Sun Valley Area Drainage Master Plan

TECHNICAL DATA NOTEBOOK:

Approximate Zone A Floodplain Delineation Study of White Tank Piedmont

APPENDIX G

Flood Control District of Maricopa County

September 2006

APPENDIX G

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REPORT

Geologic Mapping of Flood Hazards in Arizona: An Example From the White Tank Mountains Area, Maricopa County

by

John J. Field and Philip A. Pearthree

Arizona Geological Survey
Open-File Report 91-10

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Prepared in cooperation with
the Flood Control District of Maricopa County
and the Arizona Department of Water Resources

This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards

Introduction

Assessment of the character of flood hazards and the extent of flood-prone areas on the piedmonts of Arizona is an increasingly important concern to floodplain managers as urban areas continue to expand. Piedmonts are the low-relief, gently sloping plains between mountain ranges and the streams or playas that occupy the lowest portions of the valleys. Proper management of flood hazards on piedmonts is important because much of southern, central, and western Arizona is composed of piedmonts; they comprise most of the developable land around Phoenix and other rapidly expanding population centers of the State.

Management of flood hazards in Arizona and elsewhere in the western United States is complicated because portions of many piedmonts are composed of active alluvial fans. During floods, these fans are subject to widespread inundation and local high-velocity flow, and substantial changes in channel patterns may occur. Development that proceeds on piedmonts without regard to the locations of active alluvial fans is likely to place people and property at risk during large floods.

Geomorphic analyses and geologic mapping of piedmonts provide the best data for determining if active alluvial fans exist on a given piedmont and which portions of that piedmont may be subject to alluvial-fan flooding. Active alluvial fans have distinctive physical characteristics, including distributary drainage networks and laterally extensive, geologically young alluvial surfaces (Pearthree, 1989; Pearthree and Pearthree, 1989). Typically, large portions of piedmonts in Arizona have not been subject to flooding for many thousands of years and thus are not active alluvial fans. These areas can be distinguished from active alluvial fans by examining differences in drainage patterns, topographic relief, soil development, and surface characteristics (Christenson and others, 1978; Pearthree, 1991; Pearthree and others, in prep).

The principal objective of this study was to use geomorphic analyses and geologic mapping to delineate different flood-hazard zones on the piedmonts around the White Tank Mountains. Flood hazard designations on piedmonts obtained through geomorphic analyses and mapping are more reliable than those generated by hydrologic and hydraulic models currently available. These models, by necessity, make assumptions about rainfall intensity and duration, runoff characteristics, and flow behavior during floods. The validity of flood-hazard assessments derived through hydrologic modeling thus depends on the validity of the underlying assumptions and input parameters (Baker and others, 1990). In contrast, geologic mapping of flood hazards is based on analysis of surface characteristics and drainage patterns that actually exist on piedmonts. Geomorphic studies typically cannot resolve the details of individual floods, but they document which areas have actually been subject to significant flooding over thousands of years. Detailed geologic maps derived from these studies thus provide a long-term perspective on the distribution of flood-prone areas.

This report outlines the methods used to map and characterize flood hazard zones on the piedmonts around the White Tank Mountains. Studies of this kind could be used to delineate flood hazards on any undeveloped or sparsely developed piedmont in Arizona. Because of their wide applicability, the procedures used to map alluvial surfaces of different ages and to develop flood-hazard maps are described in some detail. The distribution of flood-prone areas around the White Tank Mountains is representative of many piedmonts in Maricopa County and elsewhere in Arizona. The report, therefore, also describes typical differences in the character and distribution of flood hazards in the upper, middle, and lower piedmont areas.

Methods Used to Map Alluvial Surfaces of Different Ages

The distribution of alluvial surfaces of different ages was the fundamental data set used to develop flood-hazard maps for this study. Interpretation of aerial photographs and field surveys provide much of the data used in our analyses, because surface characteristics evident on photographs and on the ground are related to the age of the surface. (See Table 1 for sources of data.) Aerial photographs depict surface color, dissection, vegetation density, and drainage patterns over large areas, some of which are inaccessible to motor vehicles. Subsequent ground surveys more thoroughly define the surface characteristics identified on aerial photographs and supply additional information on desert pavement, rock varnish, soil development, depositional topography, and vegetation.

Interpretation of Aerial Photographs

For this study, we interpreted 1:24,000-scale stereo-paired color aerial photographs provided by the U.S. Bureau of Land Management. Many surface characteristics are also evident on high-quality black-and-white photographs. Widely available, 1:24,000-scale, black-and-white orthophotoquads offer less resolution of surface characteristics, but they serve as an excellent base map for transferring information to 7.5' USGS topographic maps. Three characteristics that are visible on aerial photographs reflect surface age: surface color, drainage patterns, and depth of dissection and surface relief.

Surface Color. The color of alluvial surfaces depicted on aerial photographs is primarily controlled by soil color, and to a lesser extent, rock varnish. Significant soil development begins on an alluvial surface after it becomes isolated from active flooding and depositional processes (Gile and others, 1981, Birkeland, 1984; Birkeland and others, 1991). Over thousands of years, distinct soil horizons develop. Two typical soil horizons in old (> 10,000 years) alluvial sediments of Arizona are reddish brown argillic horizons and white calcic horizons. (See further description of soil formation below.) As a result, on color aerial photographs older alluvial surfaces characteristically appear redder or whiter (on more eroded surfaces) than younger surfaces.

Older surfaces have a dark brown color where darkly varnished desert pavements are well preserved. This colors is present in only small areas on the White Tank Mountain

Topographic Maps	Aerial Photographs
Drainage patterns	Surface Color
Drainage spacing	Drainage patterns
Depth of dissection	Drainage spacing
Relief between surfaces	Depth of dissection
	Relief between surfaces

Ground Survey	SCS Soil Maps
Surface color	Soil development
Drainage spacing	
Depth of dissection	
Relief between surfaces	
Desert pavement	Vegetation Maps
Rock varnish	Vegetation distributions
Soil development	
Depositional topography	
Vegetation types and distributions	

Table 1. Data sources for geomorphic analyses and mapping of alluvial surfaces on piedmonts of Arizona. Note that there are sometimes multiple sources of information for a single characteristic (i.e. depth of dissection).

piedmonts, probably because desert pavements have been disturbed by animal burrowing and uprooting of large vegetation. These activities expose the underlying white and red soils.

Drainage Patterns. Differences in the drainage patterns between surfaces provide clues to surface age and potential flood hazards. Young alluvial surfaces that are subject to flooding commonly display a distributary (branching downstream) or braided channel pattern; young surfaces may have very little developed drainage if unconfined shallow flooding predominates. Dendritic tributary (branching upstream) drainage patterns are characteristic of older surfaces that are not subject to extensive flooding. (See Plates 1a through 1d for examples of drainage patterns on young and old alluvial surfaces.) Tributary drainage networks typically extend headward with time, and the spacing between drainages tends to decrease with time as the drainage network becomes better developed.

Depth of Dissection and Surface Relief. Relief between adjacent alluvial surfaces and the depth of entrenchment of channels can be determined using stereo-paired aerial photographs and topographic maps. Young flood-prone surfaces appear nearly flat on aerial photographs and are less than 1 m (3 ft) above channel bottoms. On these young surfaces, channel infilling or bank erosion might redirect floodwaters anywhere on the surface. Active channels are typically entrenched 1 to 10 m (3 to 30 ft) below older surfaces. In these areas, floodwaters are conveyed in the entrenched channels and have not affected the adjacent old surfaces for 10,000 years or more.

Younger surfaces are commonly inset into and topographically lower than older surfaces in upper piedmont areas (Figure 1a). Long-term climatic, tectonic, and base-level changes have resulted in lower surface gradients on younger surfaces, so the depth of dissection on older surfaces generally decreases away from the mountain front. In some middle and lower piedmont areas, relief between surfaces of different ages is minimal (figure 1c), so other surface characteristics are needed to estimate surface ages.

Field Investigations

Field investigations provide additional information on surface characteristics and topographic relationships between surfaces of different ages. Characteristics that are best observed on the ground are used to refine map units and to further describe surfaces already identified through interpretation of aerial photographs. These characteristics include development of desert pavements, rock varnish, and soils; preservation of small-scale depositional topography; and vegetation types.

Desert Pavement. Desert pavement is a concentration of pebbles and cobbles at the surface, which forms as windblown silt and clay accumulates between pebbles and cobbles. Repeated wetting of the surface by rain causes the silt and clay to swell, thereby lifting and pushing more cobbles and pebbles towards the surface. Repeated drying of the surface causes the formation of cracks in which more silt and clay can accumulate. Over thousands of years a surface mantling of closely packed pebbles and cobbles develops over

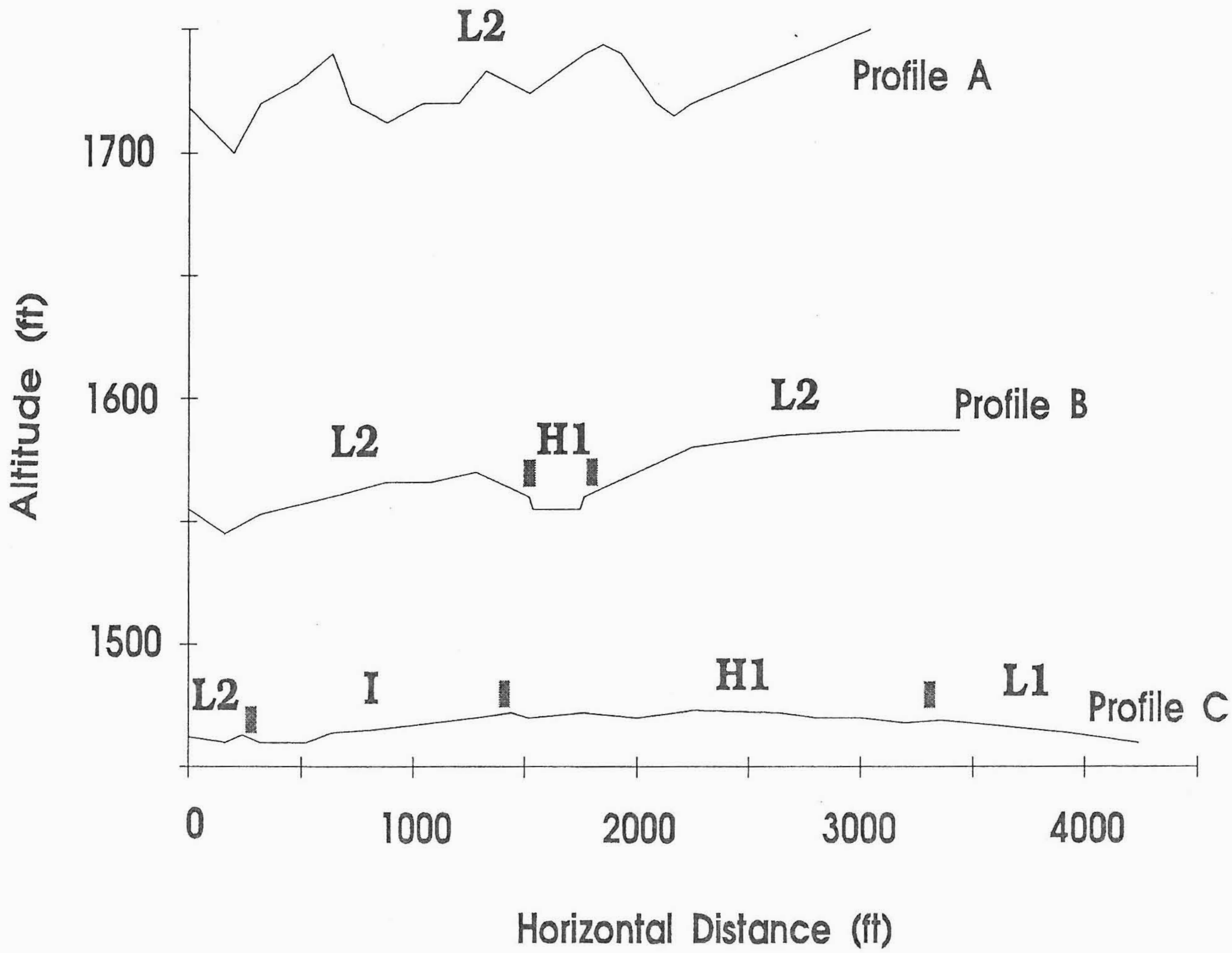


Figure 1. Topographic profiles showing changes in the extent of flood-prone areas downstream and away from the mountains. Profiles were constructed perpendicular to a large stream draining the western side of the White Tank Mountains. Flood-hazard zones are discussed in the text.

a) Upper piedmont area, where channels are deeply entrenched and flood-prone areas are very limited.

b) Transition to the middle piedmont, where flood-prone areas are still of limited extent but topographic confinement of channels is much less.

c) Middle piedmont area, where flood-prone areas are extensive, there is minimal topography on active alluvial fans, and there is little relief between areas that have been flooded recently and those that have not been flooded for 10,000+ years.

a silt- and clay-rich soil layer (Dohrenwend, 1987; Vanden Dolder, 1992). Desert pavements are generally most closely packed on relatively old alluvial surfaces; they are more open and poorly developed on intermediate aged surfaces. Young alluvial surfaces that have been flooded within the past few thousand years do not have desert pavements because surface sediments have been recently reworked by floodwaters. As noted above, desert pavements can be disrupted by animal activity or vegetation. The best developed desert pavements in Arizona are in relatively arid areas, where little vegetation grows on the alluvial surfaces.

Rock Varnish. Rock varnish forms on pebbles and cobbles at the land surface; these pebbles and cobbles are often incorporated into a desert pavement. Rock varnish that forms on rock surfaces exposed to the atmosphere is a brown to black patina composed of manganese oxides and clay minerals precipitated on the rock surface by microbial organisms (Dorn and Oberlander, 1982; Vanden Dolder, 1992). As the surface exposed to the atmosphere darkens, the undersides of the pebbles and cobbles are simultaneously reddened by the accumulation of iron oxides and clay minerals. The varnishing process is very slow in arid regions and only occurs on gravel that is continuously exposed at the surface and has not been moved for thousands of years. Rocks with weakly developed varnish indicate that a surface has not been subject to significant flooding for thousands of years; rocks with well-developed varnish have not been disturbed by flooding for tens to hundreds of thousands of years. Young surfaces that have been flooded in the past few thousand years are unvarnished because the rocks have not been in place long enough to develop varnish.

Soil Development. Soil development generally increases with the age of an alluvial surface. When the accumulation of stream deposits on a land surface ceases, the sediment beneath the surface begins to be altered into distinct horizons by soil-forming processes. The most important process that leads to the development of soils on the piedmonts of Arizona is the accumulation of material from the atmosphere (windblown dust and calcium carbonate dissolved in rainwater) in the first 1 to 2 m (3 to 6 ft) below the land surface. The ages of these soils can be roughly estimated from the amount of silt, clay, and calcium carbonate that has accumulated in them (Table 2).

Because of accumulation of windblown dust, the first 1 to 10 cm (1 to 4 in.) of sediment beneath alluvial surfaces is typically silt-rich even if the parent material (the original stream deposit) is sand and gravel. Beneath this surface horizon, rainwater percolates into the sediment and alters the parent material, producing a weak fabric in the soil (soil structure) or slight soil reddening or both; this horizon is called a cambic horizon. Suspended clay is also carried from the surface and concentrated in this portion of the soil. As the amount of clay increases with time, the cambic horizon develops into an orange to reddish brown, clay-rich argillic horizon. The strength of cambic or argillic horizon development depends on the age of the surface and climate. Cambic horizons probably form in a few thousand years to 10,000 years in Arizona. Weak argillic horizons probably forme in 10,000 years or more in most areas, and strongly developed argillic horizons have developed over hundreds of thousands of years (Gile and others, 1981; Pearthree and

Estimated Age	Soil Development			Drainage Patterns	Surface Dissection	Surface Topography	Rock Varnish
	Color	Texture	Calcic Horizon				
Late Holocene (< 3 ka)	brown	sand	thin, discontinuous rock coatings	distributary	< 1 m	bars and swales channels	none
Mid- to early Holocene (3-10 ka)	brown to orange	sand to sandy loam	discontinuous to continuous rock coatings	distributary or tributary	< 1 m	bars and swales obvious	minimal brown/ orange
Late Pleistocene (10-150 ka)	brown to orange	loamy sand sandy loam	continuous coatings whitened matrix	tributary	< 3 m	bars and swales well preserved	moderate dark brown/ orange
Late to Middle Pleistocene (150-300 ka)	orange to reddish brown	sandy loam loam	continuous coatings whitened matrix	tributary	< 6 m	bars and swales moderately to poorly preserved	moderate black/ reddish brown
Middle Pleistocene (300-800 ka)	reddish brown	clay	thick coatings locally cemented matrix	tributary	< 6 m	smooth, bars and swales poorly preserved	strong black/ reddish brown
Early Pleistocene (> 800 ka)	orange to white	loam	cemented very thick coatings	tributary	10 to 15 m	erosionally rounded ridges	variable poorly preserved

Table 2. Selected surface properties that change with increasing alluvial surface age around the White Tank Mountains. Estimated ages are in thousands of years old (ka); soil colors and soil textures reported are from the zone of silt and clay accumulation; rock varnish colors are from exposed surfaces/undersides of cobbles.

