SECTION 2B (GEOMORPHOLOGY) Technical Memo from Watershed Sciences by Laurel Collins and James Chayka, 3/7/07

A collaborative effort was made to understand the current channel morphology and to analyze the associated flooding problems associated with different segments of Wildcat Creek. Watershed Sciences examined approximately 8500 ft of Wildcat Creek, from slightly downstream of the AT&SF railroad bridge to the upstream edge of Vale Street box culvert. This reach of channel is referred to as the study reach. The data was used to characterize the channel to determine where problems existed and to develop conceptual solutions and restoration strategies that could be implemented in both ongoing and future projects.

The Rosgen Stream Classification (1996) approach was chosen to categorize segments of the study reach. This approach examines bankfull channel conditions with respect to a river's capacity to flood - a natural process that allows a channel to efficiently move a given volume of water and its sediment load downstream. The classification system specifically requires measurement of width and depth dimensions, and characterization of the streambed particle size. A chart of stream classes and their descriptions is shown in Figure 1. Table 1 provides a general description of the expected stability for the different classes. For Bay Area channels we use a slightly modified condition of the Rosgen Classification by modifying the threshold for the width/depth ratio, which helps establish stream class. It has been modified from 12 as reported by Rosgen (1996) to 10 and the degree of uncertainty changed from +/-2.0 to +/- 3.0. This number and degree of resolution was agreed upon after detailed discussion with Rosgen (1999). The difference in width/depth threshold might be due to bias toward snowmelt streams in the data sets from which the classification system was developed.

Many of the problems associated with Wildcat study reach have stemmed from increases in runoff associated with land use impacts over the last two centuries within the entire watershed (SFEI , 2001). To accommodate increased flow, adjustments in bankfull channel dimensions started to occur along the study reach, the floodplain and banks of which were also becoming rapidly urbanized. Stream instability and excessive bank erosion lead to property damage and loss. As a result, revetments, and other instream structures that artificially fix the position of the channel were applied to prevent lateral migration. Yet where there has been excessive artificial bank hardening, the primary erosive force has become streambed incision. Many of the revetments are now deteriorating and falling into the creek. Where the banks have not had structural revetments applied, bank erosion is still common because the larger floods held within the incised channel exert greater shear forces on the banks than its former condition.

A channel is considered moderately entrenched when its ratio of floodprone width to bankfull width is 1.4 to 2.2. It is severely entrenched when the ratio is greater than 2.2. An entrenched channel is inherently unstable and lacks sufficient floodprone width. Rosgen defines floodprone width as the width of the channel at two times the maximum bankfull depth. In the upper portion of the study reach, channel incision is causing moderate to severe entrenchment. In the lower portions of the study reach, sedimentation has been leading to loss of capacity and increased flood potential. In some instances, excessive sedimentation is associated with poor design and placement of box culverts. Subsequently, dredging has been required on an annual basis near several of the box culverts and the reach below the Rumrill box. To determine the status of channel stability throughout the study reach, we determined the Rosgen Stream Class by measuring cross section dimensions at transition zones and at sites where there were extreme differences in channel geometry. The sequence of the stream classes can be seen on Map Plate 1 Wildcat Creek “Rosgen Stream Classification.”

The dominant particle size of the bed surface is numerically represented in the Rosgen Classification system (Figure 1). For example, 4 represents a gravel dominated streambed, whereas 5 represents sand dominated. Gravel was the dominant class in the study reach.

