Lesser Prairie Chicken Surveys
New Mexico Department of Game and Fish Prairie Chicken Management Areas
&
Radio Telemetry Study
Caprock Wildlife Management Area

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Introduction

Over the last 100 years, populations of Lesser Prairie Chickens (LPCH, *Tympanuchus pallidicinctus*) have been declining sharply over the bird's entire range in Kansas, Oklahoma, Texas, Colorado, and New Mexico (Lesser Prairie Chicken Interstate Working Group 1998). In 1995, the US Fish and Wildlife Service (Service) received a petition to list the LPCH as threatened (Biodiversity Legal Foundation 1995). In June, 1998, the Service ruled the LPCH listing as "warranted but precluded," meaning that, although the species should be listed, the Service will first act on behalf of other species of higher priority. The LPCH will be reconsidered in one year. The recent ruling underscores the necessity of acting to conserve this species and its habitat.

Long-term lek survey data collected by the Bureau of Land Management (BLM) Roswell Resource District indicate that LPCH populations in New Mexico, although larger than in some states, are no exception to the range-wide trend. In response to the decline, the New Mexico Department of Game and Fish (NMDGF) recommended that the State Game Commission close the 1996, 1997, and 1998 LPCH hunting seasons. In 1997, the New Mexico Natural Heritage Program conducted surveys of lekking birds for the NMDGF on its Lesser Prairie Chicken Management Areas (PCAs). NMDGF also cooperated with BLM by providing matching funds for a trapping and radio-telemetry study on the BLM Caprock Wildlife Management Area in 1997 and 1998. The NMDGF is expected to rule in mid-1998 on a petition to list the species as endangered under the New Mexico Wildlife Conservation Act.

The purposes of this study were to conduct 1998 surveys of lekking LPCH at the NMDGF PCAs and to provide matching funds for the ongoing BLM radio telemetry study. The BLM study compares three types of radio transmitters and develops trapping and tracking methods for eventual application to future studies on the NMDGF PCAs.

Methods

Surveys

We surveyed NMDGF PCAs from 14-27 April, 1998. We surveyed the following Management Areas for the presence of LPCH at lek sites: Milnesand, North Bluit, South Bluit, Black Hills, Crossroads #1-2, Marshall, Gallinas Wells #1-6, Claudell, and Liberty (Maps 1-12).

Surveys were conducted between 0450 and 0756 h. The surveyor approached survey sites by vehicle and listened for gobbling males. Where possible, we attempted a closer approach by vehicle or on foot, for purposes of obtaining exact counts of birds. Birds were counted and sex recorded whenever possible, but we attempted to avoid flushing birds from the leks. However, many lek sites were outside PCA boundaries and not accessible by vehicle or on foot. If we could not approach closely enough to count birds on leks, we estimated the number of individuals heard. For all leks located inside the

boundaries of PCAs, except for Crossroads #2, we were able to return to lek sites until we obtained exact counts of bird numbers.

We mapped and numbered all active leks (see Appendix 1 for UTM coordinates of 1998 leks). Locations of those detected off the PCAs were estimated by triangulating from two or more points away from the leks. Leks that moved less than one kilometer from previous years were given the same designation as in previous years. We entered survey data into an Access database and queried the database for trends in lek size and number from 1996-1998.

Trapping and Telemetry

During the peak lek attendance period, 31 March, 1998, to 6 May, 1998, we trapped LPCH at three BLM lek sites, 2N, 24N, and 45N. Lek 2N was trapped on 11 days between 8-18 April; lek 24N was trapped on 22 days between 31 March and 5 May; and lek 45N was trapped on 34 days between 31 March and 6 May. The total number of lek trapping days was 67.

Birds were trapped in circular welded wire walk-in traps, placed in a line across each lek and connected with chicken wire leads (Toepfer et al. 1987). The following data were recorded for each bird: age, sex, weight, right tarsus, left tarsus, right wing chord, left wing chord, culmen, and comb color (by Munsell color standard, males only). Each bird trapped was uniquely banded with plastic color bands and numbered aluminum Game and Fish bands. Each female was fitted with a radio transmitter. Approximately 50 microliters of blood was taken from the brachial vein and stored in cell lysing buffer for later DNA analysis. A blood smear was made for blood parasite analysis, and a fecal sample was taken for gut parasite analysis. The fecals were taken from the ground after the birds were released or from the box in which the bird was held before processing. All birds were safely released after approximately 30 minutes handling time.

Males subsequently sighted at leks were identified by their color bands, and re-sighted females were identified by either bands or transmitter frequency. We tested three types of transmitters, loop necklaces from AVM (15g) and loop necklaces (11g) and whip antennas (7g) from Telemetry Solutions (TS). We attempted to locate each female at least twice each week after banding. When a hen's nest was located, we re-checked the nest once or twice during incubation to look for signs of predation. With assistance from BLM personnel, we collected vegetation data at each nest site, after all nests were empty (the week of June 15), using the BLM vegetation monitoring protocol, combined with methods used by Davis et al. 1979.

Vegetation Sampling

We employed two methods of vegetation sampling at nests, both used by Davis et al. in their 1979 study. In the line-point transects (also known as step-point method), an X-shaped transect was centered at each nest, with arms extending north, south, east, and west from the nest. Each arm consisted of 100 steps, with a point taken at the toe of the right boot every other step, such that each arm contributed 50 points and each transect 200. At each point, bare ground, litter, or plant species touched by the boot tip was

recorded. If no plant was hit by the boot, the species of the nearest plant ahead of the toe was recorded. We then computed the percent vegetation composition at each nest by dividing the number of points of each plant species or ground cover type by 200.

A second method was used to characterize the area within 10 feet of the nest site. The same method was employed by Davis et al. (1979) to assess daily activity sites. These transects had eight arms extending 10 feet to the N, S, E, W, NE, SE, NW, and SW. Data points were taken at one-foot intervals, such that each arm provided 10 points, for 80 total points per nest. As on the large transects, litter, bare ground, and plant species were recorded. Height of the plant nearest the transect center and the plant nearest each third data point were recorded. Vegetation composition within 10 feet of the nest was then computed from these data.

Results

Surveys

Compared to 1996 (Figure 1) and 1997 (Figure 2 and Johnson et al. 1997), the 1998 surveys were extremely successful (Figure 3). In 1998, we detected 32 individual leks, 12 inside PCA boundaries and 20 outside PCA boundaries (Table 1). We estimated at least 181 birds, and possibly as many as 210. This total is not exact, because we estimated, rather than counted, birds at the majority of leks. Note that for leks visited twice, there was little consistency between the estimate and the count. This may indicate that attendance fluctuated over the two-week survey period or that auditory estimates of male numbers are unreliable.

Transmitter Function

We captured 12 hens and 9 cocks, 21 birds total. All hens were fitted with transmitters. Three received TS whip antennas, four received TS necklace transmitters, and five received AVM necklace transmitters purchased in 1997. One of the TS necklace transmitters was used twice, after it was found off the first hen we placed it on.

The majority of transmitters functioned well, but four of 12 transmitters fell off or were removed by hens. We lost track of two hens, both wearing the AVM transmitters from 1997. These hens could have been lost due to transmitter failure, because the AVM transmitters were over one year old. These two transmitters were functioning when applied to hens, but their batteries could have been weak if magnets were not placed properly. It is also possible that the transmitters were damaged or buried by predators or the hens traveled too far for us to detect them. The mortality sensors functioned properly on other transmitters. Two other AVM necklaces were found off the birds, suggesting that the birds removed them or they fell off. The fifth AVM transmitter remained on a bird that nested.

One of the TS necklace transmitters was used twice, after it was found on the ground with dried blood or tissue on it, making it a suspected mortality. The second hen that wore the transmitter was found dead wearing it. The other two TS necklaces were found off the birds. The three TS whip necklaces remained on the birds and appeared to

Management Area	Property (in or out)	Lek #	Survey Date	# Males	# Females	# Sex Unknown	Total
Milnesand	inside	GM-5	4/14/98	≥4			≥4
		GM-5	4/23/98	2			2
Milnesand	inside	GM-6	4/14/98	3			3
Milnesand	inside	GM-2	4/14/98	≥4			≥4
		GM-2	4/23/98	10	1		11
Milnesand	inside	GM-4	4/14/98	≥5			≥5
		GM-4	4/23/98	2			2
Milnesand	inside	GM-7	4/16/98	≥8			≥8
		GM-7	4/23/98	≥8		≤3	11
Milnesand	outside	GM-8	4/16/98	≥3			≥3
Milnesand	inside	GM-9	4/16/98	≥8			≥8
		GM-9	4/23/98	3		1	4
North Bluit	inside	GNB-1	4/16/98	9	2		11
South Bluit	outside	GSB-1	4/16/98	≥4			≥4
Black Hills	outside	GB-5	4/17/98	2	1		3
Black Hills	outside	GB-6	4/17/98	≥4			≥4
Black Hills	outside	GB-7	4/17/98	≥4		≤6	10
Crossroads # 2	inside	GC2-2	4/18/98	≥4			≥4
Crossroads # 2	inside	GC2-1	4/18/98	≥8			≥8
Crossroads # 2	inside	GC2-3	4/18/98	≥2			≥2
Crossroads # 2	outside	GC2-4	4/18/98	≥3			≥3
Crossroads # 1	inside	GC1-5	4/18/98	4 or 5			5
Crossroads # 1	outside	GC1-6	4/19/98	≥4			≥4
Crossroads # 1	inside	GC1-4	4/19/98	≥5		≤5	10
Crossroads # 1	outside	GC1-7	4/23/98	>4			≥4
Crossroads # 1	outside	GC1-8	4/23/98	≥4			≥4

Crossroads # 1	outside	GC1-9	4/23/98	≥5			≥5
Marshall	outside	GMA-1	4/19/98	≥5		<u>≤5</u>	10
Marshall	outside	GMA-2	4/19/98	≥4			≥4
Gallinas Wells # 6	outside	GGW6-1	4/19/98	≥2			≥2
Gallinas Wells # 5	outside	GGW5-1	4/24/98	≥4			≥4
Gallinas Wells # 5	outside	GGW5-2	4/24/98	≥4			≥4
Gallinas Wells # 1	outside	GGW1-1	4/25/98	2		2	4
Gallinas Wells # 1	outside	GGW1-2	4/25/98	2			2
Gallinas Wells # 2	outside	GGW2-2	4/25/98	≥10		12	22
Gallinas Wells # 2	outside	GGW2-3	4/25/98	≥2			≥2
Claudell	outside	GCL-2	4/27/98	≥10			≥10
	12 inside	**32 leks**					**~181-210 birds**
	20 outside						

Table 1. Results of 1998 surveys at PCAs.

