Geologic Resource Evaluation Scoping Summary
El Morro National Monument, New Mexico

This summary highlights a geologic resource evaluation scoping session for El Morro National Monument held in Grants, New Mexico, on March 30, 2006. The NPS Geologic Resources Division (GRD) organized this scoping session in conjunction with El Malpais National Monument in order to view and discuss geologic resources, address the status of geologic maps and digitizing, and assess resource management issues and needs. Participants at the meeting included GRD staff, park staff, and cooperators from the New Mexico Bureau of Geology and Mineral Resources and Colorado State University (table 1). Prior to the meeting, on March 16, 2006, Ken Mabery (geologist and former management assistant at El Malpais National Monument), Bruce Heise (geologist, NPS Geologic Resources Division), and Katie KellerLynn (geologist/research associate, Colorado State University) participated in a conference call to gather pertinent background information about geologic resources of El Malpais and El Morro National Monuments; Mabery was not able to attend the scoping meeting on March 30 in New Mexico.

Table 1. Scoping Session Participants

Name	Affiliation	Phone	E-Mail
Tim Connors	NPS Geologic Resources Division (geologist)	303-969-2093	tim_connors@nps.gov
Kayci Cook Collins	El Malpais and El Morro National Monuments (superintendent)	505-285-4641	kayci_cook@nps.gov
Nelia Dunbar	New Mexico Bureau of Geology and Mineral Resources (geologist)	505-835-5783	nelia@nmt.edu
Bruce Heise	NPS Geologic Resources Division (geologist)	303-969-2017	Bruce_Heise@nps.gov
Katie KellerLynn	Colorado State University (geologist/research associate)	801-364-1716	katiekellerlynn@msn.com
Ron Kerbo	NPS Geologic Resources Division (cave specialist)	303-969-2097	ron_kerbo@nps.gov
Ken Mabery*	Fort Necessity National Battlefield and Friendship Hill National Historic Site (superintendent)—formerly with El Morro and El Malpais	724-329-5802	ken_mabery@nps.gov
Greer Price	New Mexico Bureau of Geology and Mineral Resources (geologist/chief editor)	505-835-5752	gprice@gis.nmt.edu
Peter Scholle	New Mexico Bureau of Geology and Mineral Resources (state geologist)	505-835-5294	scholle1@nmt.edu
Herschel Schulz	El Malpais and El Morro National Monuments (chief ranger)	505-285-4641, ext. 25	herschel_schulz@nps.gov

*Participated in March 16, 2006, conference call only.

Thursday, March 30, involved a welcome and introduction to the Geologic Resource Evaluation (GRE) Program, including the status of reports and map products. During the welcome, Kayci Cook Collins, superintendent for El Morro and El Malpais National Monuments who has studied geology, said "We're glad you're here. Rocks are our friends," which got the session off to a good start. The morning's

discussion focused on map coverage of the monument and other "quadrangles of interest" in the vicinity of El Morro. In addition, Bruce Heise facilitated a group discussion regarding the geologic processes and features at the monument.

Overview of Geologic Resource Evaluation Program

Geologic features and processes serve as the foundation of park ecosystems and an understanding of geologic resources yields important information for park decision making. The National Park Service (NPS) Natural Resource Challenge, an action plan to advance the management and protection of park resources, has focused efforts to inventory the natural resources of parks. Ultimately, the inventory and monitoring of natural resources will become integral parts of park planning, operations and maintenance, visitor protection, and interpretation.

The Geologic Resource Evaluation (GRE) Program, which the NPS Geologic Resources Division administers, carries out the geologic component of the inventory. Staff associated with other programs within the Geologic Resources Division (e.g., abandoned mine land, cave, coastal, disturbed lands restoration, minerals management, and paleontology) provide expertise to the GRE effort. The goal of the GRE Program is to provide each of the identified "natural area" parks with a digital geologic map and a geologic resource evaluation report. In addition, the Inventory, Monitoring, and Evaluation Office of the Natural Resource Program Center is preparing a geologic bibliography for each of these parks. Each product is a tool to support the stewardship of park resources and is designed to be user friendly to non-geoscientists.

