SULPHUR CREEK WATERSHED RESTORATION STRATEGY

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AND
MOHAWK VALLEY WATERSHED RESTORATION COMMITTEE

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March 2005

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INTRODUCTION

Watershed Description

Located on the eastern edge of the Sierra-Nevada crest (Mohawk Ridge), the Sulphur Creek watershed abuts the headw the North Yuba River to the west and the Carman Creek watershed to the east. Sulphur Creek flows directly to the Fork Feather River at Clio.

The Sulphur Creek watershed is distinctly divided into a western half and an eastern half by the Mohawk Fault. This part of the larger, active system defining the Sierra-Nevada mountain range. Sulfur hot springs flow from one of the parallel faults at the White Sulphur Springs Ranch, on the east side of Highway 89.

The west side slopes draining to the main stem of Sulphur Creek rise from the valley floor at an elevation of 4500 feet 8000 feet at Haskell Peak. This contrasts sharply with the east-side, where the elevation rise is 2000 feet less, ranging f valley floor to just over 6100 feet. The effect is the formation of a “rain-shadow” on the eastern half with an average precipitation amount of 30 to 40 inches. To the east lies Sierra Valley, which receives an average of 12 inches annua average annual precipitation along the western half is from 40 inches near its base to over 60 inches near its summit, r the form of snow.

Another striking difference between the two sides of the watershed is their aspect, the general compass direction and a the suns rays. The western side generally faces north and east, receiving much less direct sun throughout the year t eastern side, which generally faces south and west. The eastern side also contains gentler slopes that are exposed to t rays’ overhead, during the hottest time of the day. The east side of the Sulphur Creek watershed not only receiv precipitation, but the greater evaporation and vegetation transpiration leads to less runoff than that from the west side watershed. The west side receives more snow and it lasts longer into the year. There is also more water available on t side to percolate into the ground, feeding more springs and streams with more water. Most of the streams on the west si to flow year-long, while even the two main tributaries draining the east side (there are only two draining the entire ea become dry or nearly so most years.

The west side is still rising (tectonically active), while the east side appears to be standing still and is slowly eroding aw has very important implications on how these two very different sides of the Sulphur Creek watershed behave. The eas mostly experiencing surface erosion while slope failures are common on the steep westside. Massive slope failures are and episodic in occurrence, responding to either rain-on-snow or seismic events. The 1997 rain-on-snow event caused f in the valley and slides and debris torrents that deposited large amounts of coarse material into Sulphur Creek ab Whitehawk Ranch and onto the landscape where each tributary channel drains into the valley.

Rock types within the Sulphur Creek watershed are metamorphic, granitoid and volcanic. Granitic rock types are exp both sides of the watershed and the soils associated with this rock type are very erosive. Highway 89 was constructed in weathered granitic rock and soil where it traverses the eastside along the middle reach of Sulphur Creek. Soils from th rock types are composed of much finer material that decay into sand and smaller sized soil particles. These soils are mu erosive, but still provide large quantities of sediment where flows are concentrated or on steep slopes where vegetatio or rock is sparse.

An arm of Lake Mohawk extended into what is now the lower and middle reaches of Sulphur Creek. Lakebed deposits out at the 5000-foot elevation (Durrell 1960). Erosion of these lakebeds continues today and forms the sloping meado on both sides of the Sulphur Creek valley. Sulphur Creek has become entrenched within its valley. *Entrenchmen process, or results of the process, whereby a stream erodes downward so as to form a trench* (Figure 1). An entrench commonly referred to as a gully.

Before Lake Mohawk drained (as recently as 20,000 years ago), the climate of the region had been cooling and culminating in the formation of glaciers. The lower ends of these glaciers rode out into the lake, leaving behind moraines *(mounds or ridges of unsorted, unstratified glacial drift* (*heterogeneous mixture of clay, silt, sand, grav boulders*)) as they receded. Several of these moraines deposited onto the lakebeds along the westside.