Hen ID	# Times Located	Date Nest Found	# Eggs	Transmitter Found	Nest Depredated	Hen Depredated
.500	10	5/5/98	9, 0	-----	6/3/98	6/3/98
.480	4	-----	-----	4/28/98	-----	-----
.460	7	5/13/98	?, 2	6/2/98	6/2/98	-----
.440	5	-----	-----	-----	-----	4/30/98
.425	13	-----	-----	-----	-----	-----
.400#1	3	-----	-----	4/28/98	-----	4/28/98 ?
.400#2	3	-----	-----	-----	-----	5/20/98
.210	3	-----	-----	-----	-----	disappeared
.190	9	5/12/98	10,0	5/26/98	6/3/98	-----
.170	8	-----	-----	5/12/98	-----	-----
.160	5	-----	-----	-----	-----	disappeared
.130	11	5/19/98	6,1	-----	6/2/98	-----

Table 2. Results of Roswell telemetry study.

function well, although we noted that signal strength on one varied, apparently with the hen's foraging movements.

Fate of Hens

Of the 8 hens that kept radios, three were found dead and we suspected that a fourth was predated, based on the dried tissue found on the transmitter. All three carcasses we found were completely consumed, except for a few feathers, and we suspected coyote predation (Table 2). Coyote tracks were found near one of the three. Four hens lost transmitters, we lost track of two hens (see above), and two were known to be living when last located in early June. Thus, the mortality rate between April and early June, 1998, was at least 33% and possibly as high as 83%.

Fate of Nests

All four of the nests we located were entirely or partially predated (Table 2). Two nests, having nine and ten eggs, respectively, were completely predated during incubation. No shell fragments were found in or near these nests, suggesting predation by snakes. One other nest that had six eggs when located on May 19 had one egg on June 2 and was empty when checked on June 17, thus could not have produced more than one chick. We suspect snake predation of the entire clutch. The hen did not flush from a fourth nest when it was found on May 13; therefore, we do not know how many eggs were laid. On June 2, only two eggs and no shell fragments were present, suggesting that the other eggs were predated by a snake. The nest was empty on June 17 and thus could not have produced more than two chicks.

One hen apparently did not nest. She was located in the same area 13 times between 14 April and 2 June, never on a nest. We suspect that her nest was predated very early in incubation or that she did not nest at all. Including this hen as a reproductive failure, either due to predation or failure to nest, with the depredated hens, the rate of reproductive failure for this study was at least 50%, and could have been as high as 100%. Reproductive success could therefore not have exceeded 50% and may have been as low as 0%.

Discussion

Surveys

The survey results strongly suggest an increase in LPCH populations on the PCAs and nearby areas over 1996 and 1997 levels. In 1996, NMDGF biologists detected 11 leks on PCAs and counted 29 birds. In 1997, we counted 28 birds on nine leks and estimated 10 on a 10th, for an estimated total of 38 birds. The 1998 surveys reveal more than a three-fold increase in number of leks detected and a five-fold increase in number of birds. This is consistent with the increase in numbers of birds per lek observed in 1998. Most 1996 and 1997 leks had one to four birds per lek. The largest number of birds counted in 1996 was five. In 1997, the largest number was six, although one lek at Marshall may have had as many as 10. In 1998, we counted or estimated 10 or more birds at eight leks, and 22 leks had at least four birds.

How can these increases be explained? We believe they should be considered in light of the surveys conducted in other parts of the state. In 1998, we also surveyed 29 traditional lek sites in the BLM Carlsbad Resource Area. We entered data from these leks, collected since 1985, into the NMNHP Access database. Numbers of active leks and total numbers of booming males at the Carlsbad leks have declined dramatically since the early 1990s. Increases similar to those observed at the PCAs were not seen at Carlsbad, and 1998 was the worst year ever for prairie chickens in the Carlsbad Resource Area**.** Only one of 29 lek sites was active in 1998, and there were six males at that lek. This decline strongly suggests that Lesser Prairie Chickens will be extirpated from the Carlsbad area in the next few years.

The Palmer Drought Index and local rainfall data (www.ncdc.noaa.gov/cgi-bin/ginterface) indicate that the Carlsbad climate was wetter than average in 1997 and did not differ appreciably in 1996-7 from that in Portales, where the PCAs are located. Oil and gas activity is higher in the Carlsbad area than on the Caprock or at the PCAs, and grazing is also practiced. It appears that human impacts are responsible for the dismal state of the LPCH population in the Carlsbad area. However, there are no data available to test alternative hypotheses such as predation, disease, or loss of genetic variability.

Data from 1998 surveys suggest that the Caprock LPCH population has increased approximately 100% over 1997. The number of active leks increased from 19 in 1997 to 25 in 1998. Although this increase is encouraging, the Roswell population is still only one-sixth as large as it was during years in the mid-1980s in which comparable survey

effort was exerted. The 1998 increase at Roswell was also not as dramatic as the increase on the PCAs. As in Carlsbad and Portales, the drought of the early 1990s broke in 1997, one apparent reason for the 1998 LPCH increases at Roswell. Oil and gas impacts are fewer on the Caprock, but grazing is widespread there. Populations at both the PCAs and the Caprock probably suffered the effects of the drought in the early 1990s, but LPCH habitat has been more heavily grazed at the Caprock than at the PCAs, most of which are not grazed. It is possible that more suitable nesting habitat was present at the PCAs, and the birds were able to efficiently utilize the nesting habitat when the rains brought food and further increases in cover.

In summary, differences in land use patterns at the three areas may have impacted the abilities of LPCH populations to make a comeback after a severe drought. At the PCAs, where petroleum exploitation and grazing are light or non-existent, LPCH populations began to rebound after drought. At Roswell, females nested in shinnery pastures, but nests were not typically constructed in large clumps of bluestem grass, as found by Davis et al. (1979). The LPCH population there was able to respond somewhat in response to increased precipitation, but not to the extent observed at the PCAs. At Carlsbad, it appears that populations were so small and/or impacts so great, that the LPCH population has not been able to rebound, and in fact extinction of that population may be imminent. These data suggest that nesting habitat preserves near lek sites, such as the PCAs, are effective conservation tools.

BLM Telemetry Study

A serious problem with this study was that transmitters came off the birds' necks, apparently because the necklace opening was too large. Only the whip antennas stayed on well, because these transmitters had to be worn much tighter for the antennas to stay in place down the middle of the bird's back. Even necklaces which had bibs attached to reduce the size of the necklace were lost. All seemed to transmit relatively well; however, one female wearing a whip antenna gave fluctuating signals, apparently due to the hen moving while foraging. We conclude that whip antennas transmit well and stay on the birds best, but if improperly attached they could interfere with flight.

Because so many transmitters were dropped, we do not have exact data regarding survival and reproductive success. Even the ranges in this study, however, are alarmingly low. A mortality rate of even 33% would be high for adult birds, and it is difficult to imagine a population being sustained with reproductive failure rates between 50% and 100%.

It is clear that predation is greatly impacting the Caprock Lesser Prairie Chicken population. This is consistent with other telemetry studies of Lesser and Greater Prairie Chickens (Roger Applegate, Don Wolfe, pers. comm.). There are several plausible hypotheses to explain the extraordinary predation rates detected in these studies. First, habitat quality may be too poor to provide sufficient cover for hens to avoid predators and hide their nests. In this study**,** two nests were built under yucca plants providing little cover, but all nests were found in shinnery pastures. Pastures with sizeable grass clumps appeared to have little shinnery and vice versa. Hens may be choosing nest sites based

on shinnery cover in the pasture as a whole, while ignoring grass cover for nest sites, which tends to be low in grazed shinnery pastures.

Second, predator populations may be higher now than in the past, due to extermination of wolves and reduction of predator control by ranchers. Further study of predator populations would address this hypothesis. A negative correlation between LPCH population and predator control rates by ranchers could also address this hypothesis.

Third, the post-drought age structure in the Caprock population may be biased toward young hens. Seven of the 12 hens we captured (58%) were second-year birds (i.e., in their first breeding season). It is possible that inexperienced hens choose poorly-protected nest sites.

Finally, and of most concern, investigators may be cueing predators to the location of nests. Predators could be following investigator scent to nest sites. This hypothesis seems unlikely for coyotes, because two nests were only partially predated and no shell fragments were found, suggesting snake predation. It is possible that snakes follow researcher scent to nests and harvest eggs over several days. The investigator hypothesis also does not explain predation on hens that were not on nests when killed. That predation rates were higher on nests (100%) than on non-nesting hens (33%-83%), may suggest investigator impact on nest predation; however, nests may be easier to find and predate than non-nesting hens. In addition, we created many more false trails through the dunes than trails that actually culminated at nests.

Nesting Habitat and Bird Measurements

The analysis of the vegetation data is still in progress. It will be available in the BLM Roswell report, to be completed during the fall, 1998. Data on the traits measured will also be included in that report.

