# URANIUM LEVELS AND RADON POTENTIAL IN SELECTED AREAS NORTH OF PHOENIX, IN THE ST. JOHNS AREA, AND NORTH OF TUBA CITY, ARIZONA

by
**Raymond C. Harris, Robert S. Leighty,**
**Robert B. Scarborough, and Jon E. Spencer**

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416 W. Congress, Suite #100, Tucson, Arizona 85701

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## INTRODUCTION

Radon is a colorless, odorless gas produced by the natural radioactive decay of uranium. The U.S. Environmental Protection Agency has determined that exposure to indoor radon increases human risk of developing lung cancer. Indoor-radon levels generally correlate with uranium concentration in underlying rocks and soil, and some areas of Arizona are known to have elevated levels of uranium.

In many areas in Arizona calcareous lake beds deposited in middle to late Cenozoic time have elevated uranium levels and these rocks are by far the most significant potential radon source in Arizona (Spencer, 1992, 1993). With funding from an EPA State Indoor Radon Grant (SIRG year 8, Grant K1-009544-08-0), the Arizona Geological Survey conducted a survey of uranium levels in previously unstudied calcareous lake beds in the New River area north of Phoenix (Maricopa County), calcareous rocks that are probably lake beds in the St. Johns area (Apache County), and limestones of uncertain age at Preston Mesa north of Tuba City (northeastern Coconino County, Navaho Indian Reservation). A variety of other rock types were also examined in the New River area. Uranium concentrations were measured using a portable gamma-ray spectrometer. The spectrometer survey followed the methods outlined in Duncan and Spencer (1993a) and the same equipment was used during both investigations. The results and an evaluation of their significance are presented here.

## GAMMA-RAY SPECTROMETER SURVEY

### Survey Methods

The Arizona Geological Survey conducted a survey of the Cave Creek-Carefree area using an EG&G geoMetrics model GR-310 portable gamma-ray spectrometer. The machine employs an external detector containing a 347-$cm^3$, thallium-doped, sodium iodide crystal and a high-gain photomultiplier tube. Four independent channels provide measurements of the diagnostic gamma radiation for uranium (via bismuth-214, 1.76 million electron volts [MeV]), thorium (via thallium-208, 2.62 MeV), needed for uranium assay corrections, as well as total gamma radiation (0.4 to 4.0 MeV) and potassium.

Count times of 1, 10, 100, or 1000 seconds may be selected, and due to the random nature of radioactive decay, longer count times generate less statistical error and greater precision. Periodic comparisons of 100- versus 1000-second count times confirmed that the shorter count time was sufficiently accurate for the purposes of this study and so was used for data acquisition. Uranium concentrations in parts per million (ppm) were calculated from the field data using correction factors and assay equations developed by Duncan and Spencer (1993a). Results are presented in Table 1.

### Survey Area Geology

**New River area.** The New River area north of Phoenix consists of scattered hills and mountains separated by flat to gently sloping alluvial valleys. The alluvial valley fill has never been known to be a problem in Arizona with regard to radon emanation. The bedrock in the New River area, however, consists of a variety of rock types with highly variable uranium concentrations. Bedrock consists of Precambrian metavolcanic, metasedimentary, and granitic rocks overlain by Miocene basalt, tuff, siltstone, marl, and related sedimentary and volcanic rocks. The marls in particular have been of interest because of high uranium levels identified in similar, nearby rocks (Duncan and Spencer, 1993b; Harris, 1997). Precambrian volcanic and granitic rocks in Arizona are also known to have high uranium levels in a few areas (Duncan and Spencer, 1993b; Proctor and others, 1993).

**St. Johns area.** Tufa of probable lacustrine origin caps many terraces, mesas, and buttes at elevations of 6000 to 6700 feet along the Little Colorado River Valley near St. Johns. Exposures at

Stinking Springs Mountain and Mesa Parada are flat-lying and extensive. Lyman Lake exposures are smaller in extent, comprising many small buttes, but these probably represent erosional remnants of a formerly more extensive, continuous deposit. At Sanders, one tufa-capped butte was found; others may be present in the area but would require more field work to locate. All of these exposures lack signs of a pedogenic origin (i.e., are not caliche), such as soil, sand, or gravel included within the carbonate.

**Preston Mesa.** At Preston Mesa on the Navajo Indian Reservation north of Tuba City, small limestone outcrops suspected to be lake beds are exposed around the mesa, which is composed entirely of Jurassic Navajo Sandstone. The limestone is gray, with abundant chert, and some biogenic structures. Limestone caps most of the isolated mesas and buttes around Preston Mesa, all at 6000 feet elevation, but whether these layers continue into the main mesa could not be determined. Partly because of the nature of silts underneath the limestone, these deposits are remarkably similar to silts and calcareous sedimentary rocks of the Miocene Bidahochi Formation in the Hopi Buttes area. However, Navajo Sandstone is known to contain a few limestones of lacustrine origin, so there is a possibility that these limestones are Jurassic, rather than Miocene. These limestones and associated silts have not been dated, and their age remains unknown.

## Survey Results

Uranium levels in the New River area are not unusually high (>6 ppm U is considered high or anamolous), at least in the studied areas, except for two out of 28 measurements in which Precambrian metavolcanic rocks contained 9 and 10 ppm U. This is not particularly high, but if a large housing development were to be planned for an area underlain by this rock type, it would be prudent to survey the area more thoroughly and to alert home builders if > 10 ppm U levels are widespread. Continued geologic mapping will be directed in part at determining the extent of this rock type.

The tufa and related sediments surveyed in the Saint Johns area did not contain anomalous (>6 ppm) uranium levels at any of the surveyed sites.

Four measurements in the Preston Mesa area north of Tuba City were all anomalous, with uranium levels between 7 and 13 ppm U. Exposures of the cherty limestone that contain these uranium levels are not, however, widespread. If development should extend into this area it would be advisable to inform the Navaho tribal authorities so that more detailed surveying and perhaps installation of radon reduction equipment in homes can be carried out.