Because of the gently sloping sides from the eroding lakebed material, the valley is not a typical, nearly flat r floodplain. The floodplain of Sulphur Creek is much more narrow than the valley width. The width of the historic flo was about 400 feet while the valley is up to 8000 feet wide. The westside is drained by several, nearly parallel stream ch as opposed to the two, highly branched systems draining the east side (Barry Creek and Calfpasture Creek). This con drainage patterns supports the idea that the east side is older and more stable. Parallel drainage patterns usually denote a landscape while highly branching patterns usually denote a mature landscape.

Where each stream channel opens out into the valley, large fan shaped deposits of sediment called alluvial fans have f The alluvial fans associated with the two tributaries of the watershed's eastside are generally composed of fine material fans associated with the westside channels are generally composed of loose rock material. The historic flood of Jan 1997, deposited large amounts of this coarse sediment onto these westside fans as a result of debris flows (*a moving rock, soil, and mud*) that started high up in headwater areas. Landslides and slumps are common, naturally occurring processes that provide abundant sedimentary material to the west side streams. Much of this sediment is carried downst debris flows, a common and very important, natural transport mechanism.

Stream Channel Conditions

There are in general two types of streams (Figure 2), those that move sediment because they are steep and narrow (tr channels) and those that collect sediment and respond to changes in the watershed (response channels). The stream c draining the Sulphur Creek watershed are classic examples of these two general types. Most, if not all, of the stream degradation (entrenchment and widening) occurs in the fragile environment occupied by the response channels. vegetation is lost or water flows concentrated in these fragile, highly erodible environments, the entrenchment (gully) progresses with earnest. At the headward expansion of each entrenched channel is a headcut (*an abrupt change in el marked by a rapidly eroding waterfall*). Downstream of each headcut is a narrow trench, acting as a very efficient se transport channel. Further downstream, the trench has widened and the channel slope (energy gradient) has decreased capacity to transport sediment has diminished. Further widening results in the development of an entrenched valley inset channel system (Figure 3). Although a lot of sediment is still transported through such a development, large depo features of coarse material called gravel bars form. Gravel bars force streamflows into adjoining banks of fine mate accelerate valley widening (Figure 4).

Streams flowing into the valley from the east are delivering much less coarse sediment. Several headcuts are migra Calfpasture Creek in the valley, dewatering that portion of the meadow and sending fine-grained sediment to Sulphur The lower Barry Creek channel has entrenched and is in the process of widening.

The degradation of the main Sulphur Creek channel has progressed upstream to a short bedrock-control section at an el of approximately 5000 feet. Surface water no longer flows on top of the historic valley meadow and its floodplain, bu through the valley within the entrenchment, accentuating flood flows and decreasing groundwater recharge and storag valley aquifer is currently maintained by water input from tributary channels and water diversions. Most of the se generated in the upper and middle Sulphur Creek drainage areas eventually moves through the entrenched valley and system before entering the Middle Fork Feather River (MFFR). This change in water and sediment flows will continue adjustments to the entrenched valley and channel with continued widening, bank loss, and disruption of the aqua riparian ecosystems.

Causal Agents

There are few obvious, direct causes for the conditions described above. Channel entrenchment can usually be traced instability and drop in the base elevation downstream. The MFFR has certainly downcut where Sulphur Creek flows The mouth of Sulphur Creek (the location where it discharges in the MFFR) was apparently relocated from immediatel of where the Clio bridge is presently located to upstream of the bridge. The MFFR and its floodplain was also truncated location.

Other factors either played into the many potential causes or are aggravating the degraded conditions. Upper watershe are potentially delivering water faster than historically, leading to higher and more frequent peak flows. This in turn adjustments downstream mainly to the response channels in the valley bottom. Upper watershed areas are not only de water differently but also delivering more sediment than historically. Changes in water and sediment flows are now continued channel instability and slowing natural recovery processes.

