represented by the centerline of the channel, a line drawn approximately halfway between the banklines on an aerial photo.

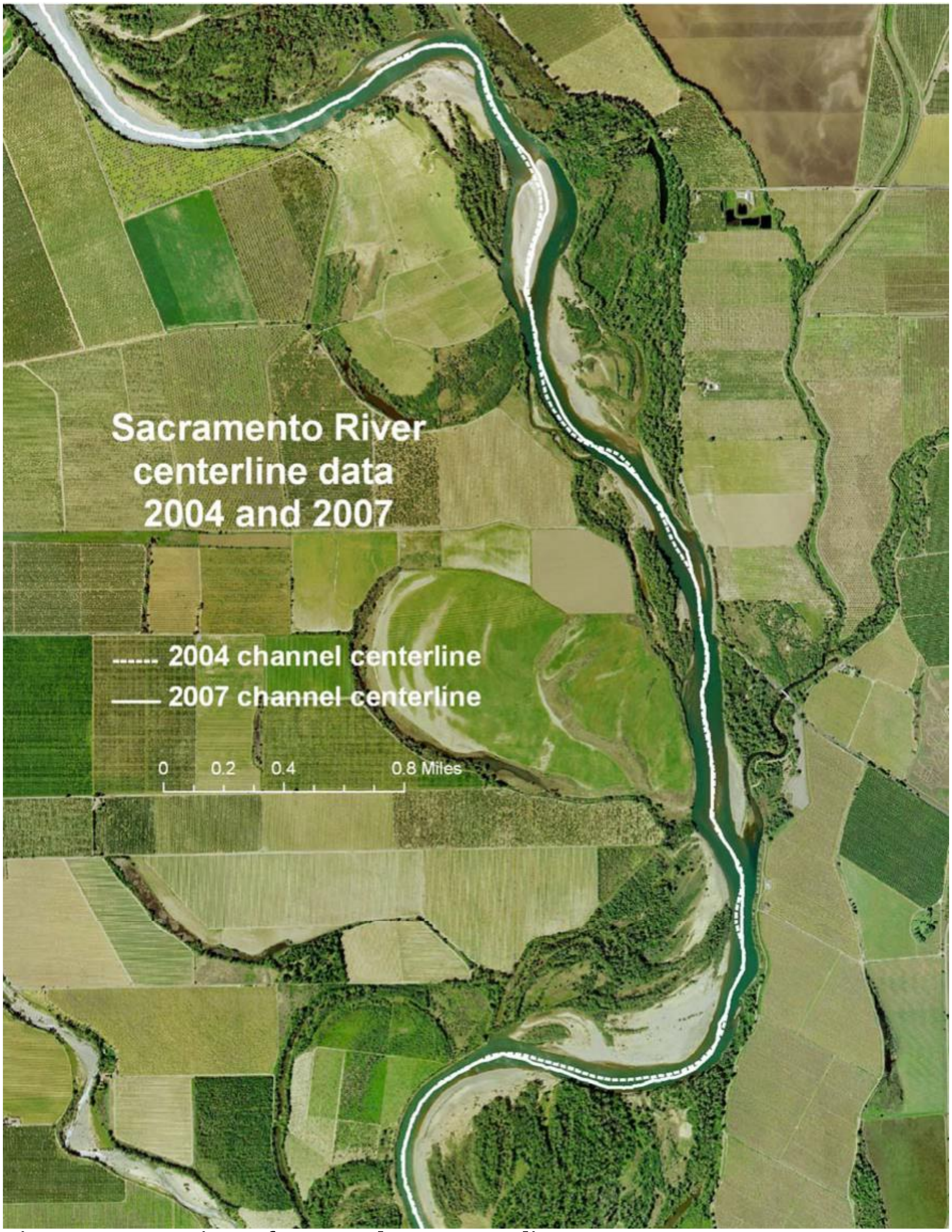

Figure 2 Comparison of 2004 and 2007 centerlines

Model Input Variables

Model Parameters for Prediction Run

The following hydraulic input parameters (typifying hydraulic conditions at a 2-yr flow) were used.

