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STN-50-530 Palo Verde Nuclear Station, Unit 3, Arizona Publi 05000530
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TEDESCO,R.L. Assistant Director for Licensing

SUBJECT: Forwards Draft responses to NRC Questions 231.1 to 231.5 per 810803 request for addl info.Three oversize drawings encl Aperture cards will be available in PDR.

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ARIZONA PUBLIC SERVICE COMPANY

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September 1, 1981
ANPP-18810-JMA/KWG

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U.S. NUCLEAR REGULATORY COMMISSION

Mr. R. L. Tedesco
Assistant Director for Licensing
Division of Licensing
Office of Nuclear Reactor Regulation
U. S. Nuclear Regulatory Commission
Washington, D. C. 20555

Subject: Palo Verde Nuclear Generating Station (PVNGS) Units 1, 2 and 3
Docket Nos. STN-50-528/529/530
File: 81-056-026, G.1.10

Reference: Letter from R. L. Tedesco, NRC, to E. E. Van Brunt, Jr., dated August 3, 1981, Subject: Request for Additional Information (Geology)

Dear Mr. Tedesco:

Please find attached our draft responses to NRC questions 231.1 to 231.5 transmitted by the referenced letter.

If you have any questions, please contact this office.

Very truly yours,

E. E. Van Brunt

E. E. Van Brunt, Jr.
APS Vice President,
Nuclear Projects
ANPP Project Director

EEVBJr/KWG/bj

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Attachments

cc: J. Kerrigan (w/a)
P. Hourihan (w/a)
A. C. Gehr (w/a)

STATE OF ARIZONA)
) ss.
COUNTY OF MARICOPA)

I, Edwin E. Van Brunt, Jr., represent that I am Vice President Nuclear Projects of Arizona Public Service Company, that the foregoing document has been signed by me on behalf of Arizona Public Service Company with full authority so to do, that I have read such document and know its contents, and that to the best of my knowledge and belief, the statements made therein are true.

Edwin E. Van Brunt
Edwin E. Van Brunt, Jr.

Sworn to before me this 3rd day of September, 1981.

Connie Lou Armstrong
Notary Public

My Commission expires:

June 24, 1983

There is no evidence of subsidence in the site area such as basin downwarps, fissures, or cracks. The closest known occurrence of land subsidence and earth fissuring is in the Luke Air Force Base region, about 25 miles east of the site. A comprehensive analysis of areas of known subsidence and comparison of those areas to the site area has shown that land subsidence and earth fissures should not be anticipated at the site (sec tions 2.5.1.1.7 and 2.5.4.1.1.

No mineral extraction has taken place in the area of the site and none is anticipated. However, according to the Arizona Oil and Gas Commission, two applications are on file to drill exploratory test holes in the site vicinity. Table 2.5-1a lists the location and status of the applications.

Table 2.5-1a
Mineral Resource Exploration Application
in the Site Vicinity

Applicant	Location	Status
Gemini Oil and Mineral	SW¼, SW¼, Sect. 27, T2N, R7W	2500 feet test hole complete
Philips Petroleum	NE¼, NE¼, Sec. 16 T2N, R4W	8000 feet test hole proposed, no drilling performed to date

Note: Due to proprietary nature of exploration drilling, drill logs are not available for public inspection until one year following submittal of logs to the Arizona Oil and Gas Commission.

Groundwater withdrawal has been analyzed (Seciton 2.4.13) and does not represent a hazard.

2.5.1.2.9 Groundwater

A detailed discussion of site groundwater conditions is presented in section 2.4.13.

2.5.2 VIBRATORY GROUND MOTION

2.5.2.1 Seismicity

2.5.2.1.1 Data Base

Data describing the earthquake history of the region surrounding the Palo Verde site are found in a number of sources. A basic compilation of historical records of earthquakes in the region is the catalog of Townley and Allen(91) which lists earthquakes for 1769 through 1928. In 1971, Sturgul and Irwin(92) published an "Earthquake History of Arizona and New Mexico, 1850-1966". They supplemented the Townely and Allen data with subsequent report of earthquakes that had been felt and some instrumentally determined epicenters to bring the list up to 1966. Annual issues of "United Stated Earthquakes" by the U.S. Department of Commerce, beginning in 1928, contain about 30 additional small shocks that were not included in the Sturgul and Irwin catalog. These sources, together with the current newspapers, provide an exhaustive list of report of

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Question 231.1

Eberly and Stanley's (1978) paper addresses the structural geology in the site vicinity (within five to ten miles). Discuss the impact (and validity of their interpretation of the subsurface with respect to:

a. The existence of mountain-basin bounding faults in the Arlington-Gillespie Dam area.

b. The validity of their interpretation of the site vicinity geologic structure as shown on their Figure 8, p. 933.

c. The significance of Eberly's and Stanley's interpretation with respect to site safety.

Response to Question 231.1

The field work and research leading to Eberly and Stanley's 1978 paper was accomplished between 1971 and 1973 and represented about an 18-month effort to synthesize a broader picture of Arizona's Cenozoic stratigraphic and tectonic history than was currently available in published literature. The ultimate purpose of the study was for application to Exxon's oil and gas exploration program. Their study involved:

- o incorporation of all previous geologic data
- o reconnaissance geologic mapping from 93 outcrop locations
- o results of 57 water, gas and oil borings
- o 4 new test borings
- o hundreds of miles of vibroseis reflection profiling
- o 57 radiometric age dates

The greatest emphasis of Eberly and Stanley's work was on the correlation of one major and several minor unconformities in the Cenozoic stratigraphic section throughout southwest Arizona. As a result of this broad stratigraphic work, they were able to document two distinct orogenic episodes and provide a chronologic framework for the development of two major structural trends throughout southwest Arizona. Eberly and Stanley interpreted structural trends along their traverses based on seismic lines and reconnaissance mapping. These interpretations were depicted in a series of small scale, vertically exaggerated cross sections which extend east from Yuma along the Gila River and south along the Phoenix-Tucson corridor.

