



**FINAL REPORT**

**BIOLOGICAL RESOURCES INVENTORY**

**MOVEMENT STUDY, TUCSON DIVISION**

**PHASE B - CENTRAL ARIZONA PROJECT**

**PREPARED FOR**

**BUREAU OF RECLAMATION**

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Final Report for the  
Biological Resources Inventory  
Contract Extension, Tucson Division-  
Phase B--Central Arizona Project Aqueduct

Presented to:  
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## 16. ABSTRACT

Home range sizes were determined using radio telemetry for two javelina (Dicotyles tajacu), 27 mule deer (Odocoileus hemionus), 4 bob cat (Lynx rufus) and 15 coyote (Canis latrans) along the western route of the proposed Central Arizona Project aqueduct in Pima County, Arizona, from 1982 to 1983. Coyotes had the largest average home range size (11,563ha), followed by bobcat (4,079ha), mule deer (2,048ha), and javelina (289ha). Areas where the proposed aqueduct would impact these species were identified. Methods recommended to mitigate these impacts were wildlife fencing, crossing structures, water sites, land acquisition, minimizing construction disturbance, and patrolling construction areas. Monitoring kit fox responses to construction was recommended.

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## Introduction

The Central Arizona Project (CAP) is a multipurpose water resource development and management project designed to provide supplemental water to central and southern Arizona. Although conceptualized many years earlier, construction was not authorized until September 30, 1968 (Public Law 90-537).

As with any linear intrusion, the CAP has a number of environmental concerns that must be addressed prior to construction. The Wellton-Mohawk Canal in southeastern Arizona is an example of a project where potential impacts adversely affecting wildlife were not addressed before construction. Over the last 20 years, over 1,000 deer have fallen into the canal. As many as 13 deer have died in a single day in this canal (AGFD unpublished data).

With an increase in environmental awareness and the enactment of federal legislation such as the National Environmental Protection Act (1969), Endangered Species Act (1973, as amended), and the Fish and Wildlife Coordination Act (1958), agencies are required to identify impacts to fish and wildlife resources and to consider mitigation for resource loss on projects such as the CAP.

Acting under those mandates, in January 1981 the Bureau of Reclamation (BR) signed a contract with the Arizona Game and Fish Department (AGFD) to conduct a biological resource inventory of the area encompassed by the Tucson Division-Phase B of the CAP. The inventory was designed to identify habitat components that were of high value to wildlife. The areas around all proposed alternate aqueduct routes were included within the study area.

In February 1983, the AGFD presented its findings to the BR in a report entitled Biological Resources Inventory, Tucson Division-Phase B, Central Arizona Project, Contract #32-V0151. Although the findings in the original report fulfilled contract specifications, such as a floral and faunal species composition, vegetation mapping, big game home ranges and habitat utilization, it also identified an additional important study need - the need to identify specific wildlife movement corridors and high-use areas along the proposed aqueduct alignment which was selected as the agency's proposed plan.

As a result, the BR entered into a one-year extended contract with the AGFD to conduct big game and predator biotelemetry investigations with the primary objective being the identification of wildlife movement corridors and high-use areas throughout the entire Tucson Division-Phase B proposed westside aqueduct alignment. Although there are

several alternate routes for segments of the western alignment, the route is generally as follows (Map A-1):

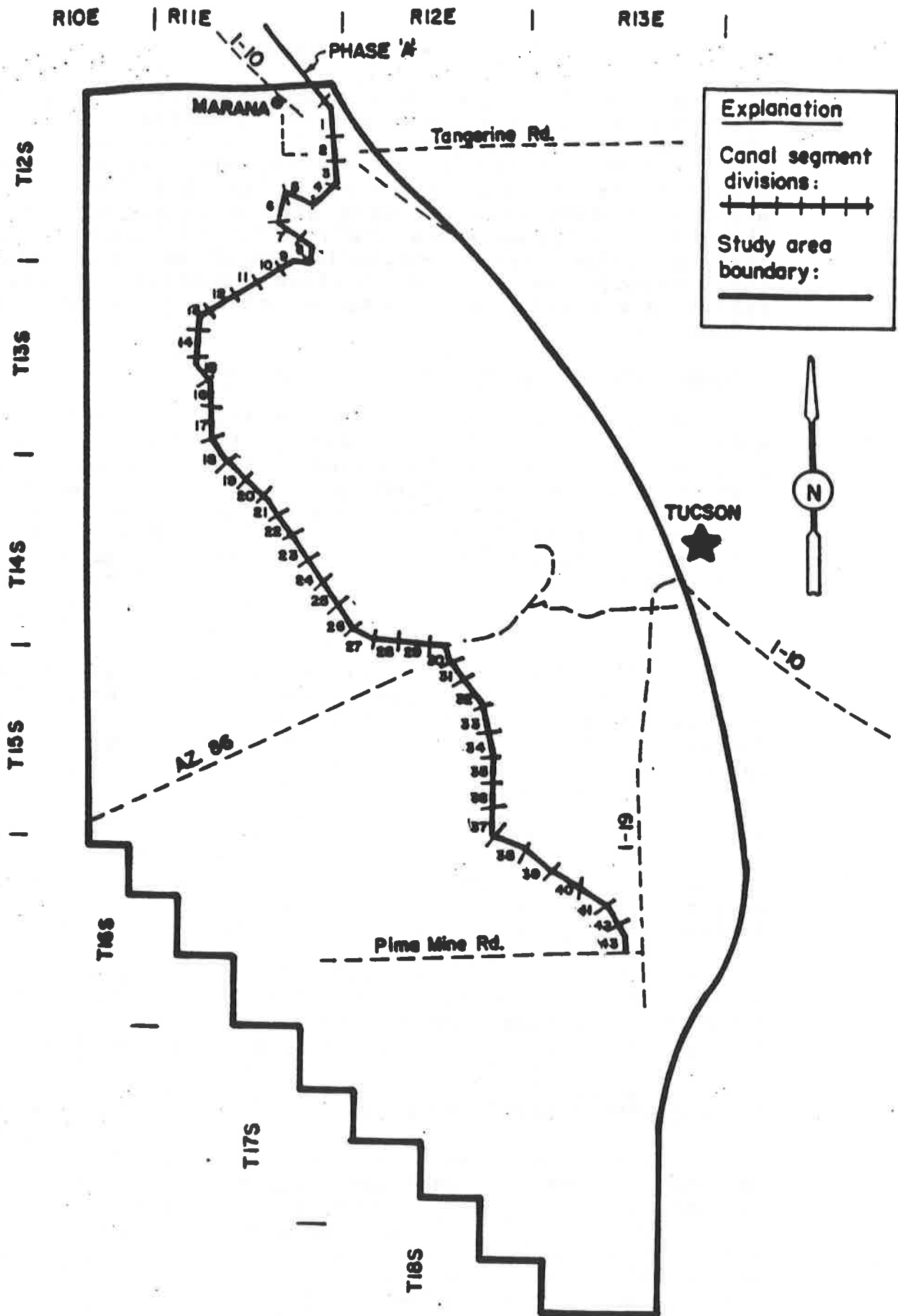
The canal crosses Interstate 10 near Tangerine Road heading south to the Santa Cruz River where it turns to the southwest for one mile. It then turns to the northwest for one mile, then south one mile and southeast for two miles. From this point, it proceeds to the southwest for five miles. The canal then heads to the south and southwest along the western edge of the Saguaro National Monument and Tucson Mountain County Park to a crossing at Highway 86. At Highway 86, the route continues to the southwest, passed Black Mountain, to the terminus.

When animals were captured for this phase of the study, efforts were made to select animals that were on or near the proposed westside alignment route to ensure that the maximum amount of information as possible was collected on animal interactions with the proposed route. As the intent of this study was to identify the specific locations where wildlife/canal interactions were likely, this capture scheme was justified.

The topography of the area varies from relatively flat bajadas found in Avra Valley to the more precipitous Tucson Mountains. When viewed as a whole, the study area is within the Tucson basin, surrounded by the Catalina Mountains to the northeast, the Santa Ritas to the southeast, the Sierritas to the southwest, and the Roskruges, Silverbells, and Ragged Tops along the western edge.

With the exception of the Tucson Mountain range, elevation in the study area varies little. Saharita to the south has an elevation of 820m; Rillito to the north is 626m in elevation. Data from two weather stations indicate that the area is generally warm and dry. The maximum and minimum mean yearly temperature at the Saharita weather station and the Tucson Campbell Avenue Experimental Farm Station are as follows: Saharita 29.4<sup>0</sup>C maximum - 8.9<sup>0</sup>C minimum, Tucson 29.0<sup>0</sup>C maximum - 9.3<sup>0</sup>C minimum. Average annual rainfall for the two stations are quite similar (Saharita 27.6cm, Tucson 28.3cm) (Sellers-Hill 1974).

# Map A-1 Proposed westside aqueduct alignment



## **Executive Summary**

This section presents a summary of the data that were collected during the 1982-1983 CAP predator and big game movement report. The purpose of this section is to provide readers with a synopsis of our findings. It is important that readers of this report recognize that five different methods of data analysis were used in examining the data. There are instances where the results from each method of analysis differ for a particular canal segment. Each of these methods are designed to allow a different approach to examining wildlife use of area around the proposed westside alignment.

### **Big Game and Predator Movement Patterns**

Radio-telemetry was the basis for determining high-, medium- and low-use areas along the proposed aqueduct alignment as well as home-range and long-range movement corridors, potential wildlife crossing locations and habitat utilization for mule deer, coyote, bobcat and javelina. Both weekly aerial locations and 12-hour dusk-to-dawn radio-tracking investigations were conducted to obtain data. Radio-tracking locations were plotted within specific distance zones along 43 separate canal segments of the Tucson Division-Phase B, Central Arizona Project (Map A-1).

Aerial radiolocations were used to identify "general-use" areas along the proposed aqueduct alignment. General high-use areas were identified along seven canal segments for radio-collared mule deer, with general medium-use areas along nine canal segments (Figures B-1&2). Coyote had 17 canal segments identified as general high-use areas, with 3 canal segments identified as general medium-use areas. Bobcat had general high-use areas along three canal segments, with two canal segments identified as general medium-use. One javelina had aerial locations near the proposed aqueduct alignment which revealed two canal segments as general high-use areas for that individual.

Eleven long-range movement corridors were identified within the study area. Individual coyote and mule deer exhibited long-range movement capabilities in excess of 30km during the study. Five of the long-range movement corridors included sections of the proposed aqueduct alignment, while six simply indicated the movement capabilities of animals trapped within the study area.

Dusk-to-dawn 12-hour radio tracking locations were used to identify "specific-use" areas along the proposed aqueduct alignment. As such, dusk-to-dawn tracking efforts identified 16 separate canal segments as specific high-use areas for big game and predators. Three canal segments were identified as specific medium-use areas, with five canal segments falling within the specific low-use area category.

Dusk-to-dawn 12-hour radio tracking locations identified 36 separate crossings of the proposed aqueduct alignment by predators and big game. Mule deer had 21 recorded crossings, followed by coyote with 12, javelina with 2 and bobcat with 1. The wildlife crossings occurred within canal segments 6, 15, 16, 21, 22, 37, 38, 39 and 40. Canal segment 22 had the highest number of recorded crossings with a total of 18, followed by canal segment 16 with 6.

The majority of the wildlife crossings occurred during the post-midnight and dawn periods when the animals were most active.

Home range size was determined for 27 mule deer, 15 coyote, 4 bobcat, and 2 javelina. Coyotes had the largest average home range size (11,563ha), followed by bobcat (4,079ha), mule deer (2,048ha), and javelina (289ha). Nearly the entire proposed aqueduct alignment fell within low home-range use areas for the radio-collared coyotes, with 5 canal segments falling within the high home-range use areas for the radio-collared coyotes. Radio-collared mule deer home range areas included 7 canal segments within their low home-range use areas, with 5 canal segments falling under the high home-range use areas. Radio-collared bobcat home range areas included 11 canal segments, with 5 canal segments falling within their high home-range use areas. One radio-collared javelina had a home range which included portions of the canal. Canal segments 37 and 38 fell within the high home-range use area for that animal.

## A Methods

Data that were used in determining movement corridors, high-use areas, home range and wildlife crossings were collected with the aid of biotelemetry equipment. All biotelemetry equipment was manufactured by Telonics, Inc., Mesa, Arizona. Data from the first phase of this study indicated that mule deer and coyote were the most mobile terrestrial wildlife within the study. Capture efforts for the second phase concentrated on these two species because of their mobility and that they would be most likely to cross the proposed aqueduct alignment.

Mule deer (Odocoileus hemionus) were captured using one of the following three methods. The first involved darting animals from a helicopter with Etorphine (M-99) and Azaperone or Rompun. Single dosages of M-99 varied from 3.5mg to 4.5mg, in combination with 20mg Azaperone or 50mg of Rompun. On several occasions, multiple darts were required to effect ataxia. The antagonist to M-99, M50-50, was utilized to reverse the effect of the immobilizing agent. The dosage rate for M50-50 was 2.0mg/1.0mg of M-99.

The second method involved firing a triangular net over a deer as it was pursued by the helicopter. The net was 5.8m on each side and was fired from a hand-held gun powered with a .308 caliber blank. The net gun and operator were supplied by Far West Humane Animal Capture, Inc., Mesa, Arizona.

The third capture method involved a tangle net that encircled a permanent water source. The net was laid out on the ground with weights attached at five different points. The weights were tied to uprights with string which was attached to a blasting cap. When a deer entered the trap, the blasting caps were fired causing the net to rise to the height of the uprights (2.4m). The deer, frightened by the firing, ran into the net and became entangled.

Predators were captured using double-longspring #3 leg-hold traps with padded offset jaws (Stewart 1978). Dirt hole and scent-post trap sets were made in washes and along travel routes. Captured animals were immobilized with ketamine hydrochloride. Information on sex and age, radio frequency of collar, and physical condition for captured animals was recorded. All animals were injected with a broad spectrum antibiotic and placed in a protected site for recovery. Javelina (Dicotyles tajacu) were captured using aerial darting from a helicopter or as an accidental capture in traps set for predators.

In addition to animals that were captured specifically for this segment of the study, any big game or predator collared during the first phase of the study commonly found

along the proposed aqueduct alignment was included in this study. Species that were included in this classification were bobcat (Lynx rufus), javelina, coyote (Canis latrans) and mule deer.

For this portion of the study 25 mule deer, 12 coyotes, and 2 bobcats were captured. In addition to these animals that were specifically trapped for this study, 2 deer, 4 coyotes, 2 bobcats and 2 javelina had radio collars that functioned at least during a portion of the second phase of the study. These additional animals are included in the data analysis and discussion portions of this report where appropriate.

In order to identify those specific areas where movement corridors and wildlife crossings occurred, the proposed aqueduct alignment was divided into 43 segments, 1.6km in length (Map A-1). Each segment had 21 - 100m zones located at a 90° angle to the canal centerline. All the area of each segment that was beyond 2,100m (zone 21) was considered to be in zone 22. This method allowed for each location to be broken down into specific segments and distance from the canal. In instances where overlap could occur between adjacent sections, professional judgement was used to assign radio locations to specific sections.

To meet the objectives outlined in the contract, data were analyzed by five different methods. They are as follows:

#### **A-1 General High and Low-use Areas**

This method utilized locations that were collected using aerial methods. Locations were plotted on USGS 7.5 or 15-minute quadrangles. All aerial locations were recorded as Universal Transverse Mercator (UTM) grid coordinates.

General high, medium, and low-use areas were identified along those canal segments which had recorded aerial locations of radio-collared animals. The canal segments having recorded locations within zones 0 through 10 (as well as zones 11 through 22) were termed general high-use areas. Those canal segments having recorded locations which were limited to zones 11 through 21 were termed general medium-use areas. General low-use areas occurred within those canal segments with all recorded locations falling in zone 22.

The word "general," which precedes the level of use within the canal segments, is used to indicate that only aerial locations were used in analysis. This was done to avoid interjection of the bias where specific animals were selected for intense radio-tracking as is the case in the specific use section.

## **A-2 Long-Range Movement Corridors**

Weekly aerial radiolocations were utilized in determining long-range movement corridors. Corridors which exceeded 5km were identified for all species. Those animals with long-range movement corridors which included portions of the proposed aqueduct alignment as well as those not affected by the proposed aqueduct alignment were identified. Long-range movement corridors in excess of 20km were plotted on USGS 1:250,000 maps. All other movement corridors were either shown on animal home-range maps or described in the text.

## **A-3 Specific High- and Low-Use Areas**

Dusk-to-dawn, 12-hour ground tracking sessions were conducted to provide data on short-term movement and identify specific high and low-use areas along the proposed aqueduct alignment. Animals were selected for these sessions because of their proximity to the proposed aqueduct alignment. Each animal was located by ground triangulation using a hand-held "H" antenna. Locations on each animal were attempted every two hours during the session, which usually provided six locations per session. During dusk-to-dawn tracking sessions, all animals that were in the same area were selected for monitoring. Efforts were made to collect data on animals along all areas of the proposed aqueduct alignment. All locations were plotted from compass bearing taken at known points and recorded as UTM grid coordinates.

All dusk-to-dawn radiolocations were assigned a canal segment and zone classification value as described in Section A-1. Specific high-use areas were determined from dusk-to-dawn radiolocations which revealed repeated movement (within zones 0 through 10) to and from points which crossed or paralleled a particular canal segment. Specific medium-use areas were determined from dusk-to-dawn radiolocations which revealed repeated movement within zones 11 through 22 without crossing the canal. Specific low-use areas were recorded for those canal segments which had all recorded occurrences in zone 22.

The word "specific" which precedes the level of use within a particular canal segment, is used to specify the extent of radio-telemetry procedures. That is, the 12-hour dusk-to-dawn radiolocations provided a specific short-term species movement account along individual canal segments, as compared to the general movement account obtained from weekly flights.

The following definitions were used in separating locations by season and time of day; "Dusk" is 4 p.m. to 7 p.m., "Pre-midnight" is 7 p.m. to 12 midnight, "Post-

midnight" is 12 midnight to 5 a.m., and "Dawn" is 5 a.m. to 8 a.m. Winter is 1 November to 15 May, Summer is 15 May to 31 October.

#### **A-4 Wildlife Crossings of the Proposed Aqueduct Alignment**

Dusk-to-dawn radio tracking sessions were used to identify specific locations where animals crossed the proposed aqueduct alignment. All radio-collared animals located near the canal during aerial surveys received tracking priority to optimize identification of wildlife crossing locations. All documented wildlife crossings occurred during one or more of the two-hour tracking rounds. The beginning and ending points of a wildlife crossing were plotted on USGS 7.5 quadrangles.

#### **A-5 Home Range Determination**

Big game and predator home range size were determined using the minimum area method (Mohr 1947), from both aerial and ground radio-locations. Only convex polygons were used as suggested by Jennrich and Turner (1969). The total area within the home range polygon was determined with a planimeter and converted to total hectares.

Weekly aerial radio-location points were used to determine high and low-use home range areas for all radio-collared animals within the study area. Those areas within an animal's home range showing a concentration of locations were termed high-use areas, while low-use areas were assigned to those portions of the home range having an occasional location. Only aerial locations were used for this determination because dusk-to-dawn tracking provided "biased" data, in that animals were selected for tracking due to their proximity to the canal. Aerial locations were considered random, as specific locations were not selected in advance.

--SPSS subprograms CROSSTABS and FREQUENCIES were used to analyze habitat and canal zone parameters on dusk-to-dawn and aerial radiolocations (Nie et al. 1975).

### **B Results**

#### **B-1 General High and Low-Use Areas Deer**

A total of 660 aerial radiolocations were determined for mule deer during the study. Based upon these locations, seven canal segments were classified as general high-use areas. Canal segments within this category were 4, 5, 7, 21, 22, 23 and 38. These segments occurred within three general areas along the proposed aqueduct alignment. The northernmost of these is located west of the Santa Cruz River, north of Safford and Panther Peaks. The second area

is located to the southwest of the Saguaro National Monument between the Tucson Mountain Park and the Papago Indian Reservation. The third area is located south of Black Mountain on the San Xavier Indian Reservation. The seven canal segments identified as general high-use areas, with the number of occurrences in zones 0-10, for mule deer are as follows:

Canal Segment 4: One occurrence zones 5, 19; two occurrences zone 22.

Canal Segment 5: One occurrence zones 1, 9.

Canal Segment 7: One occurrence zone 6.

Canal Segment 21: One occurrence zones 2, 4, 6; two occurrences zones 3, 5. (Canal segment 21 had a total of 86 occurrences within zones 11 through 22.)

Canal Segment 22: Two occurrences zone 0; one occurrence zones 1, 10; three occurrences zone 8. (Canal segment 22 had a total of 72 recorded locations which fell within zones 11 through 22.)

Canal Segment 23: One occurrence zones 0, 1. (Canal segment 23 had 42 recorded occurrences within zones 11 through 22.)

Canal Segment 38: One occurrence zones 5, 6, 10. (The remainder of occurrences fell within zone 22, as most of the deer collared in this area had home ranges in excess of 2,200 meters from the canal.)

These data are graphically portrayed in Figure B-1.

Medium-use areas, which are areas with mule deer locations only in zones 11-21, were identified as canal segments 2, 9, 18, 19, 20, 24, 25, 36, and 37. This category was similar to the general high-use areas with use patterns falling into three areas; north by the Santa Cruz River, central in the vicinity of the Saguaro National Monument, and south in the Black Mountain area. These data are graphically portrayed in Figure B-2.

There were 10 segments that had wildlife use only in zone 22. General low-use areas are usually adjacent to general medium-use areas. Low-use segments are: 3, 8, 10, 16, 17, 26, 27, 28, 31 and 40.

Of the 89 aerial locations in zones 0-21, 55 (63%) occurred in 3 segments (21, 22, 23). When the data are analyzed for zones 0-10, the same situation is observed. There are a total of 23 locations in these zones, 14 (61%) of which occurred in segments 21 and 22 (Figure B-1).

Figure B-1. Total number of mule deer aerial occurrences per canal mile - Zones 0-10.

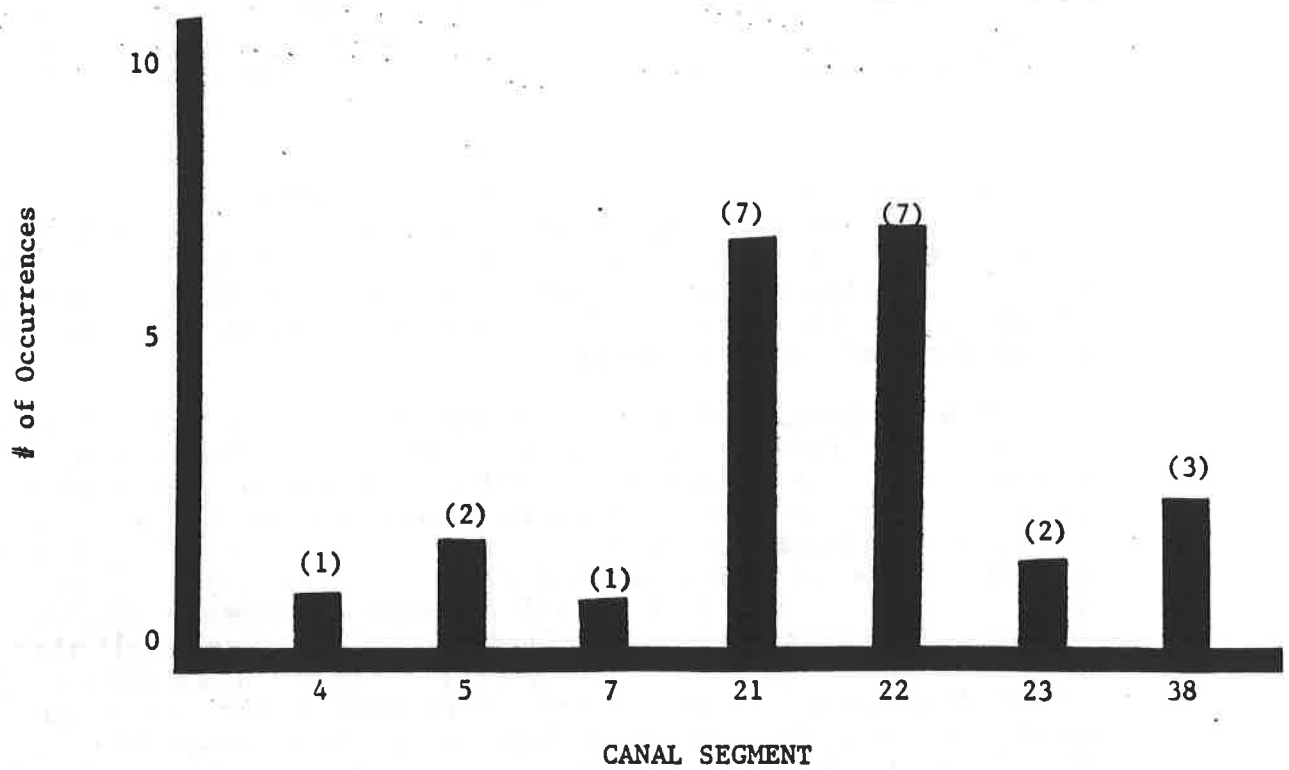
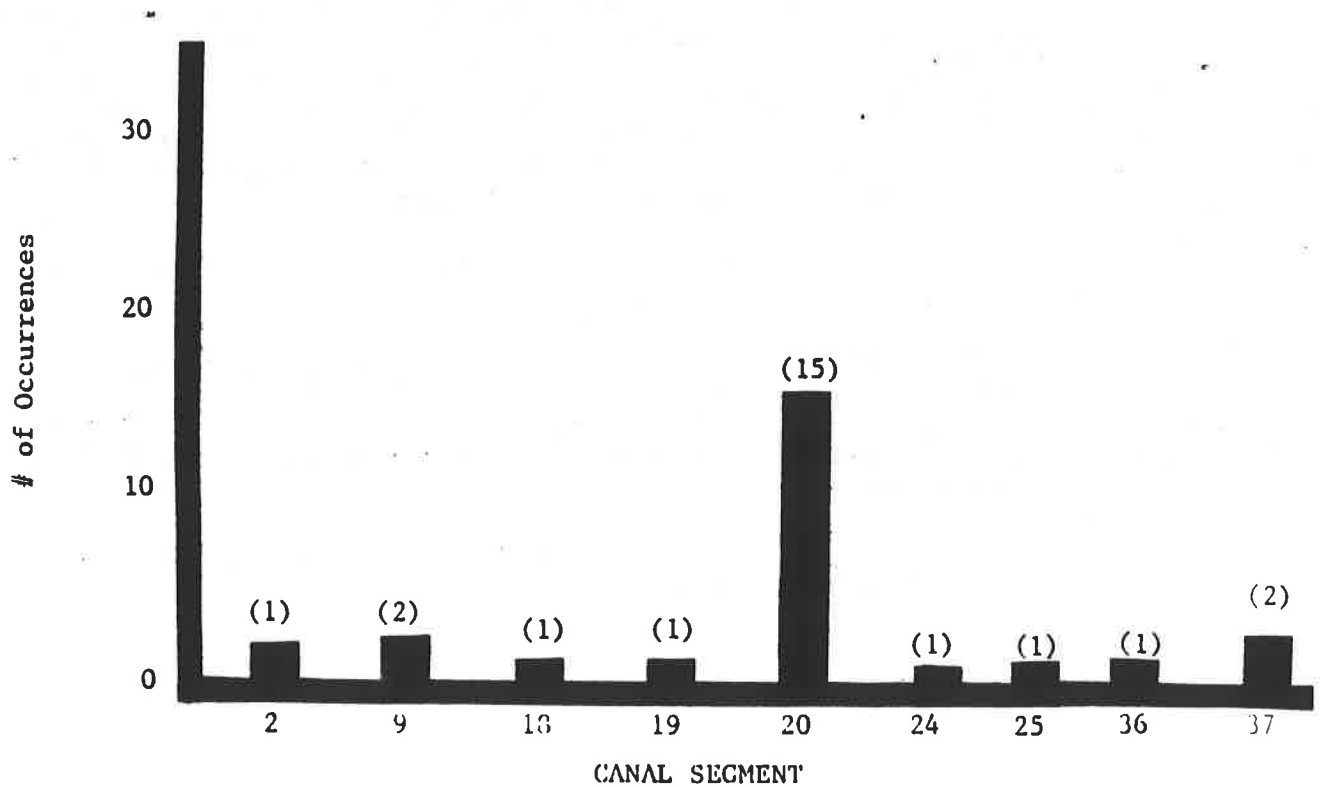


Figure B-2. Total number of mule deer aerial occurrences per canal mile - Zones 11-21.



Since aerial locations provide the most random data available in this study, these data suggest that mule deer select strongly for the areas southwest of the Saguaro National Monument that are within canal segments 20-24.

### Coyote

A total of 242 aerial radiolocations were determined for coyote during this study. Based upon these data, 17 canal segments were identified as general high-use areas. General medium-use areas were identified within three canal segments, with seven canal segments being classified as being general low-use areas.

The general high-use segments fell within two main areas. The first area occurred from the Santa Cruz River south along the proposed aqueduct alignment to segment 17 which is west of the Saguaro National Monument. Within this area, canal segments 4, 6, 7, 8, 12, 13, 14, 15, 16 and 17 all had at least one location within zones 1-10. There were no locations within zones 1-10 in canal segments 18-32. The second area that was classified as being a general high-use area occurred on the San Xavier Indian Reservation from Black Mountain to the canal terminus point at Pima Mine Road. Within this general location, canal segments 33, 37, 38, 40, 41, 42 and 43 all had coyote locations in zones 1-10.

Of the three segments that were classified as general medium-use areas, one was in the upper portion of the canal at segment 9, with the remaining two in the Black Mountain area (segments 36 and 39).

General low-use areas again fell into two areas; however, the two locations were somewhat different than the general high- and medium-use areas identified. Three of the general low-use segments were on the northern end of the proposed aqueduct (segments 2, 3, 10), with three occurring on the central portion of the proposed aqueduct alignment with locations in segments 21, 23 and 28.

A summary of the zones of occurrence for those segments having locations within zones 0-10 follows:

Canal Segment 4: One occurrence zone 3; three occurrences zone 4.

Canal Segment 6: One occurrence zones 2, 4; two occurrences zone 3.

Canal Segment 7: One occurrence zones 0, 10; two occurrences zone 2.

Canal Segment 8: One occurrence zones 0, 3, 4, 5, 10; two occurrences zones 6, 7.

Canal Segment 12: One occurrence zone 2.

Canal Segment 13: One occurrence zone 2.

Canal Segment 14: One occurrence zone 3.

Canal Segment 15: One occurrence zone 1; two occurrences zones 0, 2, 3.

Canal Segment 16: One occurrence zones 0, 1, 4, 5; two occurrences zone 10; three occurrences zone 2; six occurrences zone 3.

Canal Segment 17: One occurrence zones 1, 2, 4, 7.

Canal Segment 33: One occurrence zones 5, 8.

Canal Segment 37: One occurrence zones 9, 10.

Canal Segment 38: One occurrence zone 3.

Canal Segment 40: One occurrence zones 0, 2, 6, 8; two occurrences zone 5; three occurrences zone 4.

Canal Segment 41: One occurrence zones 0, 2, 3; two occurrences zone 7.

Canal Segment 42: One occurrence zones 5, 8, 10; two occurrences zones 0, 1.

Canal Segment 43: One occurrence zones 1, 8.

Figure B-3 presents the number of coyote aerial locations when zones 0-21 are analyzed in aggregate. From this graph, it can be observed that two segments (8, with 17 occurrences and 16, with 31 occurrences) were the most utilized. The importance of the Black Mountain area to coyote is evident in this graph, with four of the seven segments having over ten radiolocations.

Figure B-4, which displays the number of locations within zones 0-10, demonstrates the same use patterns as Figure B-3. Again, segments 8 (9 occurrences) and 16 (15 occurrences) are used to a greater extent than most other segments of the canal, with the Black Mountain area also being important.

#### Bobcat

Fifty-one weekly aerial radiolocations were determined for two bobcat during the study. These data were utilized

Figure B-3. Total number of coyote aerial occurrences per canal segment - zones 0-21

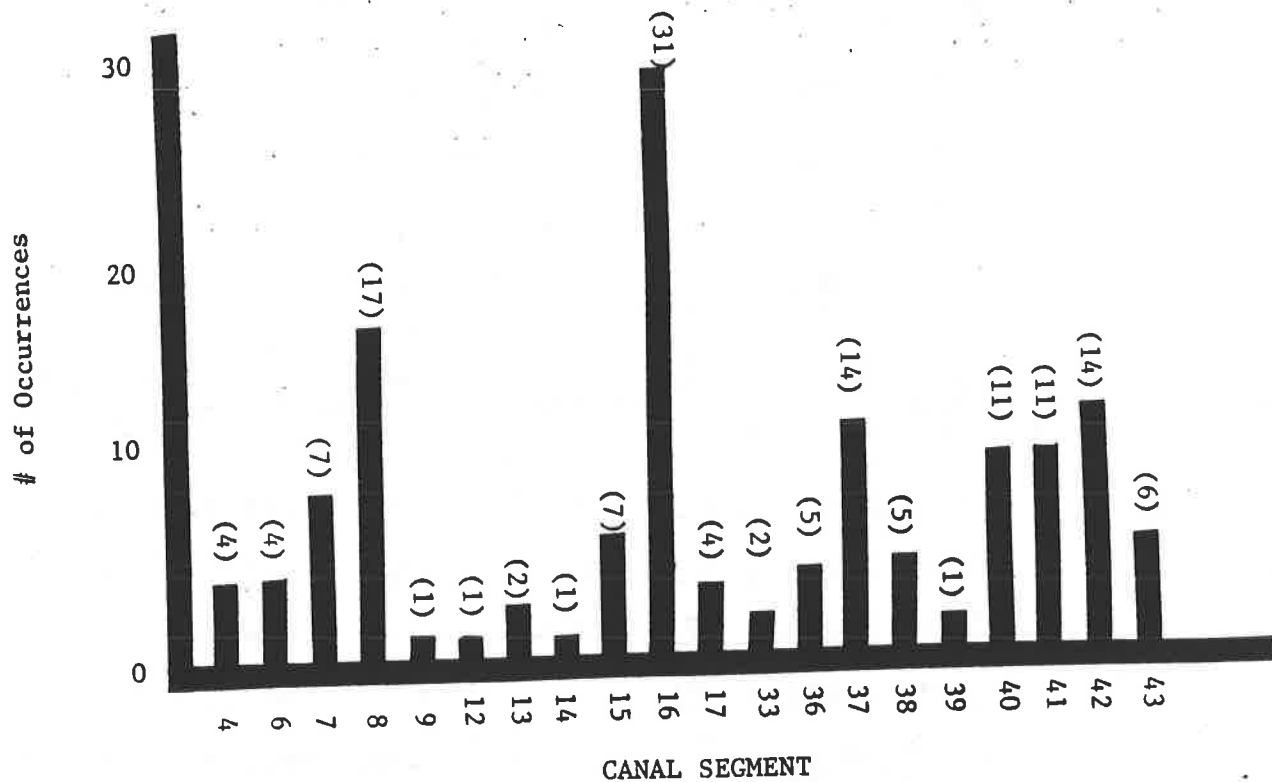
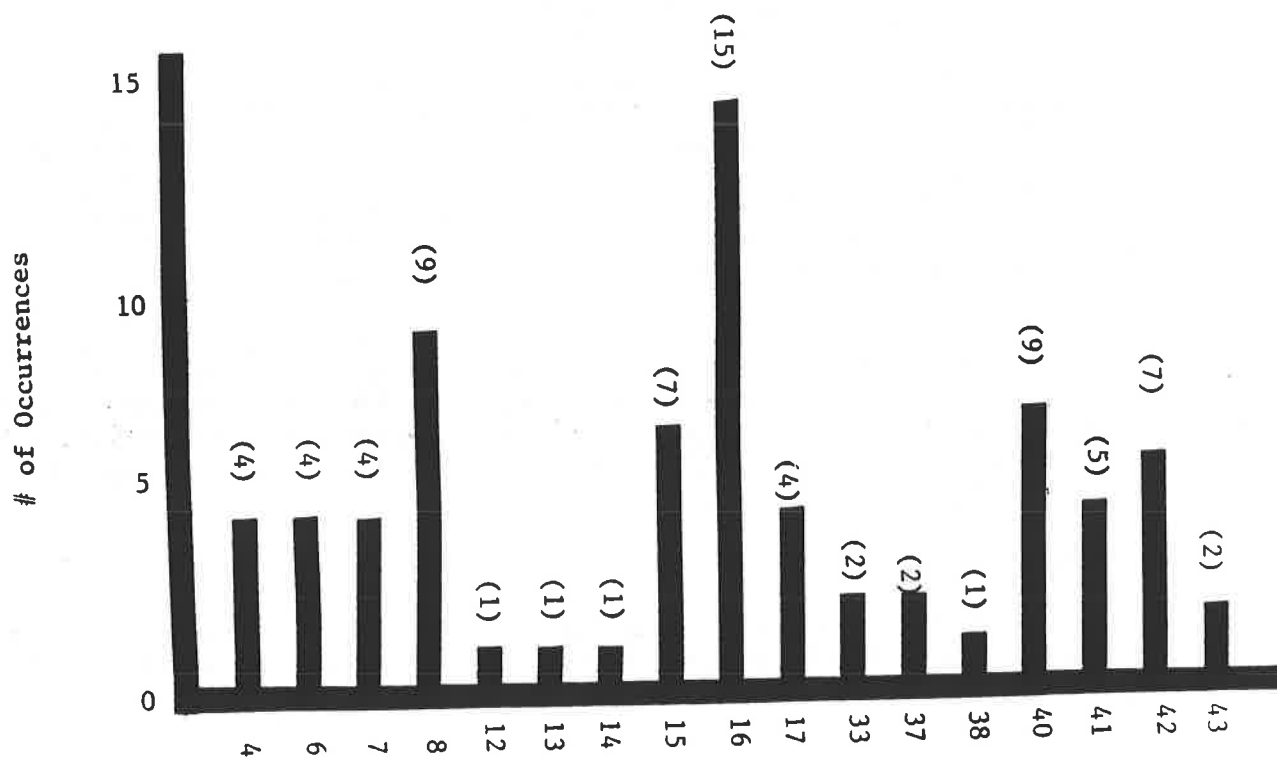


Figure B-4. Total number of coyote aerial occurrences per canal segment - zones 0-10



in identifying three segments that were classified as general high-use areas. Canal segments 21, 22 and 23 all had bobcat locations within zones 0-10. The number of locations per zone in these three segments follows:

Canal Segment 21: One occurrence zones 2, 4.

Canal Segment 22: One occurrence zone 2.

Canal Segment 23: One occurrence zone 7.

Two segments (19, 20) had bobcat locations that occurred in zones 11-21. These two segments are adjacent to the area which was classified as a general high-use area.

Canal segments 13, 16, 17, 18, 24 and 25 were classified as general low-use areas, as all locations fell within zone 22. As with the two previous classifications, general low-use areas fell within the central portion of the proposed aqueduct alignment.

Figure B-5 presents the number of bobcat aerial locations per canal segment, with zones 0-21 in aggregate.

#### Javelina

One of the nine javelina radio collared for the original contract had a functional collar through portions of this study and had a home range which included portions of the proposed aqueduct alignment. Forty-four aerial locations were collected on this animal from 10 September 1981 through 25 April 1983. This javelina used the area in the vicinity of Black Mountain. All of the locations were within three canal segments (36, 37, 38) and in zones 0-10. The breakdown of javelina occurrences for the canal segments follows:

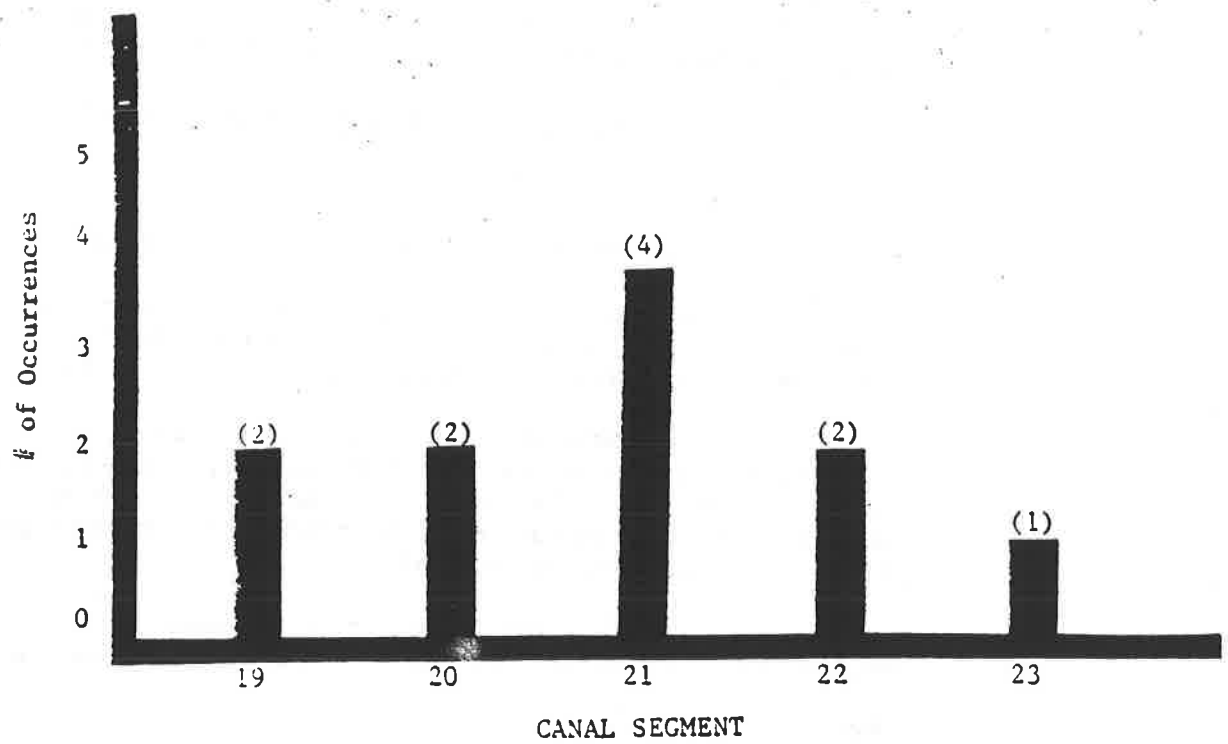
Canal Segment 36: One occurrence zones 6, 9.

Canal Segment 37: One occurrence zones 2, 6, 10; two occurrences zones 8, 9; three occurrences zone 4. four occurrences zones 5, 7.

Canal Segment 38: One occurrence zones 6, 10 two occurrences zones 5, 9.

These data indicate heavy utilization of this area with 18 locations occurring in zones 0-10 in segment 37, which makes this area one of the most heavily used locations for this javelina along the proposed aqueduct alignment.

Figure B-5. Total bobcat aerial locations per canal segment - zones 0-21.