In general, the study reach changes from an F type channel below the wooden railroad trestle crossing to mostly an E channel to about 300 feet downstream of the Church Lane, where it then changes to a B channel. Between Church Lane and Vale Road the channel

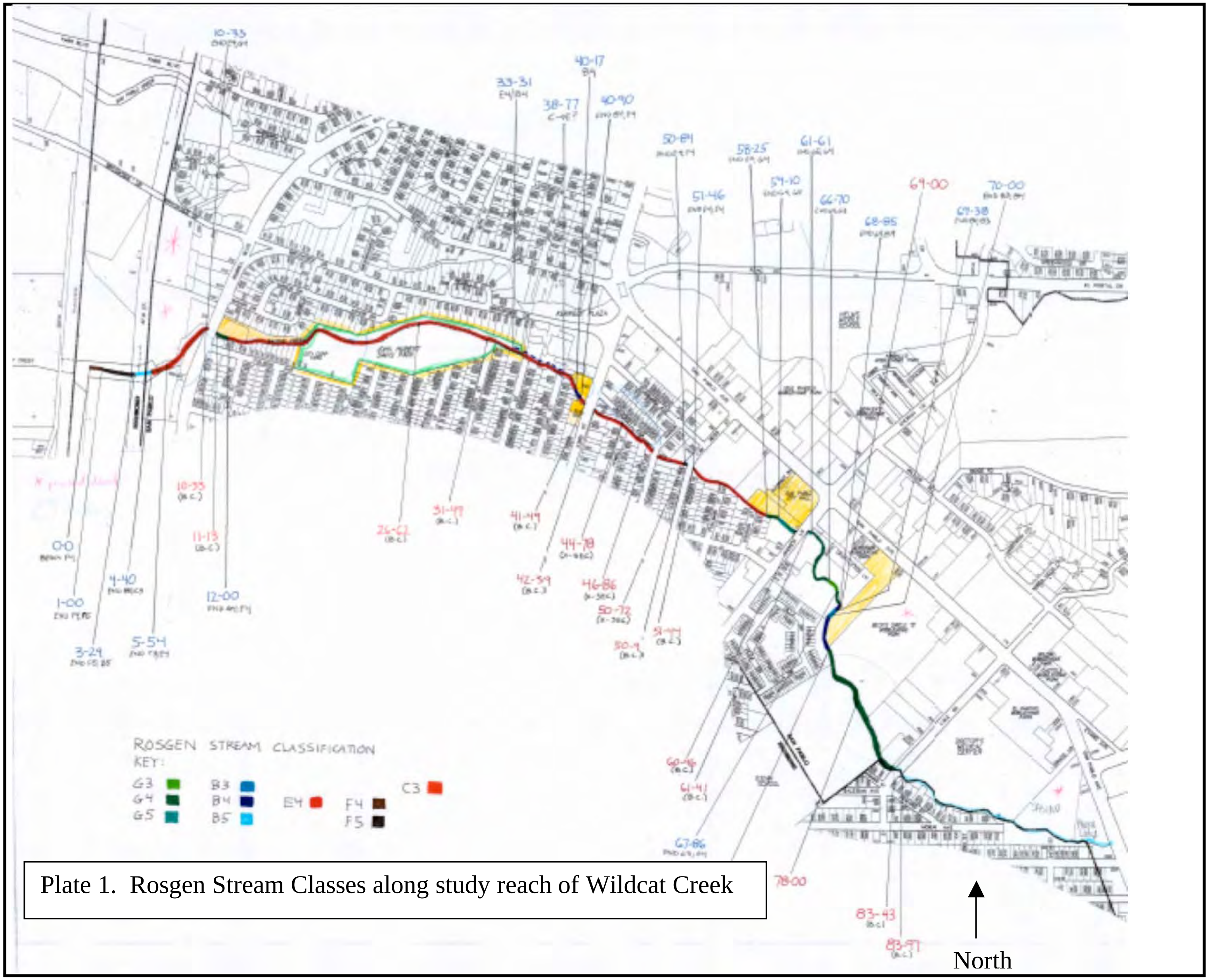

Plate 1. Rosgen Stream Classes along study reach of Wildcat Creek

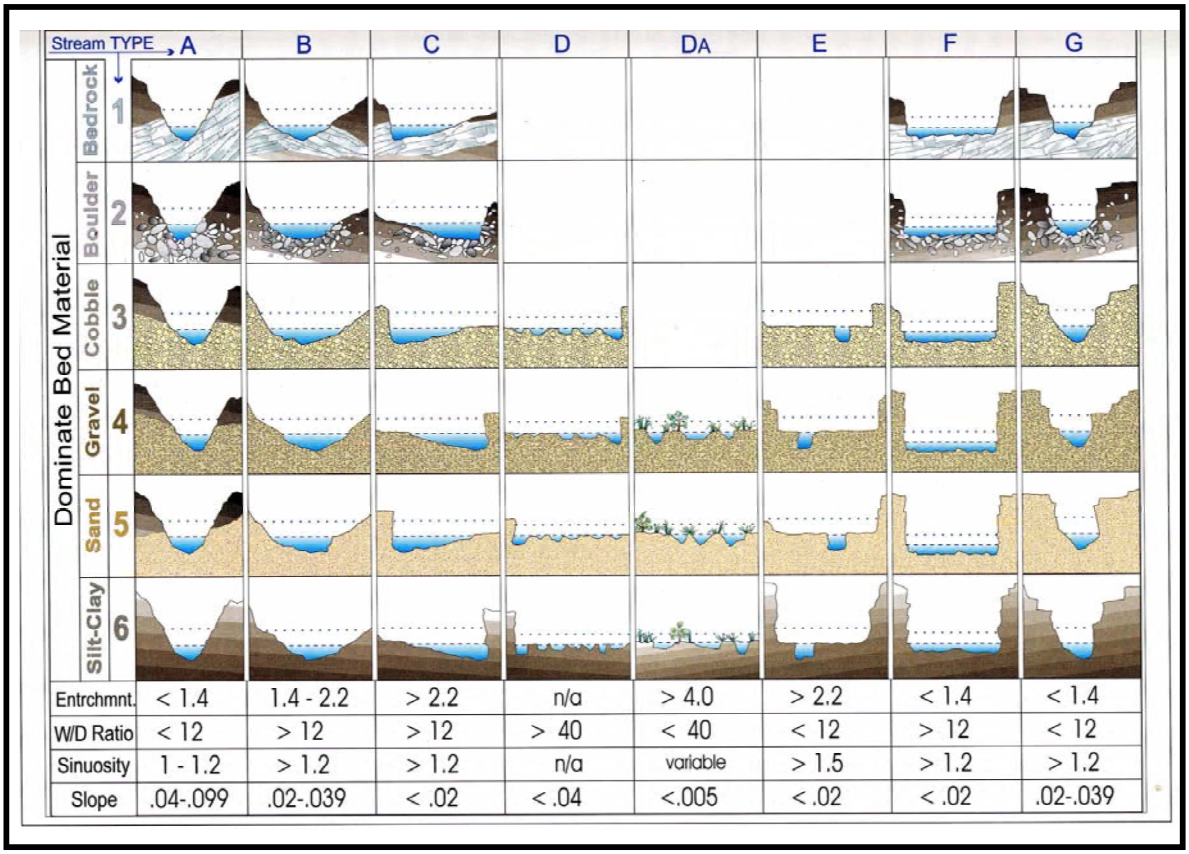

Figure 1. Rosgen Stream Classification System from Rosgen

Table 1. Modified Rosgen Stream Classification

Stream Type	Entrenchment Ratio (+/-0.2)	Width/Depth Ratio (+/- 3.0)	Description
A	< 1.4	>10	Step/pool bed morphology that can be erosional, stable, or depositional stream that is entrenched and confined with cascading reaches.
B	1.4 – 2.2	>10	Pool/riffle dominated channel with moderate gradient, moderate entrenchment, and stable banks, planform and profile
C	>2.2	>10	Pool/riffle and point bar dominated channel, slightly entrenched, with low gradient and well defined floodplain.
E	>2.2	<10	Pool/riffle, typically stable, narrow, and sinuous channel, slightly entrenched with low gradient and accessible floodplain.
F	<1.4	>10	Pool/riffle channel that is wide, unstable and highly entrenched with low gradient. Laterally unstable with high bank erosion rates.
G	<1.4	<10	Highly entrenched “gully-like’ channel with moderate gradient that is deeply incised causing high bed incision rates and bank instability.