## REFERENCES CITED


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## TABLE 1: URANIUM MEASUREMENTS

*NEW RIVER AREA*

| | Location | U(counts/sec) | Th (counts/sec) | U (ppm) |
|---|---|---|---|---|
| 1) | Daisy Mtn. 7.5' quadrangle<br>T. 6 N., R. 3 E., sec. 5, SE¼, SE¼<br>Tertiary rhyolite tuff; elev 2100' | 4.60<br>3.96 | 3.93<br>3.96 | 0 |
| 2) | Same<br>100 yards east of #1<br>pink tuff and vitrophyre | 4.24<br>5.05 | 3.53<br>3.73 | 3 |
| 3) | Same<br>150 yards east of #2<br>Tertiary basalt | 3.96<br>4.45 | 3.73<br>3.24 | 1 |
| 4) | New River 7.5' quadrangle<br>T. 7 N., R. 2 E., sec. 2, SE¼, SW¼<br>Tertiary tuff; elev 2200' | 4.30<br>4.05 | 3.35<br>3.42 | 2 |
| 5) | Same; 200 yards N of #4<br>light gray tuff | 4.56<br>4.64 | 3.50<br>3.32 | 3 |
| 6) | Same; 200 yards N of #5<br>white tuff | 4.60<br>4.66 | 3.86<br>3.51 | 3 |
| 7) | Black Canyon City 7.5' quadrangle<br>T. 8 N., R. 2 E., sec. 22, NW¼, SE¼<br>Precambrian diorite or granodiorite<br>(Rock Springs area) | 3.63<br>3.76 | 3.10<br>3.24 | 0 |
| 8) | Squaw Creek Mesa 7.5' quad<br>T. 8 N., R. 2 E., sec. 1, SE ¼, NW¼<br>white marl; elev 2720' | 4.07<br>4.15 | 3.33<br>3.33 | 1 |
| 9) | Same; 50 yards east of #8<br>white marl | 4.71<br>4.63 | 3.33<br>3.20 | 4 |
| 10) | Same; 100 yards east of #9<br>brown clay | 4.49<br>4.14 | 3.76<br>3.59 | 1 |
| 11) | Same; between #8 & #9<br>brown clay, minor marl | 3.97<br>4.36 | 3.0<br>3.32 | 2 |
| 12) | New River SE 7.5' quadrangle<br>T. 5 N., R. 3 E., sec. 6, SW¼, SW¼<br>Precambrian felsic rock; elev 1800' | 5.67<br>6.46<br>6.26 | 3.67<br>3.67<br>3.62 | 10 |
| 13) | Same; 100 yards east of #12<br>Precambrian felsic rock | 6.47<br>5.95 | 3.97<br>4.02 | 9 |
| 14) | Same; 200 yards west of #12<br>Precambrian granite | 6.16<br>5.61 | 4.67<br>5.07 | 5 |

| | | | | |
|---|---|---|---|---|
| 15) | New River SE quadrangle<br>T. 6 N., R. 3 E., sec. 24, NW¼, NW¼<br>Precambrian felsic rock; elev 2100' | 5.71<br>5.56 | 5.15<br>5.76<br>5.01 | 2 |
| 16) | Same; 100 yards SW of #15<br>Precambrian felsic rock | 6.22<br>6.42 | 5.55<br>5.46 | 5 |
| 17) | New River SE quadrangle<br>T. 6 N., R. 3 E., E line sec. 8/17<br>Precambrian felsic unit; elev 2000' | 4.99<br>4.62 | 3.77<br>4.06 | 3 |
| 18) | New river SE 7.5' quadrangle<br>T. 5 N., R. 3 E. ,sec. 8, SE¼, NW ¼<br>Precambrian granite; elev 1900' | 4.02<br>4.06 | 3.54<br>3.56 | 0 |
| 19) | New River SE quadrangle<br>T. 5 N., R. 3 E., sec. 9, SW¼, SE¼<br>Precambrian andesite, elev 1870' | 3.45<br>3.54 | 2.6<br>3.21<br>3.01 | 0 |
| 20) | Union Hills 7.5' quadrangle<br>T. 4 N., R. 3 E., sec. 26, SW¼, NW¼<br>Precambrian granite; elev 1520 | 4.46<br>4.62 | 4.11<br>4.24 | 1 |
| 21) | Hedgpeth Hills 7.5' quadrangle<br>T. 4 N., R. 2 E., sec. 18, SE¼, NW¼<br>Precambrian leucogranite; 1400' | 6.51<br>6.75 | 5.66<br>6.31 | 5 |
| 22) | Same; 200 yards SE of #21<br>elev 1450' | 3.36<br>3.06 | 2.57<br>2.43 | 0 |
| 23) | Hedgpeth Hills 7.5' quadrangle<br>T. 4 N., R. 1,2 E., secs. 13,18<br>Precambrian granite; elev 1340' | 5.79<br>5.93 | 5.57<br>5.65 | 2 |
| 24) | Hedgpeth Hills 7.5' quadrangle<br>T. 5 N., R. 2 E., sec. 31, NW¼, NW¼<br>Precambrian granite; elev 1540 | 4.45<br>4.65 | 3.37<br>3.62 | 3 |
| 25) | Hedgpeth Hills 7.5' quadrangle<br>T. 4 N., R. 1 E., sec. 3, SE¼, SW¼<br>PreC granite; elev 1480' | 3.67<br>4.37 | 3.57<br>3.66 | 0 |
| 26) | Calderwood Butte 7.5' quadrangle<br>T. 4 N., R. 1 E., sec. 4, NE¼, NE¼<br>PreC granite; elev 1440' | 3.16<br>3.18 | 2.66<br>3.04 | 0 |
| 27) | Hedgpeth Hills 7.5' quadrangle<br>T. 5 N., R. 2 E., sec. 28, SW¼, SW¼<br>PreC granite; elev 1600' | 6.27<br>5.91 | 4.76<br>4.65 | 6 |
| 28) | Union Hills 7.5' quadrangle<br>T. 4 N., R. 3 E., sec. 22, NW¼, NW¼<br>PreC granite; elev 1560' | 4.59<br>4.53 | 3.56<br>3.55 | 3 |

