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PR 568/MMC 200

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TYPE II INTERIM REPORT FOR PERIOD
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Prepared for

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GODDARD SPACE FLIGHT CENTER

Greenbelt Road
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16. Abstract

Land use, water quality and air quality trends (indices) are being deduced from both ERTS-1 MSS imagery and computer compatible tapes. This report covers six months (2nd through 7th) of Phase III - Continuing Data Analysis. Results from this six month period are as follows:

(a) Method of analysis selected in Phase I and II has been used and found to be correct. Striping effects have been examined and found uncorrectable in certain scenes.
(b) Land use for three dates for Site I (Harrisburg, Pa.) and one date for Site II (Wilkes-Barre/Scranton) have been generated
(c) Land use signatures for Site I are found to be acceptable for Site II for the same overflight date.
(d) Water quality indices for one date have been completed.
(e) Mesoscale air quality (turbidity) inferred from MSS data has been compared to Volz Sunphotometer data for five dates. Favorable correlation is shown.
(f) One of the DCP stations is in operation. The second station has had intermittent failures.

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20 September 1973

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Subject: Second Type II Interim Report, PR 568/MMC 200,
Environmental Indices from ERTS-1, NAS 5-21482

Gentlemen:

The MITRE Corporation is pleased to submit the attached second Type II Interim Report. This report covers the third phase of the contract (Continuing Analysis Phase) performed between March 1, 1973 and August 31, 1973.

Questions concerning this report should be directed to the principal investigator, Mr. Edward A. Ward at (703) 893-3500, extension 2237 or to the undersigned at (703) 893-3500, extension 2222.

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PREFACE

There are two objectives of this investigation. The first is to develop land use, water quality, and air quality indices which reveal the trends most useful to the environmental resources manager whether at the Federal, state or local level. The second objective is to define the system (software and hardware) which can produce these indices.

This interim report covers six months (2nd through 7th) of the Continuing Analysis Phase, Phase III. Phase III began on 1 February 1973 and will be completed on 31 December 1973. Results to date show promise in the generation of useful land, water and air trends (indices) using digital processing of the MSS computer compatible tapes (CCT's). The need for aircraft under-flight imagery is still found to be necessary in order to generate signatures with fidelity. A significant amount of our effort during this six months period was spent on understanding and/or eliminating the every sixth line striping error effect. After making changes in our method of handling CCT's and receiving improved CCT's from GSFC we find that striping still occurs in certain scenes.

Redirection of this project occurred in late June 1973 by the NASA Technical Officer and established an order of priority for the remainder of MITRE's investigation. The redirection placed a more concentrated effort on land use analysis for seasonal coverages of both test sites, development of water quality indices along the Susquehanna River at a number of target areas for one coverage date, and continuance of the mesoscale air turbidity correlation analysis on a noninterference basis with the land and water analysis. The microscale air pollution analysis of point sources would continue, as they are detected, during analysis of land use and water quality. Results of progress during this reporting period for all three areas are summarized here under the appropriate heading, and reported in detail in the body of the report.

Land Use

At the time of the last Type II report, spectral signature information for land use classification had been developed for the 1 August 1972 coverage of Test Site 1 (Harrisburg), and signature development was in progress for the 11 October 1972 coverage. The following are highlights of the land use investigation results since that time during this six month reporting period:

- U-2 photography became available for both test sites during this period. Through use of the Zoom Transfer Scope with the photography and USGS base maps, the capability for signature development and verification was considerably enhanced.
- Twelve valid land use classifications based on ERTS signatures for the 11 October coverage of Test Site 1 were successfully completed.
- ERTS-1 analysis and quantification of land use acreage was compared to actual land use acreage compiled by the Tri-County Regional Planning Commission for 18 municipalities in the Harrisburg area in 1967. A skill score of 85 percent agreement was achieved with the Tri-County land use data, and the

ERTS - derived land use data. Most experimenters have achieved this skill score using non-ground truth data and/or less resolution (> 50 acres).

- The land use signature information developed in Test Site 1 for 11 October was successfully applied in a classification of Test Site 2 (Wilkes-Barre/Scranton) for the same date. This is a northward translation of approximately 150 kilometers.
- New signature information was developed to classify the strip mines which are the prevalent physical feature in Test Site 2.
- Work is currently in progress to classify land use for the 9 January 1973 coverage of both Test Sites and to identify temporal trends automatically. At least two other dates will also be analyzed to complete seasonal variation over one calendar year.

Water Quality

As reported in the previous six month's Type II Report, four levels of water turbidity had been identified in a Potomac River training area. A striping effect, every sixth line lighter than normal, however, has inhibited the analysis of the lower Potomac. Highlights of progress since last Type II Report are as follows:

- Striping was corrected to some extent by GSFC, but some scenes were found to be uncorrectable. Water Quality Analysis of two areas were performed- some of the lower Potomac and 200 kilometers of the Susquehanna River for the 11 October date.

