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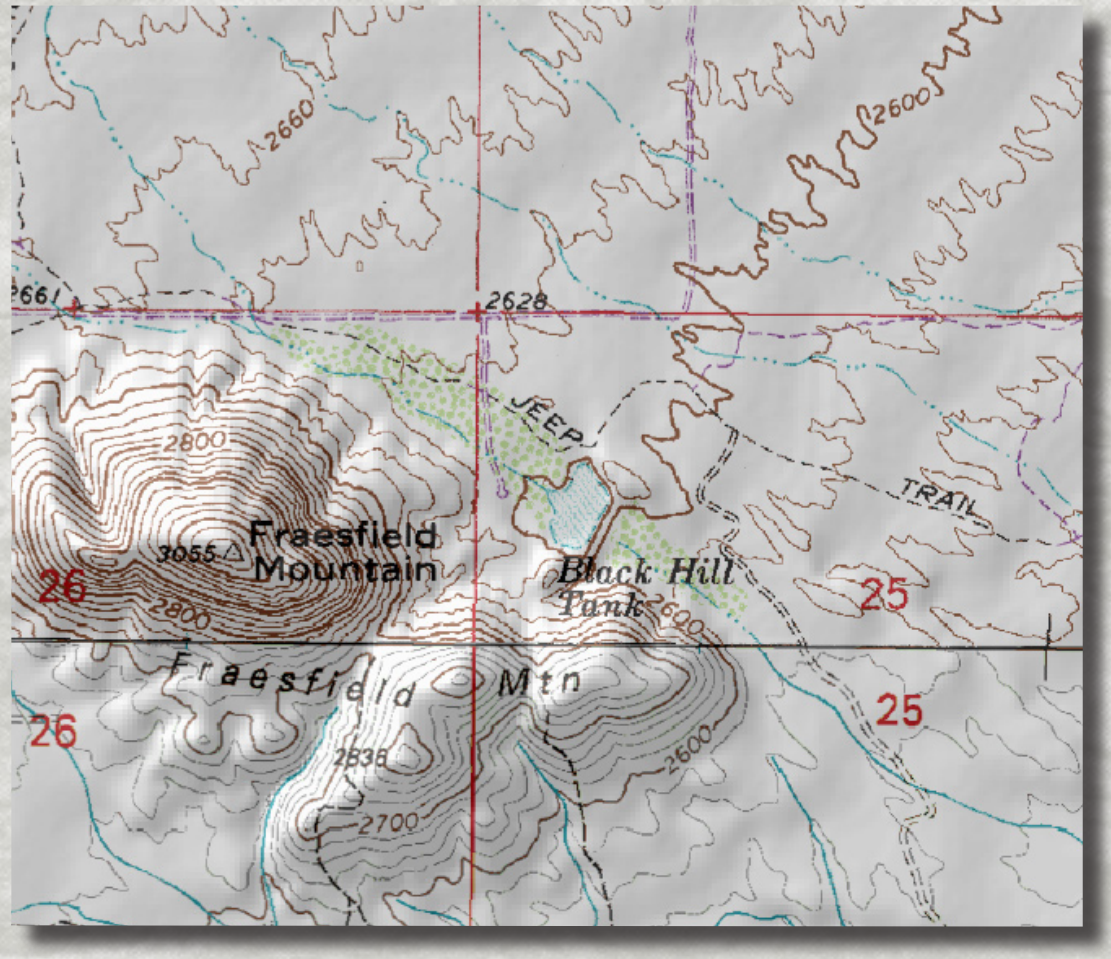
GEOLOGIC CHARACTERIZATION OF THE BLACK HILLS DAM SCOTTSDALE, ARIZONA



Prepared for the City of Scottsdale

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Geologic Characterization of the Black Hills Dam, Scottsdale, Arizona

Introduction

The purpose of this research project is to determine the origin of the materials used to construct the Black Hills Dam in order to restore the landscape to pre-dam conditions. The Black Hills Dam site is located in northern Scottsdale, Maricopa County, at 33.75° North, 111.80° West. The goals of this project are to characterize the surficial deposits and local geology of the dam site. This report presents our findings, interpretations and conclusions based on background research, a site visit to the dam site, and technical discussions with the City of Scottsdale engineer and planners.