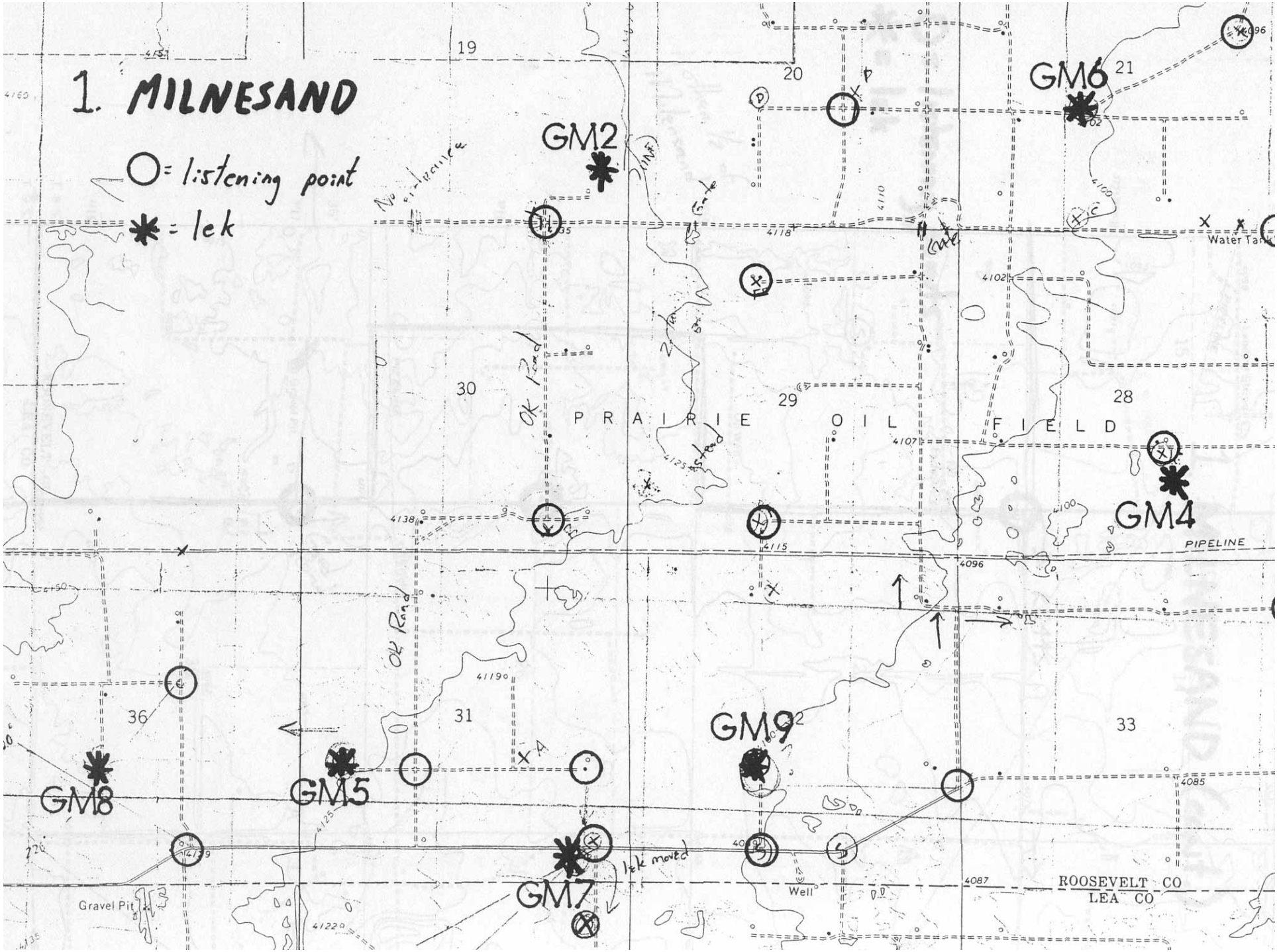
Research Recommendations

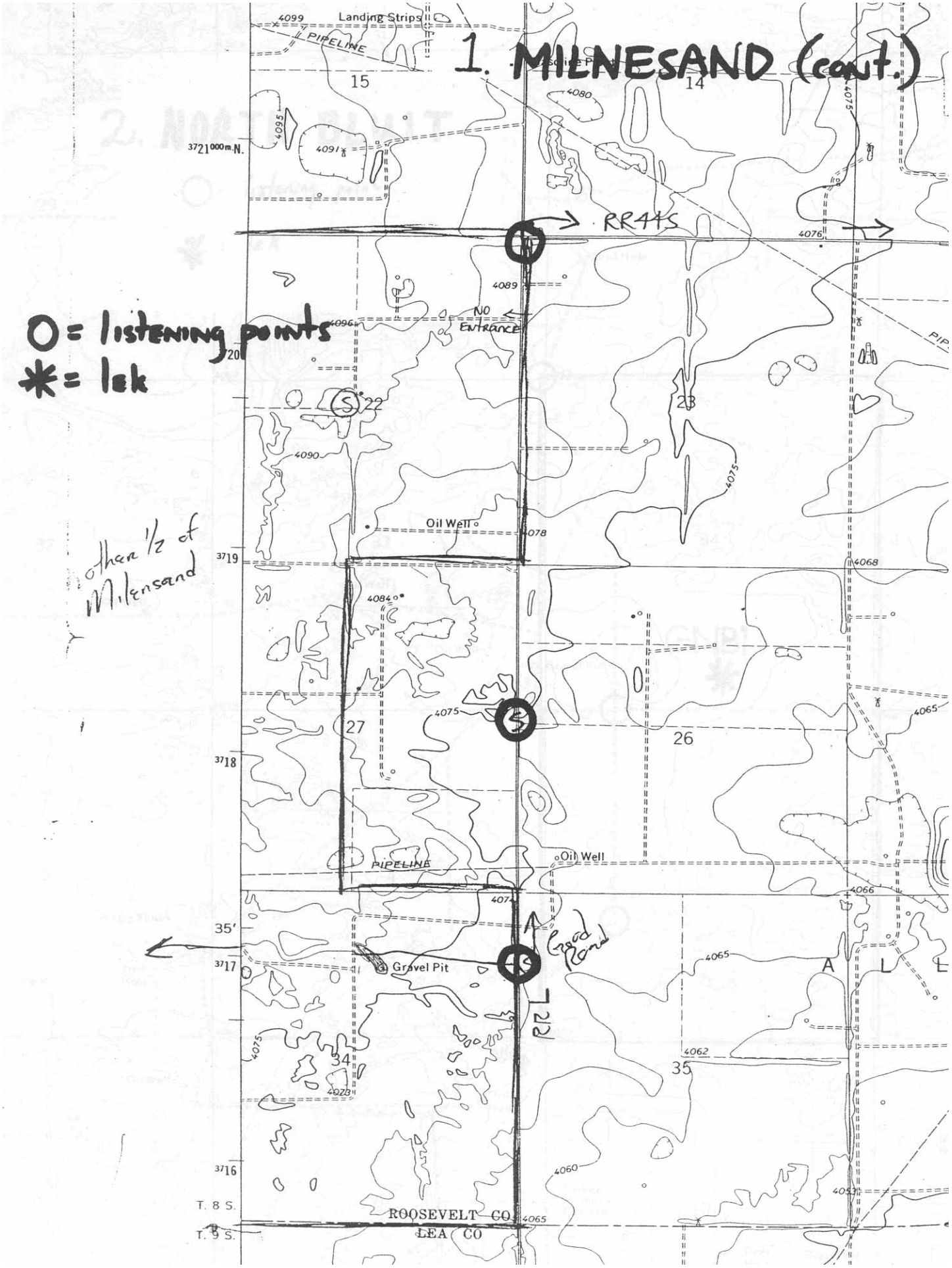
Surveys should be continued at all three New Mexico populations, and the NMNHP Access database updated yearly. We recommend that the Roswell study be continued until a larger sample of hens has been radio collared and nests found. It is important to take precautions to avoid leading predators to nests; e.g., visit nests infrequently, avoid touching nests or surrounding vegetation, and do not approach nests when ravens or other potential predators are in the area.

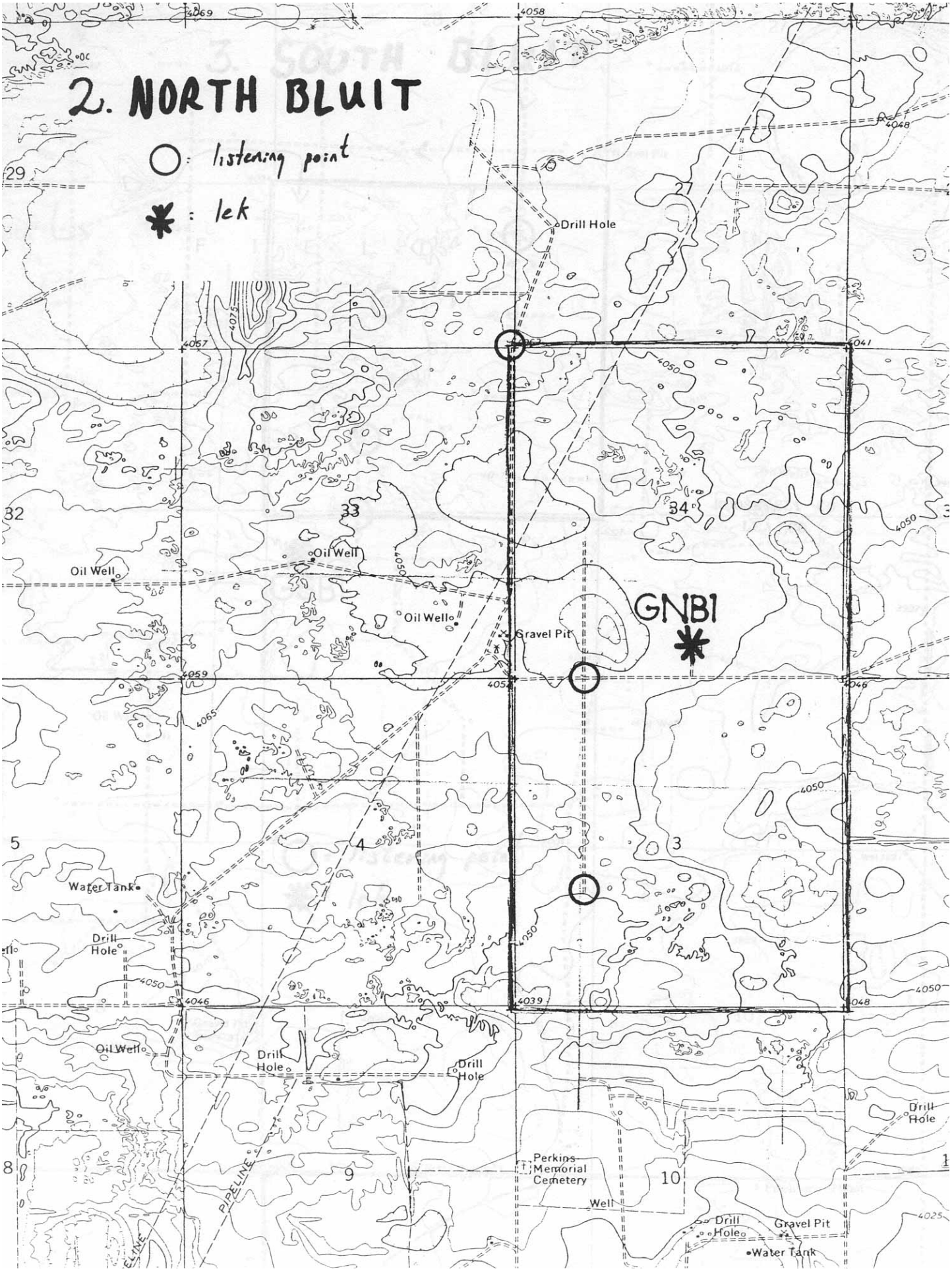
Future studies should investigate the influence of the PCAs on LPCH reproduction, nest predation, and survival rates. Are the birds detected at leks actually using the PCAs for nesting? How far are nests from leks? What is the vegetation structure at nests? What are the predation rates on hens and nests? Data on these questions could be compared to similar data at Roswell, where land management practices differ.