- Discharge: 2265 cms (80,000 cfs)
- Slope: 0.00042 m/m
- Top width: 235 m (770 ft)
- Average depth: 5.4 m (18 ft)

Some of the model parameters are internal to the model and are recorded as metadata. The first entries are the starting and ending channels for the modeled migration, and model version that was used.

"Flow parameters" are derived from acquired data.

"Computational parameters", "cutoff parameters" and "erosion algorithm parameters" are parameters that are internal to the model, and are recorded as modeling metadata.

These are the same parameters that were used in the previous modeling (Larsen 2006), and are recorded here in Appendix 1.

Heterogeneous Erosion field

The same erosion field was used as in Larsen 2006. The erosion field is briefly described in Appendix 2.

Migration Modeling

The same calibration was used as was used for the 2006 analysis and report (Larsen 2006). The procedures were used as presented in the previous reports, *Meander Bend and Gravel Bar Migration Near River Mile 192.75 of the Sacramento River* (Larsen et al. 2004), and *Future Meander Bend Migration And Floodplain Development Patterns Near River Miles 200 To 191 Of the Sacramento River* (Larsen 2005), the model was calibrated for the study reach. A calibration was done from 1980 to 2004 using the information from the 2004 centerline.

RESULTS

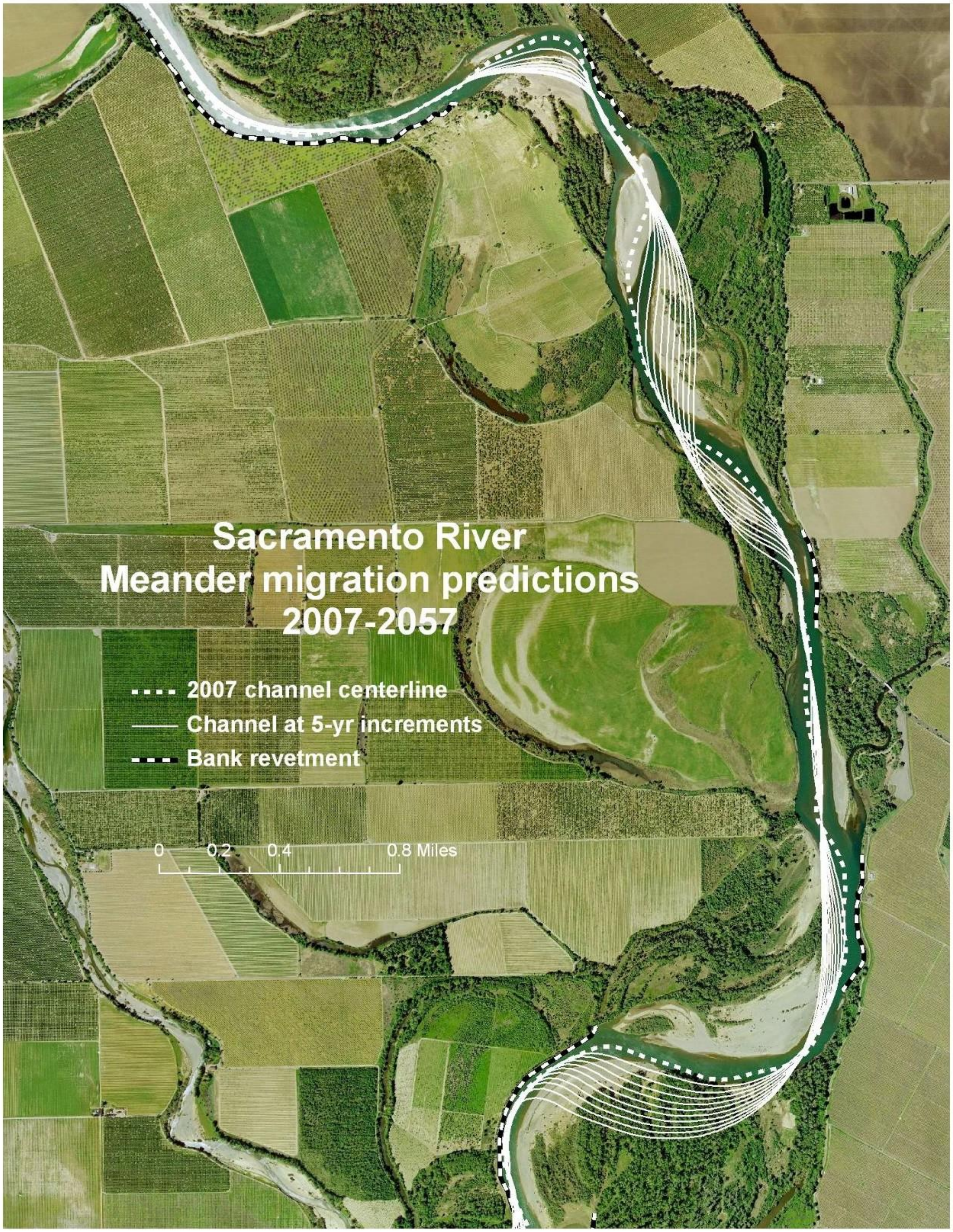

Figure 3 Prediction with 5 year increments starting from 2007 centerline

DISCUSSION

The river meander migration modeling in this report shows the tendencies of migration patterns of the river starting with a 2007 centerline.

