WILDLIFE CAMERA MONITORING
IN DEVILS CANYON AND
EAST PLANT MINE SITE VICINITY

RESOLUTION COPPER MINING

Prepared for:

Resolution Copper Mining
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July 2012
Project No. 807.43

TABLE OF CONTENTS

TABLES

FIGURES
(follow text)

APPENDICES

EXECUTIVE SUMMARY

WestLand Resources, Inc. (WestLand) was retained by Resolution Copper Mining, LLC (RCM) to conduct wildlife monitoring surveys utilizing motion-sensitive cameras in the vicinity of RCM's holdings near Superior, Arizona. Data were collected at sites in Devils Canyon in 2008 and expanded efforts included additional sites in Devils Canyon and the Oak Flat/East Plant Site areas in 2011.

Camera monitoring efforts in 2008 and 2011 recorded 28 species, including 17 mammals and 11 birds. The most commonly observed mammal species was domestic or feral cattle (*Bos taurus*), representing 35 percent of all recorded events. White-nosed coati (*Nasua narica*) and raccoons (*Procyon lotor*) were also commonly recorded, accounting for 19 and 14 percent of events, respectively. Less commonly observed species included American black bear (*Ursus americanus*), white-tailed deer (*Odocoileus virginianus*), and mountain lion (*Puma concolor*), each accounting for 6 percent or less of all events. Observations of all other mammalian species were relatively infrequent. For American black bears and mountain lions, distinguishing characteristics suggest that the cameras photographed up to nine individual bears and at least three individual lions.

Some species were recorded at many camera locations while other species were only recorded at one or two camera locations. Cattle and white-nosed coati, the two most commonly recorded species, have been recorded at nearly every camera site. Similarly, white-tailed deer, mountain lions, and American black bear were active at a majority of sites. Most deer and lion activity was documented in the middle portion of Devils Canyon, and most bear activity was documented in the southern portion of Devils Canyon. Most other mammal species were active in relatively localized areas, including raccoons, eastern cottontail (*Sylvilagus floridanus*), javelina (*Tayassu tajacu*), and three skunk species (*Mephitis mephitis*, *M. macroura*, and *Conepatus leuconotus*).

Given the purpose and design of this study, all observations of avian species were incidental and relatively rare. Combined, observations of birds accounted for 5 percent of all events, and no individual avian species accounted for more than 2 percent of all events.

1. INTRODUCTION

Resolution Copper Mining LLC (RCM) is currently conducting pre-feasibility studies for the development of a copper mine and associated facilities near Superior, Pinal County, Arizona (***Figure 1***). WestLand Resources, Inc. (WestLand) has been conducting various baseline biological surveys to support planning and anticipated permitting efforts. As part of this effort, WestLand conducted wildlife camera monitoring in the area (***Figures 2 and 3***).

For this wildlife monitoring project, the specific study area consisted of two riparian locations in Devils Canyon, Rancho Rio Creek, and at a tinaja on a tributary to Queen Creek (Study Area) (***Figure 2 & 3***). This study was designed primarily to detect medium to large mammal species in the Resolution Project Area using motion-sensitive cameras. Data were collected at three sites in Devils Canyon in 2008 and early 2009 (***Appendix A***) and at 10 sites in 2011. In 2011, expanded efforts included eight sites in Devils Canyon, one site on Rancho Rio Creek, and one site at a tinaja on a tributary to Queen Creek.

The goals of this report are to present the occurrence and distribution of medium and large mammals observations in the Study Area during all years.

1.1. AREA DESCRIPTION

For this wildlife monitoring project, the specific Study Area consisted of two riparian locations in Devils Canyon, Rancho Rio Creek, and at a tinaja on a tributary to Queen Creek (***Figure 2 & 3***). The following paragraphs provide descriptions of these areas.

Devils Canyon is a steep-walled north-south trending drainage located east of the Oak Flat/East Plant Site Area (***Figure 2 & 3***). Surface water in the canyon is seasonally intermittent in the north and perennial in the south. Elevations within the two segments of Devils Canyon surveyed for this study range from a maximum of approximately 4,000 ft (1,219 m) on a high ridge near the northern limit of the surveyed area to a minimum of roughly 3,000 ft (914 m) at the canyon bottom near the southern limit of the Study Area. Devils Canyon supports groves of Interior Riparian Deciduous Forest (Brown 1994), which include Arizona alder (*Alnus oblongifolia*), desert hackberry (*Celtis pallida*), Arizona sycamore (*Platanus wrightii*), and Fremont cottonwood (*Populus fremontii*). The south Devils Canyon study area includes a 0.2 mi (0.3 km) stretch of Devils Canyon extending from stream mile 3.0 – 3.2, and the middle Devils Canyon study are is a 0.4 mi (0.6 km) stretch extending from stream mile 5.4 – 5.8 (***Figure 2 & 3***). [North Devils Canyon is considered in the vicinity of and north of US 60.]

The Oak Flat/East Plant Site Area is roughly bounded on the north by US 60 and Queen Creek Canyon, on the east by the cliff top of Devils Canyon, on the south by Oak Creek, and on the west by the crest of Apache Leap. This area includes the Tonto National Forest (TNF) Oak Flat Campground. Parallel ridges and drainages trend toward the northeast from the Apache Leap ridgeline, becoming relatively level in the northeastern portion near Oak Flat. A subtle topographic divide separates these channels into those that drain north through Oak Flat to Queen Creek and those that drain east through Rancho Rio Creek and Hackberry Creek to Devils Canyon. Interior Chaparral vegetation dominates the Oak Flat/East Plant Site Area, though elements of Madrean Evergreen Woodland are present at several ponds and reservoirs in the area. The Study Area includes two locations in this area, one on Rancho Rio Creek and another at a tinaja on a tributary of Queen Creek (***Figure 2 & 3***).

1.2. BACKGROUND ON WILDLIFE CAMERAS

The use of motion-sensitive wildlife cameras, commonly known as "camera traps," is an established survey methodology in vertebrate ecology, particularly in studies of large mammals. Deploying camera traps is a particularly useful survey technique for examining the diversity of large mammals at a site and comparing differences in mammal diversity to adjacent habitats (Stein et al. 2008). However, data from camera trap studies is of limited use in modeling overall species densities due to inherent biases in detecting large mammals (Dajun et al. 2006), and due to biases in detecting gregarious species that forage or travel in groups compared to solitary species (Treves et al. 2010). Cameras detect the infrared heat signal in a cone-shaped zone in front of the camera (Dajun et al. 2006). The ability of a camera to detect a species is dependent on animal body size, temperature difference from the environment, distance from the camera, and presence of vegetation within the detection area of the camera. Thus, small species, such as mice and ground squirrels, are less likely to be "captured" in a photograph compared to species that are 10 to 1000 times larger. Therefore, although there is a continuous range of body size in mammals, we categorize the mammal species that we were able to detect into medium (e.g., coati) and large (e.g., bear). We incidentally detected birds, which also have small body sizes, but they were usually detected perching on vegetation close to the camera where sensitivity of the infrared detector is greater.

Trapping rates have been shown to respond to population manipulation (Bengsen et al. 2011) and to be strongly correlated to density estimates calculated using other established methodologies, such as capture-recapture analyses (Rovero and Marshall 2009). As such, a growing trend in vertebrate ecology incorporates camera traps with capture-recapture analyses to develop density estimates of large mammals (e.g., Ríos-Uzeda et al. 2007, Rovero and Marshall 2009). Because large mammals represent the top trophic levels in many ecosystems, camera trap sampling has even been proposed as the basis of a composite indicator of biodiversity for global monitoring efforts (O'Brien et al. 2010). In this study, wildlife camera methodology was employed to determine the diversity of large mammals in the Study Area and are not presently concerned with estimating density of species.

2. METHODS

Two models of motion-sensitive cameras were used for this study, including the Cuddeback® NoFlash Infrared Digital Camera and the Reconyx® HC600 Hyperfire High Output Covert IR (Infrared) Camera. The Cuddeback camera model is capable of both daylight color digital photography (3.0 megapixel) and nighttime digital infrared photography (1.3 megapixel). The Cuddeback cameras have a trigger speed of 0.75 seconds. These cameras are powered by 4 D-cell alkaline batteries and store images on a 1-gigabyte (GB) or 2-GB CompactFlash memory card (Transcend Information, Inc.). These cameras were programmed to take one photograph and a 30-second video after being triggered and to delay one minute before triggering again. The Reconyx camera has a trigger speed of 0.2 seconds and takes both daylight color digital photographs (3.1 megapixel) as well as nighttime monochromatic infrared photographs (3.1 megapixel). The Reconyx cameras are powered by Lithium AA batteries and stored images on 4-GB

Reconyx Certified SDHC Memory Cards (SanDisk Corporation). These cameras were programmed to take five photographs after each triggering event and to delay taking images between events for at least one minute. To protect these cameras from animal damage, or human theft or vandalism, each camera was deployed in a Reconyx Hyperfire Security Steel Enclosure.

In 2008, three Cuddeback cameras were deployed and in 2011 three Cuddeback and six Reconyx cameras were deployed. The cameras were deployed on March 10 and 11, 2011 at locations in the Oak Flat/East Plant Area and at two sites Devils Canyon (***Table 1***). Sites in riparian groves, at vegetated springs, and along game trails were selected as camera locations since they are likely locations for species to use for obtaining water, for traversing the habitat, and for avoiding heat. These sites included three locations in Devils Canyon previously surveyed in 2008 and 2009 (***Appendix A***). Initially, eight cameras were placed at sites in Devils Canyon and one along Rancho Rio Creek. However, one camera from Devils Canyon was redeployed to a site near the East Plant Site Area on June 28, 2011 in an attempt to include a larger spatial distribution and diversity of habitats in the Study Area. Cameras were generally secured to trees, but one camera at Site 3a (***Table 1, Figure 2 & 3***) was affixed to a rock wall adjacent to the tinaja pool. The Cuddeback cameras were attached to trees using large hose clamps and secured with chains and padlocks. The steel security enclosures of the Reconyx cameras were mounted directly to the trees with large screws. The cameras were placed within the steel enclosures that were secured with a Master Lock Python Adjustable Locking Cable.

The cameras were checked every four to 10 weeks between March and October 2011. During checks, batteries were replaced, memory cards were changed, and maintenance was performed at each camera site. Images obtained from cameras up to October 5, 2011 are included in this report.

After each check, contents of the memory cards were uploaded the onto the WestLand network, and the photographs captured by the cameras were analyzed and carefully scrutinized for the presence of animals. Species captured in the photographs were identified when possible. Each instance when an animal passed a camera was recorded as a single event, since some animals lingered in front of cameras and triggered multiple sets of photographs. Data from 2011 were compiled with data from 2008 to develop a more complete list of species. With mountain lions (*Puma concolor*) and American black bears (*Ursus americanus*), size, sex, coat color, and distinguishing marks, such as scars, were utilized to identify and count individual animals in the collection of photographs.

Table 1. Wildlife monitoring camera locations[1] and camera names from wildlife monitoring studies in 2008 and 2011.

