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BIMONTHLY ERTS-A USER INVESTIGATION PROGRESS REPORT

For Period Ending September 30, 1972

Title of Investigation: Monitoring Fresh Water Resources
ERTS-A Proposal No. 060-7
Principal Investigator: Harold L. Yarger (ST045)

(E72-10123) MONITORING FRESH WATER RESOURCES Bimonthly Progress Report, period ending 30 Sep. 1972 H.L. Yarger (Kansas Univ.) 30 Sep. 1972 22 p CSCL 08H
N72-32373
G3/13 Unclas 00123

22

Type I Progress Report for Period Ending September 30, 1972

a. Monitoring Fresh Water Resources (MMC # 060-7)

b. Harold L. Yarger (ST045)

c. We are not receiving standing order products soon enough after satellite pass to optimize reservoir sampling schemes for the next pass 18 days later. We have not gotten delivery on submarine photometer required for turbidity measurements, however, we are getting reasonably accurate turbidity measurements with secchi disc technique.

d. We have taken ≥ 10 samples and turbidity measurements from Perry and Tuttle Creek reservoirs coincident with the first four satellite passes. The following analyses have been performed on these samples: suspended and dissolved load (organic and inorganic), chlorophyll, nitrate, phosphate and potassium. ERTS images of 5 reservoirs have been density sliced on IDECS. Tuttle Creek density patterns have been compared with turbidity measurement and sample analyses for one satellite pass.

e. Water Resources-Reservoir Monitoring--
ERTS-1 imagery is promising to be very useful for studying reservoir turbidity patterns. Initial coverage indicates a strong qualitative correlation between film density and turbidity. With repeated coverage and sampling the possibility of developing a reliable quantitative correlation looks good. The question of distinguishing between organic and inorganic suspended load in Kansas reservoirs is open, but will require considerable more work to answer.

2

f. Abstract of contributed paper to Eighth International Symposium on Remote Sensing of Environment mailed to University of Michigan, May 15, 1972. Title: "ERTS-A Study of Reservoirs in Kansas" by H. L. Yarger, J. C. Coiner, G. W. James, J. R. McCauley, and G. R. Marzolf.

g. Reduction in lag time between satellite pass and image delivery.

h. 9/8/72 mailed change in standing order
9/12/72 phoned another change in standing order to Dick Stonesifer

i. Descriptor forms attached.

j. 9/8/72 mailed data request
9/14/72 mailed data request

k. none

attachments:

1) Descriptor forms.

2) Abstract of talk mailed May 15, 1972 to University of Michigan for Eighth International Symposium on Remote Sensing of Environment, October 2-6, 1972.

3) Text of talk to be delivered 10:30 a.m. October 6 at Symposium mentioned in 2) and to be published in Proceedings later.

Contributed Paper for the Eighth International Symposium on Remote Sensing of Environment.

ERTS-A STUDY OF RESERVOIRS IN KANSAS

H. L. Yarger[1], J. C. Coiner[2], G. W. James[1], J. R. McCauley[3]

The University of Kansas

Lawrence, Kansas

and

G. R. Marzolf[4]

Kansas State University

Manhattan, Kansas

Preliminary results will be presented on the properties of reservoirs which control spectral reflectance curves derived from ERTS-A imagery. Variables such as depth, suspended solids, chemical composition and algal growth will be studied for their relationship to ERTS-A imagery. Water samples and other ground truth will be collected from two or three major reservoirs during each ERTS-A overflight.

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1. Research Associate, State Geological Survey.
2. Graduate Research Assistant, Dept. of Geography and Center for Research, Inc.
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4. Associate Professor, Division of Biology.

ERTS-1 STUDY OF RESERVOIRS IN KANSAS

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L. M. Magnuson, J. R. McCauley

The University of Kansas
Lawrence, Kansas

and

G. R. Marzolf

Kansas State University
Manhattan, Kansas

Talk presented at Eighth International Symposium on Remote Sensing of Environment, October 2-6, 1972. University of Michigan, Ann Arbor, Michigan. (To be published in Symposium Proceedings)

ERTS-1 STUDY OF RESERVOIRS IN KANSAS[1]

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ABSTRACT

Images of several reservoirs from one ERTS-1 overpass have been examined. Gray level variation and comparison with turbidity are discussed.

This is a report on the preliminary phase of a study of Kansas reservoirs using ERTS-1 imagery. The long range goal of this project is to test the feasibility of monitoring reservoirs by satellite. It is hoped that results from this kind of study may eventually help to optimize reservoir management for use in flood control, agriculture, urban areas, and recreation.

The first task is to determine the properties of reservoirs which control the spectral intensity of reflected sunlight as detected by the ERTS-1 sensors. Ground truth variables such as turbidity, suspended solids, depth, rainfall, wind speed, chemical composition and algal growth will be studied for their affect on ERTS-1 imagery.

Figure 1 shows the nineteen major reservoirs in Kansas. At normal pool elevation these water bodies have large surface areas relative to ERTS-1 resolution. The surface areas vary from about 3 square miles at Lovewell to about 25 square miles at Tuttle Creek. The shortest dimension of the main part of any of the reservoirs is approximately 1/2 mile. The largest dimension is about 20 miles. Depths vary from 40 to 50 feet at the dam to 1 or 2 feet at the upper end. Normal pool capacities vary from 10,000 to 500,000 acre-feet of water. In addition to the 19 major reservoirs, there are approximately 100 smaller lakes and ponds in the State of Kansas with surface area greater than 20 acres. The various drainage basins throughout the state are located in a variety of physiographic regions such as the glaciated region in the northeast, the valleys and scarps in the southeast, the dissected plateau and alluvial plane areas in central Kansas, and the high planes in the west.

