4. ASSESSMENT OF THE CURRENT CONDITIONS AND EXPECTED EVOLUTION OF THE NAPA RIVER CORRIDOR

4.1 CURRENT CONDITIONS

A wide range of channel conditions exist in the project reach, from broad sections that appear to be in equilibrium with the watershed to very narrow, entrenched reaches with failing banks. We have used a modified version of Schumm's channel evolution model to break the project area into smaller reaches with similar conditions. Breaking the channel down in this way provides a method of simplifying the system so that we can develop an overview and prioritize reaches most in need of restoration. Since different geomorphic processes dominate the different stages of the Schumm model, classification also provides a framework for developing conceptual remedies for each type of reach. A schematic of the classification scheme, along with examples from the Rutherford reach of the Napa River, is shown in Figure 2.

4.1.1 The Modified Schumm Disturbed Channel Evolution Model

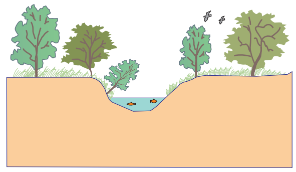
This model is based on the observed behavior of many disturbed stream systems in alluvial channels, and classifies channels into one of six stages:

- Stage 1. Undisturbed channels
- Stage 2. Disturbed channels (channels that have been engineered, for example by dredging or confined by levees, or that have been disturbed by changes in the watershed)
- Stage 3. Incising channels (channels where the bed is eroding vertically, to make a narrow and deep channel)
- Stage 4. Incised and widening channels (channels where the bed is eroding or stable, and where bank erosion and collapse processes are widening the channel)
- Stage 5. Aggrading and widening (channels where the channel is widening by bank erosion and collapse processes, and the eroded material is being deposited on the bed causing aggradation and the formation of terraces)
- Stage 6. New dynamic equilibrium (channel has created a new channel within floodplain terraces deposited below the old bank top, and is now in equilibrium with its watershed), with low levels of natural bank erosion due to meander migration

Stage 1

"Natural" Channel

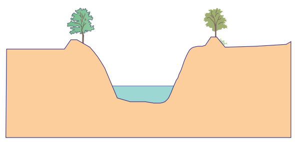
Channel is well connected to floodplain, with low banks and diverse habitat.



Stage 2

Constructed Channel

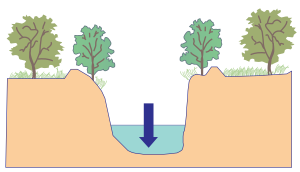
Straightening, vegetation removal and levee construction channelize the stream, increasing its gradient and increasing flow velocity.

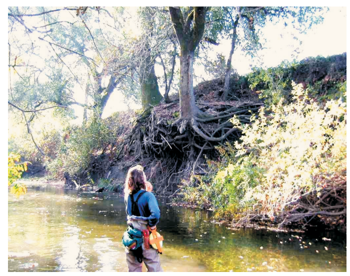


Stage 3

Incising Channel

Channel downcuts in response to channelization, dissipating excess energy through bed erosion.

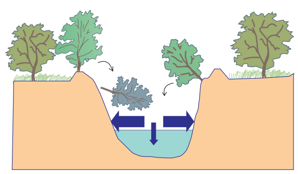


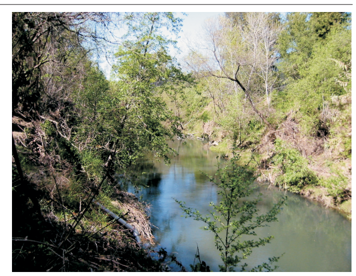


Stage 4

Widening & Incising Channel

As incision increases bank height and angle, banks collapse and channel widens.

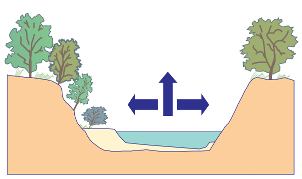




Stage 5

Widening & Aggrading Channel

Wider channel is unable to transport all collapsed bank material. Excess material forms terraces below former floodplain.



Stage 6

New dynamic equilibrium channel

Channel creates terraces and new floodplain. New channel meanders within the new floodplain, recreating a living river.