The paramount disturbance in the headwater areas is the road system. Roads located next to and crossing stream c contribute sediment and runoff directly to those streams. Roads in the Sulphur Creek watershed were primarily cons and are currently maintained in such a way that they intercept surface and subsurface water, concentrate it into ditches, and then drain that water directly to stream channels. There are few cross drains and out-sloped road segment result, the stream system is adjusting to or is aggravated by the change in the amount and timing of water and sediment. flows, common on the westside, are enhanced by poor road locations and design. Several roads and road sections ha identified that probably contributed to increasing the magnitude of debris flows and to an increased risk of future intera A large segment of the Mohawk-Chapman Road is the most notable example of this problem.

Other causal agents, or impacts, that both slow recovery and aggravate unstable conditions include livestock over especially within riparian areas, increases in impervious surfaces (houses and other buildings, access roads, parking lot mineral mining, gravel extraction, water diversions, channel straightening and realignment, bridges spanning the main Creek channel, and, possibly, wildfire suppression and ignition.

STRATEGY DEVELOPMENT

To develop a restoration strategy, several items were identified and developed in order to focus our attention on the important needs and desires. To do this we identified (1) a set of desired conditions for the Sulphur Creek watershed, (2) opportunities within the watershed that will help us attain the desired conditions, and (3) constraints that may hinder or reduce achievement of the desired conditions. Finally, a ranking system was developed to help guide us to the highest priority areas and projects, realizing that it is only a guide and that it must be periodically updated to meet social and economic changes, changes in watershed condition, and to accomplish other projects approved by the Steering Committee.

Desired Conditions

The desired conditions identified so far for the Sulphur Creek watershed are:

- Stream channel, floodplain and riparian areas that are fully functional and aesthetically pleasing.
- Minimal flood damages, including loss of property from bank erosion.
- Sediment production and loads reduced to levels that aid stream restoration efforts and improve water quality.
- Water quality levels (sediment and water temperature) that enhance all life stages of a coldwater fishery and other cold water biota.
- Maintain off-channel livestock forage production while protecting and enhancing stream and riparian areas.

Opportunities

Several opportunities for improving, rehabilitating, and restoring watershed conditions that strive to meet desired conditions are listed below. This list is not all-inclusive and can be changed at any time.

- Several landowners (and managers) wish to improve stream and meadow conditions on their properties.
- The Sulphur Creek streamflow is perennial, affording the greatest opportunity for vegetation recovery.
- There's an ample supply of large woody material (fallen trees) in the middle reach of Sulphur Creek (subwatershed 10) that can be used to help trap bedload sediment.
- No homes and few structures have been constructed within the historic floodplains, allowing the consideration of a wide array of rehabilitation options.
- Much of the main Sulphur Creek entrenchment, especially below the Whitehawk Ranch, is sufficiently wide for it to naturally develop a stable channel and floodplain system at the existing, lowered elevation with only minor assistance from us.
- A channel and floodplain system is developing through the Whitehawk Ranch reach that can be enhanced to reduce bank erosion damages.
- The Highway 89 crossing of Barry Creek is currently maintaining a base level elevation for Barry Creek that is higher than that of the adjacent Sulphur Creek channel.

Constraints

Constraints limit or reduce restoration and rehabilitation accomplishments. Like the list of opportunities, the following list of constraints is not necessarily all-inclusive and can change.

- Developments in the Whitehawk Ranch reach have occurred on the original floodplain of Sulphur Creek.
- Livestock management within the newly forming channel and floodplain area downstream of the Whitehawk Ranch reach does not currently support rehabilitation efforts.
- The main Sulphur Creek channel is moderately or severely constricted at four bridge locations, the lower Loop Road bridge, the two Whitehawk Ranch bridges, and the Highway 89 bridge. The River's Edge RV Park bridge near is within the high flow backwater area of the Clio Bridge over the Middle Fork Feather River.
- Barry Creek is confined within levees as it approaches Highway 89.
- Threatened, endangered, and sensitive plant and animal species may be present in the Sulphur Creek watershed.
- Archaeological sites have been reported within the Sulphur Creek watershed.