In terms of PVNGS, Eberly and Stanley's Figure 8, page 933, is most significant because it shows the east end of their Section B-B' which extends east-northeast through the vicinity of the Palo Verde Hills. Their structural interpretation of the Saddle Mountain - Palo Verde Hills high is based on reconnaissance mapping of the outcrops, a single Exxon vibroseis reflection profile and a single exploratory boring (Reaves No. 1 Fuqua, drilled and abandoned in 1939, total depth 4117 feet) located in Buckeye about 15 miles east of PVNGS. Five normal faults were interpreted across the area between Centennial Wash and the Hassayampa River: two on each side of the horst, apparently defining the "step down" into each adjacent basin, and one normal fault within the horst. All these faults were interpreted to be northwest trending based on reconnaissance mapping. The quality of the seismic profile and reflectors was considered only fair by Eberly (1981, personal communication), and the prime purpose for placing faults in the vicinity of the Saddle Mountain - Palo Verde Hills high was to account for the tilting of the volcanic units. He believes that the Exxon seismic line showed some permissive evidence for placing faults in the area, but the exact number and location of specific faults, as shown on Figure 9, represents some "artistic license" according to the authors (Eberly, 1981, personal communication).

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FSAR Figures 2.5-8 and 2.5-9 show tectonic interpretations for the Palo Verde site vicinity based on 1) the reconnaissance and detailed investigation for PVNGS and 2) tectonic interpretations from all available geologic sources. Cross section B-B' on FSAR Figure 2.5-9 roughly coincides with the area between Hassayampa and Centennial Wash shown on the Eberly and Stanley Figure 8. FSAR Figure 2.5-9, Section B-B' shows or infers five faults: two forming the west boundary of the structural high near Centennial Wash, two forming a graben near the Hassayampa River and one small fault in the Palo Verde Hills. The original FSAR Figure 2.5-9, Section B-B' has not shown the Centennial Wash faults projecting onto the section. The revised figure has corrected this. So, in terms of the numbers and locations of faults considered in the PVNGS site vicinity, Eberly and Stanley do not indicate any essentially unique interpretation. Therefore, the style of tectonics presented in the FSAR is conservate and, considering scale differences and vertical exaggeration, the PVNGS analysis would be more accurate. The detailed geologic mapping and geophysical surveys conducted in the site vicinity have documented the absence of any surface fault.

(other than the one noted in the Palo Verde Hills) and have confirmed the general integrity of the Saddle Mountain - Palo Verde structural high.

Regarding the age of faulting, Figure 8 shows some range bounding faults as displacing the lower sections of Unit II which implies tectonic activity ranging from 13 million years to about 10 million years before present (late Miocene block faulting episode or "mid Tertiary" orogeny). Eberly and Stanley interpret that between 10 and 6 million years ago the period of closed basins ended, streams were integrated and the area began to demonstrate a general tectonic stability. The PVNGS investigations established that major tilting of volcanic units occurred after about 17 m.y. and apparently stopped at about 16 m.y. (age of untilted fanglomerate). Actually, basin faulting must have stopped later but well prior to deposition of the Palo Verde Clay (i.e. well before 2.7 m.y.). Therefore, the minimum age of faulting presented in the FSAR is more conservative than Eberly and Stanley's observations.

Eberly and Stanley also discuss the Gila trough and describes it as a "northeast trending, sediment-filled trench underlying the Gila River Valley east of Ligurta, Arizona (east of Yuma). Thick deposits of Unit 1 indicate that the Gila trough predated late Miocene block faulting. The block faulting overprinted the older northeast-southwest structural trend, forming horsts and grabens within the Gila trough that are aligned with the northwest-southeast trend of the present day valleys and ranges." Therefore, their study indicates that the northeast structural trends of the Gila trough and the Gila lineament are clearly older than the mid-Miocene block faulting and therefore are not capable or significant to the site.

In total, the Eberly and Stanley paper confirms, in a regional sense, many of the more important findings of PVNGS related to: 1) the general location and distribution of major faults near the Saddle Mountain - Palo Verde Hills high, 2) the age of faulting and basin development, and 3) the age of basin filling, stream integretation and achievement of tectonic stability in southwest Arizona. There has been no new information presented which would alter the opinions or conclusions of safety at PVNGS and, therefore, there is no impact or significance to the FSAR.

Question 231.2

Describe your post-1978 Palo Verde 4 and 5 PSAR activities with respect to the geologic and seismological updating of the Palo Verde 1, 2 and 3 FSAR.

Response to Question 231.2

Preparation of the PVNGS Final Safety Analysis Report (FSAR) reflects the thorough assessment, re-evaluation, and compilation of previously submitted data for PVNGS Unit 1, 2, & 3 and PVNGS 4 & 5 obtained through March, 1979. Following March, 1979, an on-going, multifaceted program continues to update the geologic seismological and geotechnical engineering data base for subsequent amendments to FSAR. The updating program includes, but is not limited to:

- review and evaluation of geologic and seismologic research developing in the southwest and other regions that may influence geotechnical conclusion regarding PVNGS.
- review and evaluation of published report, maps, and other records, as they become available, pertaining to the geology and seismology of the southwest.
- periodic personal contact with the various governmental agencies, academic institutions and the private organizations involved in geotechnical projects in the southwest.
- investigation and evaluation of seismic events reported as occurring within Arizona and adjacent regions.
- continuous in-grading geologic inspection and mapping of construction excavations at PVNGS.
- analysis of settlement and subsidence network data and the reporting of results on an interim basis.
- monitoring of regional and perched groundwater conditions in the site area.

Question 231.3

Figure 2 (page 6) of a November, 1979, Department of Energy Report shows two inferred faults in the Hassayampa Plain northeast of the Palo Verde Site. Discuss the validity of these faults and their site-safety significance. The DOE report is titled "Geothermal Studies in Arizona with Two Area Assessments (DOE/ID/12009-T4)."