Calvo, 1987; Bull, 1991). The presence of reddened, clay-rich argillic horizons thus indicate that surfaces have not been subject to significant flooding for at least 10,000 years, and commonly much longer than that.

Comparisons of calcic horizon development on the White Tank Mountains piedmont with other soil sequences in the western United States provide one of the few methods of estimating the ages of the different alluvial surfaces. Calcium carbonate from dust and rainwater gradually precipitates in soils, forming a whitish calcic horizon. Geomorphologists and soil scientists recognize six morphologic stages of calcic-horizon development and have linked these states to soil ages in several areas in the southwestern United States (Machette, 1985; Birkeland and others, 1991). Calcic horizon development varies from fine white filaments of calcium carbonate in young soils to soil horizons completely plugged with calcium carbonate (caliche) in very old soils.

Soil horizons lie beneath the surface and thus must be examined in natural stream cuts, hand-dug soil pits, or backhoe trenches. Although soil development is a very useful characteristic in producing a geologic flood-hazard map, care must be exercised when interpreting soil- and surface-age relationships. A soil exposed beneath a surface may be a buried soil and unrelated to the surface that it is presently beneath. Young deposits on the lower piedmont are commonly only a thin veneer (<30 cm, or 1 ft) over much older soils. As a result, the presence of a well developed calcic horizon on the lower piedmont does not necessarily indicate that the overlying surface has not been flooded for a long time, unless other surface characteristics confirm that the surface is old.

Depositional Topography. The degree of preservation of original depositional surface features is another key to determining the age of an alluvial surface. One such feature, bar-and-swale topography, is common on alluvial surfaces of Arizona. Gravel bars deposited during large floods are separated by intervening sand-filled channel swales or troughs. After a surface is isolated from major flood events,it is gradually smoothed as bars are eroded and swales are filled in by windblown dust and sediment derived from adjacent bars. Bar-and-swale topography is readily apparent on alluvial surfaces that have been deposited within the past 10,000 years, but is more subdued on increasingly older alluvial surfaces; very old surfaces typically are quite smooth. It is important to note, however, that development of bar-and-swale topography also depends on the size of bedload particles conveyed by a stream. Streams that convey coarse bedloads (cobbles and boulders) typically have obvious, well-developed bars and swales. This topography is not evident on young, flood-prone surfaces on the lower piedmont because very little coarse-grained bedload is present far from the mountains.

Vegetation. The distribution of plant types is commonly associated with the age of alluvial surfaces. Vegetation is also controlled by elevation and rock type, however, so vegetation patterns are not as clear an indicator of surface ages as are some of the aforementioned characteristics. On the White Tank Mountains piedmonts, creosote and brittle bush are pervasive on all surfaces; thus their distributions cannot be used as an indicator of surface age. Saguaro, palo verde, ironwood, cane cholla, and barrel cactus are not as pervasive, but do not correlate definitively with alluvial surfaces of different ages. Jumping cholla, however, is abundant only on old flood-free surfaces; its distribution probably correlates with clay-rich soils.

Alluvial-Surface Characteristics -- Indicators of Recency of Flooding

The surficial characteristics discussed above impart a distinctive appearance to alluvial surfaces of a given age. In general, alluvial surfaces that have been flooded within the past 10,000 years are dominated by characteristics related to primary depositional processes. These characteristics include (1) distributary drainage patterns, (2) minimal entrenchment of stream channels below the surface, (3) brown surface colors, (4) little or no soil development, (5) obvious bar and swale topography; and (6) no desert pavement or rock varnish; . Old alluvial surfaces that have not been subject to substantial flooding for hundreds of thousands of years are typically characterized by (1) well-developed, moderately to deeply entrenched, dendritic tributary drainages, (2) reddish, whitish, or dark brown surface colors, (3) strongly developed soil profiles, (4) subdued, smoothed bar-and-swale topography, and (5) dark-brown to black varnish on exposed rock surfaces and orange to red varnish on the undersides of rocks. If local conditions are conducive, old alluvial surfaces may also have well-developed desert pavements. Characteristics of surfaces of intermediate age, which have not been flooded for tens of thousands of years, fall within the two extremes.

We estimated the ages of alluvial surfaces around the White Tank Mountains by comparing their characteristics, especially soil development (Table 2), with those of dated surfaces in similar climatic regions. Other means of directly dating surfaces include radiocarbon dating when carbon fragments are found and archaeological remains when present.

A single surface characteristic is insufficient to conclusively estimate surface age, because some of the characteristics mentioned above as distinctive of young surfaces may be attributes of old surfaces and vice versa. Not all the characteristics distinctive of surfaces of a certain age need be present to assign a surface that age designation, however. For example, deep dissection of a surface clearly indicates that it is not flood prone, but the absence of dissection does not necessarily mean the surface is young and flood prone. Large areas on the lower and middle piedmonts of the White Tank Mountains have not been disturbed by flooding for more than 10,000 years, even though the surfaces are less than 1 meter (3 ft) above the channel bottoms. In these areas, well-developed pavement, varnish, and soils are better indicators of surface age. In general, certain characteristics are only present on a surface of a given age, and are reliable indicators of the time since a surface was last flooded. Other characteristics are not always present or are attributes of surfaces of different ages (Table 3). A final surface-age designation is based on all of the surface characteristics outlined above.

Alluvial surfaces on the piedmonts of the White Tank Mountains range in age from

Flood Hazard	Surface Age	Characteristic Category*	Surface Characteristic
Low	10,000+	1	Mod. to well developed pavement Mod. to well developed varnish Mod. to strong soil development
		2	Deep dissection (>4 ft.)
		3	Abundant jumping cholla Reddish or whitish surface Mod. to closely spaced drainage Dendritic tributary drainage Absent or subtle bar and swale
Intermediate	1,000-10,000	1	Weak to mod. soil development Weakly developed pavement
		2	Incipient desert varnish Obvious bar and swale
		3	Dendritic tributary drainage Shallow dissection (<3 ft.) Mod. to widely spaced drainage
High	0-3,000	1	Incipient soil development No desert pavement
		2	Distributary drainage Fresh bar and swale
		3	Shallow dissection (<3 ft.) No desert varnish

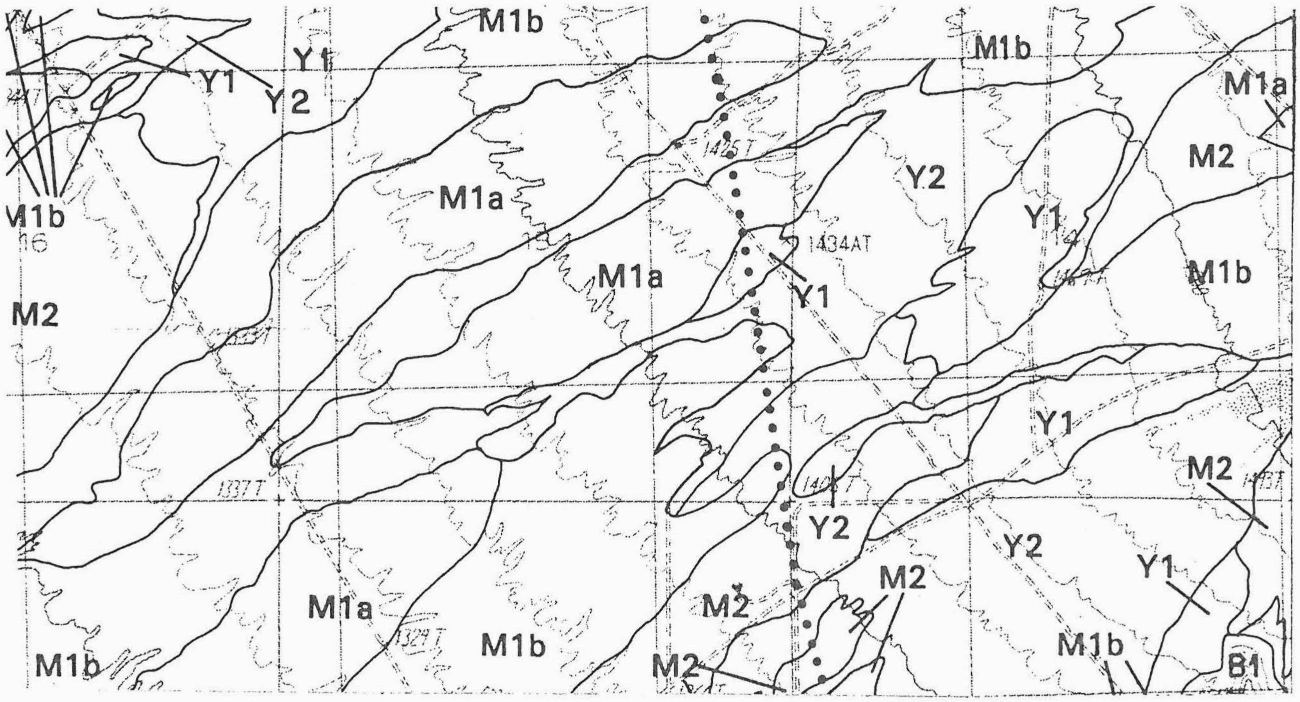
* Characteristic Category 1 - These characteristics are indicative of surface age and are almost always present on the surfaces of given age. If the characteristic is absent, the surface is most likely of a different age.

Characteristic Category 2 - These characteristics are indicative of surface age but are not always present. Absence of these characteristics from the surface does not imply the surface is of another age (as in Category 1).

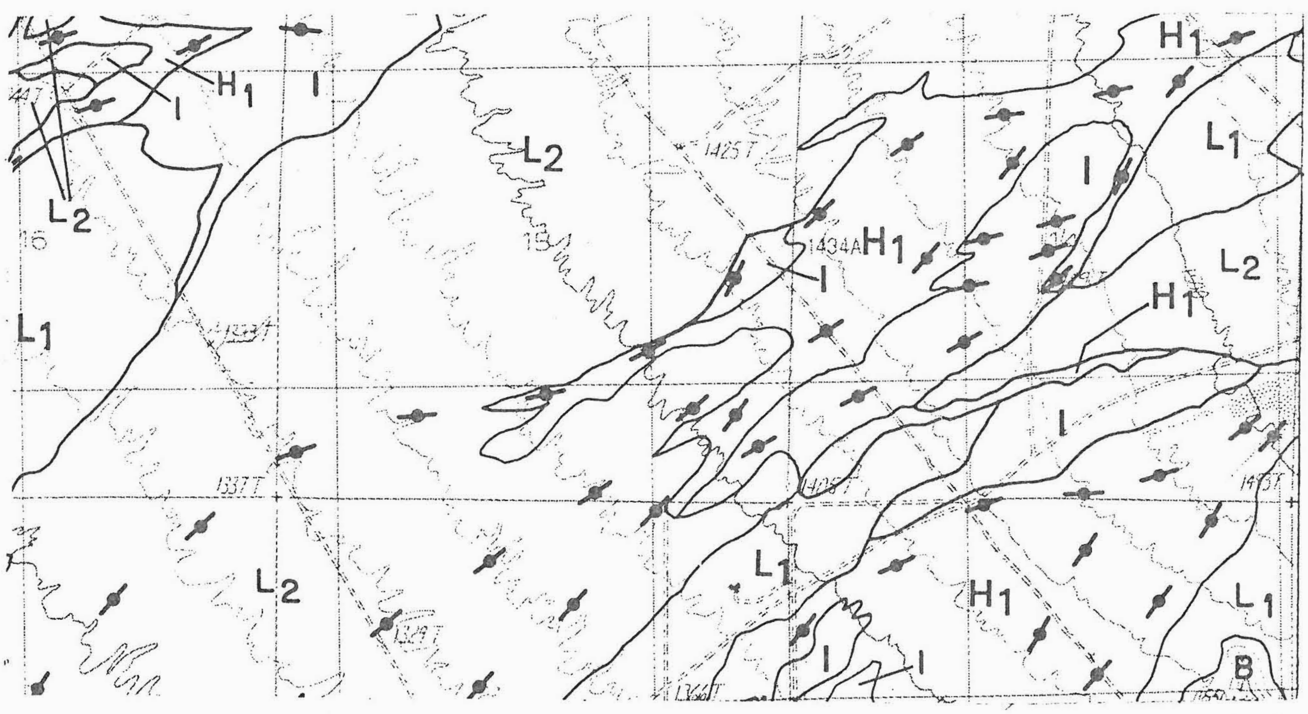
Characteristic Category 3 - These characteristics are almost always present on the surface but are not indicative of surface age, because they are found on other surfaces as well. However, if the characteristic is absent the surface is most likely of another age.

Table 3. Characteristics used to delineate three flood hazard zones on alluvial piedmonts around the White Tank Mountains. Note that the opposite of a characteristic does not necessarily imply the opposite flood hazard (i.e. shallow dissection does not always imply the surface is flood prone).

Figure 2. Development of a flood-hazard map using geologic and geomorphic data.



a) Map of alluvial surfaces covering part of the western piedmont of the White Tank Mountains. Surfaces ages (in years) are as follows: Y2, <3,000; Y1, 1,000 to 10,000; M2, 10,000 to 150,000; M1b, 150,000 to 300,000; M1a, 300,000 to 800,000.



b) Geologic flood-hazard map of the same area. Heavy dots with lines show approximate locations of channels of major drainages that head in adjacent mountains. Surface age, proximity to major drainages, local topographic relief, and evidence of channelized flow were used to delineate flood-hazard zones. See text for description of flood-hazard categories.

modern to 1,000,000 years old or more (Table 2; see Field and Pearthree, 1991, for a more complete discussion of surface characteristics and surface-age estimates). We differentiated and mapped the following alluvial surfaces: late Holocene, < 3,000 years old; late to early Holocene, 1,000 to 10,000 years old; late Pleistocene, 10,000 to 150,000 years old; late middle Pleistocene, 150,000 to 300,000 years old; early middle Pleistocene, 300,000 to 800,000 years old, and early Pleistocene, > 800,000 years old.

Development of Flood-Hazard Zones

We integrated maps of alluvial surfaces of different ages (Field and Pearthree, 1991) with other geomorphic information to delineate flood-hazard zones around the White Tank Mountains (Figure 2; Plate 1). Assessments of flood hazards were based on (1) the age of the alluvial surface; (2) local topographic relief between the surface and active channels; (3) proximity to active channels, especially channels of major distributary flow systems; and (4) the size, number, and character of active channels in the area.

The most important data we used to develop the flood hazard maps was the distribution of surfaces of different ages. The critical assumption of our analysis is that areas that have been subject to flooding over the past few thousand years are the areas that are likely to be flood prone. The potential for flooding in areas that have not been flooded for at least 10,000 years is considered to be very low, unless local circumstances suggest flow patterns have changed very recently. Areas composed of surfaces of 1,000 to 10,000 years old are considered to have intermediate or high flood potential, depending on their proximity to active channels or active alluvial fans.

Our delineation of flood-hazard zones was also based on drainage patterns, local topography, and the character of active channels. We considered areas that are within or near distributary drainage networks of the larger washes to be relatively more flood prone than areas that are spatially separated from these networks. We also incorporated local topographic relief between active channels and adjacent alluvial surfaces into our assessments. The flood potential on old surfaces that are several meters or more (5 to 10+ ft) higher than adjacent active channels is considered to be very low. In contrast, if little relief separates old surfaces and active channels, the flood potential on the old surfaces is considered to be higher because of the possibility that flooding patterns might change and affect the old surface. We subdivided flood potential in areas of extensive young alluvial surfaces based on the size and abundance of channels. Large or abundant channels indicate that relatively deep, high velocity flows are an important element of flooding. Furthermore, the positions of these channels may shift occasionally during large floods (CH2MHill, 1991), subjecting the areas covered by young deposits between the existing channels to sheet flooding or channelized flooding. Areas of extensive young deposits where channels are not evident are subject primarily to shallow sheetflooding. These areas are clearly flood prone, but the character of the flooding is far less threatening.

The characteristics of the five flood-hazard zones are summarized below.

H1 - Very high flood potential. Extensive young deposits; distributary channel system very evident. Potential for localized, high-velocity, relatively deep, channelized flows and sheetflooding; some potential for drastic shifts in channel positions.

