Montecito Debris Flow Mitigation Phase 1

Report of Findings

Montecito, California

KGT Project No. KGT18-18

Prepared by:

***KANE* GeoTech, Inc.**
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Prepared for:

Partnership for Resilient Communities
Montecito, California

May 16, 2018
Revised: June 4, 2018

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1. INTRODUCTION

1.1 General

KANE GeoTech, Inc. (KANE GeoTech) was retained by the Partnership of Resilient Communities, (Partnership) to assess the debris flow channels and recommend debris flow mitigation to protect the structures and infrastructure in the debris flow hazard area. KANE GeoTech met with Les Firestein, of the Partnership, on April 2 and 3 to tour the Project Location, Figure 1. Santa Barbara County Fire personnel escorted all personnel throughout the impacted areas and provided background information on the fire and debris flow events.

KANE GeoTech also attended a Debris Flow Scientists Symposium on April 30, 2018 to gain a better understanding of the information available from other agencies. This information will be essential during the design and engineering of any recommended debris flow mitigation.

On May 9, 2018 KANE GeoTech met Les Firestein, Santa Barbara Fire Chief Kevin Taylor, Santa Barbara County Flood Control personnel Jon Frye, and cameraman Jim Fabio to perform an aerial reconnaissance of Montecito from a helicopter.

The purpose of the aerial reconnaissance was to identify general areas to focus on during ground investigation. The ground portion is the next Phase of the project.

Figure 1. Project Location

1.2 Purpose

The purpose of this Report is to summarize work performed thus far, and to detail the methodology of possible mitigation options. During Phase 1, KANE GeoTech assessed the Project site, concentrating on mitigation options that can be constructed rapidly with the least environmental impact and need for special approval. It should be noted that additional mitigation measures may be recommended. However, these may require more time to implement than the options discussed in this Phase 1 Report.

2. SCOPE OF WORK

The following Scope of Work was proposed for the Montecito Debris Flow Mitigation Project. This Report is provided as a part of Phase 1.

Phase 1 – Geohazard Assessment

1. **Site Visits and Report of Findings.** KANE GeoTech has toured the project and re-visited the site to further evaluate the debris problems with emphasis on the source areas. A helicopter was provided to obtain an overview of the site. This focused the investigation on likely locations for debris flow mitigation. Prior to the helicopter reconnaissance, additional evaluation was carried out by vehicle. KANE GeoTech provides this Report of Findings containing preliminary recommendations derived from the Phase 1 work.

2. **Project Review Meeting**. This Phase also includes a follow-up meeting with shareholders to discuss available options.

Phase 2 – Site Investigation and Data Collection

1. **Site Investigation and Analyses.** KANE GeoTech personnel will visit the Project site to obtain detailed information on site conditions at specific locations. KANE GeoTech will investigate areas that were identified in Phase 1 as possible locations for mitigation structures.

   KANE GeoTech will conduct a debris flow analyses for each location to verify the suitability for the proposed mitigation options. We will also team with an experienced geohazard contractor to assess the constructibility at each site.

   Verification anchors will be installed and tested to determine the soil properties and strengths for design purposes. It is anticipated that this approach will eliminate the need to test anchors during construction operations, resulting in overall time and cost savings for the project.

2. **Report of Findings.** KANE GeoTech will prepare a detailed Report of Findings summarizing the site investigation and the analyses. The Report will use the results of the analyses to make final recommendations for mitigation with estimated construction costs for each location.

   The Report will be stamped by a registered California Civil Engineer experienced in debris flow mitigation.

3. **Project Review Meeting**. A project review meeting will be held following review of the Report of Findings to discuss technical aspects and construction issues.

Phase 3 – Engineering Design, Construction Drawings, and Specifications

1. **Engineering Design.** KANE GeoTech will utilize the information obtained during the site visits, as well as other available information, to design the debris flow mitigation required. KANE GeoTech will provide a Calculation Report containing engineering calculations, stamped by a registered Civil Engineer experienced in debris flow mitigation, used for the engineering design.

2. **Construction Drawings.** KANE GeoTech will provide a complete set of engineered Construction Drawings, stamped by a registered California Civil Engineer experienced in debris flow mitigation suitable for the construction of the debris flow mitigation. The Drawings will consist of layout and construction details and be delivered electronically.
3. **Specifications.** KANE GeoTech will provide Construction Specifications, stamped by a registered California Civil Engineer experienced in debris flow mitigation suitable for the construction of the debris flow mitigation and be delivered electronically.

4. **Project Review Meeting**. A project review meeting will be held following review of the Report of Findings to discuss final technical aspects and construction issues.

Phase 4

1. **Construction Oversight.** KANE GeoTech will provide construction oversight services including a pre-construction meeting, system layout inspection, and quality assurance testing. We will also supply daily construction oversight to streamline the construction process and keep it on schedule. KANE GeoTech will provide a final inspection of the installed debris flow mitigation system, including a letter of acceptance stamped by a registered California Civil Engineer. Daily field reports describing the process made each day will be supplied to the Partnership.

3. BACKGROUND INFORMATION

3.1 Site History

The Santa Ynez Mountains were impacted heavily by the Thomas Fire that began the first week of December 2017. Following the extinguishing of the fire, the areas impacted by the Thomas Fire were on high alert for the potential of post-fire debris flows. The fires scorch vegetation that would normally anchor sediment, and changes the chemistry of the soil. As a result, rapid erosion causing debris flows is common following large fire events in mountainous areas.

Montecito experienced intense rainfall during the early morning of January 9, 2018. This intense rainfall resulted in large, destructive debris flows forming in the large canyons in Montecito. The Cold Spring Canyon, Hot Spring Canyon, San Ysidro Canyon, and Romero Canyon all experienced debris flows. These flows overtopped debris basins and creeks resulting in major property damage, injuries and loss of life in the areas below the mountains. Montecito has experienced post-fire debris flows in its recent past, and geological evidence indicates the area has undergone similar events many times before.