- Signature information was developed to classify five levels of water turbidity from the 11 October Susquehanna River coverage.
- Water quality indices were calculated for 10 target areas along 200 kilometers of the Susquehanna River. Each target had been identified as areas of priority interest by the Commonwealth of Pennsylvania and/or EPA personnel.
- Three of the 10 target areas had point source turbid plumes which were detected in the ERTS-1 imagery.
- One Data Collection Platform (DCP) at Lewisburg has been in operation since April 1973, and the second at Towanda, which has had operating problems, is expected to be on line in October 1973.
- In response to a request by EPA's Region III, MITRE checked ERTS coverage of a flooded area of west-central Pennsylvania ($\sim 750\ km^2$) to determine if ERTS would be useful for flood damage assessment. Unfortunately there was excessive cloud cover on all dates reasonably close to the date of the flood.

Air Quality

Analysis of air quality for the first six month period was concentrated on a correlation of ERTS average grayness, from the 0.5 - 0.6 μ MSS channel with NOAA/EPA Turbidity Network observations for dates corresponding to ERTS coverage. With priority placed on land use and then water quality analysis, air quality analysis was conducted during the present six month period so as not to interfere with the effort in the other two areas. Results of progress are highlighted as follows:

- ERTS average grayness was calculated for two additional coverages. Good correlation trends with Turbidity Network data which was previously reported is continuing.
- In the course of the water quality analysis of the Susquehanna River, three distinct microscale air pollution plumes were detected. The point sources have been identified as two power plants (Brunner Island and Delmarva) and a lime kiln (Annville). The air pollution plume signature analysis for the Brunner Island powerplant is in progress at the close of this reporting period.

In general, significant progress has been made in all three areas of investigation during this reporting period. The investigation is on schedule, and it is expected that all major objectives will be achieved.

1.0 INTRODUCTION

This Type II Report describes the progress made by The MITRE Corporation during the second six months of effort on Contract NAS 5-21482, Investigation to Determine Environmental Indices from ERTS-1 Data. The specific objectives of the MITRE investigation include the following:

- Land use trends (indices) for two test areas in Pennsylvania over the August 1972 - September 1973 time period - once per season.
- Air quality/turbidity mesoscale trends (indices) over a large area of Pennsylvania for the August 1972 - September 1973 time period (This objective has been de-emphasized according to instructions received from the NASA Project Office).
- Water quality indices along the Susquehanna River for one overflight date, October 11, 1972.
- Specifications for an operational system using an ERTS-type system, and selected analysis software for water, land and air environmental indices calculation and display.
- Special report on the possibility of automatic digital signature determination, i.e., the elimination of signature redeterminations for each imagery.
- Cost - benefits of producing these environmental indices.

The investigation is comprised of three distinct phases. These are: (1) Phase I: Data Analysis Preparation; (2) Phase II: Preliminary Data Analysis; and (3) Phase III: Continuing Data Analysis.

This report describes tasks underway during six months of Phase III.

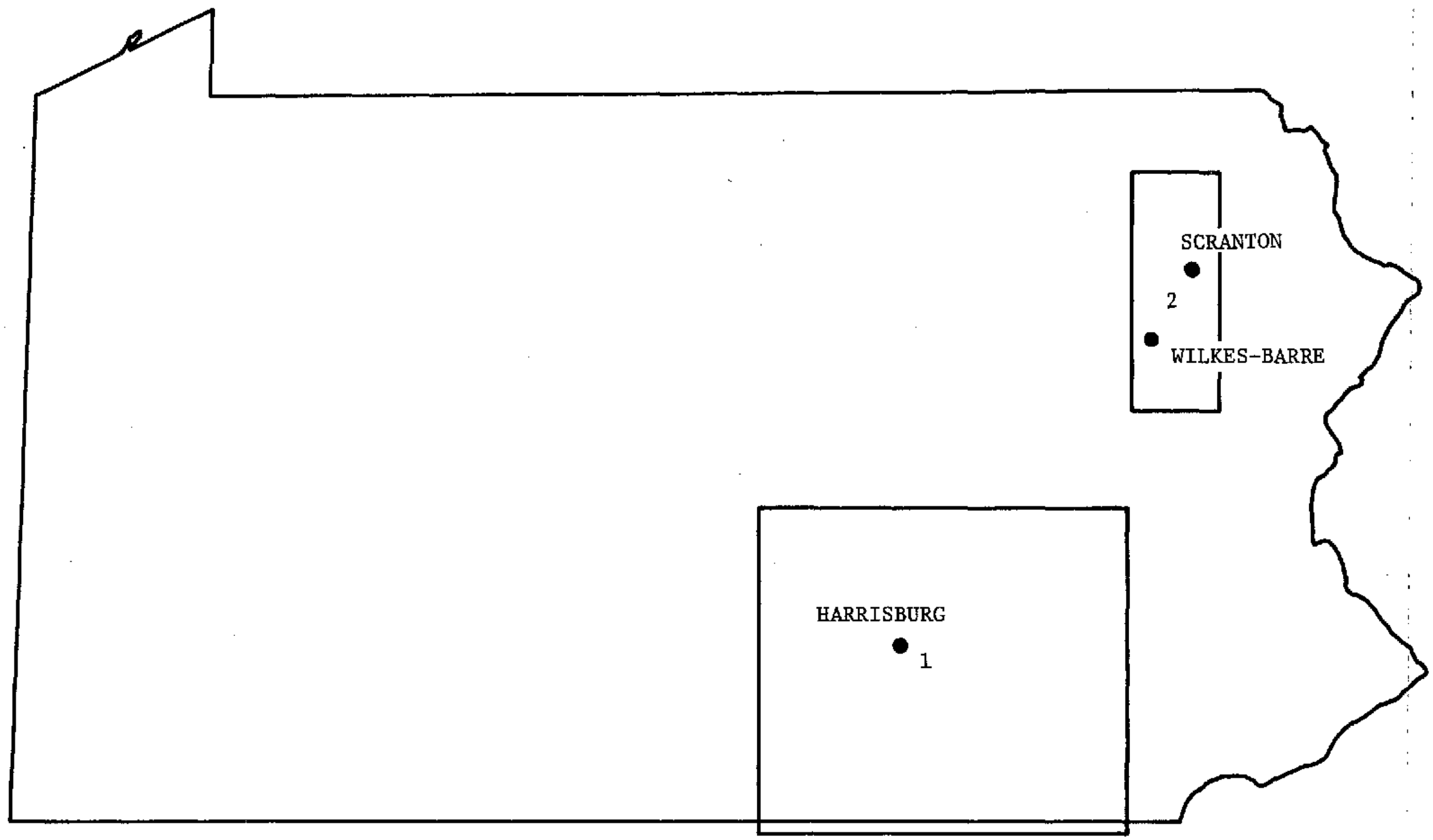
The work involved in each of the first two phases was described in our first Type II Report according to the following outline:

