# CHAPTER ONE
# McWay Landslide Restoration - Task One

*History of McWay and Restoration Activities*

The 1984 landslide at McWay Rocks south of Big Sur resulted in a massive movement of earth onto Highway One. Subsequent deposition of sediments and debris on to the beach and marine habitats below the slide created many impacts to the environment.

Moss Landing Marine Laboratories (MLML) conducted two studies on the McWay landslide. The first study investigated the marine communities affected by the initial burial by slide material and the continual input of erosion material from the slope (MLML, 1988). In the second study from 1994-1998, erosion from the site was still evident, particularly because of an El Nino event during the winters of 1994-1995 and 1997-1998. Revegetation with appropriate plant communities was determined to be the most important factor to stabilize the slope (MLML, 1998) The upper McWay engineered cut slope, located on the eastern side of Highway One, has been slow to revegetate due to nitrogen and organic matter limitations of the mineral soil, harsh winds, invasion of exotic species, and a lack of a native seed bank in the soil. On the west side of the highway, the toe of the slope is being continually eroded by the marine tidal and wave action. Rain washes surface material from the slope, actively moving soil to the marine environment. Occasional land movement of the unconsolidated fill also transports large amounts of material down slope, precluding the long-term establishment of perennial vegetation. The lack of an adjacent native seed bank and the presence of weed plant species in close proximity has resulted in the site having a high potential for exotic plant establishment and low potential for native plant recruitment.

Due in part to the need to revegetate the site and the lack of technical revegetation information, the site became a developmental working laboratory for:

- Developing and testing native plant revegetation methods
- Erosion control methods
- Technical focus on vegetation establishment

Aerial and ground photographs have been taken of the McWay slide from 1984 through this year (Fig. 1.1-1.8). Photographs document the changes and trends of the changing slope face and the gully as the sediment slowly stabilizes. Due to the long time period required for stabilization of the slope, photo documentation is one method that is cost effective in monitoring the changes over time. Aerial photographs may also be valuable for locating geologic features, such as potential slope failure sites. These photographs may assist in development of strategies for management of road sections prone to slope failure.

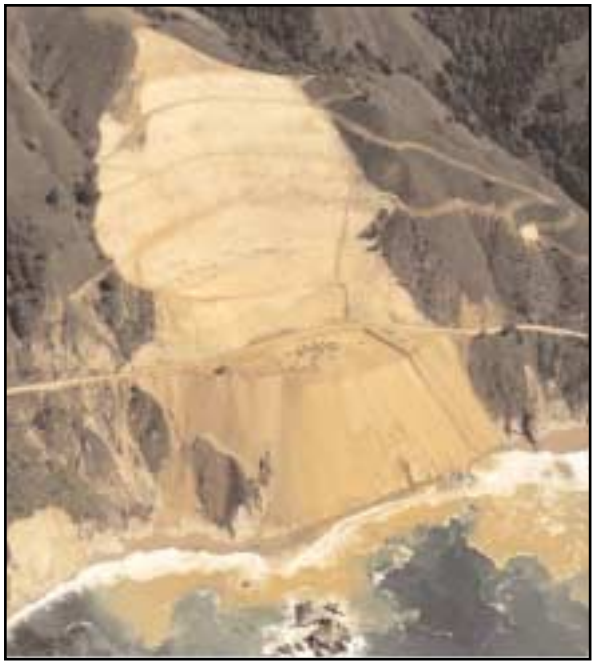

Figure 1.1 McWay 1984.

Figure 1.2 McWay 1991 looking north.

Figure 1.3 McWay 1991.

Figure 1.4 Mcway 1992 from the beach looking up at main gully.

Figure 1.5. Mcway 1993. Note the evolution of gully on right side of slide in this photograph and the following figure.