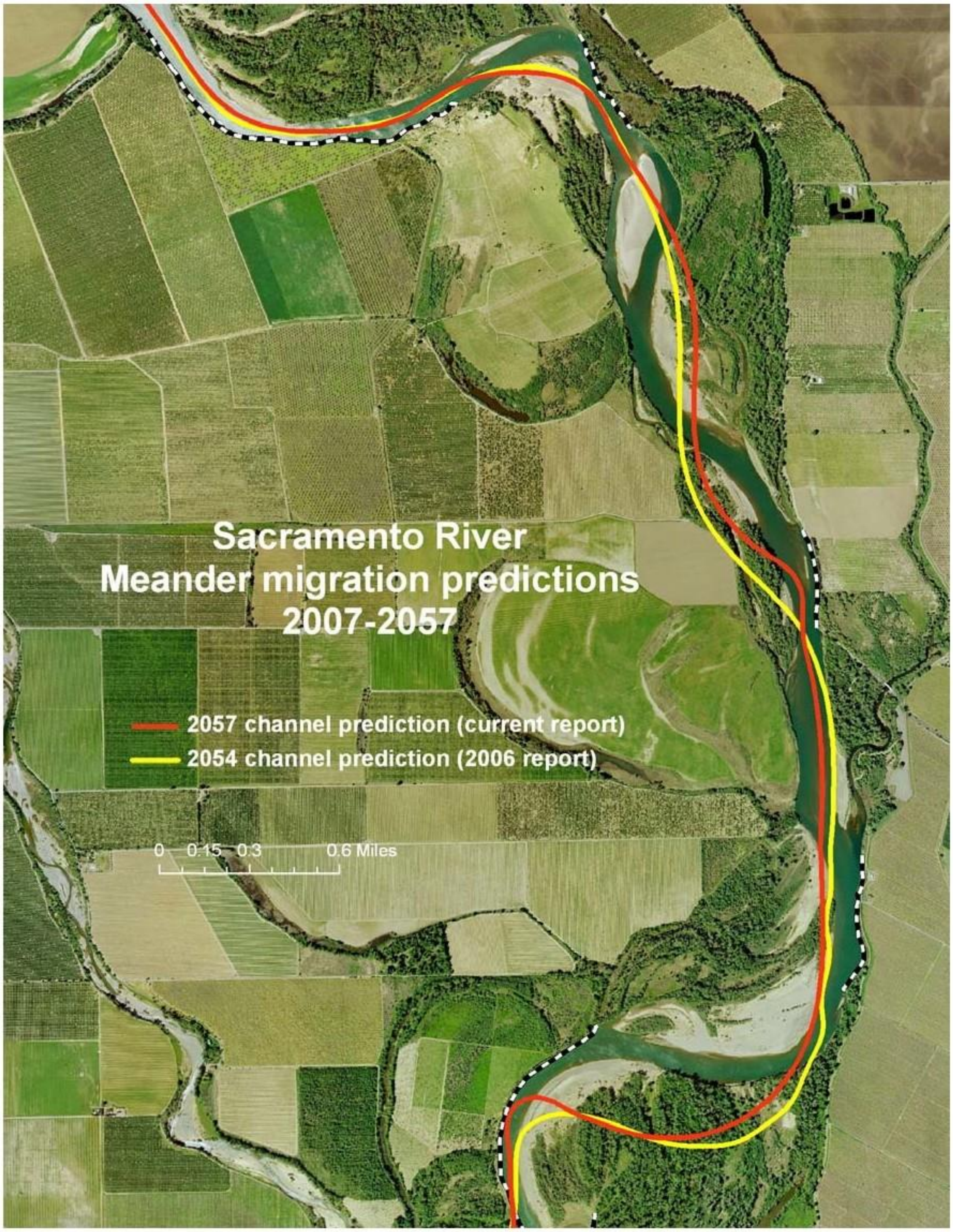

Figure 4 Comparison of 50 year predictions starting from 2004 and 2007 centerlines

The main goal of the modeling was to determine if using a 2007 centerline would result in significantly different results in where the channel would migrate in 50 years. The centerline predictions near the area of concern where the pumps are located do not show a significant difference. The conclusions in the previous reports (Larsen and Cui 2004, Larsen 2005b, a. 2006, 2007) would be the same using the new data.

REFERENCES

CDWR, 1995. Memorandum Report: Sacramento River Meander Belt Future Erosion Investigation. DWR 155. The Resources Agency, Department of Water Resources, Sacramento, CA.

Larsen, E. W., 2005a. Future Meander Bend Migration and Floodplain Development Patterns near River Miles 200 to 191 of the Sacramento River. 2005 Phase Iii Report. Ducks Unlimited for CALFED Ecosystem Restoration Program, Agreement #ERP-02-PO8-D, Amendment 2. Steering Committee Technical Memorandum., Sacramento, California.

Larsen, E. W., 2005b. Meander Bend Migration and Floodplain Development Patterns near River Miles 200 to 191 of the Sacramento River Phase Ii Report. Ducks Unlimited for CALFED Ecosystem Restoration Program, Agreement #ERP-02-PO8-D, Amendment 2. Steering Committee Technical Memorandum., Sacramento, Ca.

Larsen, E. W., 2006. Future Meander Bend Migration and Floodplain Development Patterns near River Miles 200 to 191 of the Sacramento River. Phase 3 Report. Ducks Unlimited.