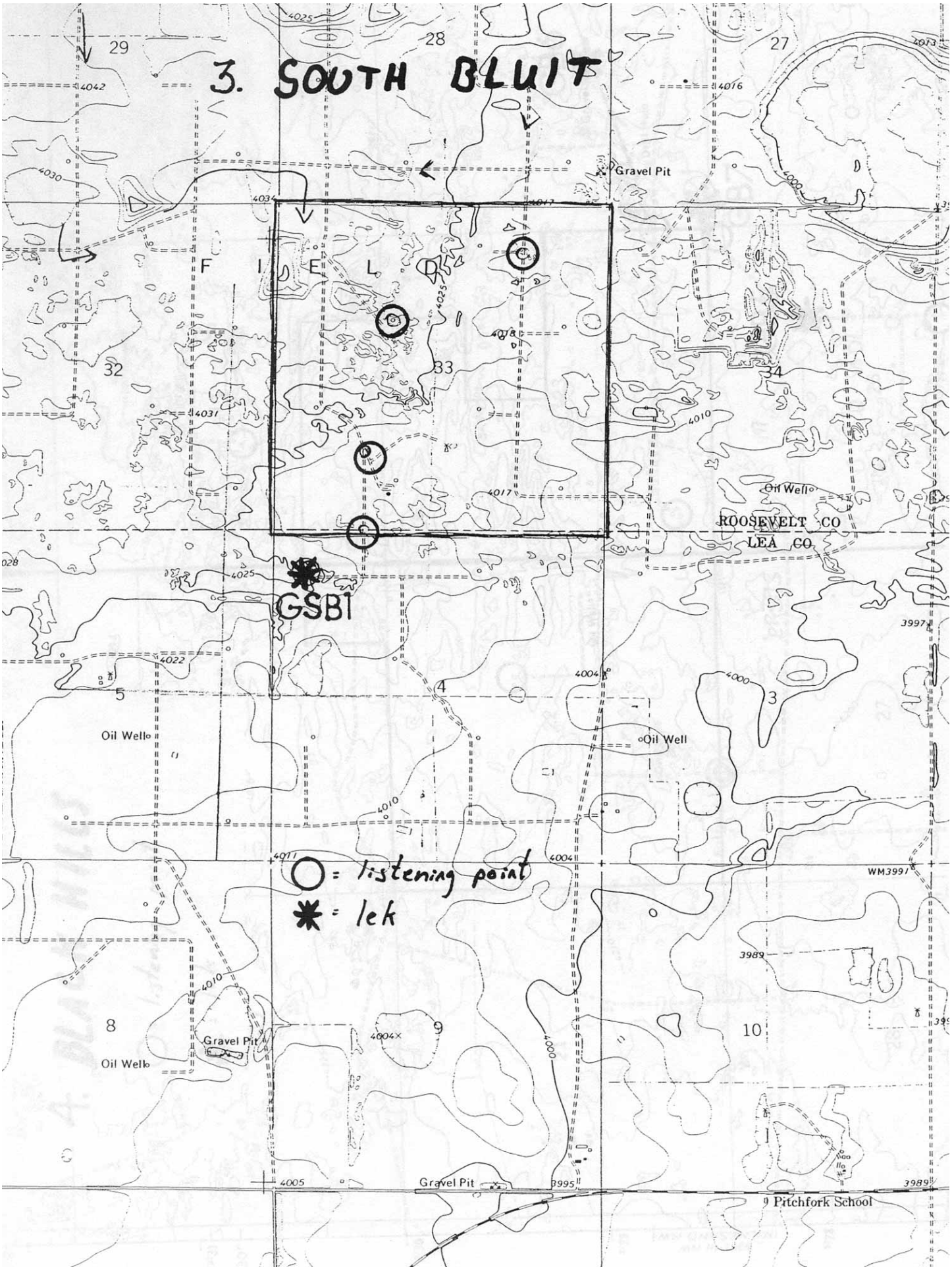
As part of the trapping study at Roswell, we drew blood for eventual analysis of genetic variation and blood parasitemia. We also collected fecal samples for analysis of gut parasites. Any of these factors has the potential to greatly impact a small, declining

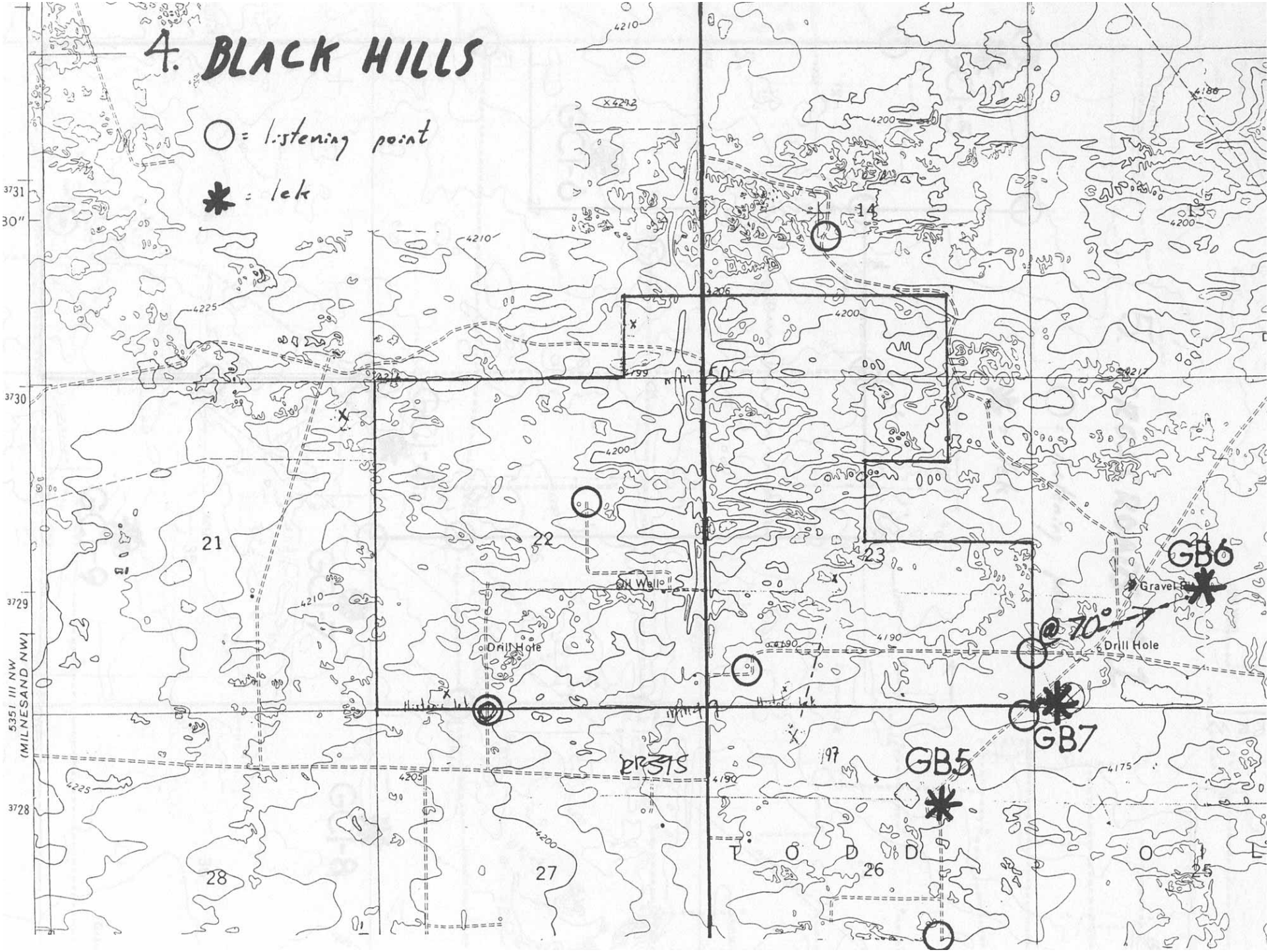
population such as the one at Carlsbad. Any future trapping studies should include DNA and parasite analysis.

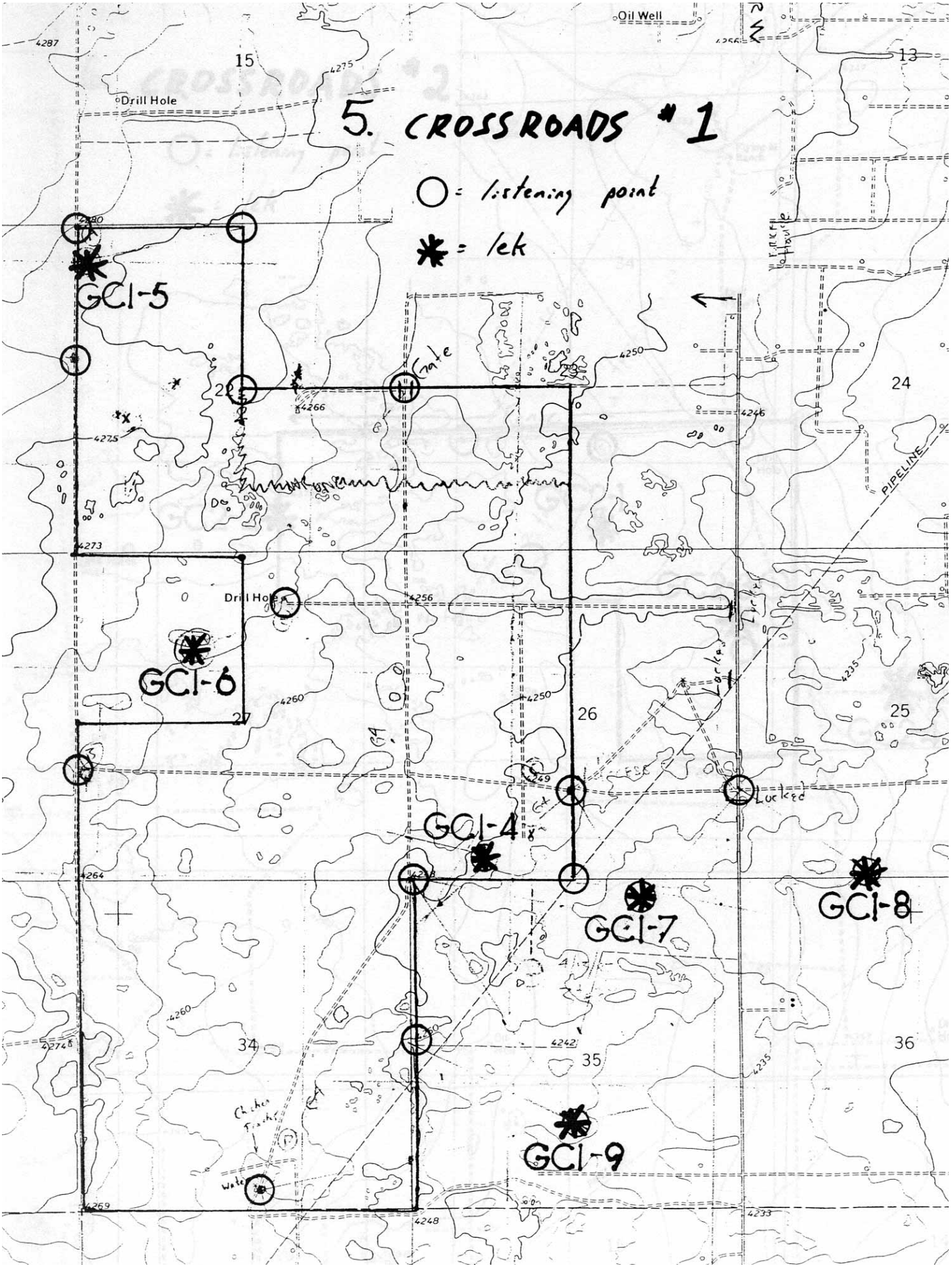

1. MILNESAND
○ = listening point
✱ = lek
GM2
GM6
GM4
GM9
GM8
GM5
GM7
PRAIRIE OIL FIELD
PIPELINE
Old Road
lek moved
Gravel Pit
Well
ROOSEVELT CO
LEA CO
Water Tank
19
20
21
30
29
28
31
33
36