*ST. JOHNS AREA*

| | Location | U (counts/sec) | Th (counts/sec) | U (ppm) |
|---|---|---|---|---|
| 1) | Lyman Lake 7.5' quadrangle | 5.07 | 3.91 | 1.03 |
| 2) | T11N, R28E, sec. 10, SW ¼, SW ¼ | 4.96 | 4.14 | |
| | Knob NE of campground | | | |
| | Tufa, south end, elev. 6000 ft. | | | |
| 2) | Same, top of knob, elev. 6116 ft. | 5.15 | 3.90 | 1.48 |
| | | 4.90 | 3.90 | |
| 3) | Same, Chinle mudstone under tufa | 6.54 | 5.22 | 4.17 |
| | | 6.69 | 5.56 | |
| 4) | Lyman Lake 7.5' quadrangle | 4.64 | 4.51 | 0 |
| | T. 11 N., R. 28 E., sec. 10, W center | 5.09 | 3.97 | |
| | Knob north of campground | | | |
| | Tufa, north end, elev. 6000 ft. | | | |
| 5) | Concho 7.5' quadrangle | 6.2 | 4.72 | 3.47 |
| | T. 13 N., R. 26 E., sec. 34, SE1/4 | 6.0 | 4.71 | |
| | Below basalt at Hwy, elev. 6160 ft. | | | |
| | sandy silt, tufa (?) | | | |
| 6) | Stinking Springs 7.5' quadrangle | 5.56 | 4.06 | 3.25 |
| | T. 14 N., R. 26 E., sec. 25, SE1/4 | 5.67 | 4.47 | |
| | Small hill N of Volcanic Mt. | | | |
| | Tufa cap, S end, elev. 5660 ft. | | | |
| 7) | same, north end, elev. 5660 ft. | 5.47 | 3.94 | 4.02 |
| | limonite-stained tufa | 5.66 | 3.99 | |
| 8) | Mesa Parada NW 7.5' quadrangle | 5.36 | 3.66 | 2.32 |
| | T. 12 N., R. 29 E., sec. 11, SW1/4, SW1/4 | 5.46 | 4.40 | |
| | Salt Lake Road, 6400 ft. | 4.29 | | |
| | Tufa, clay | | | |
| 9) | Mesa Parada NW 7.5' quadrangle | 5.79 | 5.12 | 0.85 |
| | T. 12 N., R. 29 E., sec. 7, W center | 6.10 | 5.10 | |
| | New road up mesa face, top, 6700 ft. | 6.07 | 4.86 | |
| | Silt, sand (Richville Fm) | | | |
| 10) | same, 1/3 down road, 6600 ft. | 5.76 | 5.30 | 0 |
| | clay-silt, marl, weak pedogenic carb | 6.06 | 5.50 | |
| 11) | same, 2/3 down road, 6500 ft. | 6.42 | 5.15 | 1.7 |
| | silt, clay, minor ped carb | 5.64 | 5.07 | |
| | | 6.59 | | |

*ST. JOHNS AREA (CONTINUED)*

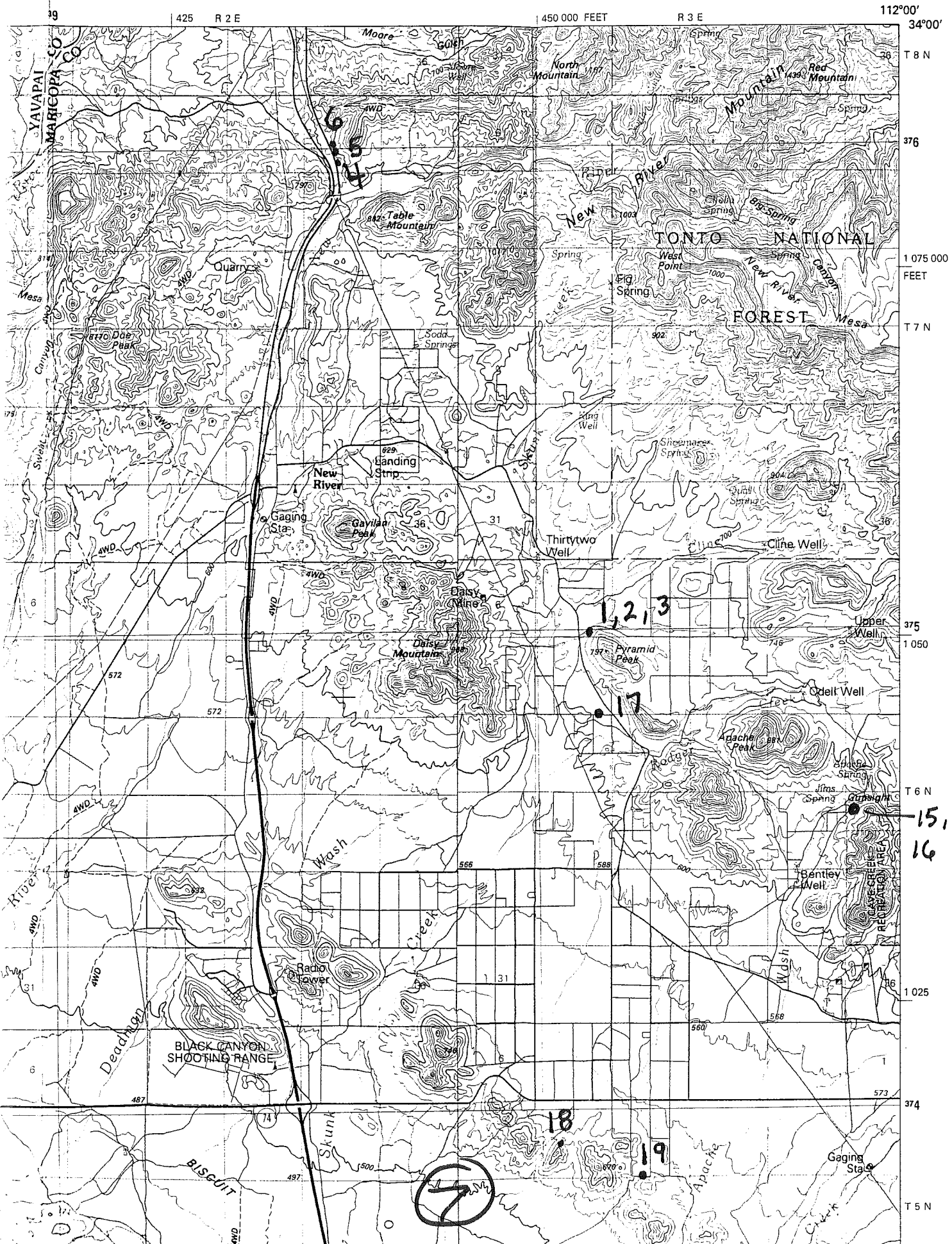
| | Location | U (counts/sec) | Th (counts/sec) | U (ppm) |
|---|---|---|---|---|
| 12) | Lyman Lake 7.5' quadrangle<br>T. 10 N., R. 28 E., sec. 2, NE1/4<br>clay, silt, marl; 6220 ft.<br>Richville Fm top of section | 6.64<br>6.10 | 5.25<br>5.03 | 4.47 |
| 13) | same, bottom of exposure<br>gypsiferous clay , 6200 ft. | 6.55<br>6.63 | 5.43<br>6.05 | 2.5 |
| 14) | Sanders 7.5'quadrangle<br>T. 20 N., R. 28 E., sec. 1, NW ¼, NW ¼, NW ¼<br>red tufa-capped knob, elev. 6000' | 5.05<br>5.42 | 4.56<br>4.40 | 0.27 |
| 15) | Sanders 7.5' quadrangle<br>T. 21 N., R. 29 E., sec. 16, SE ¼, SE ¼<br>bentonite clay, silt, elev. 6000' | 5.61<br>5.64<br>6.25<br>5.19 | 5.55<br>5.37 | 0 |

