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ASSESSMENT OF FLOOD DAMAGE IN ARIZONA BY MEANS OF ERTS-1 IMAGERY

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Abstract

ERTS-1 MSS images clearly show two important effects of a large flood in southeastern Arizona - the extent of inundation and the areas affected by severe sediment deposition and erosion - although the images were made a week and a half after the flood. On October 20 and 21, 1972, the upper Gila River had its third-largest flood on record. Peak flows attained about 42,000 and 82,000 cubic feet a second at Duncan and Safford, Arizona, respectively. Two lives were lost, hundreds of people made homeless, and more than 10,000 acres of cropland inundated.

The first ERTS-1 images after the flood were made on November 1 and 2. The inundated area is best displayed on the infrared bands, particularly on band 7, where it appears as a belt along the river that is distinctly darker than adjoining parts of the flood plain. This dark belt does not appear on ERTS images that predate the flood. Presumably the low infrared reflectance of this belt is caused by still-moist soil and by flood-stressed vegetation. Inundation limits mapped from ERTS imagery agree well with those obtained by aerial photography during the flood and by ground surveys. Areas of severe sand and gravel deposition show best on band 5. By comparing before and after flood images in this band, a quick assessment can be made of the severely flood-ravaged land.

The Gila River, the third largest in Arizona, has a history of occasional large floods that result from regional storms that drop most of their rain in the high mountains in the upper parts of its watershed, near the Arizona-New Mexico line. There are no dams on the upper Gila River or its tributaries, so the floods are uncontrolled. On October 20 and 21, 1972, the upper Gila had its third-largest flood on record. Peak flows attained about 42,000 cubic feet a second at Duncan, Arizona, and about 82,000 cubic feet a second at Safford, below the confluence of the San Francisco River, which also flooded. Two lives were lost in New Mexico, hundreds of people were made temporarily homeless, and more than 10,000 acres of cropland were inundated. Figures 1, 2, and 3 are low-altitude air photographs taken during the flood crest by personnel of the Arizona Highway Department and of the U.S. Geological Survey.

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The first post-flood ERTS images were made a week and a half after the flood, on November 1 and 2. Nevertheless, the zone that was inundated is clearly visible on infrared bands 6 and 7, particularly on band 7 (Figures 4 and 5). It shows as a belt that is distinctly darker than the adjoining parts of the river flood plain. This dark belt does not appear on the images that predate the flood. We mapped the boundary of the dark belt at 1:250,000 scale with a zoom transferscope, using the November 1 and 2 images. We also plotted at the same scale the unundation limit as determined from the low-altitude airphotographs taken during the flood. Figure 6 compares the results. The agreement is surprisingly good, considering the 10-day delay in the ERTS imagery and also the fact that the discrimination of the inundation limit from the ERTS images was done quite conservatively.

On subsequent infrared images the dark belt along the Gila River disappeared slowly. Unfortunately, heavy clouds completely obscured the upper Gila River area in the images taken by the second post-flood ERTS-1 pass (November 19 and 20) over the area. On the next pass (December 7 and 8) the dark belt is not quite as dark as previously (it contrasts less with the adjoining flood plain), and it is somewhat narrower. In the images from later passes (December 25 and 26 and afterward) the dark belt has disappeared. We surmise that the low infrared reflectance of the dark belt could be caused by both excess soil moisture and by flood-stressed vegetation. The slowness with which the dark belt "faded" suggests that a significant part of the lowered infrared reflectance was due to vegetation stress, because the soil surface likely dried out at a faster rate. The narrowing of the dark belt with time also favors this hypothesis, because flood stress on vegetation would tend to be greatest close to the main channel of the river.

Similar dark belts of reduced infrared reflectance were observed along the East Nishnabotna and West Nishnabotna River in Iowa, in ERTS images taken a week after a big flood last September.