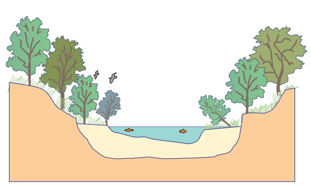


figure 2

Napa River Rutherford Restoration

Schumm's modified channel evolution classification scheme, with examples from the Napa River Rutherford reach

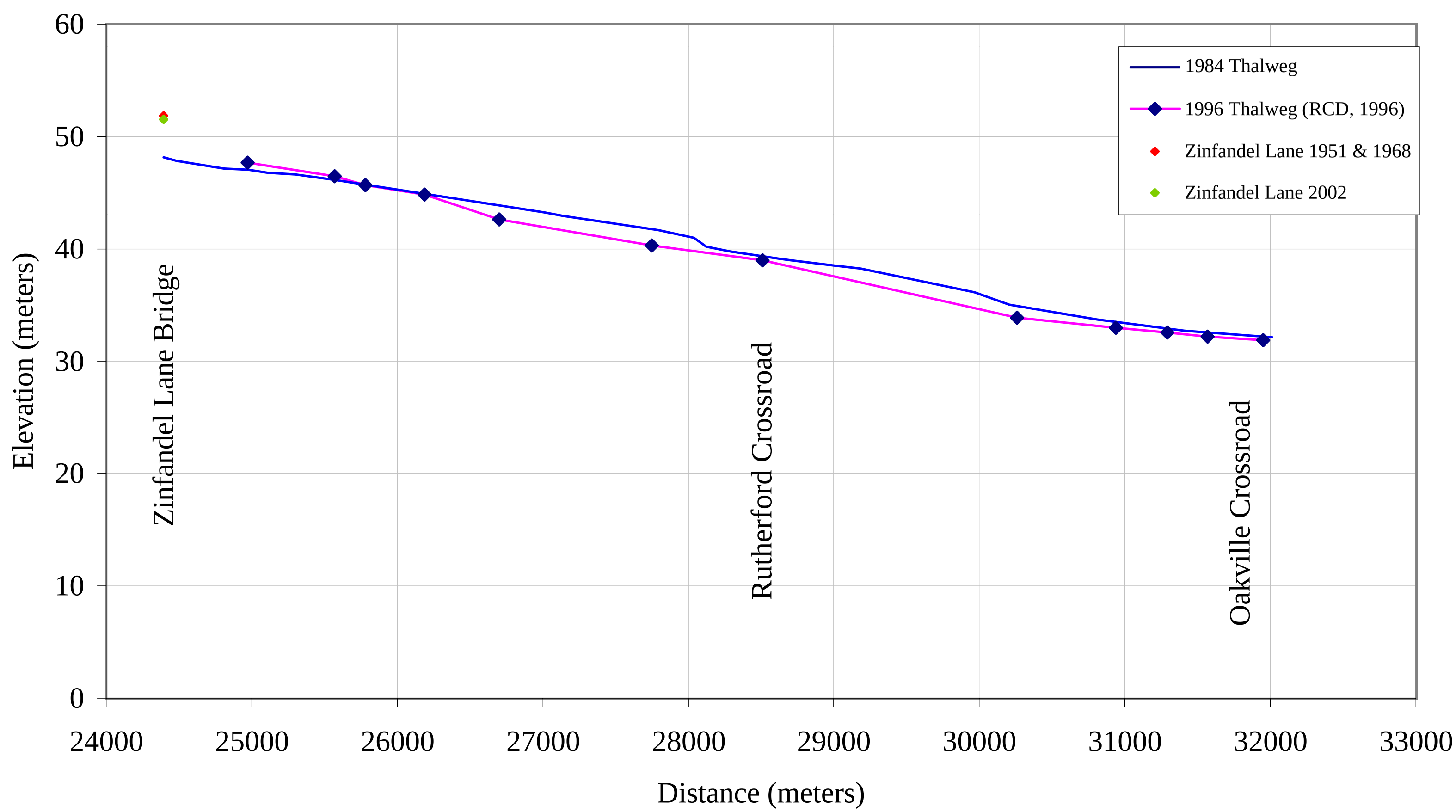
Stream reaches were classified based on a combination of channel form and evidence of channel processes. For example, Stage 4 channels tend to be narrow but very deep relative to undisturbed sections of the channel (if they exist) and show evidence of extensive bank erosion and mass failure, while Stage 5 channels are wider, have terraces forming and show evidence of bank top erosion and deposition of eroded material in the bed. For this project the classification was made using a combination of field investigation and analysis of the surveyed cross sections provided by the RCD (shown in Appendix 1). Two PWA investigators walked the RDRT channel area in Fall 2002 and made field sketches and measurements at sections corresponding to property divisions or changes in stream character. The channel form, vegetation conditions and evidence of physical properties were noted. Bed material, channel width and bank angle were measured. The RCD cross sections were analyzed to calculate channel width and depth, and qualitatively for channel form. The field notes were then overlain with the RCD cross-sections and the channel around each cross section was classified into a Schumm stage. During a subsequent field walk in Spring 2003 the channel was studied again with the field notes to confirm the classification and increase the level of detail in the classification. At this stage major areas of concern were logged using GPS and remedial measures recommended. Photos were taken at each reach site (shown in Appendix 2).