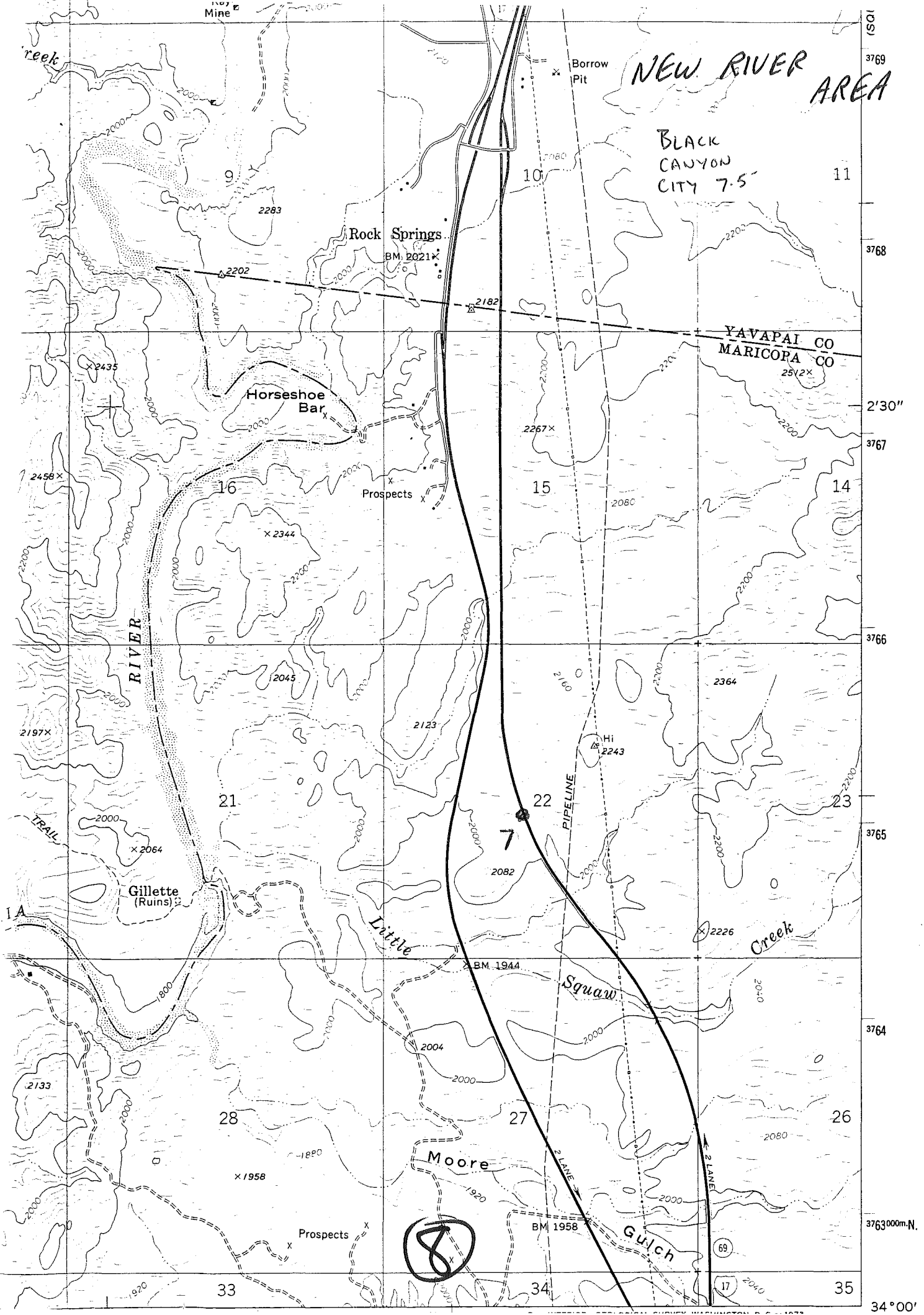
*PRESTON MESA AREA*

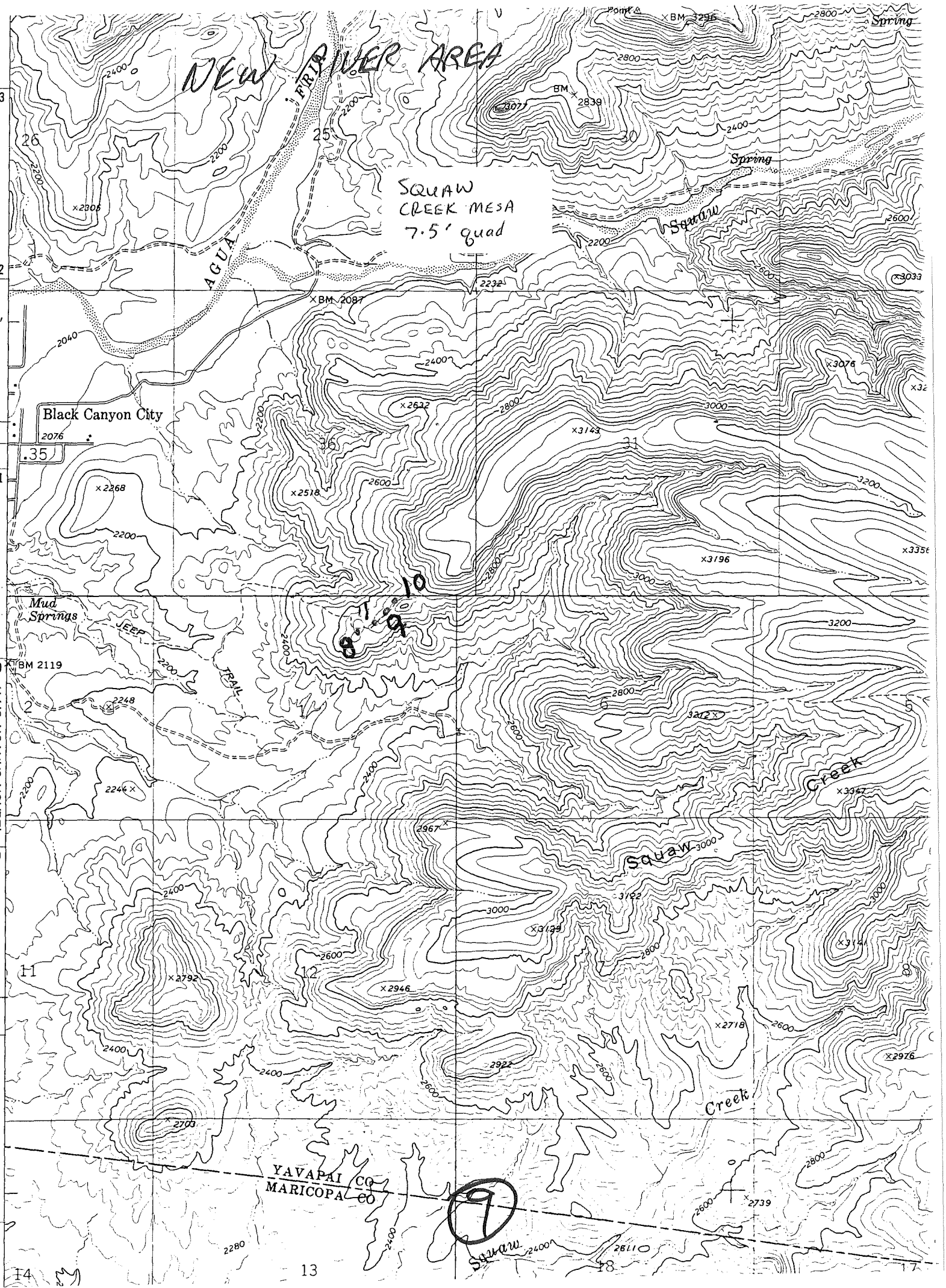
| | | | | |
|---|---|---|---|---|
| 16) | Preston Mesa North quadrangle<br>UTM 4029200N 483000E<br>Quarried hill, elev. 6000'<br>Brown limestone,<br>Red-brown & white chert | 6.45<br>7.45<br>6.51<br>6.56 | 4.52<br>4.46 | 7.29 |
| 17) | Preston Mesa South quadrangle<br>UTM 4021700N, 479300E<br>SW end of lower mesa<br>Lacustrine limestone and silt | 6.94<br>6.62 | 4.60<br>4.56 | 7.57 |
| 18) | same location, more chert | 7.97<br>7.60<br>7.66 | 4.36<br>4.44<br>4.66 | 12.38 |
| 19) | same, 100m north<br>gray limestone, lag chert | 6.65<br>6.55 | 3.96<br>4.19 | 8.43 |