3.2 Area Geology

Montecito is located in the approximately 5-mile wide area between the Pacific coast and the Santa Ynez Mountains. This area is composed of thick, Quaternary alluvium including flood plain deposits and prominent alluvial fan deposits most likely resulting from debris flow events.

The Santa Ynez Mountains are a part of the Transverse Ranges of Southern California. Bedrock is are almost entirely composed of interbedded sandstone and shale beds ranging from the Jurassic Franciscan formation to Eocene sandstone and shale. Bedding varies from thick to very thin, Figure 2. These beds exhibit differential weathering causing large, blocky sandstone overhangs seen throughout the area. These blocks eventually weather and release causing boulders of various sizes to collect in the drainages. These boulders then weather spheroidally. The beds' dip changes throughout the site and is governed by the extensive folding and faulting throughout the area. The Mission Ridge Fault is located in the western area of Montecito, while the extensive Santa Ynez Fault runs along the entire width of the Santa Ynez Mountain above Montecito. Vertical and overturned beds are found in the south-eastern area of the Santa Ynez Mountains of Montecito, (Dibblee, 1966).

Figure 2. Differential weathering of sandstone and shale beds in collectors.

4. AERIAL RECONNAISSANCE

During the aerial reconnaissance that took place Wednesday May 9, 2018, KANE GeoTech identified several areas of interest in each canyon that are potentially viable locations for debris flow mitigation, Table 1 and Appendix A. By gaining a better understanding of the topography throughout the area, KANE GeoTech will focus the site visit of Phase 2 in areas of potential mitigation sites. The flight paths taken are shown in Figures 3 and 4.

KANE GeoTech also observed the locations of the existing debris basins as well as several potential sites for the construction of new debris basins.

Considerations for debris flow barrier locations:

- Channel dimensions
- Storage potential
- Constructibility and access
- Maintenance and access
- Environmental impacts
- Property easements
- Anchoring material

TABLE 1. POTENTIAL BARRIERS

Drainage	Number of Potential Mitigation Sites
Cold Springs Canyon	15
Hot Springs Canyon	3
San Ysidro Canyon	14
Buena Vista Canyon	10
Romero Canyon	4
TOTAL POTENTIAL SITES	**46**

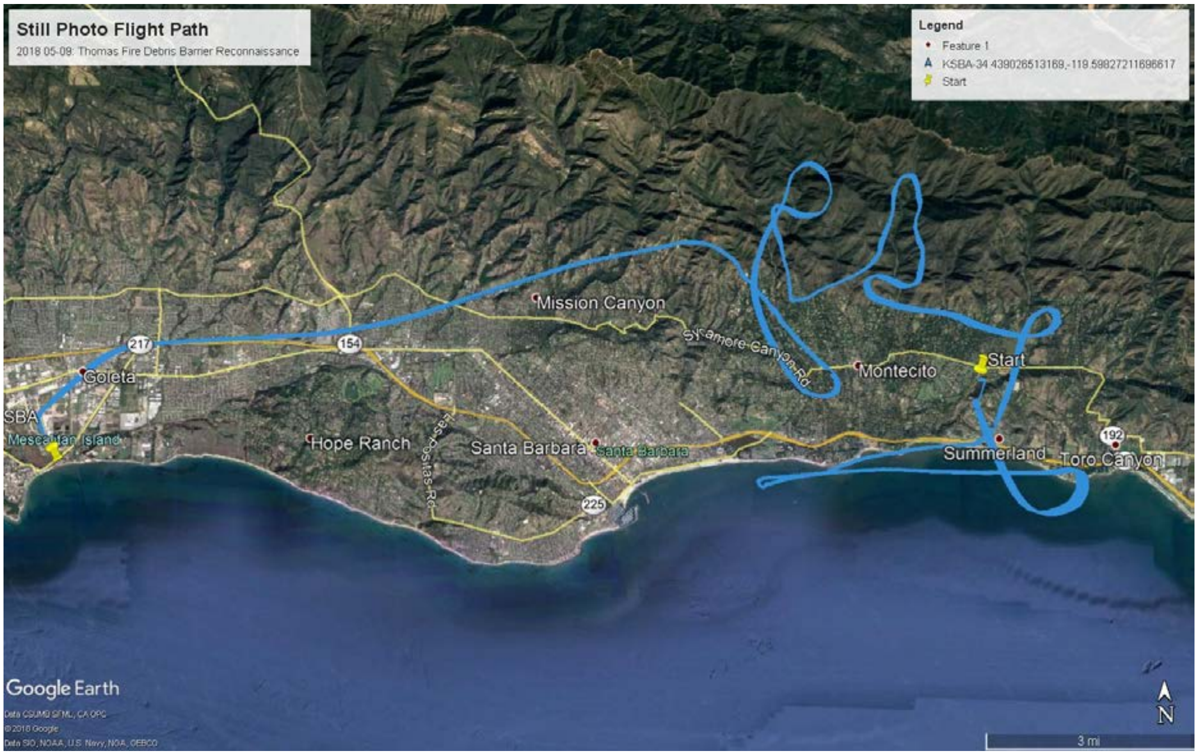


Figure 3. Flight path for still photos.