Response to Question 231.3

The existence and location of the intersecting northwest and northeast trending faults shown on Figure 2 of the Geothermal Reservior Site Evaluation in Arizona were inferred from regional geologic relationships supplemented by some reconnaissance geophysical data and a previous regional lineament study. In the case of both faults, there was no directly mappable geologic or structural discontinuities to confirm their existence (Stone, 1981, personal communication). The actual locations of the faults shown on Figure 2 were inferred from: a) the assumed position and shape of the buried pediment edge along the northeast Belmont Mountains (i.e. the nortwest trending fault), and b) buried basin topography interpreted from low resolution gravity and aeromagnetic surveys of the northern Hassayampa Plain (northeast trending fault).

According to the author, Claudia Stone, a second phase of the geothermal study has produced a higher resolution gravity survey of the northern Hassayampa Plain. This latest geophysics is just being analyzed and will be reported in a second publication available before the end of 1981. Although currently incomplete, the revised analysis will make two important changes to the structural interpretation on Figure 2. First, the northeast trending fault will be removed because the detailed data apprently do not substantiate the inferences of the original study. Second, the buried fault along the north edge of the Belmont Mountains will be sinuous to follow the shape of the pediment rather than straight as now shown (C. Stone, 1981, personal communication). Therefore, we may conclude that the northeast trending fault is not valid.

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FSAR Figure 2.5-8 shows a northeast trending hypothetical fault along the north boundary of the Belmont Mountains. However, it is located about two miles west of the northwest trending fault on Figure 2 of the referenced article. The fault in FSAR Figure 2.5-8 was taken from a small scale tectonic map of North America which placed faults along margins of most major mountain ranges. The

accuracy of location of those hypothetical faults is unknown and the geologic reasoning for their location is not described. Therefore, the fault on the FSAR Figure 2.5-8 represents essentially the same range bounding structure in Figure 2 expect that locations of the two faults vary slightly due to map scale and minor interpretive differences. FSAR Figure 2.5-8 has been revised to reflect the results of these latest studies.

The ages of faulting are not discussed in detail in the referenced article, however, it was noted that the orientations of the two faults in Figure 2 are representative of the two prominent structural trends in central Arizona: northeast trends are attributed to the Laramide Orogeny and north-northwest trends are attributed to the mid-Tertiary orogeny. This is consistent with the tectonic history outlined in the FSAR and brackets the age of movement on the younger northwest trending faults from about 13 million years to about 10 million years before present.

Surface studies in the form of aerial photographic analysis, flyover and ground reconnaissance have not revealed any evidence of Quaternary activity along the northern margin of the Belmont Mountains. Lineaments have been placed along the relatively straight segment of Jackrabbit Wash which parallels the north margin of the Belmont Mountains, but no evidence has been generated by previous studies to indicate that the stream alignment is due to Quaternary faulting.

Therefore, we conclude that the revised maps of the referenced study will be consistent with the geology as represented in the FSAR and that the postulated fault along the northeast margin of the Belmont Mountains is not capable and is not of safety significance to the site.

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Question 231.4

Describe the basis used for categorizing the fault (see FSAR Figure 2.5-6) in the Sand Tank Mountains area some 35 miles SE of the Palo Verde site as older than 500,000 years.

Response to Question 231.4

The weight of line used to depict the age of the fault near the Sand Tank Mountains is a drafting error. In the absence of any detailed geologic investigations, we consider the Sand Tank fault as younger than 500,000 years and the FSAR Figure 2.5-6 will be modified accordingly.

Richard Van Horn of the U.S. Geological Survey describes the Sand Tank scarp as follows:

> The scarp, about 3 kilometers long and 2 meters high, slopes about 20 degrees west. It is formed on an old alluvial fan that slopes about 2 degrees westward. Desert varnish is about half as well developed on the scarp as on the upper surface of the fan. The old fan deposit and the scarp have been eroded by ephemeral streams, which have deposited a younger fan alluvium in the gulches and over the old fan alluvium west of the scarp. The younger fan alluvium overlies and conceals the scarp at its north and south ends. No scarp was seen on the young fan. The young fan deposit is not stained by desert varnish.
>
> The scarp is believed to have been formed by a fault that displaced the old fan deposit downward to the west. The fault and downdropped block of old fan deposit have been completely covered by the young fan deposit. Alternative origins for the scarp that were considered and rejected include erosion by the Gila River and subsidence into a depositional basin. The age of faulting was not determined, but is probably Pleistocene.

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Since the exact age within the Pleistocene has not been determined and no detailed analysis is available, no definitive statement can be made regarding the capability of the Sand Tank fault. However, for this analysis we have assumed it is capable. In terms of site safety, the existence of the Sand Tank fault,

about 35 miles south of the site, is not considered significant because of the very conservative model used to establish the seismic design for PVNGS. The Sand Tank fault is too short and too distant from the site to represent a surface faulting hazard or to exceed the Safe Shutdown Earthquake. Therefore, there is no impact to the seismic evaluation of the site by assuming that the fault is capable.

Question 231.5

Detailed geophysical surveys (gravity and magnetic) recently conducted by C. Cloran (Geophysics, Hydrology and Geothermal Potential of the Tonopah Basin, Maricopa County, Arizona, MS Thesis, Arizona State University, May, 1977) within five miles of the Palo Verde site indicate that the Tonopah Basin is bounded by normal faults. Discuss the impact of Cloran's interpretation of the subsurface with respect to:

a. Site Safety
b. The capability (or non-capability) of the basin-bounding faults suggested by Cloran.
c. The validity of the structural interpretation of the Tonopah Desert area as shown on FSAR Figure 2.5-8 and other related FSAR figures.

Response to Question 231.5

The masters thesis by Courtney Ann Cloran (Geophysics, Hydrology and Geothermal) Potential of the Tonopah Basin, Maricopa County, Arizona, 1977) provides a reasonably detailed geophysical and structural analysis covering about two-thirds of the Tonopah Basin. Ms. Cloran performed a gravity and ground magnetic survey on one mile and half mile centers, respectively, which refined earlier geophysical work in area by others including, in part, that work by Sumner for the PVNGS PSAR (i.e. the area north of the Palo Verde Hills and into the Tonopah Desert).