H2 - High flood potential. Extensive young deposits, but channels are small or nonexistent. Predominantly shallow sheetflooding; channelized flow very limited in extent; broad areas probably inundated in large floods.

I - Intermediate flood potential. Areas have not been flooded recently. Near or within distributary drainage systems, and little topographic relief separates these areas from active alluvial fans or channels. Could become flood prone with relatively modest changes in channel configurations.

L1 - Relatively low flood potential. Areas have not been flooded for at least 10,000 years. Flooding has been confined to channels and immediately adjacent terraces for that long. However, these areas are near or within distributary drainage networks, and typically little topographic relief separates L1, I, H2, and H1 areas. L1 areas should be carefully evaluated to determine if potential for shifts in channel configurations or depositional patterns could result in these areas becoming flood prone.

L2 - Very low flood potential. Areas have not been flooded for at least 10,000 years, and typically for much longer. Drained by tributary streams that head on the piedmont. Streams entrenched 1 to 10 m (3 to 30 ft) below inactive alluvial surfaces; spatially separate from or topographically isolated from distributary drainage networks. Flood-prone areas limited to channels and adjacent low terraces.

Distribution of Flood Hazards on the Piedmonts of the White Tank Mountains

The distribution of flood hazards varies widely across the piedmonts of the White Tank Mountains. On upper piedmonts, flood-prone surfaces are restricted to channel bottoms and low terraces set well below older flood free surfaces (Figure 1a, 1b; Plate 1). Only the largest channel bottoms are mappable at this scale (1:24,000), but smaller, unmapped channel bottoms are also subject to high-velocity channelized flow (H1 flood hazard).

The largest areas with the highest flood potential (H1) are associated with active alluvial fans on the middle piedmont west and south of the White Tank Mountains (Figure 1c; Plate 1). These are areas where entrenched large drainages become unconfined downstream, distributing floodwaters into several smaller channels and sheetfloods. Extensive very young deposits (<3,000 years old) and distributary channel networks indicate that these areas are active alluvial fans. Some areas within the distributary-flow networks have not been subject to significant flooding for at least 1,000 years and are somewhat isolated from the distributary channels; the potential for flooding in these areas is less (intermediate flood potential; category I). Downstream from the active alluvial fans, distributary channels typically become reconfined into fairly narrow passages between older surfaces that have not been flooded significantly for at least 10,000 years. We have assigned a low flood hazard potential (L1) to areas where the relief between the reconfined channels and adjacent old alluvial surfaces is less than one meter (3 ft); we assigned the lowest flood potential (L2) to areas where the relief is more than one meter (3 ft). Widespread zones of fairly high flood hazards (H2) are present on the middle piedmont north of the White Tank Mountains (Plate 1a and 1b). In this area several large drainages become unconfined and floodwaters spread out into low-velocity sheetfloods.

On the lower piedmont, many of the major drainages again become unconfined and floodwaters spread out into sheetflows (Plate 1). High-velocity, channelized flood hazards (H1) are restricted to very small portions of the lower piedmont, but areas prone to shallow flooding (H2) are ubiquitous. A single large flood probably will not inundate the entire lower piedmont, but the absence of substantial relief across the lower piedmont makes it difficult to predict where the next sheetflow will occur.

Conclusions

The White Tank Mountains flood hazard map demonstrates the value of using geomorphic analyses and mapping to delineate flood potential on desert piedmonts. A single geomorphic characteristic, by itself, cannot conclusively establish the age of a piedmont surface. Suites of characteristics identifiable on aerial photographs and in the field, however, are diagnostic of surface age. Alluvial surfaces of different ages on desert piedmonts can be readily mapped using these diagnostic suites of characteristics. By integrating surface age information with topographic data and the character of drainage networks, geologists can reliably delineate flood potential zones across the entire piedmont. Similar detail and reliability is not possible with current numerical hydraulic models. Geologic and geomorphic studies, therefore, should be an integral part of any flood hazard management project on desert piedmonts.

References

Baker, V.R., Demsey, K.A., Ely, L.L, Fuller, J.E., House, P.K., O'Connor, J.E., Onken, J.A., Pearthree, P.A., and Vincent, K.R., 1990, Application of geological information to Arizona flood hazard assessment, *in* French, R.H., ed., Hydrology and hydraulics of arid regions: American Society of Civil Engineers, p. 621-626.

Birkeland, P.W., 1984, Soils and geomorphology: New York, Oxford University Press, 372 p.

Birkeland, P.W., Machette, M.N., and Haller, K.M., 1991, Soils as a tool for applied Quaternary geology: Utah Geological and Mineral Survey Miscellaneous Publication 91-3, 63 p.

Bull, W.B., 1991, Geomorphic responses to climatic change: New York, Oxford University Press, 326 p.

CH2MHill, 1991, Alluvial fan data collection and monitoring study, preliminary report: Flood Control District of Maricopa County [Arizona], 70 p..

Christenson, G.E., Welsch, D.G., and Pewe, T.L., 1978, Environmental Geology of the McDowell Mountains Area, Maricopa County, Arizona: Arizona Geological Survey Geologic Investigations Folio GI-1, 10 sheets, scale 1:24,000.

Dohrenwend, J.C., 1987, Basin and Range, *in* Graf, W.L., ed., Geomorphic systems of North America: Geological Society of America, Centennial Special Volume 2, p. 303-342.

Dorn, R.I., and Oberlander, T.M., 1982, Rock varnish: Progress in Physical Geography, v. 6, p. 317-367.

Field, J.J., and Pearthree, P.A., 1991, Surficial geology around the White Tank Mountains, central Arizona: Arizona Geological Survey Open-File Report 91-8, 9 p., scale 1:24,000, 9 sheets.

Gile, L.H., Hawley, J.W., and Grossman, R.B., 1981, Soils and geomorphology of the Basin and Range area of southern New Mexico -- Guidebook to the Desert Project: New Mexico Bureau of Mines and Mineral Resources Memoir 39, 222 p.

Machette, M.N., 1985, Calcic soils of the southwestern United States: *in* Weide, D.L., ed., Soils and Quaternary geology of the southwestern United States: Geological Society of America Special Paper 203, p. 1-21.

Pearthree, P.A., 1989, A geomorphic perspective on management of flood hazards on desert piedmonts of the southwestern United States, *in* Partnerships: Effective Flood Hazard Management: Association of State Floodplain Managers, Annual Conference, 13th, Scottsdale, Arizona, p. 105-111.

Pearthree, P.A., 1991, Geologic insights into flood hazards in piedmont areas of Arizona: Arizona Geology, v. 21, no. 4, p. 1-5.

Pearthree, P.A., and Calvo, S.S., 1987, The Santa Rita fault zone: Evidence for large magnitude earthquakes with very long recurrence intervals in the Basin and Range province of southeastern Arizona: Bulletin of the Seismological Society of America, v. 77, p. 97-116.

Pearthree, P.A., Demsey, K.A., Onken, Jill, and Vincent, K.R., in prep., Geomorphic assessment of fluvial behavior and flood-prone areas on the Tortolita piedmont, Pima County, Arizona: Arizona Geological Survey Open-File Report.

Pearthree, P.A., and Pearthree, M.S., 1989, Geomorphology and flood hazard assessment in piedmont areas of Arizona, *in* Conference on Arid West Floodplain Management Issues, Association of State Floodplain Managers, Las Vegas, 1988, p. 81-94.

Vanden Dolder, E.M. 1992, Rock Varnish and desert pavement provide geological and archaeological records: Arizona Geology, v. 22, no. 1, p. 1, 4-7.

White Tank Mountains
Flood Hazard Map - NW Section

by
John J. Field and Philip A. Pearthree
1991

E X P L A N A T I O N

Map Unit Description

H_1 **Flood Hazard:** Highest; high-velocity channelized flow and sheetflow

Distribution: Entrenched reaches of major drainages and distributary flow areas on middle and upper piedmont

Soil Group*: Torrifluvents

Channel Pattern: Braided (anastomosing) or distributary

Surface Relief: Less than 2 ft; bar and swale topography

Surface Texture: Silt to very gravelly sand

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation:** Brittle bush, rabbit bush, bunch grass, creosote

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

H_2 **Flood Hazard:** Moderately high; dominantly sheetflow with minor channel flows

Distribution: Restricted to lower piedmont and small drainages heading on the piedmont

Soil Group: Torrifluvents

Channel Pattern: Distributary; incipient dendritic drainage in less active areas

Surface Relief: Less than 2 ft with uncommon, 4-ft arroyo cuts; smooth surface

Surface Texture: Sandy silt with 10% scattered gravel; less active areas have granule to pebble lag

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation: Creosote, brittle bush

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

I **Flood Hazard:** Intermediate; has not been subject to significant flooding for more than 1,000 yrs, but lack of topographic relief between these surfaces and active surfaces (H_1 and H_2) suggests that they could become flood prone with channel filling, avulsion, or human disturbance

Distribution: Adjacent to H_1 and H_2 in distributary flow areas and on lower piedmont

Soil Groups: Torrifluvents and Camborthids

Channel Pattern: Widely spaced, dendritic tributary drainages

Surface Relief: Less than 4 ft in distributary flow areas and less than 3 ft on lower piedmont; bar and swale topography well preserved in distributary flow areas

Surface Texture: Open desert pavement consisting of granules and small cobbles

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished to weakly developed over 10% of the surface - brownish black (7.5YR 3/1) on top and orange (7.5YR 7/6) on undersides

Vegetation: Brittle bush, creosote, palo verde

Estimated Surface Age: Late Holocene to latest Pleistocene (1,000 to 15,000 yrs old)

L_1 **Flood Hazard:** Low; localized sheetflooding possible; flooding might occur if channels are altered by human disturbance because of low relief downslope from major distributary flow areas

Distribution: Downslope from and adjacent to distributary flow areas on middle and lower piedmont

Soil Groups: Camborthids and Haplargids

Channel Pattern: Moderately spaced, dendritic tributary drainages

Surface Relief: 1 to 10 ft; fairly smooth subdued bar and swale topography

Surface Texture: Open to closed desert pavement consisting of granules and cobbles

Surface Color: Bright brown (7.5YR 5/6) to orange (7.5YR 6/6)

Desert Varnish: Weakly to moderately developed over 50% of surface - brownish black (7.5YR 2/2) to grayish brown (7.5YR 4/2) on top and dull orange (5YR 6/4) to reddish brown (2.5YR 4/6) on undersides

Vegetation: Brittle bush, creosote, cane cholla

Estimated Surface Age: Latest Pleistocene to middle Pleistocene (15,000 to 250,000 yrs old)

L_2 **Flood Hazard:** Lowest; restricted to small channels and localized sheetflooding

Distribution: Upper and middle piedmont and adjacent to Hassayampa River

Soil Groups: Haplargids and Durorthids

Channel Pattern: Closely to widely spaced, dendritic tributary drainages; rounded interfluves in areas of highest relief

Surface Relief: 5 to 40 ft; fairly smooth surface; uncommon bar and swale topography

Surface Texture: Closed desert pavement consisting of cobbles and pebbles; uncommon salt-shattered cobbles; in places, surface is denuded and covered by petrocalcic fragments

Surface Color: Dull orange (7.5YR 6/4 to 5YR 6/3)

Desert Varnish: Well developed over 50 to 100% of undenuded surfaces - black (5YR 1.7/1) on top and dark red (10R 3/6) to dull orange (7.5YR 7/4) on undersides

Vegetation: Jumping cholla, brittle bush, creosote

Estimated Surface Age: Late Pleistocene to Pliocene (50,000 to 1,000,000+ yrs old)

M **Flood Hazard:** Mechanized disturbance; flood hazard unknown

B **Flood Hazard:** Bedrock outcrops; flood hazard low, but localized slope wash and debris flows possible in steepest areas

* Soil groups are taken from the Soil Conservation Service survey of the Aguila-Carefree area

** Only dominant plant types are listed

Channel bottoms of larger drainages heading in the White Tank Mountains

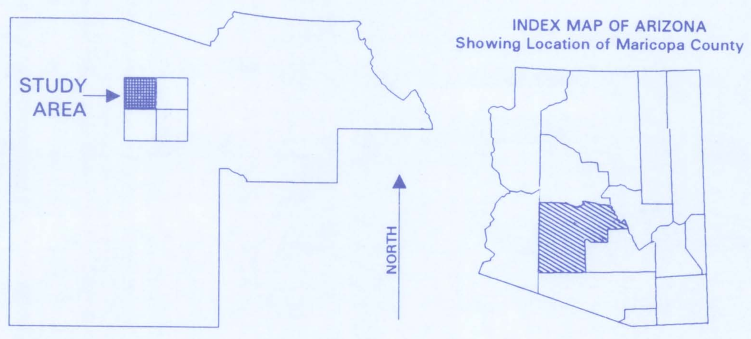
SCALE 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 5, 10, 20, 40 FEET



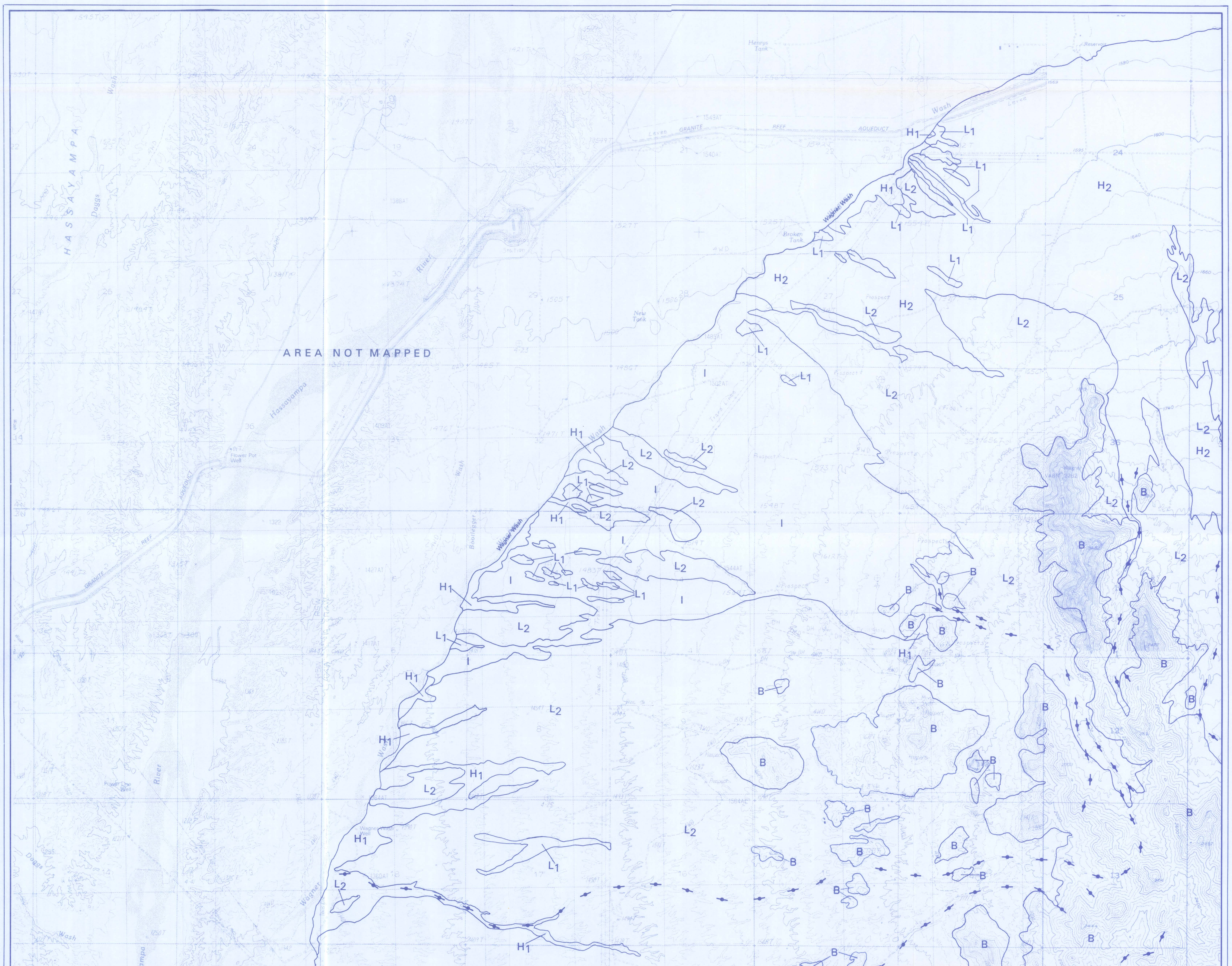


Plate Ia

White Tank Mountains Flood Hazard Map - NE Section

by
John J. Field and Philip A. Pearthree
1991

E X P L A N A T I O N

Map Unit Description

H1 **Flood Hazard:** Highest; high-velocity channelized flow and sheetflow

Distribution: Entrenched reaches of major drainages and distributary flow areas on middle and upper piedmont