Camera Locations	Year	Name of Camera	Comments
1	2008	Cuddeback	Camera location 3 from 2011
2	2008	Cuddeback	Camera location 5 from 2011
3	2008	Cuddeback	Camera location 8 from 2011
1	2011	Cuddeback 4	
2	2011	Reconyx 6	
3	2011	Reconyx 4	Camera location 1 from 2008
3a	2011	Reconyx 4	
4	2011	Cuddeback 2	
5	2011	Reconyx 5	Camera location 2 from 2008
6	2011	Cuddeback 1	
7	2011	Reconyx 1	
8	2011	Reconyx 2	Camera location 3 from 2008
9	2011	Reconyx 3	

[1] Camera location numbers match corresponding numbers on ***Figures 2 - 4***.

3. RESULTS AND DISCUSSION

The wildlife monitoring cameras placed in the Study Area captured 872 events over 2,323 camera days. At all camera locations combined, cameras documented the presence 17 mammal species (828 events) (***Table 2***). Incidental photographs documented 11 bird species (44 events). There were five mammal species that we classified as large (greater than 40 lbs (18 kg), 10 species that we classified at medium (2-40 lbs; 0.9-18 kg), and two small species (less than 2 lbs; 0.9 kg) (***Table 2***).

The most commonly observed mammal was domestic or feral cattle (*Bos taurus*), representing 35 percent of all recorded events. White-nosed coati (*Nasua narica*; ***Appendix B, Photos 11 & 12***) and raccoons (*Procyon lotor*) were also commonly recorded, accounting for 19 and 14 percent of events, respectively. Less commonly observed species included American black bear, white-tailed deer (*Odocoileus virginianus*; ***Appendix B, Photo 4***), and mountain lion, each accounted for 6 percent or less of all events (***Table 2***). Observations of all other mammal species were relatively rare. For black bears and mountain lions, analysis of individual characteristics suggests that the cameras photographed up to nine different bears (***Appendix B, Photos 8, 14, 16, & 22***) and at least three different mountain lions (***Appendix B, Photos 10 & 20***).

The distribution of events captured by the camera traps suggests that some species were active at most camera locations while other species were only active at one or two camera locations (***Table 2***). The lowest number of event recorded was at Site 6 (7 events), while Sites 4 and 5 had 33 and 28 event respectively. The highest numbers of events were recorded at cameras 3, 3a, 7, and 9 with 122, 130, 193, and 109 events respectively. The number of species observed at cameras also varied among camera locations (***Figure 4***). Cameras 2, 3, 7, and 9 recorded 9 mammal species each and camera 5 recorded 8 mammal species. Camera 6, which had the lowest number of events, recorded only two species.

Cattle and white-nosed coati, the two most commonly recorded species, were active at nearly all camera locations. Similarly, white-tailed deer, mountain lions, and black bear were active at the majority of sites, though most white-tailed deer and mountain lion activity was documented in the middle portion of Devils Canyon and most black bear activity was documented in the southern portion of Devils Canyon. Notably, two sites in middle Devils Canyon recorded 73 percent of all mountain lion events and two sites in southern Devils Canyon recorded 63 percent of all black bear events in the Study Area (***Table 2***).

Most other mammal species were active in relatively localized areas. Raccoons were only recorded in 2011 at the tinaja on the tributary to Queen Creek in the Oak Flat/East Plant Area location 3a (***Appendix B, Photo 5***). Likewise, eastern cottontail activity was only documented in 2008 at the middle Devils Canyon site. Javelina (*Tayassu tajacu*) were documented at one site in middle Devils Canyon in 2008 and at another site in southern Devils Canyon in 2011 (***Appendix B, Photo 18***). Of the three skunk species photographed in the Study Area, the striped skunk (*Mephitis mephitis*; ***Appendix B Photo 1***) had the most events, but only at Rancho Rio Creek, though the hog-nosed skunk (*Conepatus leuconotus*; ***Appendix B, Photo 19***) and hooded skunk (*Mephitis macroura*) were only observed at two and three sites in Devils Canyon, respectively (***Table 2***).

Given the purpose and design of this study, all observations of avian species were incidental and relatively rare. A number of songbird occurrences at Camera 9 in South Devils Canyon can be attributed to a fallen branch that provided a suitable perch directly in front of the camera. Combined, observations of birds accounted for 5 percent of all events, and no individual avian species accounted for more than 2 percent of all events. Nonetheless, observations of Gambel's Quail (*Callipepla gambelli*; ***Appendix B, Photo 2***) and Turkey Vultures (*Cathartes aura*; ***Appendix B, Photo 7***) comprised the majority of avian events. These species were each observed at only one camera location.

Data collected during 2008 and 2011 camera monitoring efforts contribute an inventory of medium and large mammals and other wildlife in the Study Area. These efforts have identified 17 mammal species, of which cattle, raccoons, and white-nosed coati were the most commonly observed. However, these data should be interpreted with caution, as camera trap survey methodology possesses inherent biases towards detecting large mammals (Dajun et al. 2006), such as cattle, bears, and mountain lions, and gregarious mammals (Treves et al. 2010), such as raccoons and white-nosed coati. Nonetheless, these surveys provide a measure of the mammalian diversity of the Study Area.

Table 2. Number of recorded events at camera locations in 2008 and 2011.

Species and Family	Body Size	Camera Location Numbers in 2001 & 2008[1]										Year		Number of locations species were recorded
		1	2	1 / 3	3a	4	2 /5	6	7	3 / 8	9	2008	2011	
Domestic/Feral cattle *Bos taurus* Bovidae	large	22	22	- / 2	-	4	- / 1	6	128	11 / 42	64	11	291	9
American black bear *Ursus americanus* Ursidae	large	-	6	2 / 4	-	2	1 / 3	-	1	- / 9	23	3	48	8
White-tailed deer *Odocoileus virginianus* Cervidae	large	-	13	5 / 5	-	12	7 / 1	-	2	3 / -	3	15	36	7
Mountain lion *Puma concolor* Felidae	large	1	10	- / 14	-	1	1 / 3	-	3	-	1	1	33	7
Javelina *Tayassu tajacu* Tayassuidae	large	-	-	-	-	-	4 / -	-	-	-	1	4	1	2
Raccoon *Procyon lotor* Procyonidae	medium	-	-	-	120	-	-	-	-	-	-	0	120	1
White nosed coati *Nasua narica* Procyonidae	medium	1	3	37 / 30	8	14	3 / 2	-	43	19 / -	6	59	107	9
Gray fox *Urocyon cinereoargentus* Canidae	medium	10	5	-	-	-	-	1	3	2 / -	-	2	19	5
Striped skunk *Mephitis mephitis* Mephitidae	medium	13	-	-	-	-	-	-	-	-	-	0	13	1
Ringtail cat *Bassariscus astutus* Procyonidae	medium	-	-	-	-	-	1 / -	-	7	-	1	1	8	3

Table 2. Number of recorded events at camera locations in 2008 and 2011.

Species and Family	Body Size	Camera Location Numbers in 2001 & 2008[1]										Year		Number of locations species were recorded
		1	2	1 / 3	3a	4	2 /5	6	7	3 / 8	9	2008	2011	
Hooded skunk *Mephitis macroura* Mephitidae	medium	-	1	- / 1	-	-	-	-	1	-	-	0	3	3
Hog-nosed skunk *Conepatus leuconotus* Mephitidae	medium	-	-	-	-	-	-	-	-	1 / -	3	1	3	2
Bobcat *Lynx rufus* Felidae	medium	-	1	2 / 1	-	-	1 / -	-	-	-	-	3	2	3
Unidentified skunk Mephitidae	medium	-	-	-	1	-	-	-	-	-	-	0	1	1
Eastern cottontail *Sylvilagus floridanus* Leporidae	medium	-	-	17 / -	-	-	-	-	-	-	-	17	0	1
Rock squirrel *Spermophilus variegates* Sciuridae	small	10	1	- / 2	-	-	-	-	5	-	7	0	25	5
Unidentified bat	small	-	-	-	1	-	-	-	-	-	-	0	1	1
TOTAL (Sum)		57	62	63 / 59 (122)	130	33	18 / 10 (28)	7	193	36 / 51 (87)	109	117	711	

[1] – Camera location numbers are presented for 2008 and 2011 locations and number of events when two numbers are present.

4. REFERENCES

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FIGURES

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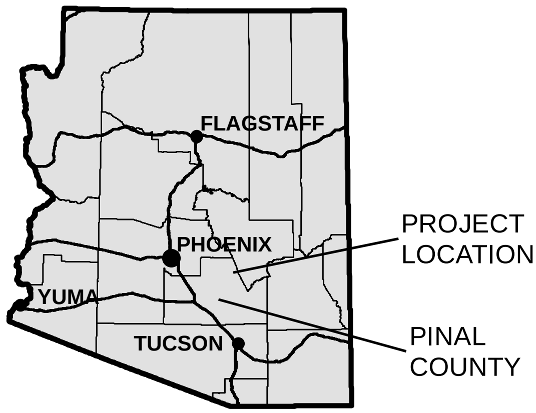
Legend

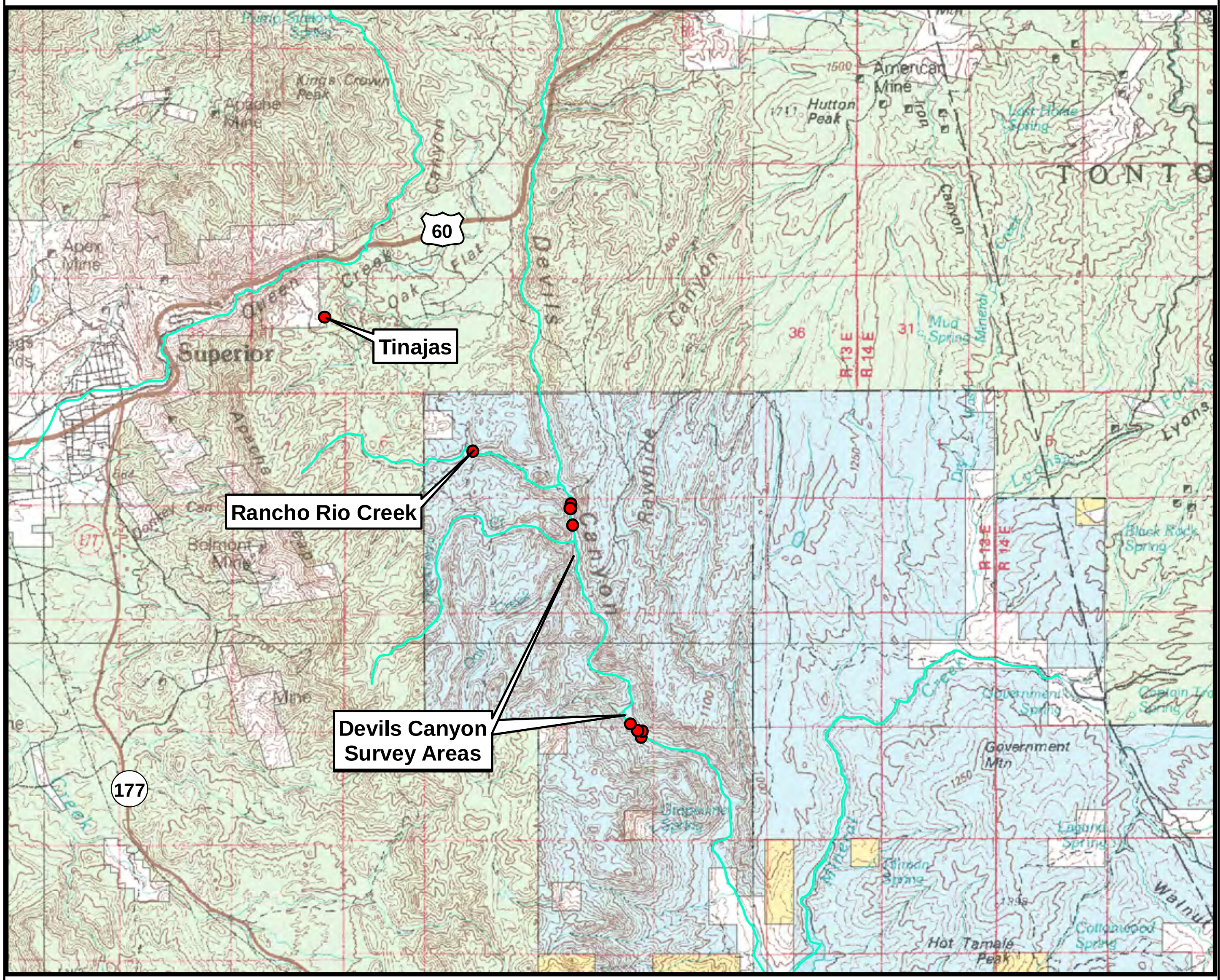
● 2011 Camera Location Points

Surface Management (BLM 2011)