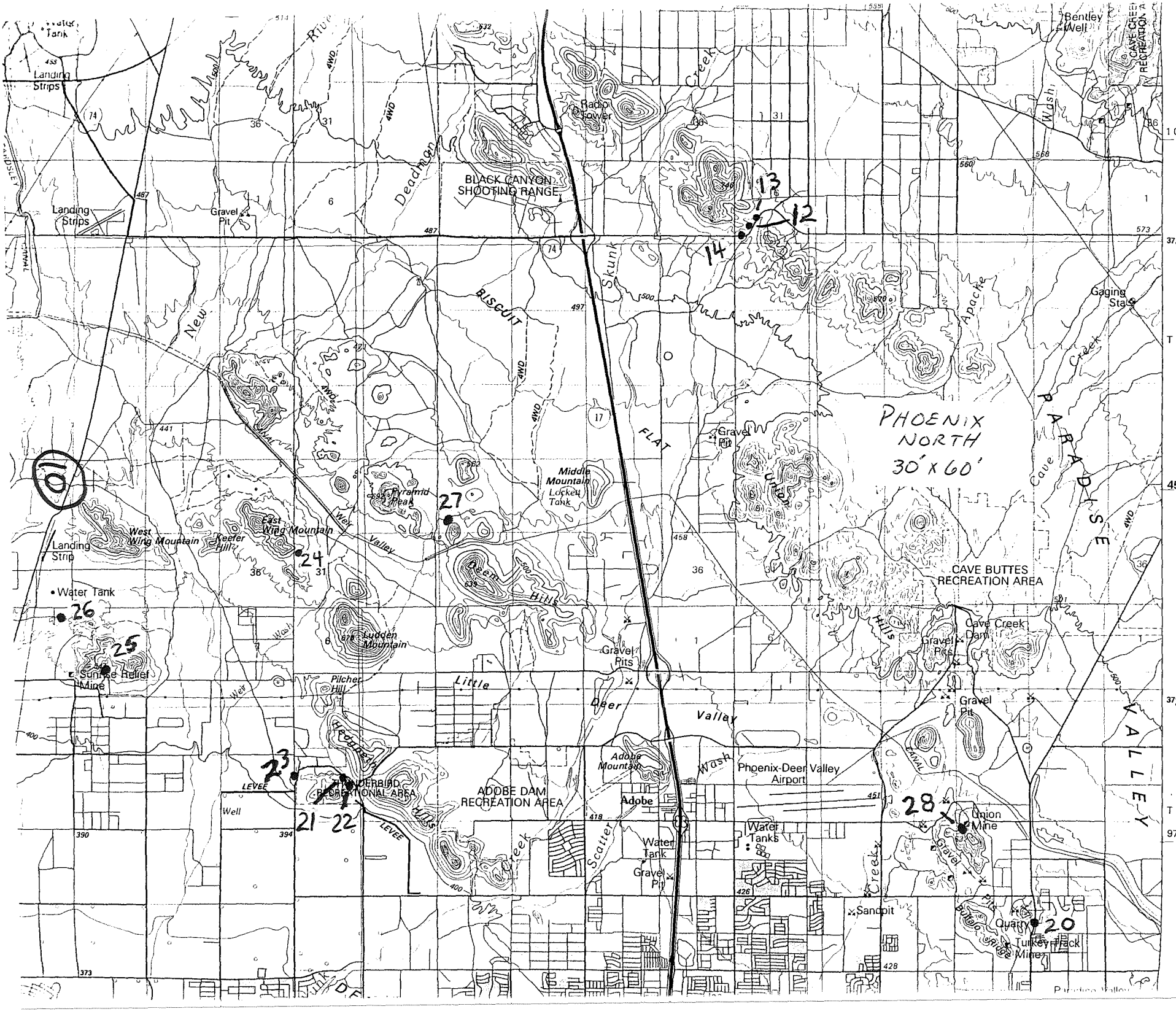
NEW RIVER AREA (North of Phoenix)

**30X60 MINUTE SERIES (TOPOGRAPHIC)**




NEW RIVER AREA
BLACK CANYON CITY 7.5'
Borrow Pit
Rock Springs
BM 2021
YAVAPAI CO
MARICOPA CO
Horseshoe Bar
Prospects
RIVER
TRAIL
Gillette (Ruins)
Little Squaw Creek
BM 1944
PIPELINE
Moore Gulch
BM 1958
2 LANE
69
17
2'30"
34°00'
3769
3768
3767
3766
3765
3764
3763000m.N.
7
8


NEW RIVER AREA
SQUAW CREEK MESA 7.5' quad
AGUA FRIA
Black Canyon City
1.4 MI. TO INTERSTATE 17
Mud Springs
JEEP TRAIL
Squaw Creek
Squaw Creek
Spring
Spring
BM 2087
BM 2119
BM 2839
BM 3296
T. 9 N.
T. 8 N.
3552 II SW (BLACK CANYON CITY)
YAVAPAI CO
MARICOPA CO
2'30"
5'
3773
3772
3771
3770
3769
3768
3767
26
25
30
36
31
2
1
6
5
11
12
8
14
13
18
17
8
9
10
9