Watershed Delineations and Ranking

The watershed was divided into 12 subwatersheds by simply delineating each tributary channel's watershed area, beginning where each discharges into the main Sulphur Creek channel (Figure 5). The main Sulphur Creek channel was subsequently divided into three reaches and their subwatersheds delineated: subwatershed 1, the valley bottom reach; subwatershed 10, the middle reach; and subwatershed 11, the headwater reach. On the watershed's eastside, Calfpasture Creek is further subdivided into its north and south branches (subwatersheds 3a and 3b) and Barry Creek is subdivided into upper and lower reaches (subwatersheds 9a and 9b). McNair Meadow (subwatershed 12) includes both an eastside channel and a westside channel (Sulphur Creek).

A system for ranking the subwatersheds was developed using systems developed by the Forest Service. The first system scores and ranks each subwatershed according to its **sensitivity to disturbance** (both natural and human). Next, the system scores and ranks each subwatershed according to its **existing condition**. Lastly, the scores are combined for an overall ranking. A weighting system was also applied because some of the elements evaluated can cause more changes to the stream and riparian system than others (See Appendix 1 for a full display of the scores and rankings). Priority 1 should be given the highest consideration for treatment.

The assessment of **subwatershed sensitivity** was based on the following:

- Existing and potential occurrence of landslides and slumps.
- Occurrence of sensitive stream channels, those prone to degradation or aggradation when changes or disturbances occur in the watershed.
- Potential soil erosion hazard following disturbances.
- Potential for large, intensive wildfires.
- Potential vegetation recovery.

Table 1. Ranking by Sensitivity

Rankings of 1, 2 and 3 are considered to be the most sensitive (highlighted).

Subwatershed Number	Name	Rank
1	Lower Sulphur Creek	4
2	Bear Wallow Creek	4
3a	South Calfpasture Creek	5
3b	North Calfpasture Creek	5
4	**Wash Creek**	**3**
5	**McKenzie Creek**	**3**
6	**Boulder Creek**	**1**
7	**Raap/Guidici Creek**	**1**
8	**Haskell Creek**	**1**
9a	Lower Barry Creek	7
9b	Upper Barry Creek	5
10	**Middle Sulphur Creek**	**1**
11	**Upper Sulphur Creek**	**2**
12	McNair Meadow	6

The **subwatershed condition** elements are:

- Number of sensitive stream channels in unstable condition.
- Potential to connect natural sediment transport channels with the existing gully system.
- Measured volume of soil and rock that has eroded from the road segments that are in direct contact with stream channels.
- Measured length of road drains connecting directly to stream channels.

Table 2. Ranking by Condition

Rankings of 1, 2, 3and 4 are considered to be the worst condition (highlighted).

Subwatershed Number	Name	Rank
1	**Lower Sulphur Creek**	**2**
2	Bear Wallow Creek	11
3a	**South Calfpasture Creek**	**3**
3b	**North Calfpasture Creek**	**4**
4	Wash Creek	5
5	McKenzie Creek	9
6	**Boulder Creek**	**4**
7	**Raap/Guidici Creek**	**4**
8	Haskell Creek	7
9a	**Lower Barry Creek**	**2**

9b	Upper Barry Creek	8
10	**Middle Sulphur Creek**	**1**
11	Upper Sulphur Creek	6
12	McNair Meadow	10

Table 3. Combined Ranking

Rankings of 1, 2, 3and 4 are considered to be the highest priority (highlighted).

