Addressing Erosive Conditions at Two Archaeological Site Areas at Marine Corps Base Camp Pendleton

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Marine Corps Base Camp Pendleton addressed potential impacts from natural and man-made erosion at two areas within archaeological sites. We used a drone to produce a photogrammetry base-line survey at one archaeological site area for an ongoing erosion monitoring program, and three separate and combined landscape methods were used to treat one site for ongoing erosion. We present both the initial results of the drone monitoring survey at the first and the successful results of the use of corrective landscaping methods at the second.

The National Historic Preservation Act (NHPA) Section 106 requires procedures for the consultation and management of cultural resource assets on federal lands. Section 110 of the NRHP requires stewardship protection of resources on federal lands. To affect the requirements, Marine Corps Base Camp Pendleton (MCB CamPen), through the Cultural Resources Section (CRS), manages resources using procedures developed to satisfy the requirements through Marine Corps regulations, and a developed Integrated Cultural Resource Management Plan (ICRMP; ASM 2017). As directed by guidelines for Section 110, MCB CamPen manages cultural resources in part by a Condition Assessment, Site Monitoring and Effects Treatment (CASMET) program which assesses damage to resources across the base on a cyclical review program. The CASMET program addresses needs that arise from ongoing impacts such as natural erosion, but also more immediate impacts such as the accidental off-roading by military vehicles, or the very occasional looting or intentional damage to archaeological sites. The first area of concern was conducted under a Section 106 project and was used to develop avoidance measures that would protect one of the subject archaeological site areas of concern from impacts. The second area of concern was part of the Section 110 program mechanism and triggered an erosion monitoring program.

Following the general archaeological site hardening guidelines put out by the Department of Defense (DOD) entitled "Protecting the Past to Secure the Future: Best Management Practices for Hardening Archeological Site on DOD Lands" Legacy Project # 06-303 (Wagner et al. 2007), MCB CamPen developed strategies to address problems regarding soil erosion impact concerns for two archaeological site areas. CRS, working with MCB CamPen military Range and Training Area Management Division (RTAMD) and consultant archaeological contractors, was able to design processes and procedures to assist in managing erosion.

As noted in the DOD Best Management Practice the process resulted in partnership for "cross purposes" (Wagner et al. 2007:5). The MCB CamPen design process included several rounds of idea sharing and field visits, and conversations and cooperation to both protect archaeological resources and provide the Marine Corps with needed training assets to support the installation core mission of training Marines. In one case, the MCB CamPen program was designed to begin a monitoring program to track any changes in a training area landscape that would indicate that military activities were causing erosion, and in a second case, to arrest ongoing erosion.

MONITORING ELEVATIONS/IMPACTS USING DRONE PHOTOMETRIC IMAGERY DATA VERSUS TOTAL STATION DATA

Under the Section 106 process, in consultation with California State Historic Preservation Office (SHPO) and tribes, monitoring at the first area of concern for potential erosion impacts to several archaeological sites in the Sierra Training Area of MCB CamPen was originally to track changes made from natural and military training erosive effects across the old agricultural landscape. It was anticipated that wind and rain could be major events effecting newly denuded agricultural fields no longer in crop, causing natural erosion. In addition, military training with vehicle traffic was anticipated to compound erosion problems to ground surface. These combined processes could allow for the erosive potential to be high. Subsequent natural infill of grasses and trees has helped to buffer some of the concern for heavy erosion from natural events, but man-made events would still need to be addressed.

MCB CamPen contracted ASM Affiliates to provide monitoring services and report results (Daniels 2016 and 2018). Two methods of ground erosion monitoring were deployed: visual inspection (not specifically addressed here), and ground elevation data collection using two methods. The first ground elevation data collection method was accomplished using a total station coupled with global positioning system (GPS) data collecting on a 40-meter interval point grid system. Permanent survey datums were established with a Trimble GeoXH (10-meter accuracy). The datums were used as base stations for back sighting for the Nikon DTM-322 total station recordings. This data was intended to be used to track subtle changes in all-over ground elevations. This method of collection took over three days to complete proving to be slow and cumbersome for the purpose, and so the second survey method using a drone was deployed. The total station data was, however, collected as a base line data set and used as a comparison for the second survey method (Figure 1, Image A).