Larsen, E. W., 2007. Sacramento River Ecological Flows Study: Meander Migration Modeling. Report for the Nature Conservancy and Stillwater Sciences Ecological Flows Study funded by California Bay-Delta Authority's Ecosystem Restoration Program (CALFED grant ERP-02D0P61, Chico California.

Larsen, E. W., 2008. Modeling Revetment Removal And Implications For Meander Migration of Selected Bends River Miles 222 To 179 of The Sacramento River. Report. Ducks Unlimited for CALFED Ecosystem Restoration Program, Agreement #ERP-02-PO8-D, Amendment 2. Steering Committee Technical Memorandum., Sacramento, California.

Larsen, E. W., and Y. Cui, 2004. Meander Bend and Gravel Bar Migration near River Mile 192.75 of the Sacramento River Phase I Report. Ducks Unlimited for CALFED Ecosystem Restoration Program, Agreement #ERP-02-PO8-D, Amendment 2. Steering Committee Technical Memorandum., Sacramento California.

Larsen, E. W., A. K. Fremier, and E. H. Girvetz, 2006a. Modeling the Effects of Variable Annual Flow on River Channel Meander Migration Patterns, Sacramento River, Ca, USA. Journal of American Water Resources Association, 42(4):1063-1075.

Larsen, E. W., A. K. Fremier, and S. E. Greco, 2006b. Cumulative Effective Stream Power and Bank Erosion on the Sacramento River, California, USA. Journal of American Water Resources Association 42(4):1077-1097.