In terms of safety significance to PVNGS, the most pertinent conclusions to Ms. Cloran's work were that:

- The Tonopah Basin is a large (15 km) Basin and Range style, block faulted structure.
- Steep gravity gradients on the basin margins to the north and south indicate steep scarps of normal faults of a series or normal faults. The number of interpreted faults vary depending on the density model but the position of major structural blocks remain about the same.
- Maximum thickness of alluvium ranges from about 7500 feet to about 10,000 feet.

- The greatest depth of the basin is in the southeast corner and the basin trends about N56^{o}W.
- The basin is bounded on the north by the buried pediment of the Belmont Mountains, to the south by the Saddle Mountains and Palo Verde Hills, to the west by the connection between Big Horn Mountains and the Belmont Mountains, and on the east by the buried granitic high trending south from the southeast end of the Belmont Mountains.
- A prominent nose exists in the southwest part of the Tonopah Basin which may be a northeast trending fault.
- Magnetic anomalies in the northwest part of the Saddle Mountains have been speculated to be faulted volcanic flows which have been intercalcated into the basin sediments. The magnetic contours suggest the faults might trend northeast and project into the central basin.
- A water temperature anomaly coincides with the general location and orientation of the northeast trending fault. The northeast trending fault is postulated to act as a conduit to hot water transfer.
- There is no discussion in Cloran's study of geologic history, tectonic history of minimum age of last displacement on faults in the Tonopah Basin.

Cloran's interpretation of faults within the Tonopah Basin is based on consistently steep gravity gradients and a few abrupt magnetic anomalies. The basin bounding faults interpreted from gravity data are shown in Section (plate 8) using two interpretations of the geophysical model. Model 2, shows the most faults and has been discussed here as the most conservative alternative. Unfortunately, there is no plan which shows the interpreted length and orientation of northwest basin bounding faults between the three cross sections. Similarly, there is no section or plan showing the location, orientation or length of the northeast trending fault along the "Tonopah Nose" or of the northeast faults defining the abrupt, high-low magnetic anomalies. These locations must be inferred from the text description. Figure A is a reduced version of Plate 4 showing our interpretation of Cloran's faults described in the text and cross sections. In addition, we have superimposed the location of the inferred and geophysical faults from FSAR Figure 2.5-8 for ease of comparison in the following discussion.

The PVNGS geophysical and subsurface investigations concentrate on the southeast edge of the Tonopah Basin closest to the site. Cloran's survey overlapped the northern edge of the PVNGS investigation and covered the remaining southern two-thirds of the entire valley. The two southernmost faults (A and B, Figure A), which were interpreted as basin bounding structures in the FSAR appear in good alignment and form a reasonable correlation with Cloran's basin bounding faults farther northwest (i.e. faults F & G). Fault F, which marks the change in gravity gradient from about -6 to -12 milligals, seems the most consistent structure and possibly correlative with fault B of the PVNGS investigation. Sumner (personal communication, 1981) has commented that Cloran's gravity contours suggest another alternative interpretation, i.e. a structural change along the 0 milligal line which roughly parallels the northwest trend of the valley. This inferred structure would project into the vicinity of faults A and B and also might be correlative with them. Therefore, a complete acceptance of Cloran's work would suggest at least one and possibly two faults (A and B) may be longer than shown on FSAR Figure 2.5-8. Another alternate interpretation could postulate one fault which might correlate to faults A or B.

Along the northern Tonopah Basin, Cloran has interpreted two bounding faults (H and I) at the change in gravity gradient near the -10 milligal contour. Fault I roughly follows the -10 milligal contour and appears to correlate among all three cross sections. The correlation of fault H among all three cross sections. The correlation of fault H among all three cross sections requires cutting across one strong prominent gradient near section C-C' (Figure 8), therefore fault H may not be as continuous as fault I. The FSAR Figure 2.5-8 shows a geophysical fault (fault E) about two or three miles north of Cloran's fault (H and I). The existence and location of fault E was based on a single gravity profile performed during the PVNGS investigation which was supplemented by regional gravity data and regional geology. Fault E was interpreted along the steep gravity gradient along the south margin of the Belmont Mountains.

Cloran's work refined the shape and location of the northern basin contours and, as a result, permits a more refined interpretation of basin faulting. Upon reviewing Cloran's work, we agree that the data suggests a range bounding fault along the northern Tonopah Basin. However, we favor placing the fault in the areas of the steepest gravity gradient, i.e. approximately along the -4 milligal

contour (Sumner, 1981, personal communication). This latter interpretation would place the range bounding fault about 1 mile south of and slightly subparallel to fault E and about one or two miles north of faults H and I. Although the locations of the different interpretations of range bounding faults may vary by a few miles, the general concept of a bounding fault along the northern edge of the Tonopah Desert has been accepted and considered in the FSAR. In addition, the FSAR has considered a hypothetical fault from published tectonic maps along the entire southern boundary of the Belmont Mountains (FSAR Figure 2.5-8).

The "Tonopah Nose" was interpreted by Cloran from the abrupt kink in gravity contours in the southwest corner of the basin (Figure A). Based on the text description, there was a fautl interpreted along the aligned contours of the kink. Although the original gravity readings and station data are not available and have not been analyzed, it is clear that the contours have been pulled out of position by an anomalous reading on one station. This leads us to suspect the accuracy of the station readings or elevations and, as a result, to question the existence of the "Tonopah Nose".

The shorter, east-west trending geophysical faults near the center of Tonopah Basin (faults C and D) correlate, in one instance, with a basin fault shown on Cloran's section A-A' (Plate 8). Fault D has no obvious correlation to any structure shown on Cloran's section B-B'. Fault C, if projected west, would generally align with several short northeast faults that Cloran interpreted at the southwest margin of the Basin, however, there is no basis for a reliable correlation.