Soil Group*: Torrifluvents

Channel Pattern: Braided (anastomosing) or distributary

Surface Relief: Less than 2 ft; bar and swale topography

Surface Texture: Silt to very gravelly sand

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation:** Brittle bush, rabbit bush, bunch grass, creosote

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

H2 **Flood Hazard:** Moderately high; dominantly sheetflow with minor channel flows

Distribution: Restricted to lower piedmont and small drainages heading on the piedmont

Soil Group: Torrifluvents

Channel Pattern: Distributary; incipient dendritic drainage in less active areas

Surface Relief: Less than 2 ft with uncommon, 4-ft arroyo cuts; smooth surface

Surface Texture: Sandy silt with 10% scattered gravel; less active areas have granule to pebble lag

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation: Creosote, brittle bush

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

I **Flood Hazard:** Intermediate; has not been subject to significant flooding for more than 1,000 yrs, but lack of topographic relief between these surfaces and active surfaces (H_1 and H_2) suggests that they could become flood prone with channel filling, avulsion, or human disturbance

Distribution: Adjacent to H_1 and H_2 in distributary flow areas and on lower piedmont

Soil Groups: Torrifluvents and Camborthids

Channel Pattern: Widely spaced, dendritic tributary drainages

Surface Relief: Less than 4 ft in distributary flow areas and less than 3 ft on lower piedmont; bar and swale topography well preserved in distributary flow areas

Surface Texture: Open desert pavement consisting of granules and small cobbles

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished to weakly developed over 10% of the surface - brownish black (7.5YR 3/1) on top and orange (7.5YR 7/6) on undersides

Vegetation: Brittle bush, creosote, palo verde

Estimated Surface Age: Late Holocene to latest Pleistocene (1,000 to 15,000 yrs old)

L1 **Flood Hazard:** Low; localized sheetflooding possible; flooding might occur if channels are altered by human disturbance because of low relief downslope from major distributary flow areas

Distribution: Downslope from and adjacent to distributary flow areas on middle and lower piedmont

Soil Groups: Camborthids and Haplargids

Channel Pattern: Moderately spaced, dendritic tributary drainages

Surface Relief: 1 to 10 ft; fairly smooth subdued bar and swale topography

Surface Texture: Open to closed desert pavement consisting of granules and cobbles

Surface Color: Bright brown (7.5YR 5/6) to orange (7.5YR 6/6)

Desert Varnish: Weakly to moderately developed over 50% of surface - brownish black (7.5YR 2/2) to grayish brown (7.5YR 4/2) on top and dull orange (5YR 6/4) to reddish brown (2.5YR 4/6) on undersides

Vegetation: Brittle bush, creosote, cane cholla

Estimated Surface Age: Latest Pleistocene to middle Pleistocene (15,000 to 250,000 yrs old)

L2 **Flood Hazard:** Lowest; restricted to small channels and localized sheetflooding

Distribution: Upper and middle piedmont and adjacent to Hassayampa River

Soil Groups: Haplargids and Durorthids

Channel Pattern: Closely to widely spaced, dendritic tributary drainages; rounded interfluves in areas of highest relief

Surface Relief: 5 to 40 ft; fairly smooth surface; uncommon bar and swale topography

Surface Texture: Closed desert pavement consisting of cobbles and pebbles; uncommon salt-shattered cobbles; in places, surface is denuded and covered by petrocalcic fragments

Surface Color: Dull orange (7.5YR 6/4 to 5YR 6/3)

Desert Varnish: Well developed over 50 to 100% of undenuded surfaces - black (5YR 1.7/1) on top and dark red (10R 3/6) to dull orange (7.5YR 7/4) on undersides

Vegetation: Jumping cholla, brittle bush, creosote

Estimated Surface Age: Late Pleistocene to Pliocene (50,000 to 1,000,000+ yrs old)

M **Flood Hazard:** Mechanized disturbance; flood hazard unknown

B **Flood Hazard:** Bedrock outcrops; flood hazard low, but localized slope wash and debris flows possible in steepest areas

* Soil groups are taken from the Soil Conservation Service survey of the Aguila-Carefree area

** Only dominant plant types are listed

↗ Channel bottoms of larger drainages heading in the White Tank Mountains

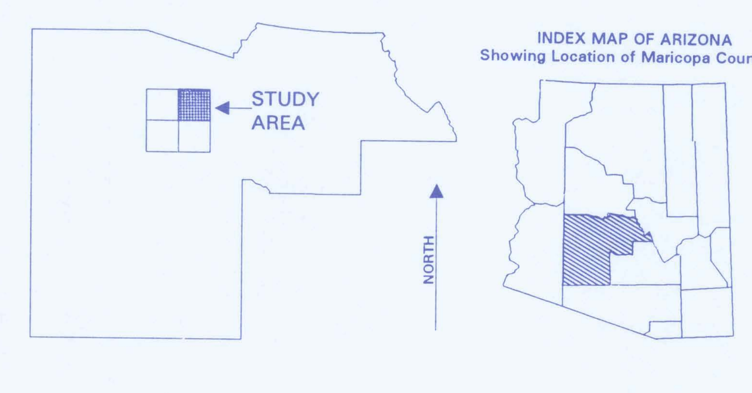
SCALE 1:24,000

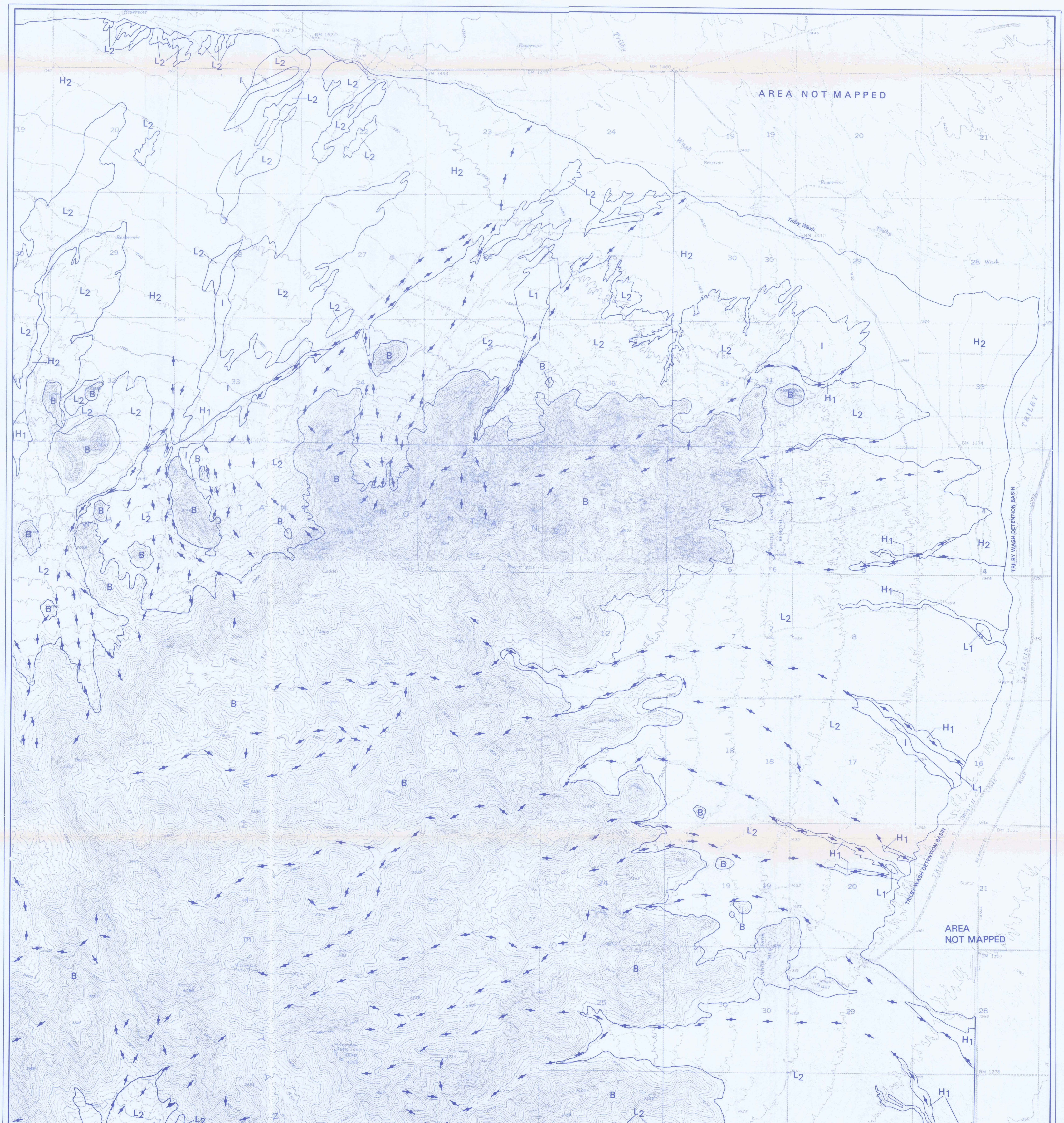
1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 5, 10, 20, 40 FEET





White Tank Mountains Flood Hazard Map - SW Section

by
John J. Field and Philip A. Pearthree
1991

E X P L A N A T I O N

Map Unit Description

H_1 **Flood Hazard:** Highest; high-velocity channelized flow and sheetflow

Distribution: Entrenched reaches of major drainages and distributary flow areas on middle and upper piedmont

Soil Group*: Torrifluvents

Channel Pattern: Braided (anastomosing) or distributary

Surface Relief: Less than 2 ft; bar and swale topography

Surface Texture: Silt to very gravelly sand

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation:** Brittle bush, rabbit bush, bunch grass, creosote

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

H_2 **Flood Hazard:** Moderately high; dominantly sheetflow with minor channel flows

Distribution: Restricted to lower piedmont and small drainages heading on the piedmont

Soil Group: Torrifluvents

Channel Pattern: Distributary; incipient dendritic drainage in less active areas

Surface Relief: Less than 2 ft with uncommon, 4-ft arroyo cuts; smooth surface

Surface Texture: Sandy silt with 10% scattered gravel; less active areas have granule to pebble lag

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation: Creosote, brittle bush

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

I **Flood Hazard:** Intermediate; has not been subject to significant flooding for more than 1,000 yrs, but lack of topographic relief between these surfaces and active surfaces (H_1 and H_2) suggests that they could become flood prone with channel filling, avulsion, or human disturbance

Distribution: Adjacent to H_1 and H_2 in distributary flow areas and on lower piedmont

Soil Groups: Torrifluvents and Camborthids

Channel Pattern: Widely spaced, dendritic tributary drainages

Surface Relief: Less than 4 ft in distributary flow areas and less than 3 ft on lower piedmont; bar and swale topography well preserved in distributary flow areas

Surface Texture: Open desert pavement consisting of granules and small cobbles

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished to weakly developed over 10% of the surface - brownish black (7.5YR 3/1) on top and orange (7.5YR 7/6) on undersides

Vegetation: Brittle bush, creosote, palo verde

Estimated Surface Age: Late Holocene to latest Pleistocene (1,000 to 15,000 yrs old)

L_1 **Flood Hazard:** Low; localized sheetflooding possible; flooding might occur if channels are altered by human disturbance because of low relief downslope from major distributary flow areas

Distribution: Downslope from and adjacent to distributary flow areas on middle and lower piedmont

Soil Groups: Camborthids and Haplargids

Channel Pattern: Moderately spaced, dendritic tributary drainages

Surface Relief: 1 to 10 ft; fairly smooth subdued bar and swale topography

Surface Texture: Open to closed desert pavement consisting of granules and cobbles

Surface Color: Bright brown (7.5YR 5/6) to orange (7.5YR 6/6)

Desert Varnish: Weakly to moderately developed over 50% of surface - brownish black (7.5YR 2/2) to grayish brown (7.5YR 4/2) on top and dull orange (5YR 6/4) to reddish brown (2.5YR 4/6) on undersides

Vegetation: Brittle bush, creosote, cane cholla

Estimated Surface Age: Latest Pleistocene to middle Pleistocene (15,000 to 250,000 yrs old)

L_2 **Flood Hazard:** Lowest; restricted to small channels and localized sheetflooding

Distribution: Upper and middle piedmont and adjacent to Hassayampa River

Soil Groups: Haplargids and Durorthids

Channel Pattern: Closely to widely spaced, dendritic tributary drainages; rounded interfluves in areas of highest relief

Surface Relief: 5 to 40 ft; fairly smooth surface; uncommon bar and swale topography

Surface Texture: Closed desert pavement consisting of cobbles and pebbles; uncommon salt-shattered cobbles; in places, surface is denuded and covered by petrocalcic fragments

Surface Color: Dull orange (7.5YR 6/4 to 5YR 6/3)

Desert Varnish: Well developed over 50 to 100% of undenuded surfaces - black (5YR 1.7/1) on top and dark red (10R 3/6) to dull orange (7.5YR 7/4) on undersides

Vegetation: Jumping cholla, brittle bush, creosote

Estimated Surface Age: Late Pleistocene to Pliocene (50,000 to 1,000,000+ yrs old)

M **Flood Hazard:** Mechanized disturbance; flood hazard unknown

B **Flood Hazard:** Bedrock outcrops; flood hazard low, but localized slope wash and debris flows possible in steepest areas

* Soil groups are taken from the Soil Conservation Service survey of the Aguila-Carefree area

** Only dominant plant types are listed

Channel bottoms of larger drainages heading in the White Tank Mountains

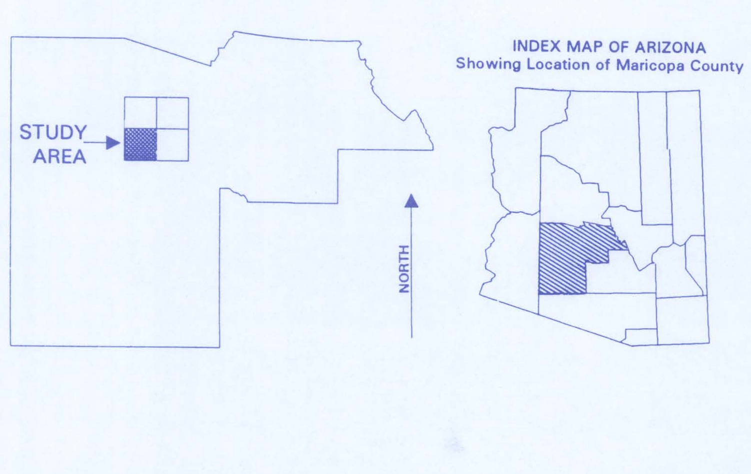
SCALE 1:24,000

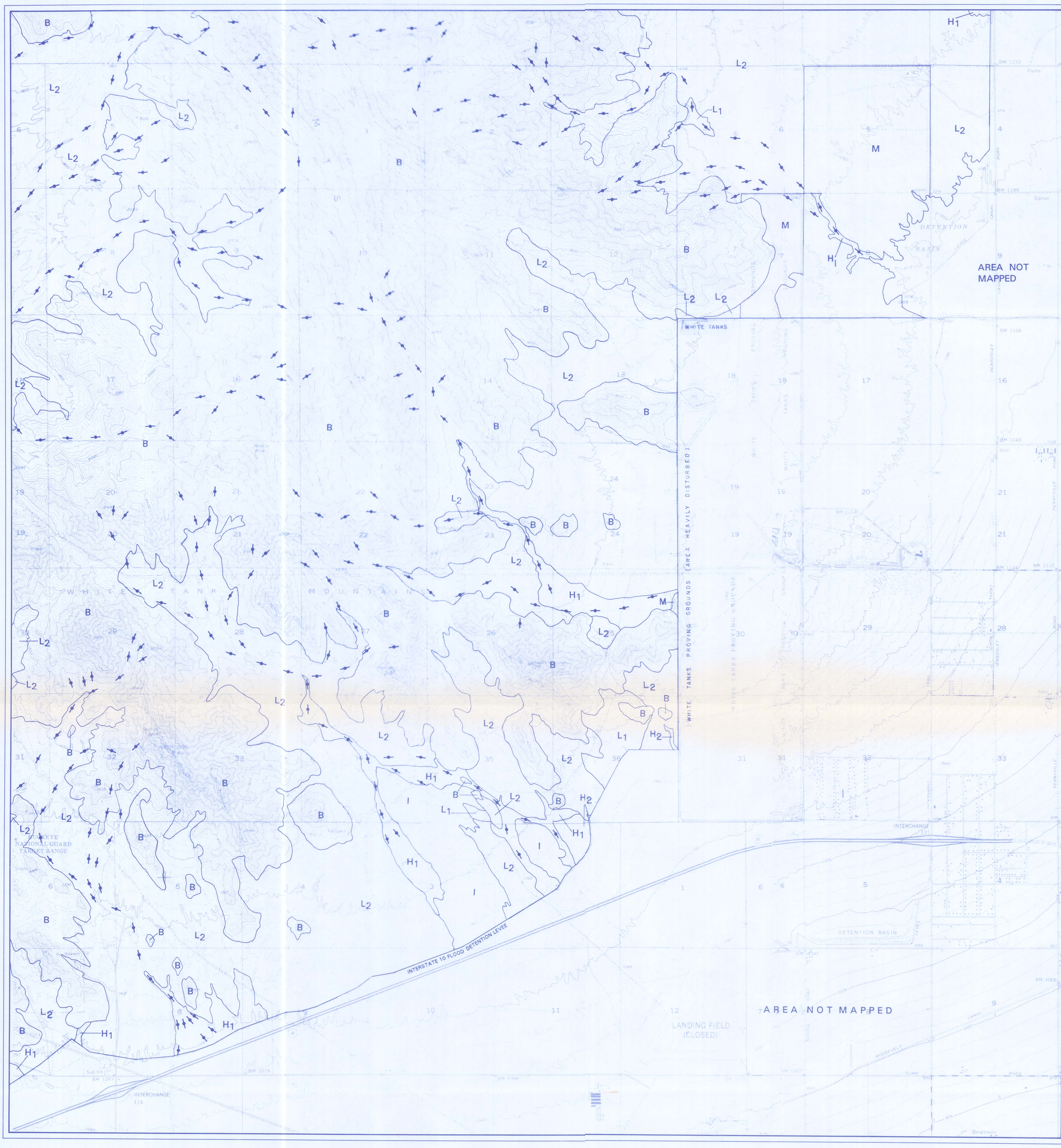
1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 5, 10, 20, 40 FEET