- Bureau of Land Management (BLM)
- Private Land (No Color)
- State Trust Land
- US Forest Service (USFS)

ARIZONA





Pinal County, Arizona,
1:100,000 Globe & Mesa USGS Quadrangles

N

0 8,000 16,000 Feet

WestLand Resources, Inc.
Engineering and Environmental Consultants

RESOLUTION COPPER MINING
Wildlife Monitoring

VICINITY MAP
Figure 1

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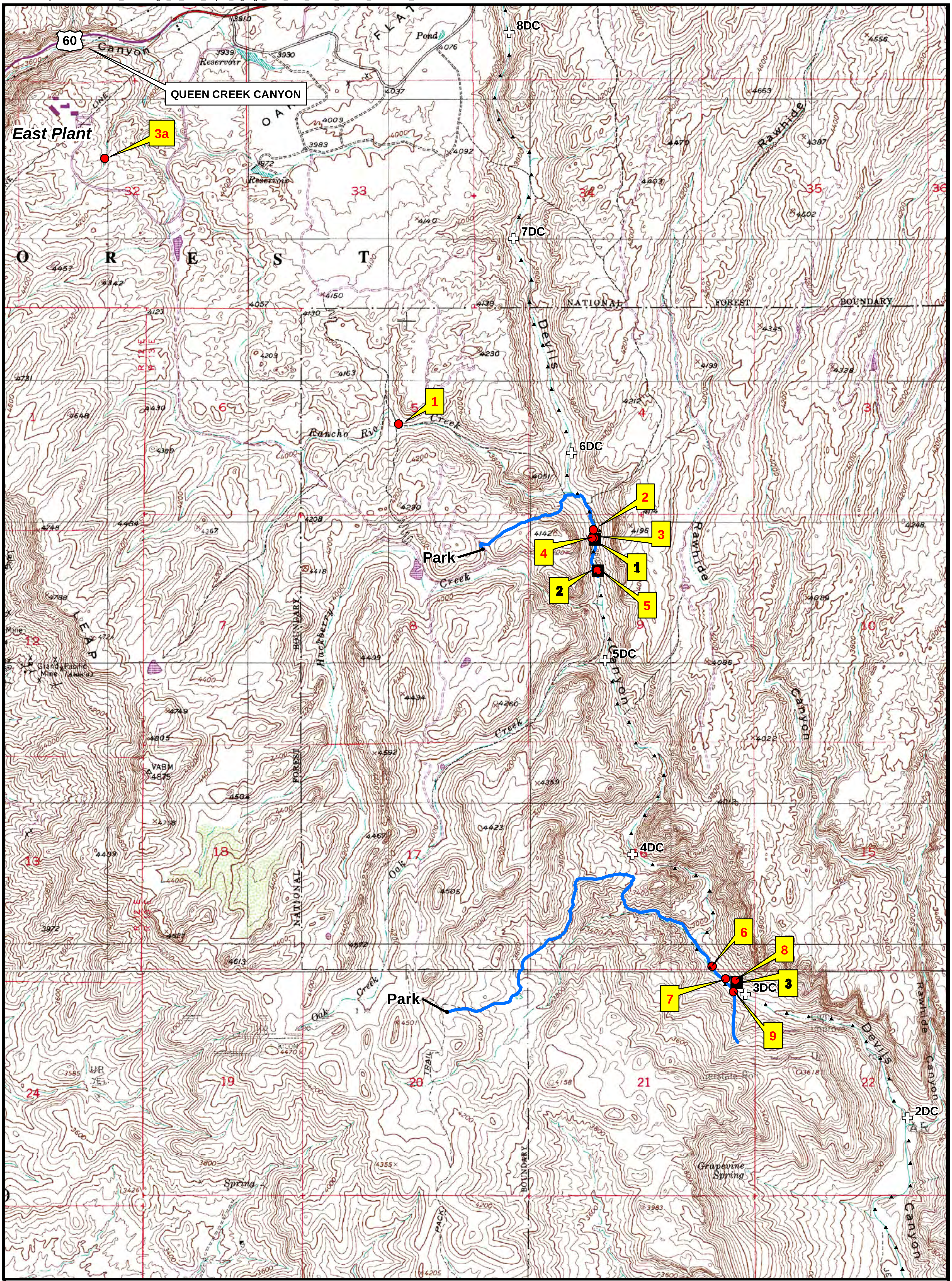

T1S, R13E, Portion of Section 32,
T2S, R13E, Portion of Sections 4, 5, 8, 9, 16, 17, 20 & 21,
Pinal County, Arizona,
Superior & Teapot Mountain USGS 7.5' Quadrangle

Legend

Track Line

6 — 2011 Camera Location Point & Number

3 — 2008 Camera Location Point & Number

2 — Stream Miles Along Devils Canyon from Confluence of Mineral Creek (Tenth Mile Increment Indicted by ▲)

N

0 2,200 4,400 Feet

RESOLUTION COPPER MINING
Wildlife Monitoring

WILDLIFE CAMERA LOCATIONS 2008 & 2011
Figure 2

WestLand Resources, Inc.
Engineering and Environmental Consultants

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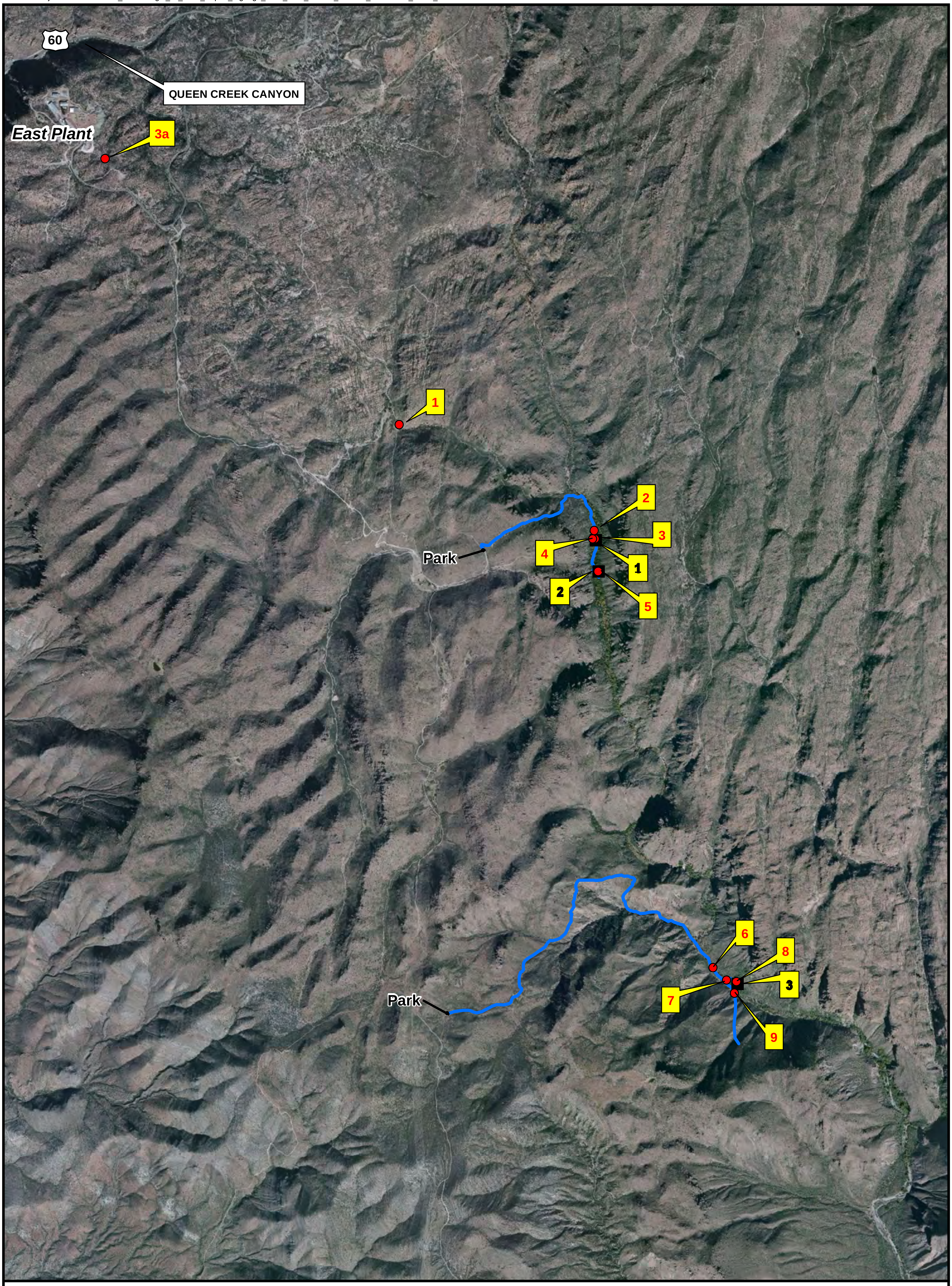

T1S, R13E, Portion of Section 32,
T2S, R13E, Portion of Sections 4, 5, 8, 9, 16, 17, 20 & 21,
Pinal County, Arizona,
Superior & Teapot Mountain USGS 7.5' Quadrangle
Photo Source: BING Microsoft Virtual Earth 2008

Legend

Track Line

6 2011 Camera Location Point & Number

3 2008 Camera Location Point & Number

N

0 2,200 4,400 Feet

RESOLUTION COPPER MINING
Wildlife Monitoring

WILDLIFE CAMERA LOCATIONS 2008 & 2011
AERIAL OVERVIEW
Figure 3

WestLand Resources, Inc.
Engineering and Environmental Consultants

APPENDIX A

TECHNICAL MEMORANDUM: RESOLUTION 2008 BASELINE BIOLOGICAL SURVEYS MOTION-SENSITIVE CAMERA RESULTS WESTLAND RESOURCES, INC. FEBRUARY 25, 2009

RESOLUTION 2008 – BASELINE BIOLOGICAL SURVEYS
MOTION-SENSITIVE CAMERA RESULTS

Prepared for: Resolution Copper

Prepared by: WestLand Resources, Inc.