Subwatershed Number	Name	Rank
1	**Lower Sulphur Creek**	**3**
2	Bear Wallow Creek	11
3a	**South Calfpasture Creek**	**4**
3b	**North Calfpasture Creek**	**7**
4	Wash Creek	7
5	McKenzie Creek	8
6	**Boulder Creek**	**4**
7	**Raap/Guidici Creek**	**2**
8	Haskell Creek	6
9a	**Lower Barry Creek**	**5**
9b	Upper Barry Creek	9
10	**Middle Sulphur Creek**	**1**
11	Upper Sulphur Creek	7
12	McNair Meadow	10

Ranking of the Roads

Even though the impacts from the road system were used to evaluate the condition of each subwatershed, each road was also evaluated separately, no matter where it is located within the larger Sulphur Creek watershed. This was performed because, generally, each road would be treated in its entirety, not just in sections defined by subwatershed boundaries. The same impact data (erosion voids and hydraulic linkages) was used to evaluate the roads and develop a priority ranking as follows (See Appendix 2 for a display of the impacts):

Table 4. Ranking of Roads by Impacts to the Total Watershed
List in order of priority.

Road	Percent Total Impacts to Watershed
22N98 (Mohawk Chapman Road)	45.0
Highway 89	17.8
22N13	15.3
21NO2 (Loop Road)	6.2
County Rd 114	3.5
21N27	3.3
22N12	2.8
21N09	2.6
21N83	0.8
21N94	0.8
21N91	0.7
21N01	0.4
21N06	0.2
22N48	0.2
21N29	0.1
21N31	0.1
22N03	0.1
Friendly Way	0.1

Restoration Priorities

Because human and natural disturbances in the watershed generate large amounts of coarse and fine sediment and because there's a good chance the historic flow regime has been altered so that flood flow peaks are greater (greater erosion potential), the major hydraulic functions that have been adversely altered need to be restored before other work can provide significant results. Watershed treatments should, therefore, initially focus on (1) capturing and storing the coarse sediment (bedload) that is moving into the main channel areas and (2) eliminating the potential sediment transport connections between headwater channels and the existing gully system. Next, the focus can change to (3) reducing sediment from in-channel and off-channel sources and (4) reducing flood peaks. As these treatments become effective, the other desired conditions will be realized, such as improved water quality and increased aquatic and riparian habitats.

Potential rehabilitation projects would be expected to restore basic hydrologic functions, thereby aiding natural recovery processes. The projects would be expected to achieve the following, in order of priority.

Priority 1. Entrenched (Downcut) Stream Channels

a. Capture large amounts of bedload in the main Sulphur Creek channel near the head of the valley, upstream of the confluence with Barry Creek, at and upstream of the lower Loop Road bridge.
b. Maintain the sediment capturing function of tributary channels and slow their further widening or eliminate the entrenchment altogether.
c. Within the lower Sulphur Creek channel reach, slow the gully widening process and facilitate recovery of the stream channel, floodplain, and riparian areas.

Priority 2. Roads and Stream Crossings

a. Obliterate high impact, unnecessary roads and relocate those running close to and parallel with stream channels.

b. Stabilize cut and fill slopes and redirect road drains away from streams and onto slopes.
c. Improve overall road drainage by out-sloping road surfaces, eliminating inside ditches, adding cross-drains, and armoring outlets.
d. Improve stream crossings so they pass flows more naturally using low-water or multi-culvert techniques.

Potential Projects (Figures 6 & 7)

The following projects are listed in order of priority and are stated as objectives. The ranking of projects does not mean that projects of lesser priority should not go forward sooner, but rather that the scheme presented here should be emphasized. To more evenly distribute the stresses of streamflow against adjacent and downstream gully banks (potentially accelerating erosion in those areas), treat entire reaches instead of short sections.

1. **Middle Sulphur at Barry.** To significantly reduce the amount of sediment transported to the lower Sulphur Creek reach, thereby reducing erosional stresses along the entrenched channel downstream, implement a project in the middle Sulphur Creek reach (subwatershed # 10) that captures sediment, including debris flow material.