In summary, it can be said that Cloran's work has expanded the geophysical interpretation of the Tonopah Basin, and in terms of the basin bounding faults nearest the site, has shown that one of the southern basin faults might be continued 8 to 10 miles farther northwest. The interpretations between Cloran and PVNGS studies regarding faults forming the north margin of the Tonopah Basin agree in principle as to the existence of a basin bounding fault, but these interpretations have placed the faults at different locations (a few miles apart) and slightly subparallel in orientation. Cloran's work has identified some short northeast trending faults near the southwest edge of the basin which would project toward Saddle Mountains. The latter faults are the only really new interpretations introduced. It is important to note that these interpretations of northeast trending faults are somewhat suspect because 1)

the high magnetic anomalies used to infer the faults occur near great thicknesses of basalt near Saddle Mountain and 2) the kink in the gravity contours used to infer the "Tonopah Nose" is based on a single station anomaly. It is a resonable alternative to postulate the presence of northeast trending dikes which are known to produce similar magnetic patterns.

Regarding the impact of this information to site safety, we can conclude:

- Cloran's work has not identified any new structures which are closer to the site or project toward the site from those structures already presented in FSAR Figure 2.5-8.
- The original PVNGS analysis considered the impact of basin-bounding faults along the north and south margin of the Tonopah Basin (i.e. those determined from direct investigation or from faults inferred on other tectonic maps). The FSAR model is conservative and its safety significance has not been changed by Cloran's studies.
- The unbroken correlation of the Palo Verde clay across the southern basin bounding faults (F and G) still demonstrates no movement in at least 2.7 million years. This age is valid regardless of how far the faults might project to the northwest.
- Potential northern basin bounding faults were evaluated with various remote sensing techniques, reconnaissance geologic mapping and geomorphic evaluations. It was concluded that there are no signs of displacement of any Quaternary formations along the south edge of the Belmont Mountains or the pediment.

- The postulated northeast trending faults interpreted by Cloran are subordinate to the northwest basin bounding faults in terms of length and inferred amounts of displacement. Although there is no discussion of the tectonic history of the basin or evaluation of ages of fault develpment and last movement, these northeast trending faults fit a regional stress pattern in central Arizona which usually places the northeast faults as Laramide structures. As a result, they precede the mid-Tertiary orogeny and are older than the northwest trending faults. There is no surface expression of the northeast trending faults or is there any evidence raised by Cloran's work that would suggest that they should be considered capable.

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In direct answer to the three questions raised by the NRC, we conclude:

a) There is no impact to site safety or to the geotechnical evaluation from Cloran's work.

b) The basin bounding faults as postulated by Cloran are not considered capable in terms of NRC siting criteria.

The structural interpretation shown on Figure 2.5-8 and 2.5-9 is still valid in terms of the basic basin geometry and the significant structural features of safety significance to the site. There will be the addition of some details from Cloran's work to make the data base more complete.