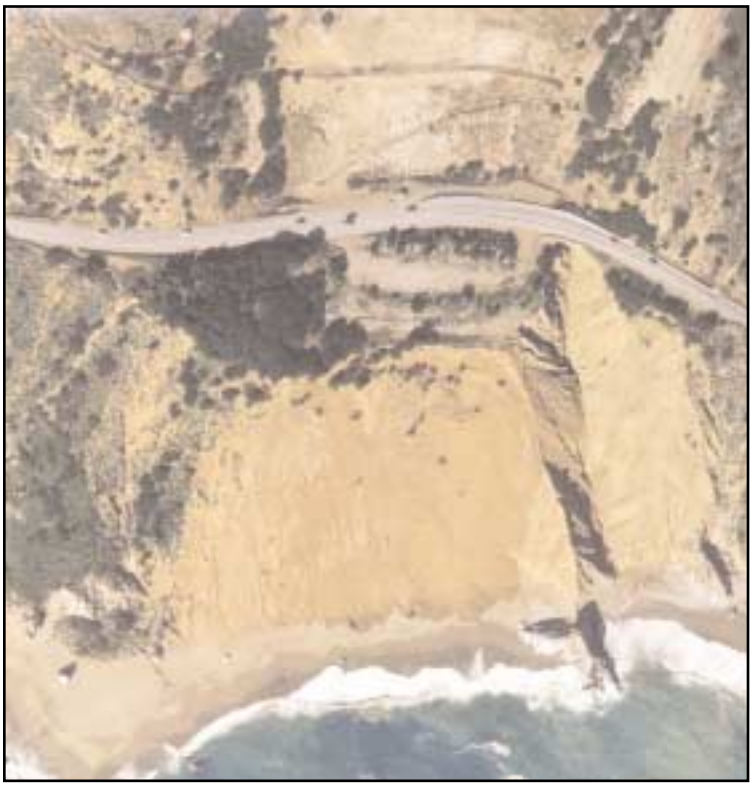

Figure 1.6. Mcway 1995.

Figure 1.7. McWay 1997 pre-slope restoration.

Figure 1.8. Mcway 1997 post- slope restoration.

*Initial Site Preparation*

Initial site preparation in 1998 included placement of straw bale slope breakers, jute netting, and irrigation lines. This formidable task was accomplished by training crews to work in climbing harnesses and ropes. (Fig. 1.9.)

Figure 1.9. 1998 McWay site preparation.

*Remedial Seeding and Willow Establishment - Main Gully at McWay*

Figure 1.10. Winter 1999-2000.

Remedial revegetation began at the McWay Landslide in 1998 and has continued on an annual basis for three years. This work has resulted in a complex assemblage of mature coastal scrub vegetation located within the main gully and bowl of the slide. As of spring 2000, six to eight foot tall willow shrubs line the drainage.

Mature seed bearing coastal scrub plants such as California sage and black sage are found throughout the site. The remedial work helped stabilize the cliff and unconsolidated soils beneath Highway One and the Highway Bridge.

Figure 1.11. Spring 2000.

Seeds of *Bromus carinatus* (California brome), *Hordeum brachyantherum* (meadow barley), *Deshampsia cespitosa* (hair grass), *Salvia mellifera* (California black sage), *Bacharris pilularis* (coyote brush), and *Lupinus arboreus* (tree lupine) were hand-broadcast . Fertilization consisted of a 12-12-12 mix applied at 150 pounds per acre. Willow pole cuttings were installed into pre-augured holes to a depth of 2.5 feet deep.

Figure 1.12. Bare slope of 1998.

Figure 1.13. Vegetation of upper main gully in spring 2000.

Figure 1.14. The main gully pictured from the beach. Arrow marks the top of the point at which the smaller, more unstable gully begins on the slope.

Figure 1.15. A close up of the top of the smaller gully showing the willows in the more stable area, and bare soils below.

The head of the main gully is bowl shaped and stable. Within the main gully a smaller gully formed during the winter of 1998. This smaller gully continues to erode and move upslope towards the more stable bowl at the

head of the main gully. Little vegetation has established at and below this unstable part of the main gully. Continued work will be required in this area in order to protect the stable areas up slope. This work would be best conducted in the fall of 2001 just prior to winter rains.

Figure 1.16. Main gully from the beach.