## B-2 Long-Range Movement Corridors

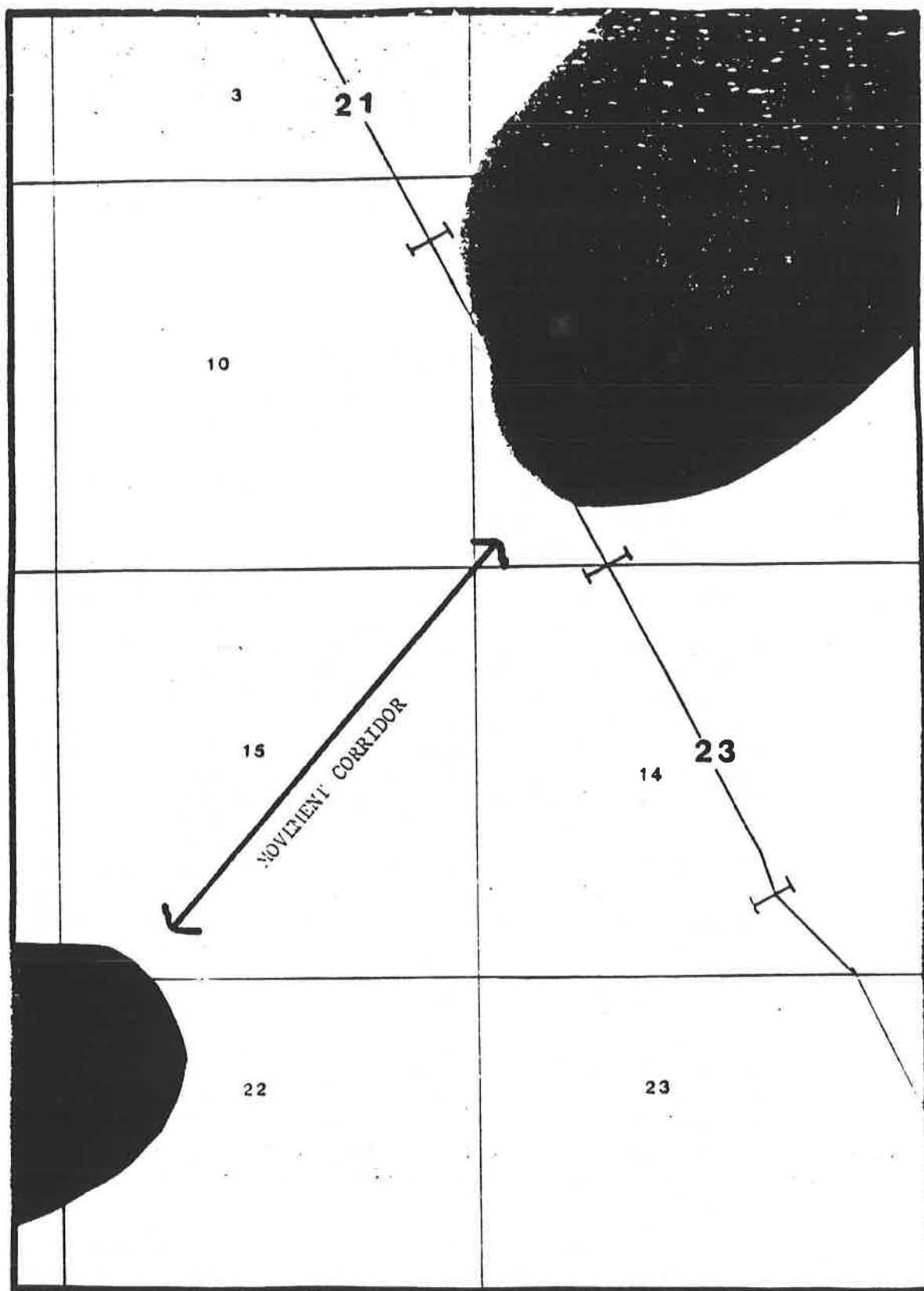
Weekly aerial radiolocations were utilized to identify long-range movement corridors (in excess of 5km) for mule deer and coyotes. Javelina did not show any long-range movement patterns. In addition to being in excess of 5km in length to be classified as a long-term movement corridor, the movement corridor had to be used on a regular basis. Using these criteria, a total of 11 long-range movement corridors were identified. Five of these corridors included portions of the proposed aqueduct alignment, with the remaining six outside the alignment. All of the movement corridors included two or more habitat types. In most cases, movement corridors began and ended in the same habitat type, often moving through different habitat types. In addition to mule deer and coyotes, bobcats also appeared to utilize long-range movement corridors. Limited data preclude finite identification of these routes; however, they are discussed in this section.

### Deer

Several mule deer utilized long-range movement corridors within the study area. Two mule deer (Nos. 55 and 58) commonly used the paloverde-mixed cacti habitat associated with the west side of Brown Mountain. Both of these mule deer utilized the same movement corridor, traveling from Brown Mountain southwest approximately 5km to a heavily vegetated mesquite bosque near Brawley Wash. This movement corridor, as well as the various habitat types encountered during the move, is presented in Map B-1. This movement corridor includes portions of canal segments 21, 22 and 23 within its boundary. On August 15, 1983 mule deer No. 55 was observed with a newborn fawn which was probably less than one hour old. Three days earlier (August 12, 1983) this doe had been located in the vicinity of Brown Mountain. It is probable that this deer had been attracted to the Brawley Wash area by the dense vegetation and remoteness of the area which provided suitable fawning conditions. Deer No. 55 remained in the area where it had fawned until September 29, 1983, at which time it was found dead from unknown causes.

A mule deer buck (No. 58) utilized the same general movement corridor as No. 55. On September 26, 1983 this buck was located in the mesquite bosque near Brawley Wash. It was located two hours later 6km to the northeast near Brown Mountain. This movement is outlined in Map B-1. During this movement, the deer crossed the proposed aqueduct alignment in segment 22.

Mule deer No. 54 used a similar movement corridor as deer Nos. 55 and 58. In addition, this deer used a second movement corridor which ran from the Golden Gate-Ironwood



● High use areas

picnic area directly to the west to the same mesquite bosque, which is a distance of approximately 8km. Aerial locations indicated travel between the mesquite bosque to Brown Mountain and between the Golden Gate area to the mesquite bosque occurred frequently, with the Golden Gate area being used most frequently. This movement corridor included portions of canal segments 24 and 25.

Two mule deer (Nos. 68 and 70) had movement corridors that showed a great deal of overlap. These corridors ran from the northwest to the southeast from Twin Peaks to Panther Peak and south to Wassen Peak. Although these deer never had an instance where they crossed the canal, the north end of the corridor was in the vicinity of the proposed aqueduct alignment just west of the Santa Cruz River. The long-range movements of these deer demonstrate the ability of deer to travel great distances where travel is uninhibited.

Mule deer Nos. 78 and 84 displayed long-range movement corridors within the southern portion of the study area. Both animals were captured on the San Xavier Indian Reservation and made long-range movements to the south. After its capture on November 5, 1982, deer No. 78 used a small area on the southwest portion of the reservation. By mid-February 1983 this deer had moved approximately 35km to the south. Subsequent aerial locations indicated the deer had established a long-term use area near the Cerro Colorado Mountains where it remained until the end of the study. Map B-2 portrays the two use areas for this deer as well as the probable movement corridor to the Cerro Colorado area. Deer No. 84 was captured west of Black Mountain. It moved to an area west of the Sierrita Mountains, where it established a second high-use area. This deer made several trips between these two areas. Map B-3 shows this movement pattern.

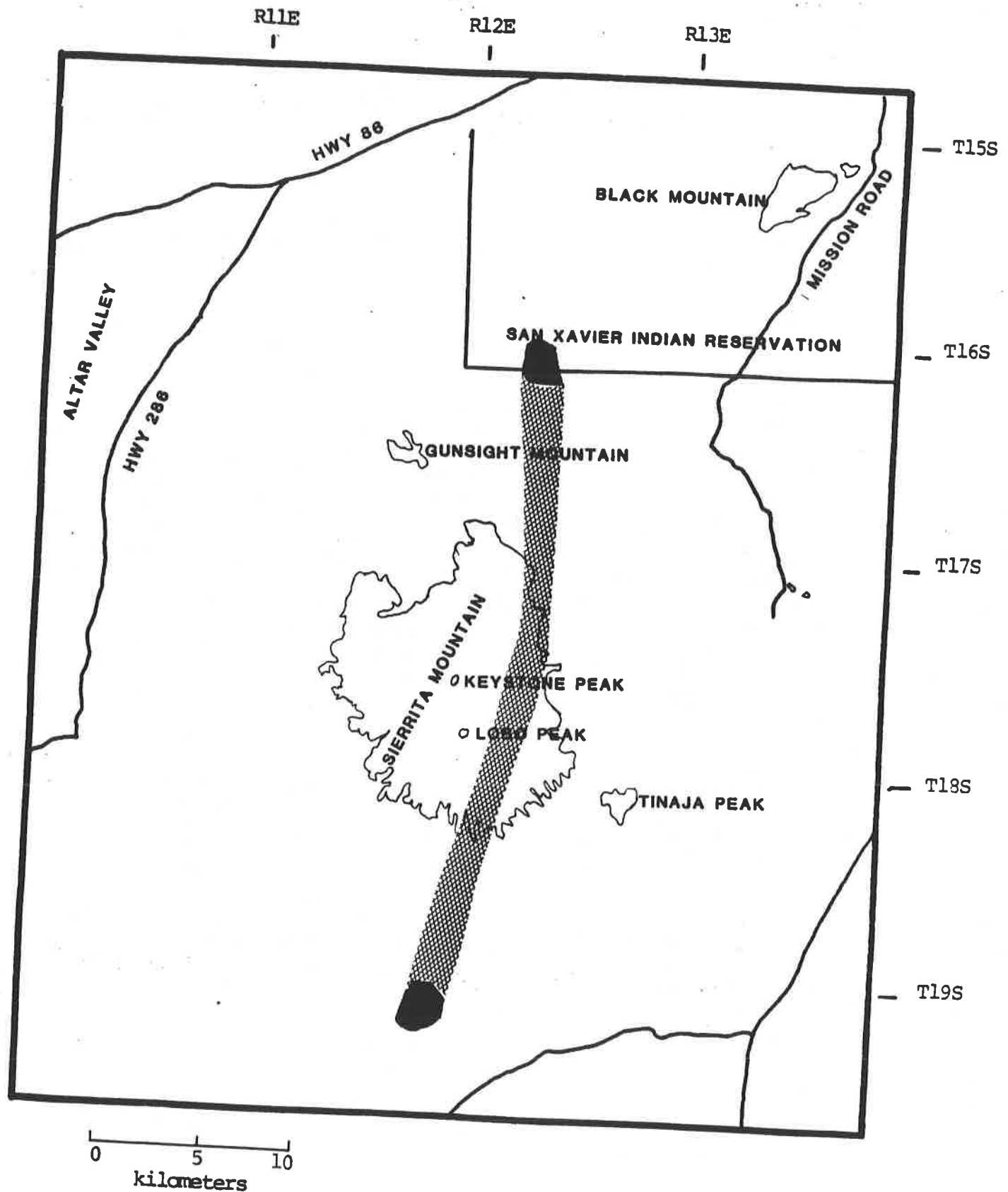
### Coyote

Coyotes most frequently displayed long-range movement patterns which attributed to their large home range size. Two of the four radio-collared coyote established long-range movement corridors. Coyote No. 71 apparently established its home range approximately 20km from the trap site prior to its radio failure. This migratory corridor included portions of canal segments 12, 13, 14, 15, 16, 17 and 18. Map B-1 indicates the entire home range for coyote No. 71, with the movement corridor identified by the dark arrow.

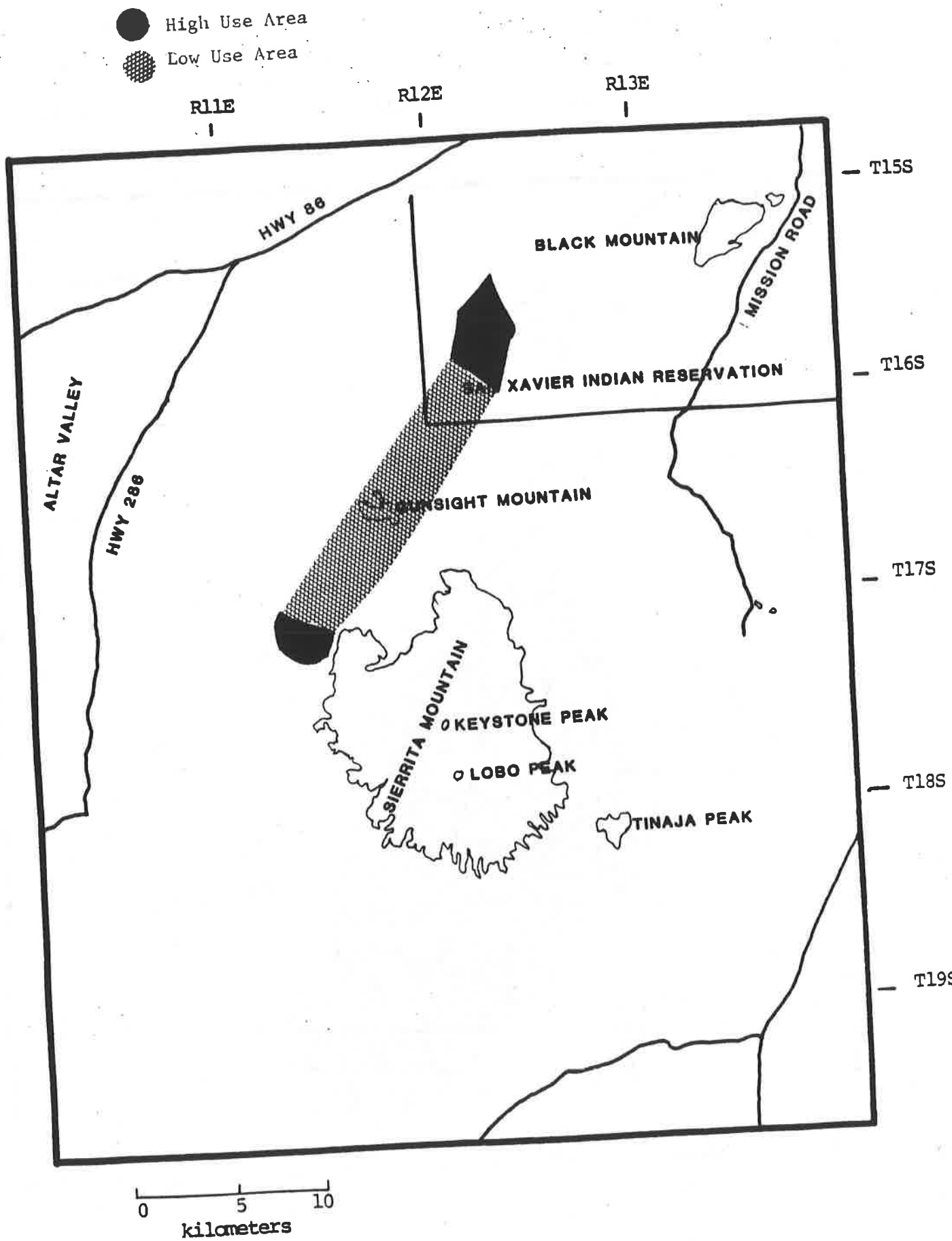
Coyote No. 72 established two high-use areas within its home range. These areas were approximately 30km apart. Aerial locations of this animal indicated that frequent movement between these two areas occurred. Portions of canal segments 4, 5, 6, 7 and 8 were included within this corridor. Map B-5 indicates the home range of coyote

Map B- 2 Long range movement corridor for mule deer No. 78

- High Use Area
- ▨ Low Use Area



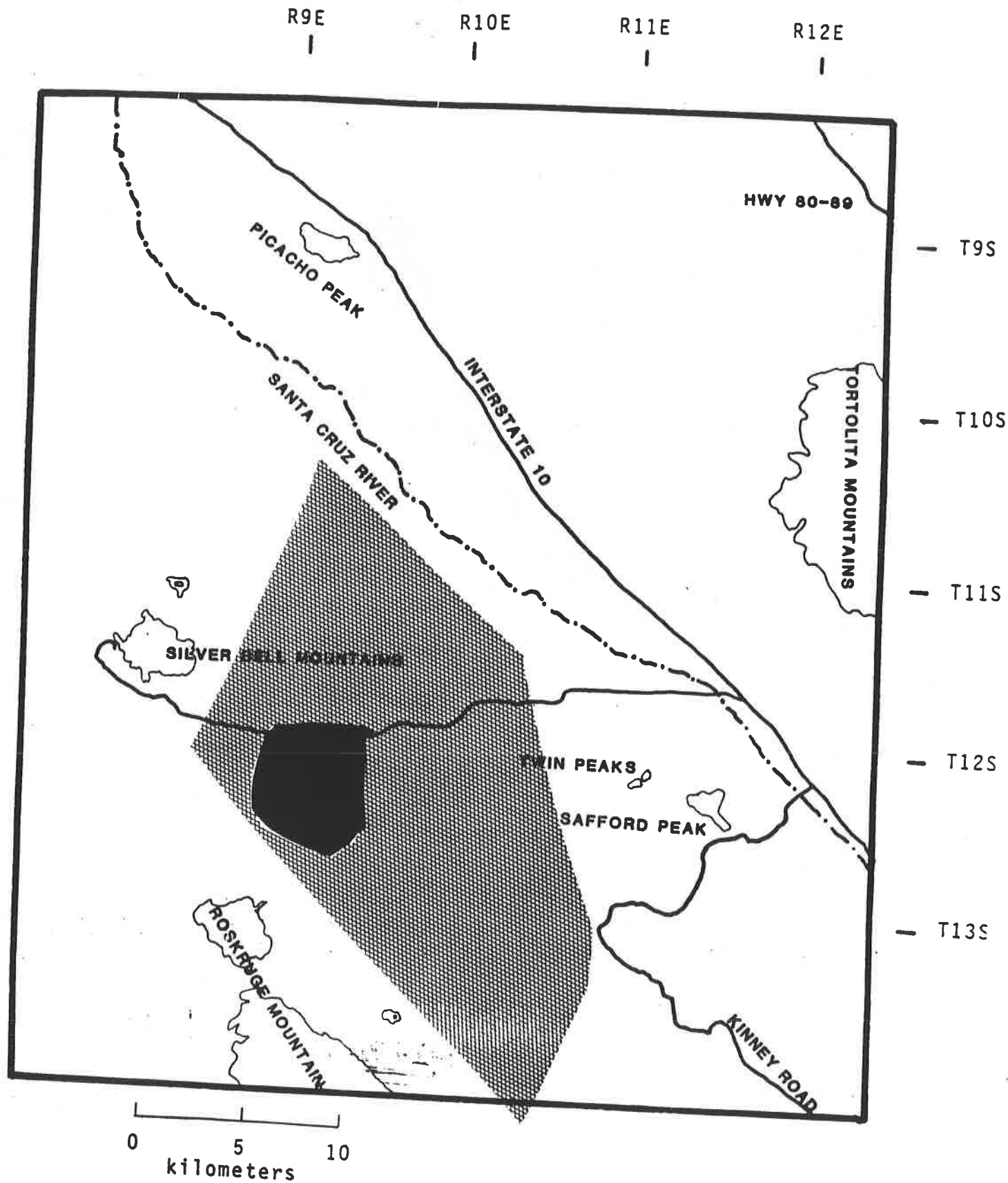
Map B- 3 Long range movement corridor for mule deer No. 84.



Map B-4. Long range movement corridor for coyote No. 71.

● Low Use Area

● High Use Area



Map 3-3 Long range movement corridor for coyote No. 72



Low Use Area



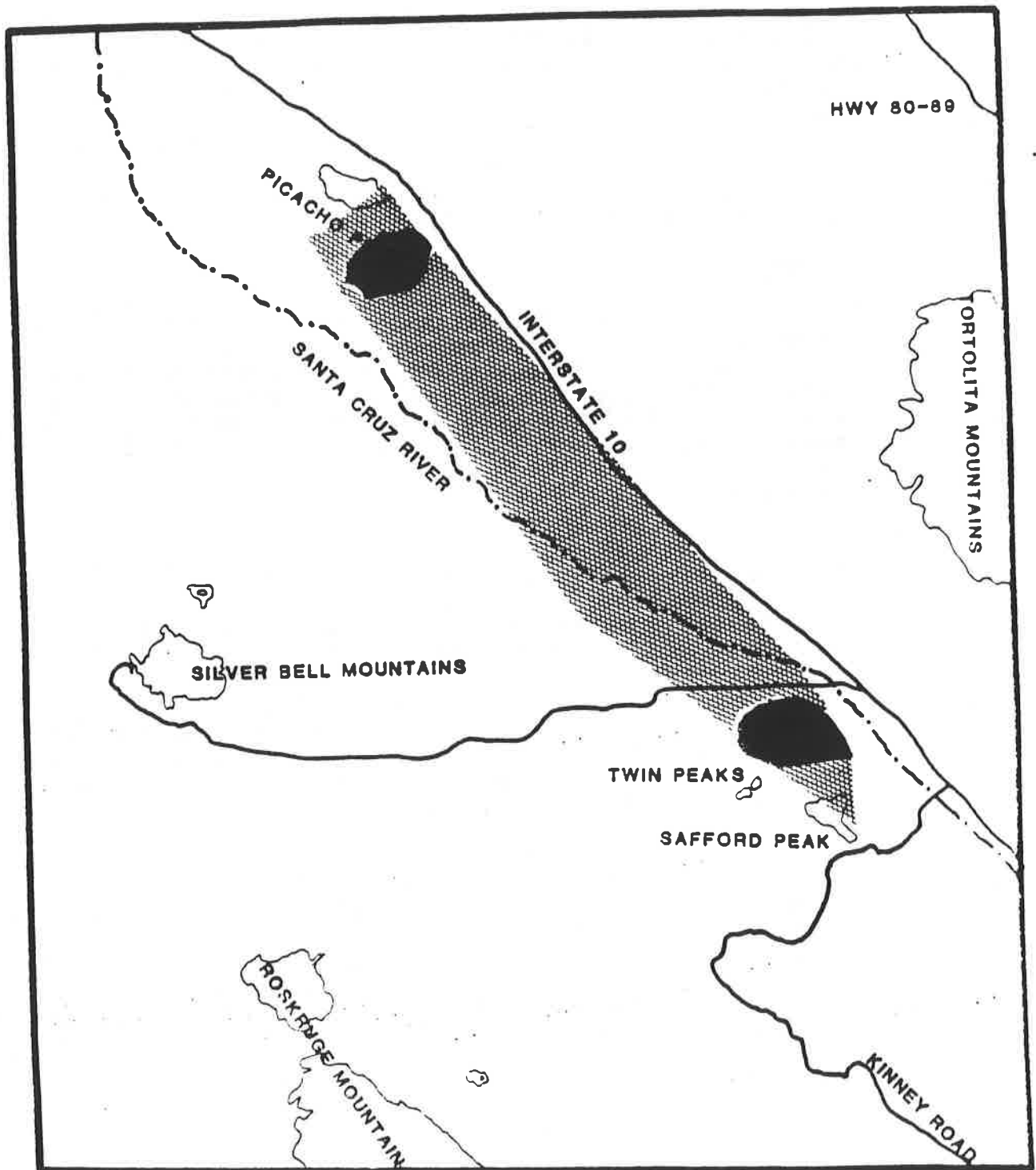
High Use Area

R9E

R10E

R11E

R12E



0 5 10  
kilometers

No. 72, with the two high-use areas and the movement corridor identified.

Radiolocations for coyote Nos. 95 and 97 indicate a large home range size with no identified high-use areas or movement routes. Movements by these two coyote resulted in occasional proposed aqueduct alignment crossings as indicated in their home-range maps in Appendix C-2. Coyote No. 95's home range included portions of canal segments 1 through 21, while coyote No. 97's home range included portions of canal segments 20 through 35, excluding segments 26 and 27. Although neither of these animals appeared to utilize a defined movement corridor, they both made the wide range movements demonstrated by coyote in previous studies (Danner 1976 and Drewek 1980).

### Bobcat

While the number of locations for bobcat are limited, a movement corridor appears to be utilized in canal segments 21, 22 and 23. Movement has been documented from the areas east of the proposed aqueduct alignment, west into Brawley Wash. Due to the limited number of locations, it is not possible to further define this movement corridor; however, it appears to be similar to the mule deer movement corridor on map B-1.

## **B-3 Specific High- and Low-Use Areas**

Unlike general-use areas where the data used for analysis were collected on a weekly aerial basis, data to define specific-use areas were collected during dusk-to-dawn intense tracking periods from vehicles. These data were used to define specific-use areas on or near segments of the proposed aqueduct alignment. Animals that were located in the vicinity of the proposed aqueduct alignment from the air were selected for dusk-to-dawn tracking.

A total of 1,499 radiolocations were obtained during dusk-to-dawn radio tracking efforts on 14 mule deer, 6 coyote, 2 bobcat, and 1 javelina. For all species together, specific high-use areas (zones 0-10) were identified along 16 canal segments, specific medium-use areas (zones 11-21) were identified along 3 canal segments, and specific low-use areas (zone 22) were identified along 5 separate canal segments.

### Deer

The highest number of locations were collected from mule deer, with 1,234 location points. Specific high-use areas were identified along six separate canal segments. These segments were found in two locations; southwest of the

Saguaro National Monument in segments 19, 20, 21, 22 and 23 and west of Black Mountain in segment 38. Figure B-6 presents the number of mule deer dusk-to-dawn locations in zones 0-22. Based upon this figure, there are two areas of concentration; the central portion from the Saguaro National Monument south to canal segment 24, and the area near Black Mountain. Also on this figure, it is apparent that canal segments 20, 21, 22 and 23 are most important with 1,120 of 1,234 (91%) of the locations occurring in these zones. Canal segment 22 is the single-most used site with 426 of 1,234 (35%) of all locations occurring there.

Figure B-7 displays the number of mule deer dusk-to-dawn locations in zones 0-10. When only these data are analyzed, several canal segments are not represented; however, the same general pattern in Figure B-1 is demonstrated. Canal segments 19 through 23 are most important with 162 of 166 (98%) locations in this area. The only other canal segment represented is segment 38, which is located near Black Mountain, with 4 of 166 (2%) locations in this area.

Specific medium-use areas occurred in only two canal segments. These segments (24 and 37) are adjacent to the two areas with segments classified as being specific high-use areas.

Canal segments 8, 10, 16 17 and 37 were classified as specific low-use areas, with all recorded locations occurring in zone 22.

Six mule deer were primarily responsible for the high number of locations in segments 19-24. These deer spent considerable amounts of time in this area, crossing the canal on a regular basis. The locations that were collected in the Black Mountain area are primarily the result of two deer that had home ranges which ran along canal segment 38. The majority of these occurrences fell within zones 11-21 (65%), with the remainder falling in zone 22.

### Coyote

A total of 226 dusk-to-dawn radiolocations were collected on coyote during this study. Based upon these data, a total of nine canal segments were identified as being specific high-use areas. These areas were located in three general areas; the vicinity of Twin Peaks, the area west of Saguaro National Monument, and the Black Mountain area. The individual breakdown of zone occurrences for the canal segments having occurrences within zones 0 through 10 is as follows:

Figure B-6. Total number of mule deer dusk to dawn locations per canal segment - zones 0 through 22.

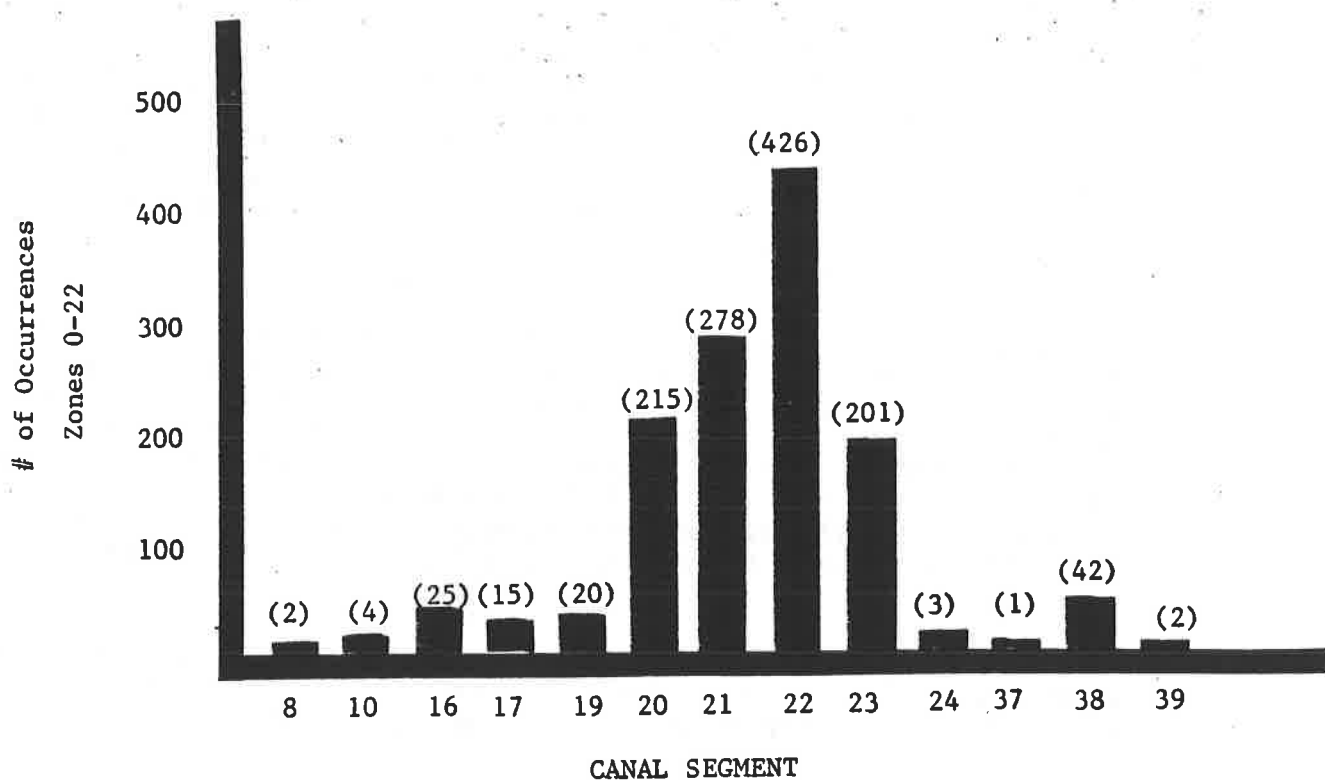
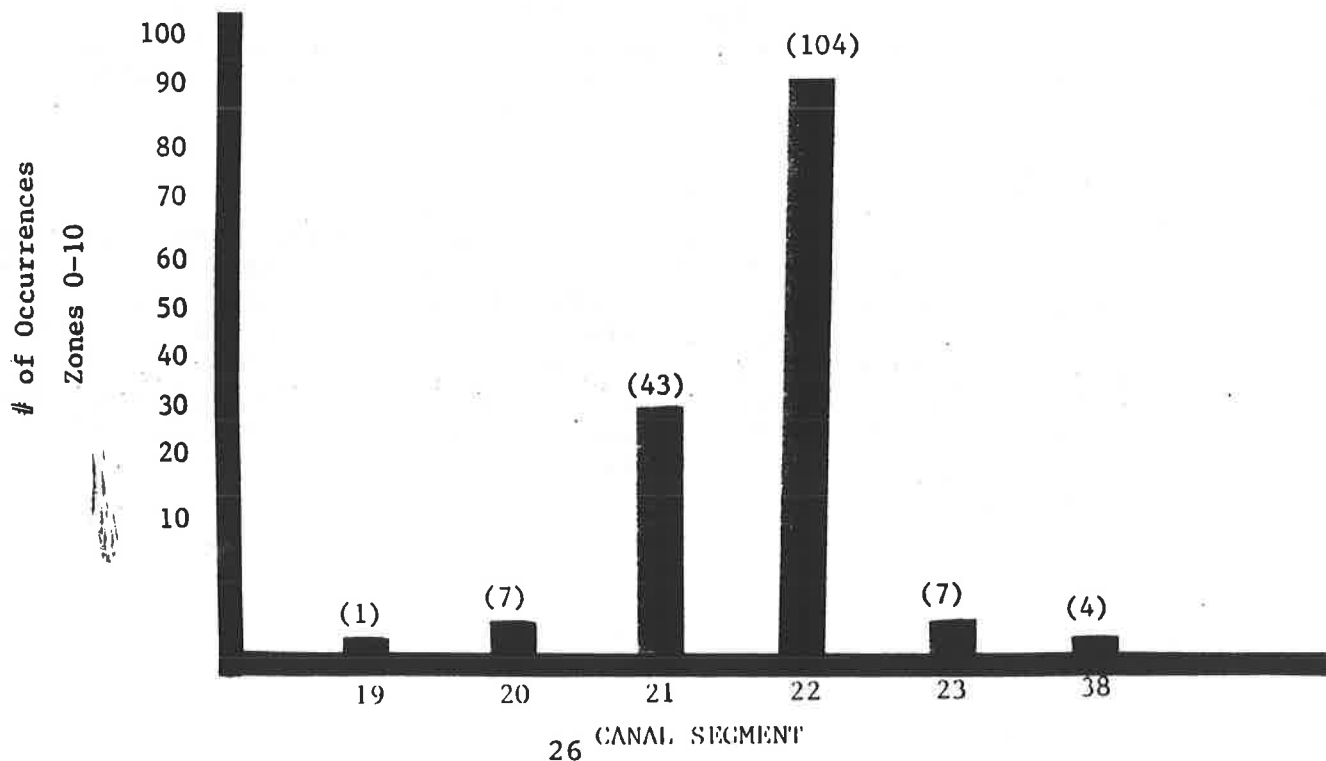


Figure B-7. Total number of mule deer dusk to dawn locations per canal segment - zones 0 through 10.



Canal Segment 6: One occurrence zone 0.

Canal Segment 7: One occurrence zone 6.

Canal Segment 8: One occurrence zone 3; two occurrences zone 7.

Canal Segment 9: One occurrence zone 9.

Canal Segment 15: One occurrence zones 1, 3, 9, 10; two occurrences zones 5, 7; three occurrences zone 6.

Canal Segment 16: One occurrence zones 1, 9; two occurrences zone 0; four occurrences zones 2, 3, 5; six occurrences zones 4, 8; seven occurrences zone 10; nine occurrences zones 6, 7.

Canal Segment 39: One occurrence zones 1, 8; two occurrences zone 0.

Canal Segment 40: One occurrence zones 4, 9; two occurrences zone 0.

Canal Segment 41: One occurrence zone 6.

The large number of occurrences within canal segments 15 and 16 are primarily attributed to coyote No. 65, which was commonly located in the vicinity of the proposed aqueduct alignment.

Specific medium-use areas were identified in four canal segments. One of these segments was near the Santa Cruz River while the remaining three were in segments 37, 38 and 42, all of which are near Black Mountain.

Only two segments (13, 21) were classified as being specific low-use areas.

Figure B-8 displays the number of coyote dusk-to-dawn radiolocations per canal segment, with zones 0-22 in aggregate. These data indicate the importance of canal segments 15 and 16, with 119 of 226 (53%) occurring in these two segments. The length of the canal corridor from Black Mountain to the terminus is also important to coyote, with 63 of 226 (28%) of all locations occurring there.

Figure B-9 displays the number of coyote locations for canal segments with locations in zones 0-10 only. Again, there are three areas of concentration; Twin Peaks, west of Saguaro National Monument, and Black Mountain. Canal segments 15 and 16 are the two most utilized segments, with 69 of 84 (82%) of the locations recorded occurring there. Segments 39, 40 and 41 are used less but still account for 9 of 84 (11%) of the locations.

Figure B-8. Total number of coyote dusk to dawn occurrences per canal segment - zones 0-22

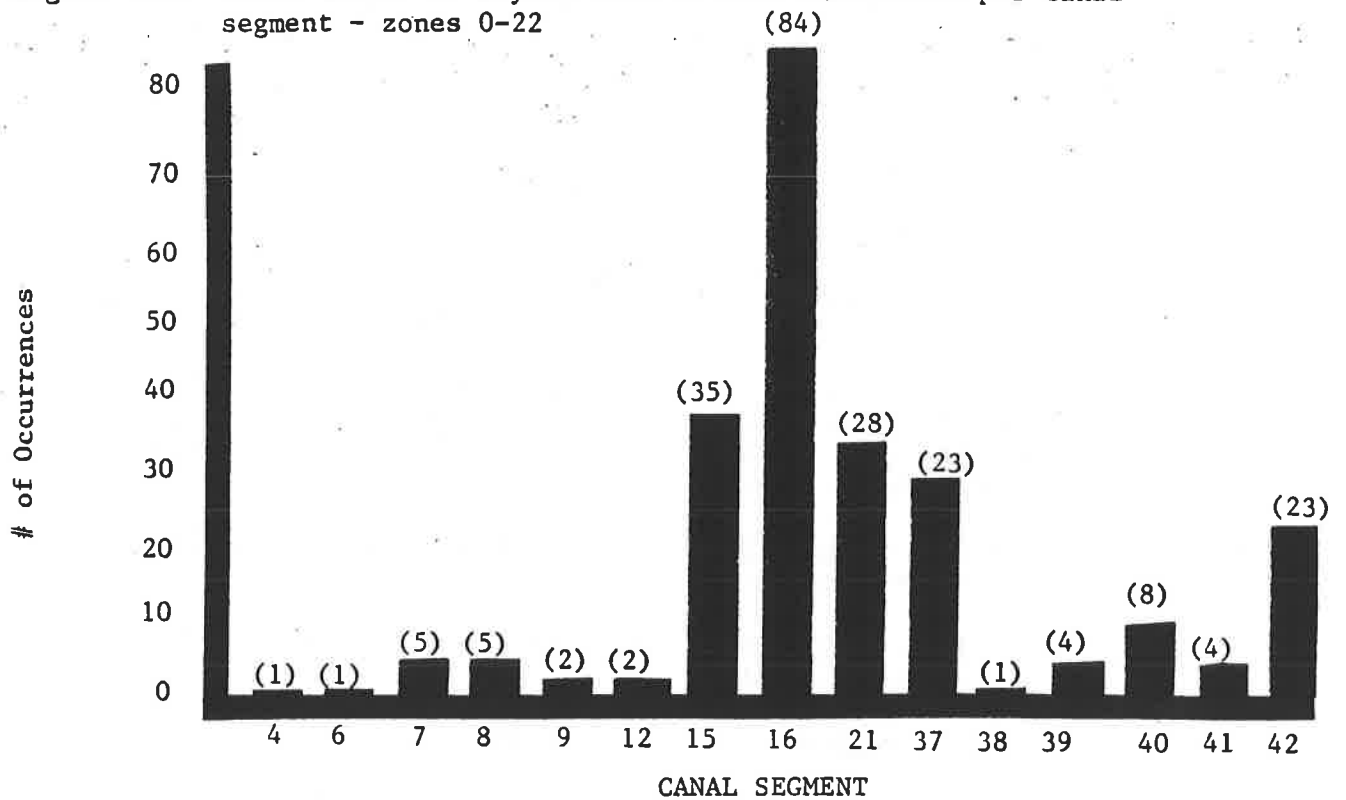
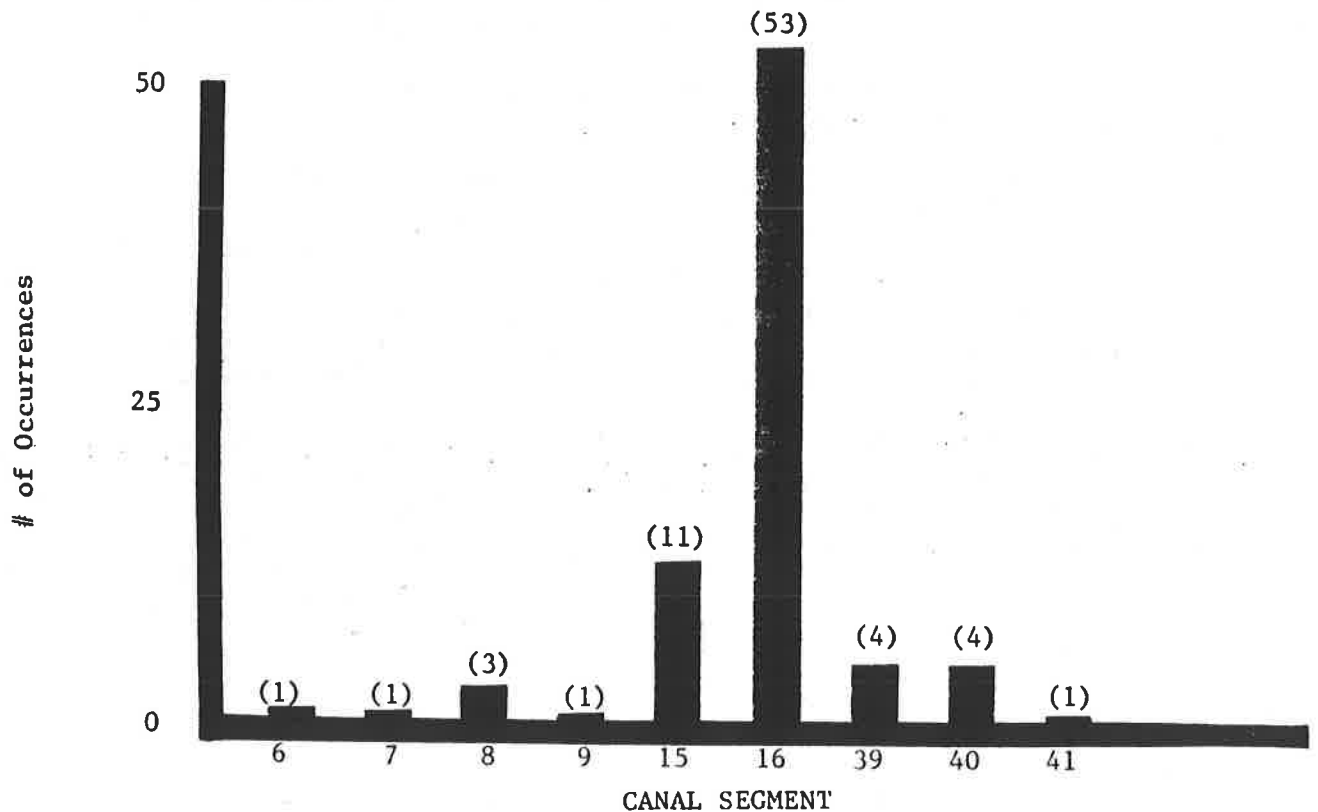


Figure B-9. Total number of coyote dusk to dawn occurrences per canal segment - zones 0-10



### Bobcat

As the result of a limited number of bobcat being radio collared, only 25 dusk-to-dawn locations were determined for this species. Based upon these data, four segments were identified as being specific high-use areas for bobcat. All of these are located in the central portion of the proposed aqueduct alignment at segments 16, 21, 22 and 23. Figure B-10 indicates the number of bobcat occurrences when all zones are considered together. With this data set, all canal segments from 16 through 23 show use by bobcat. Canal segment 16 is the most utilized segment of the canal, with 9 of 25 (36%) of all bobcat locations occurring there.

Canal segment 20 was classified as being a specific medium-use area, while segments 17, 18 and 19 were classified as specific low-use areas.

### Javelina

Javelina dusk-to-dawn radiolocations fell adjacent to canal segments 37 and 38. A single animal, javelina No. 85, was responsible for the occurrences, as the daily home range included portions of those canal segments. All of its recorded locations fell within zones 0 through 10. Seventy-one percent of the locations fell within canal segment 37. Forty-two percent of the total javelina locations occurred within the proposed aqueduct alignment.

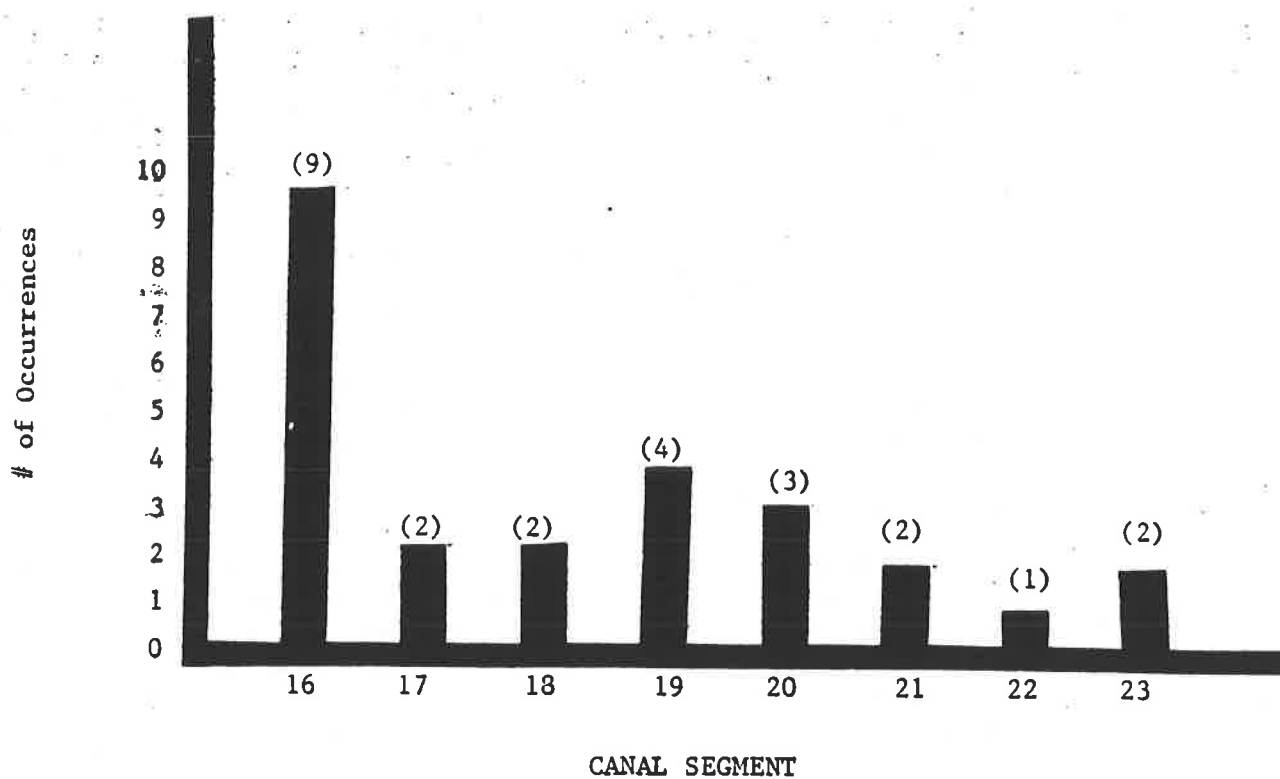
## **B-4 Wildlife Crossings of the Proposed Aqueduct Alignment**

During the collection of the dusk-to-dawn radiolocation data, a total of 36 different wildlife crossings were documented. These 36 crossings occurred in 9 different canal segments. These crossings occurred in three general areas; Twin Peaks area, west and southwest of Saguaro National Monument and near Black Mountain. Actual crossings occurred in canal segments 6, 15, 16, 21, 22, 23, 37, 38, 39 and 40. Canal segment 22 proved to be used most frequently by wildlife crossing the canal, with 19 of 36 (53%) of all known crossings occurring there. Canal segment 16 was next, with 6 of 36 (17%) of the crossings in this segment. Segments 21, 39 and 40 all had two crossings, with the remaining used segments having one each.