White Tank Mountains Flood Hazard Map - SE Section

by

John J. Field and Philip A. Pearthree

1991

E X P L A N A T I O N

Map Unit Description

H_1

Flood Hazard: Highest; high-velocity channelized flow and sheetflow

Distribution: Entrenched reaches of major drainages and distributary flow areas on middle and upper piedmont

Soil Group*: Torrifluvents

Channel Pattern: Braided (anastomosing) or distributary

Surface Relief: Less than 2 ft; bar and swale topography

Surface Texture: Silt to very gravelly sand

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation:** Brittle bush, rabbit bush, bunch grass, creosote

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

H_2

Flood Hazard: Moderately high; dominantly sheetflow with minor channel flows

Distribution: Restricted to lower piedmont and small drainages heading on the piedmont

Soil Group: Torrifluvents

Channel Pattern: Distributary; incipient dendritic drainage in less active areas

Surface Relief: Less than 2 ft with uncommon, 4-ft arroyo cuts; smooth surface

Surface Texture: Sandy silt with 10% scattered gravel; less active areas have granule to pebble lag

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished gravel

Vegetation: Creosote, brittle bush

Estimated Surface Age: Historical to late Holocene (0 to 2,000 yrs old)

I

Flood Hazard: Intermediate; has not been subject to significant flooding for more than 1,000 yrs, but lack of topographic relief between these surfaces and active surfaces (H_1 and H_2) suggests that they could become flood prone with channel filling, avulsion, or human disturbance

Distribution: Adjacent to H_1 and H_2 in distributary flow areas and on lower piedmont

Soil Groups: Torrifluvents and Camborthids

Channel Pattern: Widely spaced, dendritic tributary drainages

Surface Relief: Less than 4 ft in distributary flow areas and less than 3 ft on lower piedmont; bar and swale topography well preserved in distributary flow areas

Surface Texture: Open desert pavement consisting of granules and small cobbles

Surface Color: Dull yellow-orange (10YR 6/4)

Desert Varnish: Unvarnished to weakly developed over 10% of the surface - brownish black (7.5YR 3/1) on top and orange (7.5YR 7/6) on undersides

Vegetation: Brittle bush, creosote, palo verde

Estimated Surface Age: Late Holocene to latest Pleistocene (1,000 to 15,000 yrs old)

L_1

Flood Hazard: Low; localized sheetflooding possible; flooding might occur if channels are altered by human disturbance because of low relief downslope from major distributary flow areas

Distribution: Downslope from and adjacent to distributary flow areas on middle and lower piedmont

Soil Groups: Camborthids and Haplargids

Channel Pattern: Moderately spaced, dendritic tributary drainages

Surface Relief: 1 to 10 ft; fairly smooth subdued bar and swale topography

Surface Texture: Open to closed desert pavement consisting of granules and cobbles

Surface Color: Bright brown (7.5YR 5/6) to orange (7.5YR 6/6)

Desert Varnish: Weakly to moderately developed over 50% of surface - brownish black (7.5YR 2/2) to grayish brown (7.5YR 4/2) on top and dull orange (5YR 6/4) to reddish brown (2.5YR 4/6) on undersides

Vegetation: Brittle bush, creosote, cane cholla

Estimated Surface Age: Latest Pleistocene to middle Pleistocene (15,000 to 250,000 yrs old)

L_2

Flood Hazard: Lowest; restricted to small channels and localized sheetflooding

Distribution: Upper and middle piedmont and adjacent to Hassayampa River

Soil Groups: Haplargids and Durorthids

Channel Pattern: Closely to widely spaced, dendritic tributary drainages; rounded interfluves in areas of highest relief

Surface Relief: 5 to 40 ft; fairly smooth surface; uncommon bar and swale topography

Surface Texture: Closed desert pavement consisting of cobbles and pebbles; uncommon salt-shattered cobbles; in places, surface is denuded and covered by petrocalcic fragments

Surface Color: Dull orange (7.5YR 6/4 to 5YR 6/3)

Desert Varnish: Well developed over 50 to 100% of undenuded surfaces - black (5YR 1.7/1) on top and dark red (10R 3/6) to dull orange (7.5YR 7/4) on undersides

Vegetation: Jumping cholla, brittle bush, creosote

Estimated Surface Age: Late Pleistocene to Pliocene (50,000 to 1,000,000+ yrs old)

M

Flood Hazard: Mechanized disturbance; flood hazard unknown

B

Flood Hazard: Bedrock outcrops; flood hazard low, but localized slope wash and debris flows possible in steepest areas

* Soil groups are taken from the Soil Conservation Service survey of the Aguila-Carefree area

** Only dominant plant types are listed

(channel symbol) Channel bottoms of larger drainages heading in the White Tank Mountains

SCALE 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

TOPOGRAPHIC CONTOUR INTERVAL 5, 10, 20, 40 FEET

REPORT

Surficial Geology Around the White Tank Mountains, Central Arizona

by

John J. Field and Philip A. Pearthree

Arizona Geological Survey
Open-File Report 91-8

November, 1991

ARIZONA GEOLOGICAL SURVEY
AZGS

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John J. Field and Philip A. Pearthree

Arizona Geological Survey

Open-File Report 91-8

November, 1991

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

Prepared in cooperation with
the U.S. Geological Survey COGEOMAP Program,
the Flood Control District of Maricopa County,
and the Arizona Department of Water Resources

This report is preliminary and has not been edited
or reviewed for conformity with Arizona Geological Survey standards

Introduction

These nine maps depict the distribution and general ages of Quaternary geomorphic surfaces and associated alluvial deposits surrounding the White Tank Mountains, on the western margin of the Phoenix metropolitan area. The White Tank Mountains are one of many mountain ranges in the Basin and Range physiographic province of Arizona. The Basin and Range province in the vicinity of the study area is characterized by relatively small mountain ranges of modest topographic relief separated by wide, gently sloping piedmonts and basin bottom river drainages. The study area is drained by the Gila River. By indicating the age of alluvial surfaces and deposits, these maps provide a basis for evaluating the Quaternary geologic history of the area and assessing potential geologic hazards.

Alluvial surfaces and deposits differentiated for this map are assigned to Quaternary and Upper Tertiary geologic units primarily on the basis of the estimated timing of cessation of major deposition on each geomorphic surface. Relative topographic positions of each surface, surface characteristics, and degree of soil development in underlying deposits are the principal criteria used to assess surface age. The geomorphic surfaces and associated deposits were formed during discrete time intervals ranging from the Late Tertiary to the late Holocene. Six categories of alluvial surfaces are differentiated and mapped on the basis of surface age. Alluvial surfaces are further subdivided into piedmont and basin axis units. The characteristics of each map unit are described in detail below. The estimated ages of the units are inferred by correlation with similar surfaces and soils radiometrically dated elsewhere in the southwestern United States (Gile and others, 1981; Bull, 1991; Menges and McFadden, 1981).

The mapping is based primarily on interpretation of natural-color (1:24,000 scale) aerial photographs. Initial unit designations were later field checked throughout the map area. In extensive agricultural tracts where natural surface characteristics are altered, published soil surveys (Soil Conservation Service, 1977; 1986) were used to evaluate soil development and to delineate boundaries between surfaces of different ages. The nine 1:24,000 scale maps of this series represent a more detailed survey over a small portion of regions mapped on a reconnaissance basis (1:100,000 scale) by Demsey (1988, 1989).

This project was supported by the Arizona Geological Survey, U.S. Geological Survey Cooperative Geologic Mapping (COGEOMAP) Program, the Maricopa County Flood Control District, and the Arizona Department of Water Resources. Aerial photographs were provided by the U.S. Bureau of Land Management.

Description of Map Units

Piedmont Units

Y2 - Late Holocene alluvial fans, low terraces, and active stream channels, < 3 ka.

Alluvial fan deposits on the lower piedmont are fine silts and sands. Middle piedmont surfaces and active channels extending into the White Tank Mountains are very gravelly sands and silts. Surfaces are typically undissected and display distributary drainage patterns, although 1.5 m arroyo cuts occur locally on the lower piedmont. Surfaces are typically smooth, but bar and swale topography is present on the middle piedmont. Desert pavement and desert varnish are absent. Minimal to no soil development has occurred. Soil great groups are Torrifluvents and Torriorthents. These areas are subject to occasional to frequent flooding.

Y1 - Late to early Holocene alluvial fans and terraces, 1 to 10 ka.

Deposits on the middle piedmont are a coarse poorly sorted, angular to subangular admixture of silt, sand, and gravel. On the lower piedmont, deposits are typically fine silt and sand. Surface relief is typically less than 0.5 m above active channels. Lower piedmont surfaces are smooth and flat with an incipient dendritic drainage pattern. Middle piedmont surfaces have well preserved bar and swale topography with very little tributary drainage development. A poorly developed pebble to granule desert pavement (cobble to granule on middle piedmont) exists over 50 to 85 percent of the surface. Surface cobbles, when present, are lightly and incompletely varnished along the base of the cobble to brownish black (10 YR 2/2). An orange (7.5 YR 7/6) to dull yellowish brown (10 YR 5/4) color is rarely observed on cobble undersides. Minimal soil development has occurred in the underlying deposits -- the most strongly developed profiles contain cambic horizons (hue 7.5 YR) above stage I to II calcic horizons. Soil great groups are Torrifluvents, Torriorthents, and Camborthids. Most Y1 areas are not subject to flooding at present. However, because typically there is little topographic relief between active channels and Y1 surfaces, they could potentially become subject to flooding through minor shifts in the present depositional patterns.

Y - Undifferentiated Holocene alluvial surfaces, 0 to 10 ka.

In some places this designation is used where the Y1 and Y2 surfaces are too intricately intermingled to map separately at this scale. In other areas on the lower piedmont the designation is used where surface characteristics are not distinctive of either Y1 or Y2 surfaces but are clearly of Holocene age. These areas may be subject to occasional to frequent flooding.

M2 - Latest to late Pleistocene alluvial fans, 10 to 150 ka.

Deposits are a poorly sorted, angular to subangular admixture of silt, sand, and gravel. The surfaces are moderately dissected with typically <1 m to 3 m relief above active channels. Interfluve areas are broad and flat with original gravel bar and swale topography typically moderately to well preserved. A poorly to moderately developed cobble to granule desert pavement is found over 50 to 80 percent of the surface. Surface cobbles are incompletely varnished to very dark brown (7.5 YR 2/3) on top and reddish brown (2.5 YR 4/6) to more commonly dull orange (5 YR 6/4) on undersides. M2 surfaces are not widespread and are predominantly restricted to the middle piedmont. Underlying soils typically contain cambic horizons (hue 7.5 YR), above a stage I to II calcic horizon. Soil great groups are Camborthids and Haplargids. Most areas are free from flooding, although those areas of low relief could become susceptible to flooding with relatively minor shifts in depositional patterns.

M1b - Middle to late Pleistocene alluvial fans, 150 to 300 ka.

Deposits are a poorly sorted, angular to subangular admixture of silt, sand, and gravel. The surfaces are moderately dissected on the upper piedmont with 1-6 m of relief above active channels.

On the lower and middle piedmont relief may be less than 1 m. Interfluve areas are broad and flat with original gravel bar and swale topography poorly preserved. A moderately to well developed cobble to pebble desert pavement is found over 50 to 75 percent of the surface. Surface cobbles are incompletely varnished to black (5 YR 1.7/1) on top and reddish brown (2.5 YR 4/6) to less commonly dull orange (7.5 YR 7/4) on undersides. Underlying soils are characterized by weakly developed argillic horizons (hue 5 YR), typically above a stage II calcic horizon. Soil great groups are Haplargids and Calciorthids. Most areas are isolated from flooding except in entrenched channels, but areas of low relief on the middle and lower piedmont could become susceptible to flooding with relatively minor shifts in depositional patterns.

M12 - Middle or late Pleistocene distal alluvial fans, 10 to 300 ka.

Undifferentiated M1b and M2 surfaces. This designation is used mostly in agricultural areas where surface characteristics are destroyed and available soil descriptions do not enable differentiation of the two surfaces. This designation is locally used elsewhere in areas not field checked. Only areas of low relief may be susceptible to flooding.

M1a - Middle to early Pleistocene alluvial fans, 300 to 1,000 ka.

Deposits are a poorly sorted, angular to subangular admixture of silt, sand and gravel. The surfaces are moderately dissected with typically 1-6 m of relief above active channels but less than 0.5 m of relief above Unit M1b. Interfluve areas are broad, flat, and smooth; bar and swale topography is typically absent or poorly preserved. A well developed cobble to pebble desert pavement is found over the entire surface. Surface cobbles are completely varnished black (5 YR 1.7/1) on top and reddish brown (2.5 YR 4/8) on undersides. Surfaces are typically well preserved and are the darkest surfaces on the White Tank Mountains piedmont. Underlying soils are characterized by moderately to very strongly developed argillic horizons (hue 5 to 2.5 YR), commonly overlying a stage IV calcic horizon. (May locally be composed of river terraces west of the Hassayampa River). Soil great groups are Haplargids. These areas are isolated from active fluvial processes, and only entrenched channels are subject to flooding.

M1 - Middle Pleistocene alluvial fans, 150 to 1,000 ka.

Undifferentiated M1b and M1a surfaces. (May locally be composed of river terraces of the same age immediately north of and adjacent to Wagner Wash and Trilby Wash). On the middle piedmont this designation is used where the two surfaces are too intricately intermingled to map separately at this scale. In other areas this designation is used where surface characteristics are destroyed (agricultural areas) or where extensive field checking was not conducted (north of Wagner Wash and Trilby Wash). Only entrenched channels dissected into the surface are subject to flooding in undisturbed areas.

O - Early Pleistocene to late Pliocene alluvial fans, > 1,000 ka.

Alluvial fan surfaces and deposits of inferred early Pleistocene to late Pliocene age. This unit occupies the highest topographic positions on the White Tank Mountains piedmont and occurs only on the upper piedmont. The deposits are characteristically poorly sorted subangular gravels containing minor amounts of finer material. Deposits range in thickness from greater than 15 m to only a thin veneer (<2 m) over bedrock pediments. The surfaces are deeply dissected (10-15 m). Interfluve areas are well-rounded ridges with intervening swales or ravines; original depositional surfaces are rarely preserved. Degraded surfaces are typically covered with abundant fragments of pedogenic carbonate derived from exposed brecciated laminar petrocalcic horizons. The petrocalcic fragments commonly impart a light colored appearance to these surface remnants as observed on aerial photographs. Soils are generally stripped by erosion down to exposed remnants of stage IV to VI petrocalcic horizons. Soil great groups are Durorthids. Flooding is restricted to entrenched channels, although hillside slope wash is probable.