The scoping process includes a site visit with local experts, evaluation of the adequacy of existing geologic maps, and discussion of park-specific geologic management issues. Scoping will result in a summary (this document), which along with the digital geologic map, will serve as the starting point for the final GRE report. The emphasis of scoping is not to routinely initiate new geologic mapping projects but to aggregate existing information and identify where serious geologic data needs and issues exist in the National Park System. Scoping meetings are usually held for individual parks though some address an entire Vital Signs Monitoring Network.

Bedrock and surficial geologic maps and information provide the foundation for studies of groundwater, geomorphology, soils, and environmental hazards. Geologic maps describe the underlying physical framework of many natural systems and are an integral component of the physical inventories stipulated by the National Park Service in its Natural Resources Inventory and Monitoring Guideline (NPS-75) and the 1997 NPS Strategic Plan. The NPS geologic resource evaluation is a cooperative implementation of a systematic, comprehensive inventory of the geologic resources in National Park System units by the Geologic Resources Division; the Inventory, Monitoring, and Evaluation Office of the Natural Resource Program Center; the US Geological Survey; state geological surveys; and universities.

For additional information regarding the content of this summary, please consult the NPS Geologic Resources Division, located in Denver, Colorado. Up-to-date contact information is available on the GRE Web site at http://www2.nature.nps.gov/geology/inventory/.

The objectives of the geologic resource evaluation scoping meetings are as follows:

- To identify geologic mapping coverage and needs
- To identify distinctive geologic processes and features
- To identify resource management issues
- To identify potential monitoring and research needs

Outcomes of the scoping process include the following items:

- A scoping summary (this document)
- A digital geologic map
- A geologic resource evaluation report

Status of Scoping and Products

As of April 2006, the NPS Geologic Resources Division had completed the scoping process for 160 of 272 "natural resource" parks. Staff and partners of the GRE Program have completed digital maps for 68 parks. These compiled geologic maps are available for downloading from the NR-GIS Metadata and Data Store at http://science.nature.nps.gov/nrdata. The US Geological Survey, various state geological surveys, and investigators at academic institutions are in the process of preparing mapping products for 42 parks. Writers have completed 22 GRE reports with 18 additional reports to be completed by the end of fiscal year 2006.

Geologic Maps for El Morro National Monument

During the scoping session on March 30, 2006, Tim Connors (GRD) presented a demonstration of some of the main features of the digital geologic map model used by the GRE Program. This model incorporates the standards of digitization set for the GRE Program. The model reproduces all aspects of a paper map, including notes, legend, and cross sections, with the added benefit of being GIS compatible. Staff members digitize maps using ESRI ArcView/ArcGIS format with shape files and other features, including a built-in help file system to identify map units.

Parks in Inventory and Monitoring Networks have identified "quadrangles of interest" mapped at one or more of the following scales: 7.5' × 7.5' (1:24,000), 15' × 15' (1:62,500), or 30' × 60' (1:100,000). Often for simplicity, geologic map makers compile maps at scale 1:100,000 (30' × 60'), which provides greater consistency and covers more area. However, for the purpose of geologic resource evaluations, GRE staff would like to obtain digital geologic maps of all identified 7.5-minute (1:24,000-scale) quadrangles of interest for a particular park. The geologic features mapped at this scale are equivalent to the width of a one-lane road.