Date: February 25, 2009

Project No.: 807.16

EXECUTIVE SUMMARY

WestLand Resources Inc. (WestLand) biologists set up three motion-sensitive cameras beside springs in Devils Canyon. Cameras 1 and 2 were set up on April 25, 2008 at two springs in the alder grove. Camera 3 was set up on May 9, 2008 at a spring below the Crater Tanks. Cameras 1 and 2 were revisited on June 10, August 28, 2008 and January 24, 2009. Camera 3 was revisited on February 15, 2009. Two more cameras (4 and 5) were set up on February 15 near Camera 3. As of February 15, 2009, five cameras are in Devils Canyon. Cameras 1, 2, and 3 had periods during this study when the cameras were not functioning (due to memory card malfunction, low batteries, or after being pulled to the ground by coatis). The three cameras were demonstrably functioning for a total of 433 camera-days. During this period, Cameras 1 and 2 captured 82 identifiable images of animals representing eight mammals and two birds. Mammal species photographed included mountain lion, bobcat, black bear, coati, ringtail, collared peccary, white-tailed deer, and cottontail. The two bird species were Bewick's wren, and spotted towhee. Camera 3 captured 36 identifiable images of animals representing four mammals: cattle, white-tailed deer, coatis, gray fox, and skunk. The most common images obtained by the three cameras combined were coatis (59), cottontails (17), deer (15), and cattle (11). Three individual bears were photographed. Young of bear, coatis, and white-tailed deer were included in the images and indicate that these species are reproducing in or nearby.

1. INTRODUCTION

Resolution Copper Mining (Resolution), owned by Rio Tinto and BHP Billiton, proposes to develop an underground copper mine on Resolution Property (the Property) east of Superior, Arizona (Figure 1). Resolution has authorized WestLand to conduct a variety of baseline biological studies on and near the Property. Existing conditions on the Property are described in a separate technical report (WestLand 2004a) and will not be repeated here.

During field work on the Property and adjacent areas, WestLand biologists have made observations on fish, amphibians, reptiles, birds, and mammals in the area. In 2008, birds were censused at permanent census stations three times during the winter and three times during the breeding season. The results of the fish and bird censuses are summarized in separate reports. During field surveys, amphibians and reptiles when encountered have been identified and located using a hand-held GPS, but concerted efforts to locate the more cryptic species and to develop local range maps or population estimates have not been done. Perhaps the most understudied of the vertebrate groups as part of the biological baseline studies have been the mammals. In the Resolution area, bats are the mammal group better characterized by WestLand biologists. WestLand biologists in coordination with Arizona Game and Fish Department set up mist nets at the entrance of one adit on July 13, 2004 and across one stock tank on July 14, 2004, both sites with a high probability of bat use. No bats were caught at the adit but eight bats representing three species (*Antrozous pallidus*, *Eptesicus fuscus*, and *Myotis ciliolabrum*) were caught at the stock tank, identified, and immediately released (WestLand 2004b).

The more time-intensive approaches to characterizing non-bat mammal populations in the area would include the use of spotting scopes for large mammals, baited Sherman-type live-traps for rodents, and baited Havahart®-type live-traps for medium-sized mammals. WestLand biologists have not yet used these approaches in the Resolution area. In addition, the area of interest is vast, and large portions are remote and comprised of cliffs, unstable steep-sloped Tertiary deposits, dense chaparral, thorn-scrub, or some combination of these features. Our observations of mammal evidence in the area are at best fragmentary. Examples of our observations include the following:

- <u>Mountain lion</u> (*Puma concolor* [*Felis concolor*]). On January 30, 2008, fresh mountain lion tracks were seen on the dirt road about 100 meters southeast of Hackberry stock tank (Figure 2; **Photo 1**; 496339E, 3681576N, NAD 27). It rained the day before, so the tracks were less than 24 hours old. The lion had crossed the road and was heading out of the drainage and up the south-facing slope. The tracks in the photos were about 10 cm (4 inches) in diameter – the typical size of mountain lion tracks.

Photo 1. *Mountain lion tracks photographed January 30, 2008 on dirt road near Hackberry Creek stock tank.*

- <u>Black bear (*Ursus americanus*)</u>. Bear claw marks had been observed on the alder trees at Bear Spring prior (Figure 2) to the camera set up. We found a dead black bear at Pipe Spring (Figure 2) in 2004. The bear had been dead for several weeks and was found among the boulders within the flood channel next to the spring. On May 8, 2008, we photographed and collected bear dung about 20 meters down-slope from where we set up camera 3 at Pipe Spring. The bear dung was outside of an excavated depression in earth under dense vegetation. The depression was circular, about 1.5 meters in diameter, and was likely dug by a bear as a resting spot. The bear dung was composed entirely of the berries of graythorn (*Ziziphus obtusifolia*), an abundant understory shrub at Pipe Spring and, at the time of our visit, still with a large amount of ripe fruits on the plants.

- Coati (*Nasua narica*). While hiking to and from the alder transects during the summer of 2008, WestLand biologists saw, on several occasions, groups of coatis in Devils Canyon. On April 23 at 18:05, we observed about 6 coatis running out of the channel area near Sycamore Spring (Figure 2). On April 24 at 12:45, we observed two coatis traveling along the east cliffs above Alder Transect #12 in Devils Canyon (**Photo 2**).
- Gray fox (*Urocyon cinereoargenteus*). We observed a gray fox running along the ledges above the canyon bottom in Queen Creek in the summer of 2008. In 2004, we observed a dead gray fox on the side of the paved road only about 100 meters below the gate at Mineshaft #9.
- Collared peccary (*Pecari tajacu*). Several years ago, we observed where a group of peccaries had visited a pool of water in lower Rancho Rio wash. The peccaries had created two wallows in the wet sand beside the pool; peccary hairs were present in the wallows. Tracks of adult and young peccaries were seen in the sand. We have seen peccary tracks in the sand at several pools within Rancho Rio and Devils Canyon and have seen peccary dung in an area of Devils Canyon south of Oak Canyon. On February 15, 2009, along the trail between the power line to the west and the Crater Tanks, we found at least fifty prickly pear plants with roots exposed by peccaries digging and feeding. The soil was wet and relatively soft to dig at this time.
- Deer (*Odocoileus* sp.). We have observed tracks, dung piles, and trails of deer along the dirt roads and in the chaparral west of Devils Canyon in 2008 and 2009. When camping above Devils Canyon near Hackberry Canyon in 2008, we heard deer walking and snorting nearby during the night. In February 2009, we frequently found fresh deer dung and deer tracks on the slopes to the west and southwest of the Crater Tanks. In contrast, in 2004 and 2005 while surveying the drainages and slopes to the west of Anxiety Fault in Rancho Rio watershed, we walked along wildlife trails and found no recent signs of deer. All of the deer dung was sun-bleached and probably more than a year

Photo 2. *Two coatis above Alter Transect #12 in Devils Canyon on April 24, 2008*

old. The absence of deer may have been part of the lingering effects of the severe drought in the area in the early 2000s.

In order to augment the observations of mammals in Devils Canyon, WestLand purchased infra-red triggered motion sensitive cameras. These cameras can provide the more economical means to logging in long hours of observation of wildlife albeit within a relatively small (5-10 m) area. The strength of these motion sensitive cameras is that most images of animals obtained can be reliably identified to species and each image is taken at a known site at a known time. Commercial camera systems became widely available in the early 1990s. Motion sensitive cameras have been used primarily by hunters for remotely assessing which individual game animals are using a particular spot and their condition. However, infrared-triggered cameras have also been used by wildlife biologists for more than 40 years.

Cutler and Swann (1999) and Swann et al. (2004) recently reviewed the application of infrared-triggered cameras in vertebrate ecology. Camera systems are now used by researchers to develop population estimates (ex. Martorello et al. 2001 for black bears, Mace et al. 1994 for grizzly bears (*Ursus horribilis*), Jacobson et al. 1997 for white-tailed deer), to assess potential wildlife corridors such as highway underpasses (Foster and Humphrey 1995), to confirm the presence of rare species such as marten (*Martes americana*) (Bull et al. 1992), opossum (*Didelphis virginiana*) in southern Arizona (Babb, Brown and Childs 2004), and jaguars (*Panthera onca*) in southern Arizona (Childs 1998, Childs and Childs 2007), and to conduct mammal inventories. A few examples of how motion-sensitive cameras have been employed by wildlife biologists are provided in the following paragraph.

In a large experimental design by Fenske-Crawford and Niemi (1997) to measure predation of artificial ground nests in three ages of forests in north-central Minnesota, two motion sensitive cameras were employed to identify the nest predators. The two cameras, after 1,728 hours of operation, recorded 28 predation events caused by eight species of mammals. Camera systems have also been used to evaluate relative predation risks of mule deer (*Odocoileus hemionus*) to mountain lions in different vegetation types (Hernández et al. 2005). Main and Richardson (2002) used eight cameras in a 4 x 2 grid design in each of 52 fire management units (mean size = 206 ha) to document relative abundance of wildlife in stands of slash pine (*Pinus elliottii*) in southern Florida that were at different stages in a four-year burn rotation. Gompper et al. (2006) compared four techniques (camera traps, track-plates, scat surveys, snow tracking) to survey carnivores at two study sites in New York. Gompper et al. found that no single technique was ideal for surveying all species of carnivores in their study area; however, they found that baited camera stations detected the most species but tended not to detect coyotes (*Canis latrans*) and underestimated small carnivores (ex. weasels). Gompper et al. found that baited cameras were efficient at surveying black bears. Bridges et al. (2004) used an infrared-triggered camera at each of ten black bear dens in the mountains of western Virginia. The camera results provided more accurate den-emergence dates, cub age at den emergence, and several seldom-documented behaviors associated with den exit. This brief review of the use of infrared-triggered cameras in wildlife studies suggests that even relatively few cameras employed in a study can greatly increase the amount and precision of information obtained regarding mammal activity in small areas (at bird nests, bear dens, springs, etc.).

There are four useful kinds of information that the infrared-triggered cameras set up at several springs in Devils Canyon may provide:

- the frequency at which different species are moving through a small monitored area at each spring,
- information about the number of bears and coatis in Devils Canyon,
- documentation of movement of distinctively marked bears and coatis between the upper cameras (1 and 2) and the lower camera (3) that are separated by about 3.2 km (2 miles), and
- documentation of rare species that are currently not anticipated to occur in Devils Canyon.

Photo 3. *Cuddleback® motion-sensitive camera wired to fallen log at Bear Springs; cover removed while servicing camera on August 28, 2008.*

2. METHODS

In 2008, motion-sensitive cameras were placed at three springs in Devils Canyon, east of the Resolution Property (Figure 2, 2 **Photos 3 and 4**). Cameras 1 and 2 were set up April 25, 2008; Camera 3 was set up May 9, 2008. Two more motion-sensitive cameras (Cameras 4 and 5) were set up on February 15, 2009. The locations of each of the cameras are provided in Table 1. Cameras 1 and 2 are at springs within the major alder grove. Camera 3 is at a large spring downstream (south) of the alder grove and below the Crater Tanks. Camera 4 was set up about 8 meters southeast of Camera 3. Camera 5 was set up along the east bank of Devils Canyon stream 200 meters upstream from Cameras 3 and 4. All cameras were placed within State Trust Lands. Cameras 1 and 2 are in Section 9 and Cameras 3, 4, and 5 are in Section 21 of Township 2S, Range 13E.