This section only includes data on animals that were actually recorded crossing the proposed aqueduct alignment. Other animals have home range maps that include portions of the proposed route and other crossings have occurred during this study, but were not observed.

Mule deer, with 21 crossings, was the species that most commonly crossed the proposed aqueduct alignment, followed by coyote (12 crossings), javelina (2 crossings), and bobcat (1 crossing). These data more accurately reflect the number

Figure B-10. Total bobcat dusk to dawn locations per canal segment - Zones 0-22.



of animals within a species being collared rather than the propensity of a species to cross the proposed alignment. When considered as a percentage (the total number of a species collared crossing the canal) the results are remarkably similar. A total of 24% (6) of the collared deer, 25% (3) of the collared coyotes, 25% (1) of the collared bobcat and 11% (1) of the collared javelina within the study area crossed the canal at least once.

The following summary lists the number and type of animal which crossed the canal:

| <u>Canal Segment</u> | <u>No. of Crossings<br/>(by species)</u> |
|----------------------|------------------------------------------|
| 6                    | 1 (Coyote)                               |
| 15                   | 1 (Coyote)                               |
| 16                   | 6 (Coyote)                               |
| 21                   | 3 (Mule Deer)                            |
| 22                   | 18 (Mule Deer) 1 (Bobcat)                |
| 23                   | 1 (Mule Deer)                            |
| 37                   | 1 (Javelina)                             |
| 38                   | 1 (Javelina)                             |
| 39                   | 2 (Coyote)                               |
| 40                   | 2 (Coyote)                               |

Mapped locations of the documented wildlife crossings are presented in Appendix C 1-4.

#### **B-5 Home Range Determination**

Home range size was determined for 27 mule deer, 4 bobcat, 15 coyotes and 2 javelina (Table B-1).

##### Deer

Mule deer home range varied in size between 300ha to 6,806ha, with an average of 2,048ha with .95 confidence limits at  $\pm 628$ . Eleven of the 27 radio-collared mule deer had home ranges which included portions of the proposed aqueduct alignment. Aerial locations revealed high-use home range areas to be located within canal segments 21, 22, 23, 37 and 38, while low-use home range areas included segments 4, 5, 20, 24, 25, 36, 39 and 40 (Figure B-11). Individual mule deer home range maps are found in Appendix C-1.

##### Coyote

Average coyote home ranges were larger than any of the other animals. Coyote home range sizes varied from 307ha to 56,315ha, with an average of 11,563ha with .95 confidence limits at  $\pm 9662$ . The four largest coyote home ranges were those of juveniles. Three of the five coyotes with home ranges of less than 1,000ha were radio tracked less than

Table B-1. Home Range Sizes

| Species                                       | Sex | ID# | Collar Frequency | Home Range Size in Hectares |
|-----------------------------------------------|-----|-----|------------------|-----------------------------|
| Mule Deer                                     | F   | 50  | 149.090          | 559                         |
|                                               | F   | 51  | 148.750          | 606                         |
|                                               | F   | 52  | 149.210          | 2,004                       |
|                                               | F   | 53  | 148.920          | 466                         |
|                                               | M   | 54  | 149.680          | 2,937                       |
|                                               | F   | 55  | 148.280          | 1,771                       |
|                                               | F   | 56  | 149.710          | 932                         |
|                                               | M   | 58  | 149.650          | 2,424                       |
|                                               | F   | 59  | 148.560          | 466                         |
|                                               | M   | 60  | 149.500          | 1,631                       |
|                                               | F   | 62  | 148.700          | 300                         |
|                                               | M   | 63  | 149.570          | 1,771                       |
|                                               | M   | 66  | 149.930          | 2,097                       |
|                                               | M   | 67  | 149.530          | 653                         |
|                                               | M   | 68  | 148.520          | 1,631                       |
|                                               | M   | 70  | 148.680          | 3,543                       |
|                                               | M   | 73  | 149.670          | 466                         |
|                                               | M   | 74  | 149.635          | 4,195                       |
|                                               | M   | 75  | 149.140          | 1,673                       |
|                                               | M   | 76  | 149.614          | 2,564                       |
|                                               | F   | 77  | 149.950          | 2,237                       |
|                                               | M   | 78* | 149.420          | 5,780                       |
|                                               | M   | 79  | 149.900          | 6,806                       |
|                                               | M   | 80  | 149.550          | 1,538                       |
|                                               | F   | 84* | 149.940          | 932                         |
|                                               | M   | 89  | 148.700          | 2,564                       |
|                                               | M   | 90  | 148.560          | 2,750                       |
| x and .95 confidence limits 2,048 $\pm$ 628   |     |     |                  |                             |
| Bobcat                                        | F   | 64  | 148.960          | 1,631                       |
|                                               | F   | 57  | 149.130          | 10,303                      |
|                                               | M   | 93  | 149.380          | 2,284                       |
|                                               | M   | 94  | 148.930          | 2,098                       |
| x and .95 confidence limits 4,079 $\pm$ 6,616 |     |     |                  |                             |

Table B-1. Continued

| Species | Sex | ID# | Collar Frequency | Home Range Size in Hectares |
|---------|-----|-----|------------------|-----------------------------|
| Coyote  | M   | 61  | 149.070          | 513                         |
|         | F   | 86  | 149.310          | 4,056                       |
|         | M   | 82  | 148.730          | 885                         |
|         | M   | 81  | 149.300          | 6,433                       |
|         | F   | 71  | 149.939*         | 56,315                      |
|         | F   | 65  | 149.460          | 792                         |
|         | F   | 87  | 149.310          | 307                         |
|         | M   | 83  | 149.632          | 1,538                       |
|         | F   | 88  | 149.700          | 308                         |
|         | M   | 72  | 149.620*         | 13,906                      |
|         | F   | 69  | 149.510          | 6,153                       |
|         | F   | 95  | 149.660          | 45,128                      |
|         | M   | 96  | 149.630          | 7,599                       |
|         | F   | 97  | 149.610          | 26,340                      |
|         | M   | 98  | 149.551          | 3,077                       |

x and .95 confidence limits 11,563  $\pm$  9,662

|          |    |         |     |
|----------|----|---------|-----|
| Javelina | 91 | 149.290 | 390 |
|          | 85 | 148.710 | 189 |

x and .95 confidence limits 289  $\pm$  1,276

\* See Appendix A-1 for long range movement maps.



five months, which may have attributed to their small home range size. Fourteen of the 15 coyotes had home ranges which included portions of the proposed aqueduct alignment. Aerial locations indicated that virtually the entire proposed aqueduct alignment was within the low-use home range area for coyotes, while high-use home range areas fell within 5 canal segment sections (Figure B-12). Maps of the individual coyote home ranges are found in Appendix C-2.

### Bobcat

Bobcat home range varied between 1,631ha to 10,303ha, with an average of 4,079ha with .05 confidence limits  $\pm 6616$ . Bobcat No. 64 was radio tracked less than 5 months, which may have accounted for its apparent small home range size. Three of the four radio-collared bobcat had home ranges which included portions of the proposed aqueduct alignment. Aerial locations of these bobcats revealed high-use home range areas located within canal segments 19, 20, 21, 22 and 23, while low-use home range areas covered canal segments 14, 15, 16, 17, 18 and 42 (Figure B-13). Individual home range maps for bobcat are found in Appendix C-3.

### Javelina

Javelina home range size varied between 390ha and 189ha, with an average of 289ha. Although only two javelina collars remained active during this study, the home range size information agrees with the findings in the original report (deVos et al. 1983). One javelina had a home range which fell within portions of canal segments 37 and 38. Aerial locations indicated most of canal segment 37 was within the general high-use range for that animal. Individual home range maps for javelina are found in Appendix C-4.

## **C Discussion**

### **C-1 General High and Low-Use Areas**

#### Deer

Of the seven canal segments identified as general high-use areas for mule deer, three were located on the northern section of the proposed aqueduct alignment. Those canal segments (4, 5 and 7) all had mule deer occurrences within 600m of the proposed aqueduct alignment. Since the majority of mule deer which received 12-hour dusk-to-dawn tracking sessions moved in excess of 600m during one session, it is probable that mule deer would come into contact with the canal along those segments. The locations collected on mule deer within canal segments 4, 5 and 7 did not indicate wildlife crossings, as all of the collected locations

Figure B-12. Canal segments lying within combined coyote home range areas.

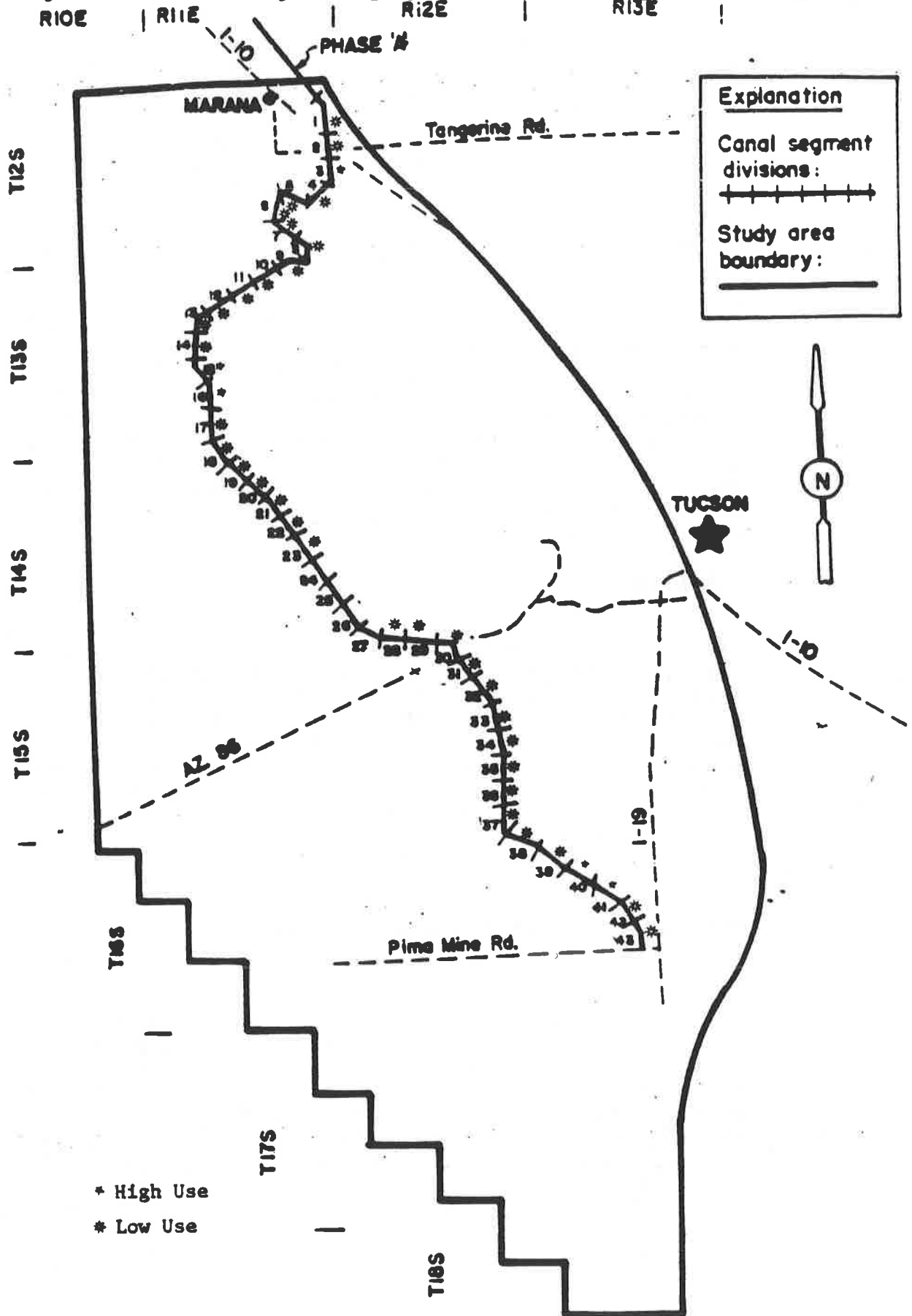
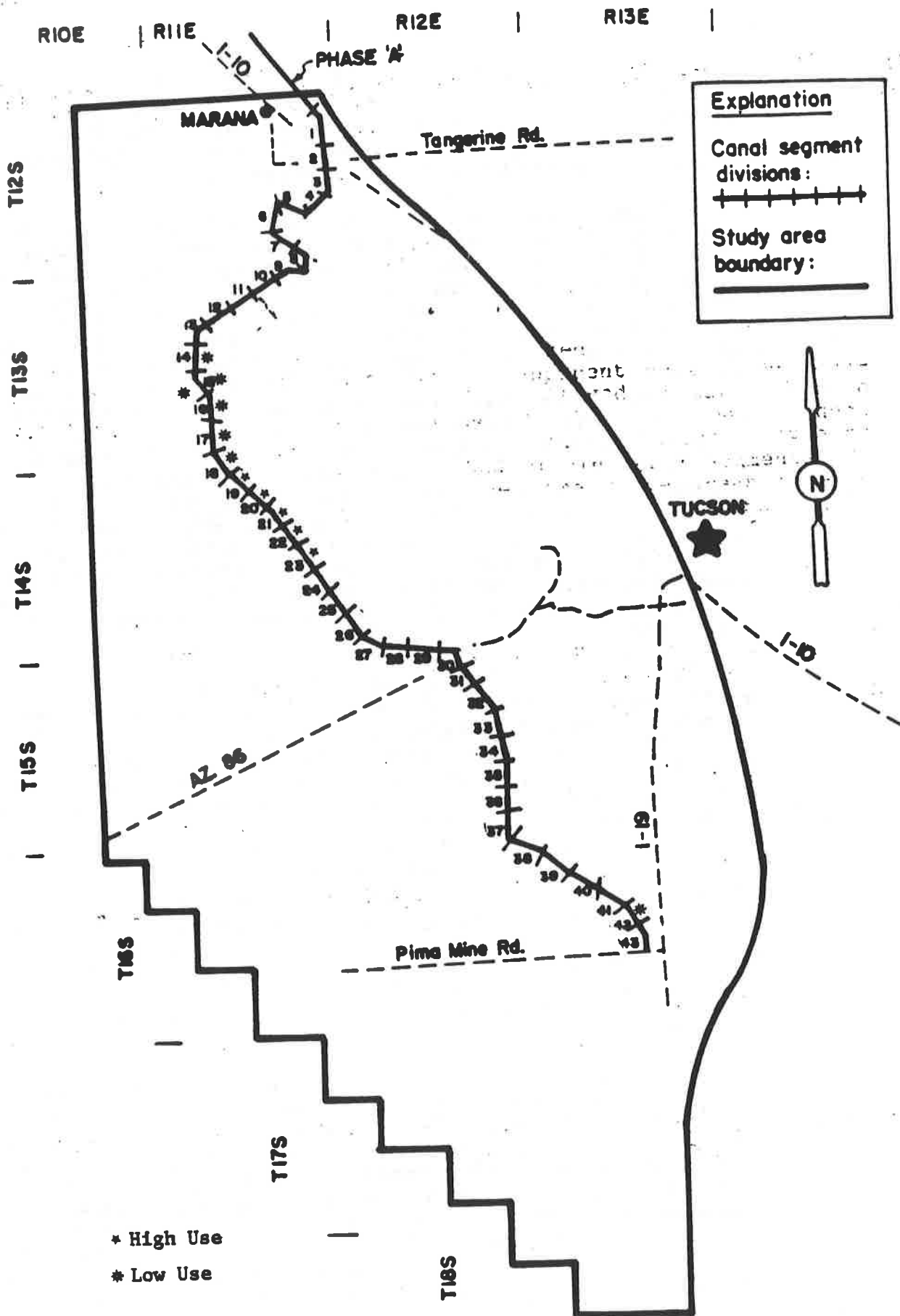


FIGURE D-15. Canal Segments 1-10 within California Desert



wildlife crossings, as all of the collected locations occurred on the southeast side of the proposed aqueduct alignment. This identifies those canal segments as hazards to mule deer in terms of entry (drowning), but probably not preventing movement within a preferred corridor.

Canal segments 21, 22 and 23 all had mule deer occurrences (as indicated by aerial radio tracking) within 200m of the proposed aqueduct alignment. The locations collected on mule deer within those canal segments showed frequent location points on both the west and east side of the proposed aqueduct alignment. Those canal segments not only pose a threat to mule deer coming in contact with the canal but would act as a barrier to movement, preventing mule deer from using preferred areas on both sides of the canal. The preferred-use areas for those mule deer frequenting canal segments 21, 22 and 23 occur approximately 2km east of the proposed aqueduct alignment near Brown Mountain. Aerial radiolocation data on three of the six mule deer frequenting canal segments 21, 22 and 23 indicate a second preferred-use area approximately 3km southwest of the canal. The fact that aerial location points for mule deer indicate movement across those canal segments identifies the area as an important movement corridor for mule deer.

During the study, all of the mule deer occurrences within canal segment 38 occurred on the west side of the proposed aqueduct alignment. Mule deer occurrences ranged from 500m to 2,000m+ along canal segment 38. Information gained during 12-hour dusk-to-dawn radio tracking would indicate a strong possibility that mule deer would come into direct contact with the canal during short-term movement periods. Data from the original inventory report indicate preferred mule deer habitat on the east side of canal segment 38. This would suggest the possibility of mule deer aqueduct crossings within this canal segment. Additionally, aerial location data collected on mule deer No. 89 during the original inventory report showed general high-use areas on both sides of canal segments 37 and 38. This would indicate the use of a movement corridor along portions of those segments.

Those canal segments identified as general medium-use areas for mule deer typically occurred next to general high-use canal segments. The number of recorded occurrences within the medium-use area classification determined the extent of impact the canal segment would have on each particular species. Canal segments 2 and 9 were two canal segments classified as general medium-use areas for mule deer. The fact that both of those segments had mule deer occurrences within 2km of the proposed aqueduct alignment suggests that they could pose a threat to those animals in this vicinity. The two mule deer that had recorded

occurrences next to canal segments 2 and 9 spent the majority (approximately 95%) of their time southeast of canal segments 2 and 9 near Panther Peak. This indicates that the area around canal segments 2 and 9, although frequented by mule deer, are not considered a threat to established mule deer movement corridors.

Canal segments 18 and 19 had general medium-use occurrences from two mule deer bucks which typically used areas northeast of the Sandario Road and Mile Wide Road intersection. The low number of occurrences (3) within those canal segments indicates the preferred-use areas for those deer exist some distance from the proposed aqueduct alignment. Several residential areas and frequently traveled roads lie between the proposed aqueduct alignment and preferred habitat-use areas for those mule deer. Data from the original inventory report indicate that, while mule deer prefer areas 900m from residences, they will use areas with low density human related intrusion. This information would indicate that those particular canal segments pose little immediate threat to existing mule deer movement corridors, but do pose a drowning threat for deer.

Canal segment 20 borders the north end of three consecutive general high-use canal segments for mule deer. Canal segments 24 and 25 border the south end of those high-use segments. These areas were used extensively by mule deer, indicating the presence of a well-defined movement corridor and high quality habitat. The presence of these high-use canal segments affected use patterns in the area, with those adjacent segments being influenced by the movement corridor. Those canal segments, particularly canal segment 20, had numerous mule deer occurrences on the east side of the proposed aqueduct alignment. The aerial tracking data suggests that mule deer crossings along canal segments 20, 24 and 25 are rare. Nevertheless, the repeated occurrences of mule deer along those canal segments will probably lead to attempted wildlife crossings. The high number of medium-use occurrences within those canal segments identifies them as potential hazards for deer entering the canal.

Canal segments 36 and 37 fell within general medium-use areas for mule deer. The fact that the canal will be underground along those segments eliminates the concern for long-term impacts on mule deer. Short-term impacts will occur during the construction phase.

For those canal segments which were classified as general low-use areas for mule deer, protective measures to prevent mule deer entry along open aqueduct lengths should be provided. Although data suggests that those canal segments occur in excess of 2,200m from preferred mule deer habitat, the possibility remains that uncollared mule deer

used portions of habitat that run adjacent to the canal segments classified as general low-use areas. Of those canal segments identified as general low-use areas for mule deer, canal segments 39 and 40 most likely had mule deer occurrences. Habitat surrounding canal segments 39 and 40 was classified as supporting a moderate density mule deer population from the original inventory report. Therefore, those particular canal segments could threaten mule deer movement as well as result in loss from drowning.

### Coyote

Of the 17 canal segments identified as general high-use areas for coyotes, canal segments 8, 15, 16, 40 and 42 all had individuals that crossed the proposed aqueduct alignment. Aerial radiolocations revealed frequent travel to preferred-use areas on both sides of the canal. These particular canal segments would pose a threat to coyote using areas adjacent to the canal. They would additionally prevent movement to areas across the canal. This could result in limiting preferred home range size and the isolation of breeding populations.

The remaining canal segments identified as general high-use areas all had coyotes whose home range areas occasionally included areas along the particular canal segments. The unpredicted movement patterns exhibited by coyote along those canal segments make it very difficult to predict where the coyote come in contact with the canal. Nevertheless, the canal will still act as a barrier impacting normal movement patterns and have the more direct effect of possible drownings along the identified high-use canal segments.

Those canal segments identified as general medium and low-use areas for coyote all had a limited number of animal locations based on aerial tracking data. This suggests that coyote occasionally used areas in excess of 1,100m from the canal. Although coyote will most likely take advantage of road crossings and piped culverts for passage routes over the canal, the canal will still inhibit normal movement patterns and pose a possible threat of drowning along those canal segments.

### Bobcat

The three canal segments identified as high-use areas for bobcat were already identified as high-use areas for mule deer. Those canal segments, 21, 22 and 23 could prevent bobcat from reaching preferred habitat areas and pose an immediate threat of drowning. As with the coyote, based on weekly movement data, it was very difficult to determine where the animal crossed a particular canal segment. The majority of the study area fell within an area

of low density bobcat distribution. As such, the canal will only represent a major disruption to bobcat movement patterns for those animals whose home range is adjacent to or bisected by the canal. Those individuals with characteristic long-range movement patterns are most likely to be affected. This will include those animals who regularly move to the Brawley Wash area.

### Javelina

Two of the canal segments (36, 37) identified as high-use areas for javelina will pose no long-term threat to javelina movements, as the aqueduct is buried pipe in this area. Canal segment 38, however, is an open aqueduct and could pose a threat to javelina by drowning as well as preventing movement to preferred-use areas.

Data that were collected during the original study indicate that javelina in this study area have restricted movement patterns. As a result, a means of eliminating javelina entry into the canal along areas of high javelina use is critical.

For this portion of the study, additional javelina were not equipped with telemetry equipment, due to the limited home range size and limited movements. Efforts were made to maximize the data collected by collaring only wide ranging wildlife. As a result, there were some canal segments that should be considered as general high-use, based on repeated ground and aerial observations of javelina. Most important of these are canal segments 20, 21 and 22. These three segments were utilized regularly by javelina.

Another area of concern that should be fenced to preclude javelina entry is along canal segments 15 and 16. These segments are west of the Saguaro National Monument where javelina use occurs. It is probable that some of these animals will come into contact with the proposed aqueduct alignment.

### **C-2 Long-Range Movement Corridors**

The identification of long-term movement corridors was an important segment of this study. In order to fully identify the impacts of a linear intrusion such as a canal, it is important to identify areas where movement corridors may be disrupted. This is especially true in this project area. The Tucson Mountain area was generally classified as high-use wildlife habitat; however, immigration and emigration in the area are limited by human impacts. The presence of the metropolitan Tucson area is certainly a barrier to wildlife movements. High density housing developments in the northwestern and southwestern portion of the study area are also impediments to movements.

The importance of maintaining long-range movement corridors within this area is supported by Smith et al. (1975) who state that "temporary subdivision of populations could result in inbreeding with lowered mean fitness of individual offspring and, thus, higher mortality rates at these times."

Smith et al. (1978) present a concept of population dispersal which appears to pertain to the importance of maintaining movement corridors. They say that there are primary and secondary populations in natural populations. Primary populations are those that are found in preferred habitat and possess such desirable features as genetic heterozygosity and high reproductive rates and are net exporters of individuals into surrounding populations. Secondary populations, which are found in less desirable habitat, display a greater degree of genetic homogeneity, with immigration exceeding emigration. This suggests that, if a movement corridor would be severed, the long-term effect would be to reduce the overall vigor of the population. It is possible that, without the input of new and varied genetic material, a population could be eliminated. Recent research was able to demonstrate the magnitude of the impact that lack of genetic diversity can play in controlling population dynamics. Ramsey et al. (1979) used starch gel electrophoresis to study the amount of genetic heterogeneity within two separate yet adjacent white-tail deer populations which demonstrated different population dynamics. In these two herds the genetic make-up was dissimilar. Within the two areas, habitat was rated as being dissimilar in composition but was rated similar in quality. One population which had a high degree of homogeneity in its genetic make-up appeared to be declining. The age structure was shifting to an older age composition. Within this herd, productivity was significantly lower than in the neighboring herd. The number of pregnant deer and the number of fetuses carried was seven and eight times lower respectively in the older-aged population. In contrast, the second population which had a high degree of heterogeneity had normal age distribution and productivity.

Based upon these studies, the concept of maintaining genetic exchange through long-range movement corridors is important to the wildlife of the Tucson Mountains. Other research that has been conducted on island populations points out the jeopardy to a species when it is restricted to an isolated population. Diamond (1975) stated that "If most of the area of a habitat is destroyed, and a fraction of the area is saved as a reserve, the reserve will initially contain more species than it can hold at equilibrium. The excess will gradually go extinct." In this same report, Diamond (1975) cited several situations in which species present in earlier studies had disappeared by

the time of the later studies. Simberloff and Able (1976) also discussed island biology and the potential impact that isolation of a small reserve will have on the continued existence of wildlife populations. These authors point out the potential impact of environmental catastrophes, such as fire or contagious disease, that could cause extinction of a species. In a semiurban situation such as that which is present in the Tucson area, over a period of time the additive impact of urban encroachment would act much the same as the sudden impact of a natural disaster and would probably result in the elimination of the majority of the deer herd.

The data from this study indicate that there are several different movement corridors within and away from the area of the Tucson Mountains. These corridors were identified for deer and coyotes. There was considerable overlap in the areas used for movement corridors, especially for mule deer. The coyotes that established long-range movement corridors did so in two sites, the northern portion of the proposed aqueduct alignment along canal segments 4-8, and the central area in canal segments 12-18. The mule deer corridor which was used to the greatest extent is found southwest of Saguaro National Monument, 5km south of the coyote movement corridor. Deer were documented using canal segments 21, 22 and 23 on a regular basis. While it is not precisely known why deer traveled through this area, one doe did travel from the Brown Mountain area to have a fawn in the dense vegetation along Brawley Wash. This same corridor was utilized by both bucks and does for ingress and egress through segments 21-23.

Another radio-collared deer utilized much of the same corridor from Brown Mountain to Brawley Wash; however, this deer also made frequent trips to the east into the Golden Gate-Ironwood picnic area. During these movements, the deer also included portions of canal segments in its movement corridor.

When all of the data for long-range movements are viewed together, the movement corridors bisecting the proposed alignment from canal segments 15-25 are most important. These corridors are utilized by a wide variety of wildlife. Although radio-telemetry equipment was utilized primarily on mobile species such as deer and coyote, extensive field observation showed that other wildlife such as javelina, bobcat and grey fox also used these sections of the proposed aqueduct alignment.

### **C-3 Specific High and Low-Use Areas**

The investigation of specific-use areas was conducted to further define the areas used by wildlife on and in the vicinity of the proposed aqueduct alignment. For this

investigation, animals were selected for study that were in proximity to the canal as determined during weekly aerial flights. Because specific animals were selected for further ground investigations, the data were intentionally biased to maximize data collection on animals near the canal.

A total of 1,499 ground locations were collected during this phase of the study. The majority (1,234, 82%) of these locations were for mule deer. Based on the specific-use data, mule deer had two areas where they were consistently located within 1,000m of the proposed aqueduct alignment. These areas correspond closely with the data collected for movement corridors. Canal segments 19, 20, 21, 22 and 23 were all identified as specific high-use areas. Three of these segments (21, 22, 23) were included in movement corridors by mule deer.

The importance of this area is apparent when the total number of locations within canal segments 20-24 are considered. Of the 1,234 locations collected during these studies, 1,120 (91%) were in these four segments.

In addition to the central area, one canal segment (38) near Black Mountain was identified as being a specific high-use area.

Coyotes were also specific in their use patterns in the areas along the proposed aqueduct alignment. Coyote use areas were in three general locations; by the Santa Cruz River, west and southwest of Saguaro National Monument, and by Black Mountain. Two of these areas are also identified as being specific high-use areas for mule deer. Canal segments 15-25 and 38-42 were general areas that were frequently used by both deer and coyote.

The single canal segment that was most important to bobcat (segment 16) was also the most important area for coyote. This segment accounted for 36% of all dusk-to-dawn locations for bobcat and 60% of all high-use area locations for coyote. Canal segments 21, 22 and 23 were also identified as specific high-use areas for bobcat. This shows considerable overlap in this general area of mule deer, javelina and bobcat movements. When all locations for bobcat are considered, canal segments 16-23 show bobcat use.

These areas that show medium and high specific-use patterns are critical because of a high probability that animals in these areas will have an adverse encounter with an open canal. Further, there is considerable overlap in the areas that are identified as movement corridors and specific high-use areas. All locations that are classified as specific high- and medium-use areas should be fenced to preclude wildlife. In addition, wildlife crossings should be concentrated in these areas.

#### **C-4 Wildlife Crossings of the Proposed Aqueduct Alignment**

Wildlife crossings are important in that they indicate a point where wildlife would have direct contact with an open canal. This would result in direct loss from drowning as well as loss from indirect impacts such as population isolation. Data obtained from this study indicate that there are three areas where wildlife crossings of the proposed aqueduct alignment occurred. These areas are generally in the vicinity of mountainous areas and reflect movements from this habitat into agricultural areas such as the northern location near the Santa Cruz River, the central portion where movements are from the mountains into Brawley Wash, and the Black Mountain area where movements are probably occurring from the San Xavier Indian Reservation to water sources to the east. In addition, the Black Mountain area was classified as medium density mule deer habitat during the original study, indicating habitat that is used by mule deer on a regular basis.

There are two canal segments which received the majority of all wildlife use. Over 50% of the wildlife crossings recorded, occurred in canal segment 22. Canal segment 16 was next with 17% of the use. As indicated in this report, these segments are important components of a movement corridor which needs to be maintained as a viable crossing point. All canal segments where an actual crossing occurred should have at least two crossing structures specifically for wildlife use. This is especially true for areas where crossings were made by deer and javelina, as these animals are less likely than coyote to use crossing structures such as water overchutes. It should be noted that mule deer crossings occurred at only three canal segments (21, 22, 23). Those segments which received heavy wildlife crossing activity will require additional protective measures that are discussed in the mitigation section (Section E).

#### **C-5 Home Range Determination**

Home ranges for the four species in this study were quite variable, both within and between species.

##### **Deer**

Home range maps for mule deer reveal a use pattern similar to that demonstrated by the other methods of data analysis for this study. Individual mule deer home ranges were bisected by or were near the proposed alignment in three general areas. As with general-use areas identified, home ranges approached the canal near segments 4 and 5 which are to the west of the Santa Cruz River, west and southwest of the Saguaro National Monument in segments 20-25 and in the Black Mountain area in segments 36 through 40.

## Coyote

As with the initial phase of this project, coyotes monitored during this second phase of the study had the largest home range of all species. The average home range of coyote was estimated to be 11,563ha in phase two, which is quite similar to the estimate of 12,883ha during the first phase.

The home range maps for coyote indicate that portions of coyote home ranges overlap the majority of the proposed aqueduct alignment. While adult coyote are generally able to climb out of a canal, fencing to preclude wildlife entry to the canal would disrupt normal coyote movements. To counter this disruption, crossing structures to facilitate movements should be constructed. These could include water overchutes, siphons and road and cattle crossings.

## Bobcat

Three of the four bobcats for which data were collected had home ranges that bisected the proposed aqueduct alignment. This occurred in two general areas. The first was to the west of the Saguaro National Monument, from segments 15 to 23 with segments 19 to 23 being high-use areas. The second area was southeast of Black Mountain at segment 42.

## Javelina

One of the two javelina home ranges was bisected by the proposed aqueduct alignment. Canal segments 37 and 38 were regularly utilized by a herd of javelina.

The importance of the home range data to this study is graphically displayed in Appendices C-1 through C-4. These maps show specific areas where radio-collared animals are in or near the proposed aqueduct alignment. These data can be used to identify areas where wildlife protection features need to be constructed.

## **D Conclusions**

Five separate methods of data analysis were used to identify specific areas on or adjacent to the proposed aqueduct alignment where high wildlife use occurred. Each method was selected to get a specific viewpoint on wildlife movement patterns. Aerial locations provided insight into long-term movements. Because efforts were made to relocate all animals, these data were usually random and reflected overall study area habitat selection by radio-collared wildlife captured near the proposed aqueduct alignment. Short-term movement data were provided by dusk-to-dawn monitoring. These data were collected from selected animals

that were in the vicinity of the canal and, as such, were less random than aerial locations.

It is interesting to note that all methods of data interpretation were remarkably similar in results. Almost all the data for mule deer reveal the same basic pattern of habitat selection. Deer use broke down into three basic locations in all analysis; the area in canal segments 2-9 with segments 4, 5 and 7 within this area being most important, the central area southwest of the Saguaro National Monument in segments 18-25 with segments 21, 22 and 23 being most important, and the Black Mountain area in segments 37-40 with segment 38 being most important. Again, the importance of each of these segments is evidenced by all of the methods of data analysis indicating that these are areas that are selected by mule deer.

Another interesting result of this inventory is the amount of overlap that occurs between species in movement corridors and use areas. The north area (segments 2-9) was primarily used by coyote; however, mule deer also used the same general area. The central area portion of the aqueduct including segments 15-25 received extensive use by wildlife. The upper segments were used extensively by predatory species moving to the west from the Saguaro National Monument. Coyote, bobcat and grey fox all utilized this area. Segments 20-25 were the most used section of the canal. The list of wildlife crossings in section B-4 indicates that 100% of all mule deer crossings occurred in segments 21, 22 and 23. In addition, the only documented crossing of a bobcat occurred in segment 22. All data that have been collected indicate that this area is important to wildlife for a variety of reasons. Mule deer, bobcat and javelina have movement corridors that bisect the proposed aqueduct alignment in this area. This area was also identified as being high-use desert tortoise habitat during the first phase of this study. These segments were also classified as both general and specific high-use areas for mule deer.

The Black Mountain area also was used by a wide variety of wildlife. During the current phase of the study, mule deer, javelina and coyotes all utilized the area. During the previous portion of this study it was classified as having moderate to high-use for desert tortoises and Gila monsters.

In summary, canal segments 2-9, 15-25, and 37-42 are high-use wildlife areas and mitigation measures should be concentrated in these locations in order to minimize the potential adverse impact on wildlife in the area.

## **E Suggested Mitigation Measures**

The initial report that was written for this project (deVos et al. 1983) suggested several mitigation features to minimize the impacts of this project. To summarize, mitigation suggested for the proposed aqueduct alignment included: wildlife fencing, wildlife crossings in selected areas, avoidance of construction in key areas during certain portions of the year, development of water catchments, patrolling of areas during construction to chase or remove animals from the area, and monitoring of kit fox populations before and during construction. These same projects still remain viable mitigation projects; however, refined data collected in the past year have dictated an altered design of some of these features. With the data from the original study and those from the current study being reviewed in aggregate, the following mitigation is recommended:

**1. Wildlife Fencing:** All segments of the alignment where an open canal is present should be fenced in such a manner to limit wildlife entry into the canal. Except in the areas listed below, a cyclone fence (woven wire) six feet in height will be adequate. In areas of medium and high mule deer activity, fencing configuration should be a minimum of eight feet tall cyclone fence. Segments included in this category are; segments 2-7, 18-25, and segments 36-38. All fencing should be topped with three-strands of barbed wire to decrease the possibility of animals jumping or climbing fences.

The segments that occur in areas of high desert tortoise and Gila monster populations should include a suitable barrier for these species. This could be accomplished with a small mesh hardware cloth (1/2" mesh) 12"-16" high at the bottom of the fence and extending out for 12"-16". Areas that should be fenced in this manner are segments 18-25 and 37-41.

**2. Wildlife Crossing Structures:** In order to preclude bisecting movement corridors for all wildlife, suitable crossings should be included in the canal design. Crossings for big game animals need to conform to the recommendations of the studies being conducted along the Granite Reef section of the aqueduct. In order to minimize the impact of the canal on large mammal movements, those segments that were identified as having canal crossings by mule deer should have two crossings per mile designed for large mammal movements. Those segments that were classified as high-use areas for deer and javelina should have one wildlife crossing structure per mile. Segments that were classified as medium or low-use areas should include a crossing structure that could be used by wildlife. This could include a road crossing or other similar bridge structure.

Segments where actual crossing by mule deer occurred are segments 21, 22, and 23. Areas that were classified as high-use segments for mule deer, excluding segments where actual crossings occurred, are segments 4, 5, 7, and 38. In addition to these seven segments, an additional eight segments were identified as medium-use areas. These include segments 2, 9, 18, 19, 20, 24, 36 and 37. In that segments 20 and 24 are adjacent to segments where actual crossings have occurred both should have a wildlife crossing. Those segments that are classified as low-use areas for mule deer include 3, 8, 16, 25, 26, 27, 28, 31, 39 and 40. Based upon the professional judgment of the field biologists, segments 27, 28 and 31 should be excluded from this category. These segments represent a situation where the canal bends in such a manner that the locations probably reflect usage of segments to the north of these three locations. An examination of Map A-1 shows how overlap in locations can occur in segments.

For javelina, segments 36, 37 and 38 are all high-use areas. These segments should have one wildlife crossing structure.

In addition to the segments discussed above, two segments are classified as high-use areas for predators. Segments 15 and 16 supported considerable movement by predators and should have two bridges. In that coyote are more adaptable than deer and javelina in using crossing structures, one of the two structures in these two segments could consist of water overchutes or other similar structure provided wildlife access is maintained. The second structure should be specifically designed for wildlife.

In addition to the above requirements, all structures designed to pass water across the aqueduct should be modified to allow wildlife use. All structures should be designed in such a manner as to allow easy access by all wildlife.

In summary, a total of sixteen wildlife crossings are recommended. The locations are as followings: one crossing in segments 4, 5, 7, 15, 16, 20, 24, 36, 37 and 38. Segments where two crossings should be located are 21, 22, and 23. This is a total of sixteen crossings, specifically designed for wildlife.

**3. Minimizing Construction Disturbance:** It is desirable that specific areas be avoided during periods of high wildlife use. An example of this situation occurs in those segments of the canal that occur in Township 13 south. This area has a high density of nesting raptors. Construction should be avoided, if possible, or disturbance minimized in this area during the period of February 1 through June 1.

**4. Patrol Area of Active Construction:** Prior to construction activities each day, the length of the canal

to be worked on should be patrolled by a member of the construction crew to remove or chase animals from the construction zone. This would be primarily targeted for special interest species such as desert tortoise; however, a wide variety of reptiles and amphibians would benefit. Training of construction crew personnel would be provided by the Arizona Game and Fish Department personnel.

**5. Monitor Kit Fox Populations Before and During Construction:** The data collected indicate that kit fox in this study area are very limited in their distribution. Once a final aqueduct alignment is decided upon, and prior to construction, the construction zone within the creosote-bursage habitat type should be thoroughly searched for kit fox den sites. If a number of den sites are located, 10-15 animals should be equipped with biotelemetry collars and monitored just prior to and during construction. If it appears that a large number of these animals are either displaced and lost through predation or are killed during construction, mitigation will be identified to offset this loss. This is a relatively small project which would require a 1/4-man-year per annum during the construction phase of the study. Field supplies would also be minimal.

**6. Catchment Construction:** Past research has indicated that it is possible to manipulate wildlife movements through the strategic placement of water developments (Remington et al. In Press). In a study conducted on the Buckskin Mesa in west central Arizona, movement patterns of desert bighorn sheep (Ovis canadensis) were altered by water placement. Sheep were not required to move to a water site across a highway from the Mesa when an artificial watering site was developed. In other instances, the development of permanent water sources has resulted in an increase in wildlife populations. An area where this has occurred is the Palomas Plains in western Arizona where mule deer populations have increased since the construction of rainwater catchments.

In order to mitigate the effect of impacts of the canal on wildlife during canal construction and during post-construction operation, a total of nine (9) water developments are recommended. The majority of these are designed to be in strategic locations to minimize the number of deer that come into contact with the canal. The remainder are designed to offset deleterious effects of the canal as well as to offset the habitat lost as a direct result of the project.

The following list of sites are recommended:

- 1) One catchment should be developed in an area southwest of Safford Peak - SW1/4 Sec32 R12E T12S. The development should be either a masonry "pothole" type

project or a rainwater catchment typically designed by the AGFD.

- 2) A development should be constructed on the north edge of the hills in the Ez-Kim-In-Zan Recreational Area - S1/2 Sec13 R11E T13S. This area would require a rainwater catchment.
- 3) A development should be constructed on the slope of the Tucson Mountains northeast of Amole Peak - NE1/4 Sec30 R12E T13S. There is a windmill in the area that could be refurbished. If this alternative is not acceptable, a rainwater catchment should be built.
- 4) A development should be built in the Tucson Mountains east of King Canyon - SW1/4 Sec32 R12E T13S. In this location, either a masonry check dam or a rainwater catchment would be suitable.
- 5) A development should be constructed in the area south of Brown Mountain - NE1/4 Sec16 R12E T14S. This location would require that a rainwater catchment be built.
- 6) A development should be constructed in the area northeast of Golden Gate Mountain - NW1/4 Sec15 R12E T14S. A development at this site would require that a rainwater catchment be constructed.
- 7) A development should be constructed in the Twin Hills Area - Sec13 R12E T14S. Topography of the area dictates that this be a rainwater catchment.
- 8) A development should be constructed on the north side of Black Mountain - S1/2 Sec30 R13E T15S. This should be a rainwater catchment.
- 9) A development should be constructed in the west central portion of the San Xavier Indian Reservation - S1/2 Sec8 R12E T16S. Topography of the area dictates that this be a rainwater catchment.

The general locations for these developments have been listed above. The specific site for the catchments should be determined by the AGFD construction or engineering personnel who are familiar with the specific requirements for various types of wildlife water developments.

**7. Wildlife Corridor Acquisition:** Throughout the course of this study, one area along the proposed aqueduct alignment has proven to be of prime importance to wildlife. Those segments that are found southwest of Saguaro National Monument and Tucson Mountain Park are utilized by wildlife for a wide variety of activities. The area around segments 20-25 was classified as a high-use desert tortoise area. As

discussed throughout this report, these segments were used extensively as a movement corridor by several species. It is the last suitable area for ungulate movement into and out of the Tucson Mountain Park. This area has been documented as being a corridor for a mule deer doe to reach the mesquite bosque surrounding Brawley Wash where it had a fawn.