NEW RIVER AREA (PHOENIX NORTH)
PHOENIX NORTH 30' x 60'
10
BLACK CANYON SHOOTING RANGE
Radio Tower
Bentley Well
CAVE CREEK RECREATION AREA
Landing Strips
Gravel Pit
Deadman
Skunk
Creek
BISCUIT
FLAT
New
Apache
Gaging Sta
Cave
Creek
PARADISE
VALLEY
Middle Mountain
Lockett Tank
Pyramid Peak
West Wing Mountain
East Wing Mountain
Keefer Hill
Landing Strip
Water Tank
Deem Hills
Ludden Mountain
Sunrise Relief Mine
Pilcher Hill
Little Deer Valley
Gravel Pits
CAVE BUTTES RECREATION AREA
Cave Creek Dam
Gravel Pits
Gravel Pit
Union Hills
Adobe Mountain
Adobe
Phoenix-Deer Valley Airport
ADOBE DAM RECREATION AREA
THUNDERBIRD RECREATIONAL AREA
LEVEE
Well
Scatter Wash
Water Tank
Gravel Pit
Water Tanks
Union Mine
Gravel Pits
Sandpit
Quarry
Turkey Track Mine
Buffalo Ridge
1 025
374
T 5 N
45'
373
T 4 N
975
12
13
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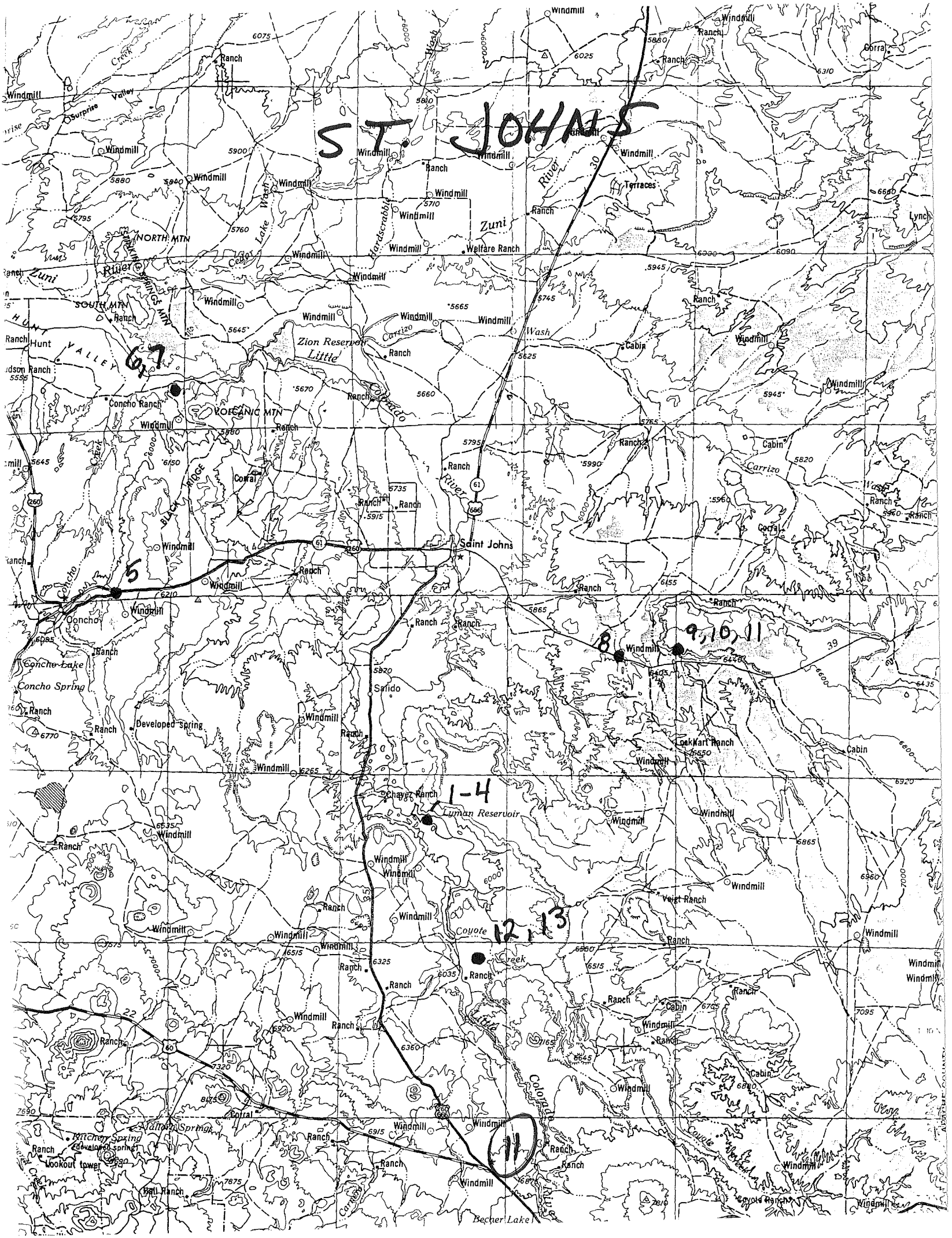
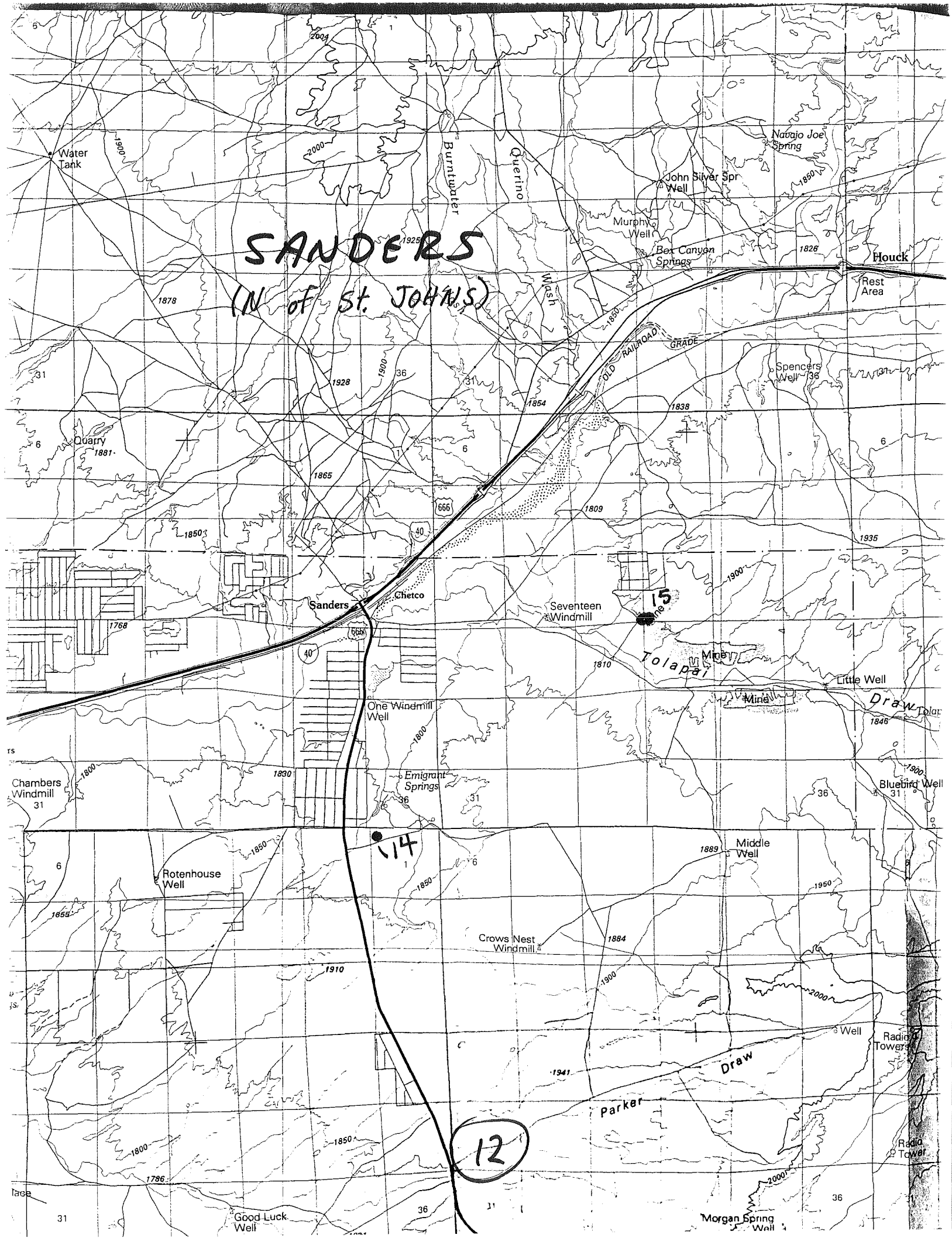
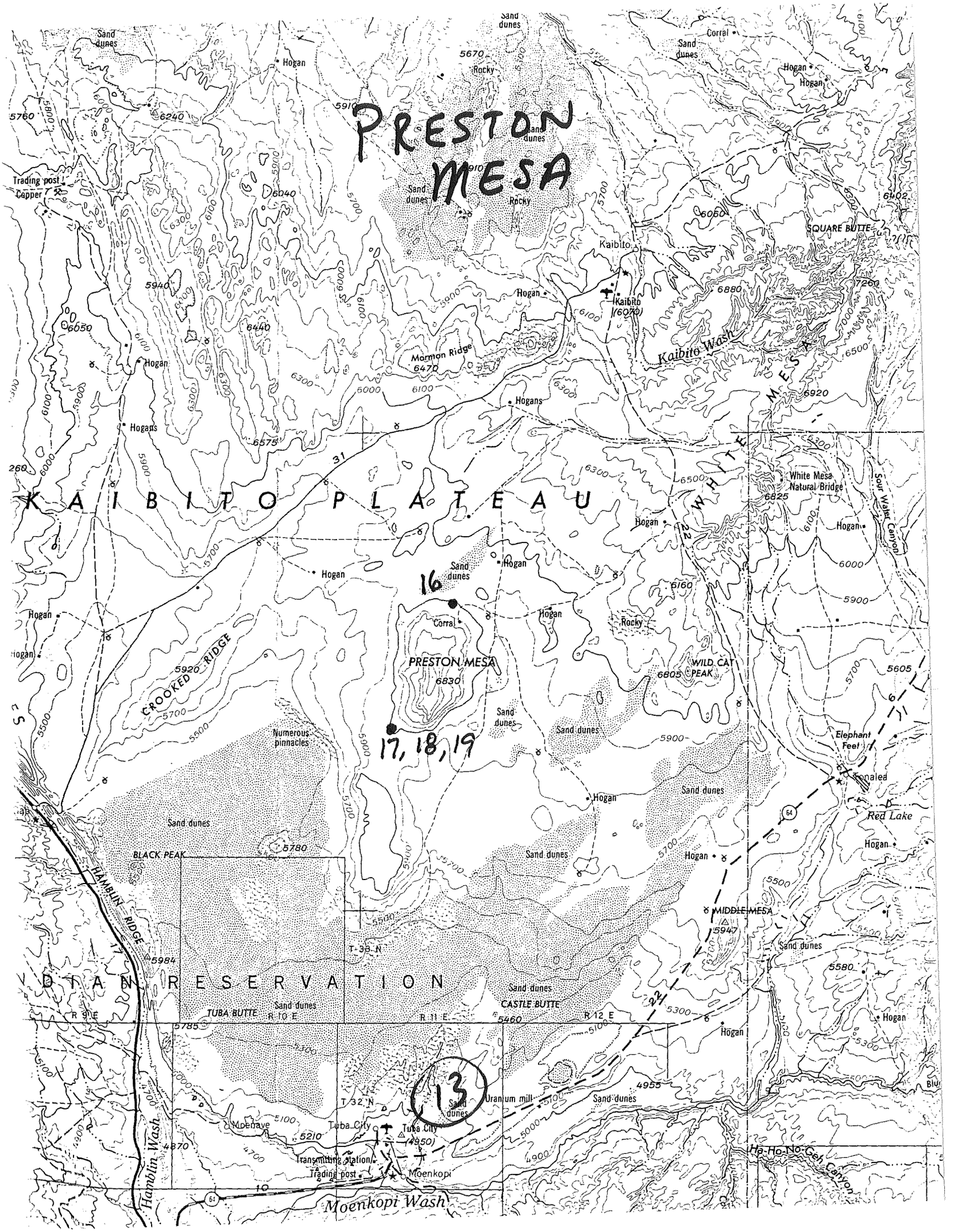
28