We also noticed in the ERTS images taken after the Gila River flood that certain reaches of river-channel deposits had widened considerably, compared with the pre-flood images. The channel deposits, sand and gravel, show most clearly on band 5 as a very light-toned strip inside the inundated belt that appears dark on the infrared bands. The greatest widening of the channel-deposit strip is at the upper ends of two intermontane basins, the Duncan-Virden Valley and the Safford (Gila) Valley, where the Gila River debouches from narrow box canyons. Evidently these were the sites of strong sand and gravel erosion and deposition.

In conclusion, the repetitive multispectral ERTS images appear to have considerable potential for assessing two important effects of large floods -- the extent of inundation and the areas affected by severe erosion and sediment deposition -- even from images taken a week and a half after the flooding.

Figure 1. Low-altitude airphoto showing the inundation at Duncan, Arizona, near the crest of the October 20-21, 1972 flood on the upper Gila River. U. S. Geological Survey photograph.

Figure 2. Low-altitude oblique airphoto of eastern Safford (Gila) Valley, near the peak of the October 20-21, 1972 flood on the upper Gila River. U. S. Geological Survey photograph.

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Figure 3. Vertical low-altitude airphoto near Safford, Arizona, taken shortly after the crest of the October 20-21, 1972 flood on the upper Gila River. Many homes in the village in lower center (Hollywood) were destroyed. Arizona Highway Department photograph.