It is important to maintain this movement corridor to avoid forming a genetic island in the Tucson Mountains. In the past, researchers have indicated that formation of "habitat islands" is done at the expense of faunal diversity (MacArthur and Wilson 1967). Recent investigations by Arizona Game and Fish Department biologists indicate that small, isolated herds of desert bighorn sheep may lack the heterogeneity to ensure long-term survival (AGFD unpublished data).

Investigations into "island" biology have pointed out the long-term deleterious effects of isolating populations. This is caused by a reduction in population mobility. Researchers who have investigated this problem have developed at least one solution. Simberloff and Able (1976) suggest that small refuges can be improved through construction of corridors between the refuges. Diamond (1975) evaluated several different strategies to maximize the value of small refuges for wildlife. He indicates that a preferred strategy to manage disjunct habitat units is to maintain a movement corridor between the two areas. He states, "If there are several disjunctive reserves, connecting them by strips of the protected habitat may significantly improve their conservation function at little further cost in land withdrawn from development." He based this conclusion on the fact that species are able to use the protected habitats without crossing large expanses of unsuitable habitat.

With the placement of a barrier such as a canal across the area of segments 20-25, the movement corridor will be severed. There are management options that could be employed that would significantly minimize the adverse impact of an open aqueduct. Two of these options are based on the acquisition of a 4.25-section block of land to ensure that housing developments or other disturbances are prohibited on this parcel. The description of this land is as follows:

Sections 10,11,14,15 and SW $\frac{1}{4}$  Section R11E T14S.

The four management options that have been reviewed are listed in the order of preference as follows:

1. Bury pipeline through segments 21, 22 and 23. Acquire the above-referenced movement corridor.

2. Bury pipeline through segments 21, 22 and 23. No corridor acquisition.
3. Acquire the movement corridor. Open canal with crossings and fencing.
4. No corridor acquisition. Open canal with crossings and fencing.

Of these options, the first three would provide adequate mitigation for severing movement routes. The fourth option would not provide adequate mitigation for the cessation of movement. It is probable that, without corridor acquisition, the development pattern in the proposed mitigation area would, before the end of the life of the project, render crossings unacceptable to mobile wildlife, especially mule deer.

All of the suggested mitigation features recommended above were based upon the proposed westside alignment as it was in early 1984. Recommended features such as the number of wildlife crossings will be modified if different alternatives are selected.



## APPENDICES



Appendix A-1. Duration of tracking data on radio-collared animals. Collars which remained active at termination of field work on December 2, 1983 are indicated with an asterisk (\*).

| Species   | Sex | ID# | Collar Frequency | Capture Date | Termination Date | Comments                |
|-----------|-----|-----|------------------|--------------|------------------|-------------------------|
| Mule Deer | F   | 50  | 149.090          | 04-20-83     | *                |                         |
|           | F   | 51  | 148.750          | 04-20-83     | *                |                         |
|           | F   | 52  | 149.210          | 04-20-83     | 10-24-83         | Probable collar failure |
|           | F   | 53  | 148.920          | 04-20-83     | *                |                         |
|           | M   | 54  | 149.680          | 03-11-83     | *                |                         |
|           | F   | 55  | 148.280          | 04-20-82     | 09-19-83         | Unknown                 |
|           | F   | 56  | 149.710          | 04-10-83     | *                |                         |
|           | M   | 58  | 149.650          | 03-11-83     | *                |                         |
|           | F   | 59  | 148.560          | 04-20-83     | *                |                         |
|           | M   | 60  | 149.500          | 11-04-82     | *                |                         |
|           | F   | 62  | 148.700          | 04-20-83     | *                |                         |
|           | M   | 63  | 149.570          | 04-20-83     | *                |                         |
|           | M   | 66  | 149.930          | 11-04-82     | *                |                         |
|           | M   | 67  | 149.530          | 03-11-83     | 09-06-83         | Unknown                 |
|           | M   | 68  | 148.520          | 04-20-83     | *                |                         |
|           | M   | 70  | 148.680          | 07-16-82     | *                |                         |
|           | M   | 73  | 149.670          | 04-21-83     | 08-08-83         | Unknown                 |
|           | M   | 74  | 149.635          | 11-06-82     | *                |                         |
|           | M   | 75  | 149.140          | 04-21-83     | 11-01-83         | Unknown                 |
|           | M   | 76  | 149.614          | 11-04-82     | *                |                         |
|           | F   | 77  | 149.950          | 11-05-82     | *                |                         |
|           | F   | 78  | 149.420          | 11-05-82     | *                |                         |
|           | M   | 79  | 149.900          | 11-06-82     | *                |                         |
|           | M   | 80  | 149.550          | 11-03-82     | *                |                         |
|           | M   | 84  | 149.940          | 04-21-83     | *                |                         |
| Bobcat    | F   | 64  | 148.960          | 01-15-83     | 04-25-83         | Unknown                 |
|           | F   | 57  | 149.130          | 11-23-82     | *                |                         |

Appendix A-1. Continued

| Species | Sex | ID# | Collar Frequency | Capture Date | Termination Date | Comments  |
|---------|-----|-----|------------------|--------------|------------------|-----------|
| Coyote  | M   | 61  | 149.070          | 01-15-83     | 04-25-83         | Dead      |
|         | F   | 86  | 149.310          | 12-17-82     | 02-30-83         | Unknown   |
|         | M   | 82  | 148.730          | 12-17-82     | *                |           |
|         | M   | 81  | 149.300          | 12-16-82     | *                |           |
|         | F   | 71  | 149.390          | 10-14-82     | 08-01-83         | Unknown   |
|         | F   | 65  | 149.460          | 10-13-82     | *                |           |
|         | F   | 87  | 149.310          | 09-30-82     | 12-16-82         | Road Kill |
|         | M   | 83  | 149.632          | 09-29-82     | *                |           |
|         | F   | 88  | 149.700          | 09-21-82     | 12-21-82         | Unknown   |
|         | M   | 72  | 149.620          | 09-21-82     | *                |           |
|         | F   | 69  | 149.510          | 09-21-82     | *                |           |
|         | F   | 92  | 149.140          | 10-15-82     | 11-28-82         | Trapped   |
|         |     |     |                  |              |                  |           |
|         |     |     |                  |              |                  |           |

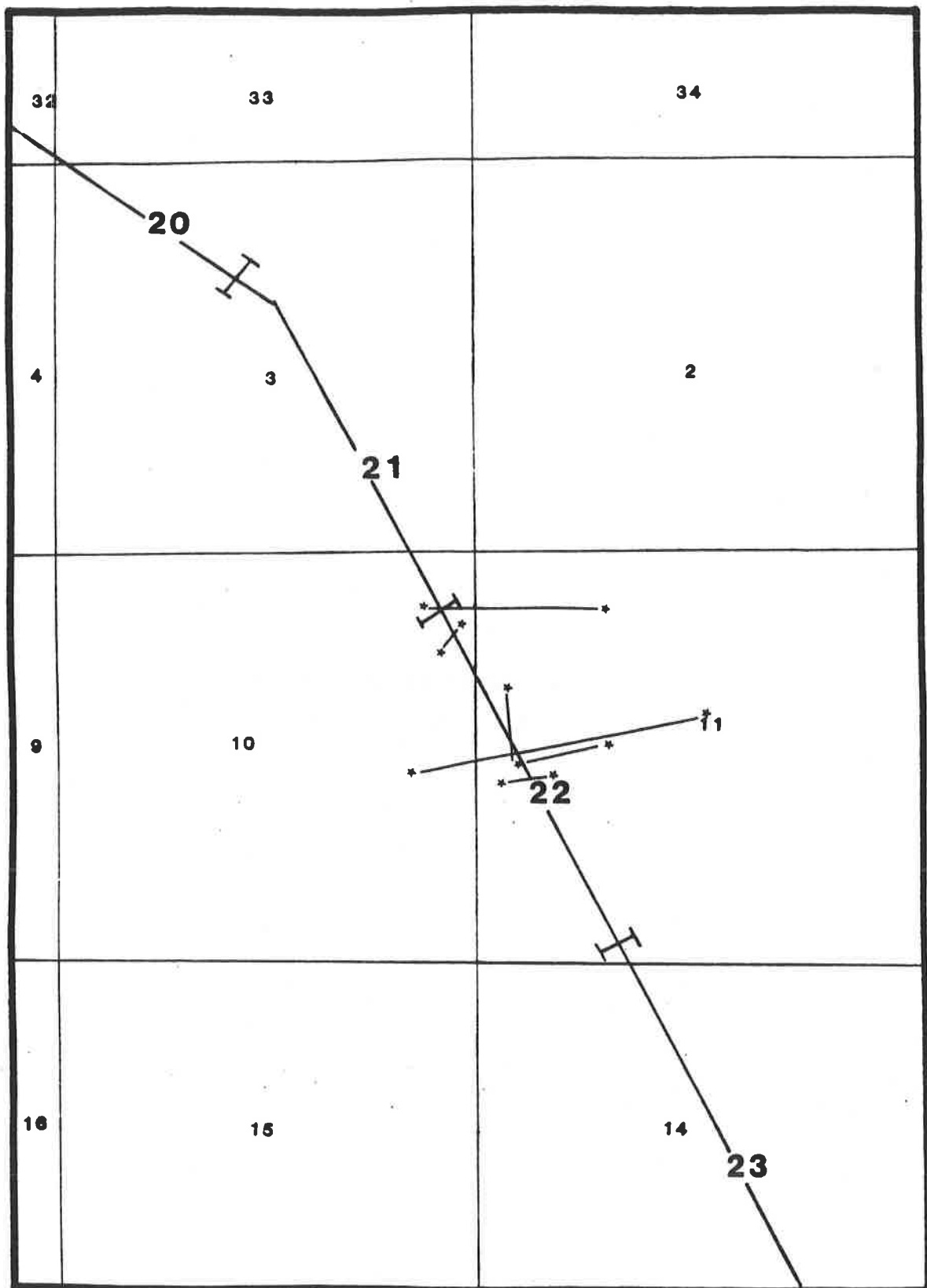
56

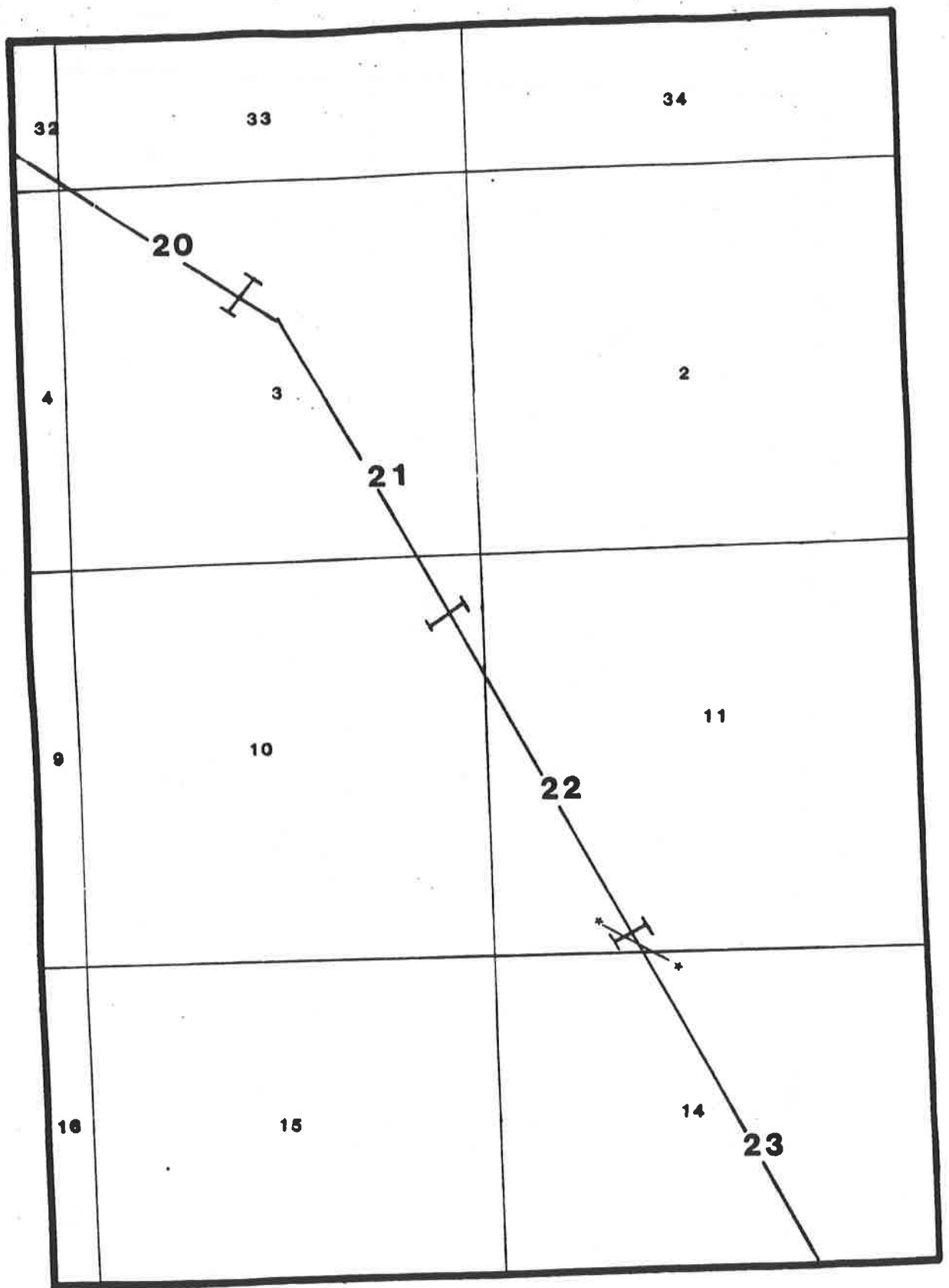
Radio-collared animals from original study which remained active during portions of this study, or provided additional data regarding potential wildlife corridors.

| Species  | Sex | ID# | Collar Frequency | Capture Date | Termination Date | Comments                  |
|----------|-----|-----|------------------|--------------|------------------|---------------------------|
| Deer     | M   | 89  | 148.700          | 11-20-81     | 01-03-83         | Unknown                   |
| Javelina | M   | 90  | 148.560          | 03-18-81     | 01-24-83         | Unknown - dead            |
|          | F   | 91  | 149.290          | 03-18-81     | 01-17-83         | Slipped collar?           |
|          | F   | 85  | 148.710          | 09-10-81     | 04-25-83         | Dead collar               |
| Bobcat   | M   | 93  | 149.380          | 07-24-81     | 01-10-83         | Collar failure            |
|          | M   | 94  | 148.930          | 03-27-81     | 01-03-83         | Collar failure            |
| Coyote   | F   | 95  | 149.660          | 03-27-81     | 03-25-82         | Unknown                   |
|          | M   | 96  | 149.630          | 08-04-81     | 03-12-82         | Killed as a chicken thief |
|          | F   | 97  | 149.610          | 03-26-81     | 12-11-81         | Radio failure?            |
|          | M   | 98  | 149.551          | 09-10-81     | 03-25-82         | Unknown                   |

Appendix B-1  
Canal Segment Crossing Locations  
For Mule Deer

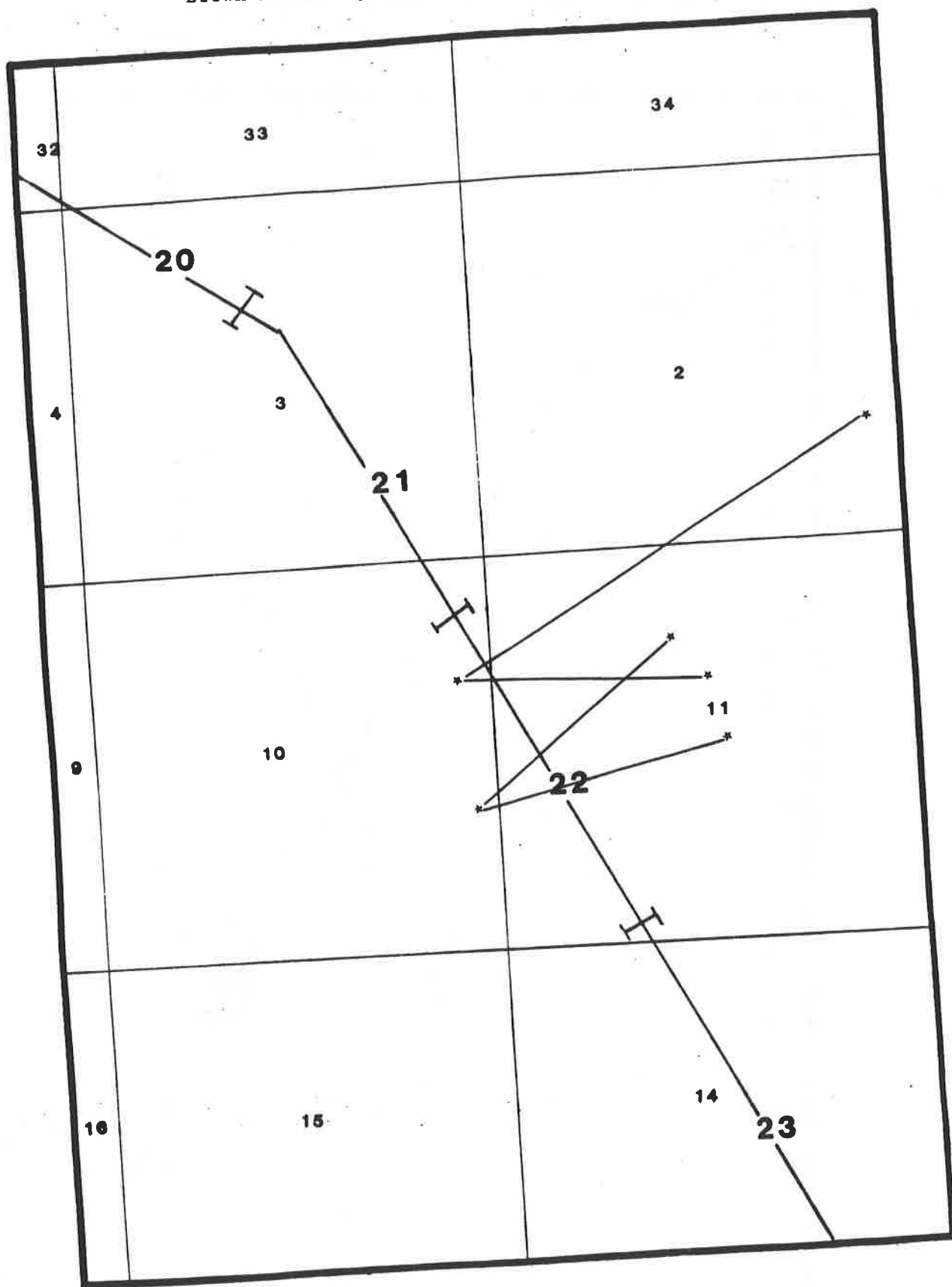
Appendix B-1. Mule Deer No. 53 - plotted from USGS 7.5 Quadrangle, Brown Mountain, Arizona, Range 11E, Township 14S.



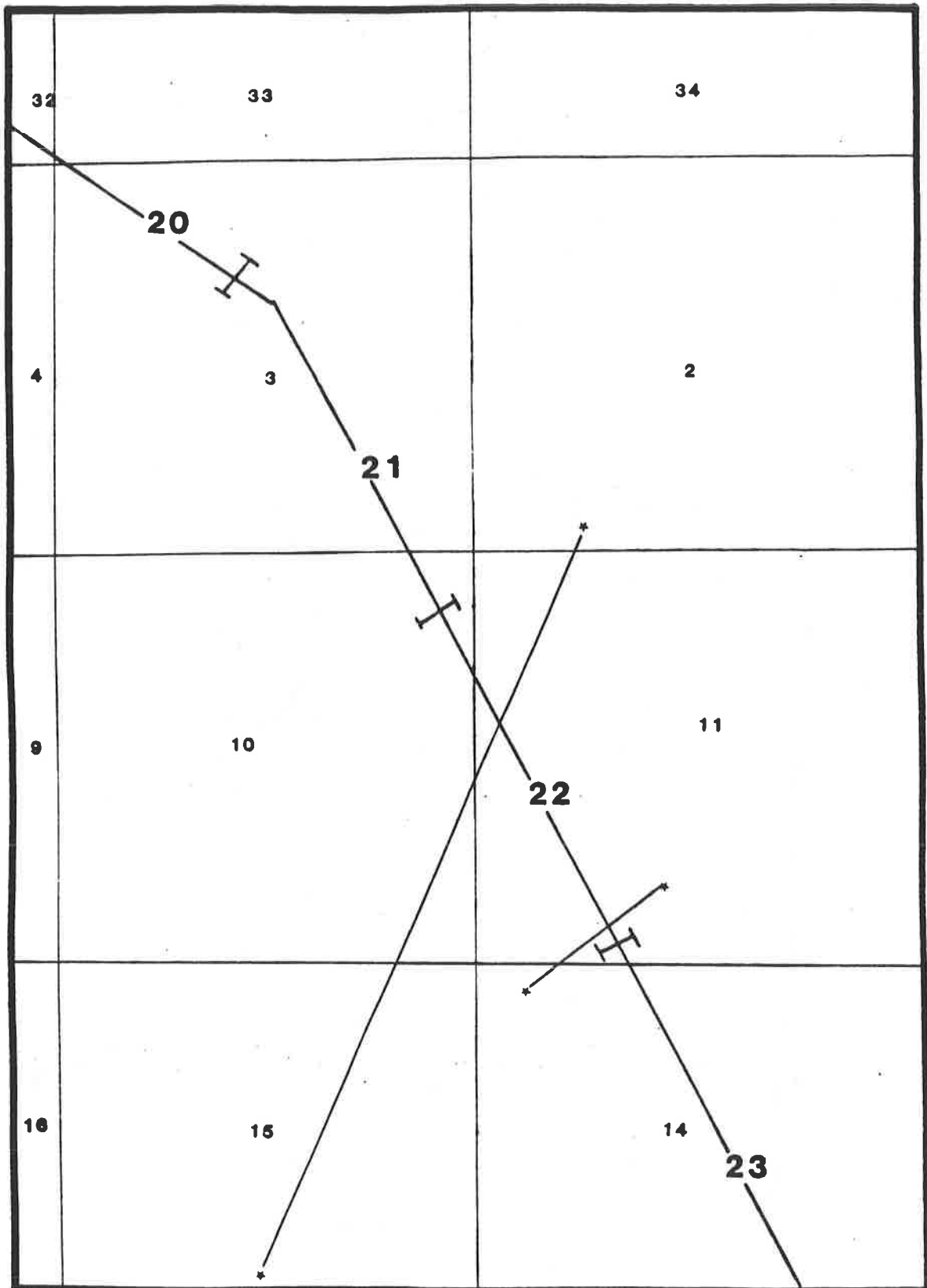


A hand-drawn map on a grid showing a path of numbered points (20, 21, 22, 23) and other labeled areas (32, 33, 34, 2, 4, 3, 9, 10, 16, 15, 14, 11). The path starts at point 20, goes to 21, then to 22, and finally to 23. There are also lines connecting 20 to 21 and 22 to 23. A cluster of points labeled 11 is near point 22. Error bars are present on the line segments 20-21 and 22-23.

Appendix B-1. Mule Deer No. 56 - plotted from USGS 7.5 Quadrangle,  
Brown Mountain, Arizona, Range 11E, Township 14S.



Appendix B-1. Mule Deer No. 58 - plotted from USGS 7.5 Quadrangle,  
Brown Mountain, Arizona, Range 11E, Township 14S.



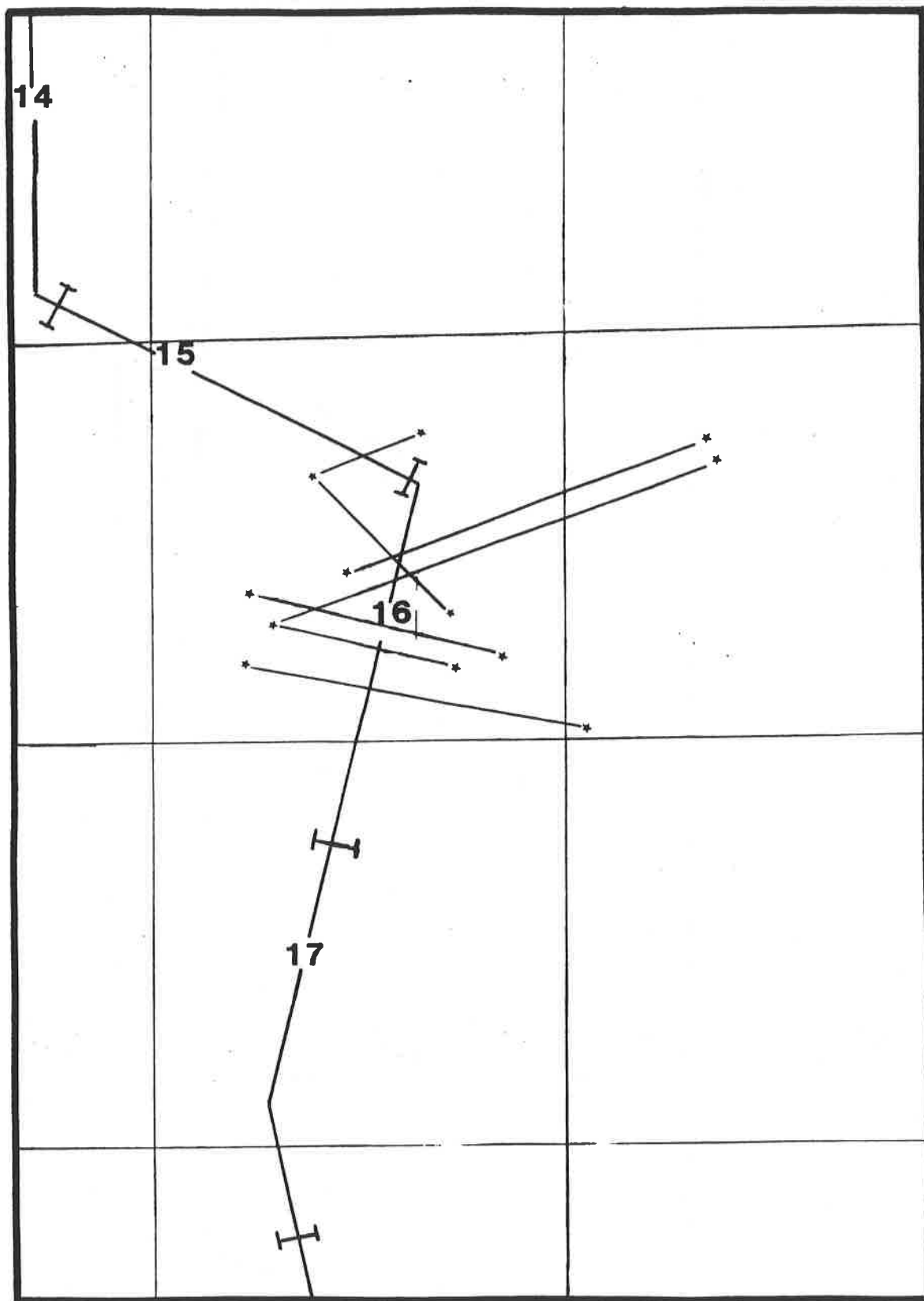




Appendix B-2  
Canal Segment Crossing Locations  
For Coyotes

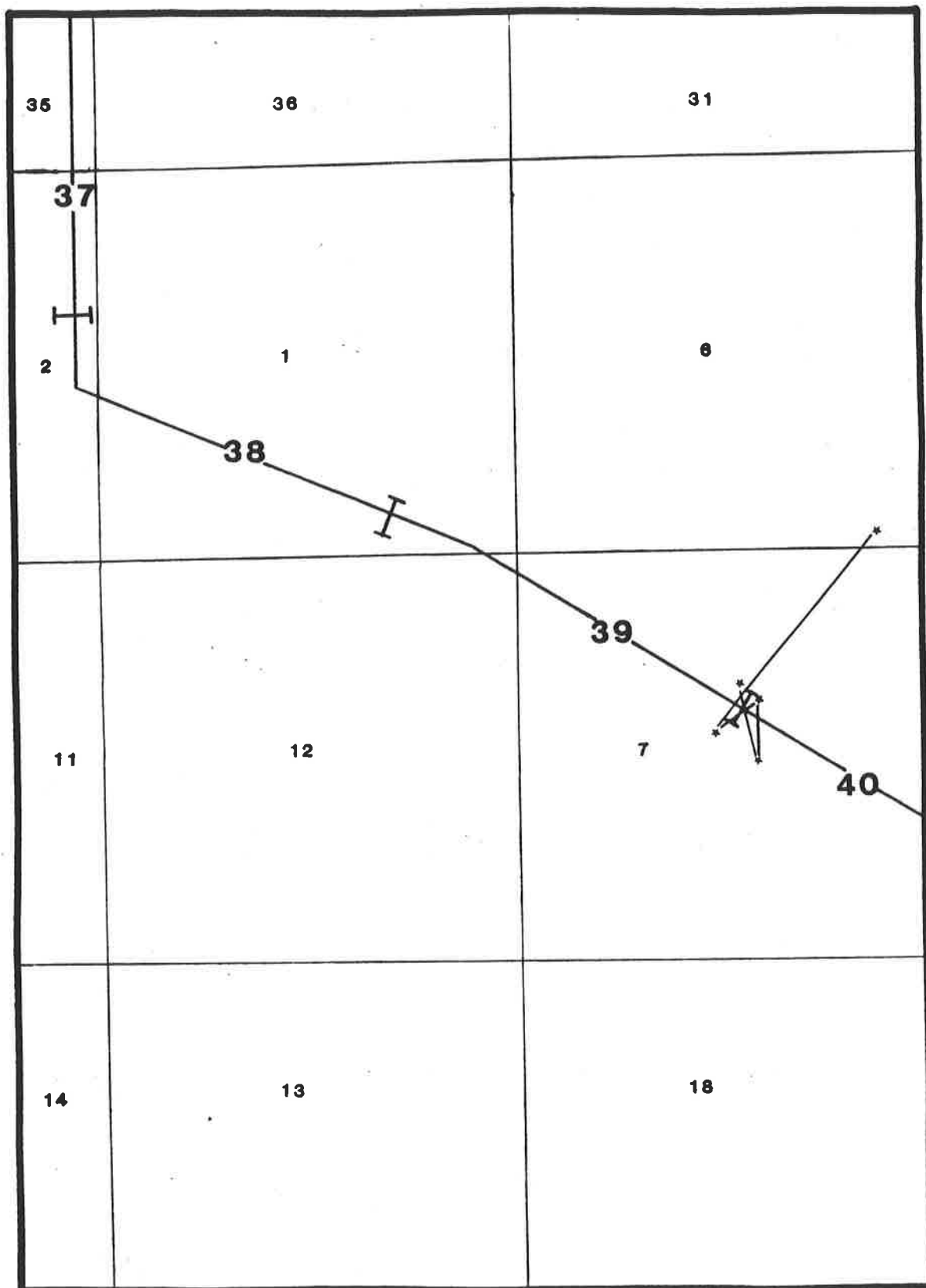


Appendix B-2. Coyote No. 65 - plotted from USGS 7.5 Quadrangle, Avra, Arizona, Range 10E, Township 13S.



A 3x3 grid with numbers 2 through 9. A path of 9 cells is highlighted, starting from the top-right cell (row 1, column 3) and ending at the bottom-left cell (row 3, column 1). The path consists of the following cells: (1,3), (1,2), (2,2), (2,3), (3,3), (3,2), (3,1), (2,1), and (1,1). The numbers in the grid are: Row 1: 4, 3, 2; Row 2: 9, 10, 11; Row 3: 16, 15, 14. The path cells are numbered 6, 7, 8, 9, 23, 9, 8, 7, 6 respectively from top to bottom. There are also some small symbols like stars and crosses on the grid.

Appendix B-2. Coyote No. 83 - plotted from USGS 7.5 Quadrangle,  
San Xavier Mission, Arizona, Range 13E, Township 16S.

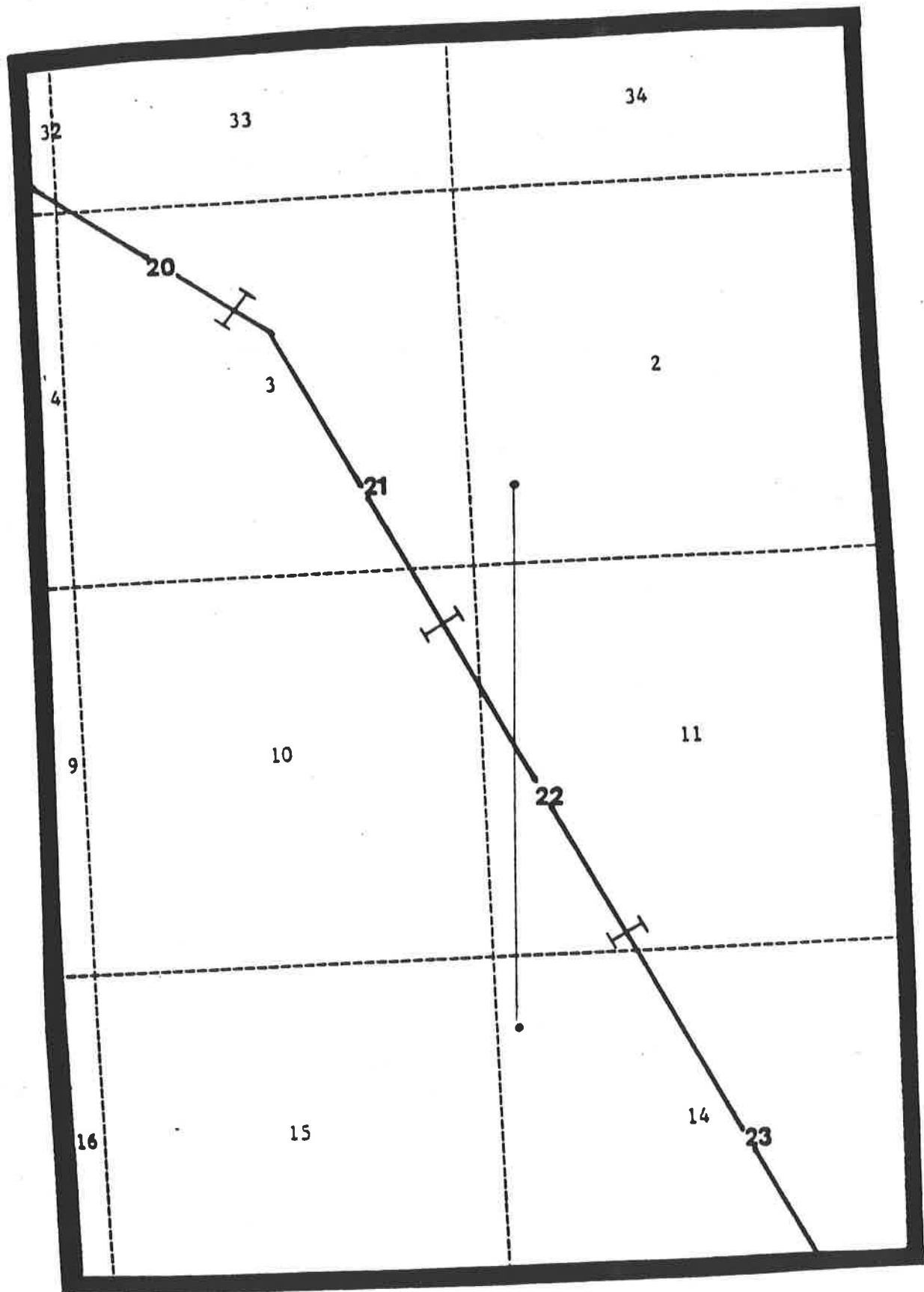




Appendix B-3  
Canal Segment Crossing Locations  
For Bobcat



Appendix B-3. Bobcat No. 57 - plotted from USGS 7.5 Quadrangle,  
Brown Mountain, Arizona, Range 11E, Township 14S.

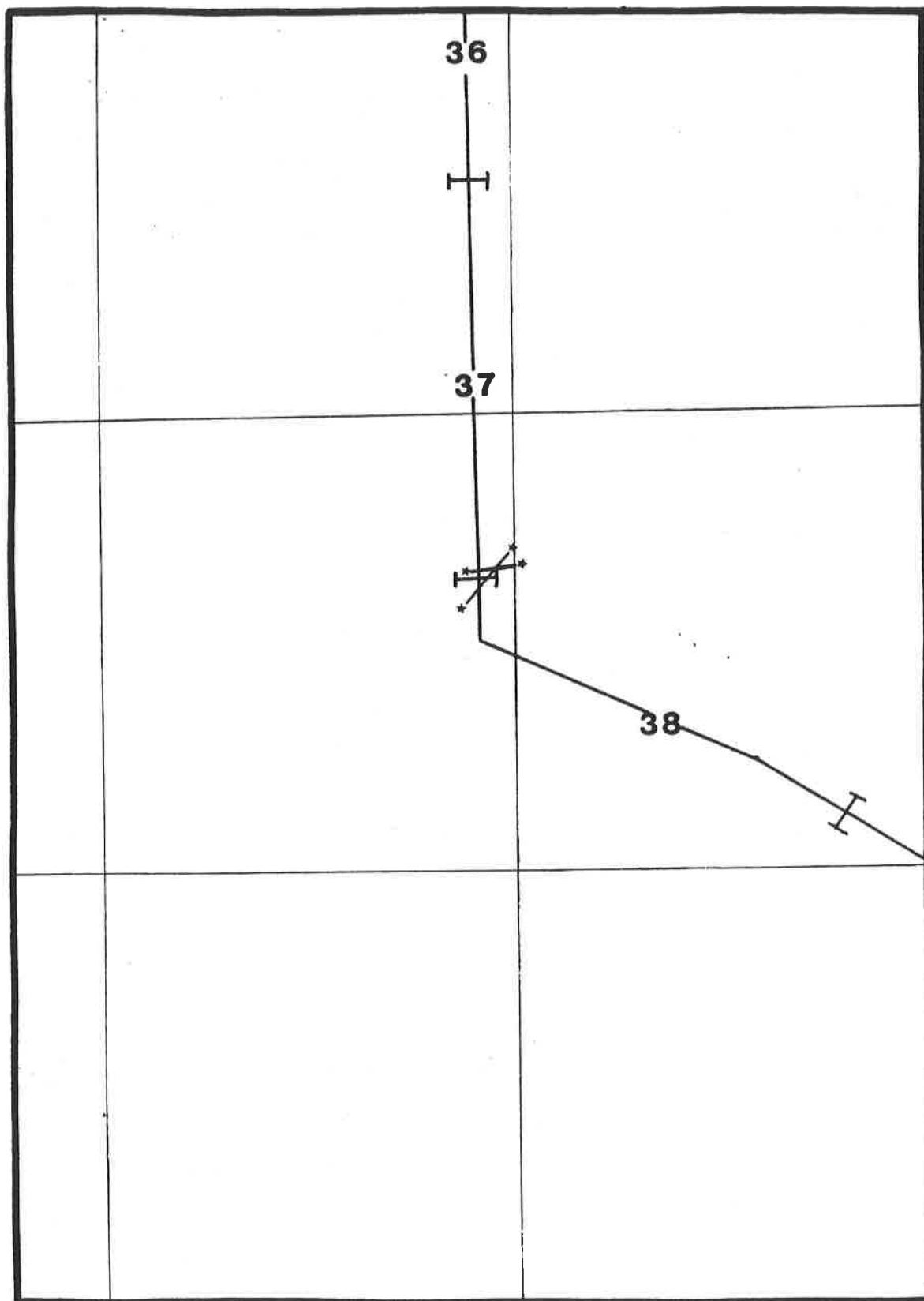




Appendix B-4  
Canal Segment Crossing Locations  
For Javelina



Appendix B-4. Javelina No. 85 - plotted from USGS 7.5 Quadrangle,  
San Xavier, Arizona, Range 13E, Township 16S.