Table 2. Quadrangles of Interest for El Morro National Monument

Quadrangle	Map citation	Paper	Digital
GRE Plan: Digitize NMBG&MR map			
El Morro	Anderson, O.J., and Maxwell, C.H., 1991, Geology of El Morro quadrangle, Cibola County, New Mexico: New Mexico Bureau of Mines and Mineral Resources Geologic Map 72, scale 1:24,000 (GMAP 73325).*	Yes	No
GRE Plan: Digitize USGS maps			
Togeye Lake	Mapel, W.J., 1985, Geologic map of the Togeye Lake quadrangle, Cibola and McKinley Counties, New Mexico: US Geological Survey Miscellaneous Field Studies Map MF-1726, scale 1:24,000 (GMAP 13464).*	Yes	No
Goat Hill	Mapel, W.J., and Yesberger, W.L., 1985, Geologic map of the Goat Hill quadrangle, Cibola County, New Mexico: US Geological Survey Miscellaneous Field Studies Map MF-1727, scale 1:24,000 (GMAP 1070).*	Yes	No

*GMAP numbers are identification codes used in the GRE database.

Map coverage for El Morro National Monument consists of the El Morro 7.5-minute quadrangle (scale 1:24,000), which is situated on the Zuni 30' × 60' sheet (see fig. 1). In addition, the quadrangle to the west, Togeye Lake, and to the south, Goat Hill, would be useful to park managers for understanding how geologic processes and features influence the resources at El Morro. GRE staff will digitize three

quadrangles (scale 1:24,000 scale) for El Morro: GMAP 73325, GMAP 13464, and GMAP 1070 (see table 2). GMAP numbers, which appear throughout this document, are identification codes, part of the GRE database.