1. MILNESAND (cont.)
O = listening points
* = leak
other 1/2 of Milnesand
Landing Strips
PIPELINE
15
14
4099
4095
4091
4080
4075
3721 000m.N.
RR44S
4076
4089
NO ENTRANCE
4096
20
22
23
4090
4075
Oil Well
4078
3719
4068
4084
27
26
4075
4065
3718
PIPELINE
Oil Well
4066
4071
35'
3717
Gravel Pit
(good Road)
RR L
4065
34
4075
4073
4062
35
3716
4060
T. 8 S.
ROOSEVELT CO.
4065
T. 9 S.
LEA CO


2. NORTH BLUIT
○: listening point
✱: lek
GNB1
Drill Hole
Oil Well
Oil Well
Oil Well
Gravel Pit
Water Tank
Drill Hole
Oil Well
Drill Hole
Drill Hole
Drill Hole
Perkins Memorial Cemetery
Well
Drill Hole
Gravel Pit
Water Tank
PIPELINE
E/LINE
29
32
33
34
5
4
3
8
9
10
4058
4048
4041
4050
4057
4059
4065
4046
4039
4025


3. SOUTH BLUIT
FIELD
GSB1
Gravel Pit
Oil Well
ROOSEVELT CO
LEA CO
Pitchfork School
○ = listening point
✱ = lek


4. BLACK HILLS
○ = listening point
✱ = lek
GB6
GB7
GB5
@ 70°
Drill Hole
Oil Wells
Gravel Pit
Drill Hole
5351 III NW
(MILNESAND NW)
21
22
23
24
26
27
28
25
14
50