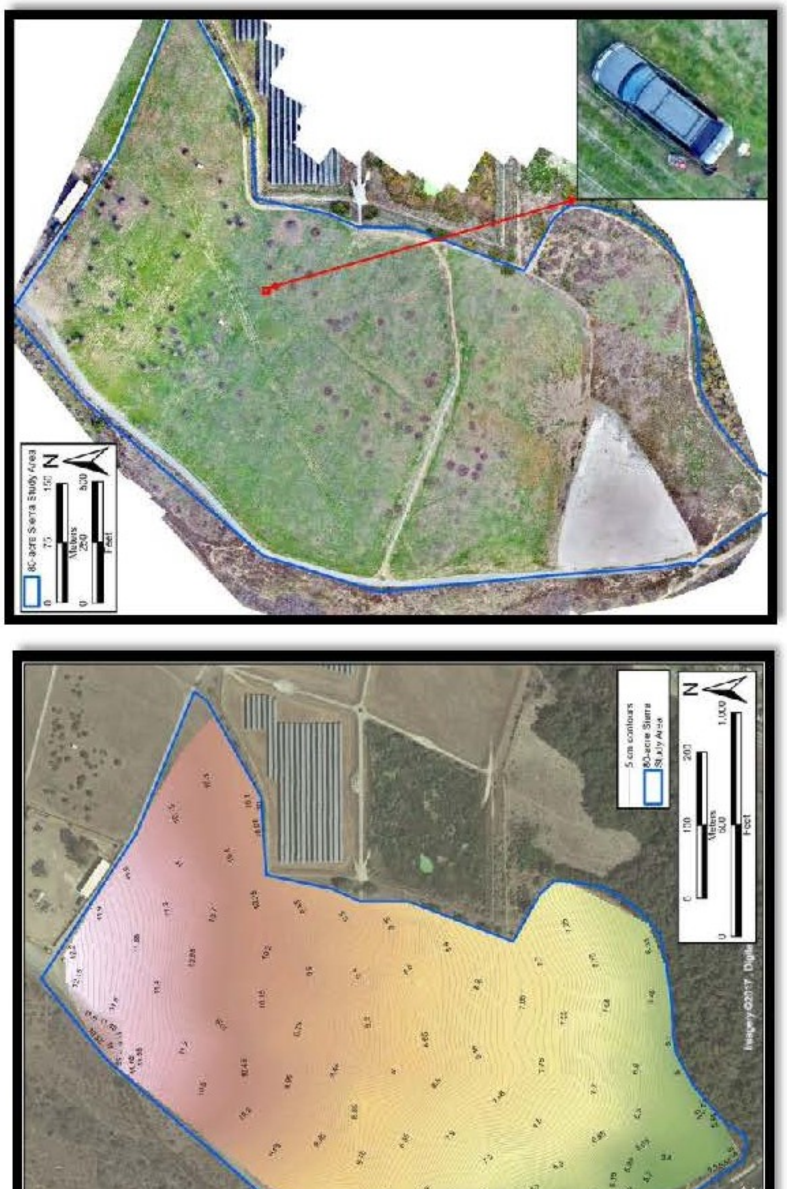
A second ground elevation data collection survey method employed photogrammetric Image-Based Modeling (IBM) using a drone equipped with a camera using a photogrammetric image capture method to collect 1.11 centimeter/pixel resolution for three-dimensional imagery. This process uses two-dimensional (2D) images to build 3D representations, employing Structure from Motion (SfM) 3D point cloud data, in this case for ground images with elevation data. The 80-acre subject area was flown using a Monarch-AG 002 unmanned quadcopter with a Sony A6000 camera using a 20-millimeter lens at an elevation above ground surface of 200 feet, traveling at 11 miles per hour (Figure 1, Image B). The aerial fly-over took a little over an hour.

The method easily picked up even minor elevation changes in the landscape ground surface (Figure 2 Image A). Details include vehicle track marks and old agricultural furrows. The data sets can be enhanced to provide a variety of visual aids in tracking even subtle visual changes in the landscape (Figures 2 Image B). This technique exaggerated the impacts to the ground surface and also shows the bushes as tall trees. This imagery has its advantages and limitations if used for interpretation. In addition, as a comparative to the drone imagery, the MCB CamPen LIDAR Hillshade was reviewed for effectiveness (Figure 2, Image C). While the LIDAR was impressive the photogrammetric images from the drone were clearer.

This set of data was the first in a series of monitoring activities that will take place over time and provides for a base line data set for later comparisons. Follow on visual inspections and drone elevation surveys will take place on future dates.