Our initial approach has been to measure turbidity and collect water samples from two reservoirs, Perry and Tuttle Creek, during days of ERTS overflight. After images from several passes over the remaining reservoirs have been examined a subset of these reservoirs will also be sampled. As of September 25 ERTS has made four passes over Kansas. However, due to a combination of cloud cover and lag in film delivery, we report now on only single pass coverage over 5 reservoirs. We have imagery over Cedar Bluff, Webster, Tuttle Creek, Milford and Council Grove reservoirs. To date Tuttle Creek is the only reservoir for which water sample analysis is coincident with imagery.

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Figure 2 is an MSS6 image of Tuttle Creek, Milford, and Council Grove reservoirs. The infrared bands (MSS6 and MSS7) are particularly good for identifying water bodies. The black appearance allows precise determination of the water's edge. The infrared images can be used as a template for determining the correct shoreline on the visible wavelength images (MSS4 and MSS5). Since near infrared is absorbed by the first few inches of water[1], any reflected radiation is indicative of suspended material on or very near the surface. The lighter gray levels at the shallow turbid ends of Tuttle Creek and Milford are probably caused by the sun's near infrared radiation reflecting from material suspended near the surface. In addition to the main reservoirs, numerous smaller water bodies are easily identified on this image.

Figure 3 is an MSS5 image of the same scene. The predominantly red wavelengths in this band are beginning to penetrate the water and reflect off suspended material. The probability of light reflecting from the bottom of the reservoir is extremely low. Extensive turbidity measurements in past years[2] indicate that 2/3 of the penetrating sunlight is attenuated in ≤ 1.0 meter at the deep end and ≤ 0.1 meter at the shallow end. It is expected that this result will hold in general for most reservoirs in Kansas. The apparent turbidity pattern in Tuttle Creek is quite evident. Water with high suspended load, entering from the north, deposits sediment as it moves toward the dam. The bend in the reservoir combined with wind from the south causes the turbid water to hug the western bank. The causeway at the northern tip of Milford is apparently trapping significant amounts of suspended material which results in relatively clear water near the dam. Also apparent is the flow of turbid water through a bridge at the western end of the causeway.

The Image Discrimination, Enhancement and Combination System (IDECS)[3] located at The University of Kansas was used to provide a "first look" at some of the standard 9.5" ERTS images. Figure 4 is the result of a six level density slice on an x15 magnification of Tuttle Creek Reservoir. The unequal density intervals were chosen to obtain approximately equal area per level over the scene containing Tuttle Creek (the levels on the reservoir itself do not occupy equal area because the reservoir is only part of the scene analyzed by IDECS). This band (red) exhibits substantial gray level variation across the width and length of the reservoir. The location of sampling stations were chosen at random without prior knowledge of resolution or gray level patterns. The number of stations will have to be increased to confirm (or deny) the existence of such a detailed turbidity pattern.

Figure 5 compares film density with turbidity and suspended load at each station. As expected, increasing turbidity corresponds to decreasing density (increasing reflectance). With more images and sampling of the same reservoir it is hoped this qualitative relation between gray level variation and suspended load can be parameterized. As can be seen the turbidity correlates well with total suspended load. Although turbidity is primarily dependent on total suspended solids, initial water sample analysis indicates a secondary albeit weak dependence on the ratio of volatile (organic) solids to heat stable (inorganic) solids. Perhaps gray level information from several multiband passes will make it possible to sort out this relationship. Although there appears to be a good qualitative correlation between red reflectance (MSS5) and turbidity the green reflectance (MSS4) may show a more detailed correlation because of the ability of green light to penetrate water to considerable depth.[1]

The result of a seven level density slice on an x15 magnification of Milford Reservoir is shown in Figure 6. As was evident on the original image (Fig. 3) there is very little gray level variation over the lower half of the reservoir. The sharp increase in gray level over the upper half probably corresponds to a steep turbidity gradient between the bend in the reservoir and the causeway.

MSS7 (infrared), RBV1 (green), and MSS5 (red) images of Cedar Bluff and Webster reservoirs are shown in figures 7, 8, and 9. This coverage has provided us with the first opportunity to compare green and red bands of the same water body. The rather ill defined shorelines, particularly in the RBV1 band, emphasizes again the usefulness of the MSS7 band as a template for delineating land/water boundaries. Density slices for the red and green bands are shown in figures 10 and 11. Both images have decreasing density towards the upper end of the reservoir indicating increasing turbidity. The green band (Fig. 11) indicates a fairly regular decrease in density along the length of the reservoir, whereas the red band indicates a fairly low density gradient along the lower part of the reservoir and a sharper gradient along the upper part. This difference in density gradient is probably due to the fact that green light penetrates water better than red light. The less turbid water near the dam is able to reflect green light more effectively. A pattern of density bands along the mid part of the reservoir appears in Figure 11, but not in Figure 10. Most of this may be due to the prominent scan lines in the RBV1 image.

In summary, ERTS-1 imagery is promising to be very useful for studying reservoir turbidity patterns. Initial coverage indicates a strong qualitative correlation between film density and turbidity. With repeated coverage and sampling the possibility of developing a reliable quantitative correlation looks good. The question of distinguishing between organic and inorganic suspended load in Kansas reservoirs is open, but will require considerably more work to answer.

REFERENCES

1. Scherz, James P., "Monitoring Water Pollution by Remote Sensing": Journal of the Surveying and Mapping Division, ASCE, vol. 97, no. SU2, Proc. Paper 8550, Nov. 1971, pp. 307-320.

2. Osborne, John A. and Marzolf, G. Richard, "Effect of Spectral Composition on Photosynthesis in Turbid Reservoirs": Contribution No. 106, Kansas Water Resources Research Institute, Manhattan, Kansas, June 1972.

3. Anderson, P. N., "Image Processing with a Hybrid System: The IDECS": Bulletin of Engineering No. 64, Univ. of Kansas, 1972.