- Phase I: Data Analysis Preparation
  - MSS Experiment Planning
  - DCP Experiment Planning
  - MSS Implementation
  - DCP Implementation
- Phase II: Preliminary Data Analysis
  - First ERTS-1 Data Analysis
  - Data Analysis Plan Development
  - Data Requirements Revision

Phase I was essentially the resource review, planning, and testing out stage for the investigation. Optimum use of the Data Collection Package (DCP) was made; software and techniques for processing MSS data were developed and tested; appropriate environmental parameters in the areas of land use, water quality, and air quality were selected; and the two test sites in Pennsylvania were reviewed with Federal and Commonwealth personnel (see Figure 1 for test site boundaries).

Phase II was the stage wherein preliminary analysis of ERTS data was performed and the Data Analysis Plan for the remainder of the investigation was refined and formalized.

During Phase II land use for 1 August 1972 was completed and 11 October 1972 partially completed. Also water quality for 11 October 1972 was partially completed but ran into striping problems in the raw data. During Phase II air quality for 1 August, 11 October and



PENNSYLVANIA

FIGURE 1
MITRE ERTS-1 TEST SITES

16 November 1972 were completed and compared to ground based measurements.

Phase III, the Continuing Analysis Phase, has been in progress for seven months. Selection of the overflight dates to be analyzed has been inhibited by lack of data. As of the middle of July 1973 the following information on useful data in hand existed.

TABLE 1, OVERFLIGHT DATA IN - HAND

	Test Site 1	Test Site 2
Overflight Opportunities	86	57
Overflight Acceptable*	16	12
Acceptable Overflights which show Training Area in Test Site	3	3

* Less than 20% cloud cover and all four channels good, (G).

Thus it is seen that for only 4.2% of the overflight opportunities do we obtain usable images. Table 2 shows the overflight opportunities which have occurred and Table 3 the acceptable overflight of which the six acceptable dates have been selected. Table 4 below shows the overflight dates selected for land use analysis.

TABLE 2
OVERFLIGHT LOGS

SAT. NO.	I.D. NUMBER: DAYS SINCE LAUNCH	I.D. NUMBER: HOUR	I.D. NUMBER: MIN.	I.D. NUMBER: TNTH. OF MIN.	CLOUD COVER (%) CC	ORBIT NO.	RBV 1	RBV 2	RBV 3	MSS 4	MSS 5	MSS 6	MSS 7	DATE	SITE NO. 1	SITE NO. 2	REMARKS	DATE RECEIVED: TAPE	DATE RECEIVED: B/W IMAGES	DATE RECEIVED: COLOR IMAGES
1	007	15	12	4	100	96	G	G	G	G	G	G	G	Jul. 30		x				
1	007	15	13	1	100	96	F	F	F	G	G	G	G	Jul. 30	x					
1	008	15	18	0	100	111	G	G	G	G	F	G	G	Jul. 31		x				
1	008	15	18	3	100	111	P	P	P	G	F	G	G	Jul. 31	x	x				
1	008	15	18	5	100	111	G	G	G	G	G	G	G	Jul. 31	x					
1	009	15	24	1	40	124	G	G	G	G	G	G	P	Aug. 01	x		Special ordered 9/28/72	11/6/72	11/25/72	12/19/72
1	009	15	24	4	20	124	G	G	G	G	G	G	P	Aug. 01	x		Special ordered 9/28/72	11/6/72	12/29/72	12/19/72
1	025	15	12	4	100	347				F	G	G	G	Aug. 17		x				
1	025	15	13	0	100	347				G	G	G	G	Aug. 17	x					
1	026	15	18	0	90	361				G	G	G	G	Aug. 18		x				
1	026	15	18	2	80	361				G	G	G	G	Aug. 18	x	x				
1	026	15	18	5	80	361				G	G	G	G	Aug. 18	x					
1	027	15	24	2	60	375				G	G	G	G	Aug. 19	x		Reviewed at GSFC-No good			
1	027	15	24	5	60	375				G	G	G	G	Aug. 19	x		Reviewed at GSFC-No good			
1	043	15	13	0	70	598				G	G	P	G	Sep. 04	x	x	Reviewed at GSFC-No good			
1	044	15	18	2	50	612				G	G	P	G	Sep. 05	x	x				
1	044	15	18	5	90	612				F	F	P	G	Sep. 05	x					
1	045	15	24	3	10	626				G	G	P	G	Sep. 06	x		Tape Ordered 10/27/72		10/26/72	5/18/73
1	061	15	12	5	30	849				G	G	G	G	Sep. 22		x				
1	062	15	18	1	20	863				G	G	P	G	Sep. 23		x	CC 100% over site 2		10/30/72	
1	062	15	18	4	40	863				G	G	P	G	Sep. 23	x	x	CC 100% over site 1			
1	062	15	19	0	10	863				G	G	P	G	Sep. 23			Special Order D.C. scene	2/15/73	1/29/73	5/18/73
1	063	15	24	2	90	877				G	G	G	G	Sep. 24	x					
1	079	15	13	1	0	1100				G	G	G	G	Oct. 10		x		12/6/72	11/14/72	3/3/73
1	079	15	13	3	10	1100				G	G	G	G	Oct. 10	x			12/6/72	11/14/72	3/3/73
1	080	15	18	3	0	1114				G	G	G	G	Oct. 11		x		12/5/72	11/17/72	5/18/73
1	080	15	18	5	0	1114				G	G	G	G	Oct. 11	x	x		12/5/72	11/17/72	5/1[illegible]/73
1	080	15	19	2	0	1114				G	G	G	G	Oct. 11	x			12/5/72	11/17/72	3/3/73
1	081	15	24	4	100	1128				G	G	G	G	Oct. 12	x					
1	081	15	25	0	80	1128				G	G	G	G	Oct. 12	x					