2. **High Risk Tributary Stream Channels.** To eliminate the chance that high risk tributary channels will discharge their sediment loads to the lower Sulphur Creek channel, further aggravating erosional stresses, rehabilitate or restore tributary channels and floodplains as follows:

NAME	SUBWATERSHED NUMBER
Boulder Creek	6
Raap/Guidici Creek	7
Wash Creek	4
McKenzie Creek	5
Calfpasture Creek	3

3. **Mohawk-Chapman Road (FS 22N98).** To reduce the size and intensity of westside debris flows (a naturally occurring sediment transport mechanism) remove a large portion of the high-risk, Mohawk-Chapman road, connector road (FS 21N91) and spur roads A and B.

4. **Whitehawk Ranch Reach.** To enhance the development of a properly functioning stream channel and floodplain within the existing entrenchment, to slow the gully widening process, and to reduce the amount of sediment that would be transported downstream, remove fill material placed within the developing floodplain and treat eroding banks with treatments that promote full and dense vegetation cover and protection.

5. **Livestock Management.** To help improve channel and riparian conditions and to protect project work and vegetation plantings, implement livestock management plans that are compatible with riparian area protection and enhancement.

6. **Lower Sulphur Creek Reach.** To enhance the development of a properly functioning stream channel and floodplain within the existing entrenchment and to slow the gully widening process, treat eroding banks to promote full and dense vegetation cover and protection.

7. **Sulphur Creek Constriction near Confluence with the Middle Fork Feather River (MFFR).** Because Sulphur Creek was re-routed near its confluence with the MFFR, a 200-foot wide constriction in the new valley now exists near the River's Edge Park. To raise the elevation base level for the entire Sulphur Creek valley, to raise the permanent water table to near meadow elevation, and to capture sediment before it enters the MFFR, construct a grade control structure within the existing channel that allows flood flows to access the original channel way now crossed by Highway 89. Reconstruct the highway at this location and provide for full distribution of flows using multiple culverts or similar technology.

8. **Bridges.** **(a)** To eliminate the risk of bridge loss and channel adjustments both at the bridge site and downstream, replace the lower bridge in the Whitehawk Ranch reach with a low-water crossing that conforms to the developing channel and floodplain dimensions. **(b)** To reduce the risk of bridge loss and channel adjustments both at the bridge site and downstream, provide flood flow relief at the upper bridge in the Whitehawk Ranch reach.

9. **McNair Meadow.** To eliminate the risk of gully development in McNair Meadow, treat existing headcut area.

10. **Yarrington Meadow.** To eliminate the risk of further gully development in Yarrington Meadow, treat the existing headcut area.

11. **Roads.** To improve streamflow and sediment conditions within the Sulphur Creek watershed, move roads away from streams (no matter what the channel size), eliminate unnecessary roads, and eliminate direct

drainage of roads to streams. The treatment of roads should generally be emphasized in the following order:

Highway 89 in Subwatershed # 10
Forest Service Road (FS) 22N13
FS 21N02 (Loop Road)
County Road 114
FS 21N27
FS 22N12
FS 21N09
FS 21N83
FS 21N94
FS 21N91
All Others

ESTIMATED PROJECT COSTS

A preliminary budget was developed for each of the projects listed above, Appendix 3, and summarized in the following table. The projects are listed in order of priority of importance.

Table 5. List of Potential Projects and Estimated Costs

Project Name	Proposal	Cost Estimate
Sulphur Creek @ Barry Cr.	Gully obliteration + grade control	$225,000
Boulder Creek	Gully obliteration + grade control	$213,000
Raap/Guidici Creek	Gully obliteration + grade control	$161,000
Wash Creek	Gully obliteration + grade control	$151,000
McKenzie Creek	Gully obliteration + grade control	$110,000
Calfpasture Creek	Gully obliteration + grade control	$150,000
Mohawk Chapman Road + Spurs	Obliterate road & crossings	$323,000
Sulphur Cr. @ Whitehawk Ranch	In-channel erosion control + reveg	$176,000
Lower Sulphur Creek	In-channel erosion control + reveg	$181,000
Sulphur Creek Constriction	Base elevation control structure	$225,000
Lower Whitehawk Bridge	Remove & const. low-water xing	$34,000
Upper Whitehawk Bridge	Open channel & add relief culverts	$27,000
McNair Meadow	Obliterate headcuts + grade control	$66,000
Yarringtom Meadow	Obliterate headcuts + grade control	$86,000
Highway 89 (Middle Sulphur)	Slope reveg + sediment control	$404,000
County Road 114	Slope reveg + sediment control	$31,000
Forest Service Road 22N13	Reconstruct to improve drainage	$253,000
21N02	Reconstruct to improve drainage	$165,000
21N27	Reconstruct to improve drainage	$238,000
22N12	Reconstruct to improve drainage	$208,000
21N09	Reconstruct to improve drainage	$94,000
21N83	Reconstruct to improve drainage	$59,000
21N94	Reconstruct to improve drainage	$209,000
Total		**$3,789,000**
Citizen Monitoring Program	Monitor long-term watershed health	**$8,000 / year**