By classifying reaches of the channel we can build up an overview of the system's conditions and behavior. We can also make tentative predictions of the likely future behavior of the channel. For example, in channels where no additional disturbance occurs and there is no human intervention, reaches are likely to evolve from Stage 3 through to Stage 6 over time, as bank erosion widens the stream corridor and terraces develop. Stage 6 reaches also provide reference conditions showing an equilibrium condition that we might want to use as a target for restoration in reaches that are still recovering.

4.2 CHANNEL DOWNCUTTING

As the channel has been straightened and vegetation removed, flows have become faster and more erosive since the overall channel slope is steeper and hydraulic roughness (friction) due to vegetation is less. The channel has responded, initially by incising (downcutting). Once the channel banks exceeded their critical stable height and angle they collapsed. As the channel became deeper, flood flows that would previously have escaped from the channel and dissipated their erosive force as shallow flows on the floodplain have been confined within the channel. In natural channels flows that occur less frequently than every one to two years would have gone 'out-of-bank' in this way. As the channel incised, flows of increasing size were confined within the channel. Provisional hydraulic analysis by PWA shows that flows as infrequent as the 50 to 100 year event remain within the channel in many locations, where their full erosive force is expended against the bed and banks (see Appendix A).

We have compared two channel profiles to measure the amount of downcutting; the 1990 FEMA profile (derived from 1984 topographic maps) and the 1996 RCD profile. There appears to be a discrepancy in the datum's used in the two profiles; fixed points such as the main bridges do not line up in the profiles. More work is needed to identify which profile is correct. The two profiles have been adjusted to align known points such as Zinfandel Lane Bridge. Superimposing these profiles suggests that up to 6 feet of channel erosion has taken place in 12 years (see Figure 3). This is a very rapid rate of incision, and poses a potential threat for any bank stabilization work in the project reach. Incision threatens to undercut bank stabilization structures that are not keyed into the bed sufficiently deep. In order to evaluate whether incision has taken place between 1996 and the present, PWA identified four potential cross sections where incision was likely. These were sections 26190 and 26700 in the reach between Rutherford Rd and Zinfandel Lane, and 30260 and 30940 between Rutherford rd and Oakville Cross Rd. Re-survey was carried out by the Napa County RCD. High flow conditions prevented re-analysis of the two downstream sections, and one of the two upper sections could not be located with sufficient precision to compare sections. In the section 26190 a successful re-survey was carried out (Figure 4). The figure, confirmed by field evidence, shows 2.6 feet of incision between 1996 and 2003. While care must be taken inferring system change from one cross section, the combination of profile and cross section evidence supports the view that the Napa River project reach is, or has very recently been, subject to downcutting. Field and literature evidence suggests that around 12 – 15 feet of incision has taken place since the 1940s.