Considerations for debris flow barrier locations:

- Channel dimensions
- Storage potential
- Constructability and access
- Maintenance and access
- Environmental impacts
- Property easements
- Anchoring material

Considerations for debris basins:

- Topography
- Storage potential
- Constructibility and access
- Maintenance and access
- Environmental impacts
- Property easements

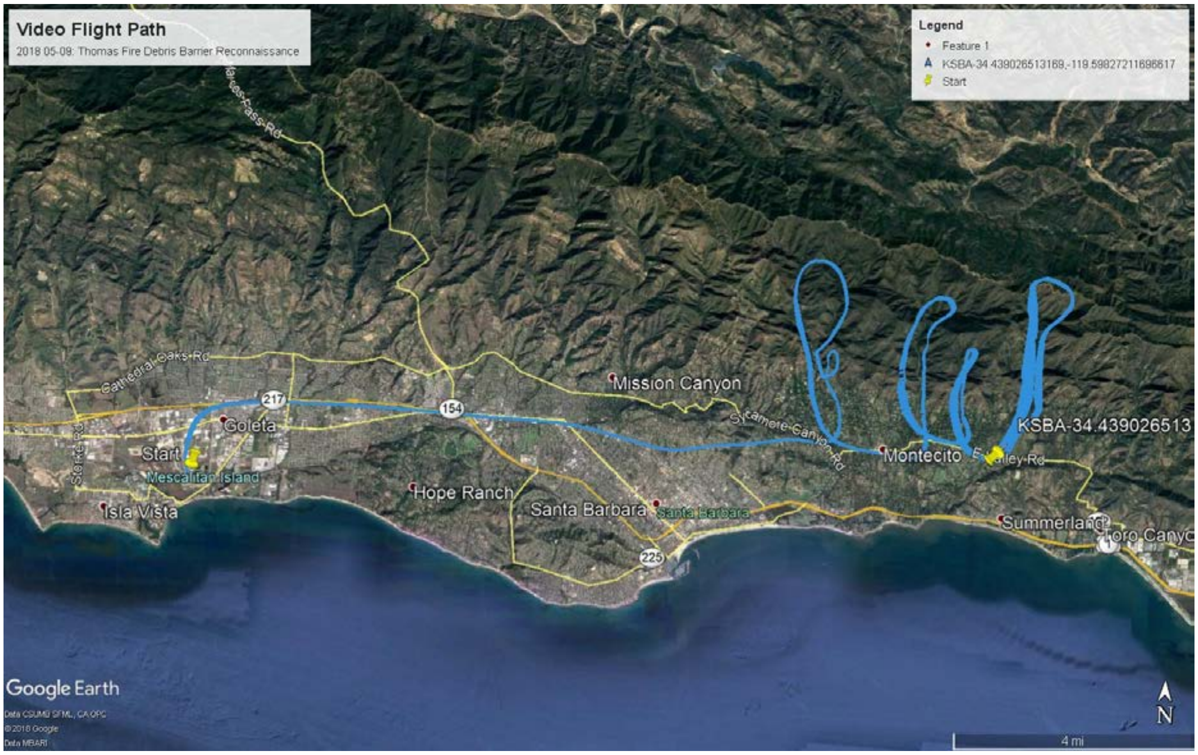


Figure 4. Flight path for video recording.

5. CONCLUSIONS AND RECOMMENDATIONS

It is our conclusion that the debris flow hazards in Montecito can be mitigated. We recommend that an immediate response to the debris hazards should be implemented. This entails the construction of a number of debris flow barriers to retain the material that is still available to mobilize from the collector channels. It is important to prevent this material from entering the large channels, Figures 5 and 6.

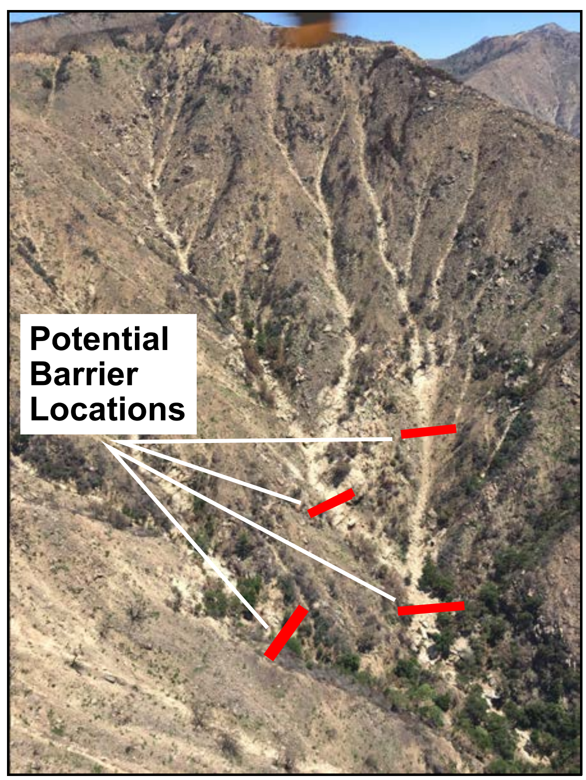


Figure 5. Potential barrier locations

The potential barrier locations are proposed within the collector channels as well as the main streams of each canyon at the higher elevations. Debris flows gain energy with higher volumes of material. Constructing the barriers at the higher elevations will decrease the amount of material flowing reducing the volume entering debris basins. It will also decrease the destructive energy of the debris flows.

Once locations for mitigation are finalized, KANE GeoTech will prioritize the locations we believe will be most effective for mitigation. The prioritizing will consider how much material is expected from each canyon, available storage in basins, and each canyons' damage from past events.