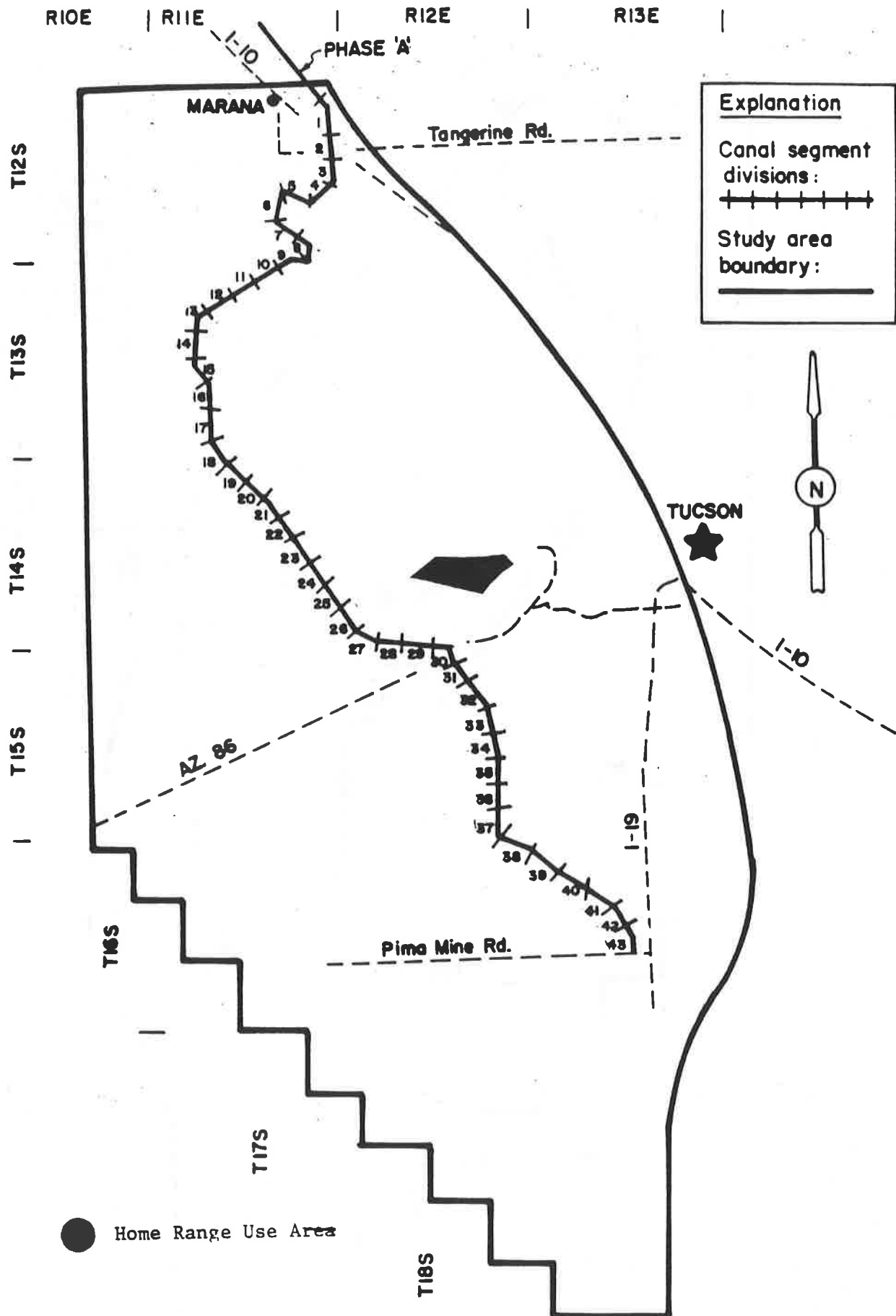




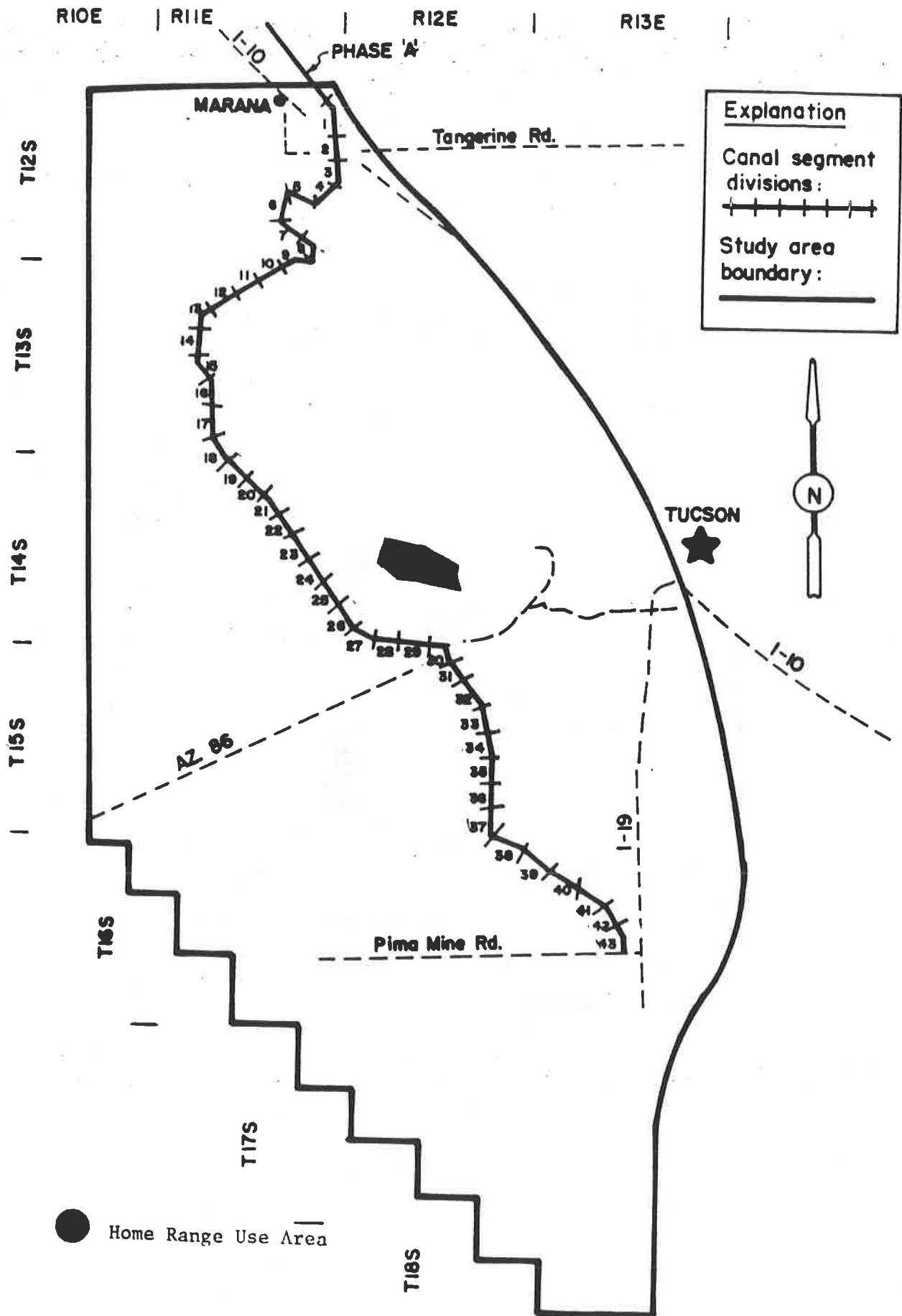
Appendix C-1  
Mule Deer Home Range Maps



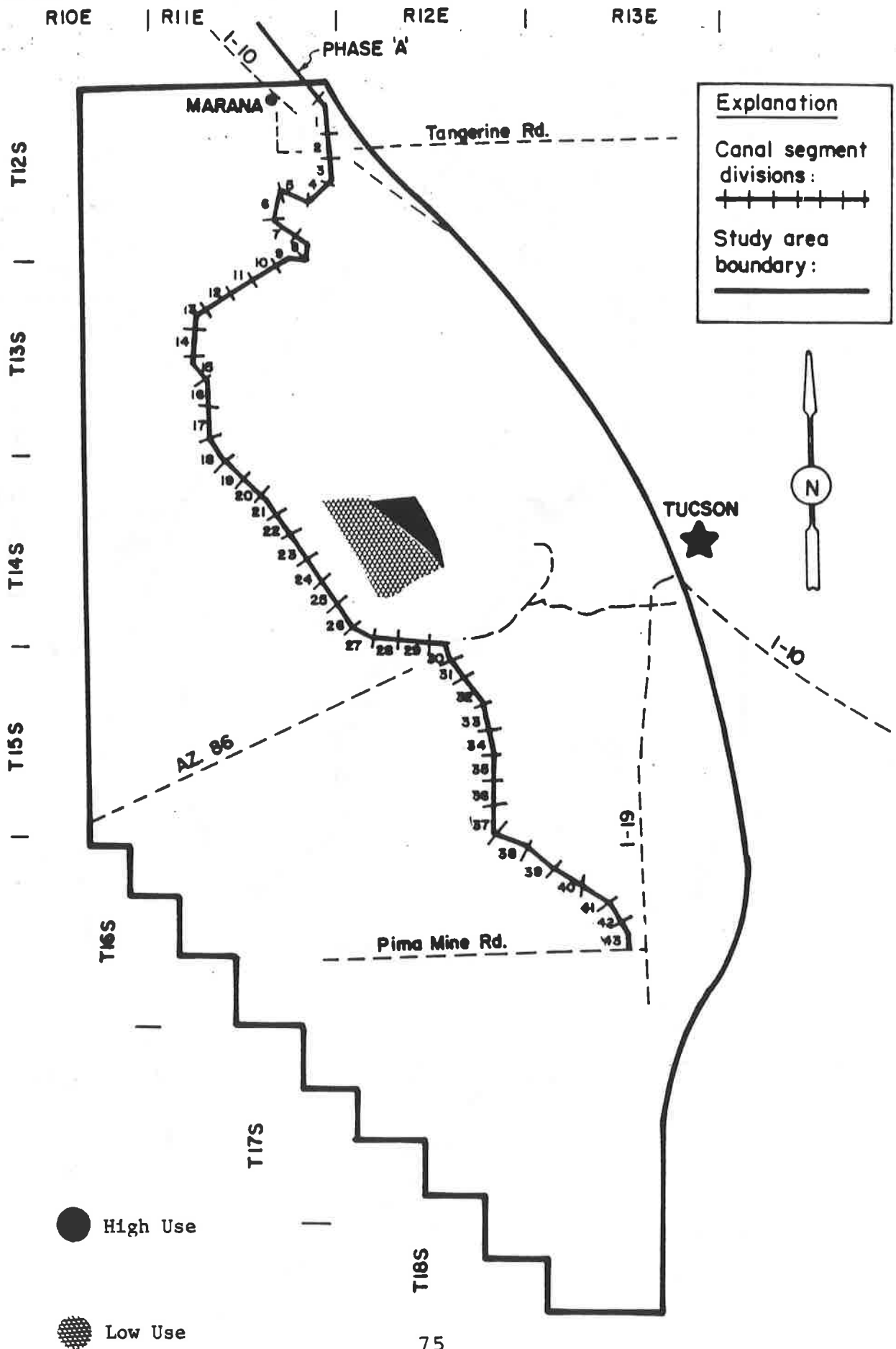
Appendix C-1. Home Range Map - Mule Deer ID No. 50



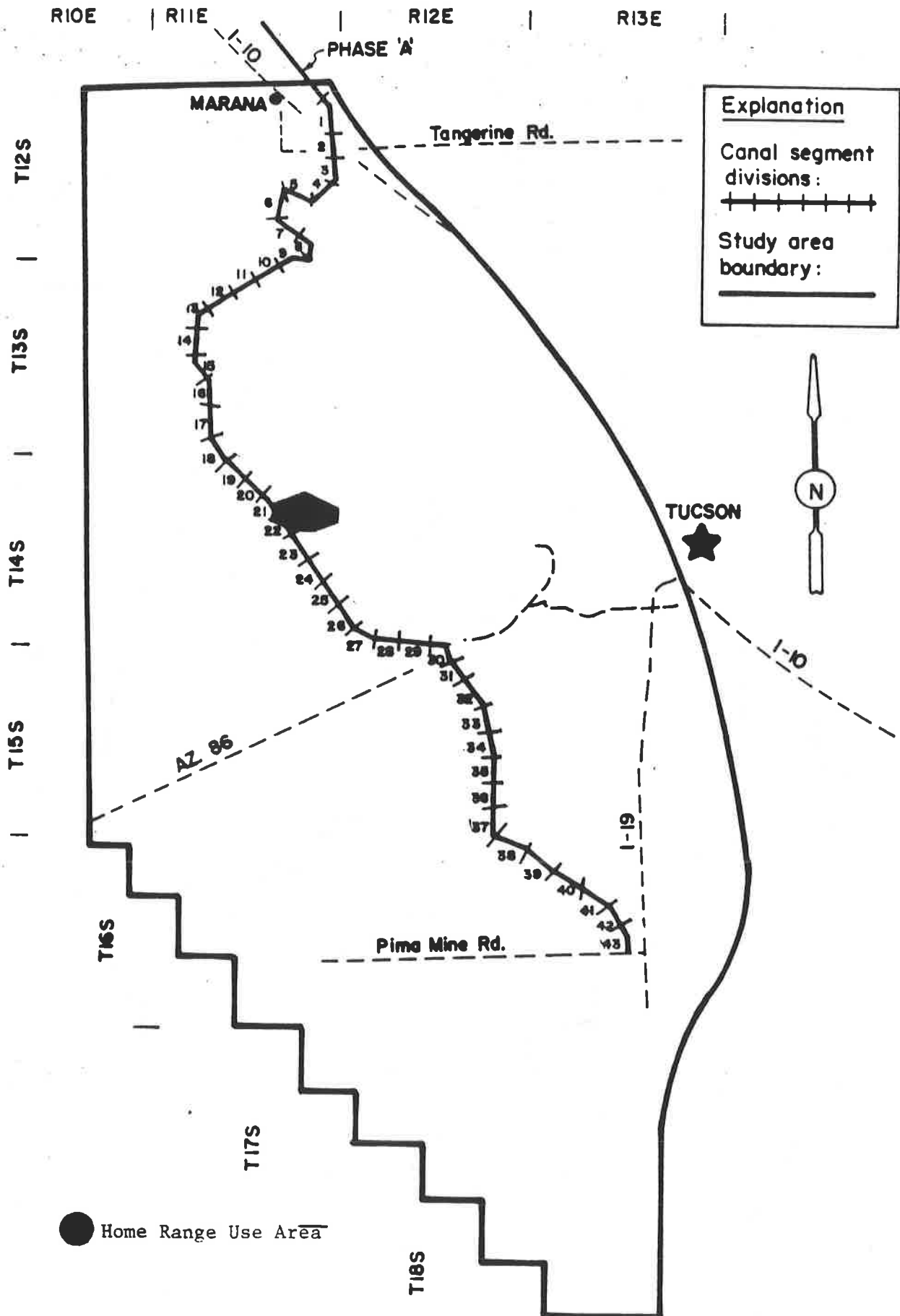
Appendix C-1. Home Range Map - Mule Deer ID No. 51

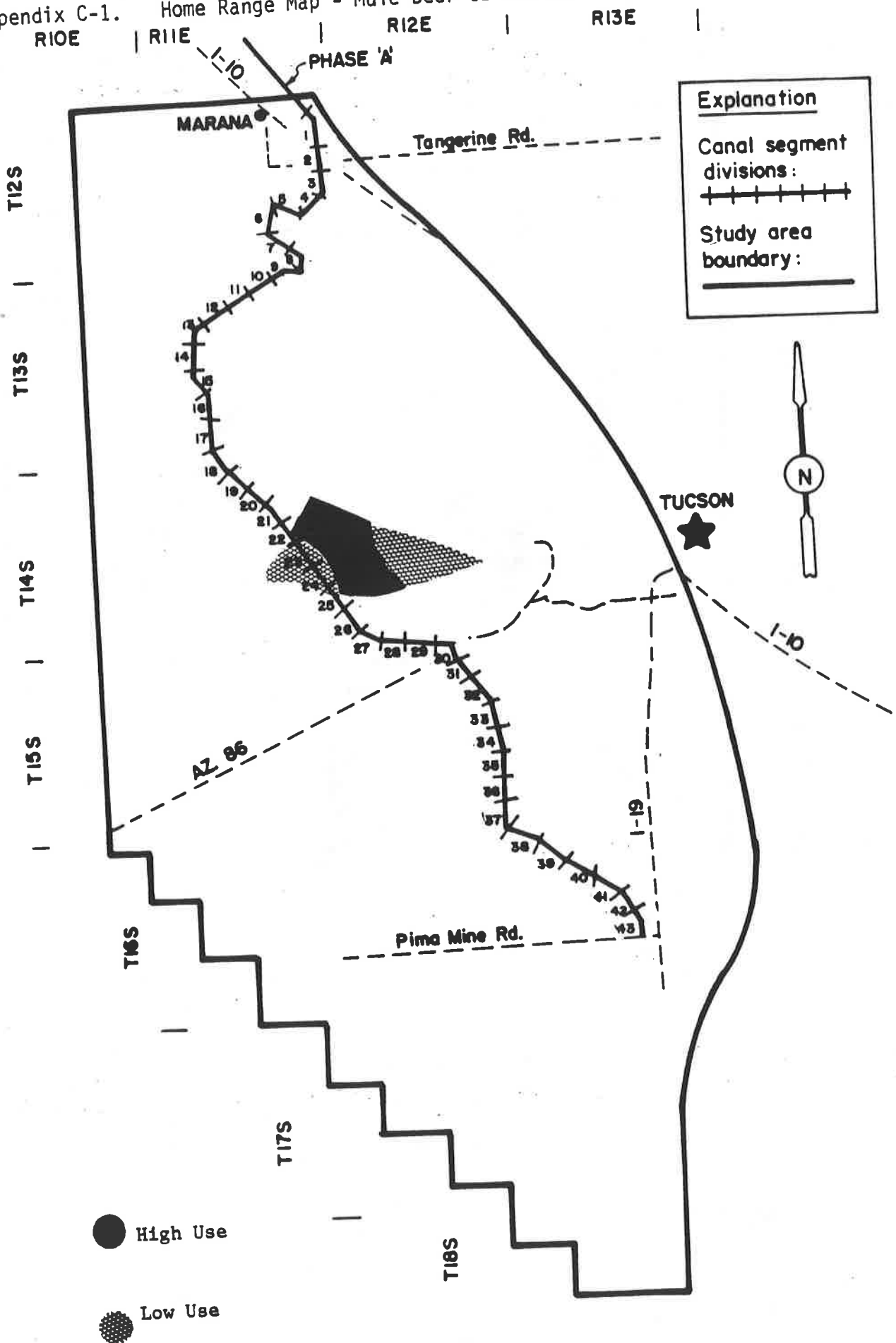


Appendix C-1. Home Range Map - Mule Deer ID No. 52

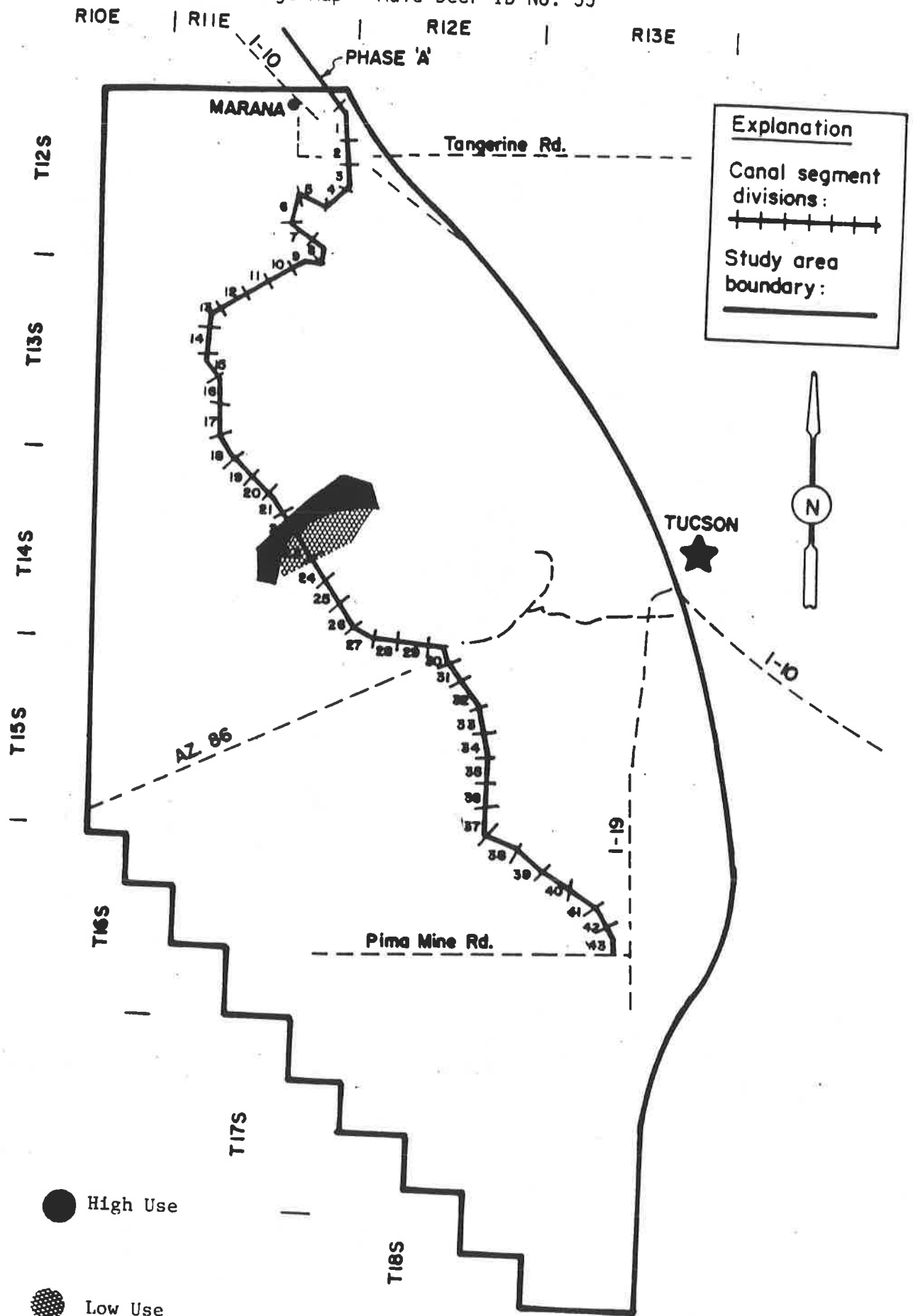


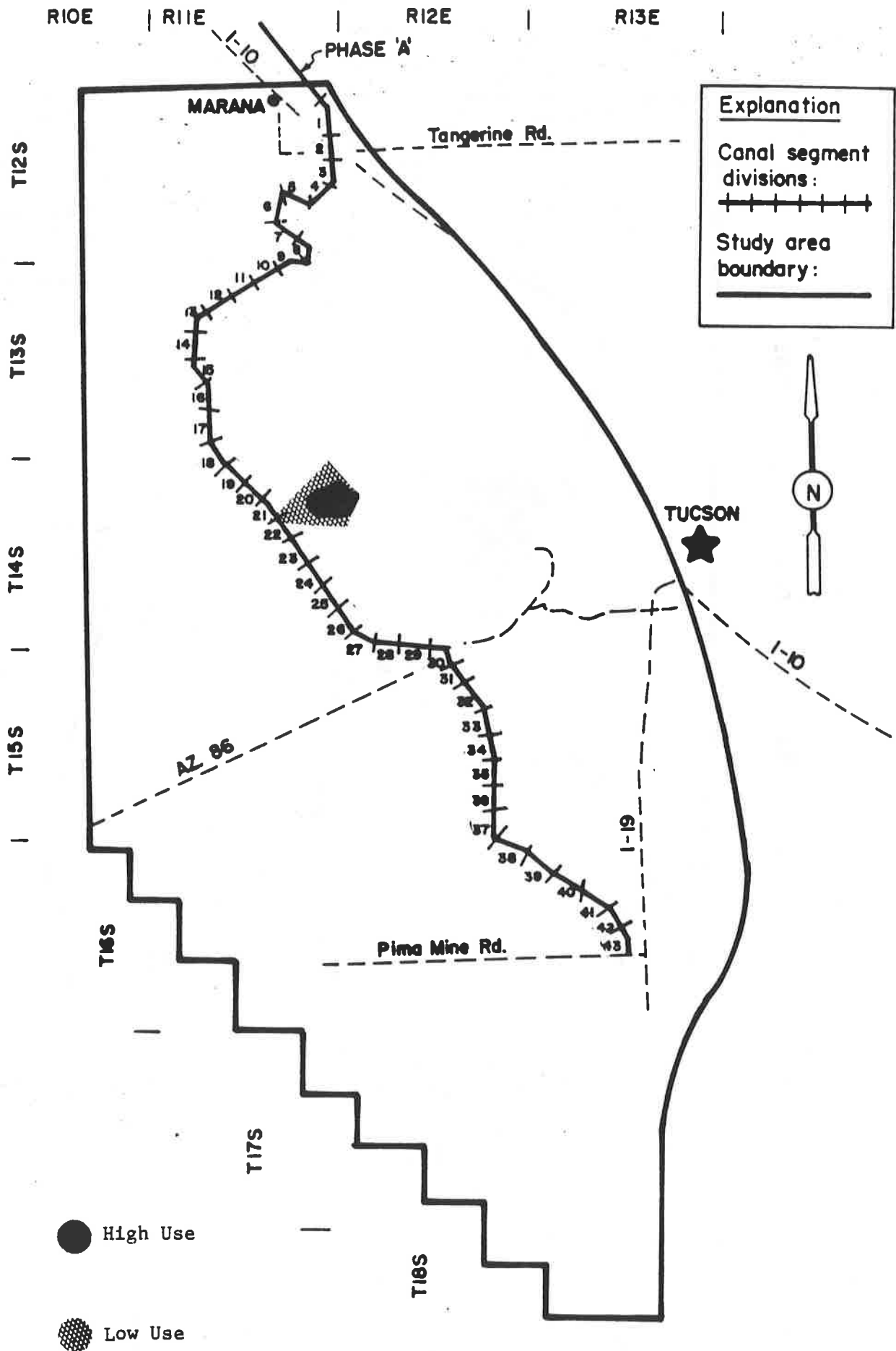
Appendix C-1. Home Range Map - Mule Deer ID No. 53



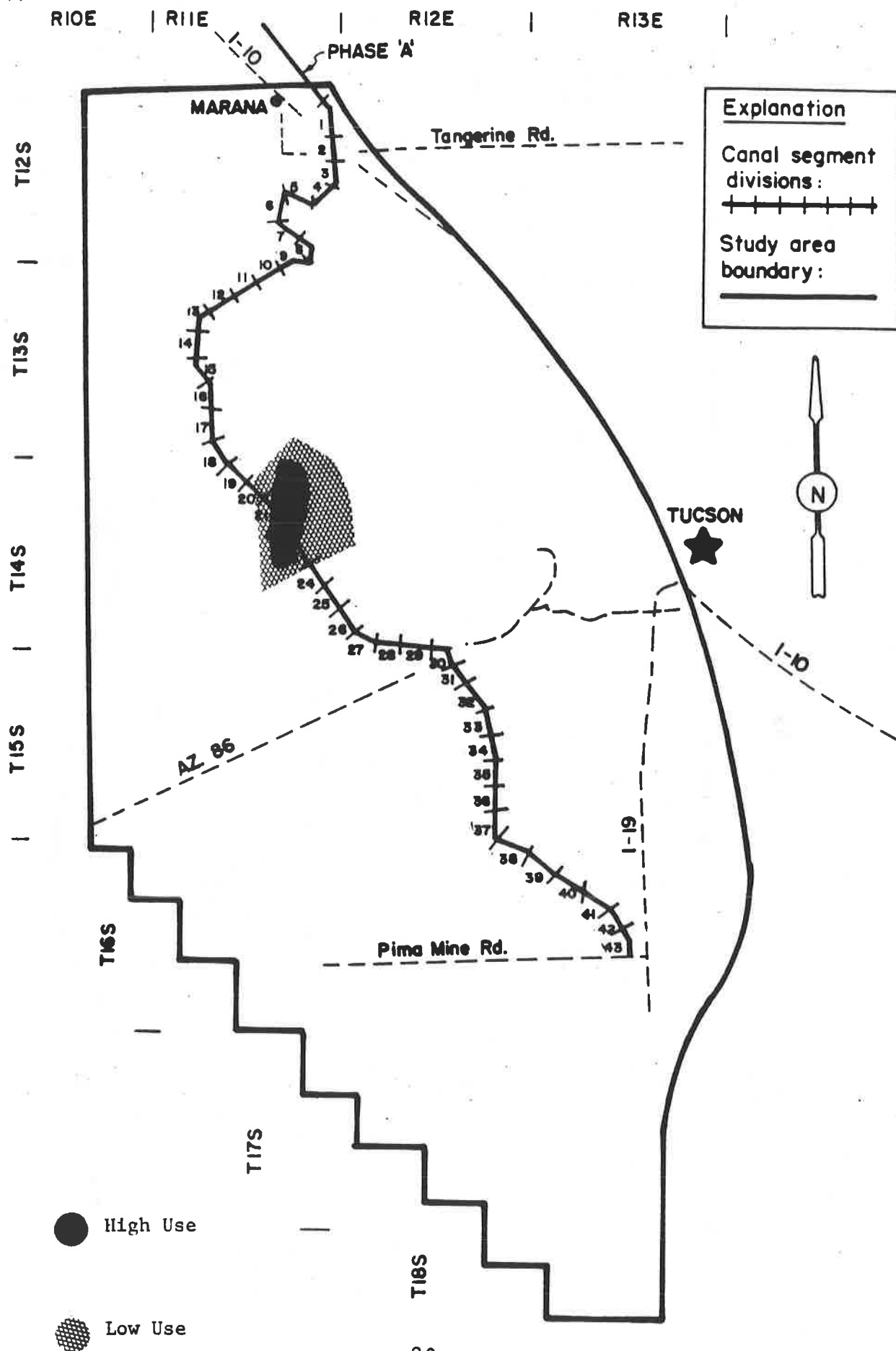


Appendix C-1. Home Range Map - Mule Deer ID No. 55

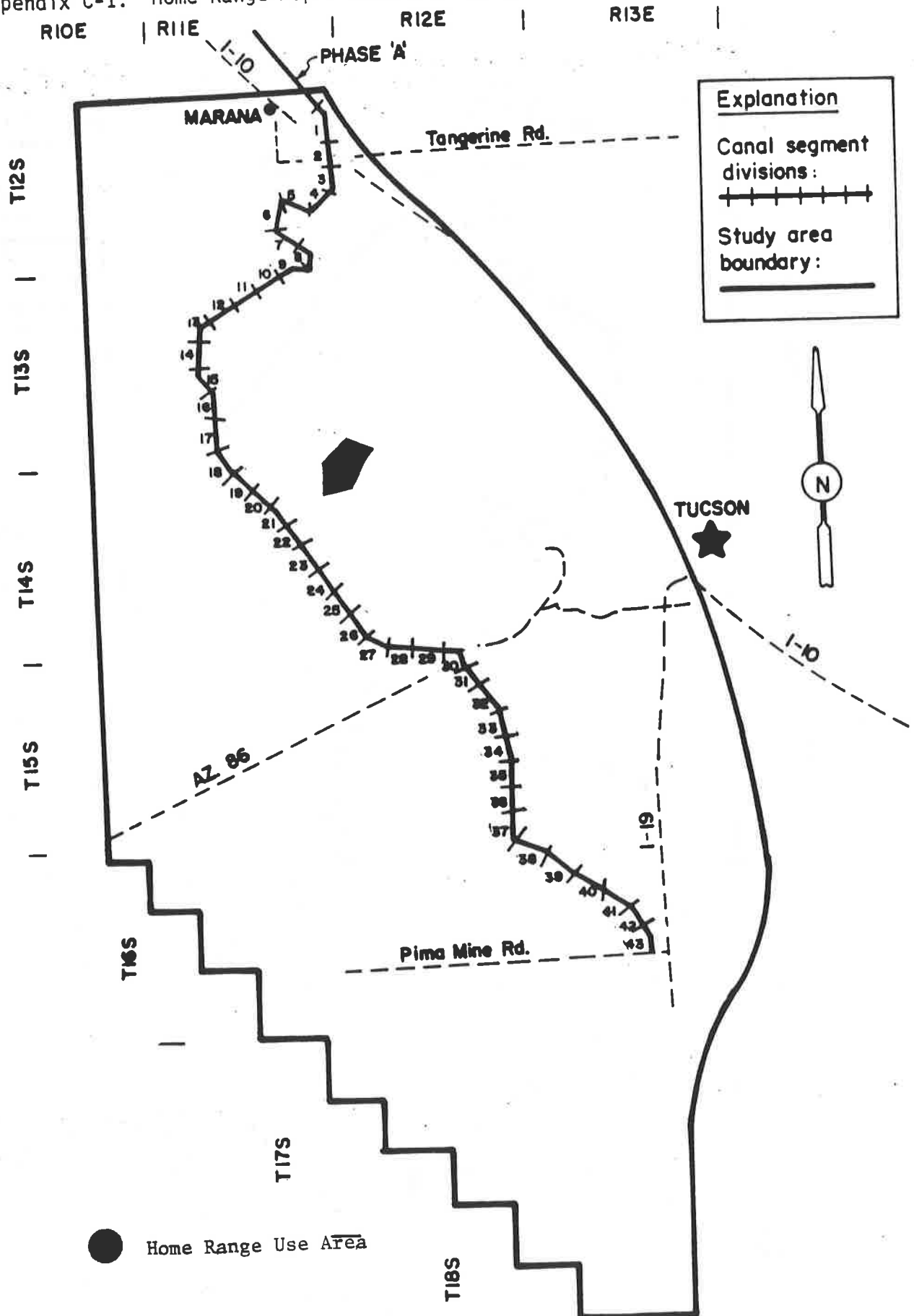




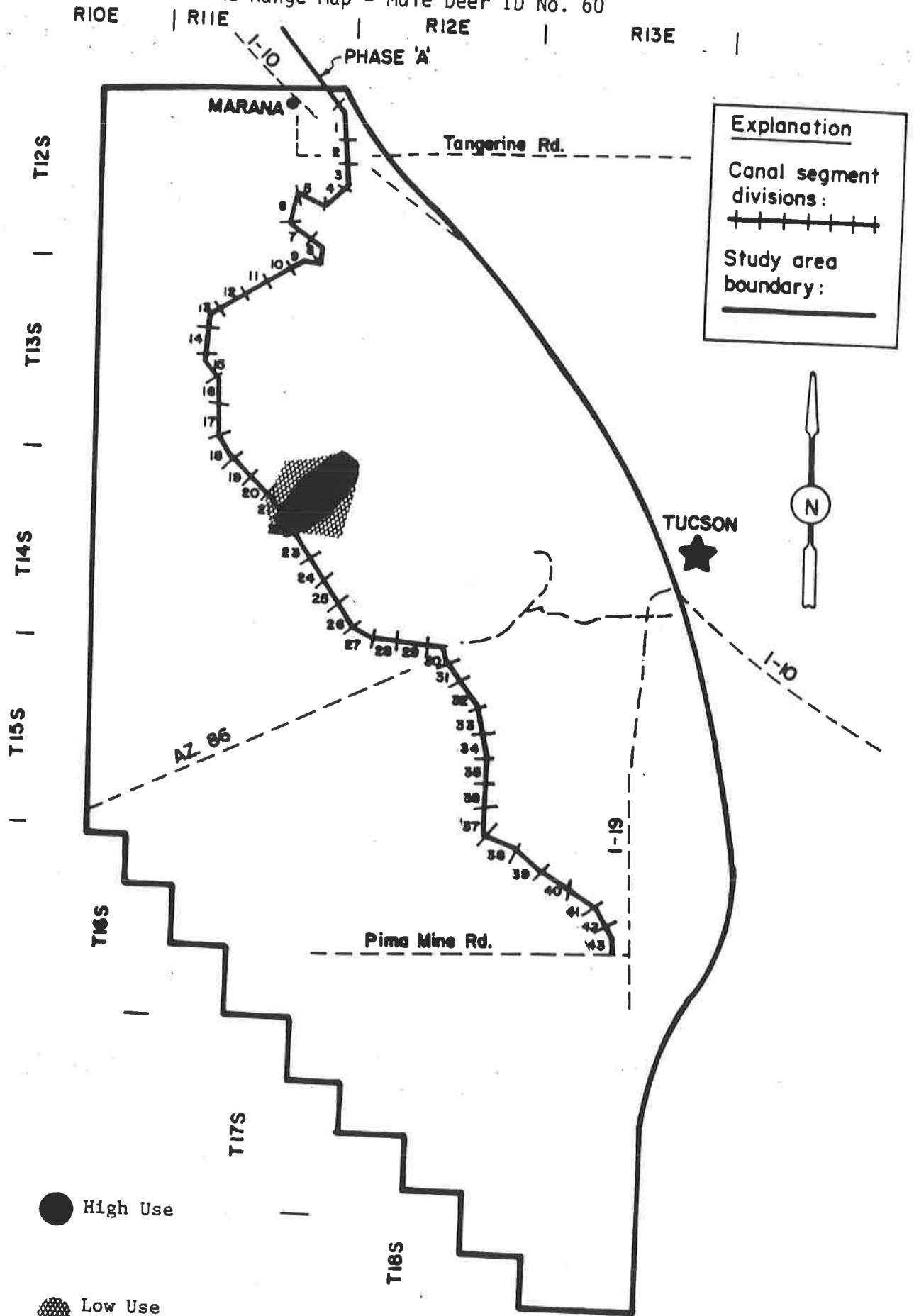
Appendix C-1. Home Range Map - Mule Deer ID No. 58

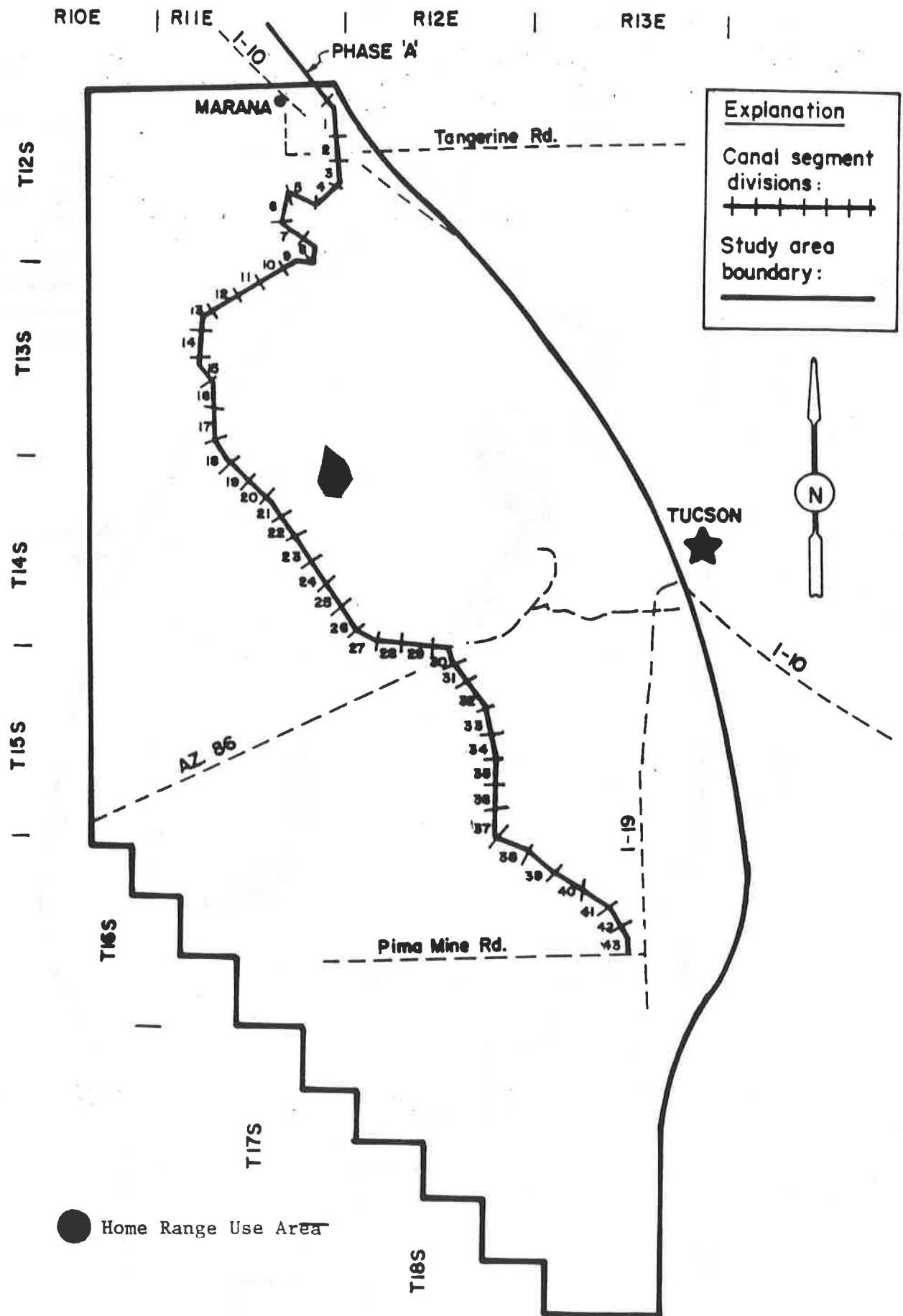


Appendix C-1. Home Range Map - Mule Deer ID No. 59

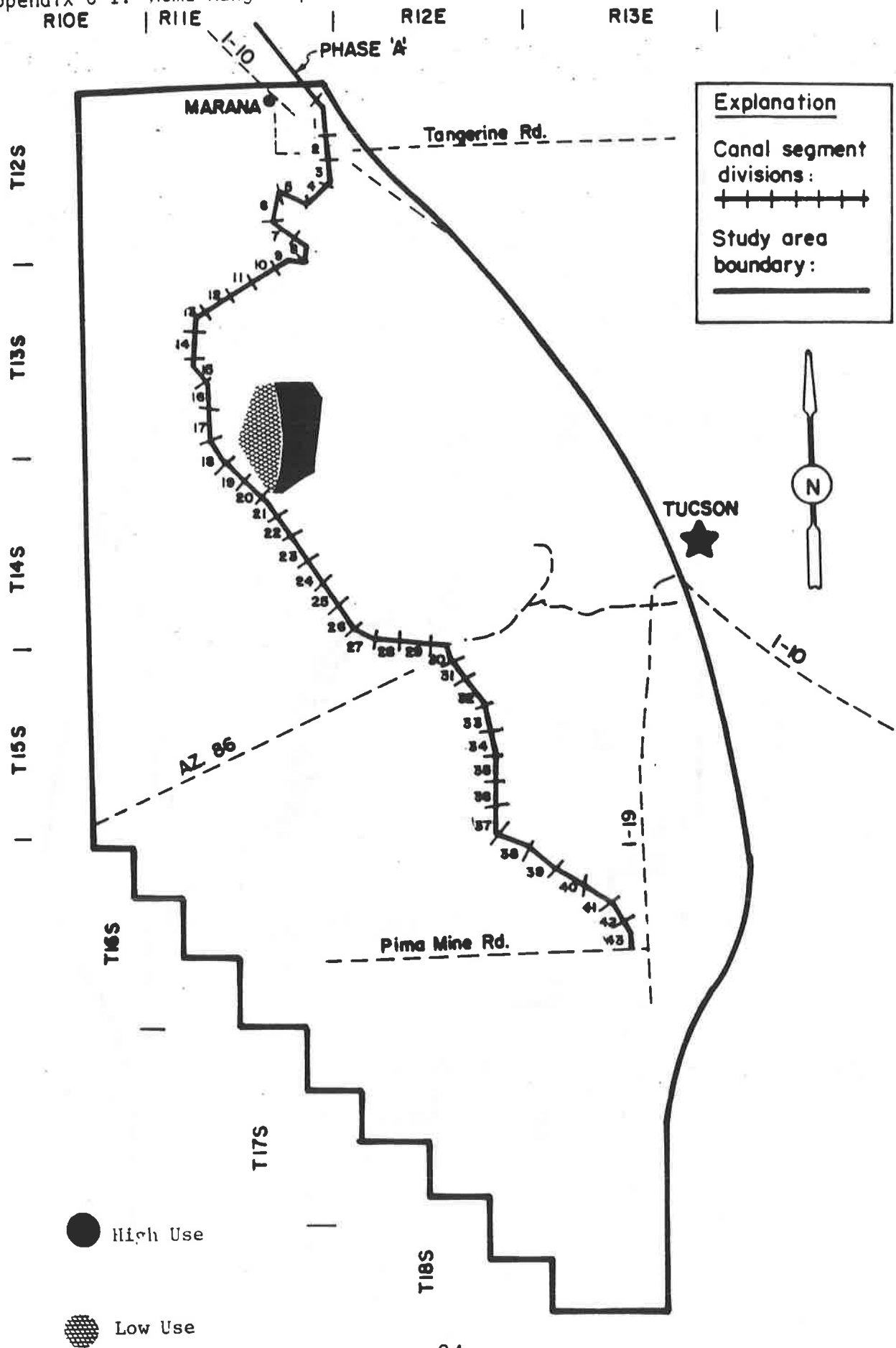


Appendix C-1. Home Range Map - Mule Deer ID No. 60

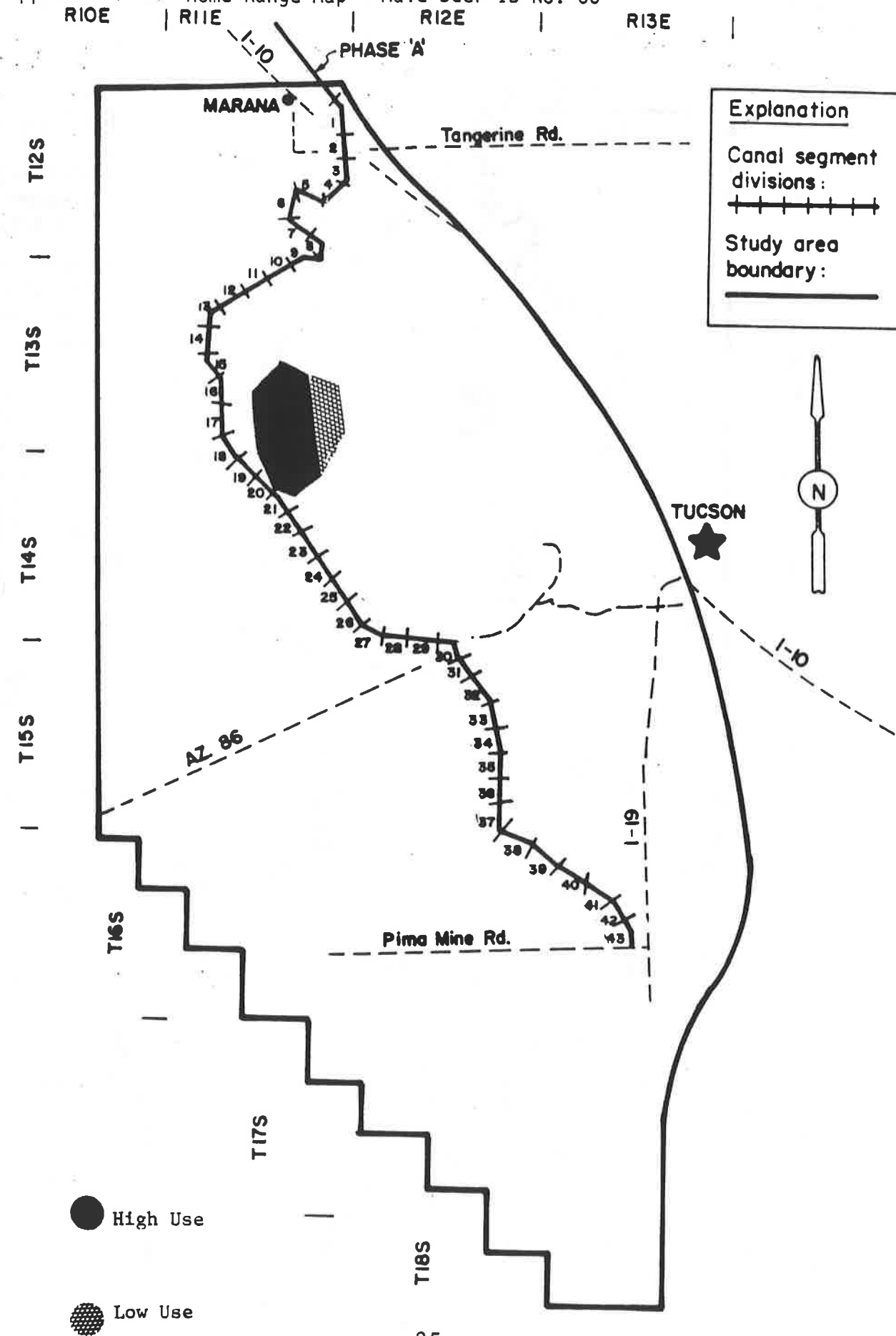




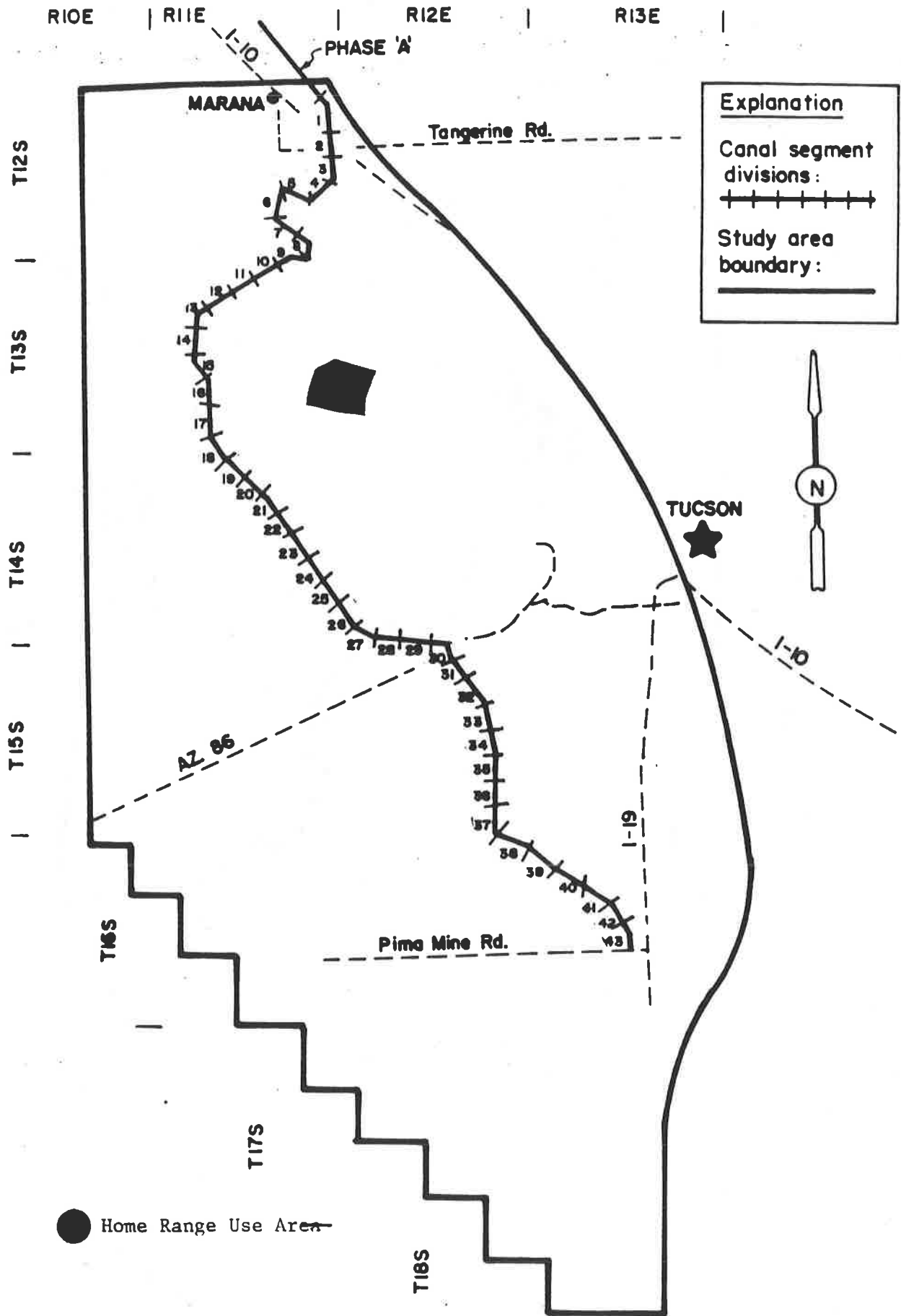
Appendix C-1. Home Range Map - Mule Deer ID No. 63