Background Research

We searched archival libraries at the Arizona Geological Survey, Maricopa County Assessor's Office, and Arizona State University for archival aerial photographs and existing geologic reports. The earliest aerial photos available for the site area were from September 1962. The 1962 photos were compared with high-resolution 2007 aerial photography provided by the City of Scottsdale. The 2007 imagery was accompanied by a 1-foot topographic contour map (constructed 1993, City of Scottsdale). Figure 1 shows the site area with the 2007 imagery and topographic contours. Previous work by Péwé et al. (1984) provided regional and local context to geologic units in the area.

Findings and Interpretations

For the purposes of meeting project goals the following areas of the Black Hills Dam site were observed on an April 21, 2009 site visit with the City of Scottsdale representatives. Figure 2 illustrates the relationships between the geology of the site area and dam/post-dam deposits.

1. Composition and morphology of the dam
2. Surrounding bedrock and stream terrace deposits
3. Post-dam sediments and morphology
4. Undisturbed floodplain sediment and morphology

Composition and morphology of the dam

The Black Hills Dam is an earthen dam composed of coarse sand, gravel and cobbles, with minor silt and trace clay. The sand, gravel and cobbles are all components of local geologic units, including surficial deposits and local granitic and quartzite units which form the adjacent Fraesfield Mountain. The dam is composed of approximately 90% decomposed granite. The remaining approximate 10% is composed of gravel-size to medium cobble-size angular clasts of quartzite.

The dimensions of the dam are 131 meters long at its crest, 110 meters long at its base, 5.8 meters above the basin floor on the northwest (upstream) side, and 7 meters above the southeast (downstream) side of the dam. The interior structure and composition of the dam are unknown.

Gullies incised into both sides of the dam are regularly spaced between 2 to 4 meters along the length of the dam. The width of the gullies range from 0.2 to 2 meters wide and from 0.1 to 1 meter deep. A jar sample collected from the wall of a gully incised into the dam yielded ~80% sand, ~20% silt, and less than 1% clay.

Given the small volume of dam materials and their compositional similarity with exposed rock and sediments, it seems likely that the dam materials were derived from local surficial and bedrock deposits.

Surrounding bedrock and stream terrace deposits

Relatively thin stream terrace deposits were observed overlying bedrock on both sides of the wash. Additionally, the eastern end of the dam is buttressed against an outcrop of quartzite bedrock; the dam's west end is buttressed against granitic bedrock (Figure 2).

On the southwest side of the wash granite bedrock was observed at the surface in small, localized outcrops covered by loose hillslope deposits and older stream terraces (Figure 2). Three small tributary channels are eroded in-between granite outcrops, two upstream and one downstream of the dam. The tributary channels exhibit typical vegetation and slopes and show no signs of previous modification by scrapers or dozers. Older stream terrace deposits cap bedrock on the southwest side of the channel. These older stream deposits, which have well-developed clay horizons indicative of an age greater than 10,000 years, also show no signs of human-caused disturbance.

Based on the presence of undisturbed stream terraces and the apparent lack of disturbed or modified side-channel deposits, the southwest side of the wash was not the source area for material used to construct the dam.

On the northeast side of the wash a branch of an existing dirt road ends on a flat surface near waypoint ID 518 (Figure 2). This surface is formed on stream terrace deposits approximately one to two meters thick, which are composed of decomposed granite sand (grus) and 10 to 20% sub-angular to sub-rounded, cobble-size clasts of quartzite. As with the stream terraces on the southwest side of the wash, a clay horizon is present, indicating that the stream

terrace deposit is older than 10,000 years old. This deposit overlies granite bedrock near waypoint ID 519 (Figure 2). Immediately southwest of here toward the active channel along the same terrace deposit, the slope is 14 to 17 degrees. This steep slope has abundant and well-developed vegetation. A low saddle is present at the end of the road near waypoint 518 and a gully incised into the west side of this terrace drains into the active channel. A gentle 3-degree slope drains east into the dam's basin (Figures 2 and 3, labeled "likely source area"). This gentle slope lacks abundant and mature vegetation in contrast to the surrounding deposits of similar age and composition. In addition, the opposing drainages and difference in slope are atypical for this age and type of deposit adjacent to an active wash. The aerial image from 1962 shows this slope lacked vegetation even then (Figure 4).