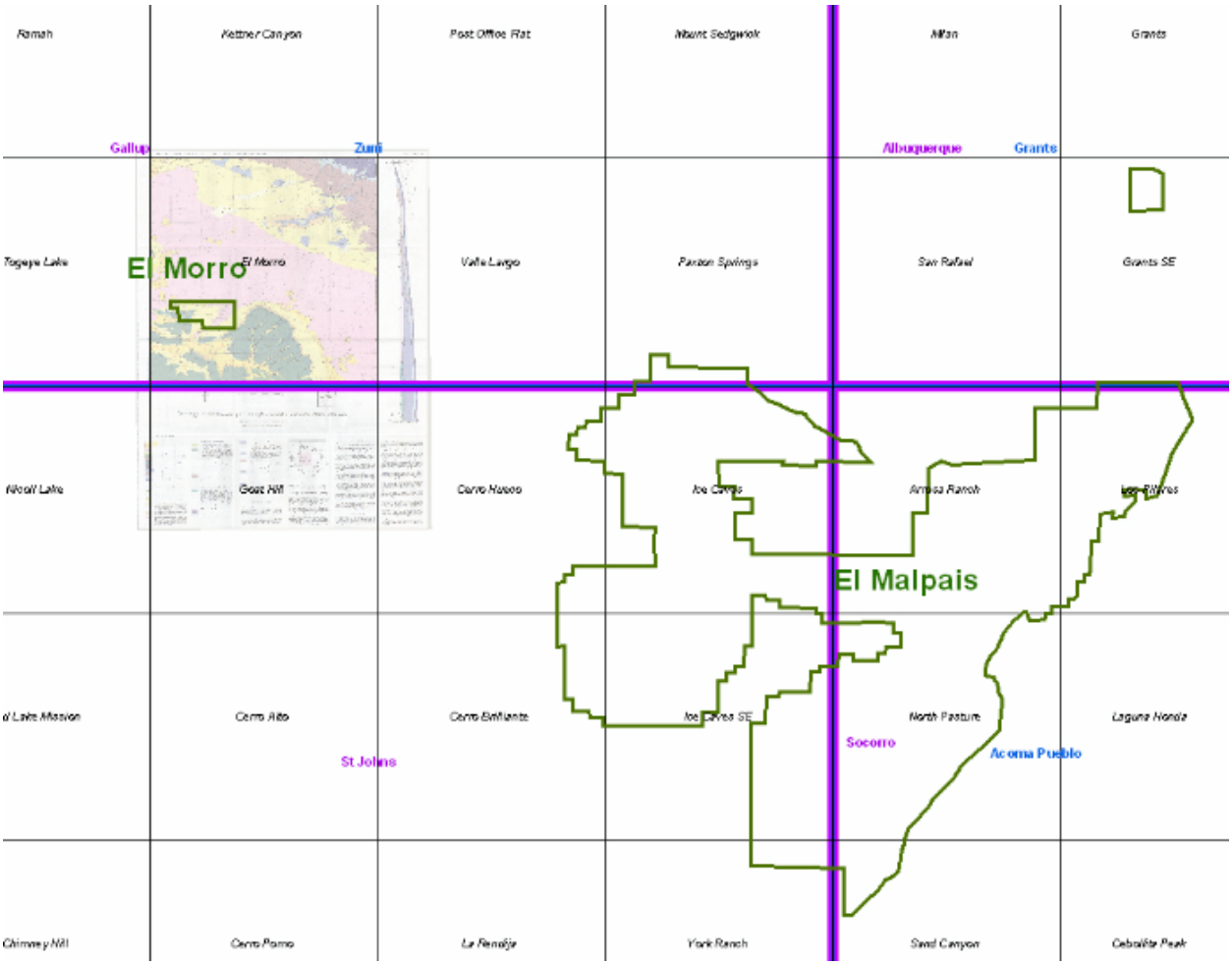

Figure 1. Quadrangles of interest for El Morro National Monument, New Mexico. Names in black indicate 7.5-minute quadrangles (scale 1:24,000); names in blue indicate 30-minute by 60-minute quadrangles (scale 1:100,000); names in purple indicate 1-degree by 2-degree sheets (scale 1:250,000). Green outline indicates the boundary of El Morro and El Malpais National Monuments.

Geologic Overview

In contrast to the nearby volcanic (igneous) rocks of El Malpais National Monument, the majority of rocks at El Morro National Monument are sedimentary. Most notably, the Zuni sandstone (155–165 million years old) was part of a sand sheet when it was deposited during the late Jurassic Period. This is the rock unit into which travelers carved their inscriptions. With respect to natural resources, the unit displays cross beds. The top of the Zuni sandstone is bleached, an indication of the 90-million-year hiatus between formation of the Zuni sandstone and deposition of the Cretaceous-age Dakota sandstone. The base of the Dakota Formation cuts into the Zuni sandstone, indicating deposition under fluvial conditions.

Geologic Resource Evaluation Report

Geologic Resource Evaluation reports include sections about geologic resources of concern for management (referred to as “issues”), geologic features and processes, the park’s geologic history, a map unit properties table that highlights the significant features and resource concerns for each map unit in the

park, references (different from the bibliography), and various appendices (e.g., map graphics and scoping summary). This document (scoping summary) will serve as a starting point for information to be included in the final GRE report that will accompany the digital geologic map for El Morro National Monument.

Geologic Features, Processes, and Issues at El Morro National Monument

The scoping session for El Morro National Monument provided the opportunity to capture a list of geologic features and processes operating in the monument, which will be highlighted and expanded in the GRE report. Some of these features and processes may be of management concern.

El Morro National Monument is administered with El Malpais National Monument, though the geology of the two units is quite different. El Morro consists of a big sandstone block, the Cretaceous-age Zuni sandstone, with some small volcanic flows. The primary geologic management issue for El Morro is that the Zuni sandstone is extremely friable, and erosion of this unit is "melting" the inscriptions. Participants also discussed the following features and processes during the scoping session:

Lake (Lacustrine) Features and Processes

The culturally significant pool upon which travelers depended lies under a shaded overhang. As passersby rested in the shade of the bluff, they etched inscriptions into the rock. The perennial pool is a surface-water catchment in which runoff and snowmelt is stored. Today the pool is an important source of water for flora and fauna. Box Canyon also hosts a spring-fed catchment.