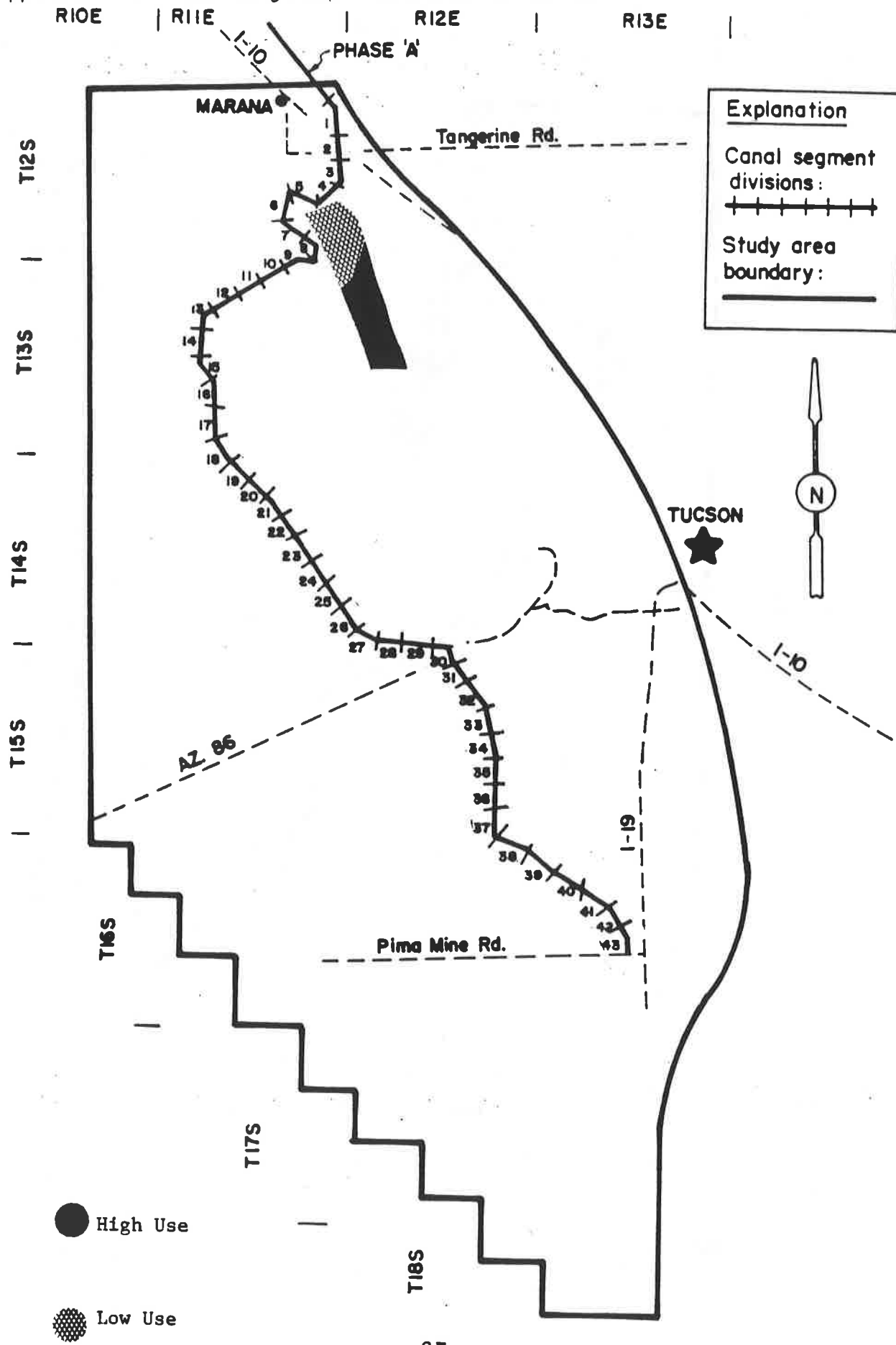
Appendix C-1. Home Range Map - Mule Deer ID No. 66



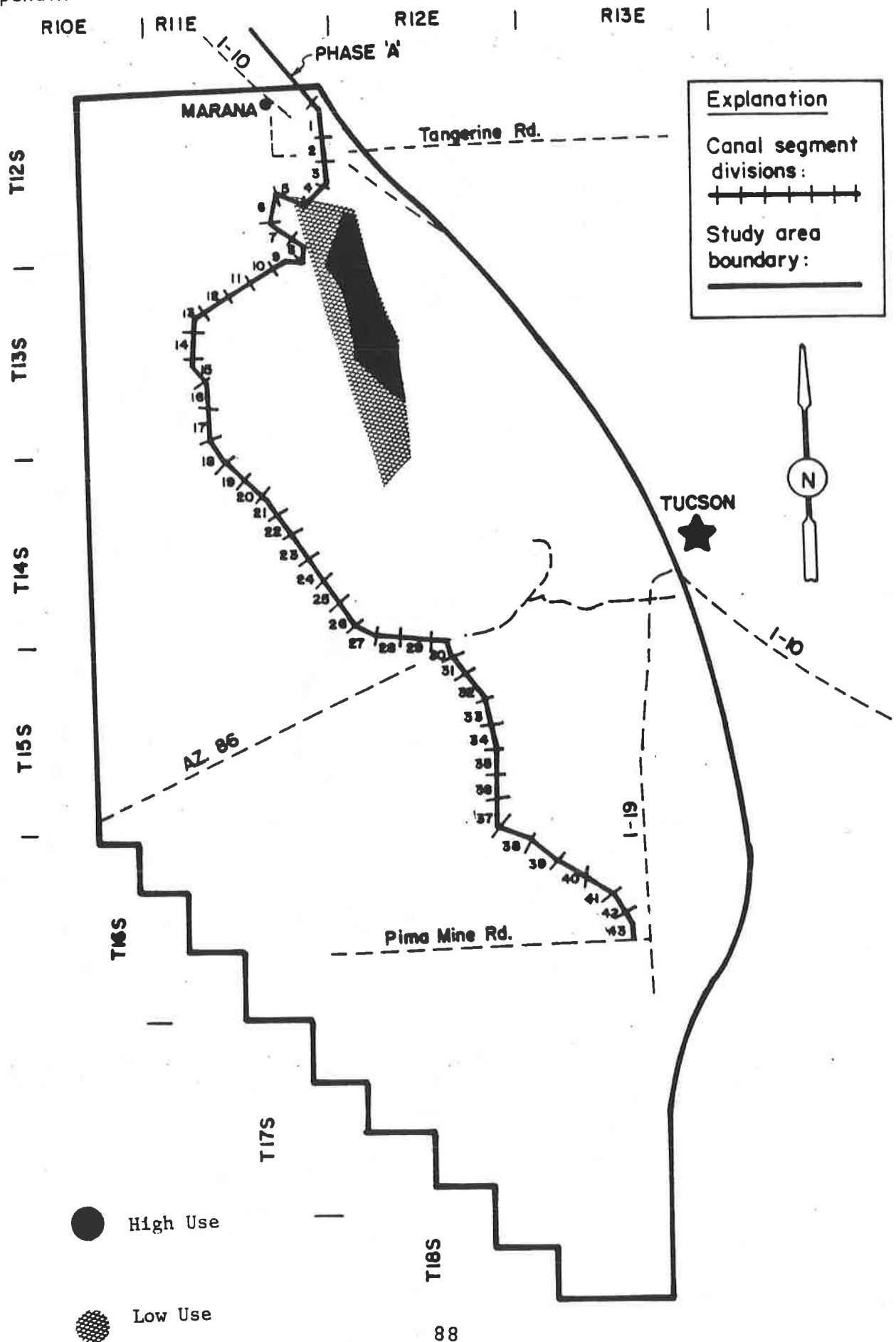
Appendix C-1. Home Range Map - Mule Deer ID No. 67

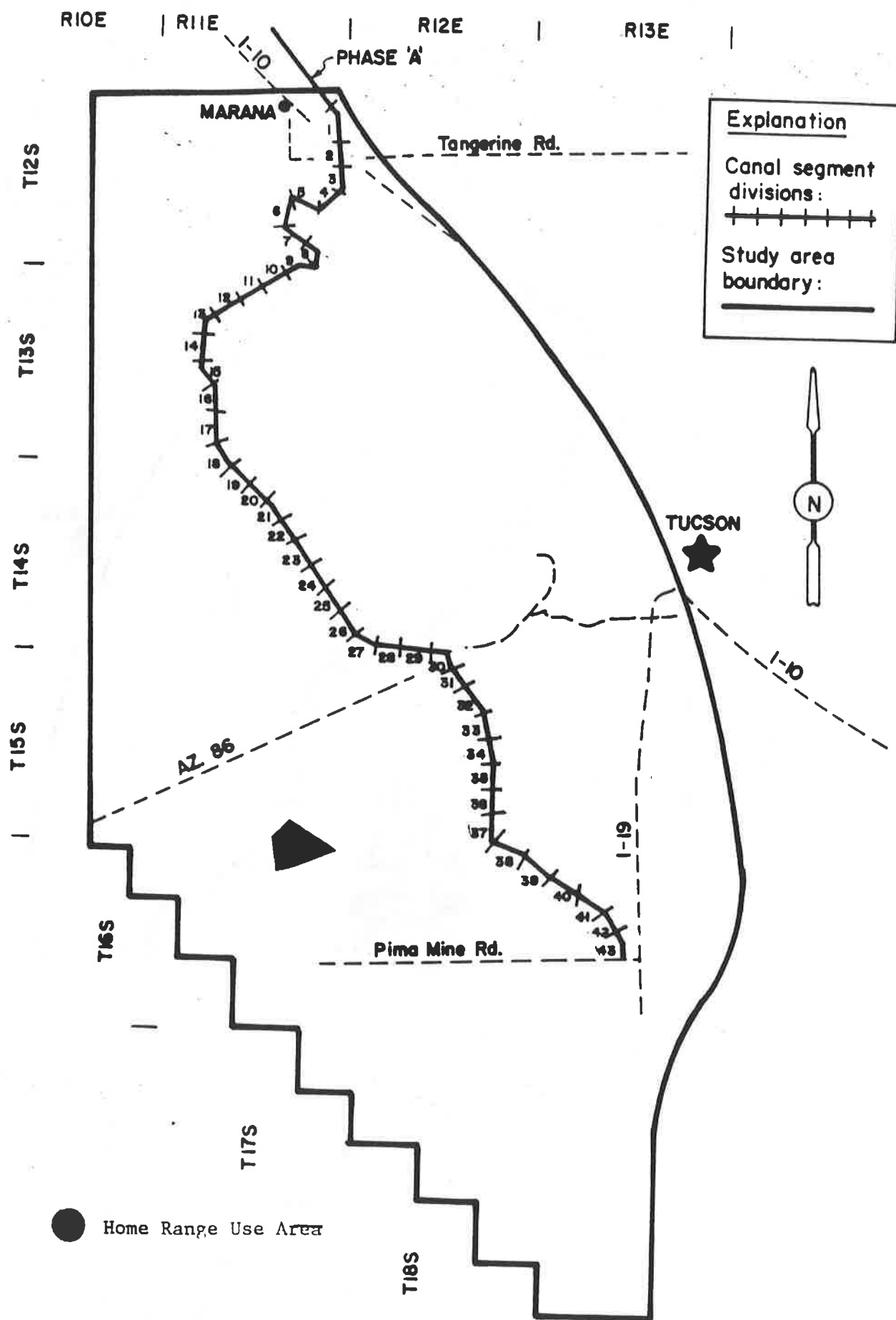


Appendix C-1. Home Range Map - Mule Deer ID No. 68

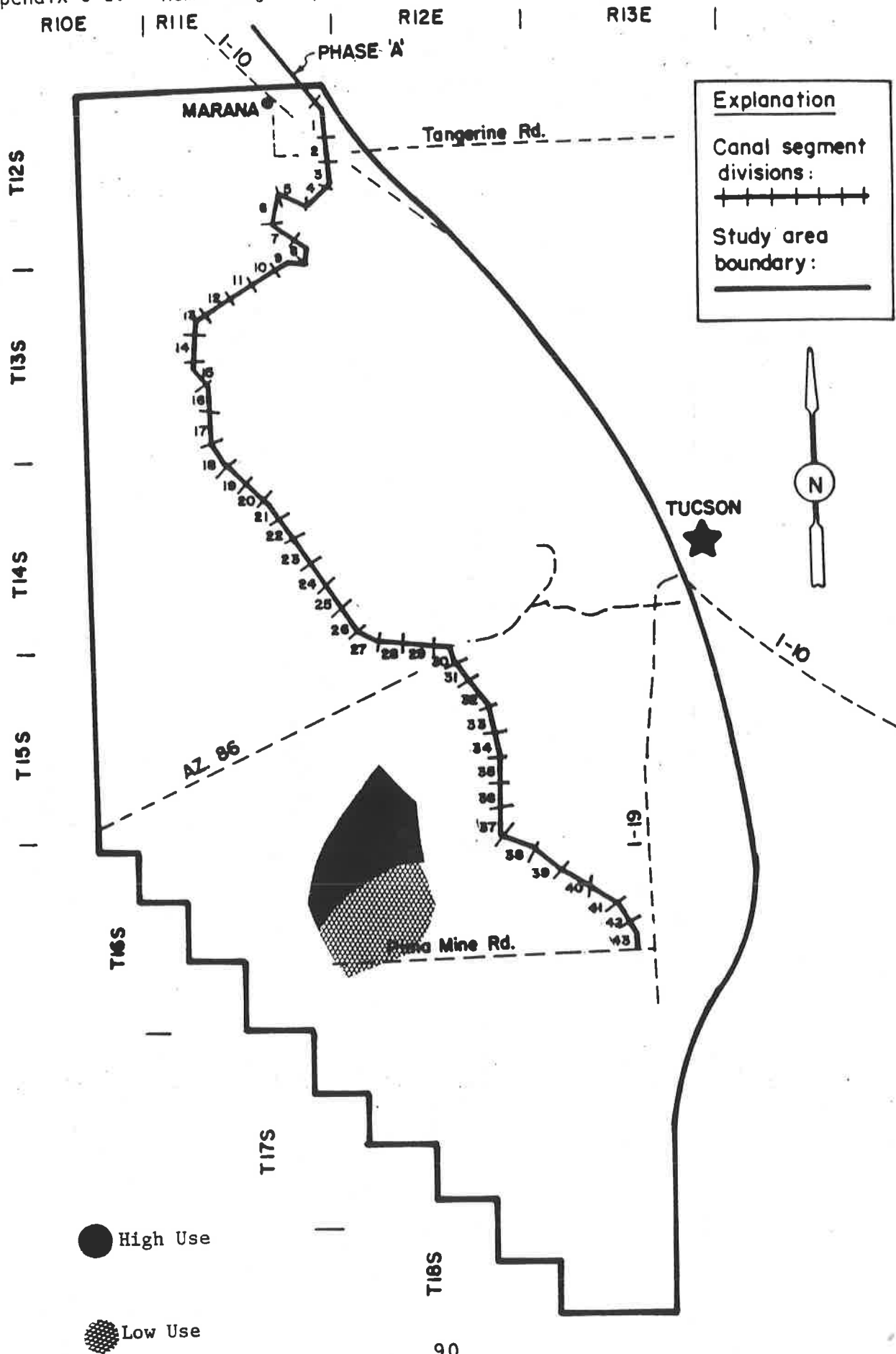


Appendix C-1. Home Range Map - Mule Deer ID No. 70

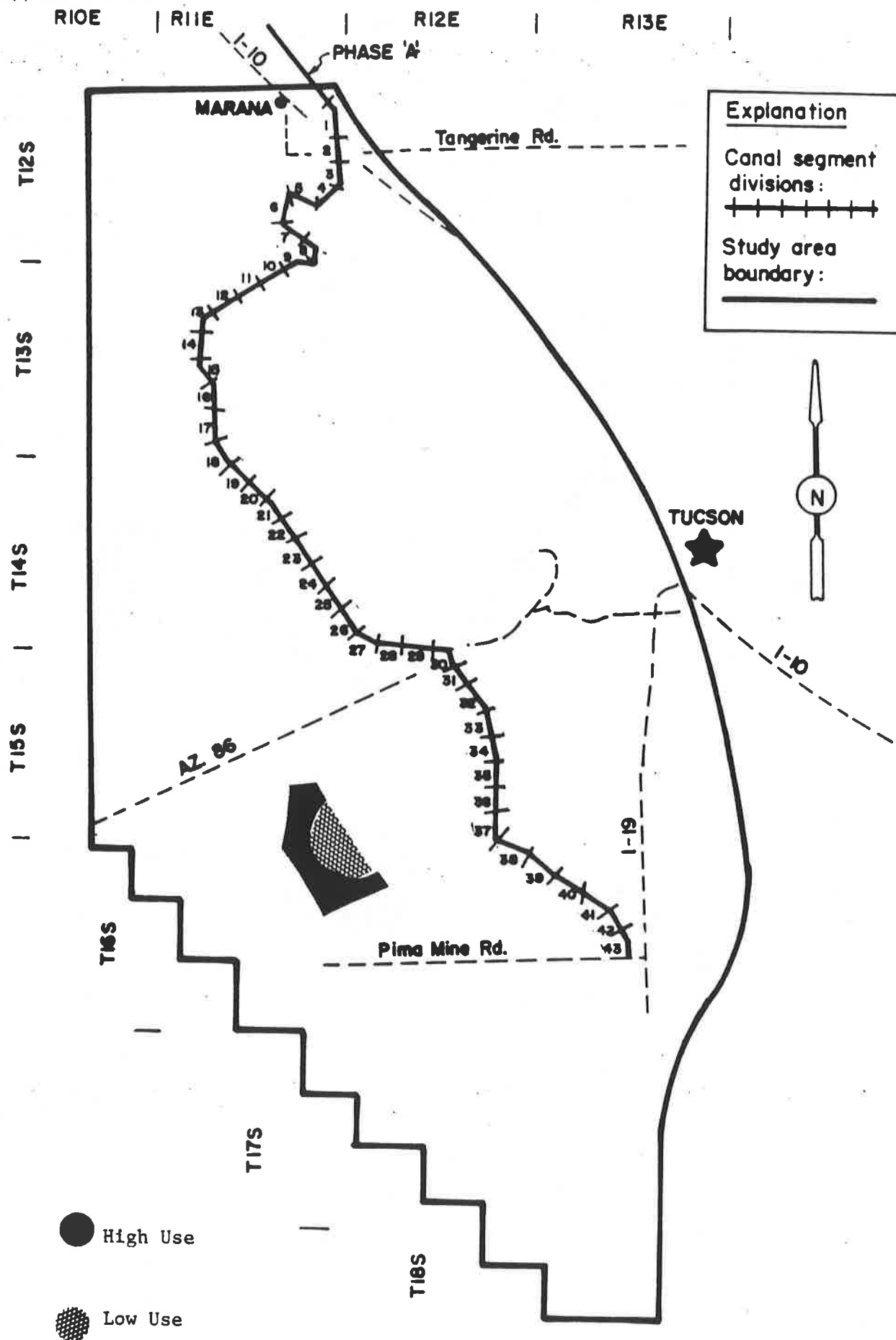




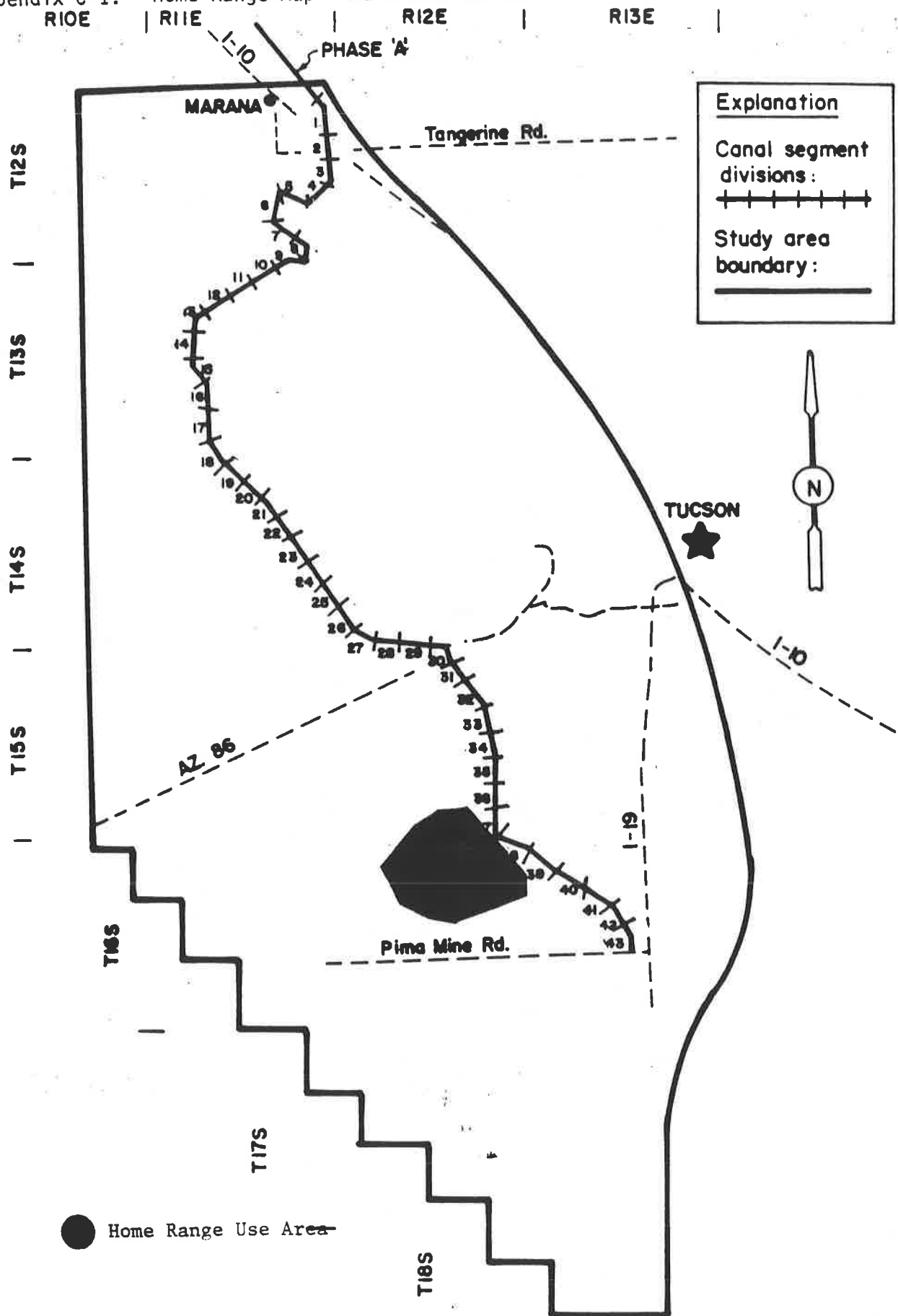
Appendix C-1. Home Range Map - Mule Deer ID No. 74

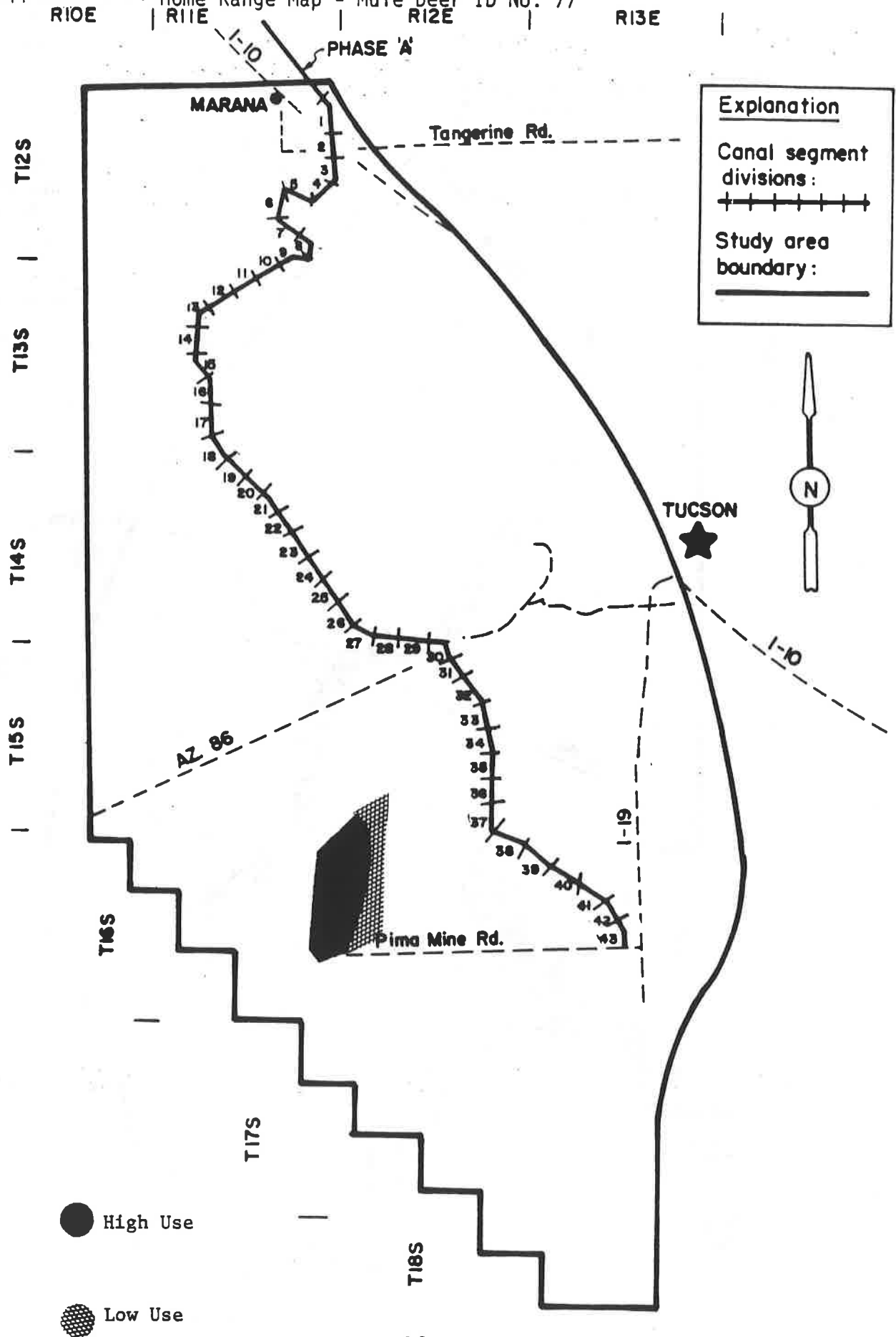


Appendix C-1. Home Range Map - Mule Deer ID No. 75

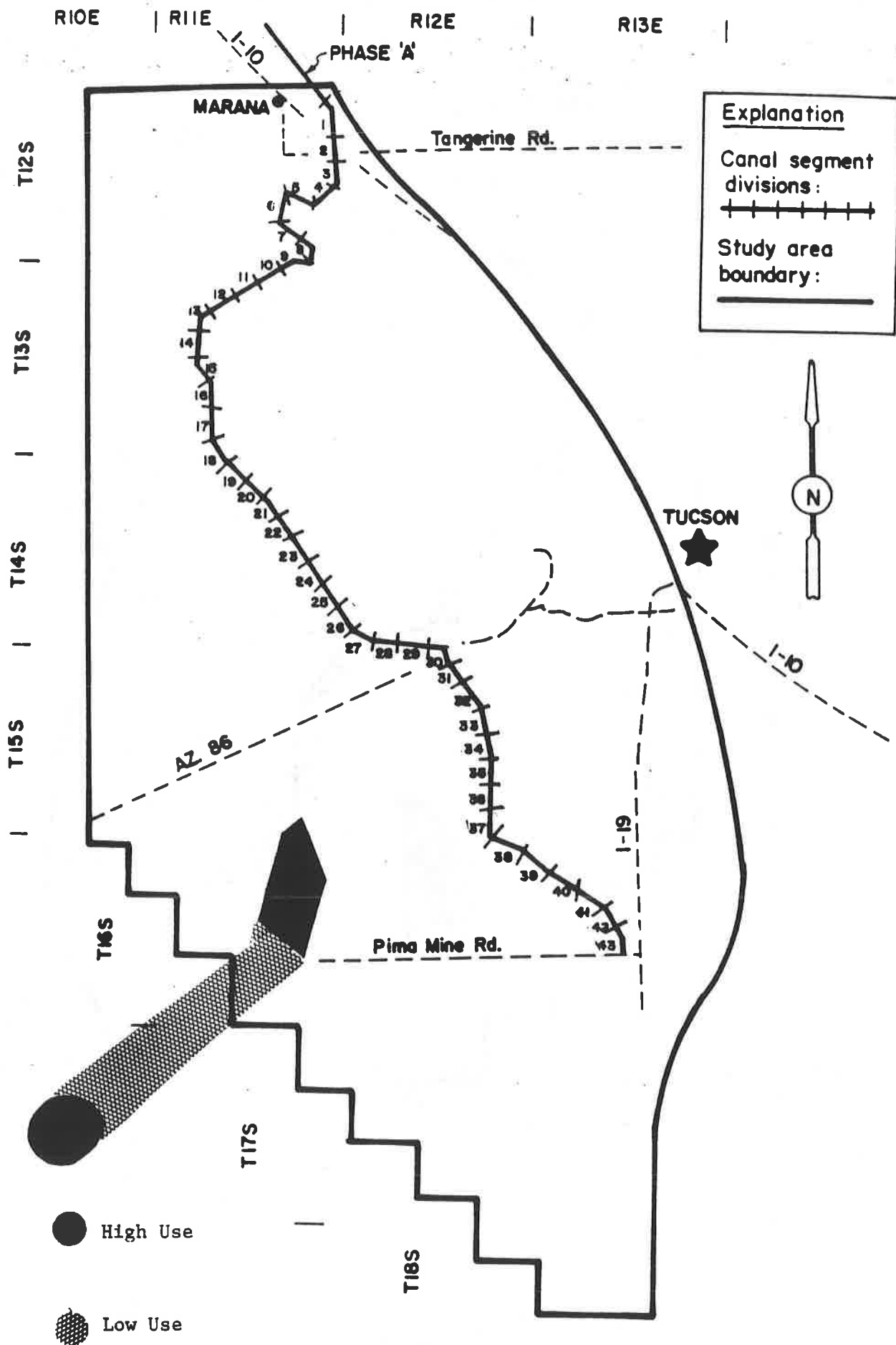


Appendix C-1. Home Range Map - Mule Deer ID No. 76

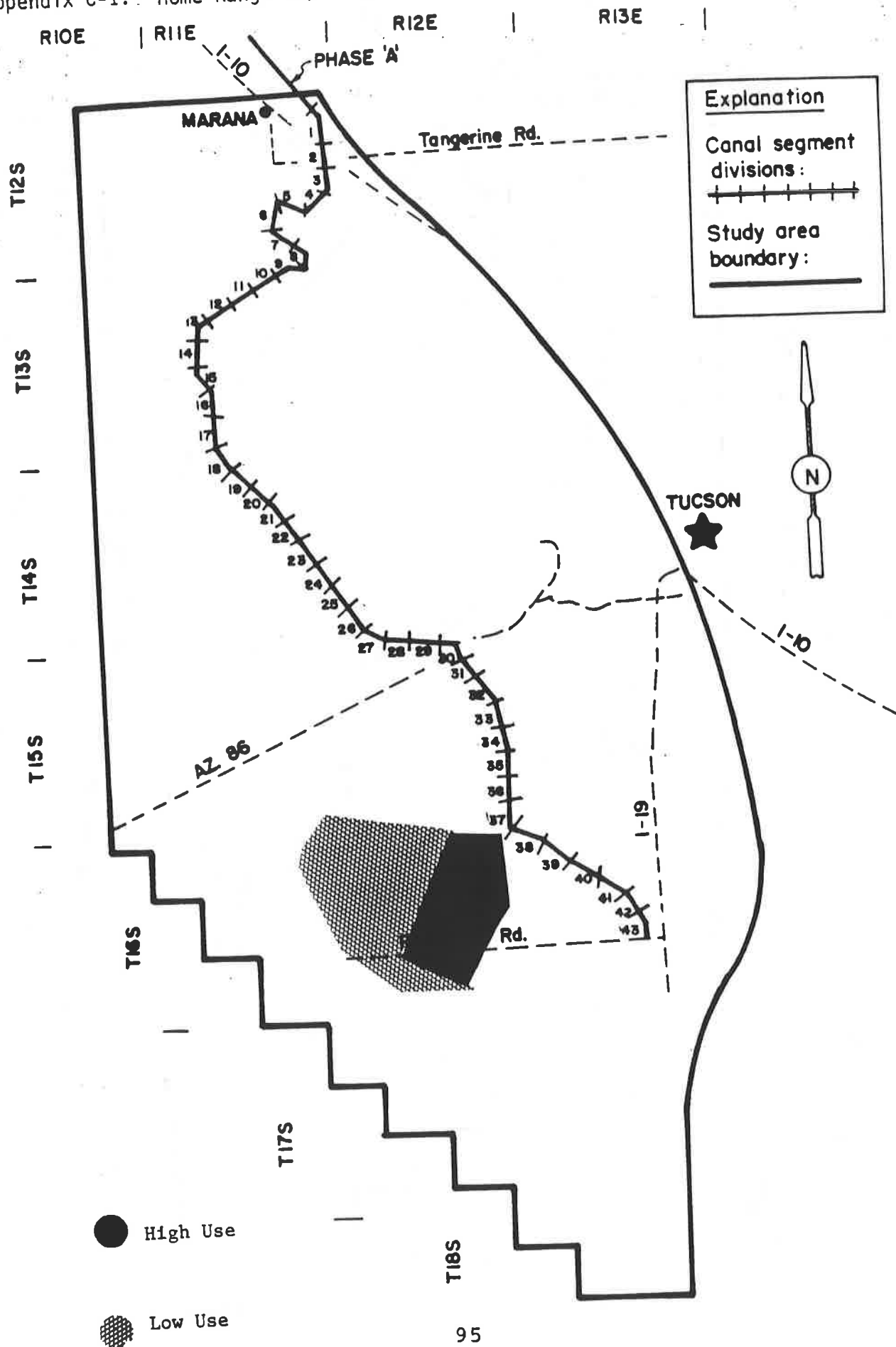




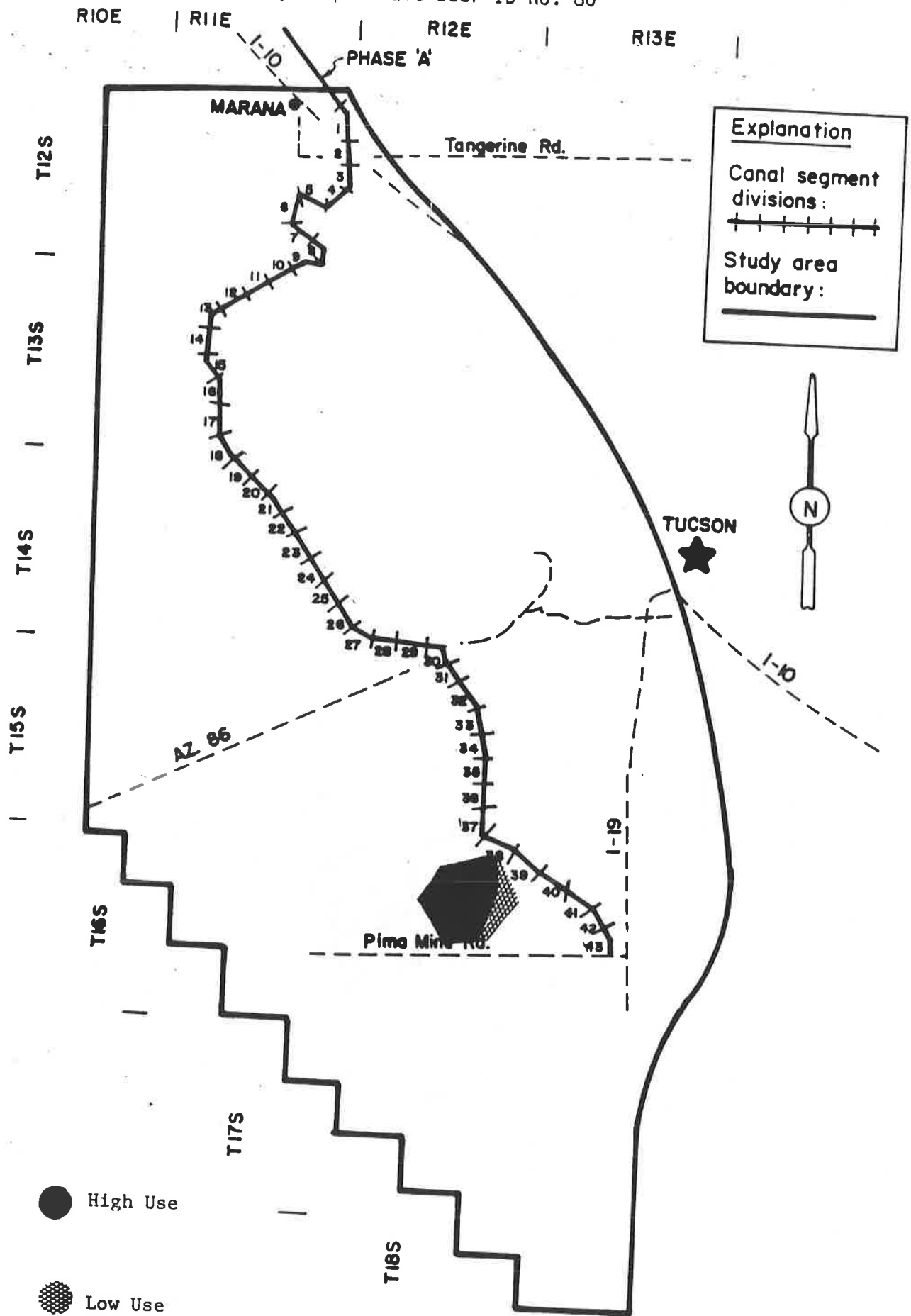
Appendix C-1. Home Range Map - Mule Deer ID No. 78



# Appendix C-1. Home Range Map - Mule Deer ID No. 79



Appendix C-1. Home Range Map - Mule Deer ID No. 80



Appendix C-1. Home Range Map - Mule Deer ID No. 84

R10E | R11E | R12E | R13E

T12S

T13S

T14S

T15S

T16S

T17S

T18S

MARANA

PHASE 'A'

Tangerine Rd.

TUCSON

AZ 86

Pima Mine Rd.