5. CROSSROADS #1
○ = listening point
✱ = lek
GC1-5
GC1-6
GC1-4
GC1-7
GC1-8
GC1-9
Oil Well
Drill Hole
Drill Hole
Lake
PIPELINE
Locked
15
13
24
25
26
27
34
35
36
4287
4275
4266
4246
4250
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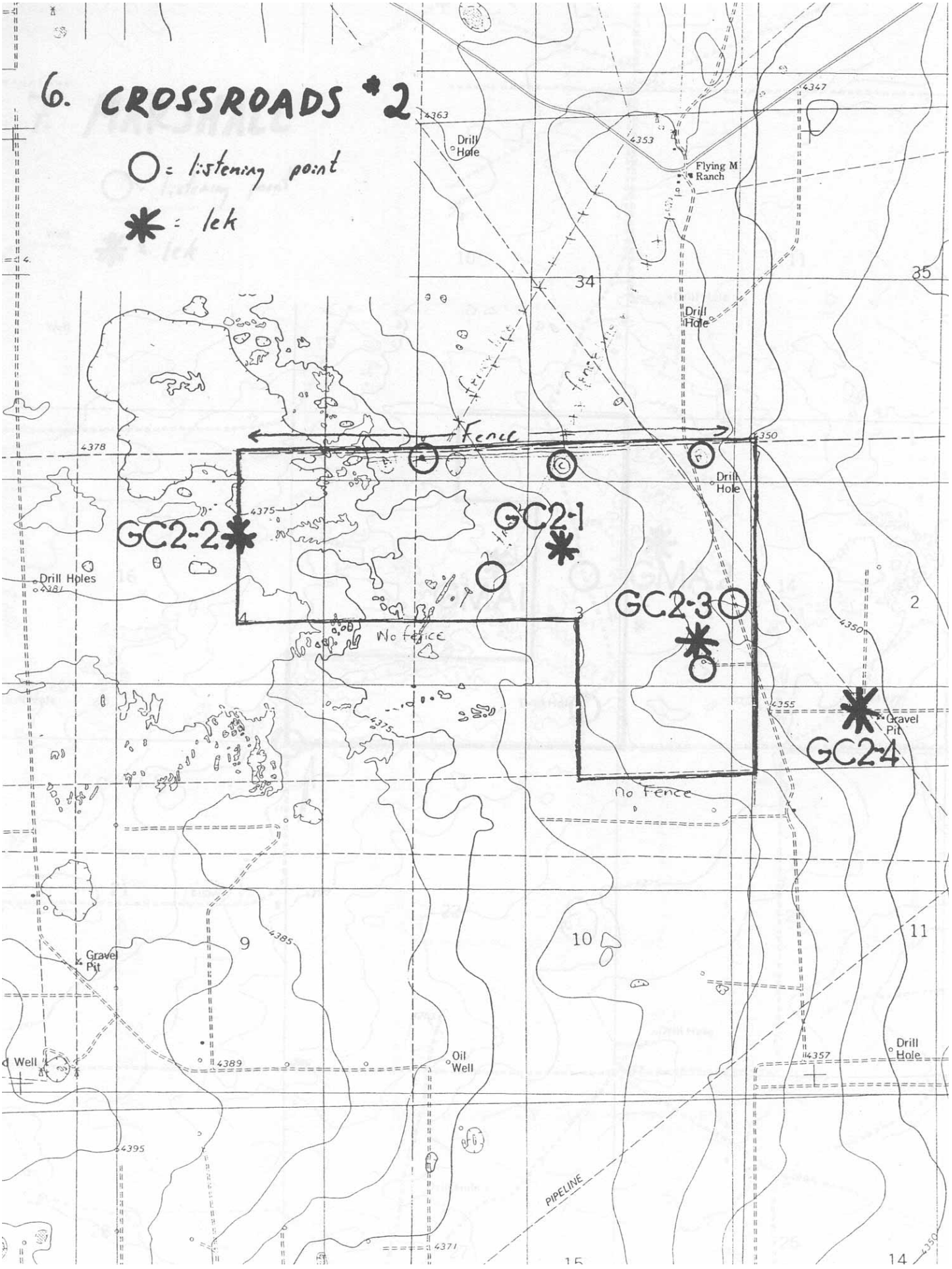
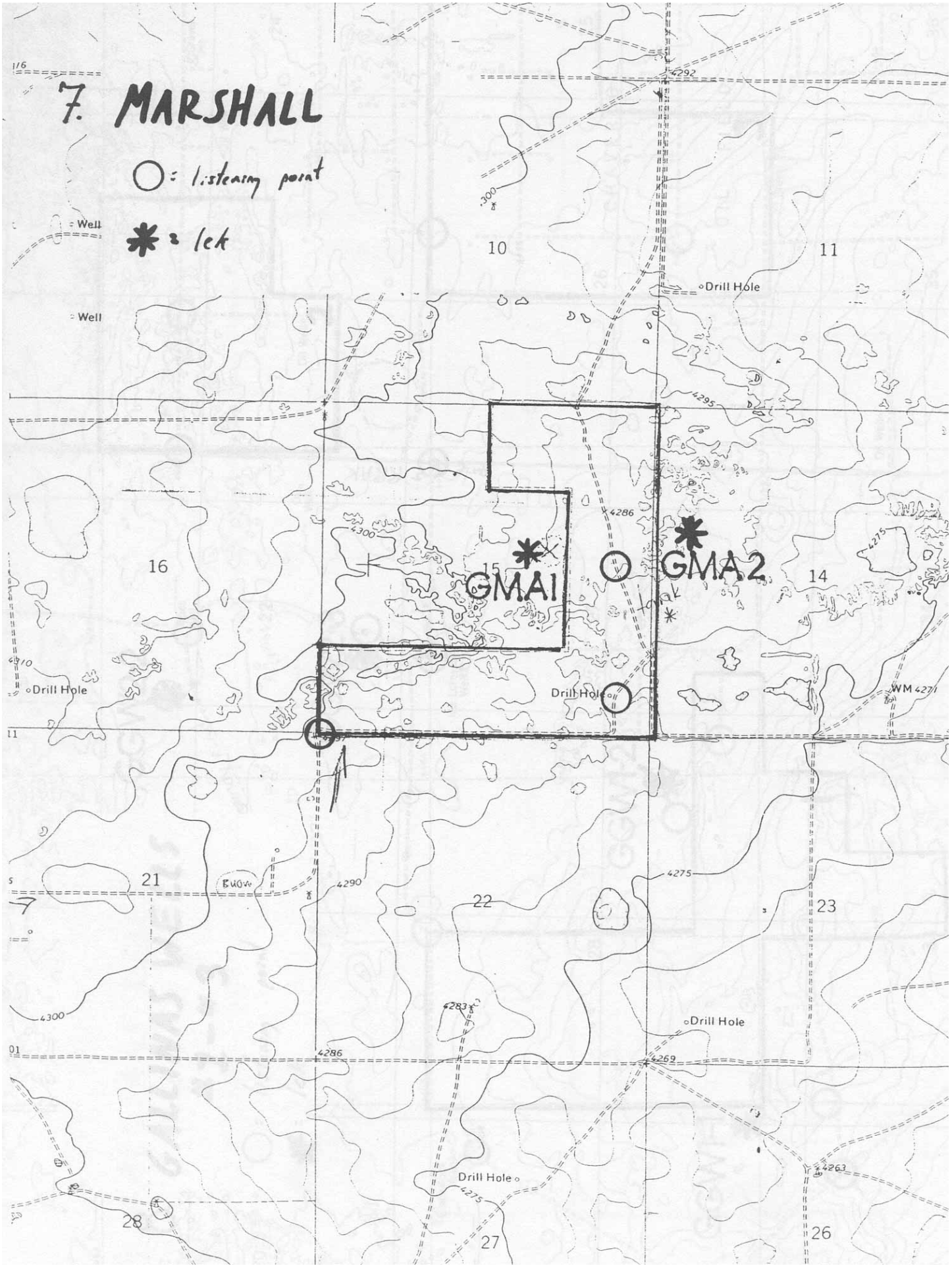
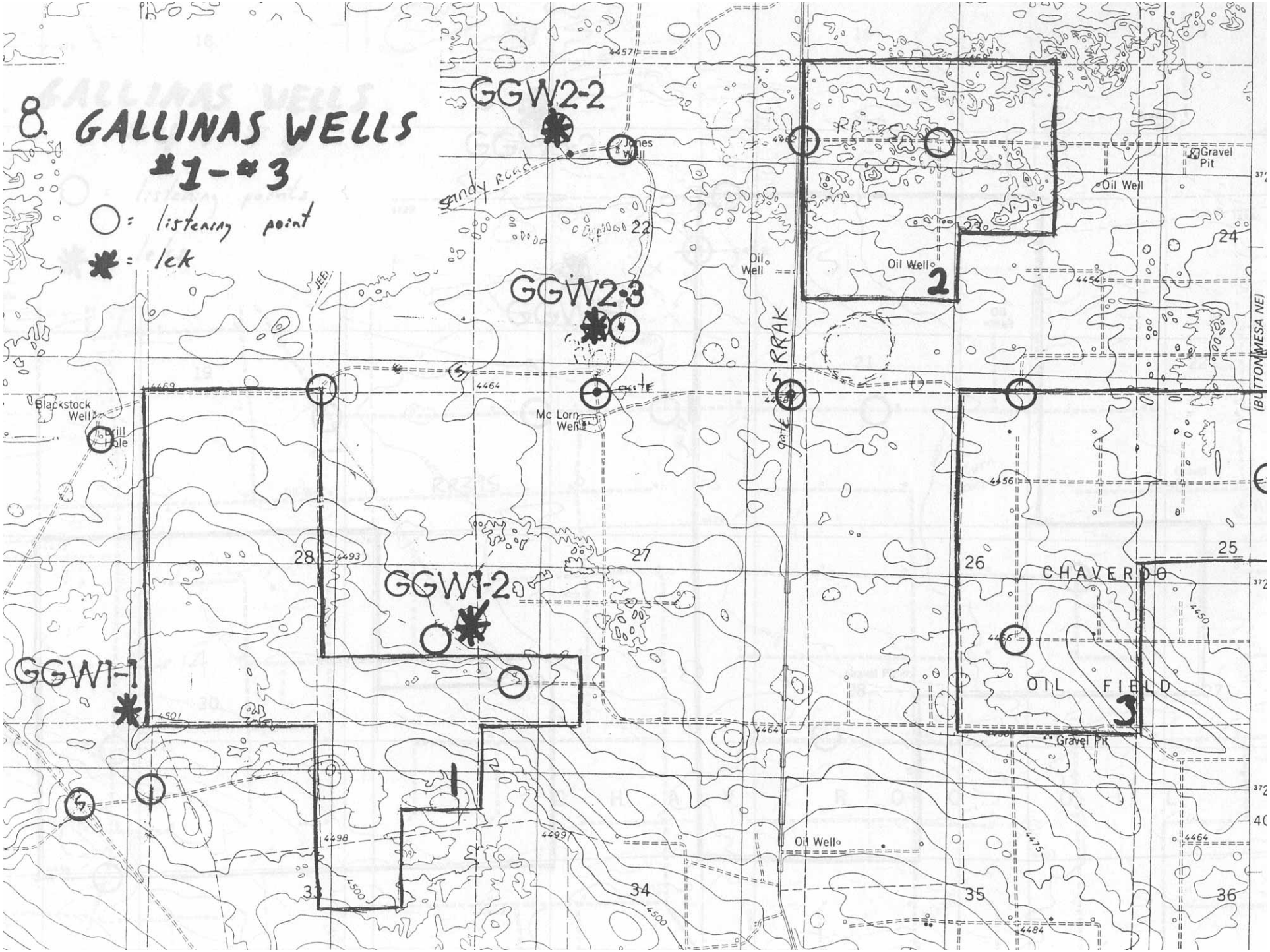
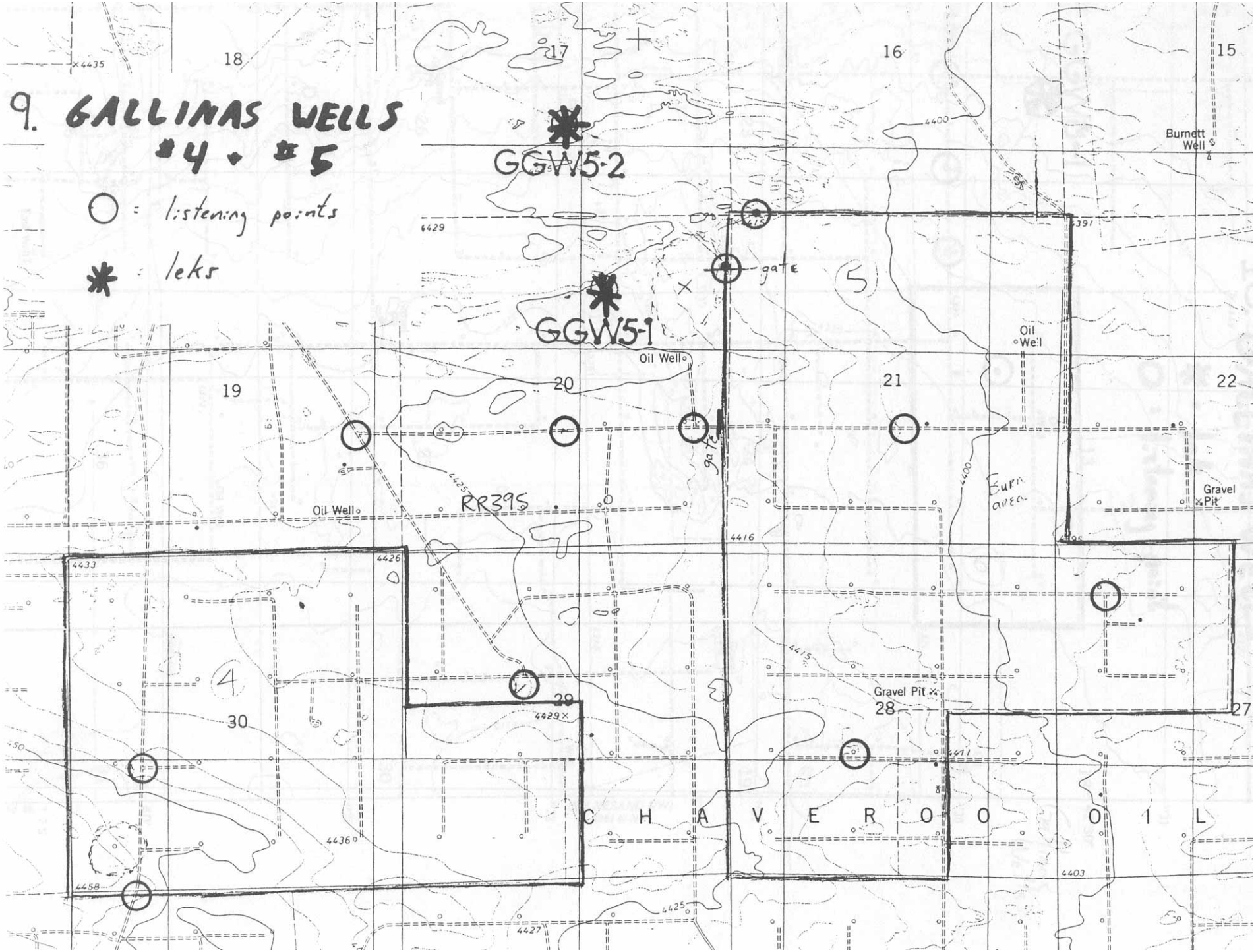
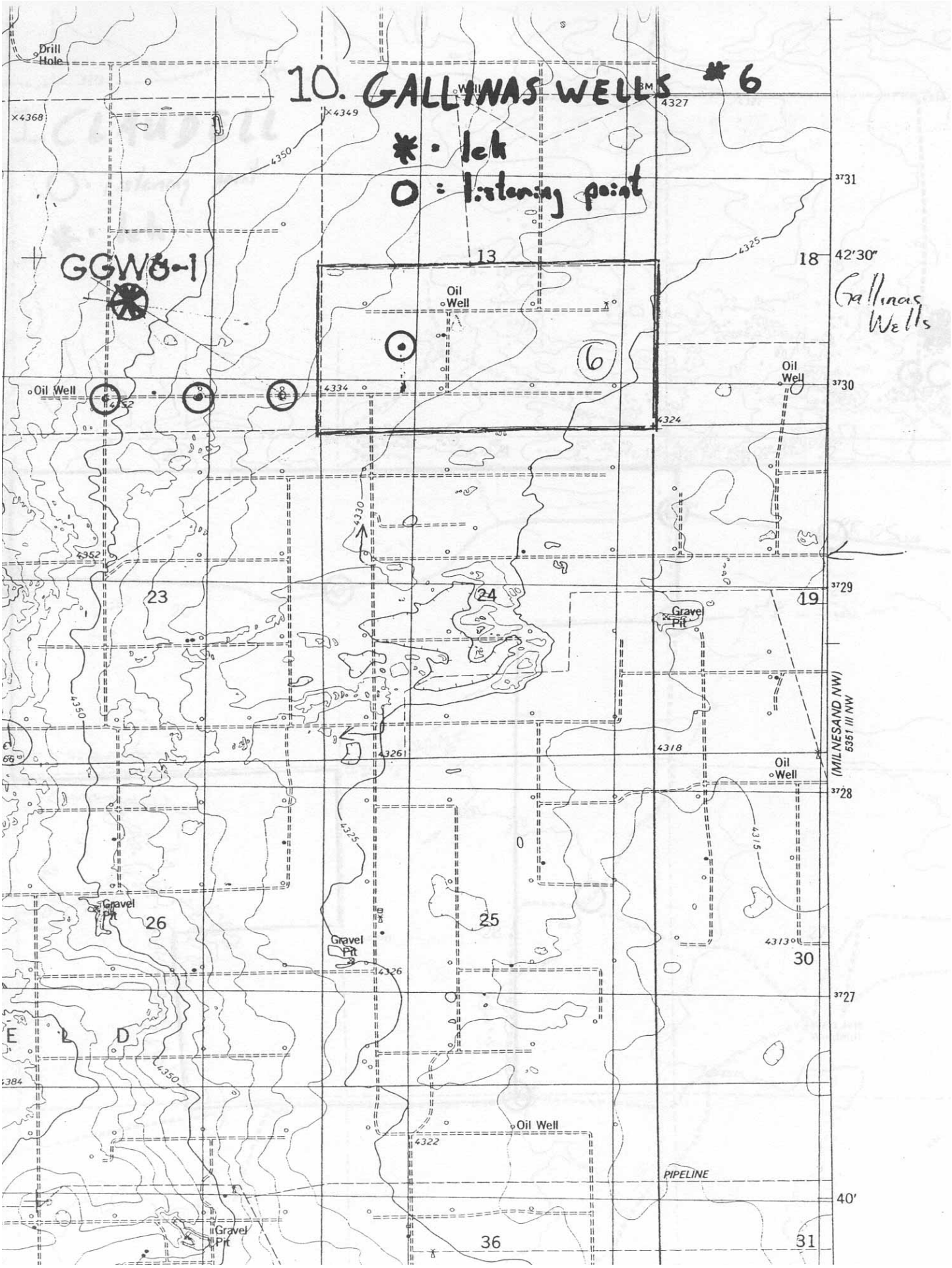
4249
4264
4242
4235
4233
4248
4269