ST. JOHNS
6,7
5
8
9,10,11
1-4
12,13
11
Saint Johns
Zion Reservoir
Little Colorado River
Zuni River
Concho Lake
Concho Spring
Salido
Luman Reservoir
Coyote Creek
Becher Lake
Hunt Valley
Concho Ranch
Welfare Ranch
Terraces
Lockhart Ranch
Veigt Ranch
Coyote Ranch
Developed spring
Lookout tower
Kitchen Spring
Mallory Springs
Hardscrabble Wash
Cedar Lake Wash
Carrizo Wash
Surprise Valley
Hunt
Concho
Corral
Windmill
Ranch
Cabin
Lynch


SANDERS
(N of St. JOHNS)
Water Tank
Burntwater
Querino
Wash
Navajo Joe Spring
John Silver Spr Well
Murphy Well
Box Canyon Springs
Houck
Rest Area
OLD RAILROAD GRADE
Spencers Well
Quarry
Sanders
Chetco
Seventeen Windmill
15
Mine
Tolapai
Little Well
Draw
One Windmill Well
Emigrant Springs
Chambers Windmill
Bluebird Well
114
Middle Well
Rotenhouse Well
Crows Nest Windmill
Well
Radio Towers
Draw
Parker
12
Radio Tower
Good Luck Well
Morgan Spring Well


PRESTON MESA
KAIBITO PLATEAU
WHITE MESA
Kaibito
Kaibito (6070)
Kaibito Wash
SQUARE BUTTE
Mormon Ridge 6470
White Mesa Natural Bridge
Sour Water Canyon
PRESTON MESA 6830
WILD CAT PEAK 6805
CROOKED RIDGE
Numerous pinnacles
Elephant Feet
Tonalea
Red Lake
BLACK PEAK
HAMBLIN RIDGE
MIDDLE MESA 5947
T 33 N
T 32 N
R 9 E
R 10 E
R 11 E
R 12 E
TUBA BUTTE
CASTLE BUTTE
Uranium mill
Moenave
Tuba City
Tuba City (4950)
Transmitting station
Trading post
Moenkopi
Moenkopi Wash
Hamblin Wash
Ha-Ho-No-Geh Canyon
Trading post
Copper
Sand dunes
Hogan
Hogans
Corral
Rocky
16
17, 18, 19
13