Of the estimated total cost, $1,854,000 (49%) would go for in-stream project work and $1,935,000 (51%) for road and bridge improvements. The cost for each project includes three years of project monitoring. In addition, the long-term Citizen Monitoring Program used to measure and document overall watershed health is estimated to cost $8,000 per year. There is no ending date for this program, being tied into both the restoration program and the analysis of the data collected by the program. The termination of the program is to be determined by the citizens themselves.

MONITORING AND MAINTENANCE

The FR-CRM has developed simplified, effective project monitoring techniques that can be carried out over the long term. Two levels of monitoring are expected to occur within the Sulphur Creek watershed. The first level is described in "Sulphur Creek Citizen Monitoring Program", Petroelje 2004, set up to describe existing (baseline) conditions and to track long term, cumulative, instream changes as a result of implementing this strategy. Citizen Monitoring is expected to be an integral part of the FR-CRM's work in the Sulphur Creek watershed. However, there is no long term funding for the program. The Citizen Monitoring Program is an important component of the strategy because of the recognized need and benefit for local watershed residents to engage in observing changes in the watershed over time. This knowledge encourages beneficial changes vital to meeting the long-term goals of both restoring and maintaining proper watershed functions.

The second level would evaluate individual project performance. Monitoring costs for each project have been included in the cost estimates listed in the section above. These monitoring costs include FR-CRM staff time, as well as time for a subcontracted Sulphur Creek Citizen Monitoring Coordinator. While the nascent Citizen Monitoring Program in Sulphur Creek continues to grow, it relies on a paid position to coordinate and train the monitors and manage their data. Continued funding for the position is expected to come out of project funds. Data collected by the program will continue to be used to document the current condition of flow and basic water quality parameters in the watershed. As projects are funded, it is expected that citizen monitors will collect pre-and post-project effectiveness monitoring data such as photo points and vegetation.

Level 1 Monitoring: Long Term Watershed Health
General Overview of the Citizen Monitoring Program

The Sulphur Creek Citizen Monitors have been collecting data to answer three specific study questions.

1. What is the current streamflow regime of Sulphur Creek?
2. What are the current baseline water quality conditions of Sulphur Creek?
3. Will the parameters studied change after restoration treatments?

The current program monitors streamflow, water temperature, electrical conductivity, turbidity, and rainfall to answer these questions. The program has been designed to adapt and change as new questions and concerns arise.

To answer the first question, a continuous recording station has been established near the Highway 89 bridge to record air and water temperatures and streamflow stages. To supplement this data, volunteers are collecting daily rainfall data and daily or weekly streamflow elevation data at four sites. The rating of each gage site to determine streamflow versus gage height is under development.

The volunteers are collecting air and water temperature, turbidity and electrical conductivity data on a monthly basis to determine existing water quality conditions. Temperature and turbidity were identified as water quality concerns for Sulphur Creek. Electrical conductivity is a good, general indicator of water quality changes due to different sources and over time. Citizen Monitors are currently documenting the existing water quality conditions. This is expected to continue so that water quality changes can also be documented.