Based on the composition of the terrace deposit, lack of developed vegetation, and atypical drainage and slope, the area labeled "gentle slope" is interpreted to be one likely source for the earthen dam material.

Post-dam sediments and morphology

Post-dam sedimentation from the main and side-channels are shown in Figure 2. These sediments consist of coarse sand from decomposed granite and lack gravel and cobbles. Sediment thickness is unknown. A preliminary analysis of slopes in the active channel upstream and downstream of the basin area suggests some sediment was scoured from the basin area for use in construction of the dam, and this area subsequently filled with post-dam sediment.

Although no volumetric analyses of the post-dam sediments were done, restoration of the earthen dam sediments should take into consideration the composition, distribution and thickness of the post-dam sediments.

Undisturbed floodplain sediment and morphology

Upstream and downstream of the dam and post-dam sediments, the active channel exhibits normal, undisturbed channel morphology and vegetation (Figures 1 and 4). The active channel has a bar and channel morphology. Multiple bars or islands across the channel width consist of a mix of sand, gravel, cobble, and boulders separated by sandy channels composed of predominantly decomposed-granite sand or grus. Vegetation is dense and consists of mesquite trees and dense shrub communities. The active channel appears undisturbed and is interpreted to represent the former pre-dam channel morphology.

Summary and Conclusions

The following summarizes conclusions based on the aforementioned observations and interpretations at the Black Hills Dam site:

1. The earth dam material was derived from local surficial deposits.
2. Surficial deposits used to construct the dam were not derived from deposits on the south side of the active channel.
3. It is unlikely that sediments from the active channel upstream of the post-dam sediments and downstream of the dam were used in dam construction.
4. One likely source area for sediment used to construct the dam is underlying the area of the post-dam basin.
5. A second likely source area is a relatively unvegetated gentle slope on older stream terrace deposits on the north side of the wash.

Our overall conclusion is that the sediment used to construct the Black Hills Dam most likely was derived from the active channel where the present basin sediments are and from stream terrace deposits immediately northwest of the dam adjacent to a knob of bedrock. Post-dam basin sediments and sheet deposits derived from active channels formed after the dam was built. Their distribution is mapped, but their thickness was not determined.

If the Black Hills Dam is removed and relocated locally, factors such as proximity to the 100-year floodplain, dam/post-dam sediment volumes, compaction, vegetation, and runoff should be considered. These factors are not analyzed or modeled as a part of this project scope. The unknown volume of the post-dam sediment is largely coarse sand and could easily be eroded and transported downstream in a single small-flood event. The post-dam sediment should also be considered part of the restoration and mitigation process of the site.

If materials from the Black Hills Dam are redistributed locally, one option could be to distribute the dam-materials upstream to the former likely source area between the terrace and bedrock knob, above the 100-year floodplain. In addition, the adjacent elevated stream terrace shown in Figure 3 could be considered as an additional site to place some of the dam-sediments.

References Cited

Péwé, T.L., Bales, J., and Montz, M., 1984, Reconnaissance Environmental Geology of Northern Scottsdale, Maricopa County, Arizona, AZGS Contributed Report, CM-94E.

Figure 1. Aerial Topographic Map with one-foot contours. Image courtesy of City of Scottsdale.