TABLE 2 (CONTINUED)
OVERFLIGHT LOGS

SAT. NO.	I.D. NUMBER: DAYS SINCE LAUNCH	HOUR	MIN.	TNTH. OF MIN.	CLOUD COVER (%) CC	ORBIT NO.	RBV 1	RBV 2	RBV 3	MSS 4	MSS 5	MSS 6	MSS 7	DATE	SITE NO. 1	SITE NO. 2	REMARKS	DATE RECEIVED: TAPE	B/W IMAGES	COLOR IMAGES
1	097	15	13	3	100	1351				G	G	G	G	Oct. 28	x					
1	098	15	18	5	100	1365				G	G	G	G	Oct. 29	x	x				
1	098	15	19	1	100	1365				G	G	G	G	Oct. 29	x					
1	099	15	24	3	90	1379				P	G	G	G	Oct. 30	x					
1	099	15	25	0	70	1379				G	G	G	G	Oct. 30	x					
1	115	15	13	4	100	1602				P	G	G	G	Nov. 15	x	x				
1	116	15	19	0	50	1616				G	G	G	G	Nov. 16		x				
1	116	15	19	2	10	1616				G	G	G	G	Nov. 16	x	x			1/9/73	
1	117	15	25	1	70	1630				G	G	G	G	Nov. 16	x					
1	133	15	13	5	10	1853					P	P	G	Dec. 03	x	x			1/17/73	
1	134	15	19	0	100	1867					P	P	G	Dec. 04		x				
1	134	15	19	3	100	1867					P	P	G	Dec. 04	x	x				
1	135	15	25	1	90	1881					G	G	G	Dec. 05	x					
1	151	15	13	4	100	2104				G	G	G	G	Dec. 21	x	x				
1	152	15	19	0	90	2118				G	G	G	P	Dec. 22		x				
1	152	15	19	2	90	2118				G	P	P	G	Dec. 22	x	x				
1	153	15	25	1	90	2132				G	G	G	G	Dec. 23	x					
1	169	15	13	2	80	2355				G	G	G	G	Jan. 08		x				
1	170	15	18	4	0	2369				G	G	G	G	Jan. 09		x			3/19/73	
1	170	15	19	1	0	2369				G	G	G	G	Jan. 09	x			7/15/73	2/15/73	
1	171	15	24	3	30	2383				G	G	G	G	Jan. 10	x					
1	171	15	24	5	10	2383				G	G	G	G	Jan. 10	x				2/13/73	
1	187	15	13	3	0	2606				G	G	G	G	Jan. 10		x			3/3/73	
1	187	15	14	0	0	2606				G	G	G	G	Jan. 26	x				3/3/73	
1	188	15	18	5	70	2620				G	G	G	G	Jan. 27		x				
1	188	15	19	2	90	2620				G	G	G	G	Jan. 27	x	x				
1	188	15	19	4	90	2620				G	G	G	G	Jan. 27	x					
1	189	15	25	0	90	2634				G	G	G	G	Jan. 28	x					
1	189	15	25	3	90	2634				G	G	G	G	Jan. 28	x					
1	205	15	13	2	0	2857				G	G	G	G	Feb. 13		x			3/29/73	
1	205	15	13	5	0	2857				G	G	P	G	Feb. 13	x	x			3/29/73	
1	205	15	14	1	0	2857				G	G	P	G	Feb. 13	x				3/27/73	