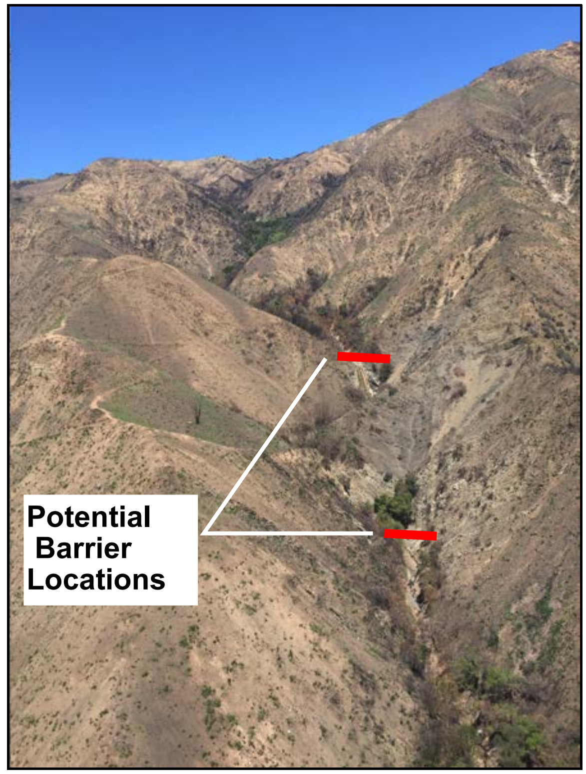


Figure 6. Potential barrier locations

For long term response to the debris flow hazard, the slopes need to be re-vegetated and restored. This can occur naturally over time, but the process should be accelerated by implementing a habitat restoration plan. Using innovative technology, such as cloud harvesting with nets can limit the effects of long-term drought conditions common in this area. Additional responses such as flood conveyance and building code requirements should also be implemented.

The barriers should be instrumented to collect data and provide alerts when there is a possible debris flow event. This will be essential to help authorities and residents remain informed. Instruments such as load cells, strain gauges, and extensometers can be installed on the constructed barriers. The instrumentation systems will record loads and deformations in the barriers. An alert can then be sent via radio and transmitted cellularly to the authorities for evaluation of the severity of the event.

These instruments should also be installed in coordination with rain gauges and geophones. The rain gauges will record real-time rainfall rates that may trigger debris flows. The geophones will sense seismic motion that occurs during a debris flow. Similar systems have been implemented with success in Europe with Geobrugg flexible debris flow barriers.

LiDar imaging should also be utilized to accurately monitor area conditions. LiDAR imaging should be used periodically to monitor the accumulation and migration of debris material in the collector channels.

6. GEOBRUGG RING NET DEBRIS FLOW BARRIERS

Geobrugg Protection Systems began as part of a wire-rope manufacturing firm, Fatzer A.G., of Romanshorn, Switzerland. Early on, Brugg, as it was called then, began fabricating nets made from wire rope to use as snow nets for avalanche protection in the Swiss Alps. During spring season net maintenance, the nets were often observed full of rock from rockfall. The connection was made and Brugg began manufacturing barriers made of wire rope nets for the purpose of rockfall protection.

In 1989, Brugg opened its first North American factory in Santa Fe, New Mexico to manufacture wire rope net rockfall barriers. In the early 1990s, the California Department of Transportation (Caltrans) began using the rockfall barriers with a high degree of success. Caltrans also experienced a number of debris flow events that were inadvertently stopped by the rockfall barriers. About the same time, ring net barriers, which were much stronger than wire rope nets and could absorb more energy, began to replace the rope nets in rockfall barriers.

In 1996, Caltrans; California Polytechnic University, San Luis Obispo; and the U.S. Geological Survey began flume experiments for the purpose of developing an understanding of the forces acting on a debris flow barrier. Meanwhile, similar research had begun in Europe and Japan.

In the winter of 2005, devastating floods and debris flows impacted Switzerland. As a result, Brugg, now Geobrugg, and the Swiss Federal Institute for Forestry, Snow and Landscape Research, (WSL) embarked on a multi-year, several million Euro program to develop, test, and install debris flow barriers. These barriers were to be engineered according to the dynamics of debris flow.

As a result of this research, Geobrugg developed two systems of engineered debris flow barriers. These barriers were designed to fit within stream flow channels, or chutes. They are engineered to absorb the initial dynamic impact forces and the subsequent static loads imposed on the barriers. Their flexible design allows for much of the impact energy to be absorbed in deformation of the flexible net and brake elements.

The two barrier types are referred to as VX and UX barriers. VX barriers are intended for use in relatively narrow V-shaped chutes, up to about 15 meters wide. They consist of wire rope anchors between which are suspended wire rope support ropes with braking elements. High-strength steel

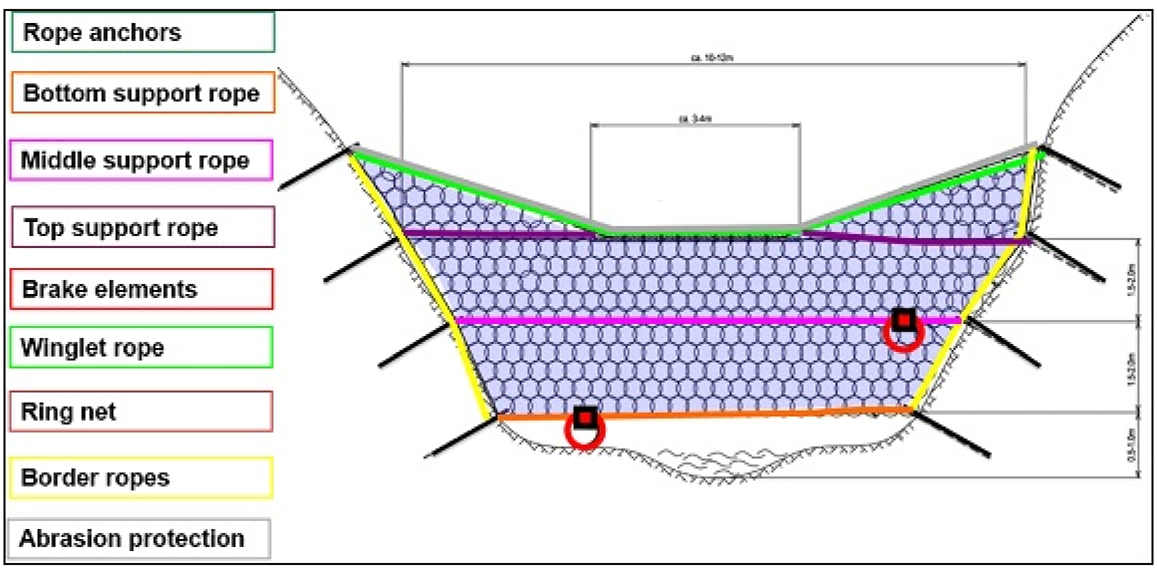


Figure 7. Geobrugg VX debris flow barrier and its components

ring nets are installed on the top, middle, and bottom support ropes, Figure 7. The system is designed to flex outward downslope on impact to absorb and dissipate energy of the debris flow. Consequently, the barrier must flex outward a few meters as it absorbs the energy. Any design must include this distance downslope of the barrier. It is also necessary for the barriers to be designed to withstand a static load after impact, similar to a retaining wall.