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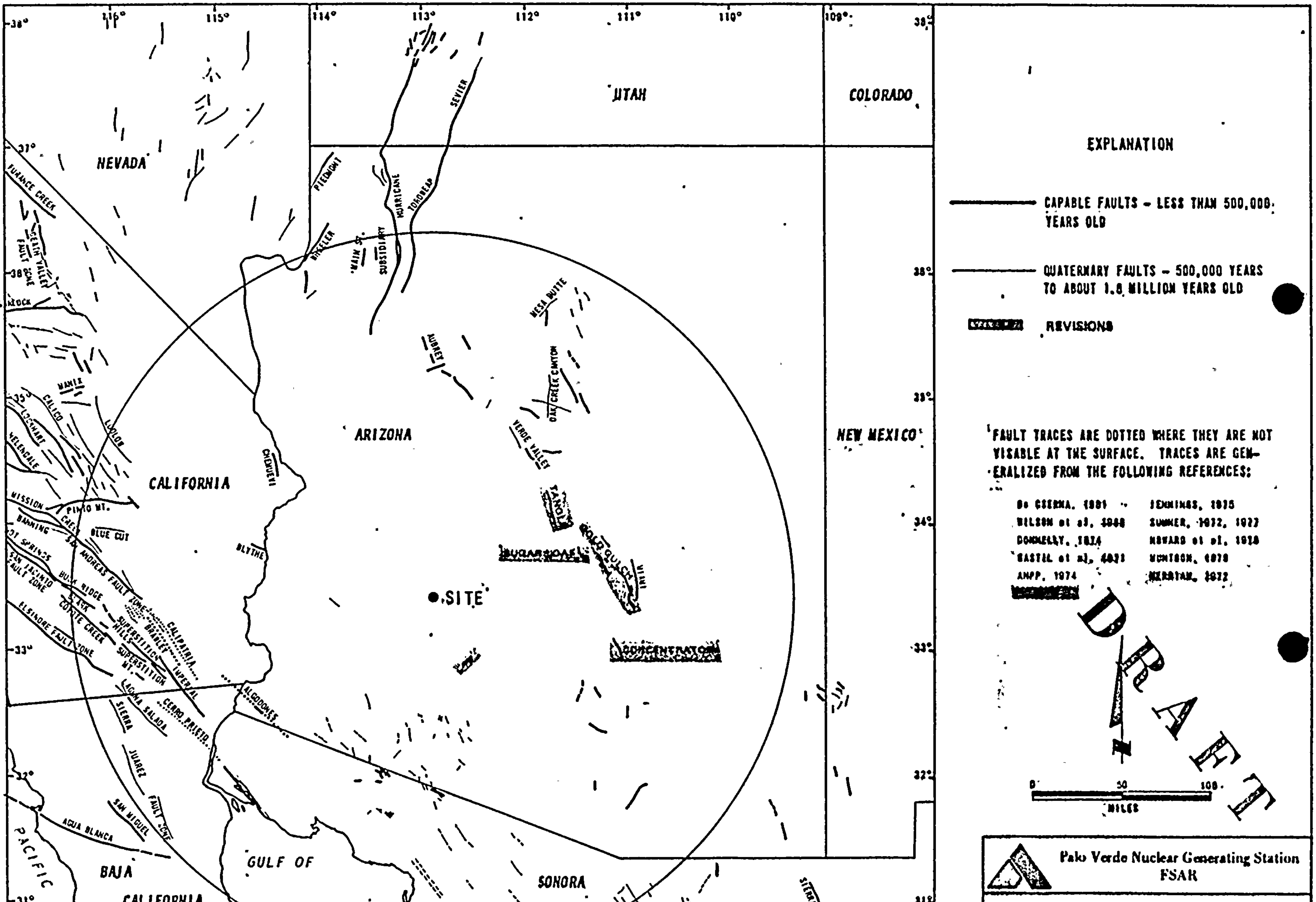
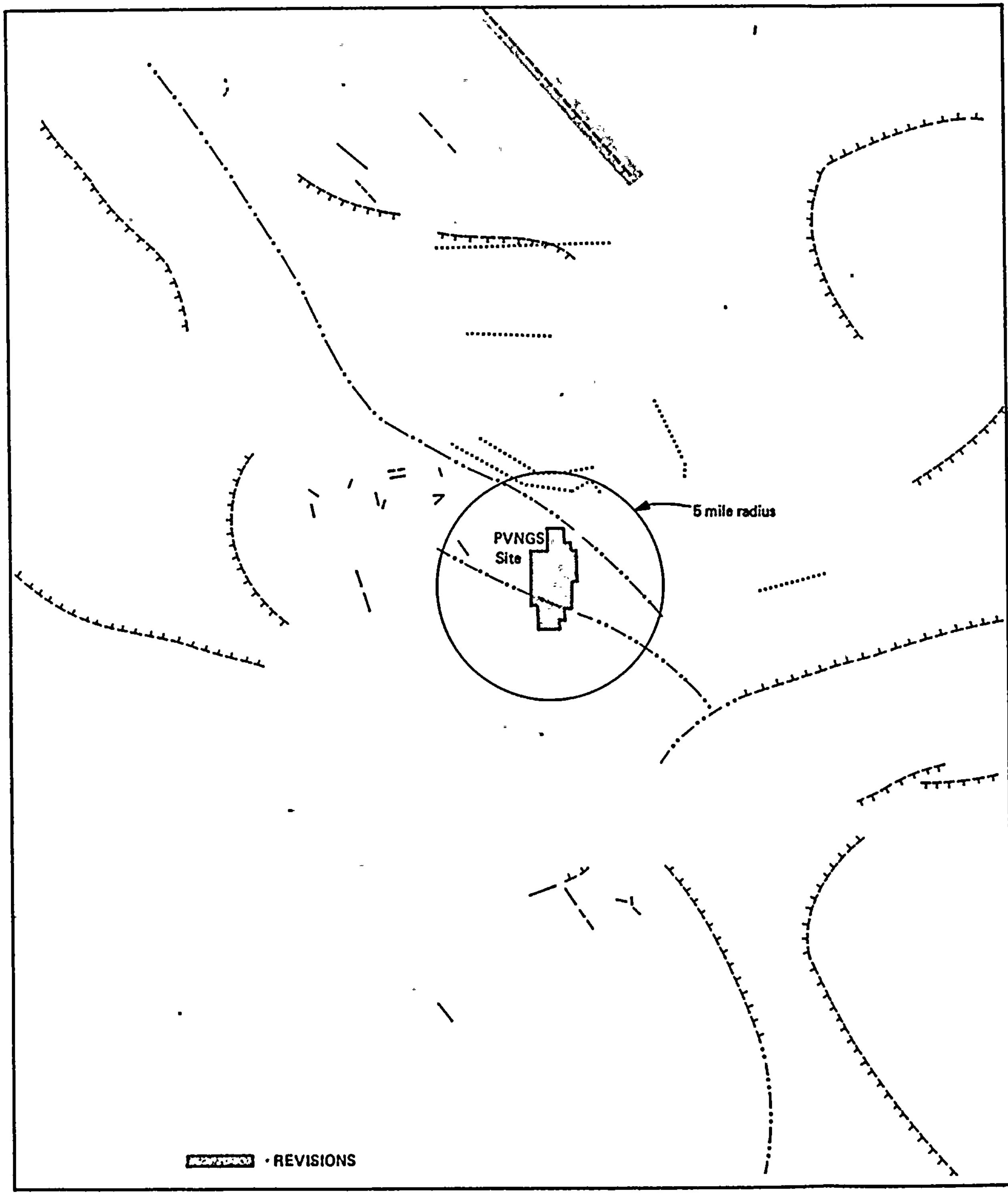


CAPABLE AND QUATERNARY FAULT MAP

Figure 2.5-6



EXPLANATION

HYPOTHETICAL OR INFERRED FAULTS

THESE FAULTS HAVE BEEN HYPOTHESIZED OR INFERRED ON THE BASIS OF EXTRAPOLATIONS OF REGIONAL TECTONIC CHARACTERISTICS OR ON INDIRECT GEOPHYSICAL CHARACTERISTICS ACCORDING TO THE FOLLOWING SOURCES.

USGS-AAPG, 1962

ARIZONA NUCLEAR POWER PROJECT 1974, APPENDIX 2P OF PVNGS 1, 2 & 3 PSAR

COOLEY, 1977

DOE, 1979

MAPPABLE FAULTS

THESE FAULTS ARE EXPOSED IN THE TERTIARY AND OLDER ROCKS OF THE PALO VERDE HILLS AS SHOWN BY PUBLISHED GEOLOGIC MAPS AND DETAILED FIELD INVESTIGATIONS BY FUGRO INCORPORATED.