Photo 4. *View of Bear Spring on August 28, 2008. Camera on log between alder and boulder in background. Bear claw marks are present on the alder tree about 7ft above ground.*

Table 1. Locations of each camera (UTM coordinates, NAD 27).

Camera Location	Northerly	Easterly	Meters accuracy	Approx. elevation (m; ft)
Camera 1 (Bear Spring)	3681877	497463	8 m	1,095 m; 3592 ft
Camera 2 (Sycamore Spring)	3681655	497484	6 m	1,100 m; 3608 ft
Camera 3 (Pipe Spring)	3678734	498464	5 m	877 m; 2876 ft
Camera 4 (Pipe Spring)	3678730	498469	5 m	877 m; 2876 ft
Camera 5 (stream-side)	3678854	498302	10 m	866 m; 2840 ft

The cameras used were Cuddeback® NoFlash Infrared Digital Camera Systems, which were capable of both daylight color digital photography (3.0 megapixel) and nighttime digital infrared photography (1.3 megapixel). According to the manufacturer, this Cuddeback model had a trigger speed of ¾ second. The cameras were programmed to take one photograph after being triggered and had a one-minute delay between triggered events. (One minute was the minimum time between triggers for this model.) Cameras 1 through 4 were placed near springs because the three springs had an abundance of wildlife tracks and diggings. Additional animal signs that indicated the springs were focal points of large mammal activity were bear claw marks on nearby tree trunks and roots, wildlife trails, and at the lower spring, a black bear "bed" with bear scat around the bed. Initially, the cameras were wired to a fallen log (Camera 1) and to live tree trunks (Cameras 2 and 3), and all three cameras were less than 1 meter from the ground. Cameras 1 and 2 were located at Bear Spring and Sycamore Spring (Figure 2), near the upper end of the alder stand. Both of these cameras were first installed on April 25, 2008. The cameras' memory cards were changed and batteries were checked on June 10 and August 28, 2008. Cameras 1 and 2 were revisited five months later, on January 24, 2009, their batteries were replaced, and their memory cards were changed. After five months, the four D-type batteries in the cameras were down to 10 percent charge in Camera 1 and had failed in Camera 2. Camera 2 was not triggered on January 24 even though the biologist moved around within the field of view for at least a minute; the last image on Camera 2 was December 13, 2008. On January 24, 2009, Camera 1 was attached about 2 meters above ground to alder tree 121 on Alder Transect #5, and Camera 2 was moved about 1.5 meters above ground to a net-leaf hackberry about 12 meters south of the camera's first position. Camera 3 was installed on May 9, 2008 at Pipe Spring (Figure 2), below the Crater Tanks. This camera was checked on February 15, 2009; it was found on the ground (**Photo 5**), face up, with the Fresnel lens bitten (**Photo 6**), and mud and water within the casement and on the casement windows for the infrared flash lens and Fresnel lens. After seven months, Camera 3's batteries were dead. After replacing

Photo 5. *Camera 3 pulled to the ground by a coati on September 27, 2008; as it appeared February 15, 2009 (Pipe Spring)*

Photo 6. *Camera 3 with its coati-bitten Fresnel lens as it appeared February 15, 2009 (Pipe Spring)*

its batteries and memory card, Camera 3 was tested and found still to be working. Camera 3 was remounted on the trunk of a live hackberry tree about 2 meters above ground and secured with several lengths of heavy insulated copper wire. Camera 4 was set up about 2 meters above ground on the trunk of a young hackberry tree (**Photo 7**). Camera 5 was set up about 2 meters above ground on the trunk of a mature mesquite tree (**Photo 8**). Camera 5 was directed towards an open area between a bedrock cliff about 2-3 meters in height to the east and the stream to the west; wildlife are expected to use this constricted corridor. Camera 3 and 4 are directed towards two segments of the same wildlife trail that leads to flowing spring water about 15 meters to the northwest.

Photo 7. *Camera 4 set up on a young hackberry tree, February 15, 2009 (Pipe Spring)*

In this report, the Wilson and Reeder (2005) compendium on current nomenclature for mammals and the AOU (2008) compendium for current bird nomenclature were used. Both sources are available online. Because some of the mammals that occurred in this study have older nomenclatures still in use by researchers and recognized by Hoffmeister (1986) in his *Mammals of Arizona*, the older nomenclatural synonyms are included in brackets.

3. RESULTS

There were 292 camera-days during which Cameras 1 and 2 were functioning between April 25, 2008 and January 24, 2009 (Table 1). There were 141 camera-days during which Camera 3 was functioning between May 9, 2008 and February 15, 2009. The number of camera-days for a given interval was determined from the date the camera was set up to the date of the last photograph. Camera-days therefore include only those days for which we have evidence the camera(s) were functioning.

Photo 8. *Camera 5 set up on a mesquite tree on the edge of lower Devils Canyon stream; February 15, 2009*

Table 2. Camera-days for Camera 1 and 2.

Camera 1	Camera 2	Camera 3	Sum
4 6 days (4-25 to 6-10)	7 days (4-25 to 5-02)	141 days (5-09 to 9-27)	53 + 141
79 days (6-10 to 8-28)	53 days (6-10 to 8-02)		132
0 days (start 8-28)	107 days (8-28 to 12-13)		107
125 days	167 days	141 days	433 camera-days

A total of 193 images have been recovered from Cameras 1 and 2 over the time period from first installation on April 25 to the second data recovery on August 28, 2008. Camera 1 produced most of these images, with a total of 168 images (87%). The first image on Camera 1 was recorded on April 26, the morning after installation, and the final image was recorded on August 28, shortly before the data were recovered. Camera 2 was apparently knocked down shortly after installation and recorded no images between May 2 and June 10, when the memory cards in both cameras were changed and the cameras reset. From June 10 to August 10, Camera 2 recorded only 23 images, and four of those were of biologists at the time of setup on June 10. The first image after that time was on June 12, and the final recorded image was on August 2.

Nineteen images were recorded from Camera 2 between August 28, 2008 and January 24, 2009. No images were recorded during this same period of time from Camera 1 because of a malfunction in the memory card. Of the nineteen images from Camera 2, one was a WestLand biologist (on August 28), fourteen showed at least part of an animal and four showed nothing. The first image after August 28 was October 28, the final recorded image was December 13, 2009.

Seventy-four images were recorded from Camera 3 between May 9, 2008 and February 15, 2009. The last 14 images were of the sky and canopy on September 27, 2009 - all taken 70 minutes after a coati pulled the camera to the ground. It is not clear why more photos of the canopy were not taken by the face-up camera. Perhaps after four months and 16 photos in quick succession on September 27, the batteries lost their charge. Of the 60 non-sky images from Camera 3, 38 included at least one animal and 22 showed nothing. The first image after May 9 was the following day at 4:02 pm with no animal in the image; the last image was on September 27.

Of the 272 recorded images, there were 119 images of identifiable animals (44%) and another nine animal images that could not be identified (3%). Images of 11 mammal species and two bird species were recorded. There were also 14 images (5.2%) of WestLand biologists setting up cameras or passing through the canyon while working on other aspects of the baseline surveys. Many of the 142 images (52% of all recorded images) do not show any animals and appear to have been triggered by wind moving the vegetation or by animals that moved out of the field of view during the ¾-second trigger delay. Many of the images of animals show only a blurred image because the animal was moving rapidly or show part of the animal because of the slow trigger delay of the camera. The animal species photographed and the number of images of each are provided in Table 1.

Table 3 Species photographed by Cameras 1 (April 25, 2008 – August 28, 2008), Camera 2 (April 25 – January 24, 2009), and Camera 3 (May 9 - September 27, 2008).

Mammal Species	Camera 1	Camera 2	Camera 3	Total Images
Mountain lion (*Puma concolor* [*Felis concolor*])	0	1	0	1
Bobcat (*Lynx rufus*)	2	1	0	3
Black bear (*Ursus americanus*)	2	1	0	3
Gray fox (*Urocyon cinereoargenteus*)	0	0	2	2
Coatis (*Nasua narica* [*Nasua nasua*])	37	3	19	59
Ringtail (*Bassariscus astutus*)	0	1	0	1
Collared peccary (*Pecari tajacu* [*Tayassu tajacu*])	0	4	0	4
Skunk, probably Hooded Skunk (*Mephitus macroura*)	0	0	1	1
White-tailed deer (*Odocoileus virginianus*),	5	7	3	15
Cattle (*Bos taurus*)	0	0	11	11
Cottontail (*Sylvilagus* cf. *floridanus*)	17	0	0	17
Bird Species				
Bewick's wren (*Thryomanes bewickii*)	1	0	0	1
Spotted towhee (*Pipilo maculatus*)	1	0	0	1
Sum	65	18	36	119

Photographs discussed in this section can be found in the **Photosheets** section following the figures.

One mountain lion was photographed by Camera 2 on November 11, at 3:32 am (**Photo 9**). It appears to be a mature animal.

Bobcats were recorded twice at Camera 1, both on infrared after dark (**Photos 10 and 11**) and once at Camera 2 during early morning. Although Camera 1's bobcat images were recorded on June 22 and August 8, it is possible that they represent the same individual. The patterns of spots on the hind legs are very similar, but a conclusive comparison is not possible because of different angles and lighting. Only the tail and hind leg of a bobcat was photographed by Camera 2 on November 6 (**Photo 12**).

Three different black bears were recorded. An adult, reddish-brown in color, was recorded at Camera 1 on the morning after initial installation (**Photo 13**). A bear with black fur was recorded at Camera 2 in early July (**Photo 14**), and a juvenile bear was recorded at Camera 1 in early August (**Photo 15**). It is interesting that all of the bear photos were recorded during daylight, during hours when biologists could be working in the canyon.

We contacted Pat Feldt[1] who has about 15 years of experience guiding bear hunters in Arizona and showed him the photographs of the bears in Devils Canyon. In his e-mail reply (January 22, 2009), Mr. Feldt considered the bear in **Photo 13** to be "a 10+ year old bear about 300 lbs", **Photo 14** to be "just mature, can't tell much other than that," and **Photo 15** to be "2.5 yrs old and 100-125 lbs."

Gray fox was photographed twice (**Photos 16 and 17**). Although the photographs were taken 67 hours apart, the fox is in nearly the same spot with a different stance, as if the two photographs were only a few frames apart in a motion film. This nearly identical position of the fox during two different nights may be due to the fox stopping in mid-track to smell a scent-post on the ground.