Axial Drainage Units

Y2r - Active channels and low terraces along axial drainages, < 3 ka.

Basin axis river channels and deposits of the Gila River, Hassayampa River, Wagner Wash, and Trilby Wash. Active channels on the present river bottoms were not separately mapped as channel positions frequently shift across the entire surface. Deposits range from silt to coarse sands but well rounded cobble bars are common along the Gila River and Hassayampa River. Flooding occurs frequently in basin axis channels.

Y1rt - Late to early Holocene terraces along axial drainages, 1 to 10 ka.

Deposits are typically fine silt and sand with common gravel lenses of well rounded cobbles. Terrace surfaces are smooth and typically less than 1.5 m above the active basin axis drainages (Y2r). These areas could potentially be flooded during very large flow events or after an extended period of aggradation in the active basin axis channels (Y2r).

M1bt - Middle to late Pleistocene river terraces, 150 to 300 ka.

High terrace of the Hassayampa River. This surface is mapped in only one area along the eastern edge of the Hassayampa River at the northern end of the Daggs Tank quadrangle. The terrace surface is flat and dissected up to 30 m by small tributaries flowing into the Hassayampa. The surface is inset 10 m below the adjacent Org deposits. Flooding may occur in entrenched channels and locally along the margin with the topographically higher Org deposits.

Ort - Early Pleistocene to late Pliocene river terraces, > 1,000 ka.

Highest terrace along the Hassayampa River. The well rounded gravel found at the surface is typically darkly varnished. In small localized areas, much of the surface is covered by petrocalcic fragments derived from underlying petrocalcic horizons. The terrace surfaces are dissected up to 30 m by small tributaries flowing into the Hassayampa River. Elsewhere the surface is very flat with a wide spacing between broad shallowly dissected (<2 m) drainages developed on the surface. Flooding restricted to entrenched channels.

Org - Early Pleistocene to late Pliocene river deposits, > 1,000 ka.

Deposits of well-rounded, well-sorted gravel and cross-stratified sand representing bedload material of major axial drainages. This unit is currently exposed along the margins of the

Hassayampa River. The deposits exhibit zones (> 1 m) strongly indurated with carbonate cement. The original depositional surface (Ort) is completely eroded in these areas exposing the underlying deposits (Org). Flooding restricted to entrenched channels, although hillside slope wash is probable.

Bedrock Units* -

T - Tertiary volcanics

TK - Tertiary or Cretaceous intrusive and volcanic rocks

X - Early Proterozoic gneiss and granite

* - Bedrock units are generalized to show lithologies and ages. Detailed lithologic contacts and structures are not shown. Rock ages from Reynolds (1988).

Key to Map Symbols

Surficial geologic contact (dashed where inferred)

Basinward pediment boundary

Upslope edge of agricultural fields

Distribution of Surficial Deposits and the Quaternary Evolution of the White Tanks Piedmonts

In general, relatively young alluvial surfaces become increasingly extensive downslope on the piedmonts of the White Tank Mountains. The oldest surfaces (O and M1a) are found along the mountain front while the youngest surfaces (Y) are dominant adjacent to the basin axis drainages. This distribution suggests a general tendency toward erosion throughout the Quaternary punctuated by periods of equilibrium or aggradation.

Thick alluvial-fan deposits associated with the early Pleistocene to late Tertiary (O) surfaces probably represent the final stage of basin-filling sedimentation associated with the Basin and Range disturbance. All of the younger surfaces are associated with thin veneers of sediment, typically several meters thick or less, overlying older deposits. As a result of erosion throughout the Quaternary, only small, deeply dissected remnants of the early Pleistocene to late Tertiary surfaces are exposed along the mountain front. The change from an aggradational to a primarily erosional phase is most likely related to the cessation of tectonic activity in the region, although integration of the major basin axis drainages and climate changes probably played a minor role.

Middle to late Pleistocene surfaces (M1a and M1b) extend from the upper to lower piedmont and cover much of the White Tank Mountains piedmonts. These relatively thin but areally extensive deposits represent pulses of deposition that punctuated the long-term tendency toward downcutting and erosion on the piedmonts. Distinct differences in surface characteristics and soil development between M1a and M1b indicate that the interval between deposition of these units was probably hundreds of thousands of years long. However, the amount of relief between M1a and M1b typically is negligible, so the net downcutting in the middle Pleistocene was minimal. As a result, distinguishing between these two surfaces is sometimes difficult and they remain undifferentiated in some areas (M1).

The younger surfaces (M2, Y1, and Y2) are found predominantly in the lower and middle piedmont areas. Associated deposits indicate these surfaces are largely the product of erosion of M1 surfaces. Most drainages supplying sediment to the younger surfaces on the lower piedmont head on M1 surfaces and do not extend into the mountains. Sediment thickness on the young surfaces is extremely thin and it is common to see small pods of older units poking through the younger surfaces.

The presence of relatively small, active distributary flow areas on the middle piedmont suggest that loci of deposition has not shifted significantly since the latest Pleistocene. Active distributary flow areas are alluvial fans that become reconfined between older deposits at their downstream ends. They are characterized by distributary channel networks and extensive, young (Y2 and Y1) deposits. Late Pleistocene surfaces (M2) are restricted for the most part to the middle piedmont, where they usually flank younger distributary flow areas.

Deep entrenchment of the Hassayampa River has occurred during the Quaternary, as the present river bottom (Y2r) is over 30 m below the early Pleistocene to Late Tertiary river terrace (Ort). Entrenchment evidently has preceded relatively continuously throughout the Quaternary as no major terraces of intermediate height are observed except for a small middle Pleistocene terrace (M1bt) in the northern portion of the study area. The piedmont surfaces appear largely unaffected by the entrenchment of the Hassayampa River as even the youngest surfaces are graded to the high river terrace (Org). Only minor dissection has occurred along the downslope edges of the piedmont units as newly formed drainages graded to the present river bottom erode headward.

References

Bull, W.B., 1991, Geomorphic Responses to Climatic Change: New York, Oxford University Press.

Camp, P.D., 1986, Soil Survey of Aguila-Carefree Area, Parts of Maricopa and Pinal Counties, Arizona: Soil Conservation Service, U.S. Dept. of Agriculture, 306 p, 53 maps, scale 1:24,000.

Demsey, K.A., 1988, Geologic Map of Quaternary and Upper Tertiary Alluvium in the Phoenix North 30' x 60' Quadrangle, Arizona: AZGS Open-File Report 88-17, scale 1:100,000.

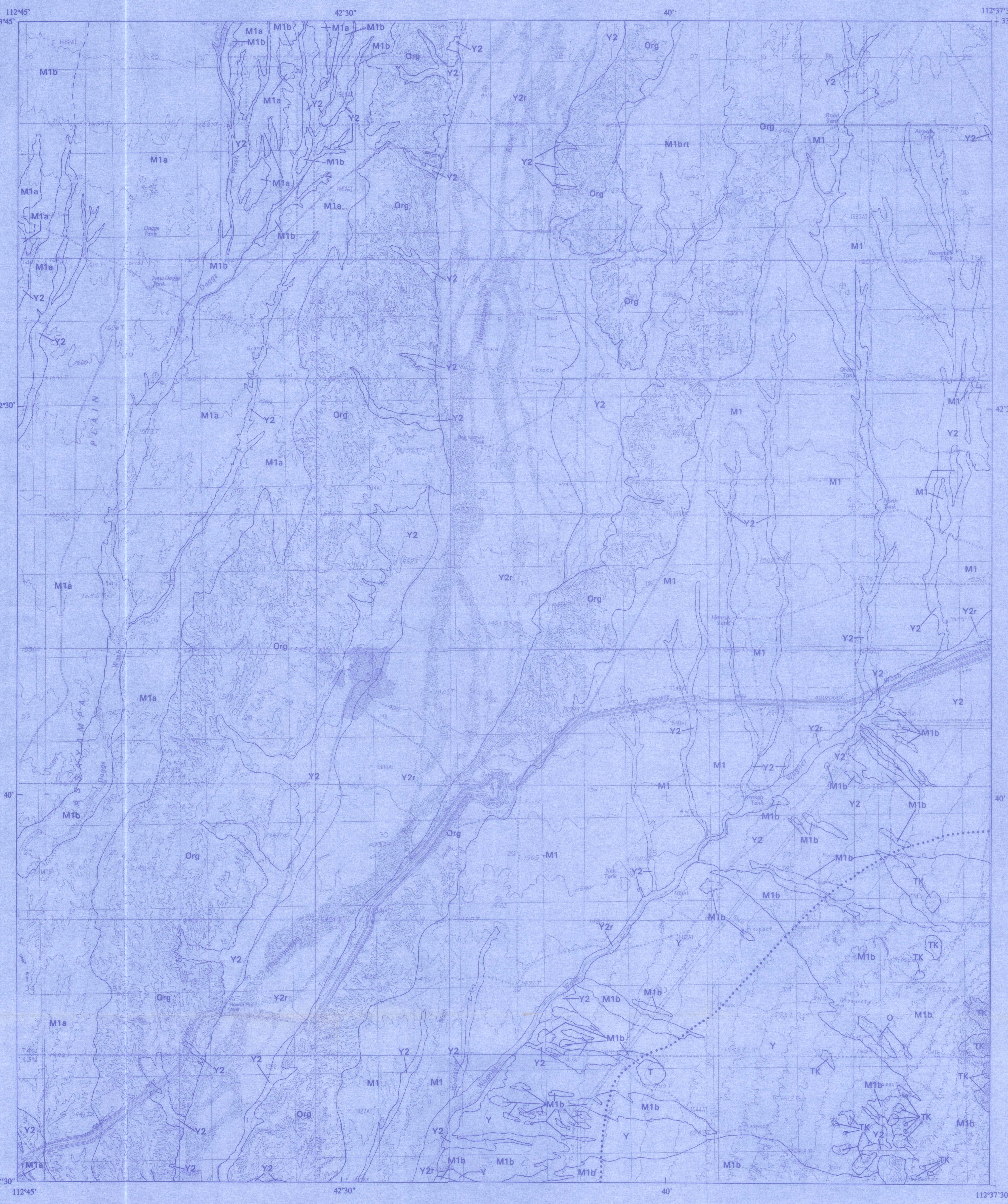
Demsey, K.A., 1989, Geologic Map of Quaternary and Upper Tertiary Alluvium in the Phoenix South 30' x 60' Quadrangle, Arizona: AZGS Open-File Report 89-7, scale 1:100,000

Gile, L.H., Hawley, J.W., and Grossman, R.B., 1981, Soils and geomorphology of the Basin and Range area of Southern New Mexico - Guidebook to the Desert Project: New Mexico Bureau of Mines and Mineral Resources Memoir 39, 222 p.

Hartman, G.W., 1977, Soil Survey of Maricopa County, Central Part: Soil Conservation Service, U.S. Dept. of Agriculture, 117 p, 128 maps, scale 1:20,000.

Menges, C.M., and McFadden, L.D., 1981, Evidence for a latest Miocene to Pliocene transition from Basin-Range tectonic to post-tectonic landscape evolution in sougheastern Arizona, in Stone, Claudia, and Jenney, J.P., eds.: Arizona Geological Society Digest 13, p. 151-160.

Reynolds, S.J., 1988, Geologic Map of Arizona: AZGS Map 26, scale 1:1,000,000.



Surficial Geology Around the White Tank Mountains, Central Arizona: Daggs Tank Quadrangle

NORTH

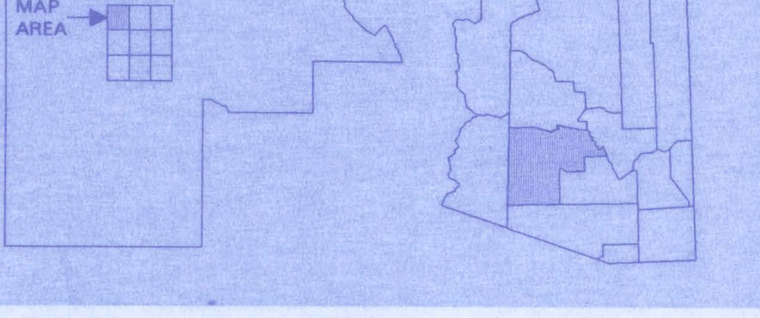
SCALE 1:24,000

1 .5 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 20 FEET



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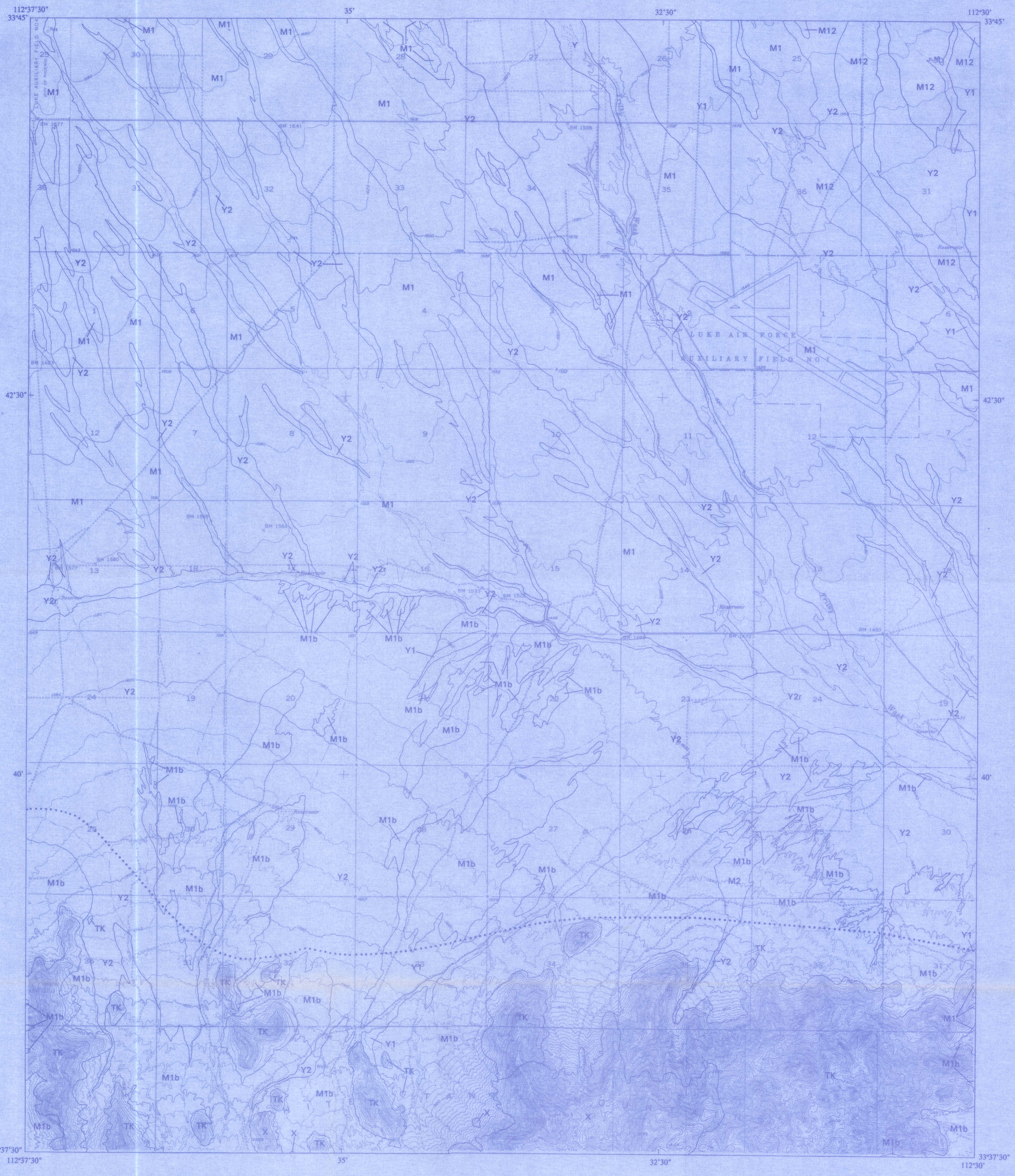
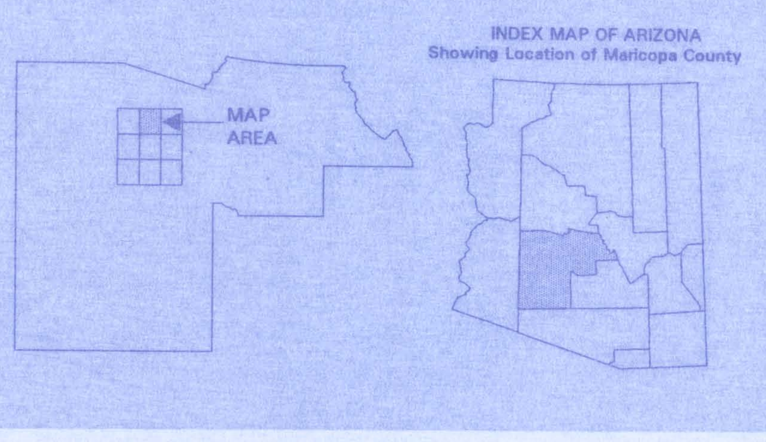