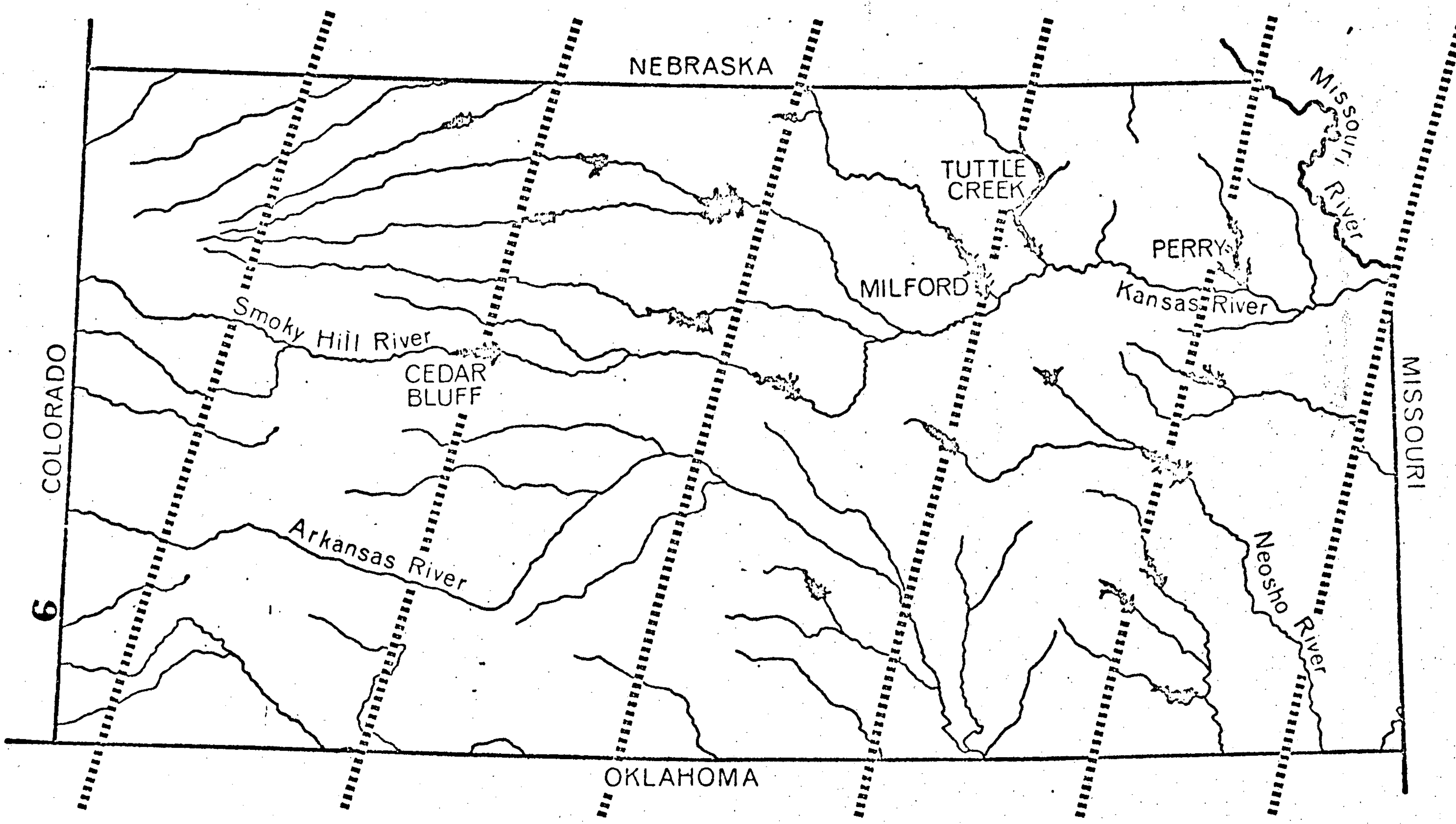

FIGURE 1. RESERVOIRS IN KANSAS.