Larsen, E. W., E. H. Girvetz, and A. K. Fremier, 2006c. Assessing the Effects of Alternative Setback Channel Constraint Scenarios Employing a River Meander Migration Model. Environmental Management 37(6):880-897.

Nelson, Charles. 2008. Personal communication. Geographical Information Center . California State University, Chico, California.

UCD 2004. University of California Davis. Landscape and Analysis Systems Research Laboratory (LASR).

Appendix 1 Model parameters for prediction run

2007 Start Year
2057 Prediction
file written 12-Sep-2008 11:50:16
Meander version: Meander 7.3.5: Finalized Code to EWL

FLOW PARAMETERS
Q = 2265 cms
H (depth) = 5.4 m
B (width) = 235 m
S (slope) = 0.00042
Ds = 25 mm

COMPUTATIONAL PARAMETERS
dyr = 1
C_max = 0.6
Spacing = 0.5
Smoothing = 3
Eo_Spacing = 1
Cf_scale = 1
Calc_uf = 1
Check_curve = 1

CUTOFF PARAMETERS
Sinu Thresh = 1.5
Recur. Int. = 0
Cutoff Routine = 0

BEND PARAMETERS
bend length= 8
straightSin= 0.0005
bendSin = 0.0005

EROSION ALGORITHM PARAMETERS
a--Eo = 1
b--Depth = 0
d--Erosion = 1

APPENDIX 2 HETEROGENEOUS EROSION FIELD

The same erosion field was used as in Larsen 2006. The description from that document is copied below.

A spatial erodibility surface was developed from GIS data by using a geology layer and a vegetation layer as done in previous studies (Larsen 2005b, a, 2006). The geology surface dataset was obtained from the California Department of Water Resources (CDWR 1995). The vegetation coverage is based on a data set from the LASR lab at UC Davis. All geology surface types were assumed to be erodible, except for Q_r (Riverbank formation shown in black), Q_m (Modesto formation shown in black), and Q_{oc} (Old channel deposits also shown in black) which represent non-erodible areas based on their soil properties, sometimes called areas of geologic constraint. The lighter and darker shadings show agricultural land and forest land respectively. The agricultural land was calibrated to erode roughly twice as fast as forest land. The dataset was converted to a 30 m grid based on erodibility potential. A map representing how certain land use areas erode at different rates was derived from this GIS dataset. This erodibility surface was used as the basis for the calibration and the different simulation scenarios. It was on this basic underlying erosion grid that the bank restraints were placed. In addition, the erosion was modified slightly during the calibration of the model.

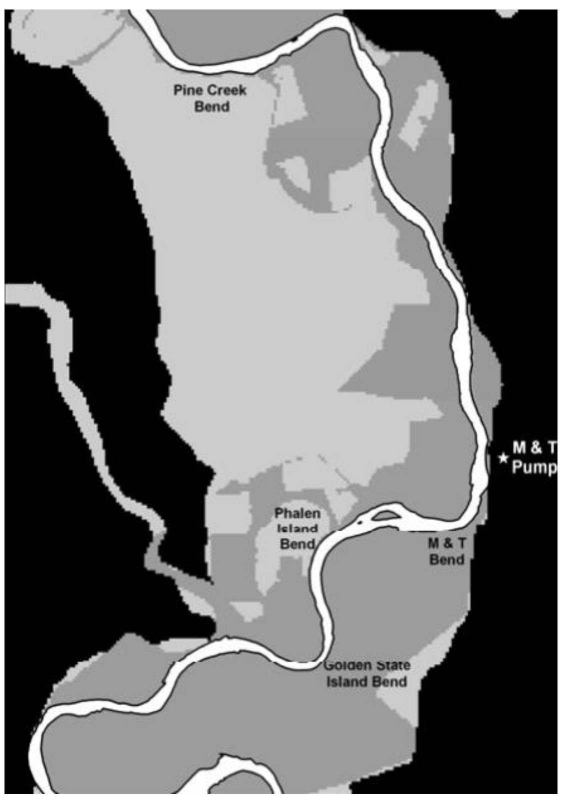

Figure 5 GIS geology and vegetation layer. (CDWR, 1995; UCD LASR lab.)