Surficial Geology Around the White Tank Mountains, Central Arizona: White Tank Mts. NE Quadrangle

NORTH

SCALE 1:24,000

CONTOUR INTERVAL 20 FEET



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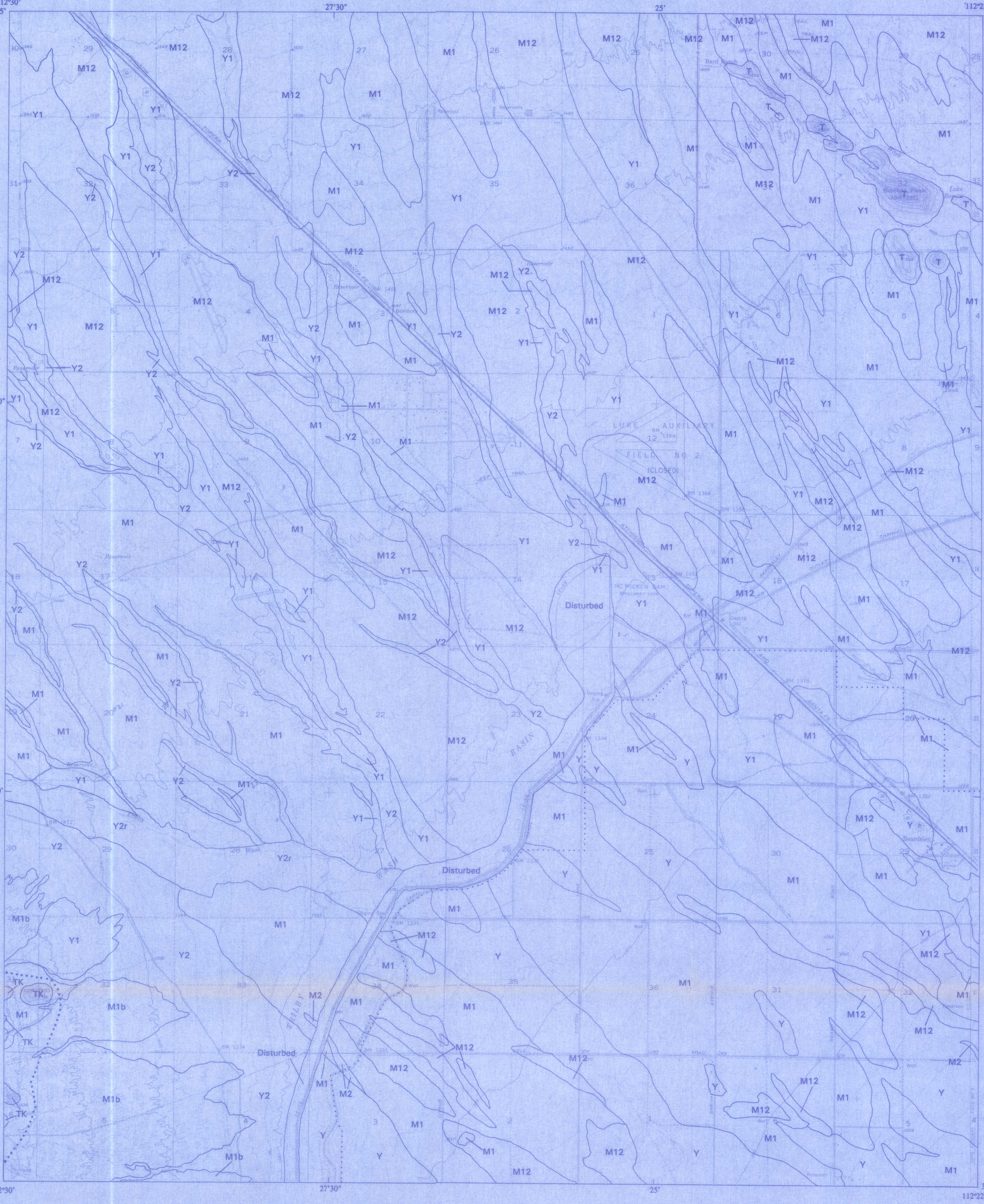

Surficial Geology Around the White Tank Mountains, Central Arizona: McMicken Dam Quadrangle

NORTH

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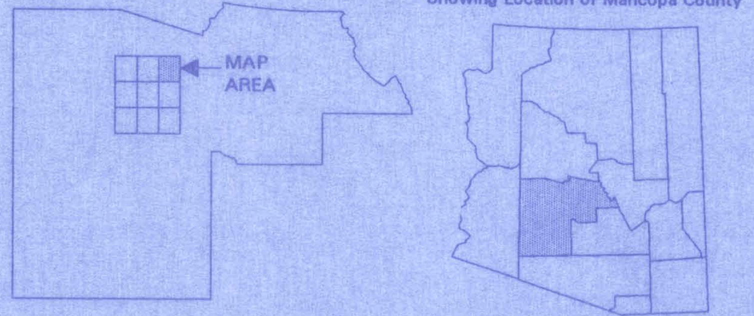
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET



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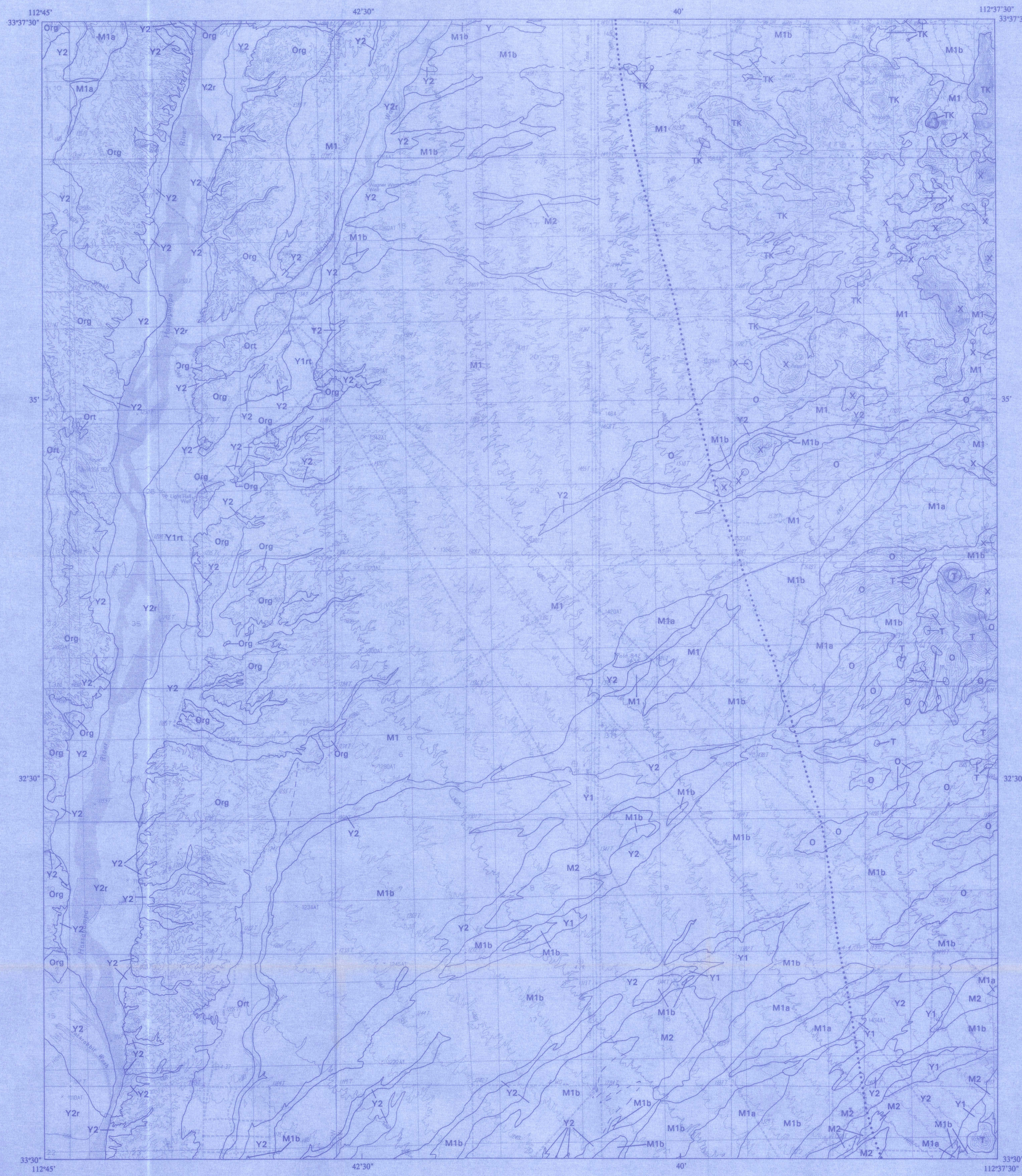

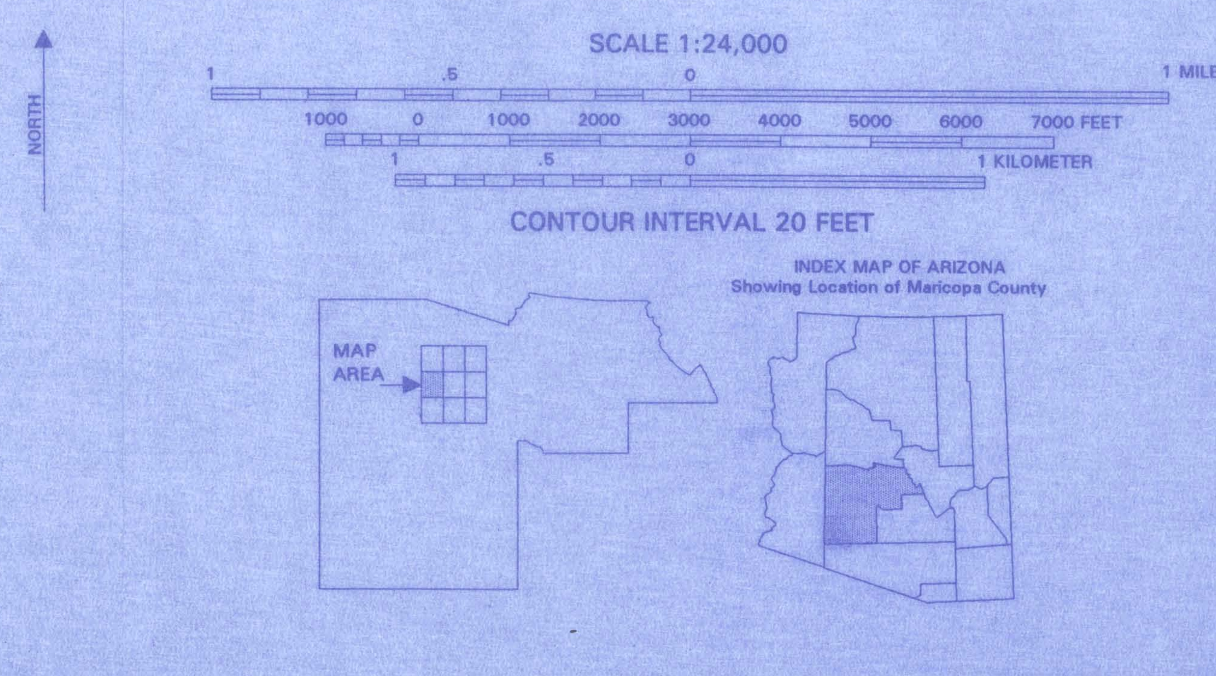

Surficial Geology Around the White Tank Mountains, Central Arizona: Wagner Wash Well Quadrangle

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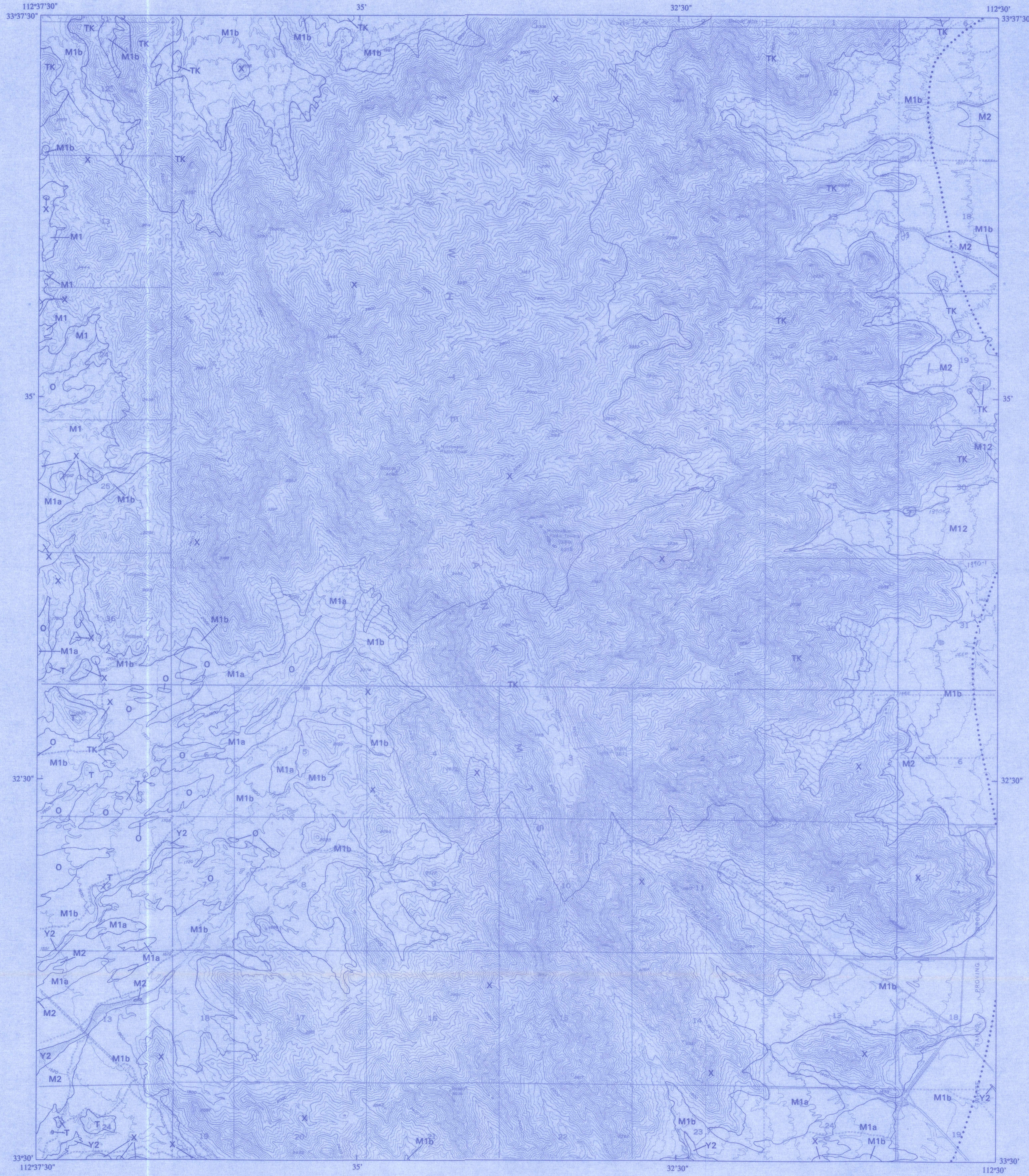

Surficial Geology Around the White Tank Mountains, Central Arizona: White Tank Mts. SE Quadrangle

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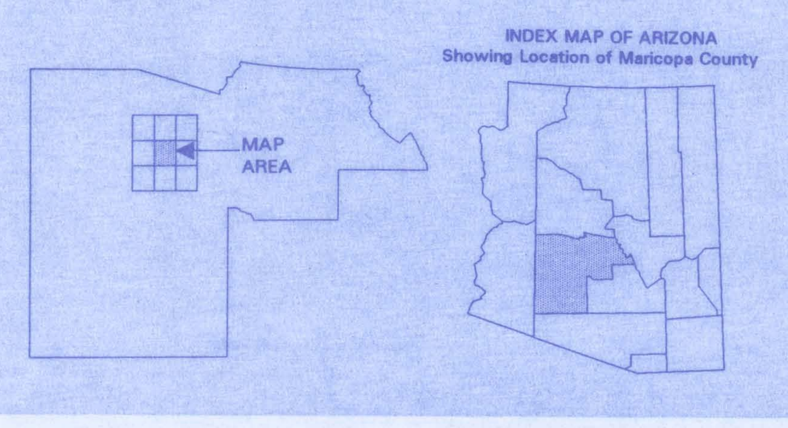