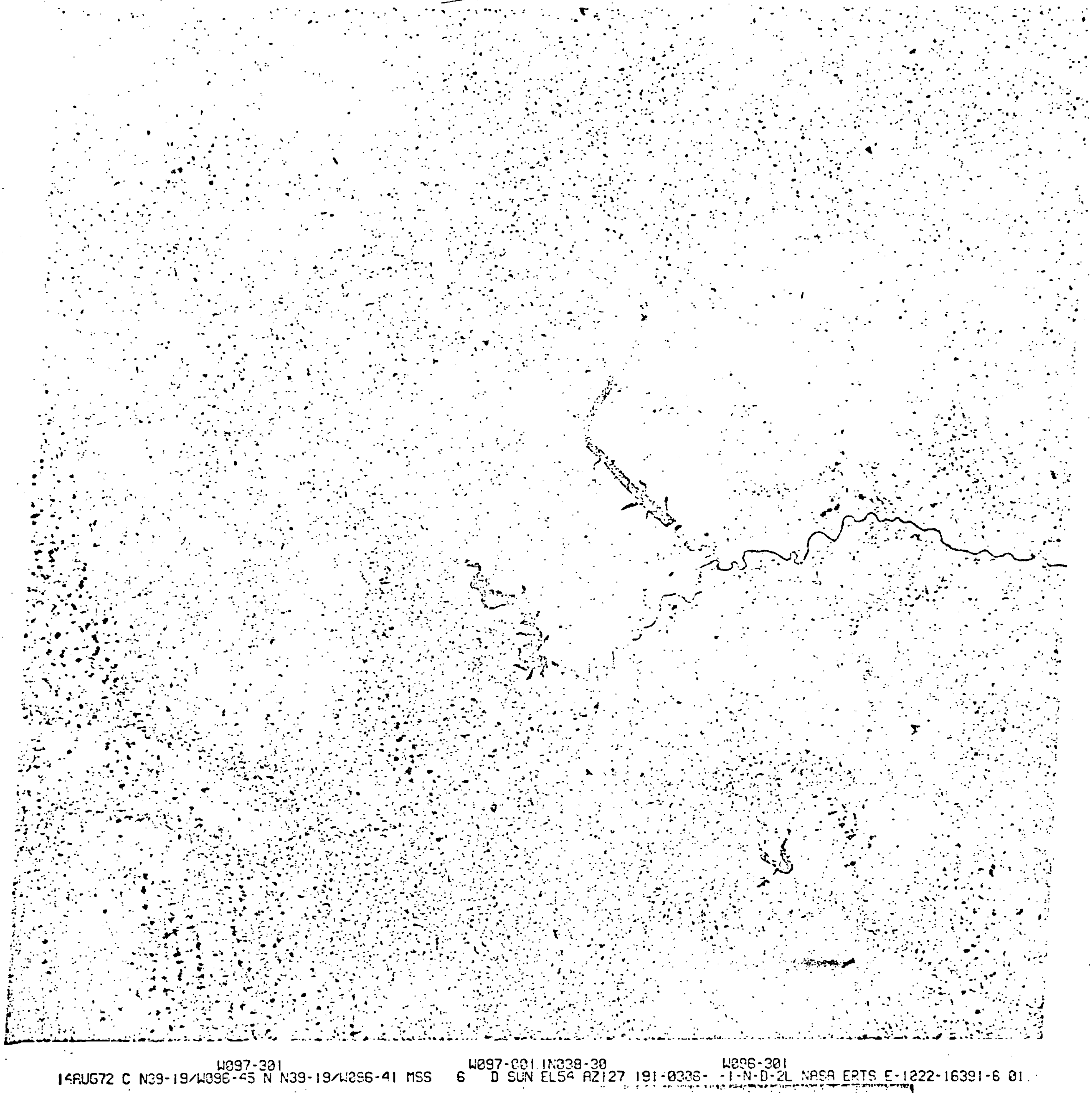

FIGURE 2. TUTTLE CREEK, MILFORD AND COUNCIL GROVE RESERVOIRS, 14 AUG. 72, MSS6. (from NASA image: ERTS E-1022-16391-6 01)

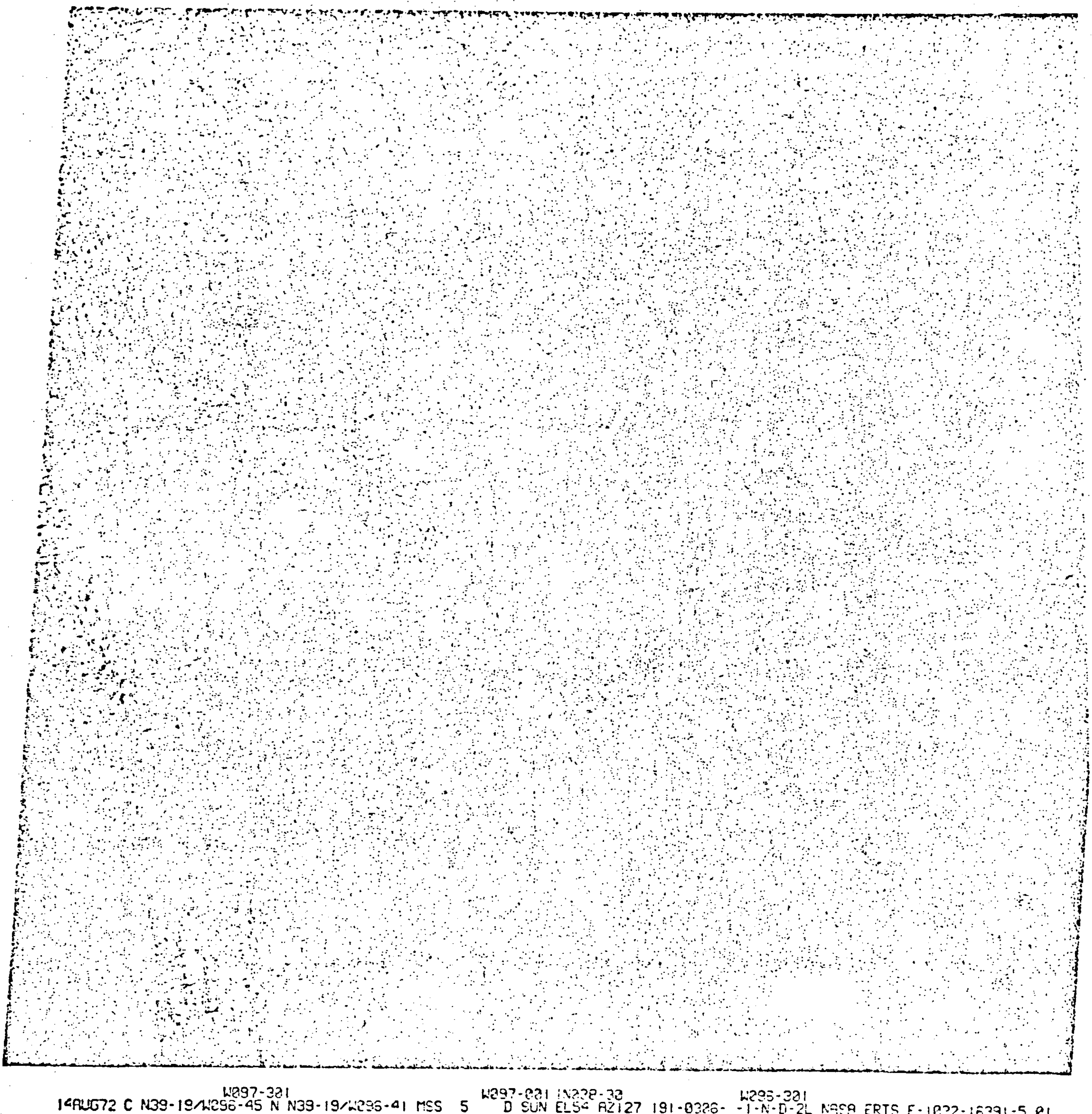

FIGURE 3. TUTTLE CREEK, MILFORD AND COUNCIL GROVE RESERVOIRS, 14 AUG. 72, MSS5. (from NASA image: ERTS E-1022-16391-5 01)