EROSION CONTROL/SITE STABILIZATION AT ONE ARCHAEOLOGICAL SITE AT CAMP PENDLETON

An erosion control program at a large National Register eligible site at Camp Pendleton, in consultation with SHPO and tribes, was initiated through the CASMET program by the CRS. MCB CamPen contracted Far Western Anthropological Research Group, Inc. to assist MCB CamPen with developing the stabilization and erosion control plan, implement the project, and provide cultural monitoring during the project activities. The site includes intact subsurface components along with bedrock milling and other features. The site in total, but particularly the subsurface component, was threatened by both human activities and natural processes. Sheet wash and subsequent erosion were affecting the integrity of the site. The site had been exposed to vehicle and pedestrian access for many years and was finally partially cordoned off with K rails in an attempt to restrict access. Although most of the site was relatively protected, portions were still used as a gathering spot with porta-potties placed along part of the K rails (Figure 3,



B

A

Figure 1. Image A Baseline Elevation Map Results from Total Station and GPS Data, and Image B Overview Aerial from Drone Photogrammetric Data with Insert Showing Quality of Data; white area is crushed rock on troop assemble area.

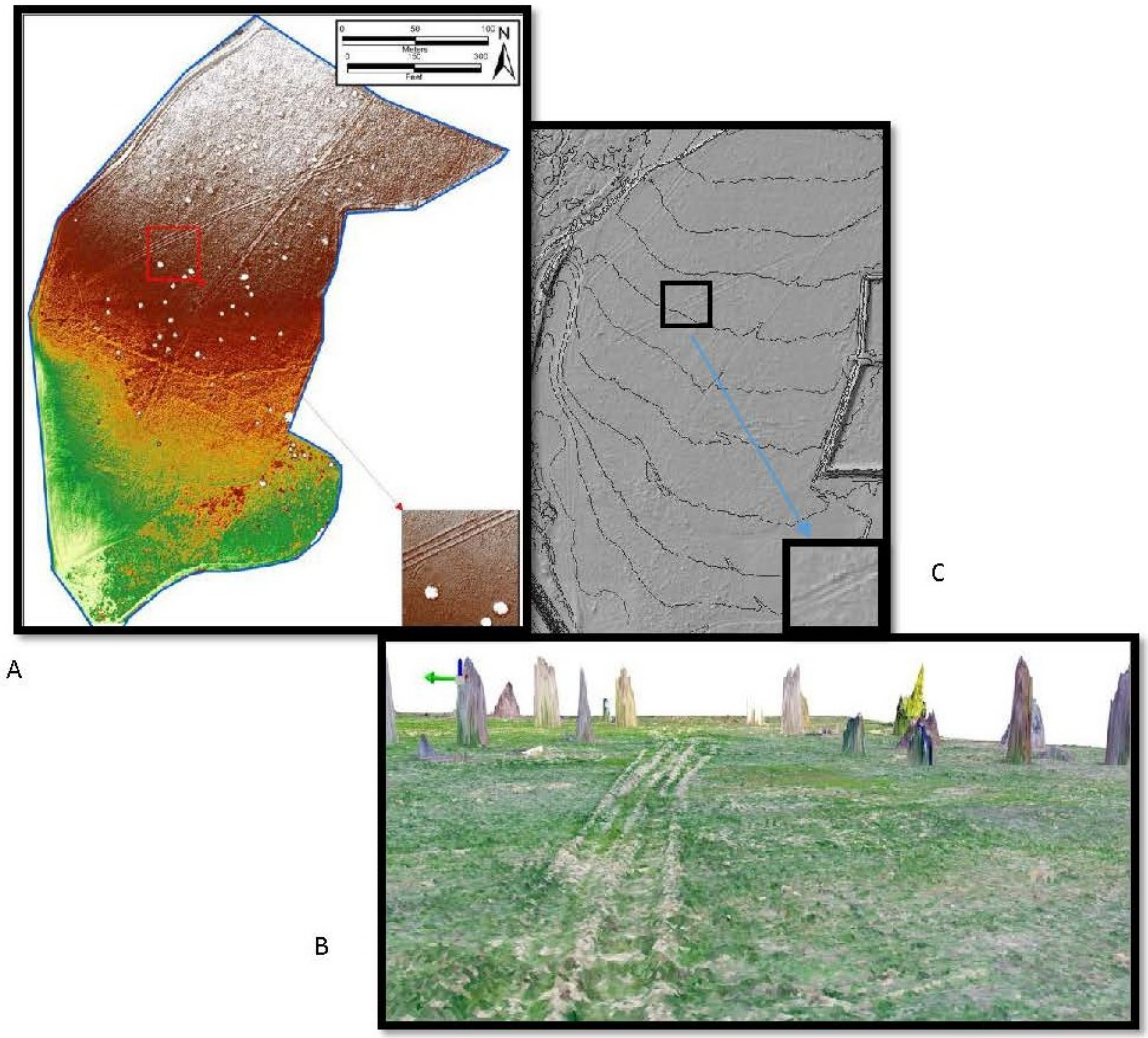


Figure 2. Image A-Drone Elevation Surface Model Coupled with Hillside Shade Effect showing Detailed Road Track Marks as Well as Old Agricultural Furrows; Image B-3D Rendering with Z-axis Elevation Exaggeration with Trees and Road Ruts; and Image C-LIDAR Image Comparing Data Quality and Detail.