TABLE 2 (CONTINUED)
OVERFLIGHT LOGS

SAT. NO.	I.D. NUMBER: DAYS SINCE LAUNCH	HOUR	MIN.	TNTH. OF MIN.	CLOUD COVER (%) CC	ORBIT NO.	RBV 1	RBV 2	RBV 3	MSS 4	MSS 5	MSS 6	MSS 7	DATE	SITE NO. 1	SITE NO. 2	REMARKS	DATE RECEIVED: TAPE	B/W IMAGES	COLOR IMAGES
1	206	15	19	1	10	2871				G	G	G	G	Feb. 14		x			3/15/73	
1	206	15	19	3	20	2871				G	G	G	G	Feb. 14	x	x			3/15/73	
1	206	15	20	0	90	2871				G	G	G	G	Feb. 14	x					
1	207	15	25	2	80	2885				G	G	G	G	Feb. 15	x					
1	207	15	25	4	60	2885				G	G	G	G	Feb. 15	x					
1	223	15	13	4	90	3108				P		G		Mar. 03		x				
1	223	15	14	0	100	3108				G		G		Mar. 03	x	x				
1	223	15	14	3	100	3108				G		G	P	Mar. 03	x					
1	224	15	19	2	100	3122				G	G	G	G	Mar. 04		x				
1	224	15	19	5	100	3122				G	G	G	P	Mar. 04	x	x				
1	224	15	20	1	90	3122				G	G	G	G	Mar. 04	x					
1	225	15	25	3	100	3136				G	G	G	G	Mar. 05	x					
1	225	15	25	5	100	3136				G	P	G	G	Mar. 05	x					
1	241	15	13	4	30	3359				G	G	G	G	Mar. 21		x				
1	241	15	14	1	40	3359				G	G	P	G	Mar. 21	x	x				
1	241	15	14	3	90	3359				G	G	P	G	Mar. 21	x					
1	242	15	19	3	70	3373				G	G	G	G	Mar. 22		x				
1	242	15	19	5	50	3373				G	G	G	G	Mar. 22	x	x				
1	242	15	20	2	30	3373				G	G	G	G	Mar. 22	x					
1	243	15	25	3	0	3387				G	G	G	G	Mar. 23	x			5/9/73	5/4/73	
1	243	15	26	0	0	3387				G	G	G	G	Mar. 23	x			5/9/73	5/4/73	
1	259	15	13	4	100	3610				G	G	G	G	Apr. 08		x				
1	259	15	14	1	100	3610				G	G	G	G	Apr. 08	x	x				
1	259	15	14	3	100	3610				G	G	G	G	Apr. 08	x					
1	260	15	19	2	10	3624				G	G	G	G	Apr. 09		x				
1	260	15	19	5	10	3624				G	G	G	G	Apr. 09	x	x		5/24/73	5/25/73	
1	260	15	20	1	10	3624				G	G	G	G	Apr. 09	x			5/24/73	5/25/73	
1	261	15	25	3	80	3638				G	G	G	G	Apr. 10	x			5/21/73	5/25/73	
1	261	15	26	0	70	3638				G	G	G	G	Apr. 10	x					
1	277	15	13	3	100	3861				G	P	G	G	Apr. 21		x				
1	277	15	14	0	100	3861				G	P	G	G	Apr. 26	x	x				
1	277	15	14	2	100	3861				G	P	G	G	Apr. 26	x					
1	278	15	19	2	100	3875				P	P	G	P	Apr. 27		x				

TABLE 2 (CONCLUDED)
OVERFLIGHT LOGS

SAT. NO.	I.D. NUMBER: DAYS SINCE LAUNCH	I.D. NUMBER: HOUR	I.D. NUMBER: MIN.	I.D. NUMBER: TNTH. OF MIN.	CLOUD COVER (%) CC	ORBIT NO.	RBV 1	RBV 2	RBV 3	MSS 4	MSS 5	MSS 6	MSS 7	DATE	SITE NO. 1	SITE NO. 2	REMARKS	DATE RECEIVED: TAPE	DATE RECEIVED: B/W IMAGES	DATE RECEIVED: COLOR IMAGES
1	278	15	19	4	100	3875				P	P	G	P	Apr. 27	x	x				
1	278	15	20	1	100	3875				P	P	G	P	Apr. 27	x					
1	279	15	25	3	100	3889				G	G	G	G	Apr. 28	x					
1	279	15	25	5	90	3889				G	G	G	G	Apr. 28	x					
1	295	15	13	3	40	4112				G	G	G	G	May 14		x				
1	295	15	13	5	40	4112				G	G	G	G	May 14	x	x				
1	295	15	14	2	30	4112				G	G	G	G	May 14	x					
1	296	15	19	1	90	4126				P	P	G	G	May 14		x				
1	296	15	19	3	80	4126				P	P	G	G	May 15	x	x				
1	296	15	20	0	80	4126				P	G	G	G	May 15	x					
1	297	15	25	2	0	4140				G	G	G	G	May 16	x			6/23/73	6/17/73	
1	297	15	25	4	0	4140				G	G	G	G	May 16	x			6/23/73	6/17/73	
1	313	15	13	2	30	4363				G	G	G	G	Jun. 01		x				
1	313	15	13	4	10	4363				G	G	G	G	Jun. 01	x	x			6/10/73	
1	313	15	14	1	10	4363				G	G	G	G	Jun. 01	x		›	6/13/73	6/10/73	
1	315	15	25	1	70	4391				G	G	P	G	Jun. 03	x					
1	315	15	25	3	60	4391				G	G	P	G	Jun. 03	x					
1	331	15	13	0	90	4614				G	G	G	G	Jun. 19		x				
1	331	15	13	3	100	4614				G	G	G	G	Jun. 19	x	x				
1	331	15	13	5	100	4614				G	G	G	G	Jun. 19	x					