Hillslope Features and Processes

The primary concern regarding mass-wasting processes is rockfall off the exposed cliffs of Inscription Rock. In particular, a monolith that towers above the loop trail will eventually topple, potentially creating a hazard for visitors and destruction of the existing trail. Other infrastructure such as the visitor center, picnic area, and campground is located away from the cliffs and associated rockfall hazards. Park staff regularly monitors the monolith's stability (e.g., with strain gauges and a tilt meter).

Volcanic Features and Processes

El Morro hosts one unit of volcanic rock: an aa lava flow. The flow, located on the eastern side of the monument near the campground, is part of the Zuni–Bandera volcanic field, which formed along a zone of crustal weakness and created in the flows, vents, and lava tubes of El Malpais National Monument.

Windblown (Eolian) Features and Processes

The source of windblown sediment at the monument is the Zuni sandstone. Windblown processes produce small sand dunes scattered throughout the monument. The resource management concern about eolian processes is that wind erodes the sandstone upon which ancient travelers made their inscriptions, slowly erasing these valuable cultural resources, which the National Park Service is obligated to protect.

Water, which is wicked into the sandstone, and lichens also facilitate erosion of the inscriptions.

Unique Geologic Features

Various geologic features enhance the distinctiveness of El Morro National Monument. For instance, the unconformity—missing rock and time—between the Zuni sandstone and the Dakota Formation shows that climate changed over a 90-million-year time span with the environment altering from eolian to fluvial conditions. The bleached top of the Zuni sandstone indicates the location of the unconformity. The cross-bedded sandstone of the Zuni Formation represents fossil dunes, and the channels cut into the Dakota Formation show the fluvial outcome of the changing climate. In addition, Box Canyon, which penetrates into El Morro, is geologically scenic.

Disturbed Lands

El Morro National Monument turned 100 years old in 2006. Yet, evidence of century-old grazing still remains. Grazing has impacted vegetation and biotic soils.

In an effort to reduce erosion and protect infrastructure in the monument, the National Park Service has filled in arroyos with barricades. Runoff from the cuesta had produced large, deep arroyos. One of these is immediately adjacent to the present maintenance compound. Perhaps the most significant arroyo was produced from the historic pool and ran along the base of the inscription rock section. When the dam at the pool was constructed in the 1920s (?), NPS staff subsequently filled in the arroyo with wood posts, forming barricades in several locations to prevent further erosion. This caused sediment filling. At present, three of these barricaded arroyos exist in the monument. In recent years, only tree trimming slash has been placed in the arroyo behind the maintenance compound. This practice may continue as determined practical (Herschel Schulz, El Morro and El Malpais National Monuments, written communication, May 9, 2006).

Park staff needs to evaluate other disturbances for their cultural significance. For example, an historic dam creates the present water level of the pool, which is much different than original "historic" levels. Also, in the 1930s, workers cut steps into the cliffs, which now cause rockfall and impact natural water runoff.

In 2003 park managers were concerned about a proposed expansion of the Tinaja gravel pit owned by C&E Concrete, Inc. The park superintendent at the time, Peri Eringen, wrote a letter outlining the concerns: visitor safety and speeding mining-operation trucks; noise and vibrations, particularly as impacts to threatened and endangered species; air quality; and new asphalt plant with possible acid deposition problems (Kerry Moss, Geologic Resource Division, written communication, March 20, 2006). However, park staff confirmed that the owner withdrew the permit request for the portable asphalt plant in March 2006 (Kayci Cook Collins, El Malpais and El Morro National Monuments, written communication, April 20, 2006).

Geologic Interpretation and Education

Educational materials for El Morro National Monument include a new brochure and some temporary exhibits about the monument's geology. Geology-related research includes laser scanning of the inscriptions. Park staff has animations of the scanning process that could be incorporated into future exhibits. The micron-size data points of the inscriptions are both exciting and daunting for resource management, particularly in light of the natural processes of erosion.