Area A,). This tended to attract more concentrated use which completely denuded the area at the west end of the site. The denuded slope in this area concentrated water run-off and this directed water was cutting riles in the site downslope (Figure 3, Area B). In addition, a dirt road on the south side of the site was becoming denuded and run-off was causing a deep drainage ditch to form, particularly at the southeast edge of the site which would eventually destabilize that portion of the site (Figure 3, Area C).

Initial professional consultation with archaeological and engineering contractors resulted in a procedure to address the erosion at the site (Stevens and Springer 2012). The original process included filling riles and covering denuded areas with class II base crushed rock covered with vegetation fabric over which soil would be placed for hydro-seeding, and filling drainages ditches with face class rip rap.

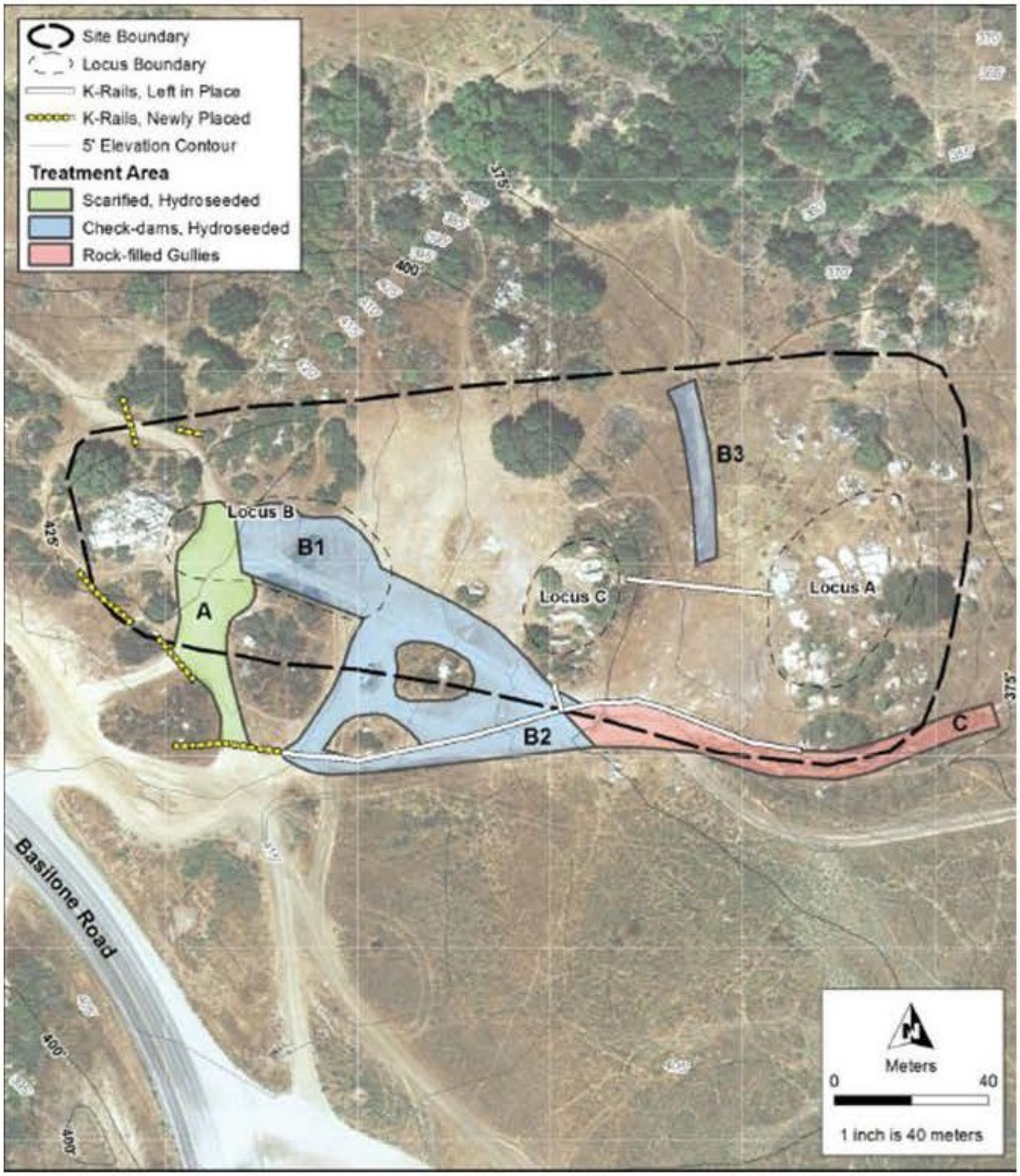


Figure 3. Overview of Erosion Control Plan.