The unconsolidated mass of soil overcast west of Highway One is unstable and subject to significant soil migration. Since these areas have often experienced additional land movements we recommend the use of inexpensive annual cover crops on unconsolidated fill and the unstable sites. Permanent revegetation seed

Figure 1.17. Two views of hydroseeded slope.

mixes of coastal sage scrub may be applied in stabilized locations. Selected annual cover crops will mitigate surface erosion and may help stabilize sites, but can not solve geologic problems on unconsolidated/non-engineered fill in areas west of Highway One.

Figure 1.18. Hydroseed truck.

In the winter of 1999-2000 the first attempt to establish native vegetation on the front face of the fill

Figure 1.19. Sediment plume from rain-washed slope.

slope occurred. One day after seeding was completed, a majority of the surface dislodged and fell onto the boulder strewn toe of the slope and washed out into the Sanctuary. Subsequently 2,500 bales of rice straw were applied to cover the exposed areas, effectively halting a significant amount of the erosion (Fig. 1.19 and 1.20.).


Front face prior to rain.


Front face after rain and debris flow.


Front face after bales of rice straw where thrown.

Figure 1.20. Front face of McWay, before and after rain. Time series photographs showing erosional events before and after rain in February 2000.

Regreen sterile wheat was also hand-broadcast. Most of the straw was retained, and the Regreen sprouted. The front slope still remains somewhat barren, and is highly susceptible to continued failure. It is recommended future erosion control seeding should be applied during winter 2000-2001.

*Seed collection*

Students of the Watershed Institute collected coastal scrub seed during the months of June through September 1999 and again in 2000. Seeds were hand-collected in the general vicinity of the McWay landslide site. Once collected, the seeds were transported to Rana Creek Habitat Restoration's seed processing facility for cleaning. Seed collected included 25 pounds black sage, 20 pounds cliff buckwheat, 10 pounds coyote bush, 30 pounds California sage, and 25 pounds tree lupine. Tree lupine seed was added to the mix because tree lupine establishes and performs well on the nitrogen deficient mineral soils found on the landslide site.

Additional seeds were collected in order to initiate a regional seed bank of selected revegetation and erosion control ecotypes. Additional species collected were seaside daisy, tomcat clover, lotus, and lizard tail. These collected seeds may be used to agriculturally increase desired plants or used for future restoration.

*Control of exotic species*

Weed control consisted of hand pulling pampas grass and French broom seedlings and also hand-applications of selective and non-selective herbicides. Garlon was sprayed at a four-percent rate on mature French broom. Two-percent Round-up was applied on pampas grass and on fennel. Herbicide application was conducted beginning in April of 2000. Remedial exotic weed control was conducted on the front slope in June of 2000. This was our third year of exotic species control on the site. Exotic weed species density equaled greater than 3 seedling plants per meter in highly infested areas. Spot spraying was conducted on outlying

Figure 1.21. Pampas grass on site.

pampas grass plants on the slope face. Continued pest plant control is recommended. The site has been maintained in this manner for the past three years. If weed control operations are suspended, the level of control gained to date would be effectively lost.

*Straw bale placement*

In the winter of 1999-2000, approximately 2,500 bales of rice straw were applied to the slope face and at the base of the main gully. The straw bales were split and the straw flakes were hand broadcast. Straw flakes have been highly effective in controlling surface erosion in gullies on steep incised cuts and at gully points. The straw protects the surface and captures sediment transported through the gully. Often the straw and sediment will glue together, creating an ideal niche for plant establishment. (Fig. 1.22.)

Figure 1.22. Loose straw cast over slope, winter 1999-2000.

*Monitoring*

The Watershed Institute staff conducted monitoring at the site. We assessed exotic weed invasions, took photographs of erosion features, and assessed overall revegetation performance. Several permanent plots were still present at the site. These plots contained the remnants of coastal sage scrub plants that were direct seeded in 1998 (Fig. 1.23- 1.29 photo points). (Fig. 1.30 monitoring plots).

1998

2000

Figure 1.23. Photo monitoring Point 1.


Figure 1.24. Map of photo monitoring points at McWay. Orientation as follows: Point 1 (W-SW), Point 2 (E-SE), Point 3 (S-SE), Point 4 (NW), Point 5 (E-NE), Point 6 (E-SE). All photo points were shot with a 50mm lens.