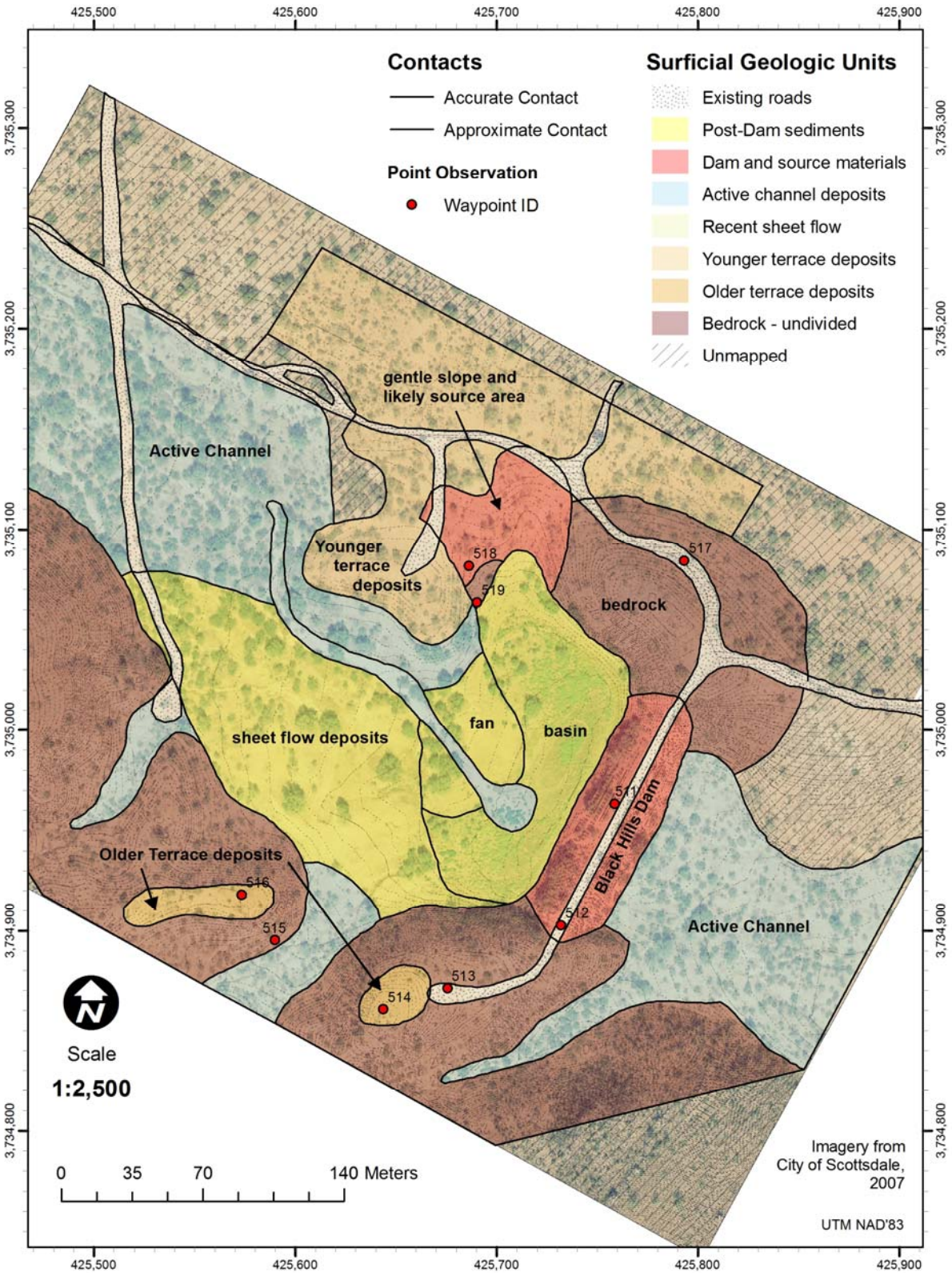

Figure 2. Geologic map of the Black Hill Tank dam area in the same spatial extent shown in Figure 1.