Upon further consultation, MCB CamPen CRS, contract archaeologists, general contractors, landscapers, and graders developed a treatment plan to refine and finalize the erosion arrest procedure (Gilreath and Darcangelo 2015). It was decided not use the vegetation fabric because water would still run below the fabric and continue to erode the soil.

Three methods were selected and used, separately or in tandem, in three areas across the site: Area A, Areas B1, B2, and B3, and C. These methods included scarifying or roughing the ground surface and hydro-seeding (using local species vegetation package); placing decomposable sand bags filled with class 3 base crushed rock as check dams coupled with hydro-seeding; and filling drainage ditches with 3-inch base crushed rock, and a combination of these methods. In addition, the K rails were moved to enclose the entire site boundary as well as limit dirt road access (Figure 3). The program was implemented through a working partnership with RTAMD, Far Western, a general contractor, and landscape and grading contractors.

The project took place over an approximate week-long period (Gilreath and Darcangelo 2016). As per SHPO and tribal consultation, archaeological and tribal monitoring of all activities was conducted during the project. The project included a surface collection of exposed artifacts in areas where the surface would be scarified. All other artifacts were left *in situ*.

Before, during, and after treatment photographs were taken during the implementation of the erosion control program, and at about a year and a half afterwards, to document the progress and success of the treatment. The Area A process included scarification and hydro-seeding which had a very successful re-establishment of indigenous vegetation (Figure 4). The establishment of this vegetation will slow downslope run-off and wash in the B1 Area.

The B1 Area process included check dams and hydro-seeding. Upon review, while it was obvious that Area B1 wash had slowed, there were still some areas that did not take to hydro-seeding, probably due to the ground surface hardness. However, vegetation is taking hold in Area B1 and another year might improve the cover (Figure 5).

The plan in Area B2, included hydro-seed of the whole area, however it was decided that the check dams would assist in holding soil in place and that the vegetation would naturally fill in. While this is a work in progress, the results are as anticipated (see Figure 5). Area B3 was a remnant of an old dirt road, but the potential for the run-off to start cutting downslope was addressed using hydro-seeding (Figure 6).

Area C was the most challenging area requiring refined planning. Several decisions were made regarding size of crushed rock to use in the deep drainage areas. Initially class 2 base crushed rock (1 inch in size) was consider, however it was finally decided that the larger 3-inch rock base would hold in place better due to weight, while still letting the water pass through. In review, using this 3-inch rock base was the correct decision for this situation, since this held in place despite heavy winter rainfall that subsequently occurred (2016–2017; Figure 7).

In addition to the landscaping procedures, the K rails were moved to encompass the entire site. Working with RTAMD to assure that military vehicle range access would not be restricted, the porta-potties were removed, and K rails were placed to restrict one segment of road through the site, leaving the road around the site open. As a result of the entire effort, the treatment process was effectively successful at stabilizing this site over all. Further treatments may be necessary, so follow-up monitoring of vegetation re-establishment will continue.

The results of the erosion control monitoring program at the first area of concern provided MCB CamPen with the opportunity to review results for best practices for monitoring for its purposes. We discovered that the aerial drone method may be the most efficient and cost-effective way to monitor providing superior visual data, and subsequently to assist in plans for addressing erosion issues in this area and other areas of the base. The site stabilization program at the second area of concern provided the base with valuable experience using land management techniques and in working with various planners and consultants to effectively protect a cultural resource.

Figure 4. Area B1: Inside K rail, (Top Left) Check Dams and Hydro Seeding, (Top Right) After Treatment and B2 Outside K Rails, (Botton Left) 3-Inch Crushed Rock and Check Dams, and (Bottom Right) After Treatment.

Figure 5. Area A: Before Treatment, During Surface Scarifying/Roughing, Hydro Seeded, and After Treatment; Looking South.

Figure 6. Area B 3, Old Road Hydro Seeded, and After Treatment.

Figure 7. Area C: Deep Drainage Looking South, Crushed Rock Placement and After Treatment with 3" Crushed Rock and Check Dams.

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