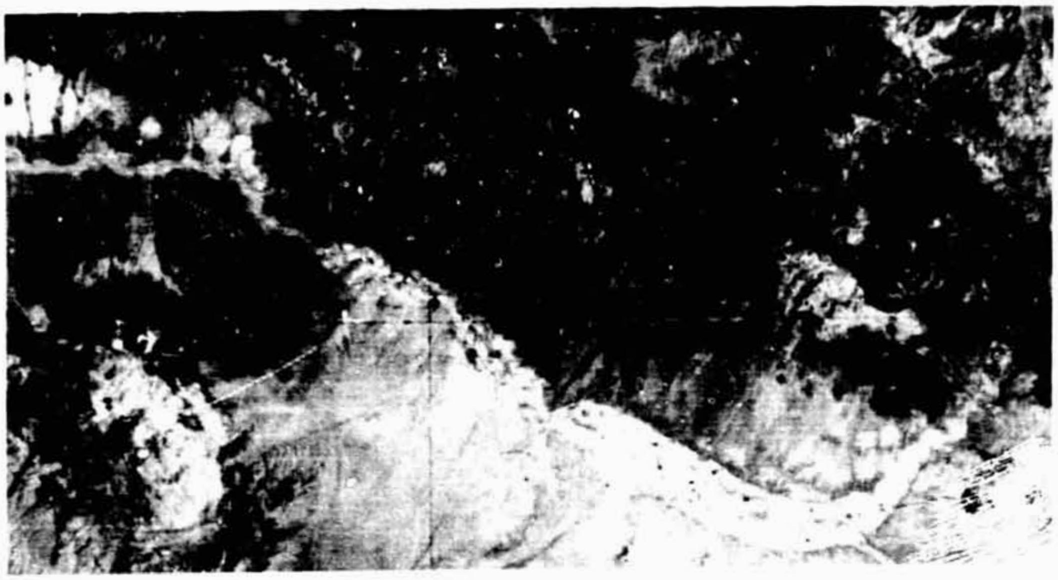
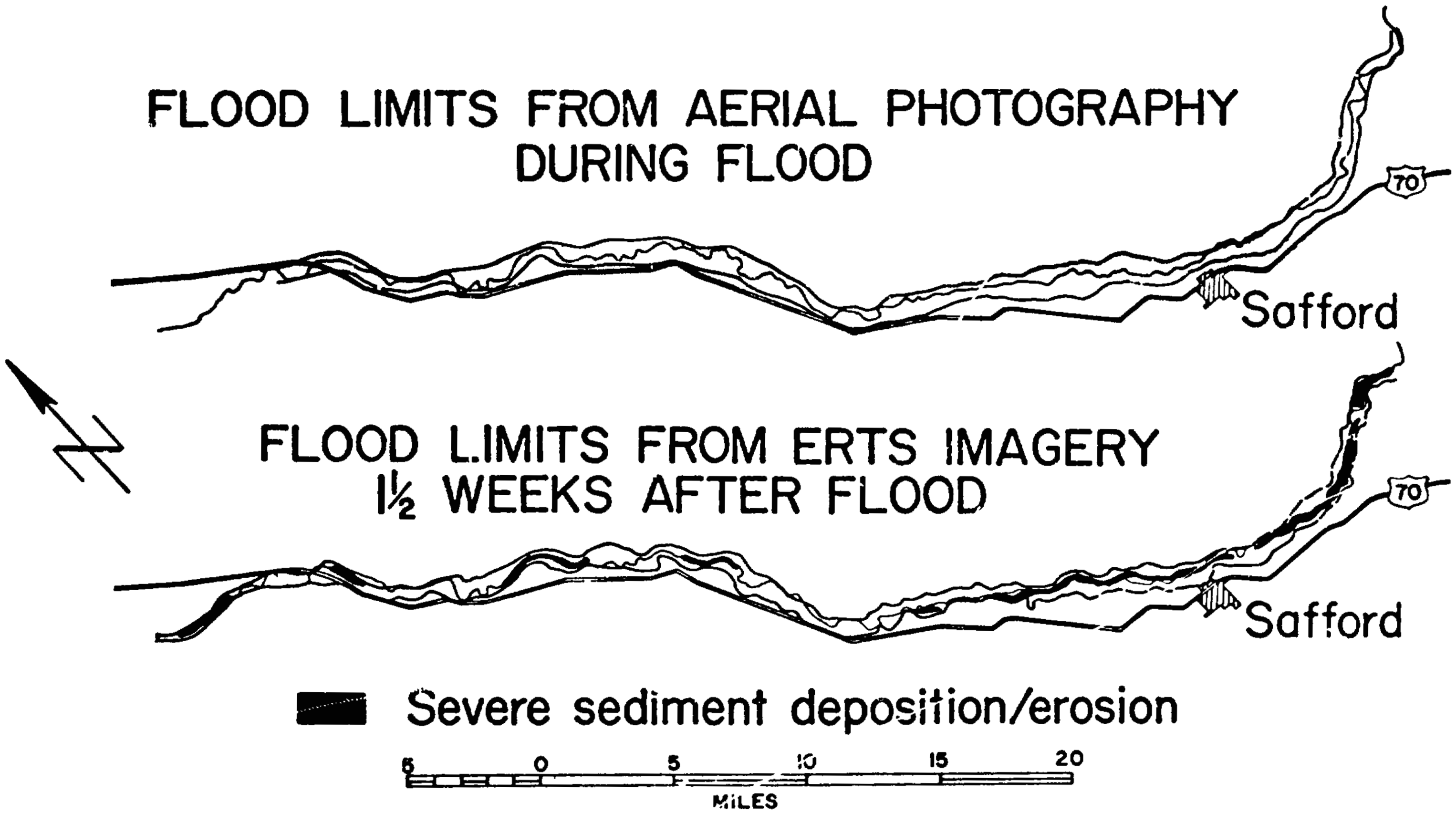


Figure 4. Conditions before the Gila River flood as shown by infrared band 7 of ERTS-1 frame 1030-17265, taken August 22, 1972. The arcuate light-toned band in the lower part of the view is the Safford (Gila) Valley, Arizona.

Figure 5. Conditions 1½ weeks after the Gila River flood of October 20-21, 1972, as shown by infrared band 7 of ERTS-1 frame 1102-17274, taken November 2, 1972. Note the dark belt of reduced infrared reflectance along the Gila River within the Safford Valley. This corresponds with the zone that was inundated and probably is caused by excess soil moisture and by flood-stressed vegetation.



6. Limits of October 20-21 flood on the upper Gila River in the Safford (Gila) Valley, Arizona, as determined from low-altitude aerial photography taken during the flood and from ERTS-1 imagery taken 1 1/2 weeks after the flood