The third question will be answered by comparing data before and after treatments are completed to evaluate the overall and long-term effectiveness of the treatments. Additional data such as photographs and groundwater elevations may be collected at restoration project sites.

All water quality data will be compared to the Regional Water Quality Control Board Basin Plan water quality objectives. Results not comparable to the Basin Plan will be evaluated by the FR-CRM technical advisors.

Chemical and physical parameters will be monitored using protocols outlined in the "*Sulphur Creek Citizen Monitoring Manual*". The protocols for flow and rainfall are adapted from the "*SWRCB Clean Water Team's Compendium of Water Quality Monitroing and Assessment*". The protocols for temperature, conductivity and turbidity are adapted from the "*EPA's Volunteer Stream Monitoring Manual*".

Level 2 Monitoring: Evaluating Individual Project Performance
Example Project Monitoring Plan

Following is a typical generic monitoring plan for a project. Each plan is different, and outlines who is responsible for each parameter, whether it be a landowner, a participating agency, or FR-CRM staff. In the example below, the FR-CRM is listed as the responsible party. The FR-CRM includes all participating parties, such as the Sulphur Creek Citizen Monitors, the Portola Schools, etc. Parameters also change as appropriate for different projects.

Meet project specific goals and objectives

1. *Visual changes and vegetation responses*: Photographs at prescribed locations would be collected at one time prior to the project and once a year for three years following project construction. The FR-CRM would be responsible for collecting and cataloging the photographs.
2. *Percent fines in pool-tail riffles and macroinvertebrate sampling*: Pre-project measurements and collections would be collected at one time prior to the project and once a year for three years following project construction. The FR-CRM would be responsible for collecting and cataloging the data.
3. *Fish sampling*: Pre-project sampling would be collected at one time prior to the project and once a year for three years following project construction. The FR-CRM would be responsible for collecting and cataloging the data.
4. *Water sampling*: Pre-project sampling would be collected at one time prior to the project and once a year for three years following project construction. Parameters would include flow, air and water temperatures, turbidity, and electroconductivity. The FR-CRM would be responsible for collecting and cataloging the data.

Effects on Site-specific design and construction success

1. *Site-specific design and construction success*: Annual field reviews by the FR-CRM for up to 3 years, depending on high flow occurrences. The FR-CRM and local landowners would accomplish long-term monitoring for an unspecified time period. The design functions to be measured include streamflow pattern and velocities. Construction success will be evaluated as integrity and stability of each project feature and the channel itself. Maintenance needs would be identified during these visits.

2. *Project critiques and technology transfer*: On-site tours to FR-CRM members and others interested in this type of work to evaluate and critique projects.

Final Project reports are forwarded to the funding agency at the end of the grant agreement term, including monitoring results.

Sometimes, project monitoring points to the need for maintenance work at a project site. Maintenance funding is not included in the above project costs. Funding for maintenance, where and if required, will require additional grant requests.

BIBLIOGRAPHY

Though not specifically cited, the following documents were used:

Bates, Robert L. and Julia A. Jackson, Editors. 1980. *Glossary of Geology*. American Geological Institute, Falls Church, Virginia.

Collins, Laurel. 2003. *Geomorphic Map of Sulphur Creek, Plumas County, California*. Waterhsed Sciences, Berkeley, California.

Durrell, Cordell. 1987. *Geologic History of the Feather River Country, California*. University of California Press, Berkeley and Los Angeles, California.

Petroelje, Michelle. 2004. *Sulphur Creek Citizen Monitoring Program Quality Assurance Project Plan*. Prepared as required by the California Proposition 13 grant that funded the Sulphur Creek Watershed Analysis. The Outline for the document was prepared by Gwen Starrett and Dominic Gregorio, both working for the State Water Resource Control Board.

Plumas Corporation. June 2004. *Sulphur Creek Watershed Analysis*. Feather River Coordinated Resource Management Group and Mohawk Valley Watershed Restoration Committee. Funded by a California Proposition 13 grant.