Coatis were the most frequently photographed animal, with 59 recorded images. Most images of coatis were recorded by Camera 1, and images were common at Camera 3, but only three images were recorded at Camera 2. As with the cottontail (see below), there are several sequences of two to six images of the same animal over a relatively short period of time. On May 2, a coati was recorded seven times over a period of 50 minutes, but the animal never presented a good view of its head (**Photo 18)**. A similar sequence of two photos in the span of two minutes on May 4 provided no good head views (**Photo 19**). An image recorded less than an hour later may or may not be the same individual (**Photo 20**). Three images within two minutes on June 21 (**Photo 21**) are undoubtedly the same individual, but another image 20 minutes later may or may not be the same individual. A good, full-body profile was finally captured on July 17 (**Photo 22**). This animal shows a large patch of hairless skin behind and below its left ear; the hairless patch appears to be either a recent injury or a scar. The hairless patch of this animal is just visible in an earlier photo taken on June 6, more than a month earlier. Two coatis, presumably a mother and young, are visible in several photos. On May 19, an adult is clearly visible at the spring (**Photo 23**), with a second, much smaller, animal nearly hidden in the grass. On August 17, a young coati is barely visible behind an adult (**Photo 24**). Two coatis are also visible on August 19, although only the heavily striped tail of the young coati is visible (**Photo 25**). The two photographs of coatis taken by Camera 2 at Sycamore Spring show the tail of a coati very near the camera on May 2, and only a portion of the tail of a coati on December 11 (**Photo 26**). Camera 3 photographed at least four coatis (and possibly more), a light yellow coati and a chestnut-and-white coati (**Photo 27**), a dark brown-and-white coati (**Photo 28**), and what appears to be a young coati with the chestnut-and-white coati (**Photo 29**). In one photograph, a coati is seated and is either resting or grooming (**Photo 30**). Photographs on September 26 and 27 show the front legs and later the hind legs as a coati reaches up to the camera to manipulate it; on the 27th, the camera fell to the ground within ten minutes after the last coati photograph.

A ringtail (*Bassariscus astutus*) was photographed once, by Camera 2 on October 31 at 3:06 am (**Photo 31**). Ringtails apparently need and use water and are most abundant in rocky canyons (Hoffmeister 1986). It is possible that this animal had descended from the cliffs only 100 feet to the east and was going to the spring which is about 30 feet to the northwest.

An indistinct image of a skunk walking away from the camera was photographed by Camera 3 at night on August 11 (**Photo 32**). The tail and the posterior half of the back of the animal are white. The hog-nosed skunk (*Conepatus mesoleucus*) and the white-marked forms of the striped skunk (*Mephitus mephitus*) and hooded skunk (*Mephitus macroura*) have white tails and backs similar to the skunk in the photograph. To be definitive to species of skunk, it would be useful to have the front portion of the animal in view as well. However, the markings that can be seen appear to conform most closely to the white-marked form of the

[1] Owner, Arizona Guided Hunts (www.arizonahunting.net)

hooded skunk. The hooded skunk is known to occur in mid-elevation rocky canyons in this area of Arizona (Hoffmeister 1986). Hoffmeister examined one specimen of a hooded skunk that was reported to have been collected from Williams Ranch 3.2 km (2 miles) west of Superior (and perhaps 10 to 16 km (6 to 10 miles) from where the cameras are in Devils Canyon). Until more sightings or photographs are available, it is not possible to say which skunk species occur within Devils Canyon and which are most common in the canyon. All four species known to occur in Arizona, hog-nosed, striped, hooded, and spotted (*Spilogale gracilis*), are known from the general area between Superior and Globe and could potentially occur within the canyon.

Collared peccaries were photographed by Camera 2 four times, once on October 28 at 9:01 am, twice on November 7 (11:04 and 11:09 pm), and once on December 13 at 7:39 pm (**Photo 33**). On October 28 (**Photo 34**), only the nose of the peccary is visible, and another unidentified mammal (possibly coati) appears to be hanging on the tree where the camera was mounted, changing the angle of the photograph. In each of the other images, the peccaries appear to be running along the wildlife trail.

White-tailed deer were recorded at least several times at each camera. The first two images, probably the same adult individual, were recorded in infrared on Camera 1, after dark on April 29, 2008, within a time span of about four minutes (**Photo 35**). Daylight images of adult white-tailed deer were recorded on Camera 1 on June 13, July 30, and August 6 (**Photos 36, 37,** and **38**). A white-tailed deer fawn (with natal spots) was recorded on Camera 2 on July 22, 2008 (**Photo 39**). In addition, white-tailed deer adults were recorded six times on Camera 2 between August 28 and January 24, once each on October 31 (**Photo 40**), November 5 (**Photo 41**), and November 17, and three times on November 18. Five of the Camera 2 deer images were daylight images, one was an image taken at dusk on November 18, 5:35 pm (**Photo 42**). White-tailed deer were photographed three times at Camera 3, two images of a buck with antlers in velvet on July 25 and one image of a doe on August 4. The buck was walking along the wildlife trail in the direction of the running water at 5:48 pm (**Photo 43**) and returning at 5:53 pm (**Photo 44**), five minutes later.

Cattle were photographed eleven times by Camera 3, but not once by Cameras 1 or 2. Of the eleven photographs of cattle, nine were taken within a thirty minute period in the afternoon of May 16 and two were taken two minutes apart on July 3. At least five different animals were photographed, all of which appear to be either steers (**Photo 45 and 46**) or male feeder-calf (**Photo 47**). Two brand marks are evident on the animals, JI and an inverted V. No sign of cattle were observed at the springs next to Cameras 1 and 2 during this camera study.

Cottontails were recorded 17 times, all of which were on Camera 1. There are two cottontail species in central Arizona, the eastern cottontail (*Sylvilagus floridanus*) found in mountain forests and the desert cottontail (*S. audubonii*) found in a variety of vegetation types at lower elevations. Among the characters used to distinguish the two species, the ear-to-hind foot ratio can be used to identify to species at least some of the photographed cottontails at Camera 1. For eastern cottontails the length of the ear is shorter than the hind foot; for the desert cottontail, the length of the ear is greater than the hind foot (Reid 2006). Based on the relative lengths of ears and hind feet in the photographs, these animals are probably all eastern cottontails. These animals were apparently foraging in the camera's view, because multiple photos were recorded on three out of five instances. On June 16, one individual was recorded twice in a ten minute period late in the evening (**Photo 48**). On June 19, one individual was recorded four times within a nine minute period in the early evening (**Photo 49**). On June 21, one individual was recorded on nine consecutive photos over a period of 48 minutes (**Photo 50**). Based on the distinctive patterns of venation in the ears, the animals recorded on June 19 and June 21 are the same individual. On June 25, another eastern cottontail was recorded. The presence of a growth or parasite on the right hip identifies this cottontail as a different individual (**Photo 51**). The infrared photographs of cottontails on June 16 and August 15 (**Photo 52**) do not provide sufficient details to recognize an individual.

Two images of birds were recorded during this project, both at Camera 1. However, it is possible that some of the photos showing only vegetation were triggered by a bird flying past the sensor and disappearing before the image could be recorded. A spotted towhee was recorded on June 15, in a patch of bare ground in front of the grasses. (**Photo 53**). A Bewick's wren was recorded on July 8, perched on the log to which the camera was attached (**Photo 54**).

Several photographs had images that could not be identified. For example, on May 19, an unidentified mammal approached Camera 1 after dark. This mammal apparently contacted and repositioned the camera, because subsequent images are aimed differently. A similar change in aiming occurred at Camera 2 on June 19. Camera 2 recorded an image (of a bobcat's face?) on October 28 when the animal was moving the camera (**Photo 55**); in subsequent images, Camera 2 had returned to its original orientation.

4. DISCUSSION

Three motion-sensitive cameras placed in Devils Canyon have successfully captured a total of 119 identifiable images representing ten species of mammals and two species of birds. The cameras took photographs of animals at the rate of 119 images in 433 camera-days, or one animal image per 3.64 camera-days. Most published motion-sensitive camera studies do not report the number of images and number of camera-days. Childs and Childs (2007) provide enough data to suggest a mean rate of image capture. They used 12 motion-sensitive cameras from January 2001 to June 2004, and when Emil McCain joined the study as part of his graduate studies at Humbolt College, and 45 cameras from June 2004 to January 2006. During this five-year period, they acquired 15,000 images of animals in 39,968 camera-days, or one image per 2.7 camera-days. Childs set up the cameras where wildlife were likely to frequent and where humans were not likely to discover the cameras. They placed their cameras near pools of water in the canyons and where wildlife were likely to be funneled through narrow canyons. It is not clear to what extent they used scent-baits in front of their cameras. They visited their cameras, changed batteries and film, and downloaded memory cards for each camera once every six weeks. Also, Fenske-Crawford and Niemi (1997) provide the length of time of their study (72 days) and the number of predation events (28) on artificial nests with eggs in Minnesota to determine the number of days per event, 2.57. They had only two cameras and moved the cameras from nest to nest and the nests were baited with eggs, so their observed rate of "image capture" is not directly comparable to ours.

Our cameras were set near springs which were beside a perennial stream in more than one mile of Devils Canyon. Camera 1 was aimed at a patch of grass and sedge that appeared from the photographs to be a food source for the cottontails and a place coatis hunted, presumably for invertebrates. Cameras 2 and 3 were directed towards wildlife trails near water. What is evident in the Childs' photographs is that Childs and his collaborators chose sites that were either wildlife corridors or water sources. Childs cameras were positioned with a greater range of view than our cameras. Had we attached the cameras higher in the tree or in a site with a greater range of view and placed a scent-bait in front of the camera, the number of camera-days per image might have been reduced. Aside from the studies by Childs and by Fenske-Crawford and Niemi and a few others, the literature on motion-sensitive cameras does not describe the results in terms of camera-days per image. Our rate of camera-days per image is not comparable to those from studies in which the cameras were aimed towards scent-baits or artificial bird nests baited with edible eggs.

The images obtained by Cameras 1, 2, and 3 confirm that this area is used by multiple individuals of several species. The images also confirm repeat visits by some of the same individuals. The images of young bear, coati, and deer confirm that these species are reproducing in the vicinity of Devils Canyon.

Each of the three bear photographs was of a different bear. Mature bears are the largest animals (aside from cattle) in Devils Canyon and along with mountain lions may constitute the fewest animals of a given species in the vicinity of Devils Canyon. It is interesting to consider how many bears may have home ranges that include Devils Canyon and how many additional bears may occasionally be present within the Canyon. In Arizona, bear populations have increased in the 1900s from very low numbers when they were regarded primarily as pests to a state-wide population of perhaps 2,000 to 3,500 (Hoffmeister 1986). From 1977 to 1979, Thomas Waddell and David Brown (1984) of the Arizona Game and Fish Department studied black bears in the Pinaleño Mountains which is about 96 km (60 miles) southeast of Devils Canyon. They actively trapped and marked bears as well as collected data on both nuisance (campsite) bears and wild bears that were harvested or found dead. Based on the data they collected, they estimated the annual population in the Pinaleño Mountains to be between 102 and 150 bears, with a bear density of 1 bear/3.0-4.2 km^2. It is the mid-elevation vegetation with junipers, oaks, prickly pear, and other species that provides much of the food base for black bears in the Pinaleño Mountains. Similar vegetation occurs near Devils Canyon. Continued long-term use of the motion-sensitive cameras may enable an estimate of the bear population in and around Devils Canyon. Comparison of long-term sets of bear photographs from Devils Canyon may suggest which bears are frequent visitors to or residents of the canyon and which bears are only occasional visitors.