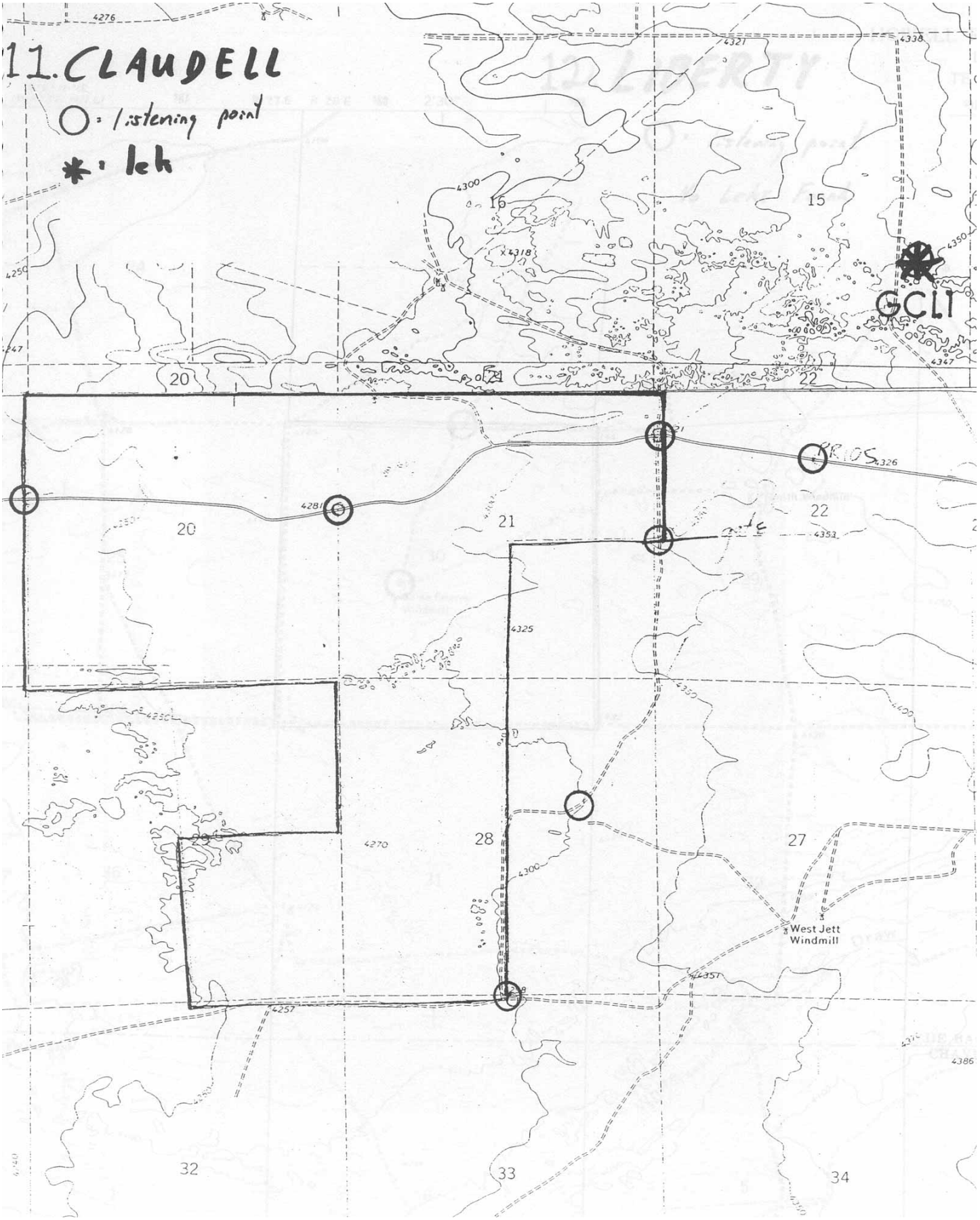

6. CROSSROADS #2
○ = listening point
✱ = lek
GC2-1
GC2-2
GC2-3
GC2-4
Fence
No fence
No fence
Drill Hole
Drill Hole
Drill Hole
Drill Hole
Drill Holes
Flying M Ranch
Gravel Pit
Gravel Pit
Oil Well
Oil Well
PIPELINE
34
35
2
9
10
11
4347
4363
4353
4378
4375
4350
4355
4385
4389
4357
4395
4371


7. MARSHALL
○ = listening point
✱ = leak
GMA1
GMA2
Well
Well
Drill Hole
Drill Hole
Drill Hole
Drill Hole
10
11
14
15
16
21
22
23
26
27
28
4292
4295
4286
4300
4275
4290
4283
4269
4263
WM 4271


8. GALLINAS WELLS
#1-#3
○ = listening point
✱ = leak
GGW2-2
GGW2-3
GGW1-2
GGW1-1
Sandy Road
Jones Well
Oil Well
Oil Well
Gravel Pit
Blackstock Well
Drill Hole
Mc Lorn Well
RRAK
CHAVERO
OIL FIELD
Gravel Pit
Oil Well
(BUTTONMESA NE)
1
2
3
22
24
25
26
27
28
34
35
36


9. GALLINAS WELLS #4 • #5
○ = listening points
✱ = leks
GGW5-2
GGW5-1
gate
gate
Oil Well
Oil Well
Oil Well
Burnett Well
Gravel Pit
Gravel Pit
RR395
Euro area
18
17
16
15
19
20
21
22
4
5
30
29
28
27
4435
4429
4400
4391
4425
4416
4433
4426
4415
4429
4411
4436
4458
4403
4427
4425
C H A V E R O O O I L


10. GALLINAS WELLS #6
* : Jetty
O : listening point
GGW6-1
Drill Hole
Oil Well
Gravel Pit
PIPELINE
(MILNESAND NW)
5351 III NW
Gallinas Wells
42'30"
40'


11. CLAUDELL
○ : listening point
* : leh
GCLT
West Jett Windmill
16
15
20
21
22
28
27
29
32
33
34
4276
4321
4338
4300
4318
4350
4250
4247
4347
4281
4326
4353
4325
4270
4257
4351
4386

12. LIBERTY

○ = listening point

No Leks Found

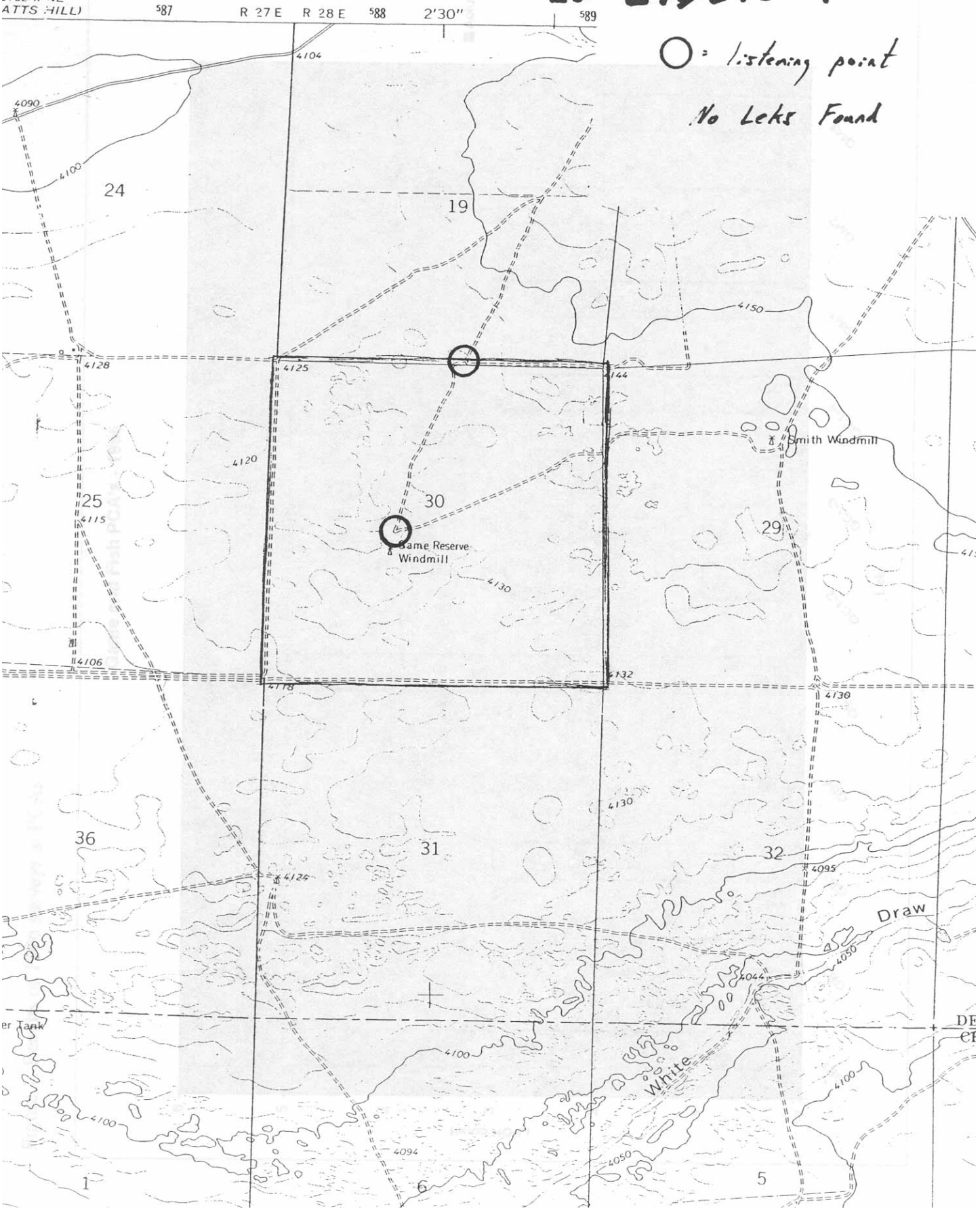


Figure 1. Results of 1996 surveys at PCAs.