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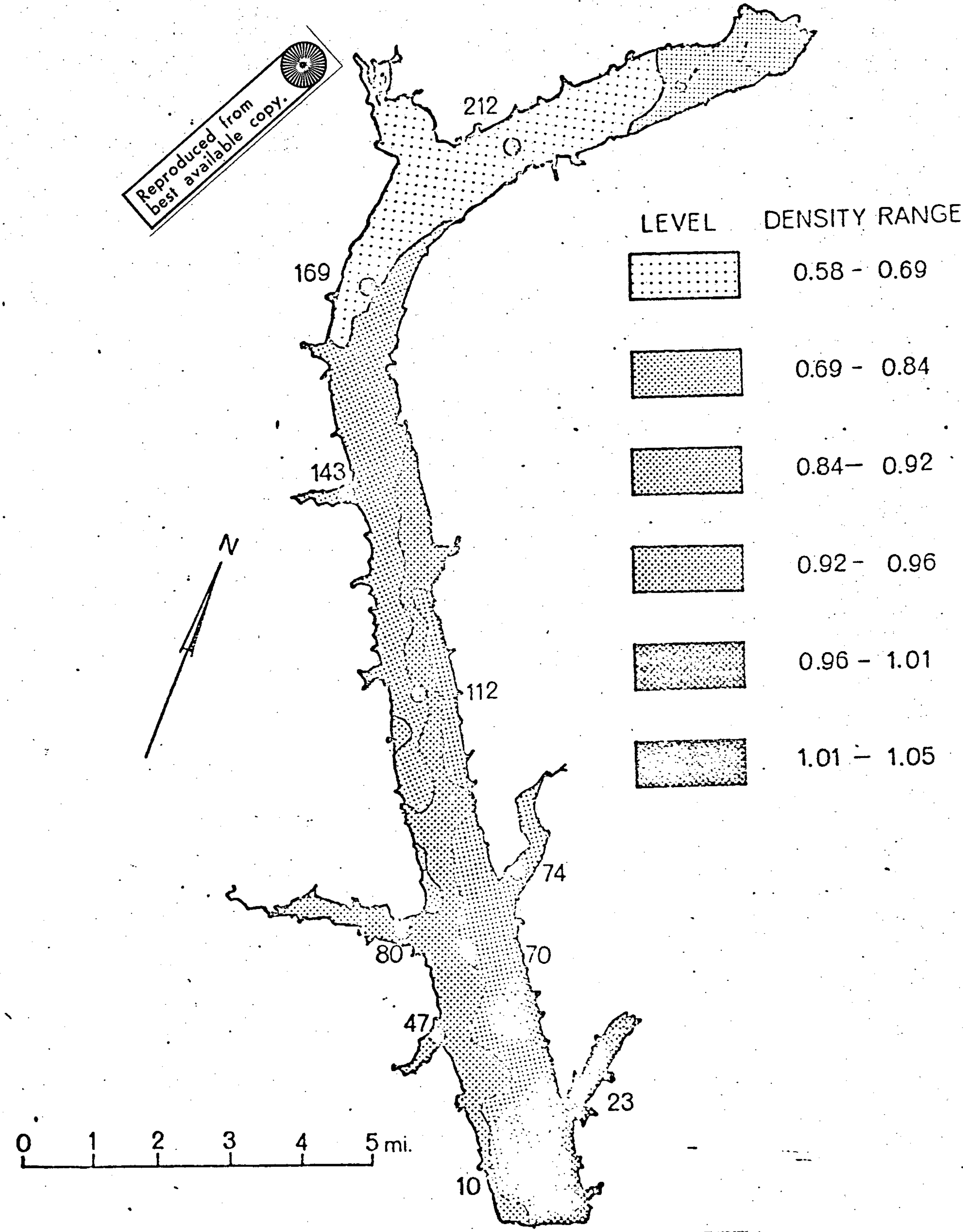

FIGURE 4. TUTTLE CREEK RESERVOIR GRAY LEVELS, 14 AUG. 72, MSS5.
(IDECS Analysis of NASA Image: ERTS E-1022-16391-5 01)