After Rosgen (1996) with modified thresholds for this project.

is mostly a G channel, with a small section of B near the middle. The E channel segments are most floodprone, while the G and F channel segments are the most inherently unstable. Bank erosion tends to predominate in F channels and bed incision predominates in G channels.

Figure 2 shows the percent length that is represented by each stream class. The E4 channel comprises 58 percent of the study length and G4 is 24 percent. Box culverts and B4 conditions each represent 4 percent, with all other conditions each representing 3 percent or less of the remaining study reach.

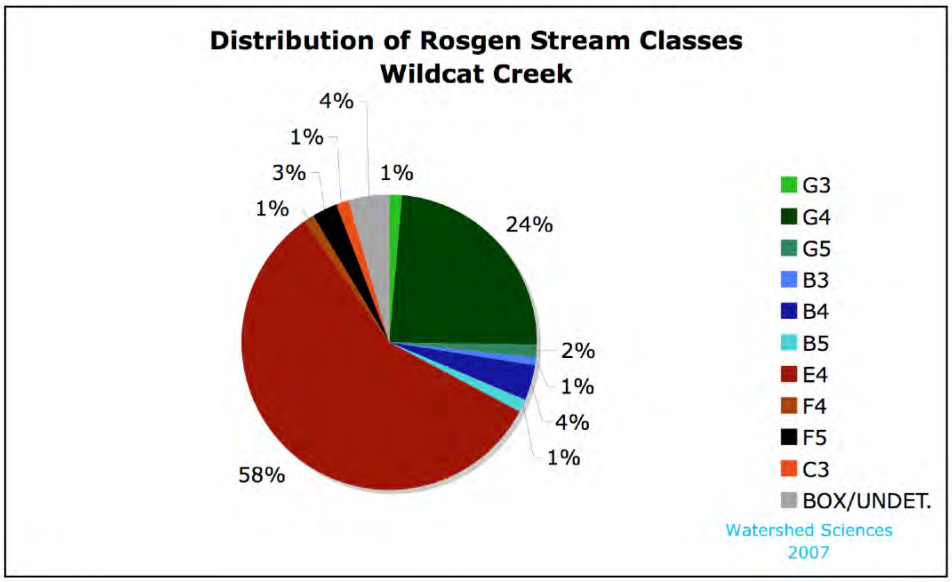

Figure 2. Percent Length of different Rosgen Stream Classes in study reach.

Our field data is too extensive to be detailed here, but has been compiled in Excel for reference. This data includes the following measurements at each cross-section:

- Bankfull Width and Depth
- Maximum Depth,
- Flood Prone Width,
- Entrenchment Ratio,
- Width/Depth Ratio,
- Rosgen Stream Class for each Cross-Section and reach,

- Flood Prone elevation above or below the measured Valley Flat elevation,
- Photos of reaches and cross-sections, and
- Notes on vegetation cover and/or revetments.

Our cross-section data, as well as personal accounts from local residents and county officials, confirm that many reaches within our study area experience flooding. Many cross-sections revealed a tendency to flood both banks, while those that do not flood, or are unable to flood, are likely to have an entrenched morphology. Figure 3 below illustrates the floodprone elevations determined at discrete cross sections. No data was collected downstream of distance station 3800 feet. The graph does not indicate the lateral extent of potential flooding. The data indicates that the segment between 23rd Street and Van Ness Avenue is most floodprone and has sections where the valley flat is 4 feet below the floodprone elevation. University Ave, which is along the north side of Wildcat Creek, corresponds to this segment, and is an area well known for flood problems.