Explanation

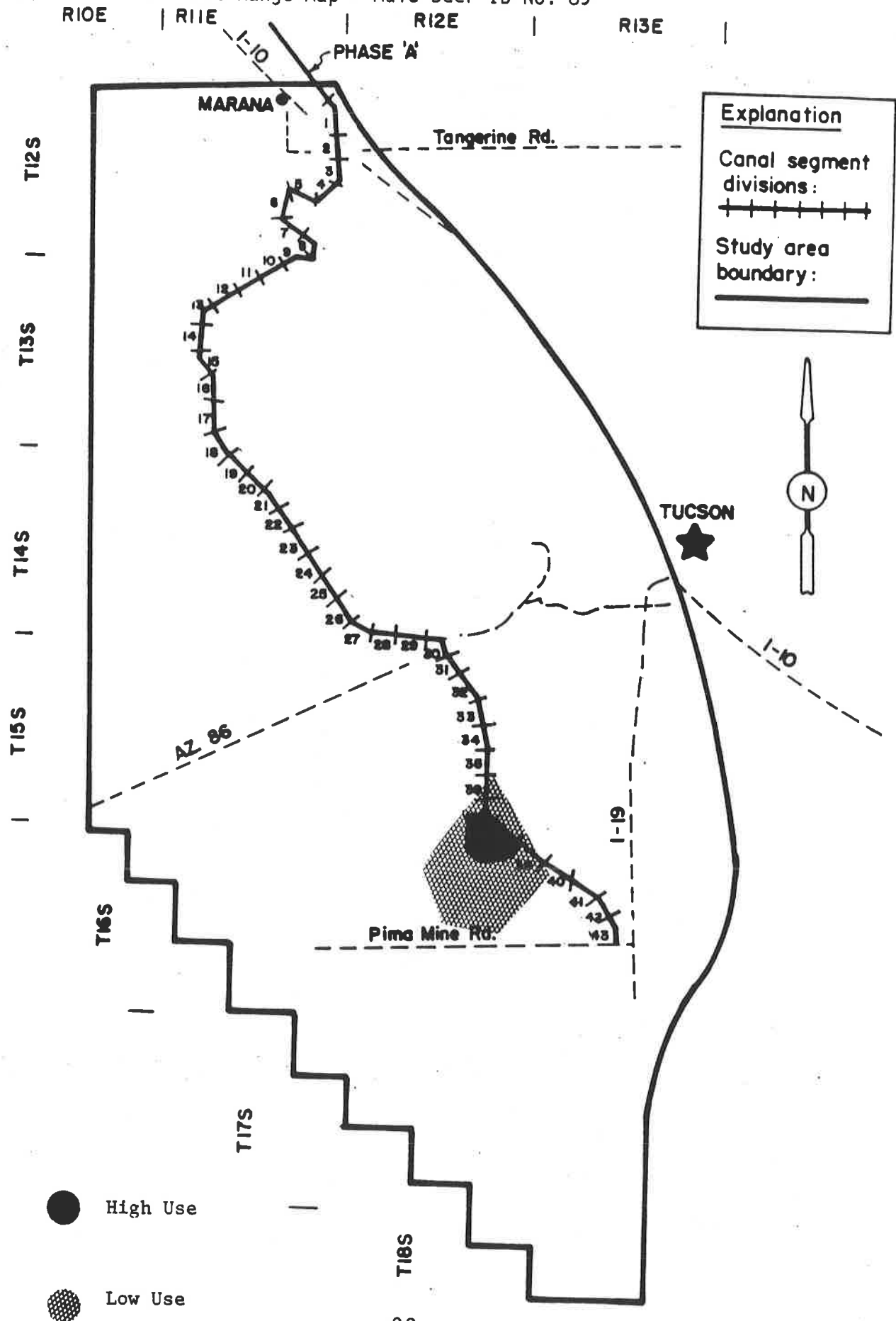
Canal segment divisions:



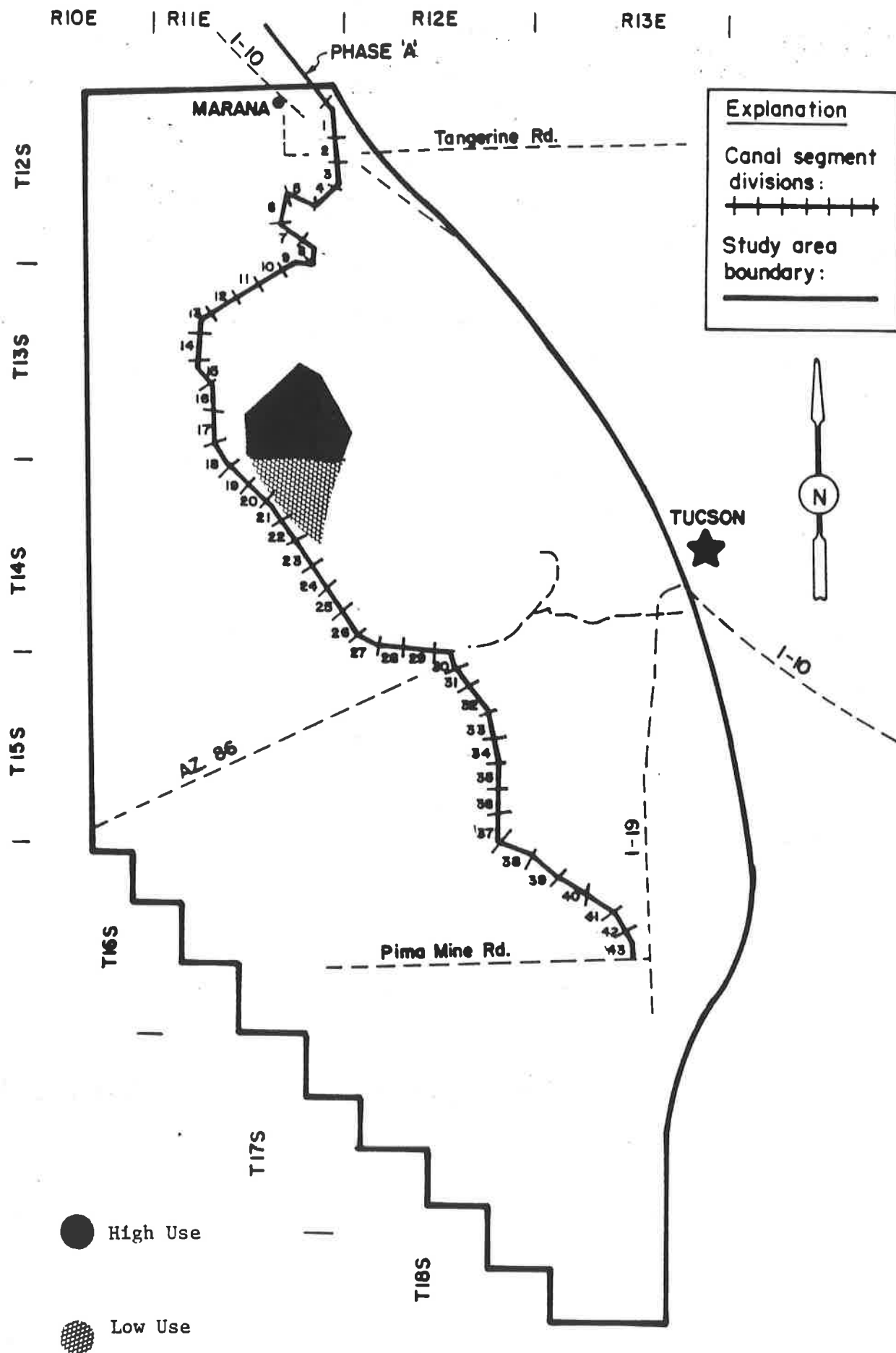
Study area boundary:



Appendix C-1. Home Range Map - Mule Deer ID No. 89



Appendix C-1. Home Range Map - Mule Deer ID No. 90

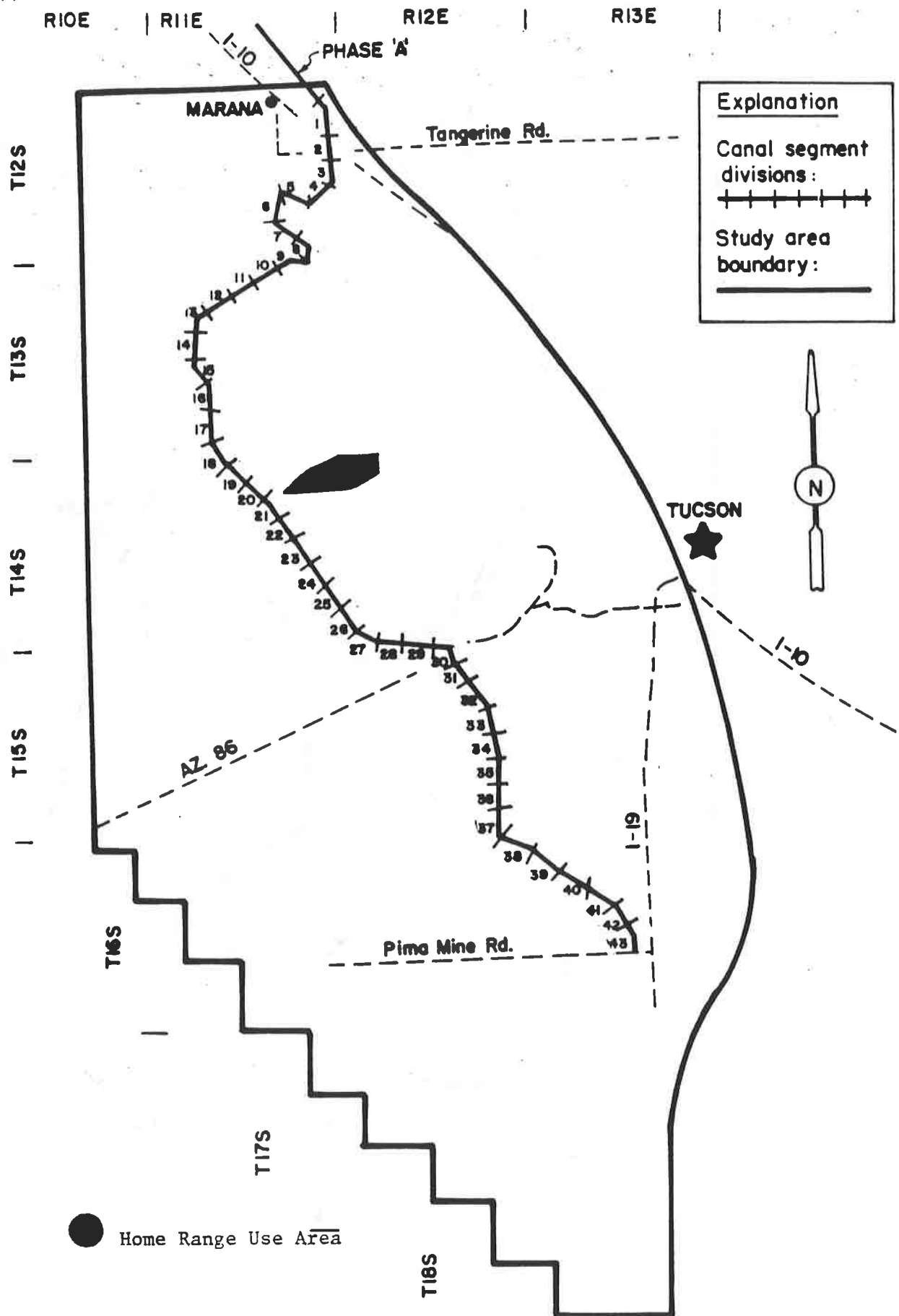




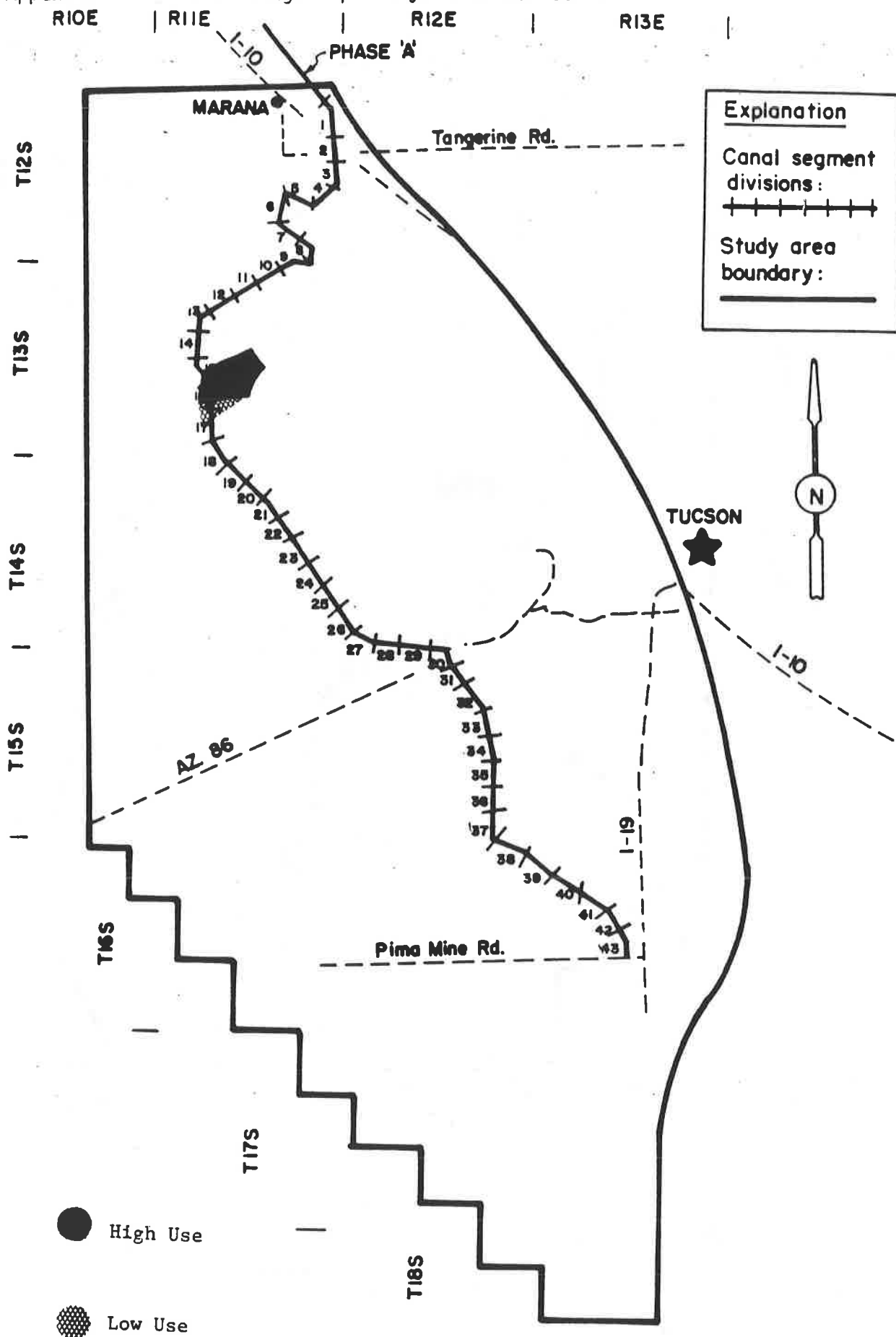
Appendix C-2  
Coyote Home Range Maps



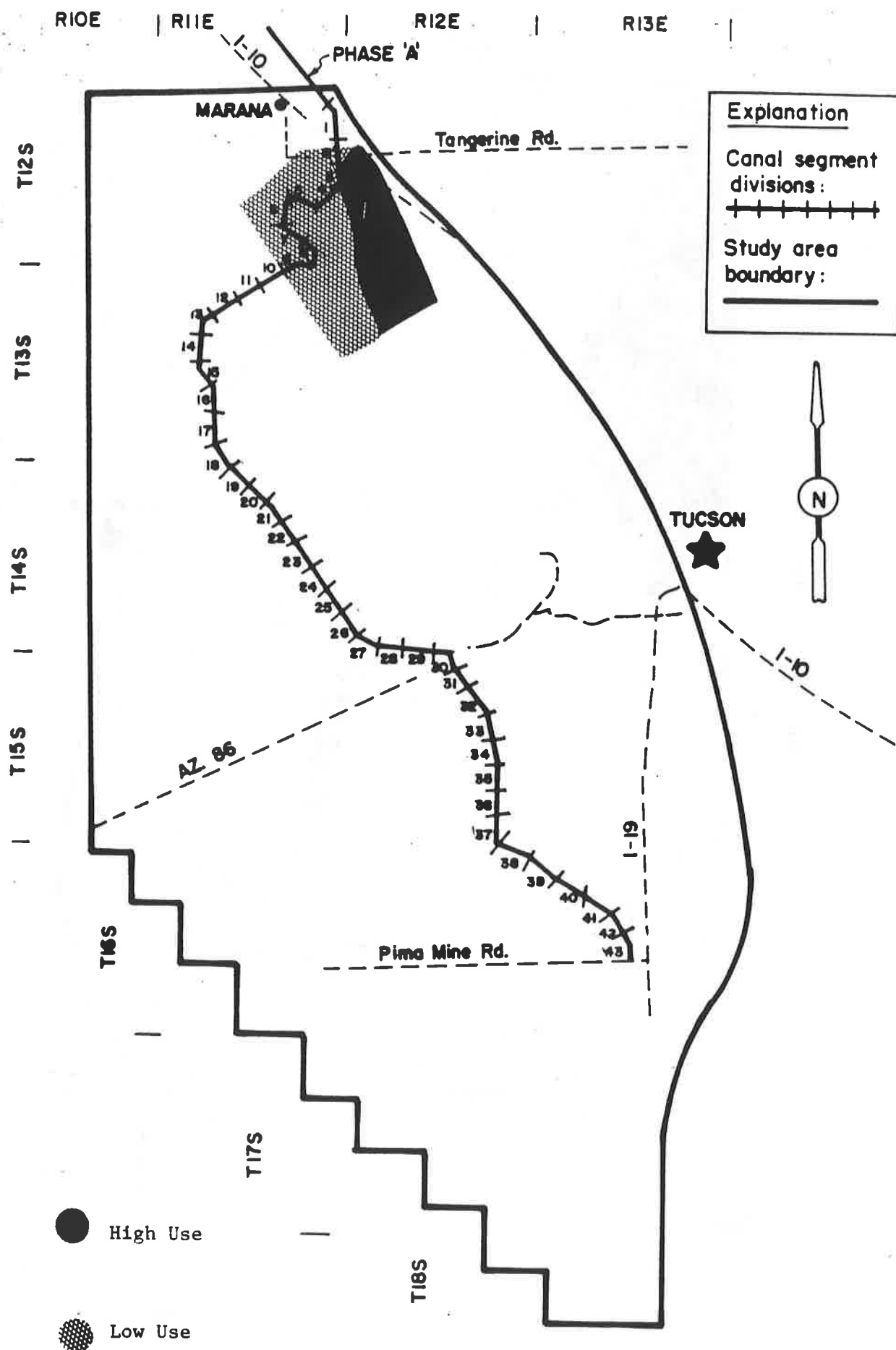
Appendix C-2. Home Range Map - Coyote ID No. 61



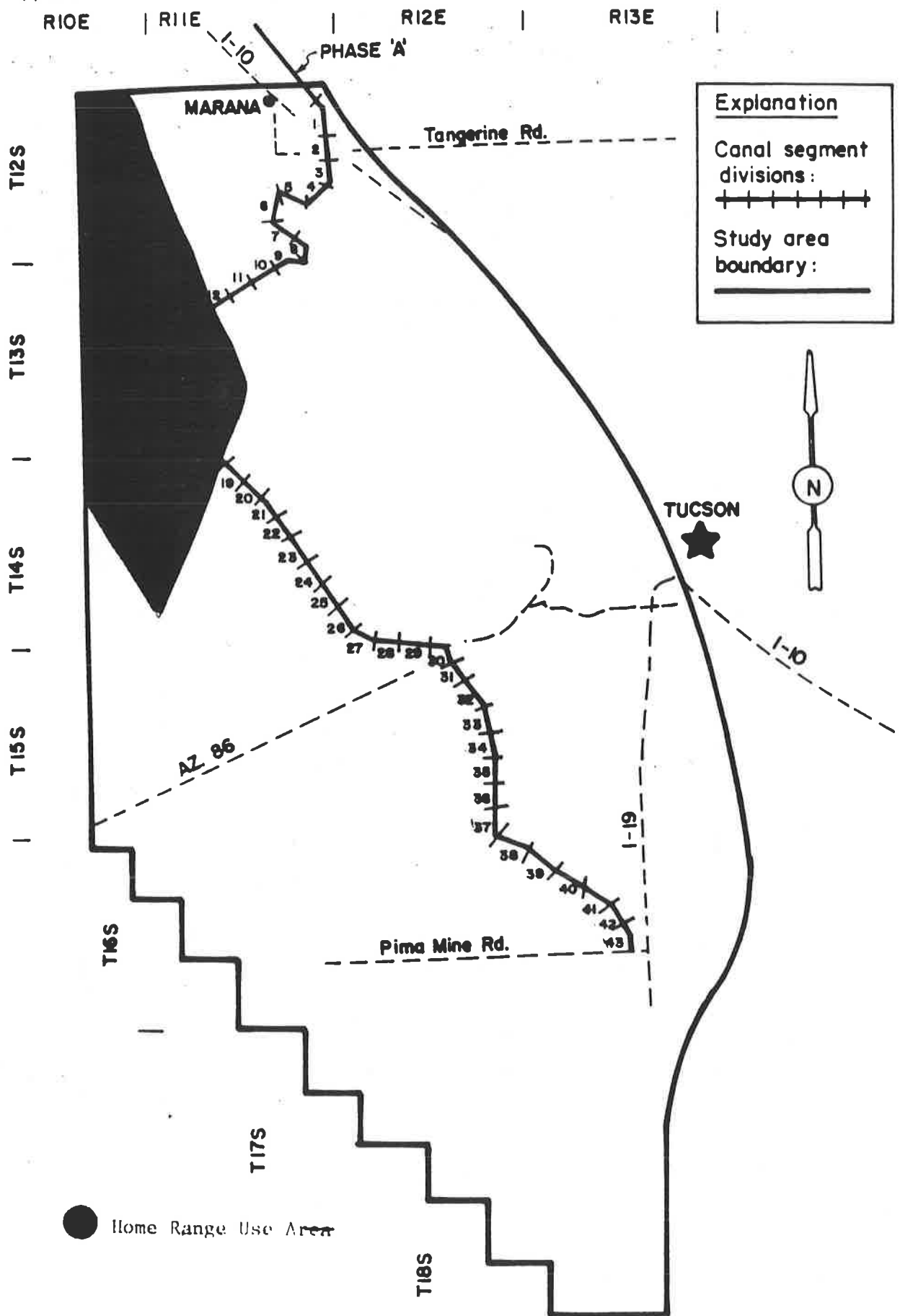
Appendix C-2. Home Range Map - Coyote ID No. 65



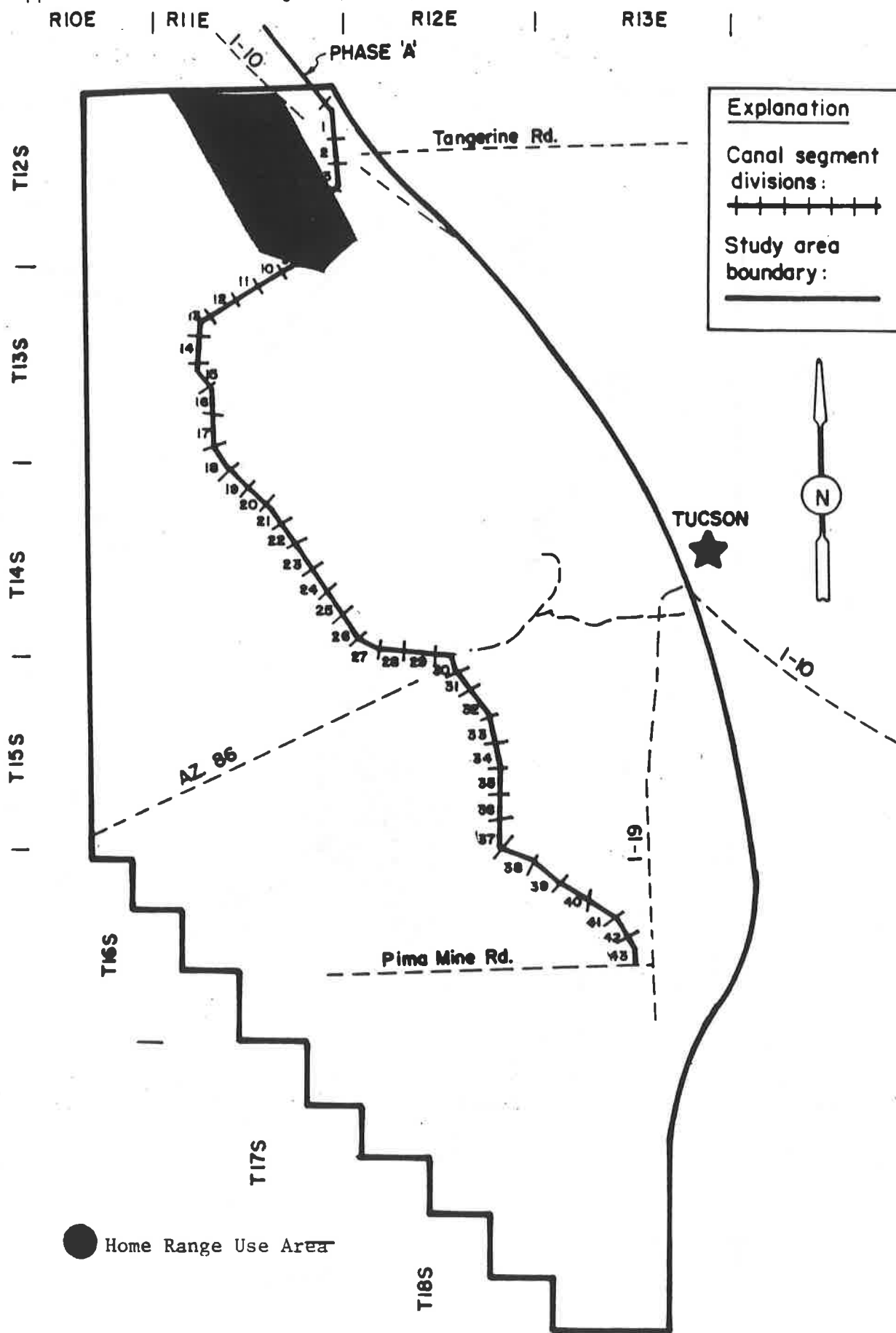
Appendix C-2. Home Range Map - Coyote ID No. 69



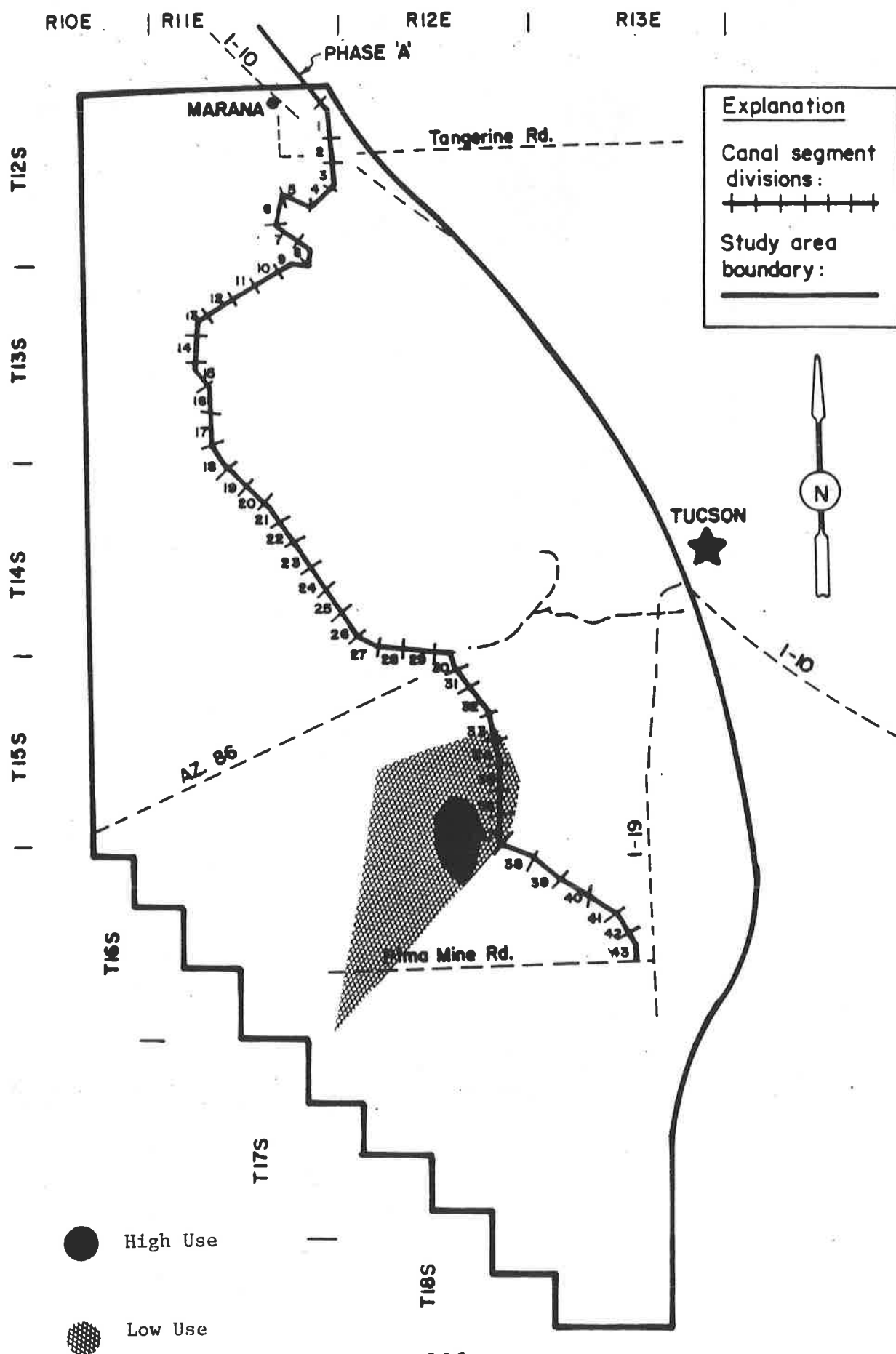
Appendix C-2. Home Range Map - Coyote ID No. 71



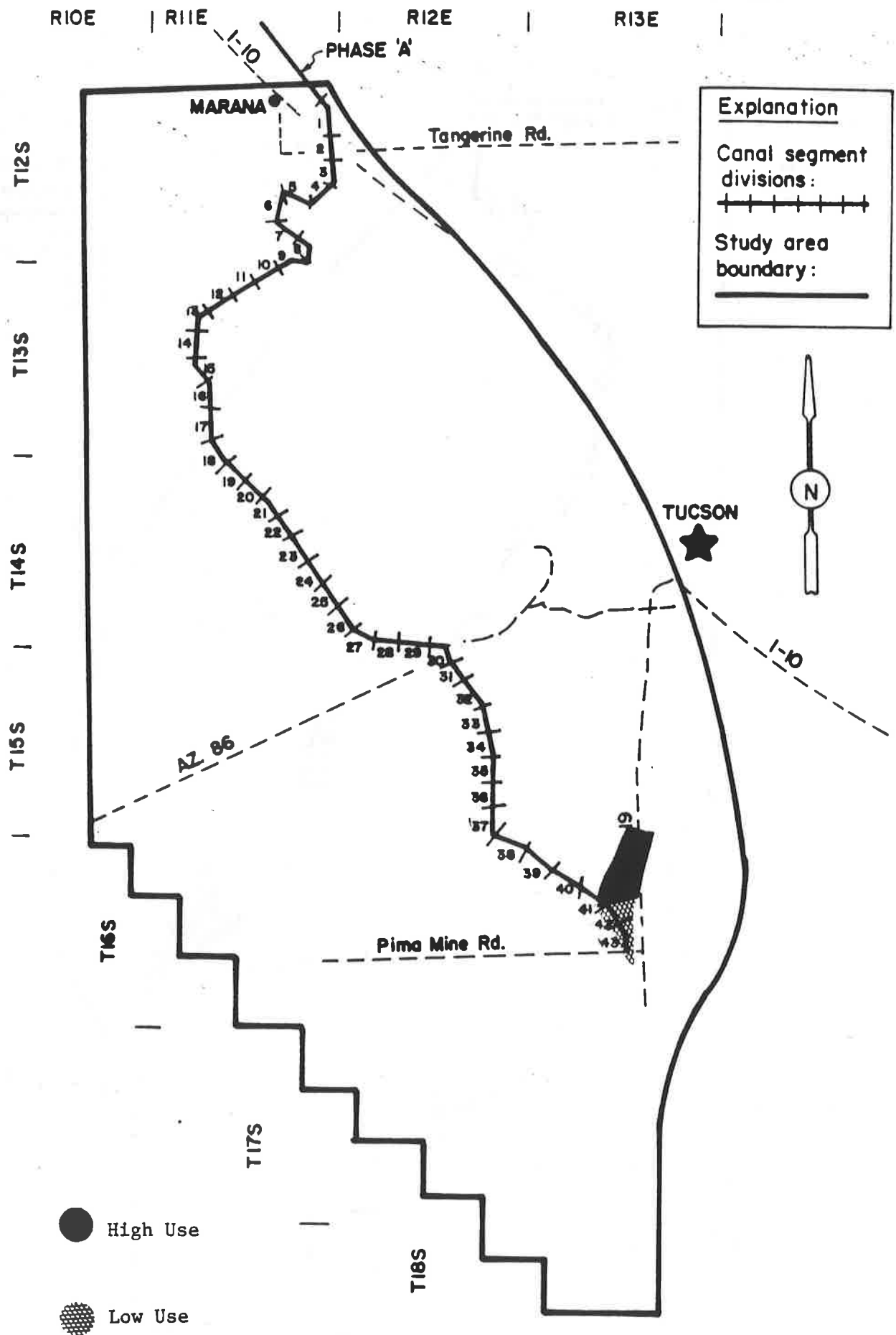
Appendix C-2. Home Range Map - Coyote ID No. 72



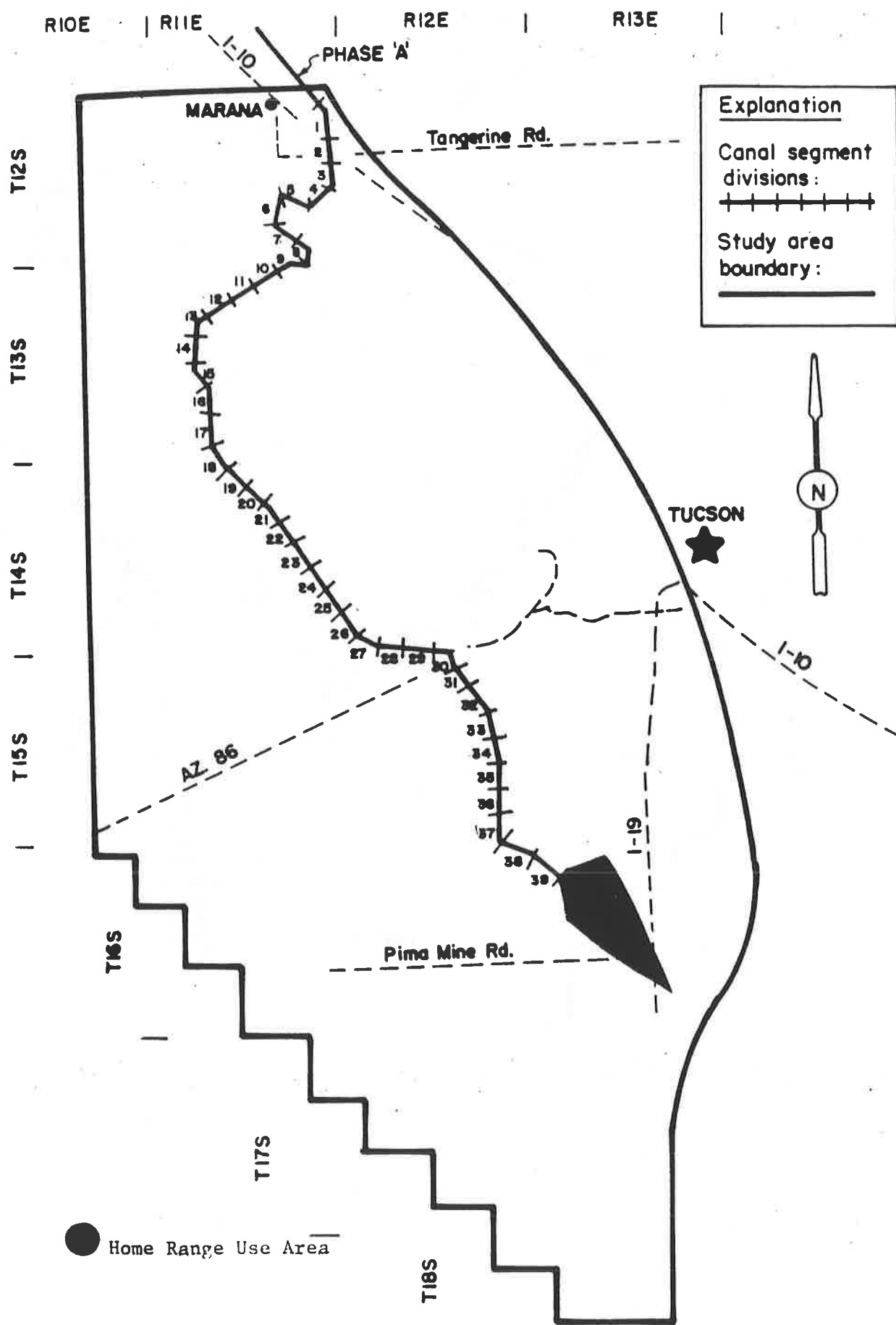
Appendix C-2. Home Range Map - Coyote ID No. 81



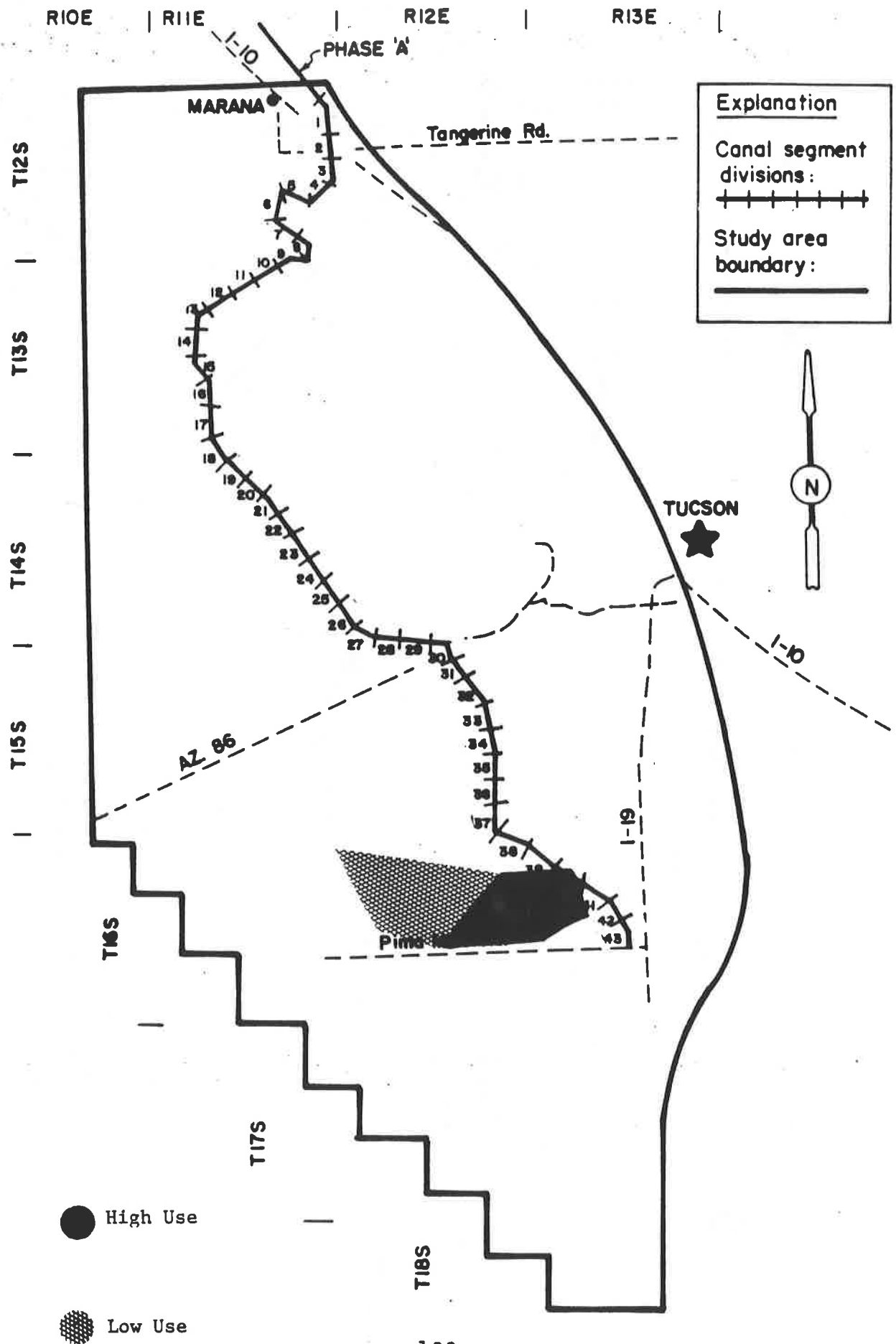
Appendix C-2. Home Range Map - Coyote ID No. 82



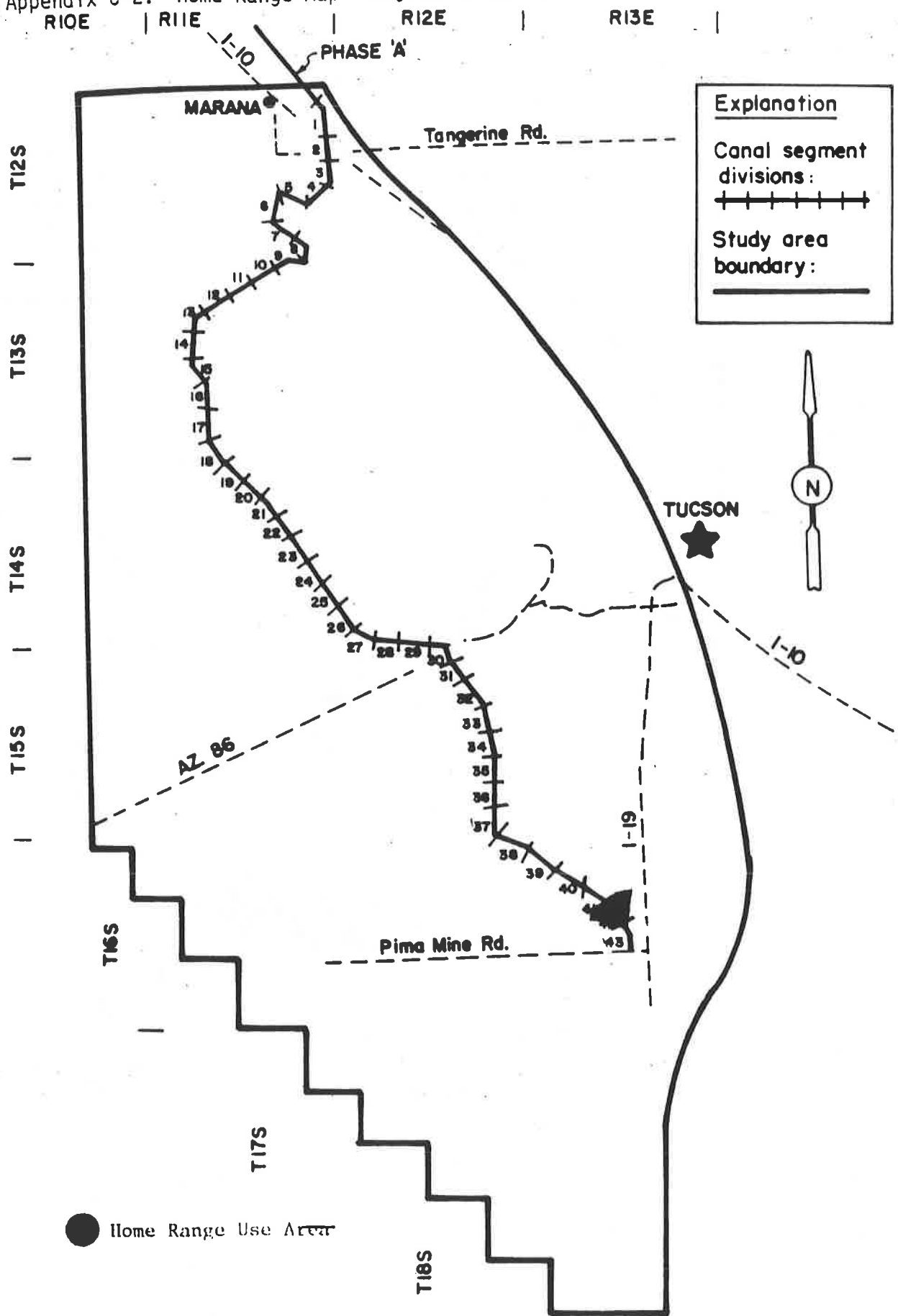
Appendix C-2. Home Range Map - Coyote ID No. 83