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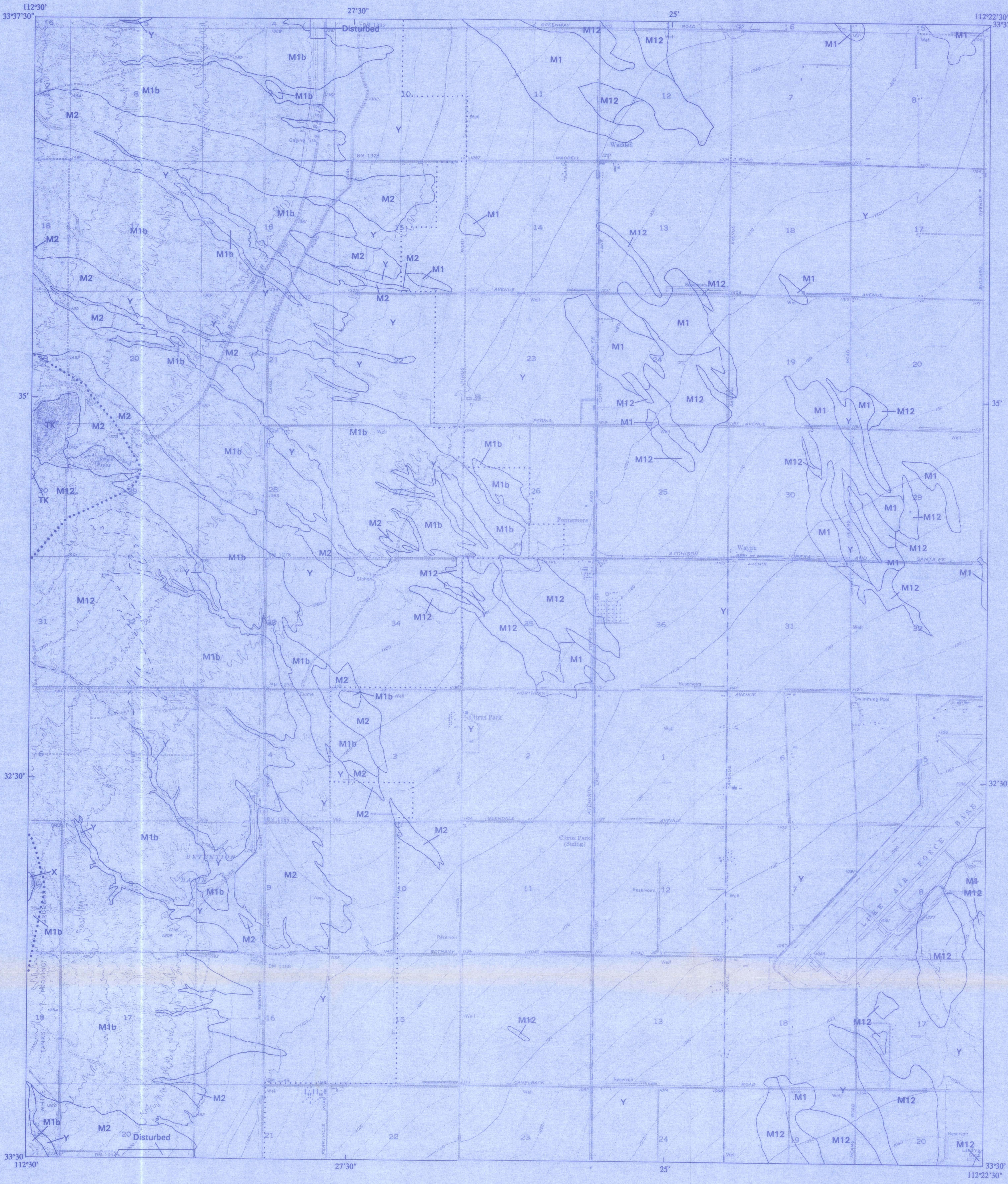

Surficial Geology Around the White Tank Mountains, Central Arizona: Waddell Quadrangle

NORTH

SCALE 1:24,000

1 .5 0 1 MILE

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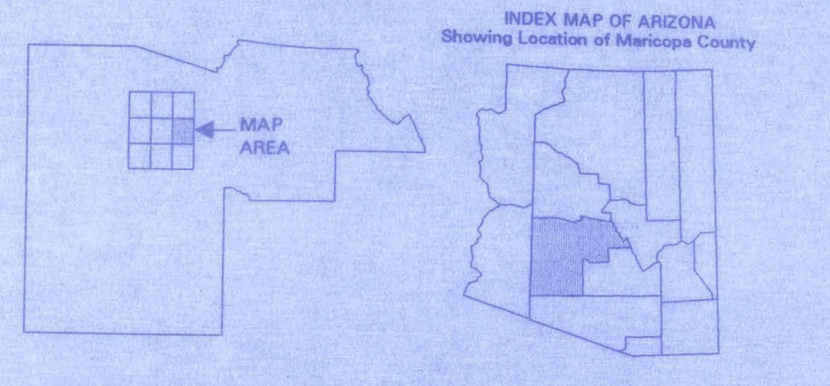
1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

INDEX MAP OF ARIZONA
Showing Location of Maricopa County



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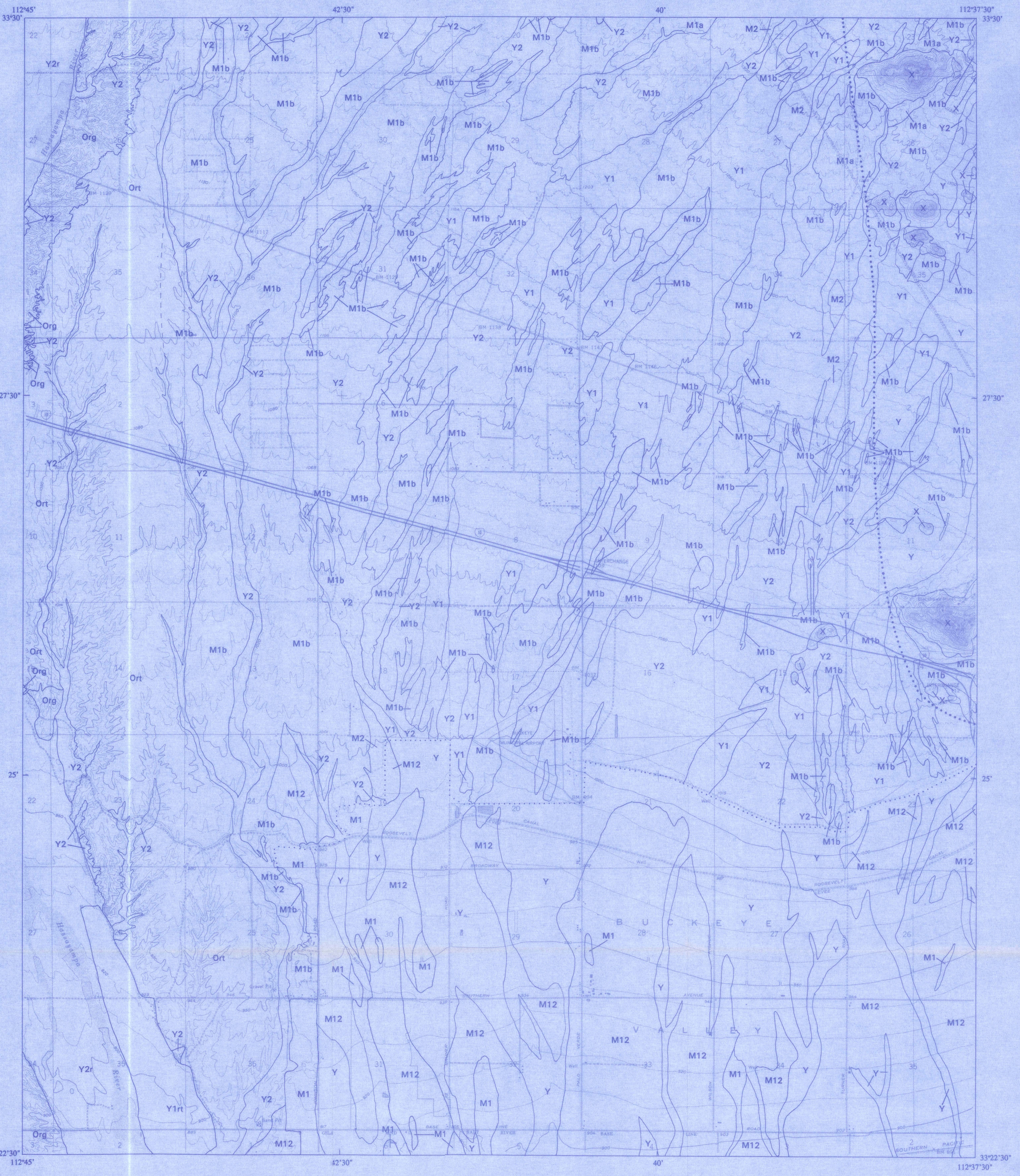


Surficial Geology Around the White Tank Mountains, Central Arizona: Buckeye NW Quadrangle

NORTH

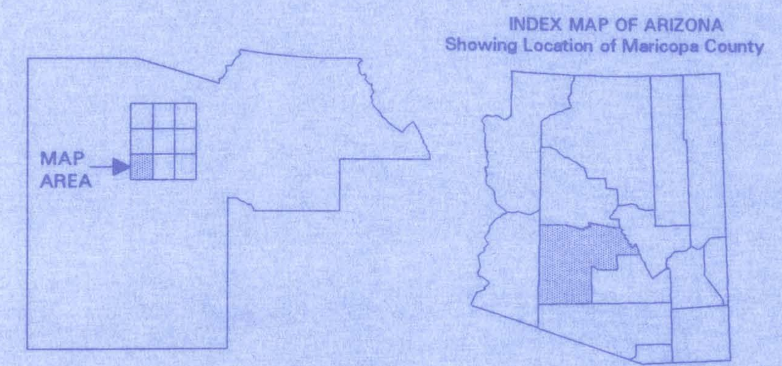
SCALE 1:24,000

1 MILE

7000 FEET

1 KILOMETER

CONTOUR INTERVAL 10 FEET



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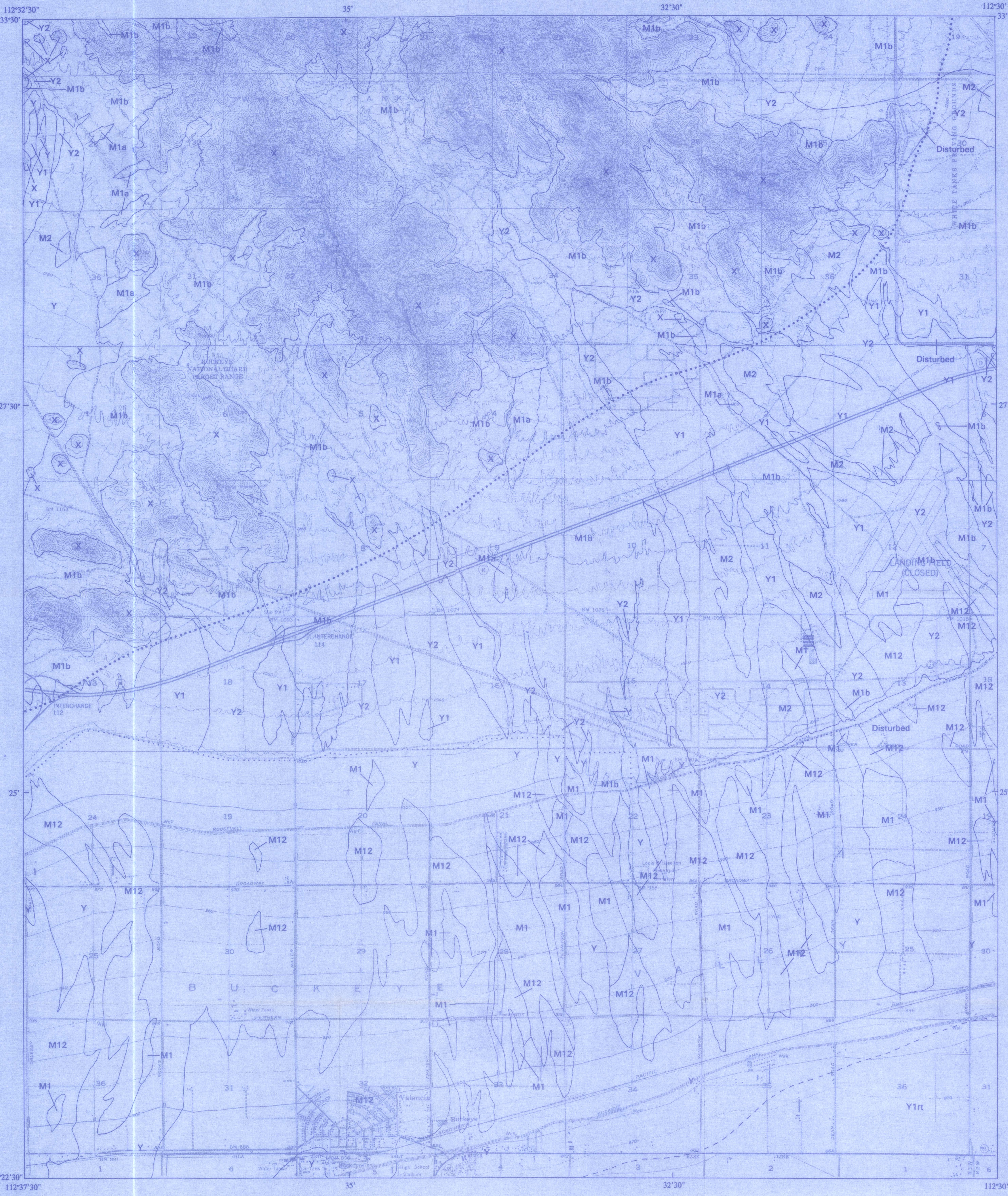

Surficial Geology Around the White Tank Mountains, Central Arizona: Valencia Quadrangle

NORTH

SCALE 1:24,000

1 MILE
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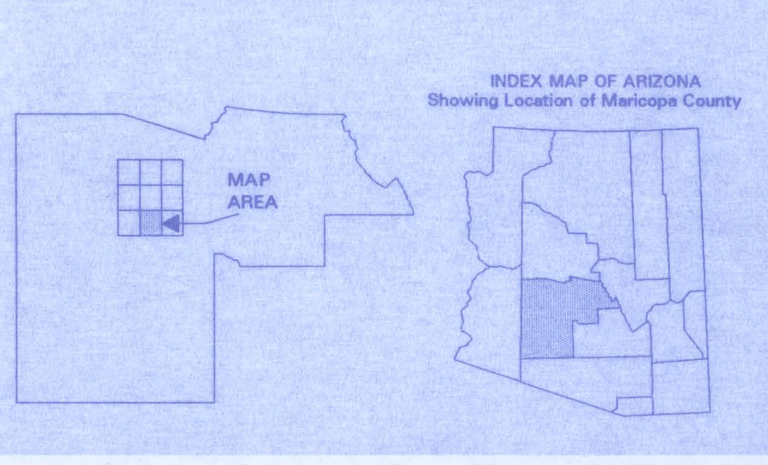
1 KILOMETER

CONTOUR INTERVAL 20 FEET



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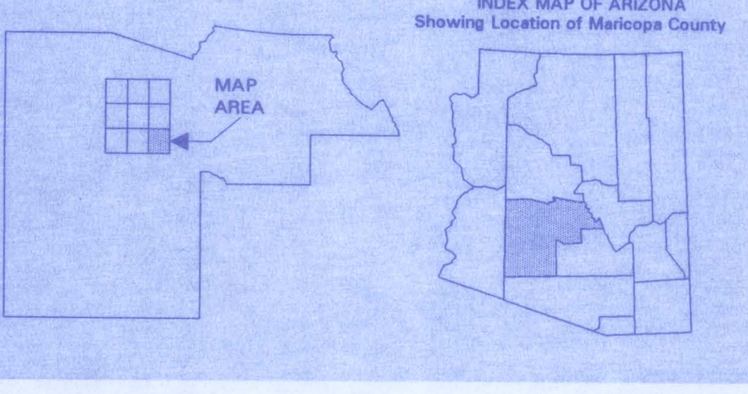

Surficial Geology Around the White Tank Mountains, Central Arizona: Perryville Quadrangle

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