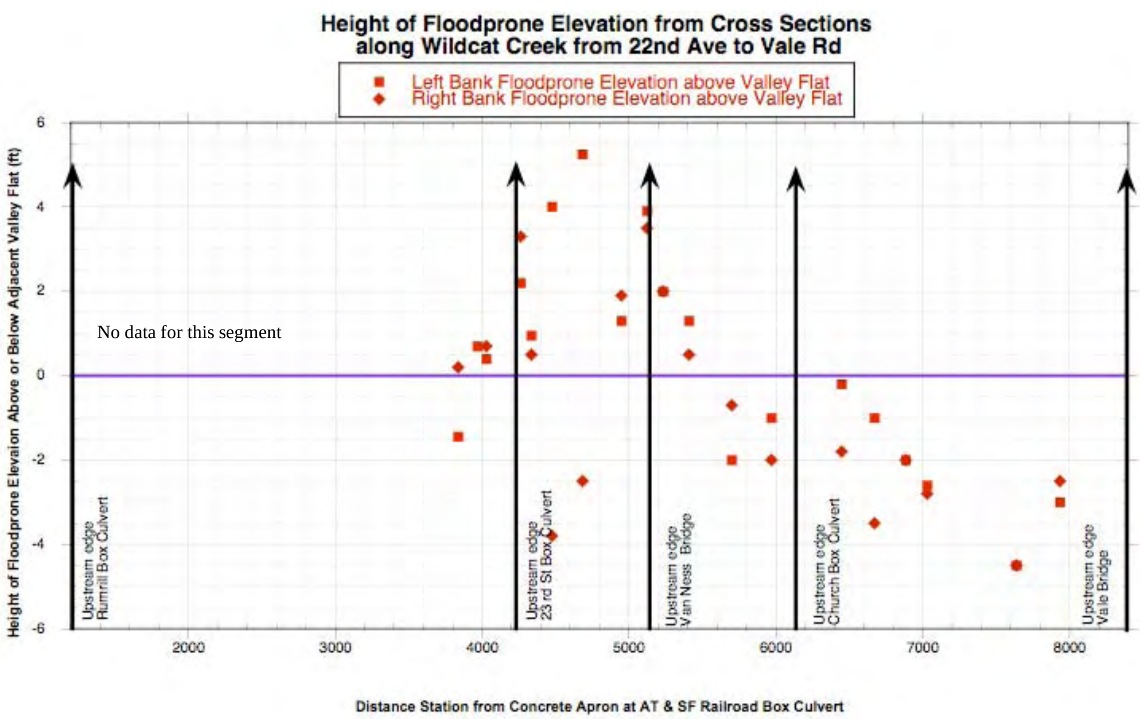

Figure 3. Floodprone elevation relative to valley flat.

SECTION 3C (ACTION PLAN: CULVERTS)

Our research indicates that box culverts and road crossings contribute to flooding problems in Wildcat study reach. Most of the box culverts and crossings in our study area, specifically those at Rumrill, 23rd, Van Ness, Church, and Vale streets, are unable to transmit the necessary flow volumes of moderate to greater size storm events. Storms with recurrence intervals of about 20 years and greater (sometimes less depending upon local conditions) are known to cause problems and without dredging in some of these culverts, flooding would be more frequent. Poor box culvert design and insufficient capacity cause a list of problems and positive feedbacks such as backwater flooding and associated erosion, and sedimentation and associated loss of capacity leading to more severe flooding.

One solution for reducing channel instability involves focusing restoration efforts at entrenched reaches that do not have sufficient floodprone width. By using natural channel geometry relations to bankfull flow and by creating inner floodplain benches within the active channel cross section, larger floods can be contained while reducing hydraulic stresses that can lead to accelerated rates of erosion and channel instability.

Another solution involves a long-term strategy of re-engineering ineffective box culverts and stream crossings throughout Wildcat Creek. A large number of resources are available which address the need for new design protocols for bridges and box culverts. These approaches tend to be more sensitive to the natural morphology of a channel, and the hydraulic geometry requirements needed to convey a range of flood magnitudes. In 2005, Watershed Sciences created a literature review of these design alternatives as part of a report for Alameda County. This document, “Literature Review of Modern Box Culvert Design,” can be found in its entirety in the appendix