A UX barrier is similar in construction except that it includes two support steel column posts. It is designed for channels wider than the VX barrier limitations. UX barriers are intended for use in channels up to about 25 meters wide. The purpose of the posts is to maintain the height of the barrier across the channel. They are not intended to supply any additional structural functions. The barriers are engineered so that all loads are dissipated through the net, support ropes, brakes, and anchors.

Shallow landslide barriers (SLBs) were developed for installations where no chute or channel is present or exceeds the maximum width of a conventional UX barrier. They rely on the same energy absorption principles as debris flow barriers. The major difference is that the top and bottom support ropes are anchored in the ground adjacent to the barriers.

Debris flow barriers are now used around the world with installations in Switzerland and other parts of Europe, Malaysia, Japan, Hong Kong, Canada, Mexico, and South America among other places. A product description of the Geobrugg debris flow barriers is found in Appendix B.

7. REFERENCES

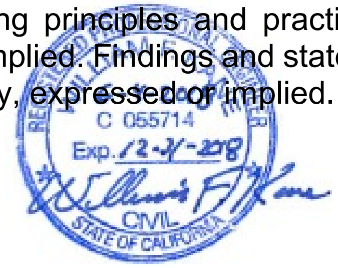
Dibblee, T. W. Jr. (1966). "Geology of the Central Santa Ynez Mountains, Santa Barbara County, California,". California Division of Mines and Geology. Bulletin 186. 1966.

8. LIMITATIONS

Debris flow can be sporadic and unpredictable. Causes range from human construction to environmental (e.g., weather, wildfire, groundwater fluctuations) effects. Because of the multiplicity of factors affecting it, it is not, and cannot be, an exact science. Therefore, the safety of individuals and property cannot be guaranteed. However, when sound engineering principles are applied to a predictable range of geodynamics, the risk of injury and property loss can be substantially reduced by the use of properly designed mitigation in identified risk areas.

The conclusions and recommendations contained in this Report are based on the site conditions observed by KANE GeoTech personnel and derived from the information provided to KANE GeoTech by others. If there is a substantial lapse of time between the submission of our report and the start of work at the site, or if conditions have changed due to natural causes or construction operations at or adjacent to the site, we urge that our Report be reviewed. The review should determine the applicability of the conclusions and recommendations considering the changed conditions and time lapse. This Report is applicable only for the project site studied. This Report should not be used after three years.

Our professional services were performed, our findings obtained, and our recommendations proposed in accordance with generally accepted engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. Findings and statements of professional opinion do not constitute a guarantee or warranty, expressed or implied.



Yours truly,

***KANE* GeoTech, Inc.**

William F. Kane, PhD, PG, PE
President and Principal Engineer
California Licensed Civil Engineer No. 55714

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APPENDIX A

POTENTIAL DEBRIS BARRIER LOCATIONS

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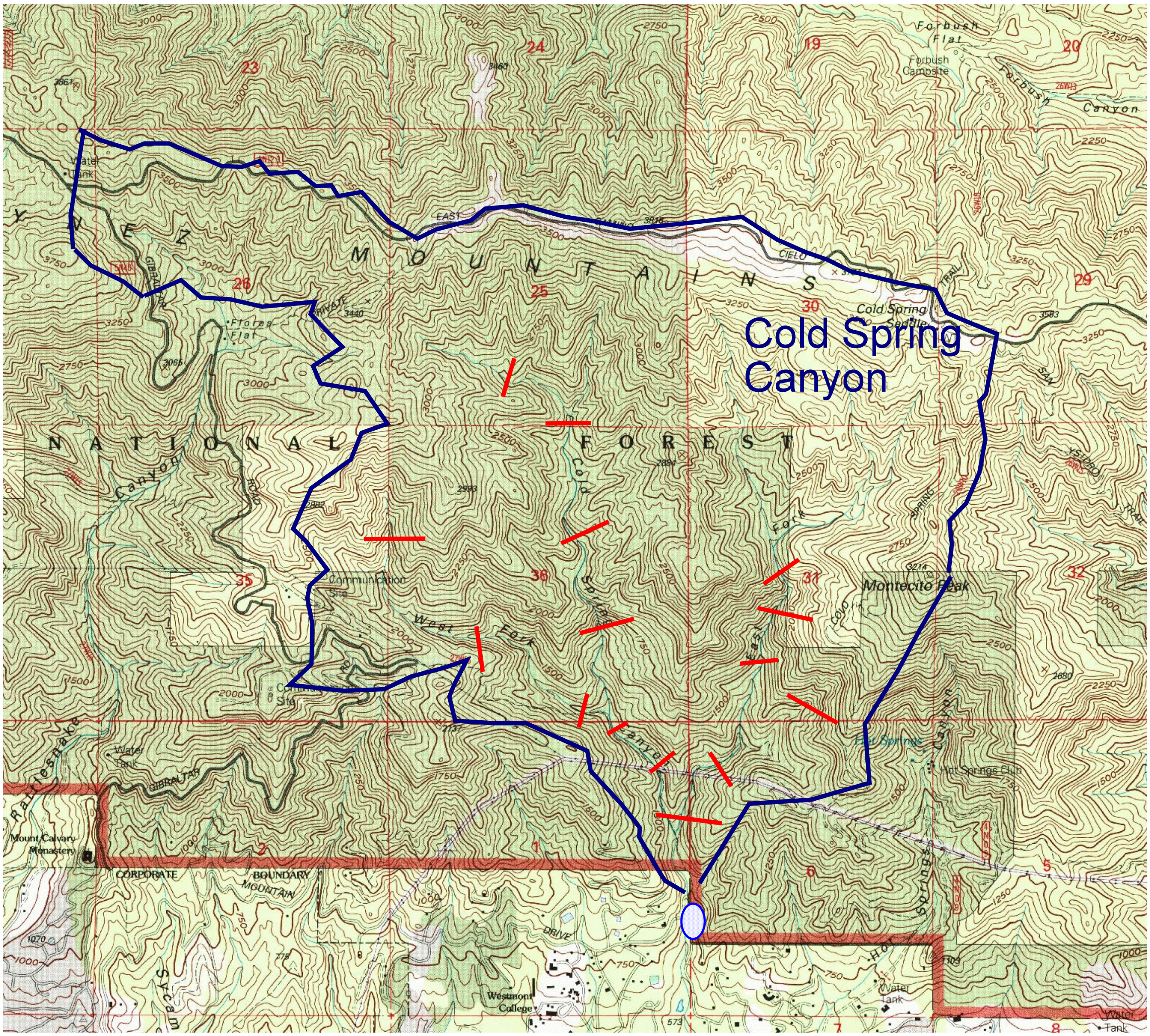