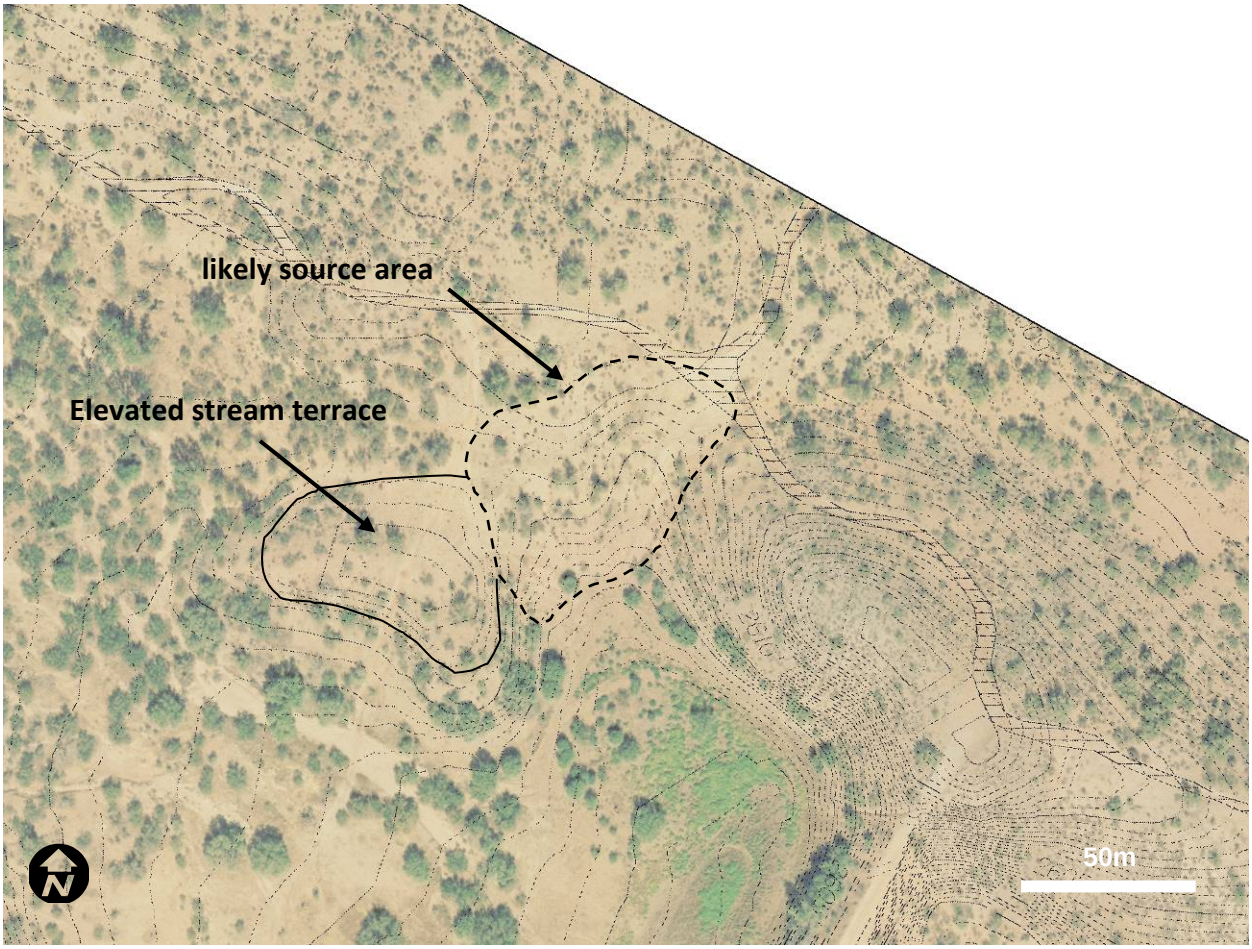

Figure 3. Enlarged area of the elevated stream terrace and relatively gentle, unvegetated slope. Interpreted to be one likely source area for dam materials. Contours are one-foot. Images provided by City of Scottsdale. Scale in meters.