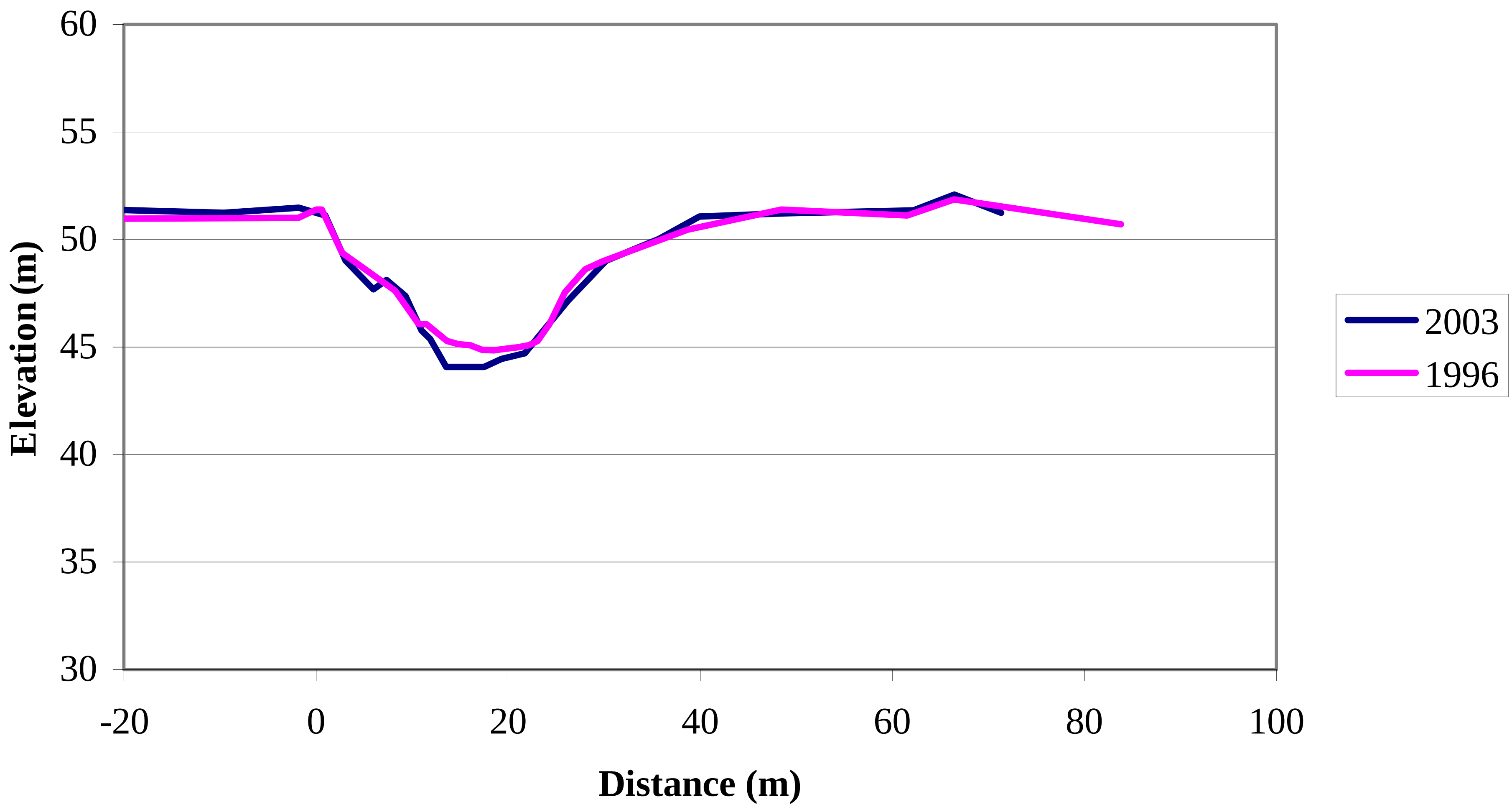


f i g u r e 3

A conceptual plan for the stabilization and restoration of the Napa River, Rutherford reach

1984 and 1996 Long Profiles for the Napa River, Rutherford

PWA Ref 1638



Notes
Source

figure 4
A conceptual plan for the stabilization and restoration of the Napa River, Rutherford reach

RCD Cross section 26190 in 1996 and 2003

PWA Ref 1638