Plate A-1. Cold Spring Canyon Potential Debris Flow Mitigation Sites

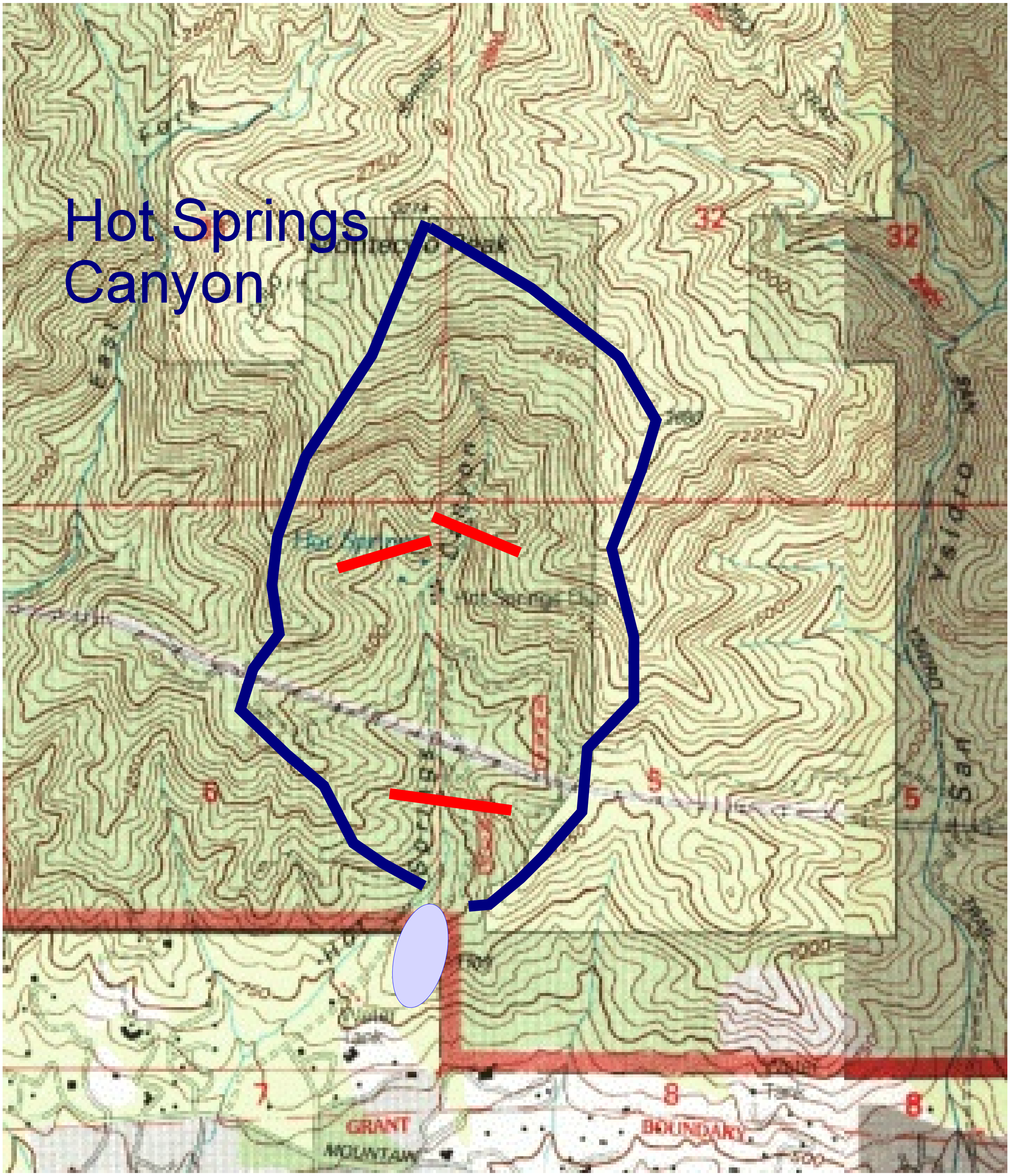

Plate A-2. Hot Springs Canyon Potential Debris Flow Mitigation Sites

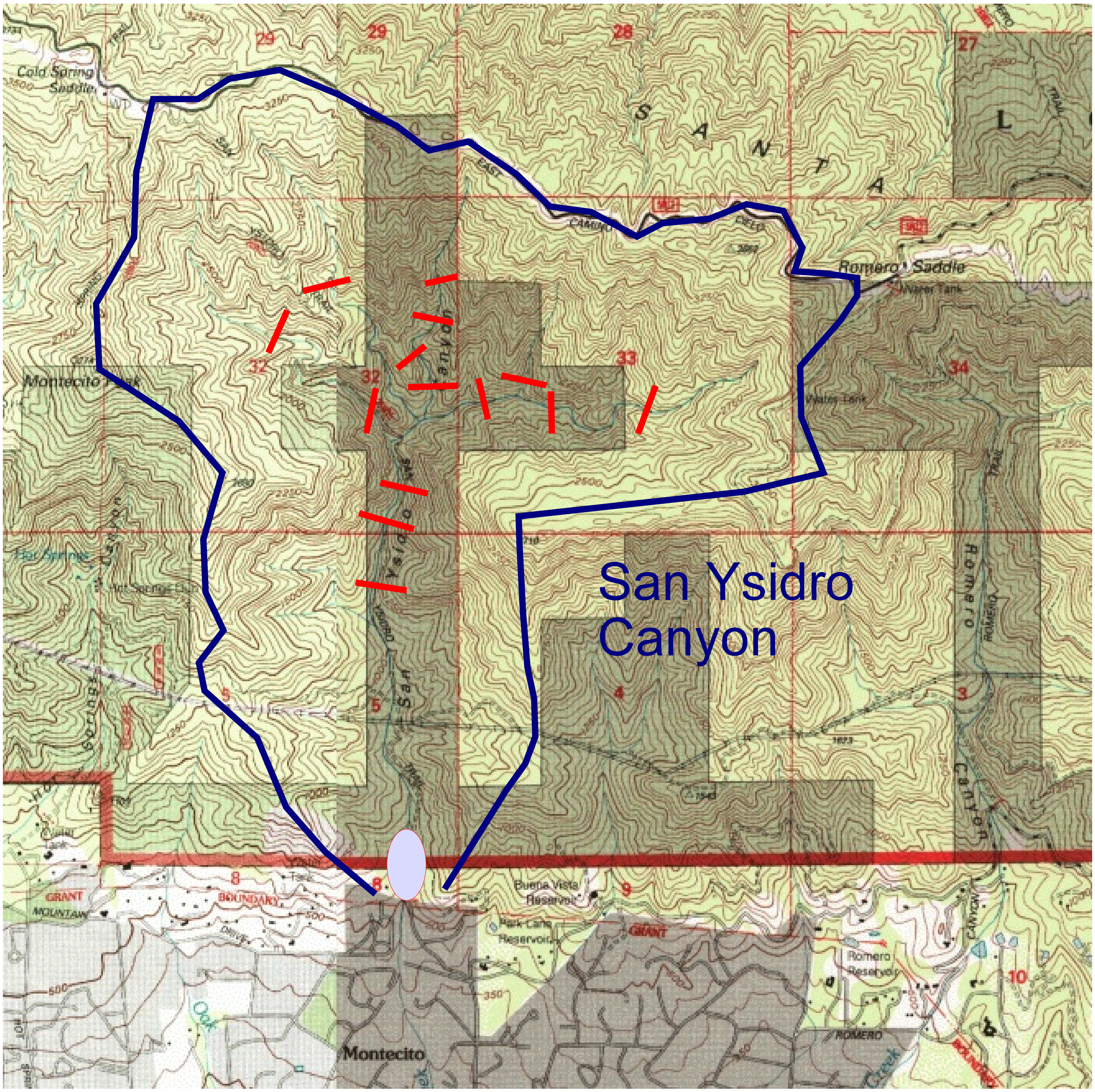