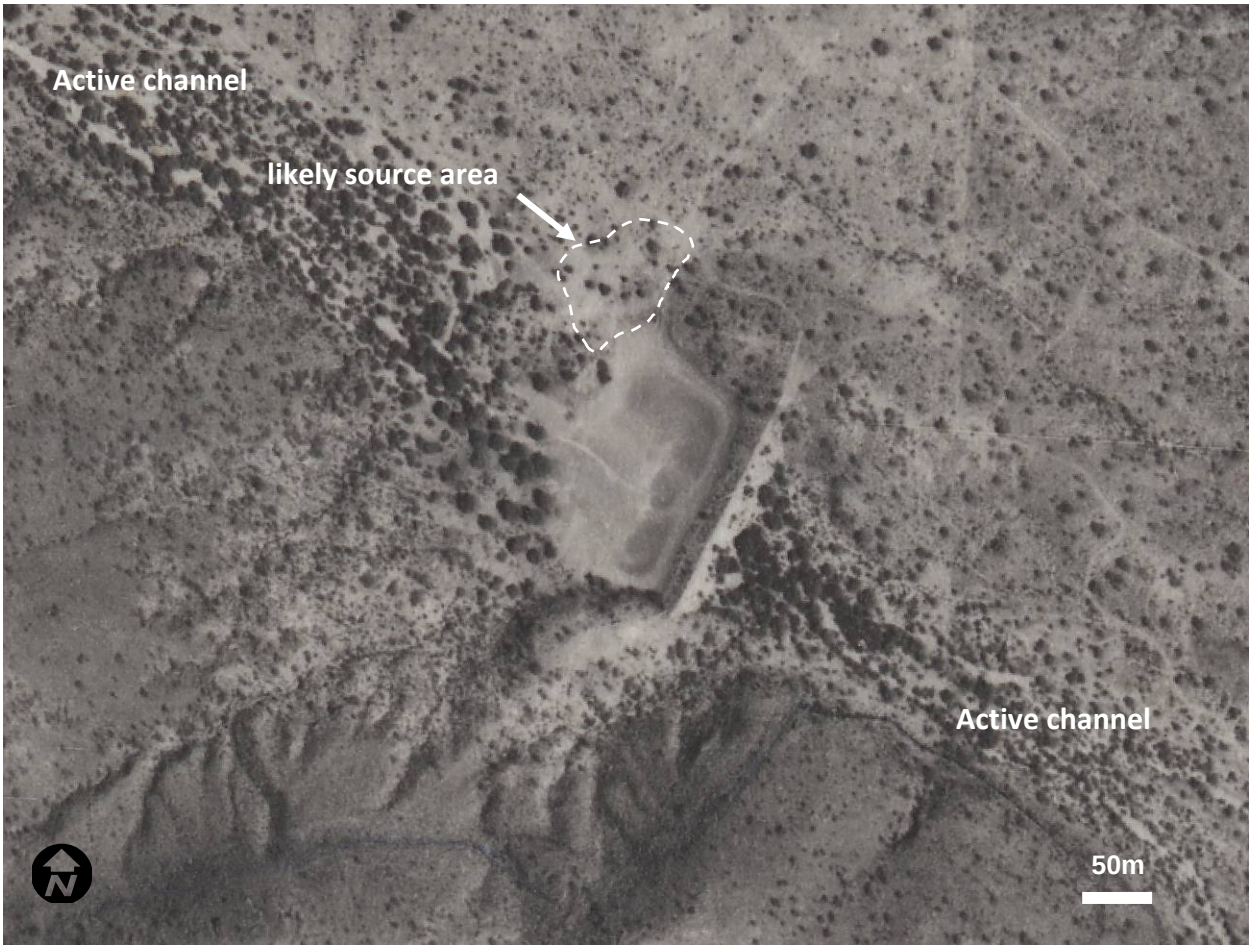

Figure 4. 1962 aerial imagery. Arrow and area show a gentle slope lacking vegetation, interpreted to be a likely source area for dam materials. Also note the density and growth of trees and shrubs both upstream and downstream of the dam area in the active channel. (Photo taken Sept. 30, 1962, ASU archives). Scale in meters.