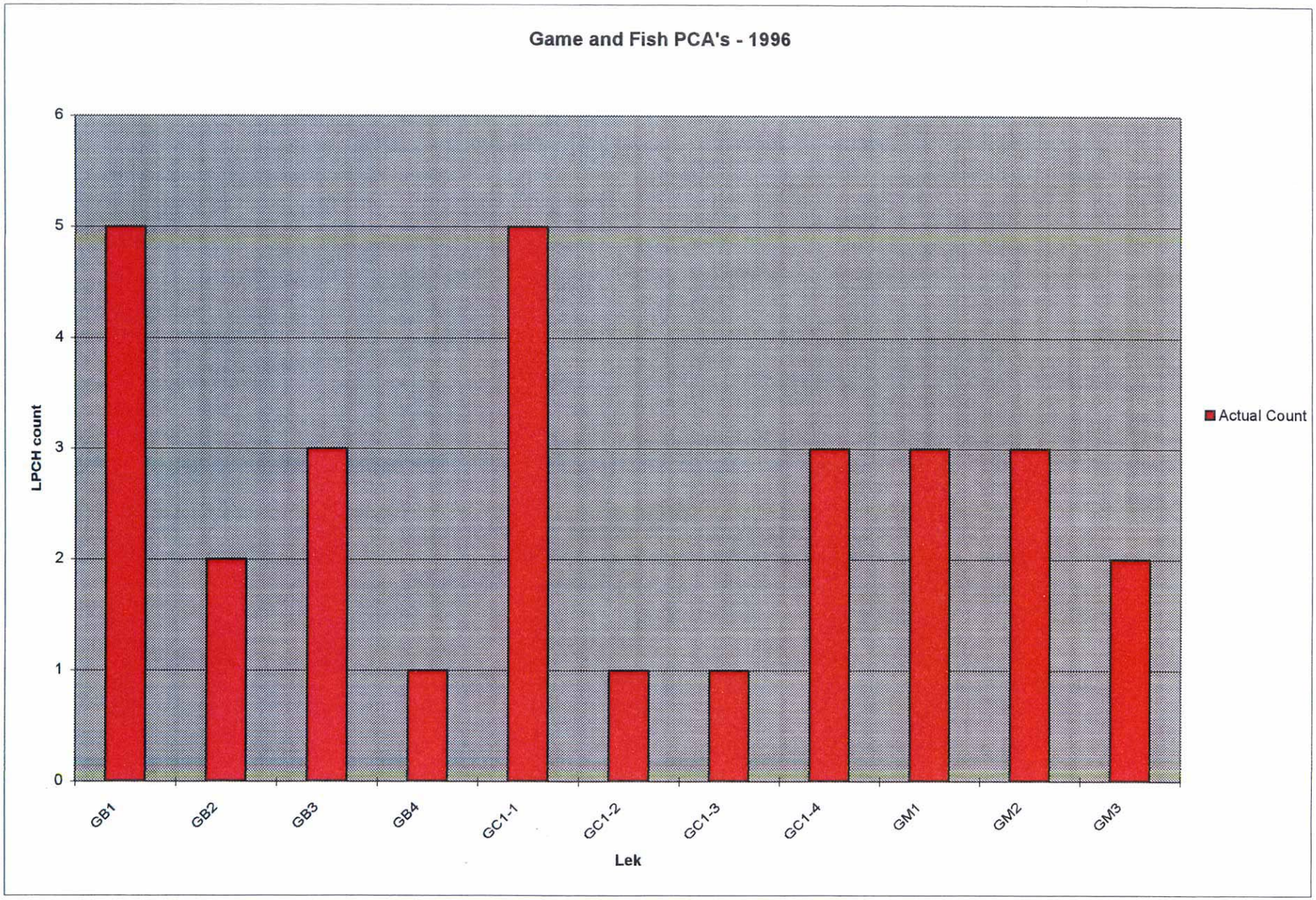


Figure 2. Results of 1997 surveys at PCAs.

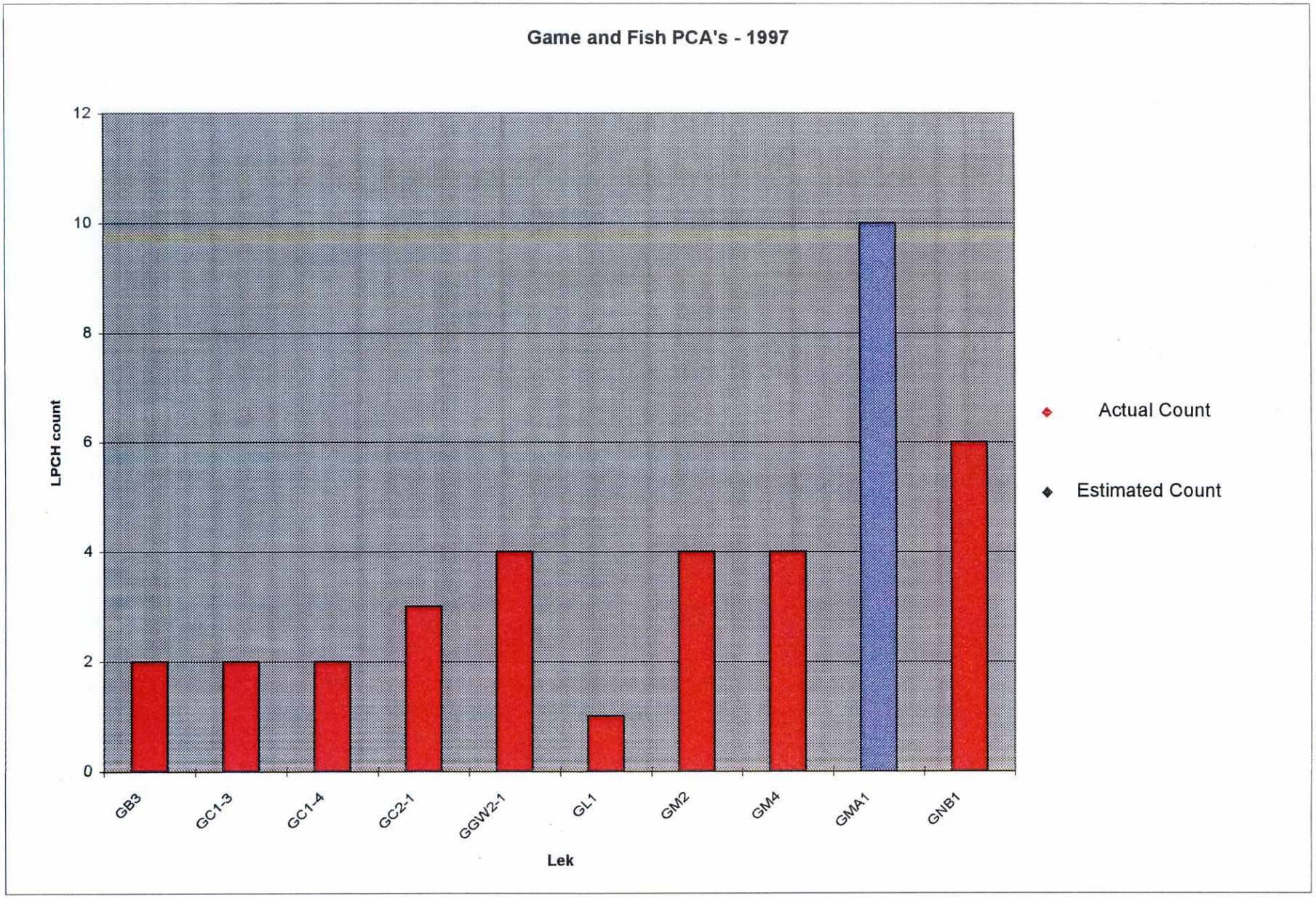
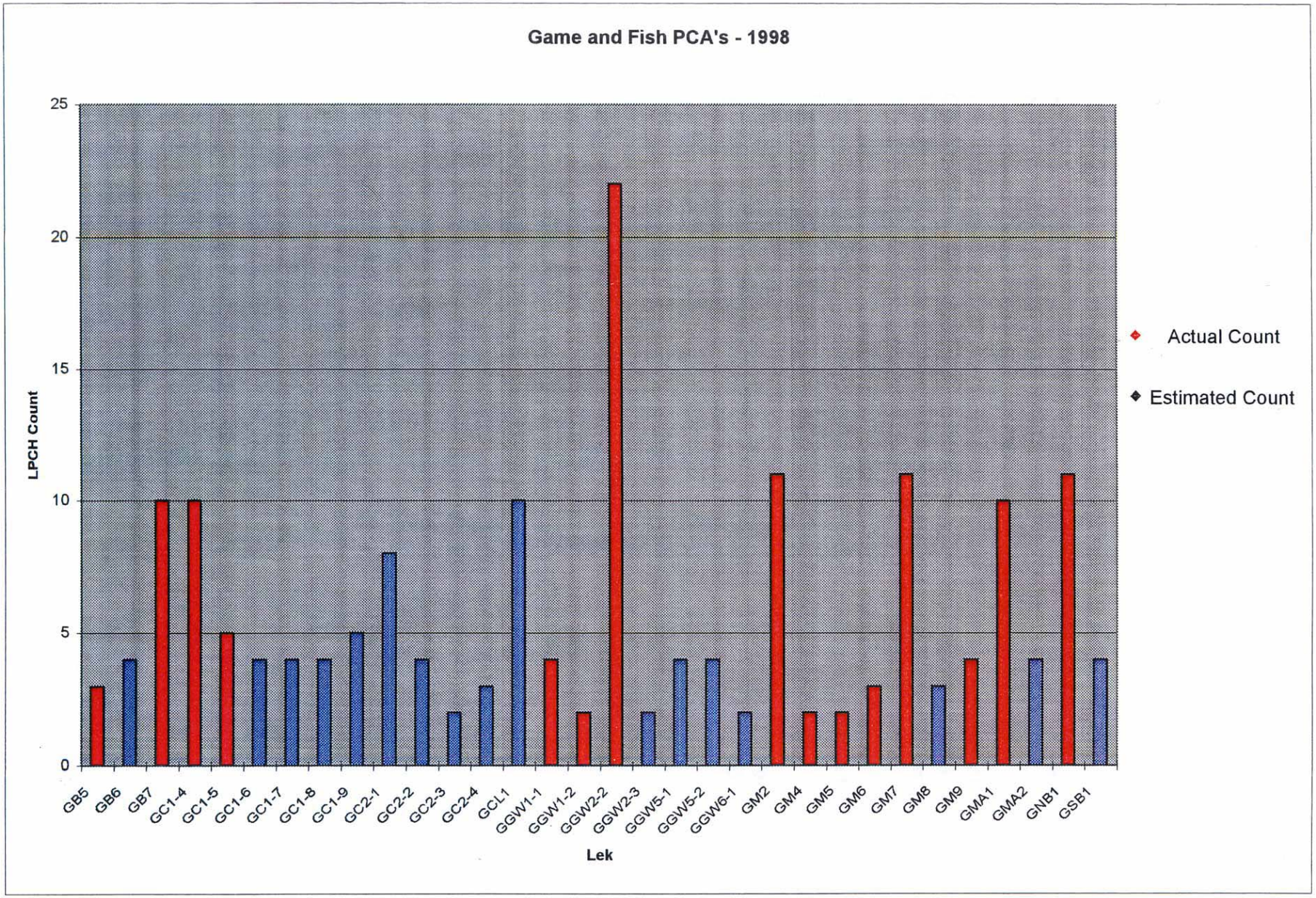


Figure 3. Results of 1998 surveys at PCAs.



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Appendix 1. UTM coordinates of all leks detected in 1998. For inaccessible leks, locations and UTMs were estimated using compass triangulation from accessible locations.

Lek Number	UTM Easting	UTM Northing
GM-5	657520	3716180
GM-6	661080	3719500
GM-2	658750	3719130
GM-4	661690	3717700
GM-7	658750	3715420
GM-8	656330	3716160
GM-9	659550	3716240
GNB-1	672570	3725690
GSB-1	670430	3715630
GB-5	655070	3727960
GB-6*	655540	3728730
GB-7	655650	3728490
GC2-2	632610	3714740
GC2-1	634060	3714620
GC2-3	634840	3714190
GC2-4	635590	3713910
GC1-5	642890	3720000
GC1-6	643460	3718100
GC1-7	645640	3716930
GC1-8	646750	3717050
GC1-9	645340	3715820
GC1-4	644880	3717100
GMA-1	643790	3730780
GMA-2	644500	3730880
GGW6-1	635620	3730370
GGW5-1	631120	3729300
GGW5-2	630920	3730120
GGW1-1	622010	3726300
GGW1-2	623670	3726730
GGW2-2	624050	3729150
GGW2-3	624260	3728180
GCL-1	603350	3777030

lek is 70^0 from this point

Appendix 2. Data sheets from 1998 surveys of PCAs.