TABLE 3
ACCEPTABLE OVERFLIGHT DATES FOR SITE 1 & SITE 2

SITE #1

SAT. NO.	I.D. NUMBER: DAYS SINCE LAUNCH	HOUR	MIN.	TNTH. OF MIN.	CLOUD COVER (%) CC	ORBIT NO.	RBV 1	RBV 2	RBV 3	MSS 4	MSS 5	MSS 6	MSS 7	DATE	REMARKS	DATE RECEIVED: TAPE	B/W IMAGES	COLOR IMAGES
1	079	15	13	3	10	1100				G	G	G	G	Oct. 10	Covers only mouth of Susquehanna	12/6/72	11/14/72	3/3/73
1	080	15	18	5	0	1114				G	G	G	G	Oct. 11	1st Harrisburg date	12/5/72	11/17/72	5/18/73
1	080	15	19	2	0	1114				G	G	G	G	Oct. 11	too far south of Harrisburg	12/5/72	11/17/72	3/3/73
1	116	15	19	2	10	1616				G	G	G	G	Nov. 16	High Cirrus throughout image		1/9/72	
1	170	15	19	1	0	2369				G	G	G	G	Jan. 09	2nd Harrisburg date	7/15/73	2/15/73	
1	171	15	24	5	10	2383				G	G	G	G	Jan. 10	Site 1 inadequately covered		2/13/73	
1	187	15	14	0	0	2606				G	G	G	G	Jan. 26	Mouth of Susquehanna only		3/3/73	
1	206	15	19	3	20	2871				G	G	G	G	Feb. 14	cloud cover 100% over Harrisburg		3/15/73	
1	243	15	25	3	0	3387				G	G	G	G	Mar. 23	too far west of Harrisburg	5/9/73	5/4/73	
1	243	15	26	0	0	3387				G	G	G	G	Mar. 23	too far south of Harrisburg	5/9/73	5/4/73	
1	260	15	19	5	10	3624				G	G	G	G	Apr. 09	3rd H-burg date-Cirrus confusion	5/24/73	5/25/73	
1	260	15	20	1	10	3624				G	G	G	G	Apr. 09	Susquehanna Mouth only	5/21/73	5/25/73	
1	297	15	25	2	0	4140				G	G	G	G	May 16	too far west of Harrisburg	6/23/73	6/17/73	
1	297	15	25	4	0	4140				G	G	G	G	May 16	too far south west of Harrisburg	6/23/73	6/17/73	
1	313	15	13	4	10	4363				G	G	G	G	Jun. 01	too far east of Harrisburg		6/10/73	
1	313	15	14	1	10	4363				G	G	G	G	Jun. 01	Susque. Mouth - no Harrisburg	6/13/73	6/10/73	

SITE #2

1	079	15	13	1	0	1100				G	G	G	G	Oct. 10	too far east of Wilkes-Barre	12/6/72	11/14/72	3/5/73
1	080	15	18	3	0	1114				G	G	G	G	Oct. 11	1st Scranton/W B date	12/5/72	11/17/72	5/18/73
1	080	15	18	5	0	1114				G	G	G	G	Oct. 11	too far south of Scranton/W B	12/5/72	11/17/72	5/18/73
1	116	15	19	2	10	1616				G	G	G	G	Nov. 16	High Cirrus throughout		1/9/72	
1	170	15	18	4	0	2369				G	G	G	G	Jan. 09	2nd Scranton/W B date		3/19/73	
1	187	15	13	3	0	2606				G	G	G	G	Jan. 26	too far So. of Scranton/W B		3/3/73	
1	205	15	13	2	0	2857				G	G	G	G	Feb. 13	does not show W B or Susque.		3/29/73	
1	206	15	19	1	10	2871				G	G	G	G	Feb. 14	CC approx. 80% over test site		3/15/73	
1	206	15	19	3	20	2871				G	G	G	G	Feb. 14	CC actually 60-70%		3/15/73	
1	260	15	19	2	10	3624				G	G	G	G	Apr. 09	3rd Scranton/W B date	5/24/73	5/25/73	
1	260	15	19	5	10	3624				G	G	G	G	Apr. 09	too far south-west of site	5/24/73	5/25/73	
1	313	15	13	4	10	4363				G	G	G	G	Jun. 01	too far east of Scranton/W B		6/10/73	

*ALL TAPES AND IMAGES WITH A QUALITY RATING, ON ALL 4 MSS BANDS, OF AT LEAST 'G', AND WITH A CLOUD COVER OF 20% OR LESS.

TABLE 4

DATES SELECTED FOR LAND USE ANALYSIS

Test Site 1		Test Site 2	
Date	Image No.	Date	Image No.
Aug. 1, 1973	1009-15244	Oct. 11, 1972	1080-15183
Oct. 11, 1972	1080-15185	Jan. 9, 1973	1170-15184
Jan. 9, 1973	1170-15191	Apr. 9, 1973	1260-15192
Apr. 9, 1973	1260-15195		

MSS data taken for July 7 and/or July 8 overflights are expected to complete our four analysis dates for Test Site 2. Test Site 1 may or may not be analyzed for this July 73 opportunity. This is to be determined, however, after the images and CCT's arrive in the next reporting period.