Plate A-3. San Ysidro Canyon Potential Debris Flow Mitigation Sites

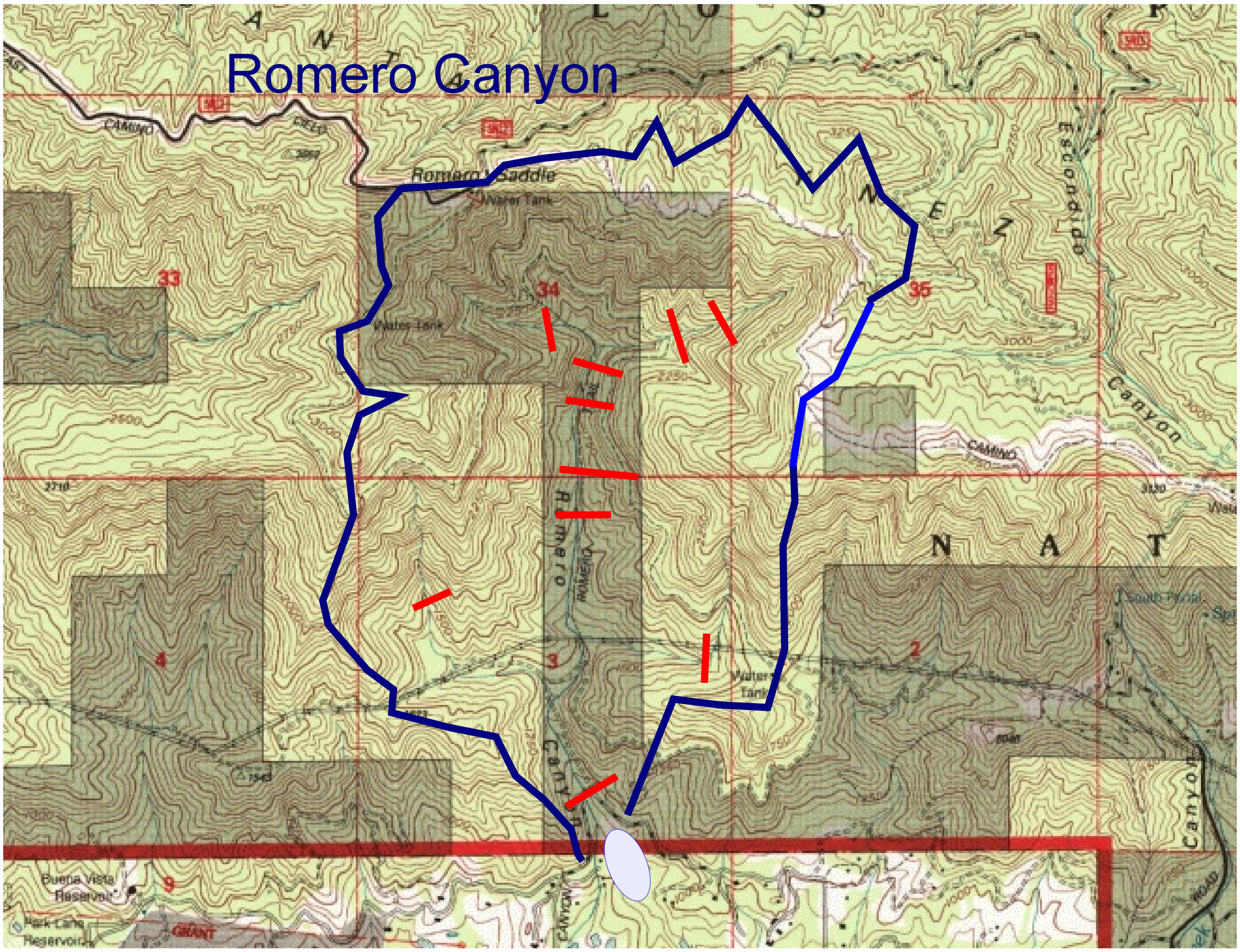

Plate A-4. Romero Canyon Potential Debris Flow Mitigation Sites

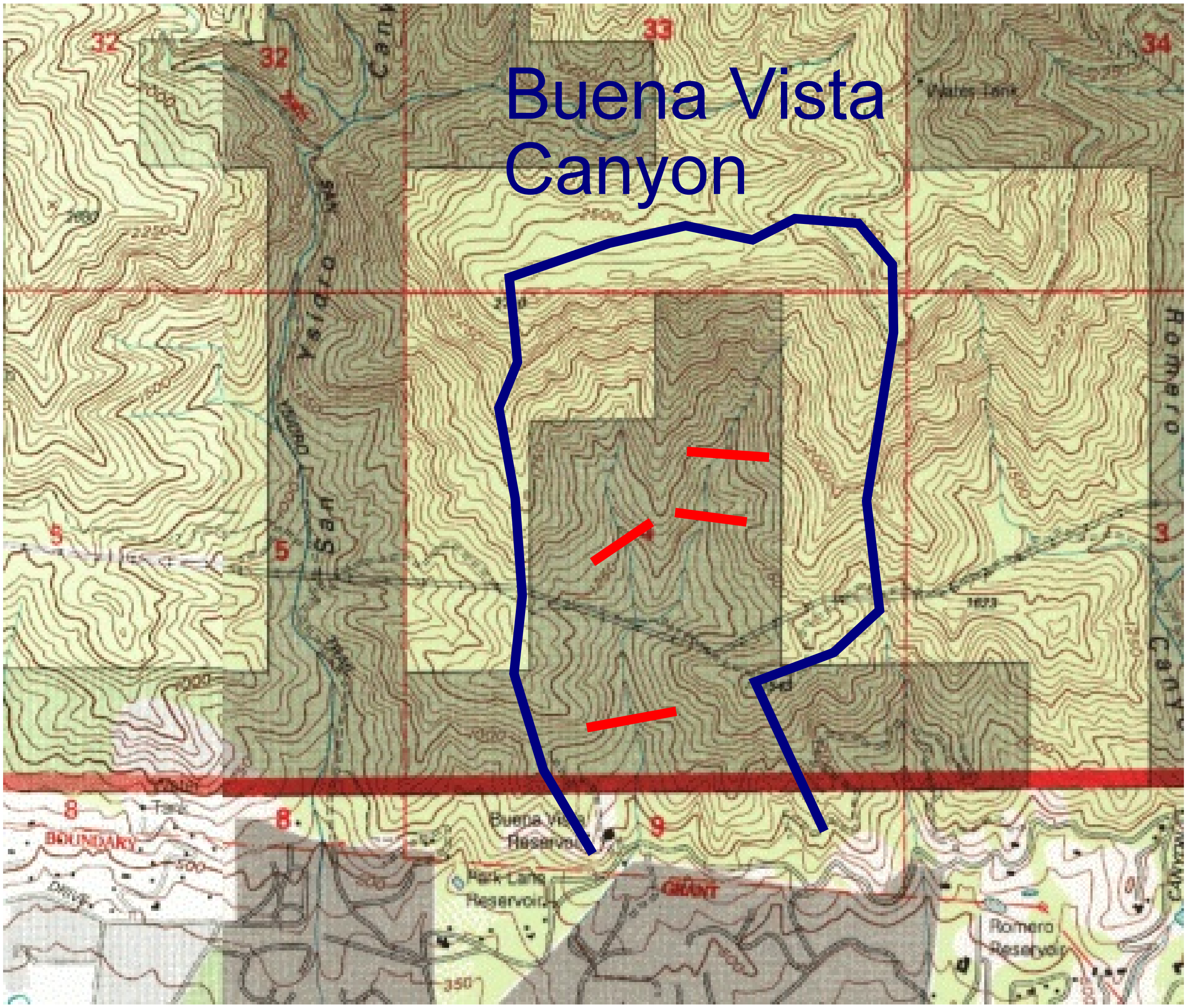

Plate A-5. Buena Vista Canyon Potential Debris Flow Mitigation Sites

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APPENDIX B

GEOBRUGG DEBRIS FLOW BARRIERS

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