Figure 1.25. Photo monitoring Point 2, left 1998, right 2000.

Figure 1.26. Photo monitoring Point 3, left 1998, right 2000.

Figure 1.27. Photo monitoring Point 4, left 1998, right 2000.

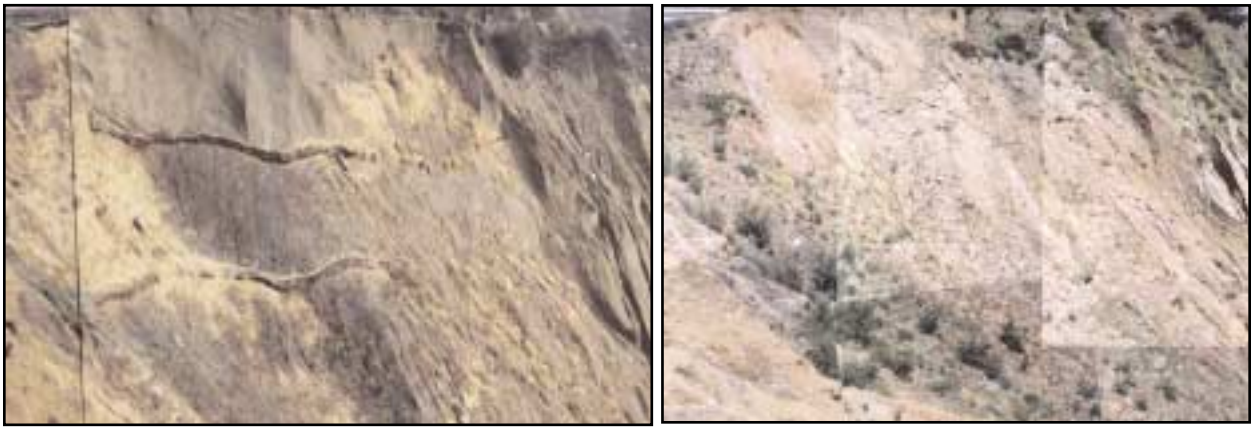

Figure 1.28. Photo monitoring Point 5, left 1998, right 2000.

Figure 1.29. Photo monitoring Point 6, left 1998, right 2000.

Monitoring of plots

Emerging seedling

Emerging seedling

Figure 1.30. Photographic monitoring of plots.

*Summary*

The McWay landslide project contained elements of the worst case site conditions for stabilizing surface soil erosion, establishing vegetation, and controlling weedy exotic plants.

The lower main gully on the south end of the slide and the adjacent unconsolidated fill face was the area upon which the study focused. This site presented the most difficulty in terms of erosion control and vegetation establishment. The main gully was so steeply incised some slope faces exceeded 70% grades. Large blocks of weathered materials were perched

precariously above the slopes. Initially it was decided to grade the escarpments into the main gully in order to lessen the slope grade and prepare the site for erosion control and surface soil stabilization. This effort did not work. The main gully is so steep and subject to seasonal springs erupting at the base, that the unconsolidated fill cracked and slumped. Much of the surface treatments moved downward and were eroded off below the gully.

The primary lesson of the study is that vegetation alone cannot stabilize materials on steep slopes. Consolidation and stabilization of these materials is necessary for the establishment of a mature vegetative cover. It is not cost effective to invest in and implement a native perennial revegetation plan on unstable sites prone to large-scale land movement. The unstable sites are cost effectively treated with an annual native vegetative cover along with sterile straw or other surface erosion control methods.

Planting willow pole cuttings was successful. Willows were planted along the drainage of the slumping materials and this treatment worked exceptionally well. Seedlings of native vegetation also established where the surface was left intact. One of the most successful erosion control and site stabilization treatments utilized was simply broadcasting large quantities of straw on the soil surface. The straw helped impede surface flows, provided a rich microclimate for germinating native seeds, and increased organic material in the soil. Planting a diverse mix of native plants worked from both seed and live plant planting.

Much of the work above needs to continue on an annual basis for several more years to ensure that vegetation takes root and becomes established. Weed control, hydroseeding, and straw placement are essential to stabilization of soils at this challenging site.