Redirection of MITRE's efforts took place at GSFC in late June 1973. At this time the cognizant ERTS Technical Officer directed our efforts to be placed firstly on land use and land use change, secondly on water quality, and to apply any remaining time and resources to reasonable air quality efforts. In Section 2.0 of this report, MITRE reports on the Phase III activities and results to date. In Section 3.0, MITRE's program for the next reporting period is discussed.

2.0 PHASE III - CONTINUING DATA ANALYSIS

During the period of the MITRE investigation reported in the first Type II Report, Phases I and II were completed and the tasks of Phase III, Continuing Data Analysis, began. The Continuing Data Analysis Phase has proceeded through the next six month period which is covered by this report. Figure 2 shows the complete work schedule from the period covered by this report through to the completion of the investigation.

This schedule has been followed through the last six months although, as noted in Section 1 above, there has been greater emphasis placed on the priority ranking of land use, then water quality, and lastly, air quality analysis. There have been no significant deviations from the Data Analysis Plan discussed in the first Type II Report submitted in February 1973. The availability of U-2 photography and use of the Zoom Transfer Scope during this reporting period has enhanced and expedited signature development and verification techniques. Continuing data analysis progress for all three areas of investigation are discussed in detail in the Sections which follow. A general summary is included here.

1. Land use: Signatures have been developed and refined for Test Site 1 (Harrisburg) for ERTS-1 coverages of August 1 and October 11, 1972, and most recently for January 9, 1973. Problems in applying all October 11 signatures to January 9 are currently being analyzed. Calculated land use acreage data for October 11 was correlated with land use acreage data provided by the Tri-County Regional Planning Commission, and an overall agreement of 85 percent was determined. Test

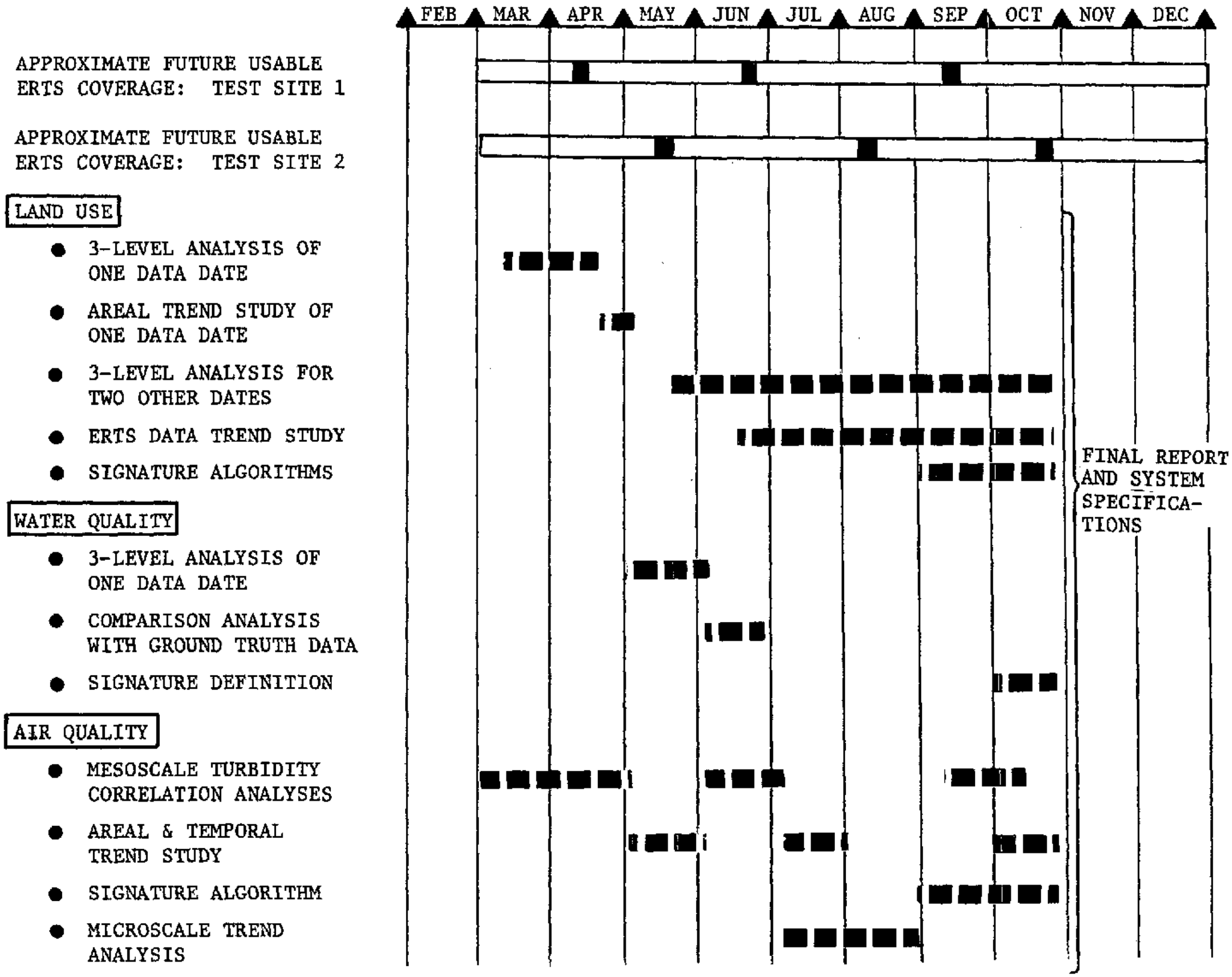


FIGURE 2

ERTS-1 DATA ANALYSIS SCHEDULE - CY 1973

Site 1 signature information for October 11 was successfully applied to Test Site 2 (Wilkes-Barre/Scranton) for the same date. A new set of signature information was developed for strip mines in Test Site 2.