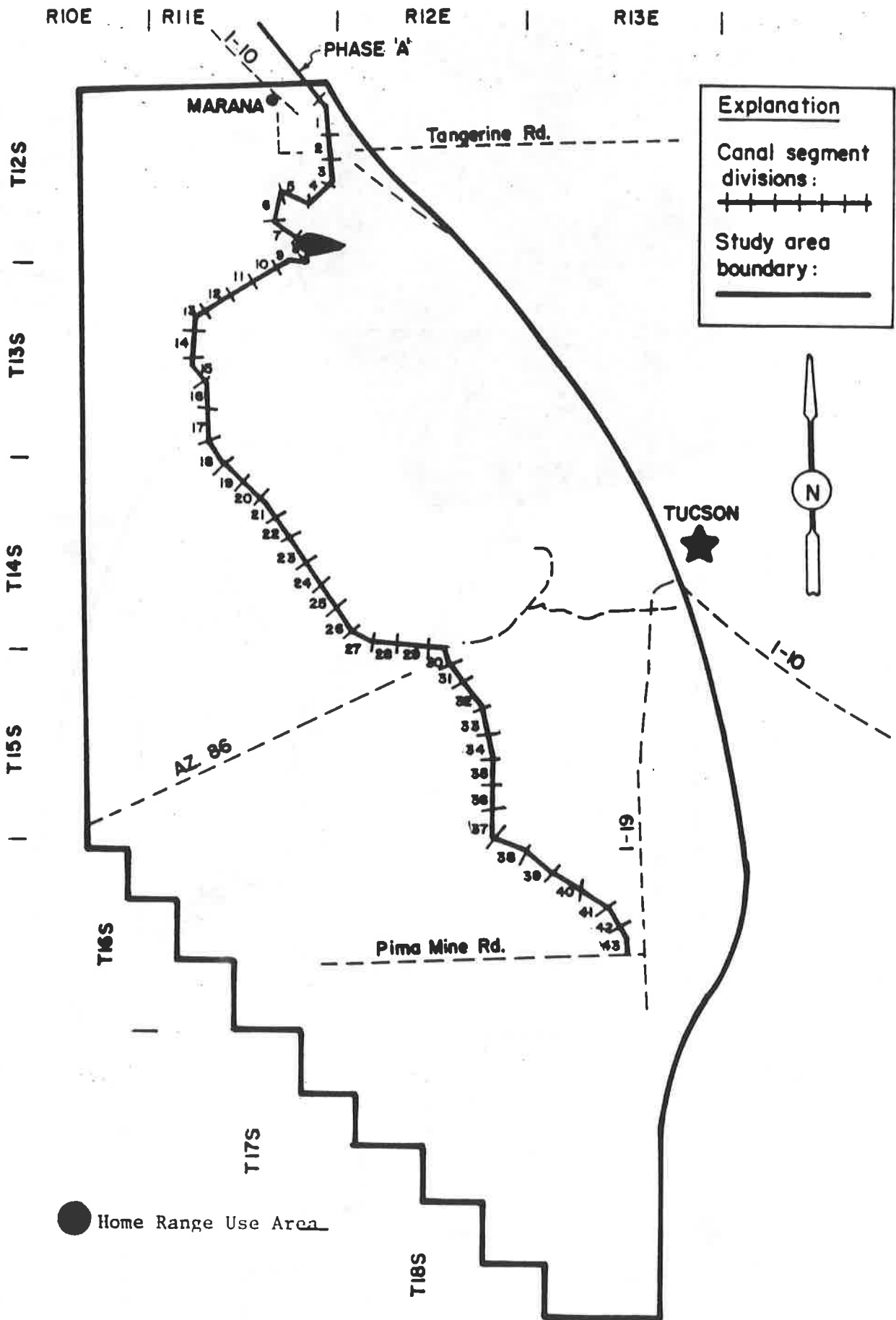
Appendix C-2. Home Range Map - Coyote ID No. 86



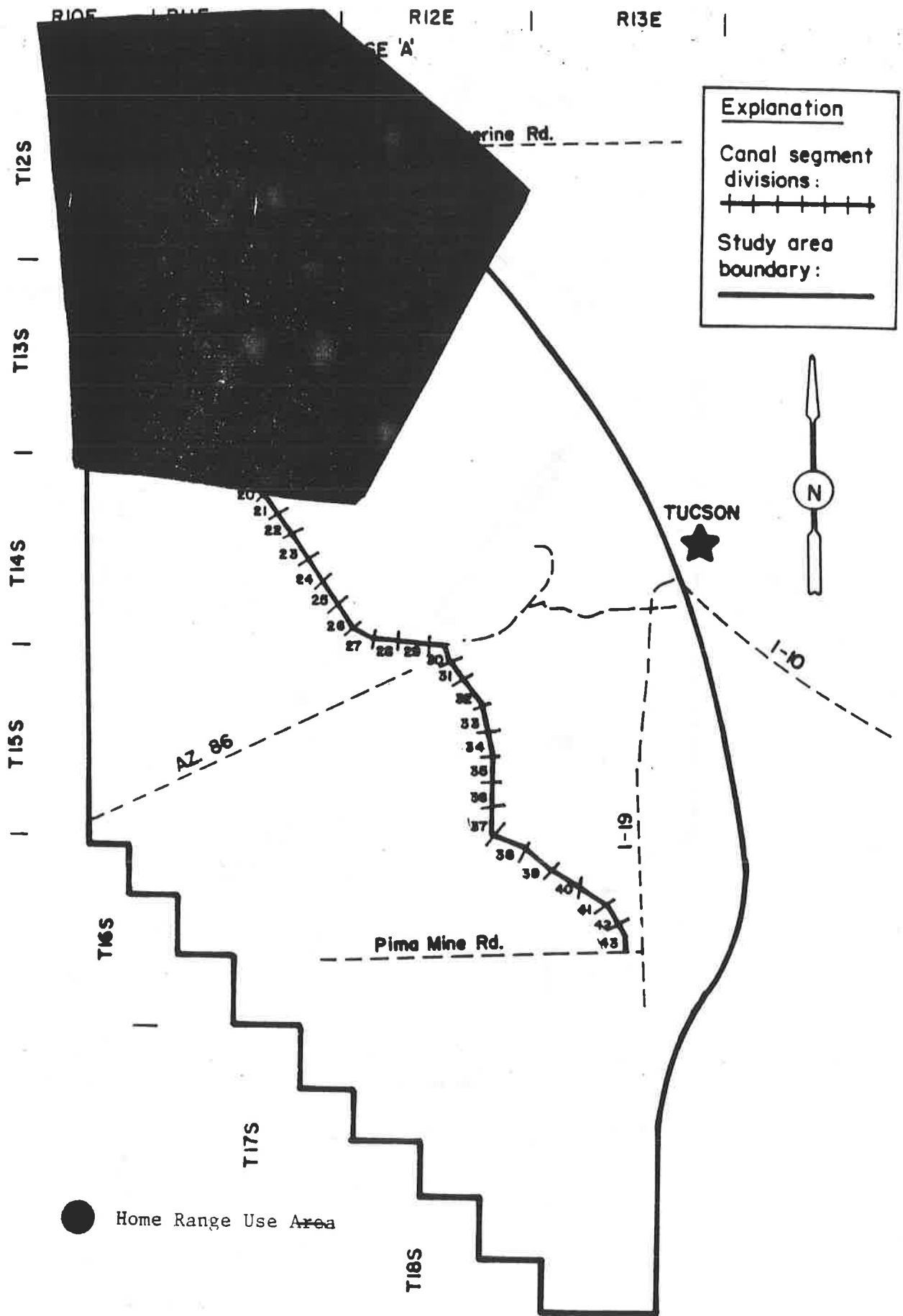
Appendix C-2. Home Range Map - Coyote ID No. 87



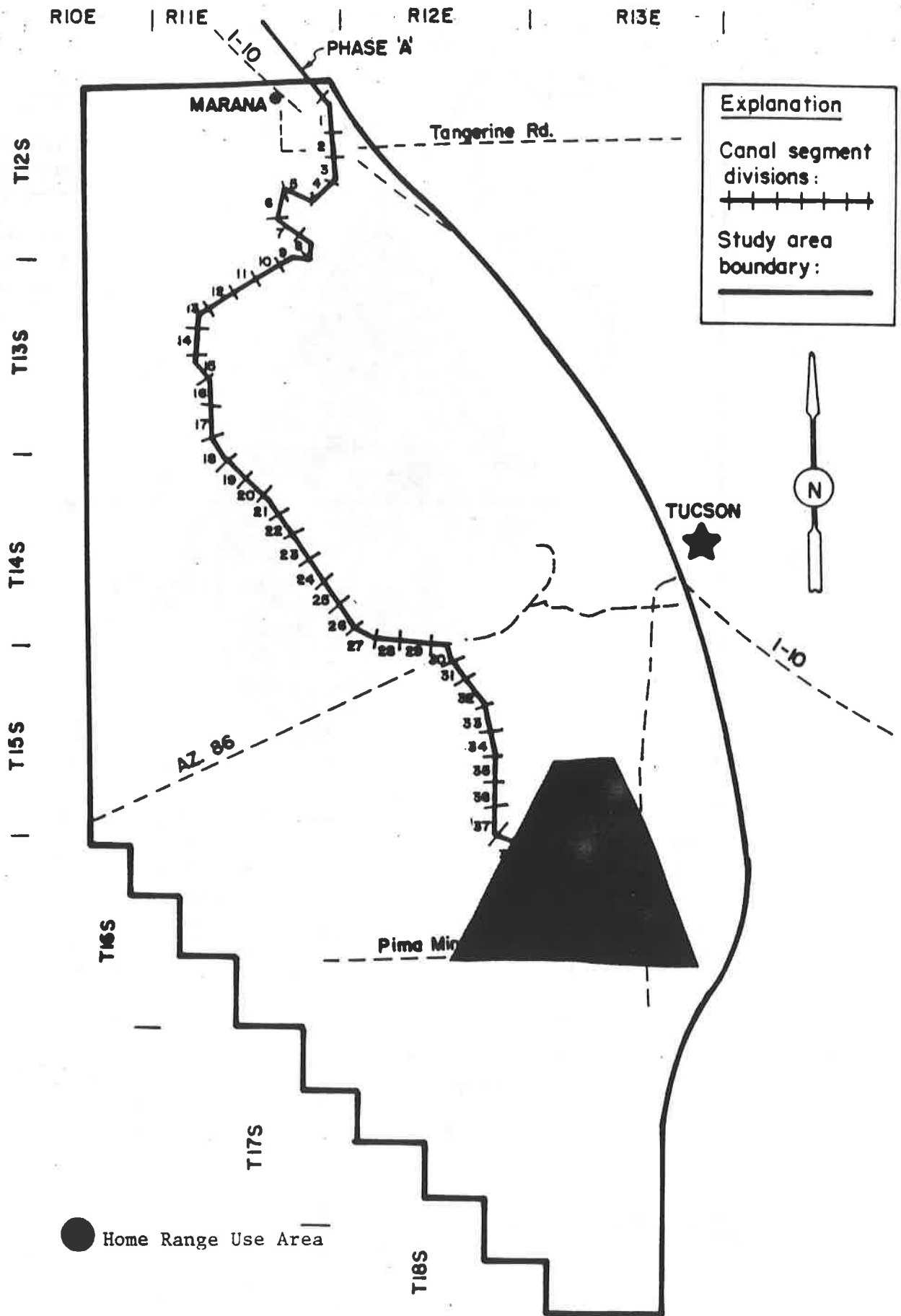
Appendix C-2. Home Range Map - Coyote ID No. 88



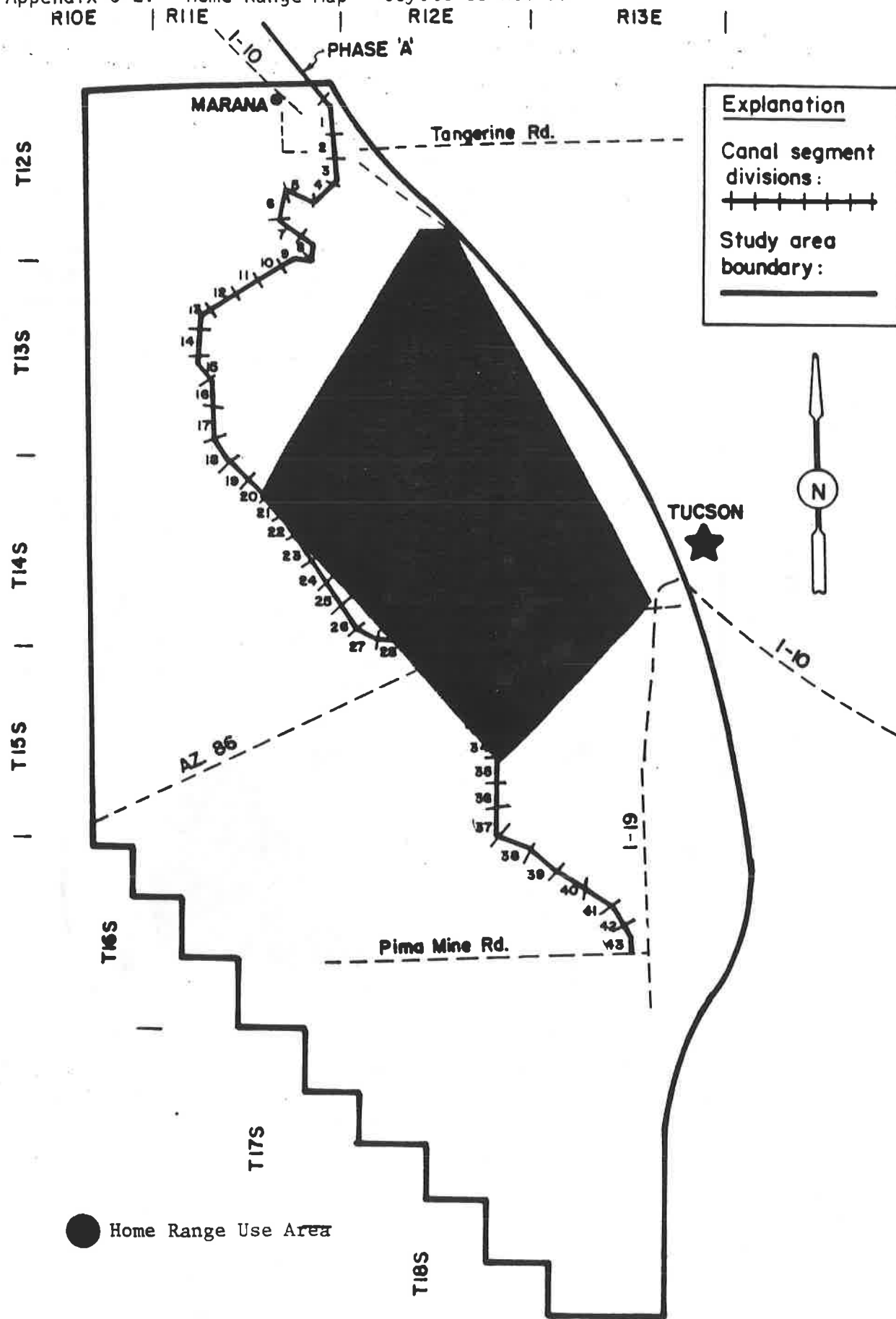
Appendix C-2. Home Range Map - Coyote ID No. 95



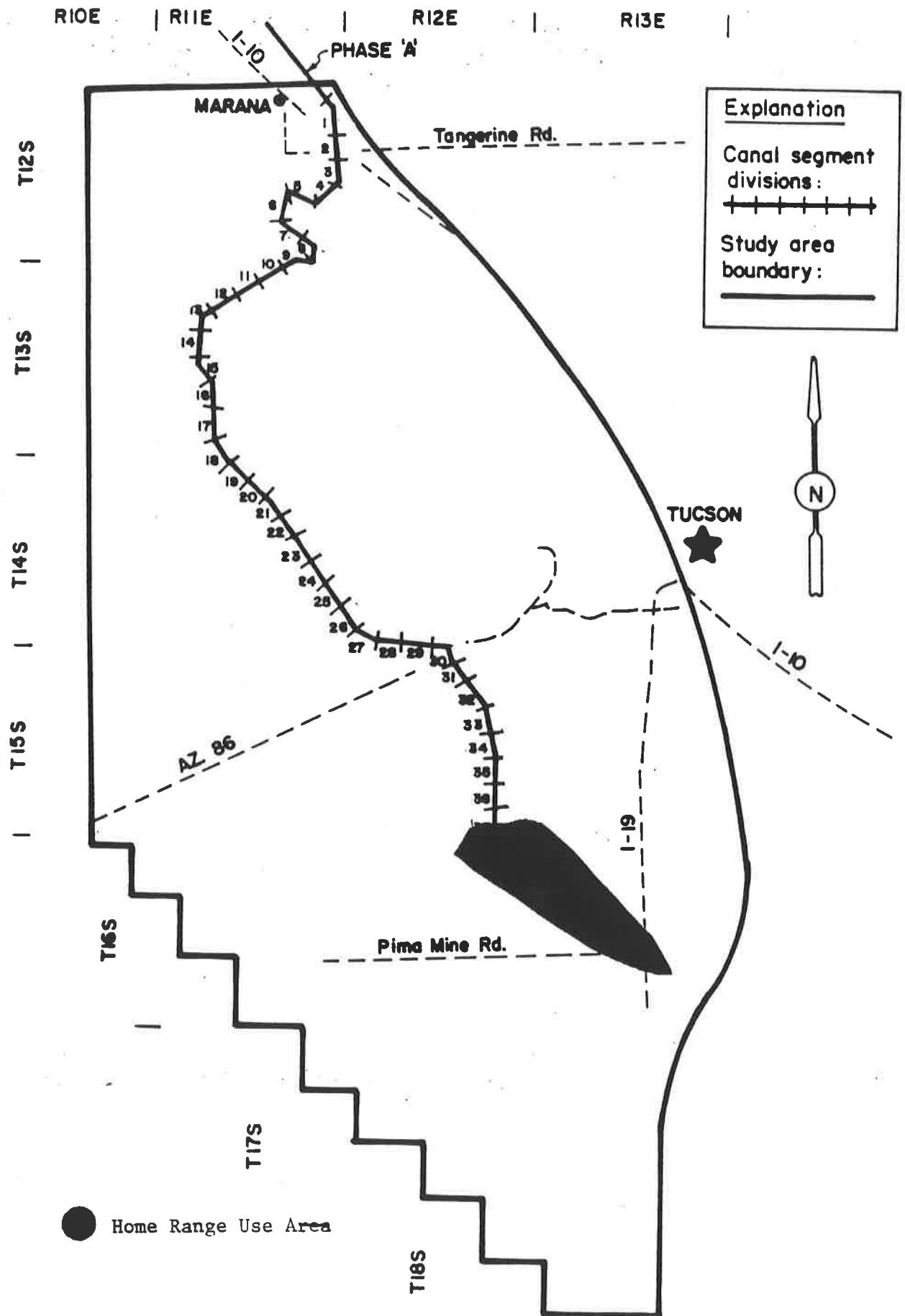
Appendix C-2. Home Range Map - Coyote ID No. 96



Appendix C-2. Home Range Map - Coyote ID No. 97

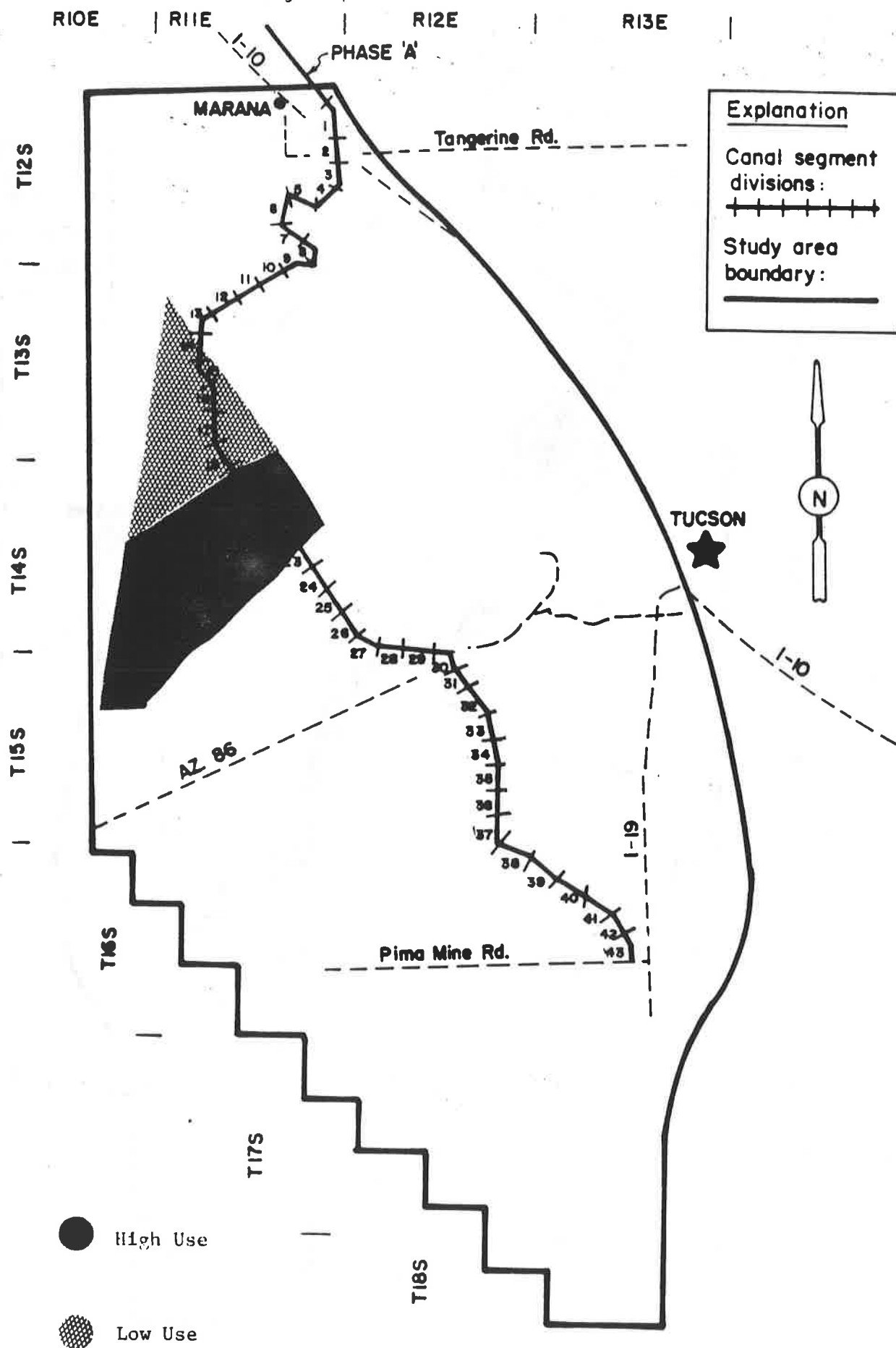


Appendix C-2. Home Range Map - Coyote ID No. 98

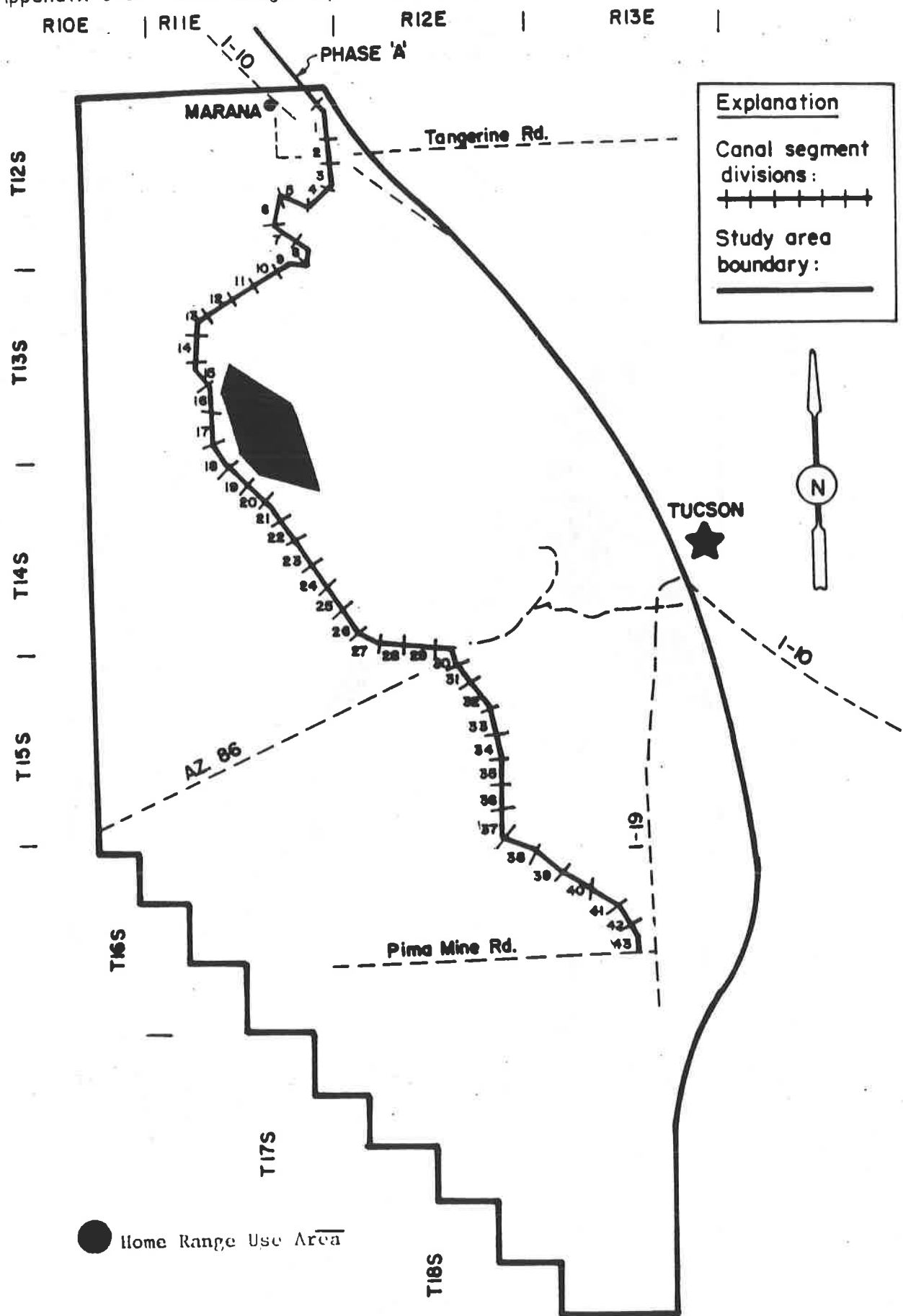


**Appendix C-3**  
**Bobcat Home Range Maps**

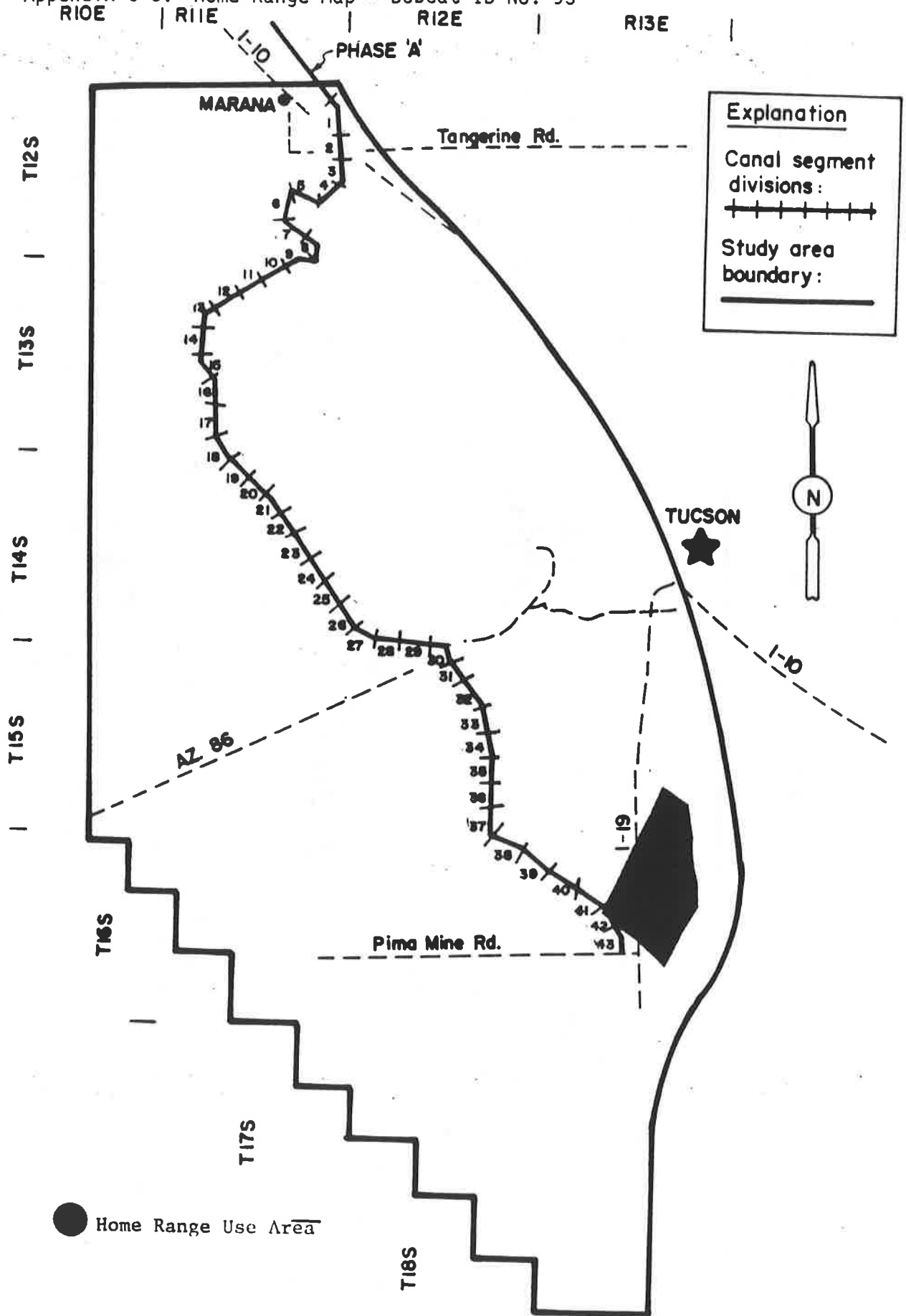
Appendix C-3. Home Range Map - Bobcat ID No. 57



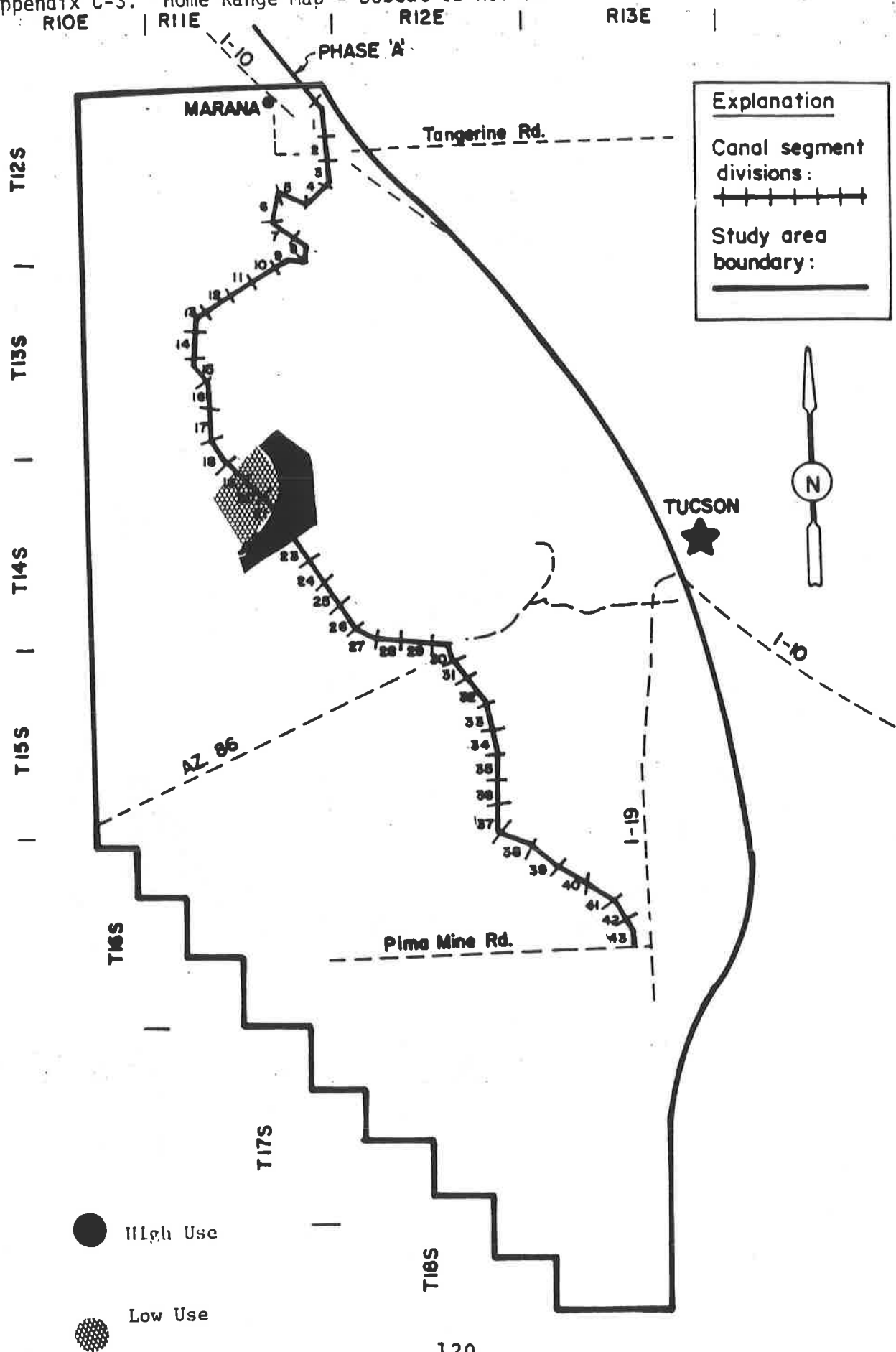
Appendix C-3. Home Range Map - Bobcat ID No. 64



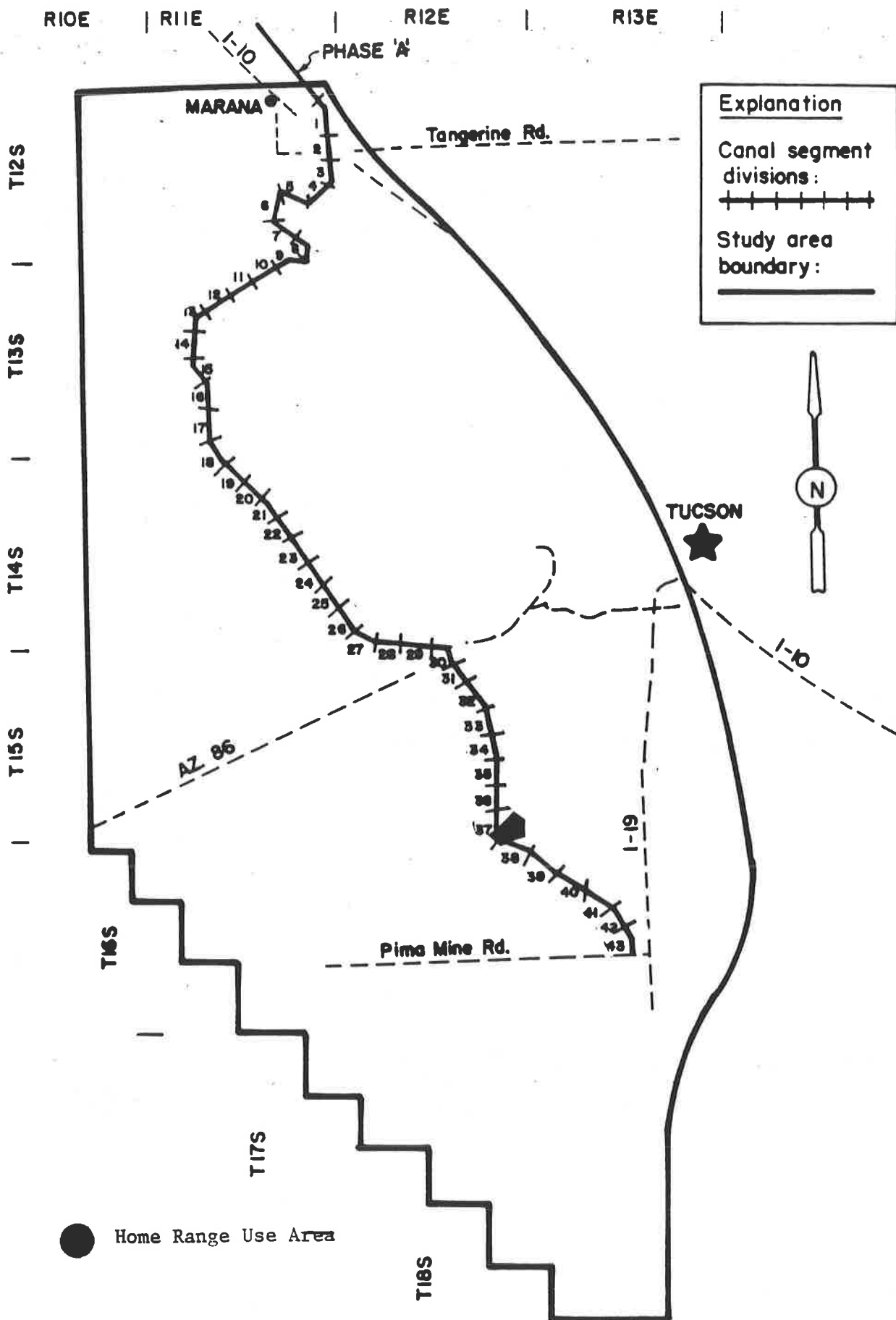
Appendix C-3. Home Range Map - Bobcat ID No. 93



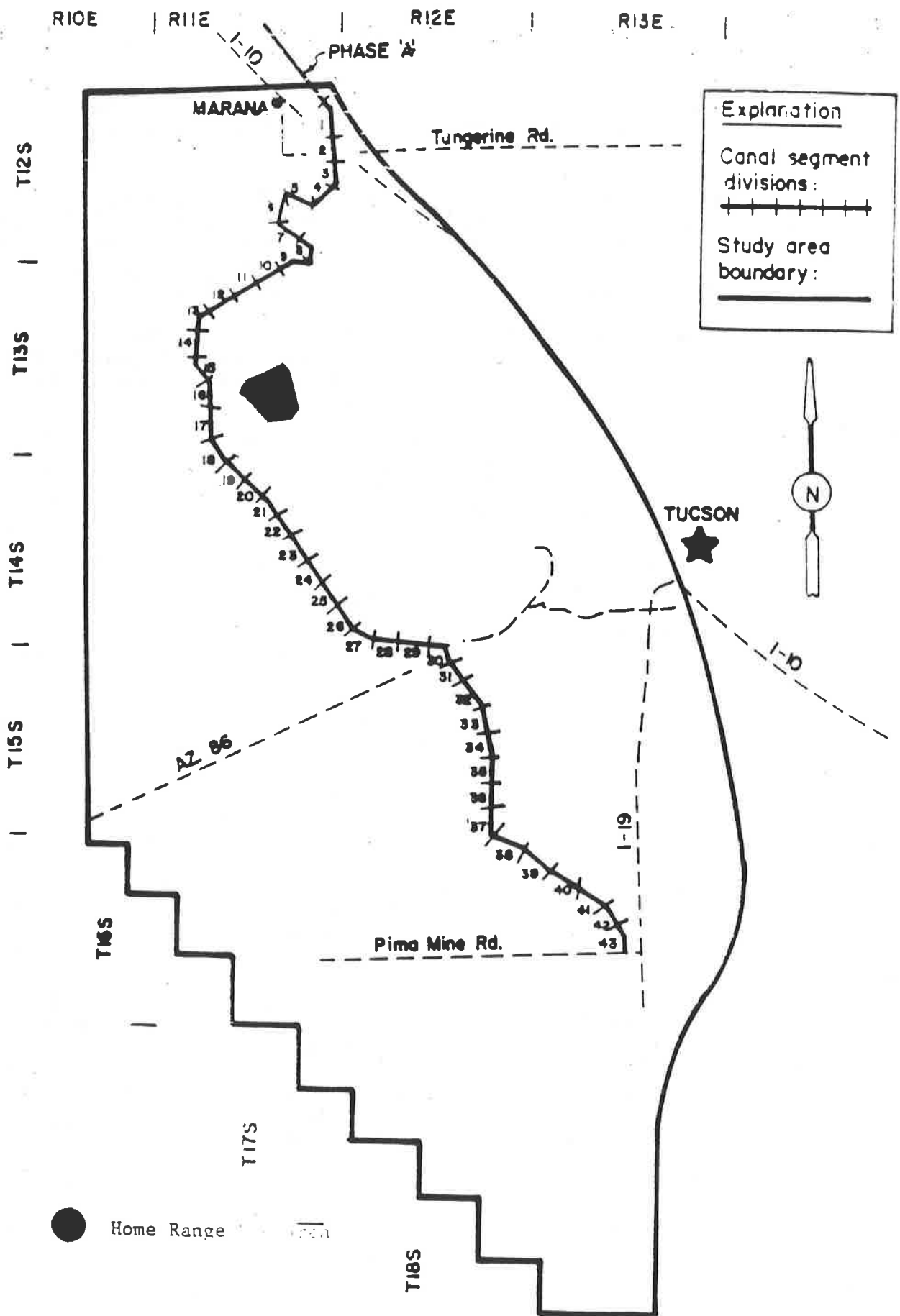
Appendix C-3. Home Range Map - Bobcat ID No. 94



Appendix C-4  
Javelina Home Range Maps



Appendix C-4 Home Range Map - Javelina JD No. 91



## Literature Cited

- Danner, D.A. 1976. Coyote home range, social organization and scent post visitation. M.S. Thesis, U. of Arizona, Tucson.
- deVos, James C., Jr., C. Richard Miller, Sandra L. Walchuk, William D. Dugh and Daisan E. Taylor. 1983. Final report for the biological resource inventory: Tucson Division-Phase B Central Arizona Project Aqueduct. Prepared for USBR. Contract #32-V0151.
- Diamond, Jared M. 1975. The island dilemma: lessons of modern biogeographic studies for the design of natural reserves. Biol. Conserv. Applied Science Publishers, Ltd. England 7:129-146.
- Drewek, John, Jr. 1980. Behavior, population structure, parasitism, and other aspects of coyote ecology in southern Arizona. PhD Thesis, Univ. of Arizona, Tucson. 261p.
- Jennrich, R.I. and F.B. Turner. 1969. Measurement of noncircular home range. J. Theor. Biol. 22:227-237.
- MacArthur, R.H. and E.O. Wilson. 1967. The theory of island biogeography. Princeton University Press, Princeton, New Jersey.
- Mohr, C.O. 1947. Table of equivalent populations of North American small mammals. Am. Mid. Nat. 37:233-249.
- Nie, Norman H., G.H. Hull, J.G. Jenkins, K. Steinbrenner, D.H. Bent. 1975. Statistical package for the social sciences. McGraw-Hill Inc., New York, New York.
- Ramsey, P.R., J.C. Avise, M.H. Smith, and D.F. Urbston. 1979. Biochemical variation and genetic heterogeneity in South Carolina deer populations. J. Wild. Manag. 43:136-142.
- Remington, Richard R. and William E. Werner. 1984. Mule deer use of a new permanent water resource. Deer of the Southwest: A Workshop (In Press).
- Sellers, William D., and Richard H. Hill, Editors. 1974. Arizona Climate -- 1931-1972. The University of Arizona Press. Tucson Arizona. pp.616.
- Simberloff, Daniel S. and Lawrence G. Abele. 1976. Island biogeography theory and conservation practice. Science 191:235-236.

Smith, M.H., C.T. Garten, Jr., and P.R. Ramsey. 1975.  
Genetic heterozygosity and population dynamics in small  
mammals. Pages 85-102 in C.L. Markert, ed., Isozymes,  
Vol. IV, Genetics and Evolution. Academic Press, New  
York.

Smith M.H., J.E. Pender, and S. Weiner. 1978. The Weibull  
distribution: a new method of summarizing survivorship  
data. Ecology 59 (1):175-179

Stewart, G.E. 1978. Live-trapping and handling coyotes for  
research. Division Report No. 9. Colorado Division of  
Wildlife. 8pp.