MAPPABLE FAULTS

NORTH

DRAFT

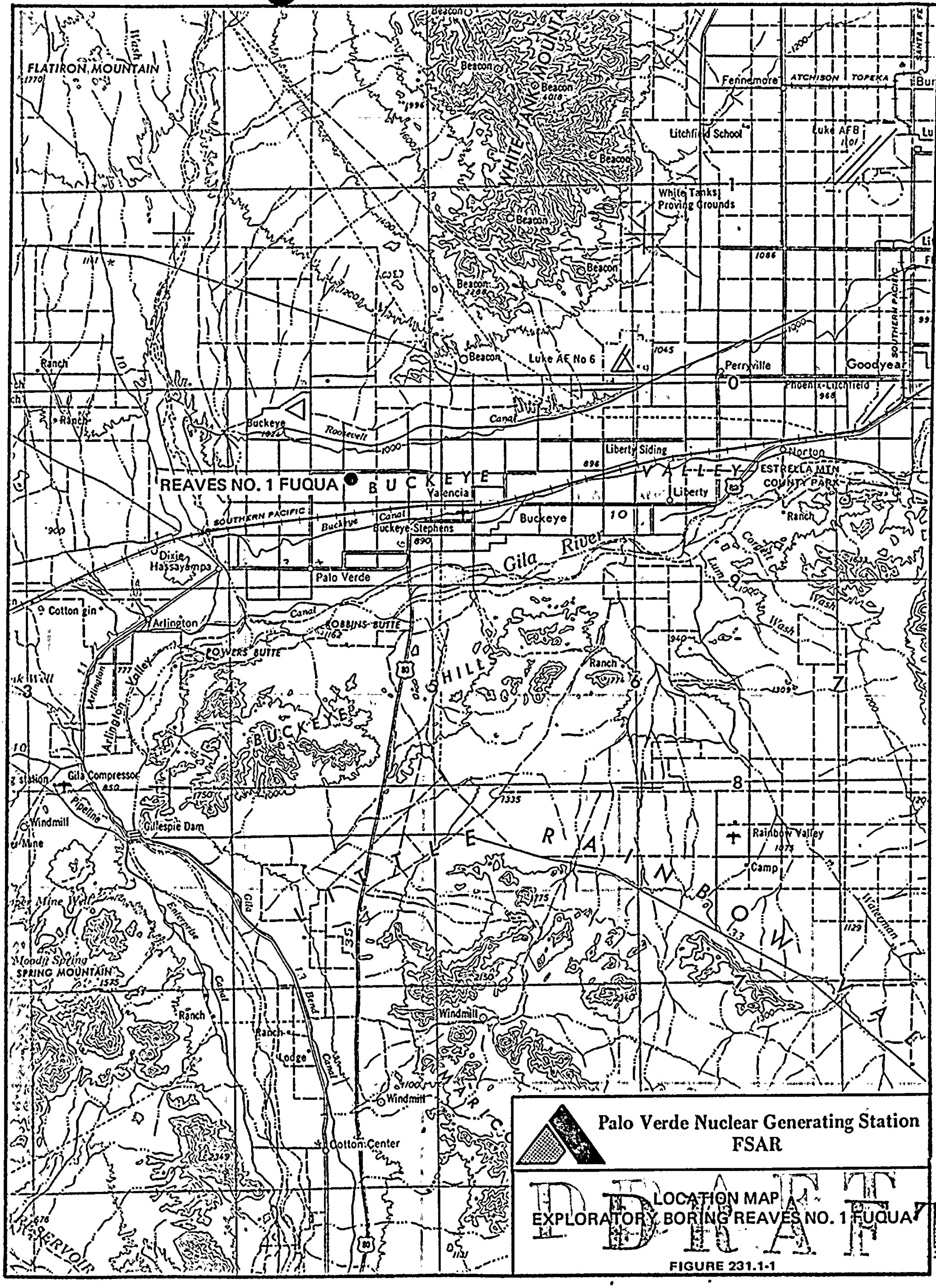
0 5 10

MILES

Palo Verde Nuclear Generating Station
FSAR

FAULTS, SITE VICINITY

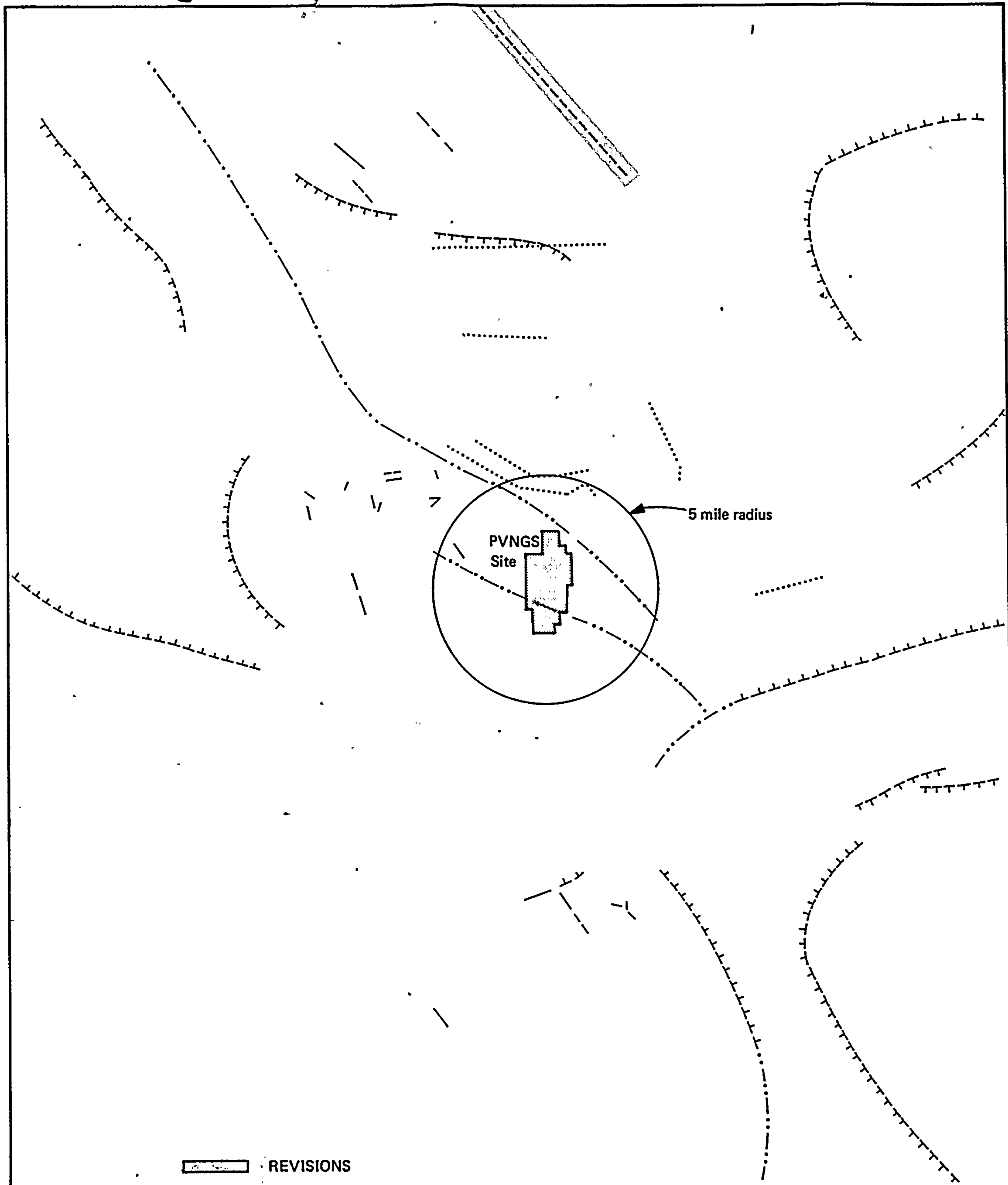
Figure 2.5-11



Palo Verde Nuclear Generating Station
FSAR

LOCATION MAP
EXPLORATORY BORING REAVES NO. 1 FUQUA

FIGURE 231.1-1



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Palo Verde Nuclear Generating Station
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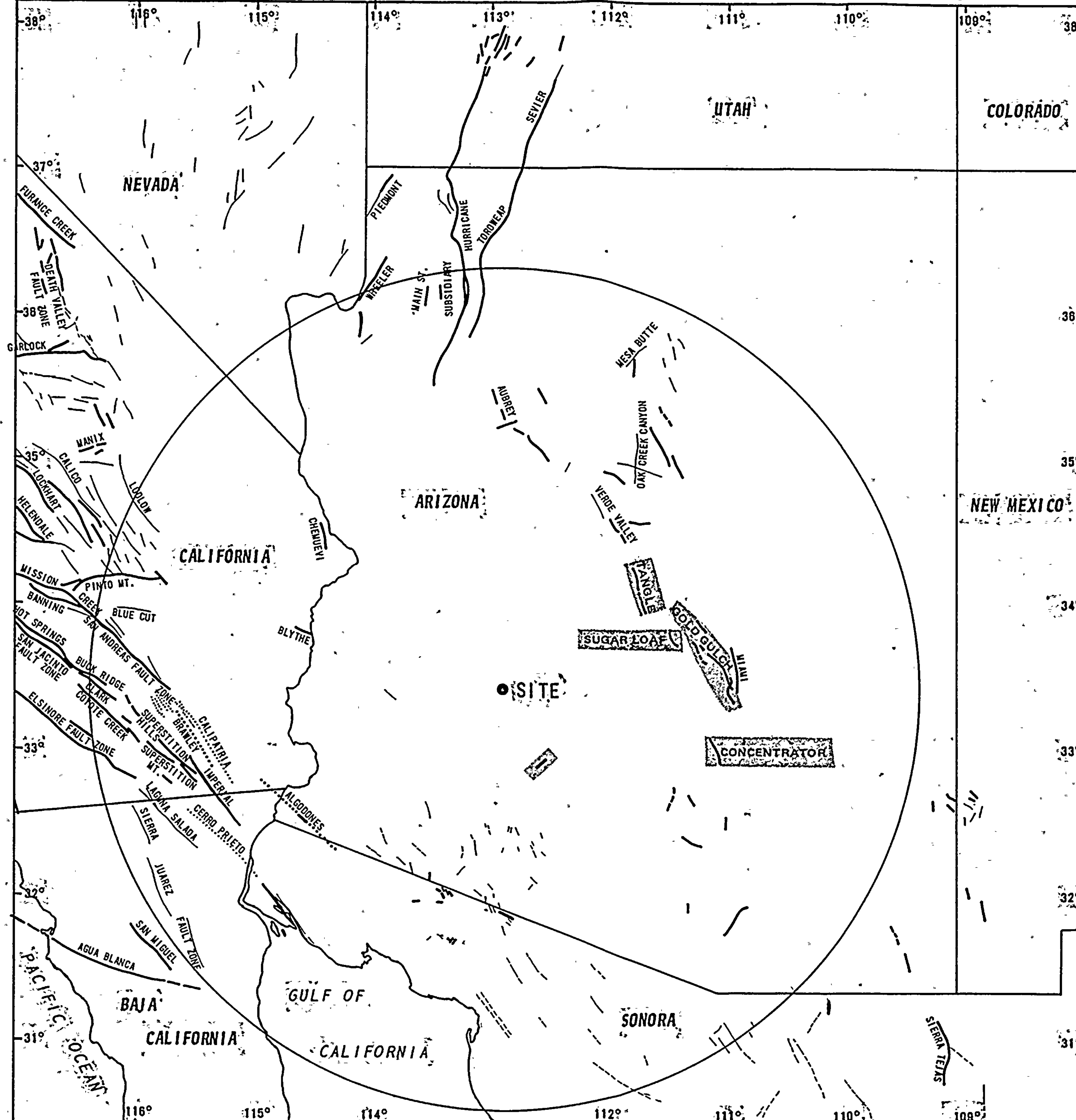
FAULTS, SITE VICINITY

Figure 2.5-11



EXPLANATION

CAPABLE FAULTS – LESS THAN 500,000 YEARS OLD

QUATERNARY FAULTS – 500,000 YEARS TO ABOUT 1.8 MILLION YEARS OLD

REVISIONS

FAULT TRACES ARE DOTTED WHERE THEY ARE NOT VISABLE AT THE SURFACE. TRACES ARE GENERALIZED FROM THE FOLLOWING REFERENCES:

De CSERNA, 1961
WILSON et al, 1969
DONNELLY, 1974
GASTIL et al, 1971
ANPP, 1974
PON, 1981
JENNINGS, 1975
SUMNER, 1972, 1977
HOWARD et al, 1978
HUNTOON, 1979
MERRIAM, 1972

DRAFT

0 50 100
MILES

Palo Verde Nuclear Generating Station
FSAR

CAPABLE AND QUATERNARY FAULT MAP

Figure 2.5-6