The photographs of the coatis at Bear Spring are interesting with respect to coati life-history and locomotion. Hoffmeister (1986) states that "mating is thought to take place in April and young are born in June" (p. 490).

As described in the results, we obtained three photographs of small, young coatis, May 19, August 17, and August 19. Although the May 19th photograph (**Photo 23**) does not show much of the young coati, it is clearly much less than one year of age. It was certainly born before June, and likely closer to the beginning of May. Bridges et al. (2004) used motion sensitive cameras set up at black bear den entrances to record the date of first emergence of the cubs. The dates recorded with the cameras in Bridges' study were earlier than previously known for their region (western Virginia). An interesting feature of coati postures seen in these photographs is the stiff-horizontal-tail posture in several coati photographs (ex. **Photo 22**). Almost always when coatis are seen walking or foraging in Arizona or elsewhere in tropical forests in Central America, their tail is held vertically. When foraging in one spot and relaxed, the tail often hangs down touching the ground (McCLearn 1992). The stiff-horizontal-tail posture may be exhibited by solitary coatis, where the vertical tail may play no role in social communication and instead may present a liability, attracting the attention of predators. The camera has documented this interesting posture; however, we would like more information on the context in which the coati used the stiff-horizontal-tail posture (whether foraging in deep grass, whether other coatis may have been in the local area, etc.). These two examples, recording time of first appearance of coati young and the unusual horizontal tail posture, suggest that the cameras in Devils Canyon have the potential of providing new information on coatis and other mammals in Arizona.

One surprise of this project is how few of the images were captured after dark. Only 28 out of 286 images (9.8%), with or without animals in the images, were recorded as infrared images after dark. Because many mammals are nocturnal, a higher proportion of nighttime images were expected. While the bobcat, deer, peccaries, and cottontails were recorded in daylight and at night, the bear and coati were only photographed during daylight, and the ringtail, mountain lion, gray fox, and skunk were only photographed at night. These patterns may likely shift as larger numbers of images of these animals become available. Another unexpected result of this study was the absence of images of mammals that are known to be or are likely to be inside Devils Canyon. For example, there are no images of raccoon (*Procyon lotor*), even though we have observed dead raccoons along the roadside at Top of the World (Pinal Ranch), about 8 km (5 miles) northeast of Cameras 1 and 2. No rock squirrels (*Spermophilus variegatus*), cliff chipmunks (*Eutamias dorsalis*), or coyotes (*Canis latrans*) were photographed.

Another surprise result is that no human traffic, other than WestLand biologists, was recorded at Camera 1. Camera 2 and 3 are positioned towards wildlife trails near springs. The amount of brush in the areas near Cameras 2 and 3 would be difficult for people to push through. People are unlikely to go through these areas unless searching for something associated with the springs. However, Camera 1 is positioned near a large, open trail about 10 feet above the channel bed of Devils Canyon. This animal trail is used by people as well when there is flood water in Devils Canyon (during late winter and perhaps after heavy summer storms). Devils Canyon is a popular hiking area, but from April 25 to August 28, hikers apparently did not traverse this trail. WestLand biologists usually walk through this area by following the stream channel and not following the game trail where the camera is located. WestLand biologists met a group of five people in mid-summer hiking along the Devils Canyon stream between Hackberry and Oak Canyons on their way to and later from the Crater Tanks. They had entered and left the canyon bottom from a location near Hackberry Canyon, downstream from Camera 1.

At the very least, the motion sensitive cameras in Devils Canyon have provided compelling evidence of the presence of particular mammal species in a given area at a particular time.

5. RECOMMENDATIONS

If this study were to be continued, we would suggest that:

- each camera be visited at least once every two months. The cameras have performed well but glitches have happened. Camera 1 had a memory card that did not work from August until January. Camera 2 was pulled down by a coati and took no photographs during most of May and part of June. Camera 3 was pulled down by a coati and took no photographs between late September and mid-February. (Even if the camera had not been pulled to the ground, the batteries were likely to be near 0% charge.) More frequent visits offset the chance that a large period of time will go by without a camera functioning. Childs and Childs (2008) visited their motion-sensitive cameras on the United States-Mexican border once every six weeks,
- a spot within the camera's range of view be baited with commercially available lures[2] for predators, and
- descented rubber gloves and rubber boots be worn by the field biologists when handling the cameras. This precaution might reduce both the time to first trigger (detection) by an animal and the likelihood that the cameras would be reoriented or pulled down by visiting animals.

If individual animals can be recognized from different locations, it would provide valuable information on use and movement patterns within Devils Canyon. With more images, it is very likely that additional species and individuals would be recorded. During our visits in 2009, we remounted the cameras higher (about 2 to 2.5 m) on the trunks of trees and aimed the cameras about 20 to 30 degrees below the horizontal. This angle is likely to capture images of entire animals more so than when the cameras were low to the ground, are more likely to be triggered while most of the animal's body is still within the field of view, and - provided the field of view does not include moving branches, sedges and grass – the cameras in this downward orientation may be less susceptible to being triggered by plants moving in the wind. In setting up the cameras in February 2009, we did use latex disposable gloves (but not descented rubber boots) while handling the cameras. An ever present trade-off in placing cameras where animals are likely to be photographed is that the cameras may be discovered (and removed) by hikers in Devils Canyon.

[2] Examples of lures available on-line from Murray's Lures & Trapping Supplies (Walker, WV) include Pred-a-getter, Creek Walker, and Coon Pone; skunk-scented lure is available as Gusto®, Minnesota Trapline Products, Pennock Minnesota.

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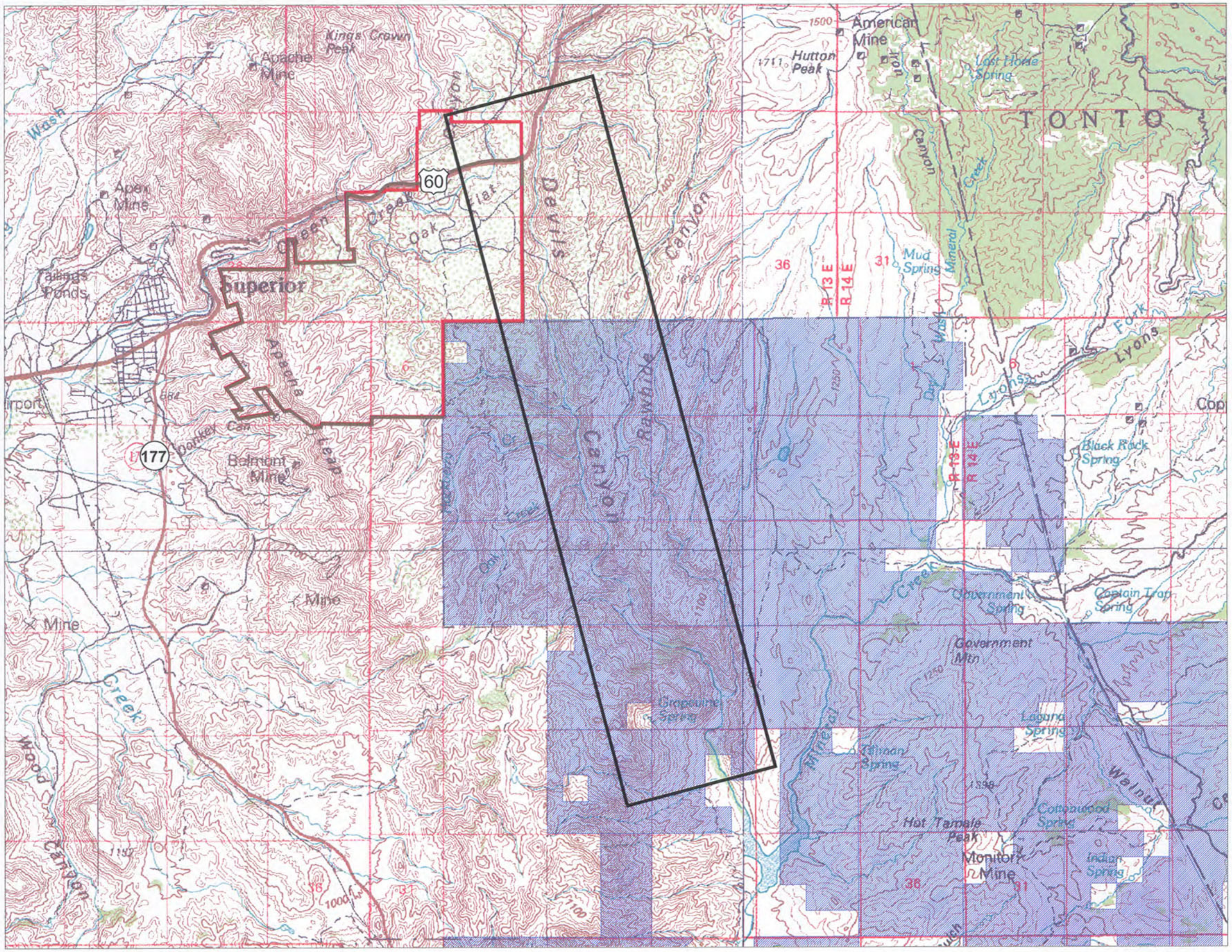
FIGURES



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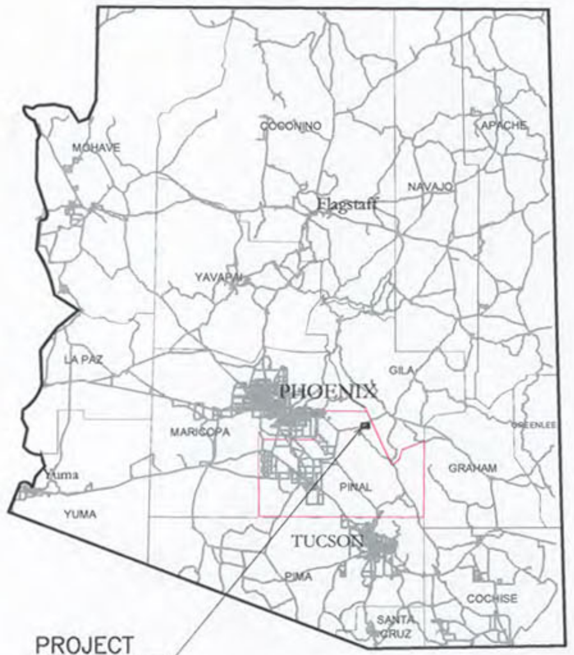