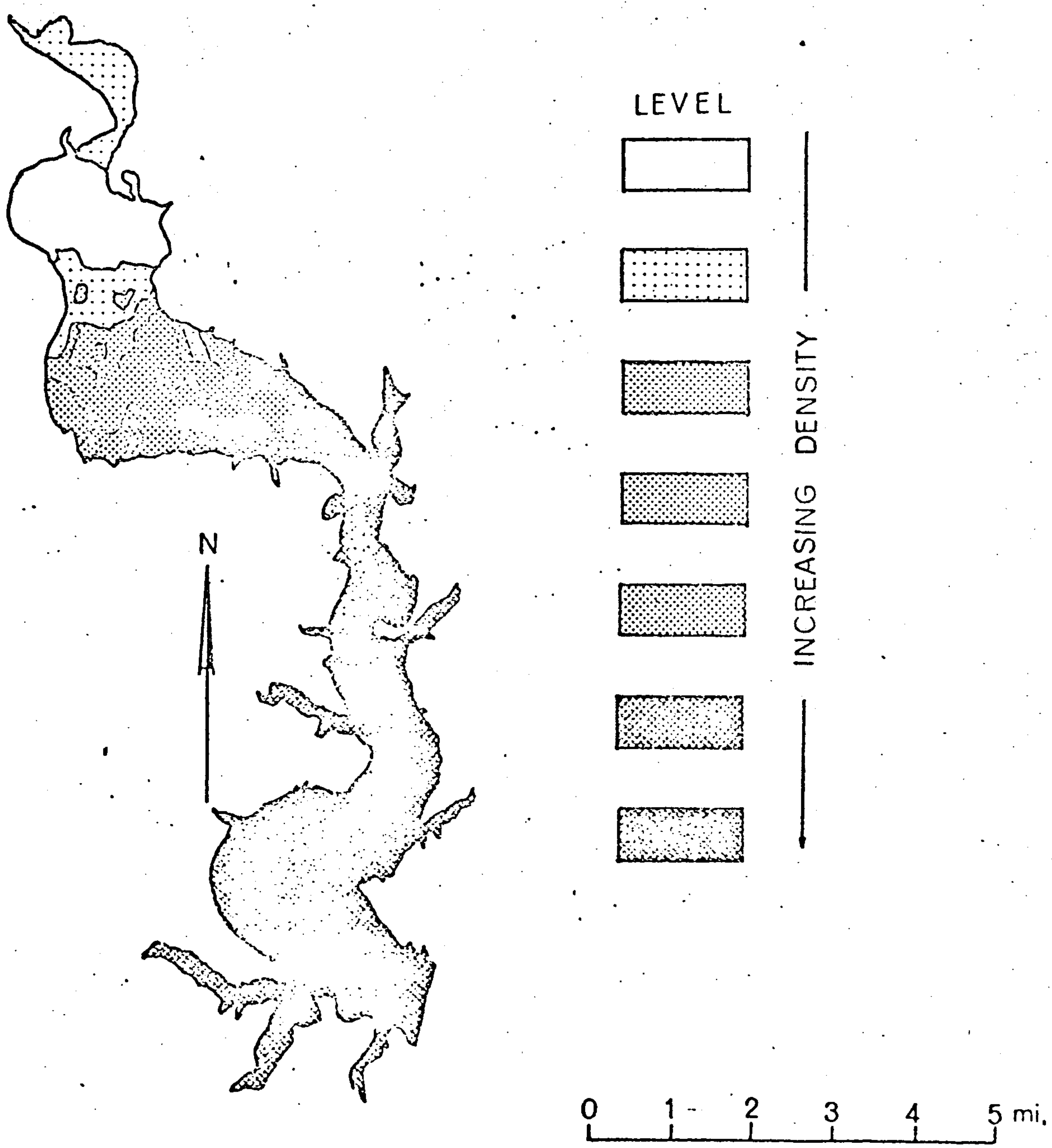

FIGURE 6. MILFORD RESERVOIR GRAY LEVELS, 14 AUG. 72, MSS5. (IDECS analysis of NASA image: ERTS E-1022-16391-5 01)

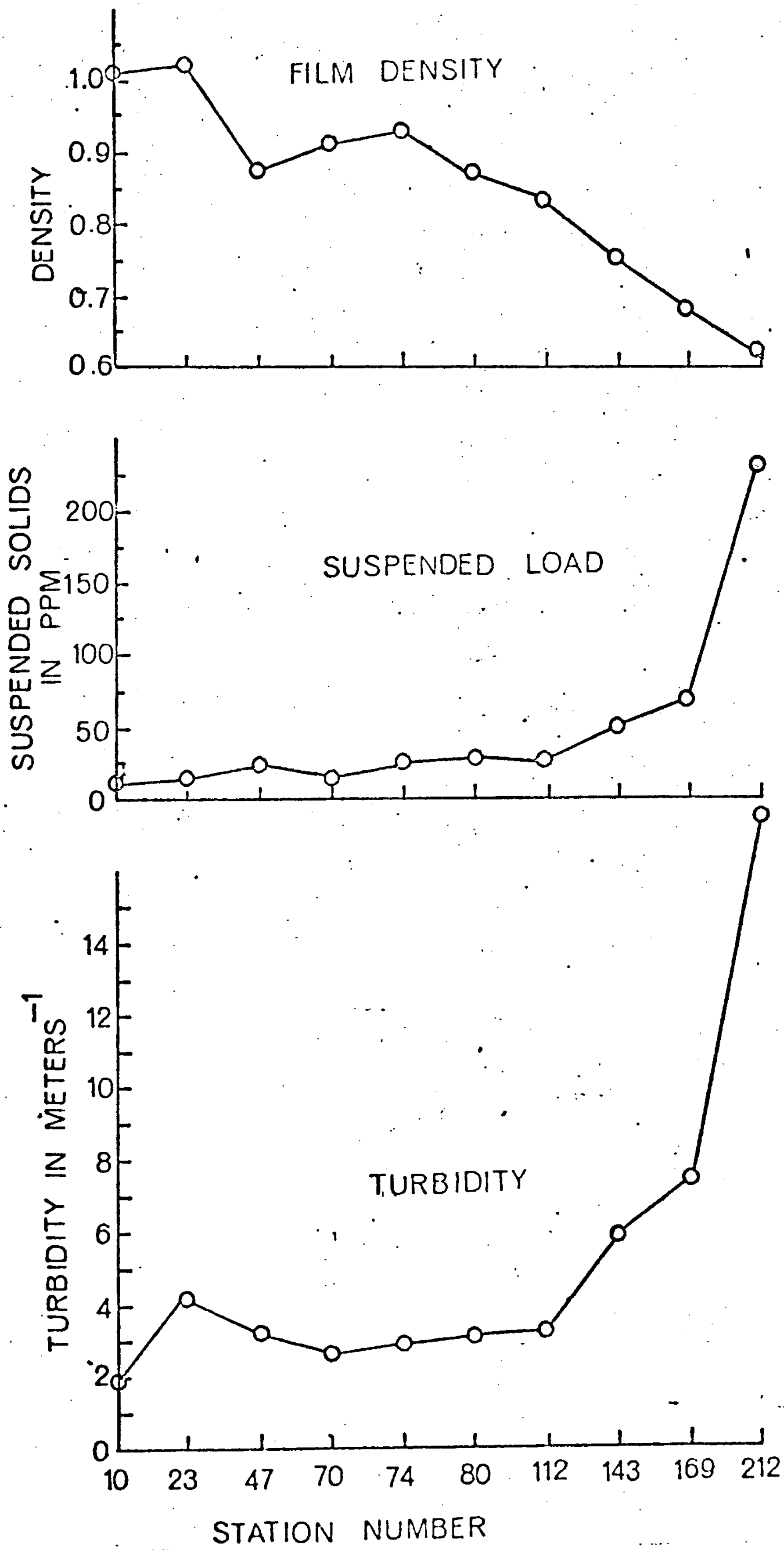

FIGURE 5. TUTTLE CREEK RESERVOIR, 14 AUG. 72. (density values were interpolated from Fig. 4)

FIGURE 7. CEDAR BLUFF AND WEBSTER RESERVOIRS, 29 JUL. 72, MSS7.
(from NASA image: ERTS E-1022-16504-7 01)

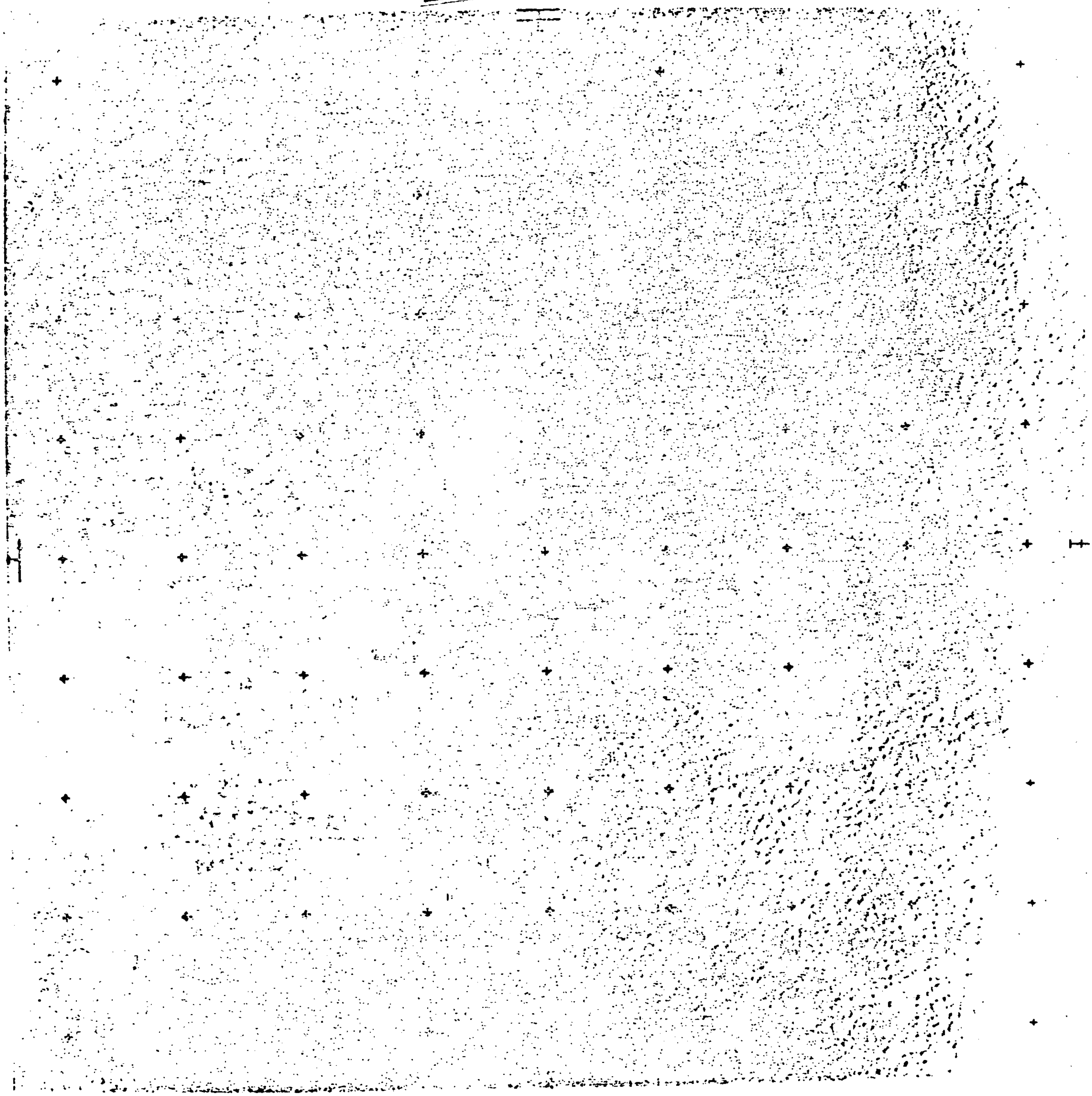

FIGURE 8. CEDAR BLUFF AND WEBSTER RESERVOIRS, 29 JUL. 72, RBV1. (from NASA image: ERTS E-1006-16504-1 01)

FIGURE 9. CEDAR BLUFF AND WEBSTER RESERVOIRS, 29 JUL. 72, MSS5.
(from NASA image: ERTS E-1006-16504-5 01)