PROJECT LOCATION

LEGEND

- Study Area
- Resolution Parcel Boundary
- State Trust Land

N

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Scale 1" = 1 MILE

Pinal County, Arizona
Mesa and Globe1:100,000 USGS Maps

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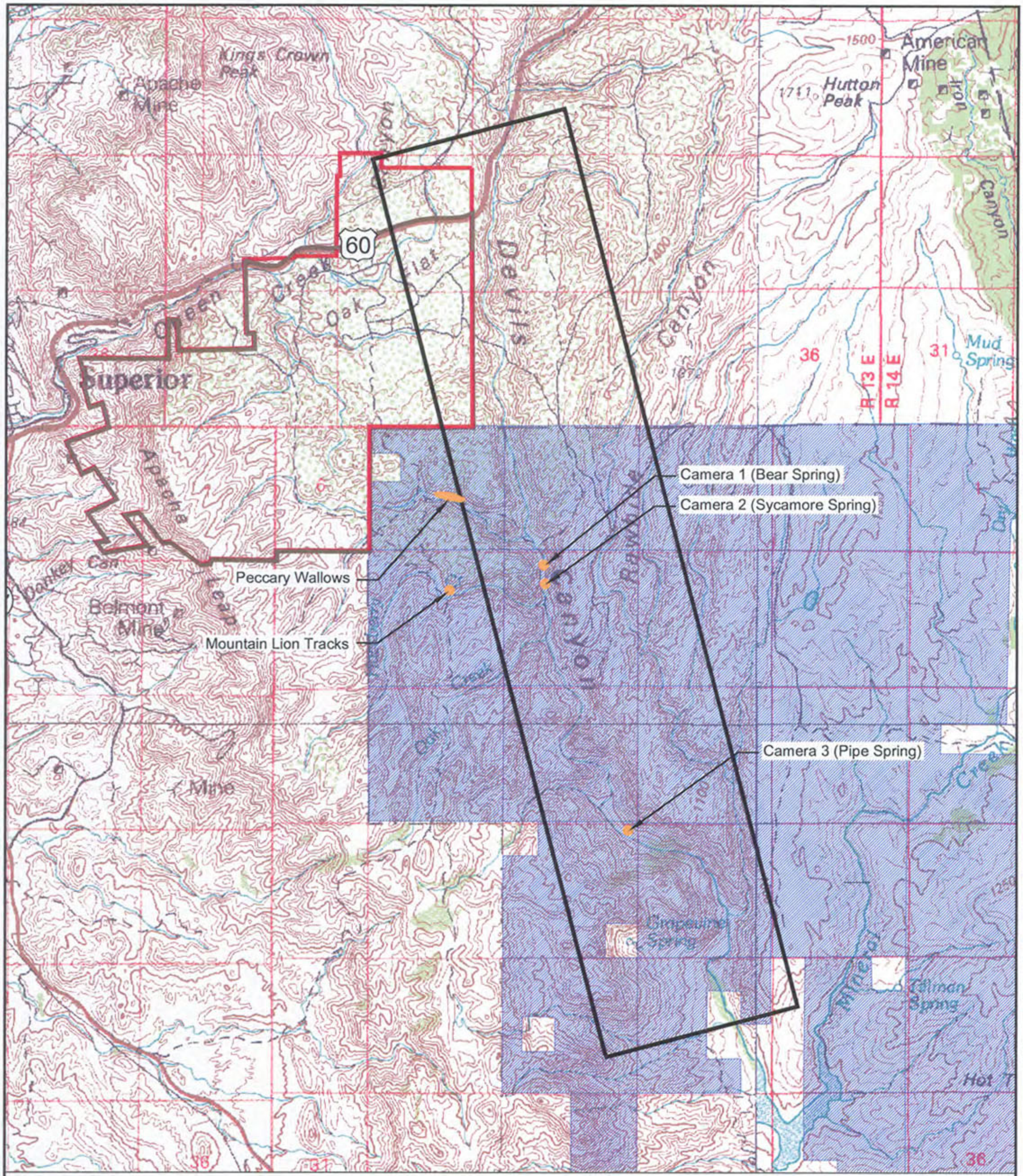
DEVILS CANYON
MOTION SENSITIVE CAMERA REPORT

Vicinity Map and Study Area

Figure 1

M:\projects\807.16\Devils Canyon Survey Transects\Motion Sensitive Camera\FIG1 VICINITY MAP & STUDY AREA.dwg



Pinal County, Arizona
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Scale 1" = 1 MILE

LEGEND
- Study Area
- Resolution Parcel Boundary
- State Trust Land

DEVILS CANYON
MOTION SENSITIVE CAMERA REPORT

Locations of the three motion sensitive cameras and evidence of mountain lion, black bear, and collared peccary

Figure 2

M:\projects\807.16\Devils Canyon Survey Transects\Motion Sensitive Camera\FIG1 VICINITY MAP & STUDY AREA.dwg

PHOTOSHEETS

Photo 9. (*D011*)

Photo 10. (*B0026*)

Photo 11. (*B0056*)

Photo 12. (*D007*)

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Motion-Sensitive Camera Results

PHOTOSHEET 1

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 13. (*A0003*)

Photo 14. (*C0014*)

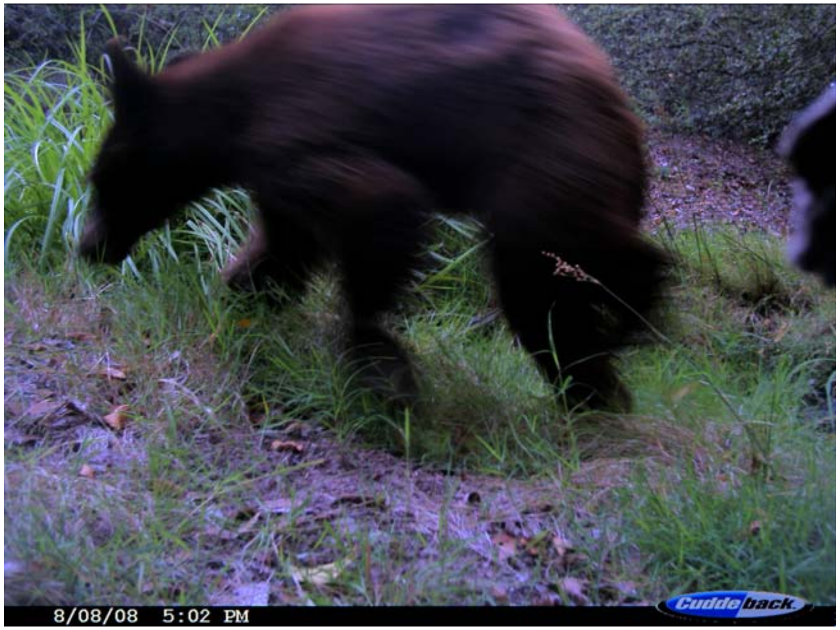

Photo 15 (*B055*)

Photo 16. (*E0036*)

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Motion-Sensitive Camera Results

PHOTOSHEET 2

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 17. (*E0048)*

Photo 18. (*A0033)*

Photo 19. (*A0037*)

Photo 20. (*A0038*)

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Motion-Sensitive Camera Results

PHOTOSHEET 3

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 21. (*B0013*)

Photo 22. (*B0043)*

Photo 23. (*A0076*)

Photo 24. (B0060)

Photo 25. (*B0061*)

Photo 26. (*D0017*)

Photo 27. (*E0049*)

Photo 28. (*E0050*)

Photo 29. (*E0045*)

Photo 30. (*E0054*)

Photo 31. (*D0004*)

Photo 32. (*E0024*)

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Motion-Sensitive Camera Results

PHOTOSHEET 6

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 33. (*D0018*)

Photo 34. (*D0002*)

Photo 35. (*A0014*)

Photo 36. (*B0004*)

Photo 37. (*B0047)*

Photo 38. (*B0053)*

Photo 39. (*C0017*)

Photo 40. (*D005)*

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Motion-Sensitive Camera Results

PHOTOSHEET 8

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 41. *D006*)

Photo 42. (*D0015*)

Photo 43. (*E0017*)

Photo 44. (*E0018*)

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Motion-Sensitive Camera Results

PHOTOSHEET 9

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 45. (*E004)*

Photo 46. (*E006*)

Photo 47. (*E0012)*

Photo 48. (*B0007*)

Photo 49. *B0009*)

Photo 50. (*B0023*)

Photo 51. (B0030)

Photo 52. (*B0058*)

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Motion-Sensitive Camera Results

PHOTOSHEET 11

Q:\Jobs\800's\807.16\motion sensitive camera

Photo 53. (*B0006)*

Photo 54. (*B0039*)

Photo 55. (*D0002*)

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Motion-Sensitive Camera Results

PHOTOSHEET 12

Q:\Jobs\800's\807.16\motion sensitive camera

APPENDIX B

REPRESENTATIVE PHOTOGRAPHS

Photo 1. Camera location 1.

A striped skunk (*Mephitis mephitis*) at Rancho Rio Spring during the night.

Photo 2. Camera location 1.

Two male Gambel's Quail (*Callipepla gambelii*) at Rancho Rio Spring.

Photo 3. Camera location 1.

A gray fox (*Urocyon cinereoargenteus*) passing by the camera at Rancho Rio Spring during the night.

Photo 4. Camera location 3.

A white-tailed deer (*Odocoileus virginianus*). This deer has a scar on its right side that may have resulted from a mountain lion attack.

Photo 5. Camera location 3a.

A mother raccoon (*Procyon lotor*) and her three young fishing for tadpoles in a tinaja near the East Plant.

Photo 6. Camera location 3a.

A Common Black-hawk (*Buteogallus anthracinus*) coming to the tinaja to drink.

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RESOLUTION COPPER MINING
WILDLIFE MONITORING

SELECTED PHOTOGRAPHS FROM VARIOUS CAMERA LOCATIONS
PHOTO PAGE 2

Photo 7. Camera location 3a.

A Turkey Vulture (*Cathartes aura*) drying off after bathing at the tinaja.

Photo 8. Camera location 7.

This unusually colored black bear (*Ursus americanus*) has a blond saddle with dark legs and head.

Photo 9. Camera location 7.

A large male mountain lion (*Puma concolor*) walking along a game trail in Devils Canyon.

Photo 10. Camera location 7.

A large male mountain lion (*Puma concolor*) sniffing a game trail.

Photo 11. Camera location 7.

There are five white-nosed coatis (*Nasua narica*) in this Photo. Note the two babies wrestling in the center.

Photo 12. Camera location 7.

A troop of white-nosed coatis (*Nasua narica*) in Devils Canyon.

Photo 13. Camera location 7.

This inquisitive ringtail cat (*Bassariscus astutus*) seems to be aware of the camera.

Photo 14. Camera location 8.

In Arizona, America black bears (*Ursus americanus*) come in a number of color phases.

Photo 15. Camera location 8.

American black bears (*Ursus americanus*) frequently investigated the cameras.

Photo 16. Camera location 9.

A large American black bear (*Ursus americanus*) near Pipe Spring.

Photo 17. Camera location 9.

The bicolored black bear (*Ursus americanus*) feeding on fallen mesquite beans.

Photo 18. Camera location 9.

Although javelinas (*Tayassu tajacu*) are common in central Arizona, they are apparently rare in Devils Canyon. This is the only javelina recorded among hundreds of Photographs taken in 2008 and 2011.

Photo 19. Camera location 9.

A hog-nosed skunk (*Conepatus leuconotus*) at Pipe Spring.

Photo 20. Camera location 9.

A nice Photo of a mountain lion (*Puma concolor*) at Pipe Spring.

Photo 21. Camera location 9.

A large black bear (*Ursus americanus*) passed by the camera after an afternoon swim in Devils Canyon.

Photo 22. Camera location 9.

A large blond phase black bear (*Ursus americanus*).

Photo 23. Camera location 9.

A male Northern Cardinal (*Cardinalis cardinalis*) perched on a branch that fell in front of the camera.

Photo 24. Camera location 9.

A Brown-crested Flycatcher (*Myiarchus tyrannulus*).