17

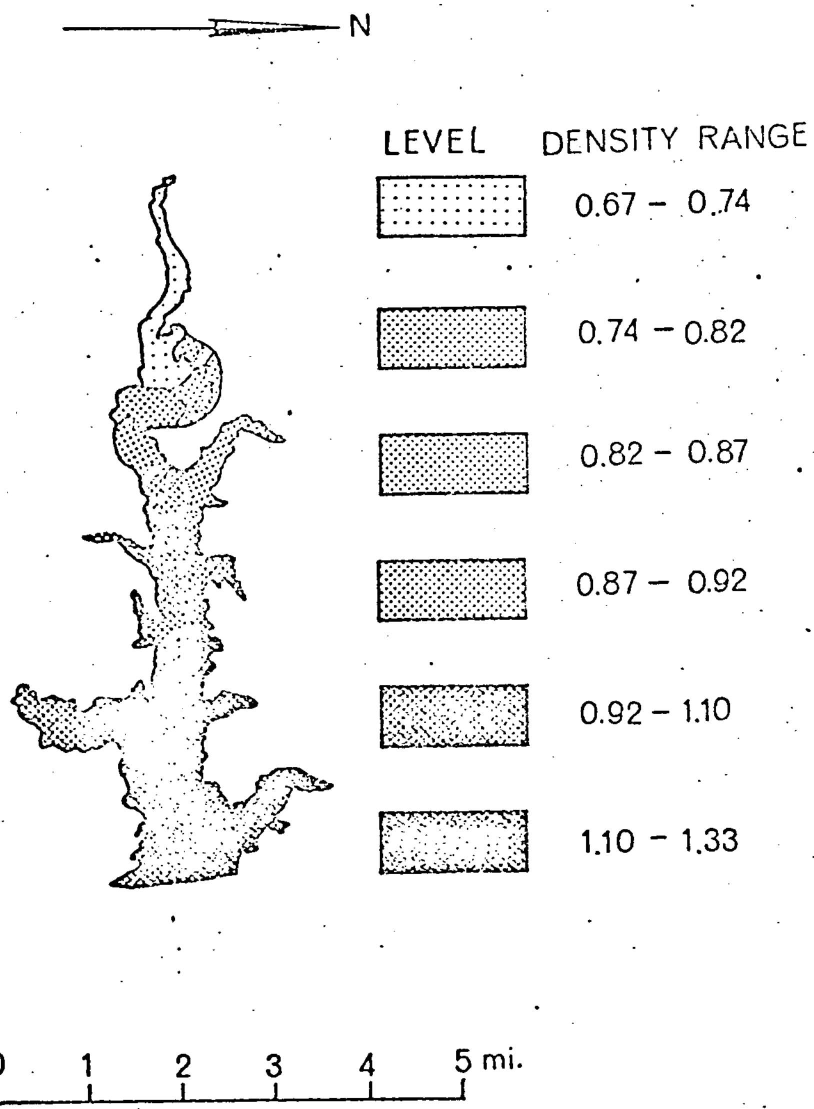

FIGURE 10. CEDAR BLUFF RESERVOIR GRAY LEVELS, 29 JUL. 72, MSS5. (IDECS analysis of NASA image: ERTS E-1022-16504-5 01)

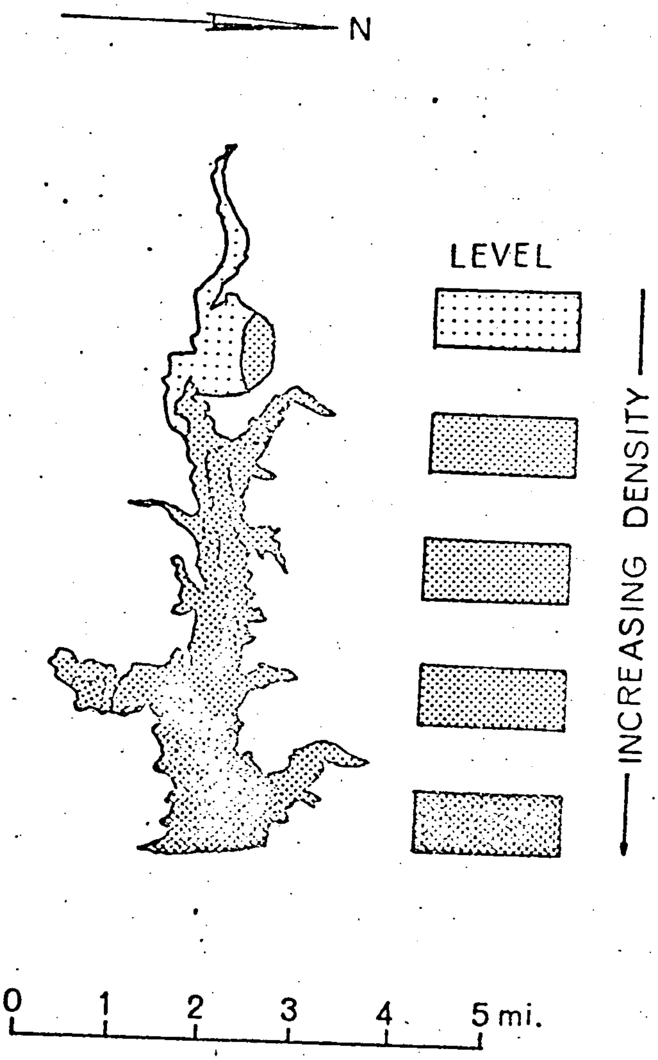

FIGURE 11. CEDAR BLUFF RESERVOIR GRAY LEVELS, 29 JUL. 72, RBV1. (IDECS analysis of NASA image: ERTS E-1006-16504-1 01)

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1006-16504-7	"	"	"	"
1006-16511-1		"	"	DUNES
1006-16504-1	"	"	"	BADLANDS.
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1006-16504-6	"	"	"	BADLANDS.
1006-16511-6		"	"	DUNES.
1007-16563-2		"	"	BADLANDS
1008-17021-2		"		
1008-17021-5		"		
1008-17021-7		"		
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1022-16393-6	"	"	"	"
1024-16505-6	"	"	"	PARALLEL DRAINAGE

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