2. Water Quality: Problems with a striping effect in the data received from NASA caused the abandonment of the Potomac River training area, and the investigation shifted to Susquehanna River targets. Five separate categories of water turbidity were determined, and a water quality index was calculated for 10 test areas. Unfortunately, USGS/Harrisburg was unable to provide validated water quality data of the October 11 ERTS coverage date for corroboration. In response to a request from EPA's Region III, a check was made to determine if good ERTS data were available for analysis of a flooded area in west-central Pennsylvania. It was found that there was excessive cloud coverage in the area of interest for all dates of ERTS coverage near the date of the flood.

3. Air Quality: Analysis of ERTS intensity and air turbidity correlation continued at a lower level of effort, with two more correlation dates for a total of five. The correlation of ERTS average grayness and turbidity reported previously is continuing. In the course of the water quality analysis, three air pollution point sources were detected and identified. Signature analysis for the plumes is underway.

2.1 Review of Analysis Methods

The step-by-step analysis for processing ERTS-1 data remains essentially unchanged from our first Type II report. The whole system has four main levels for processing:

- Preliminary Reduction: MSS scan line and element limits of Computer Compatible Tapes (CCT) are set to determine the area to be examined; cloud cover is identified and blanked out; definable spectral boundaries are delineated.
- Level 1 Mapping: Ground truth data and MSS digital output are compared to select the best training areas and classification of features within and near these training areas are performed using supervised analysis software.
- Level 2 Mapping: Signatures within and near training areas are determined independently using the unsupervised analysis software.
- Level 3 Mapping: The final phase is a reiteration and refinement of Levels 1 and 2 so the maximum area will be classified.

Our investigation of parameters land, water and air all follow this general approach; schematics for each, Figures 3, 4 and 5, show specific differences.

The ground information that we are now using consists of U-2 underflights. The U-2 photos are compared with digital maps using the Zoom Transfer Scope (ZTS) at USGS/McLean. The U-2 photos provide an up-to-date outline of our targets and the ZTS presents a quick method of aligning the maps with ground information to select accurate training areas. These two factors have resulted in quicker and more accurate decisions to be made concerning the correctness of signatures and the adjustments necessary to refine signatures.

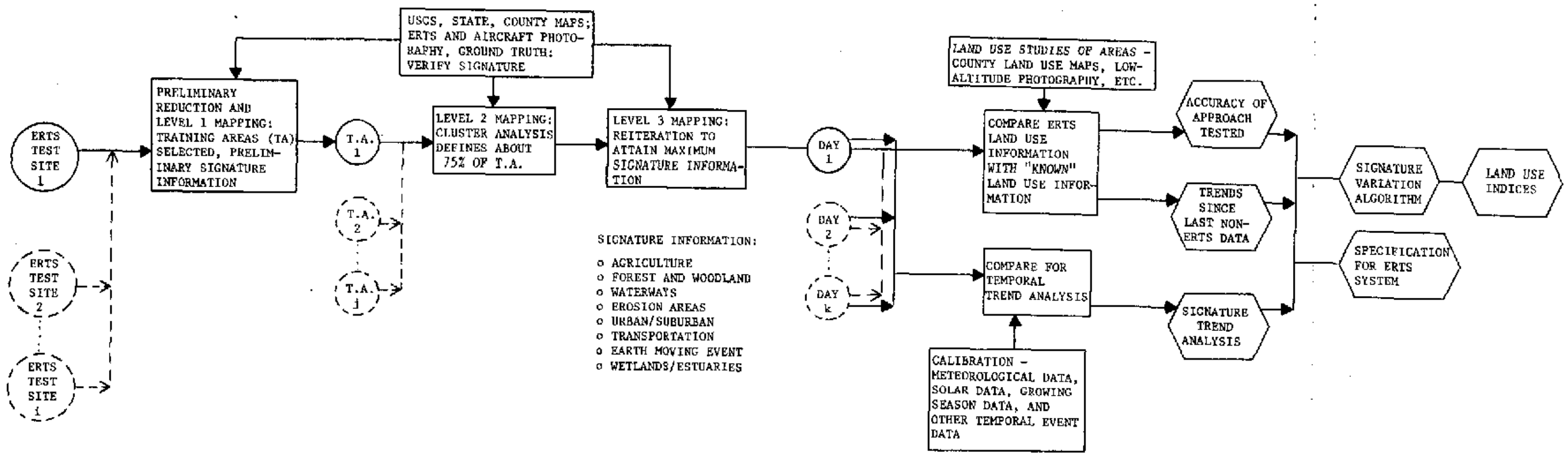


FIGURE 3

ERTS-1 DATA ANALYSIS PLAN: LAND USE

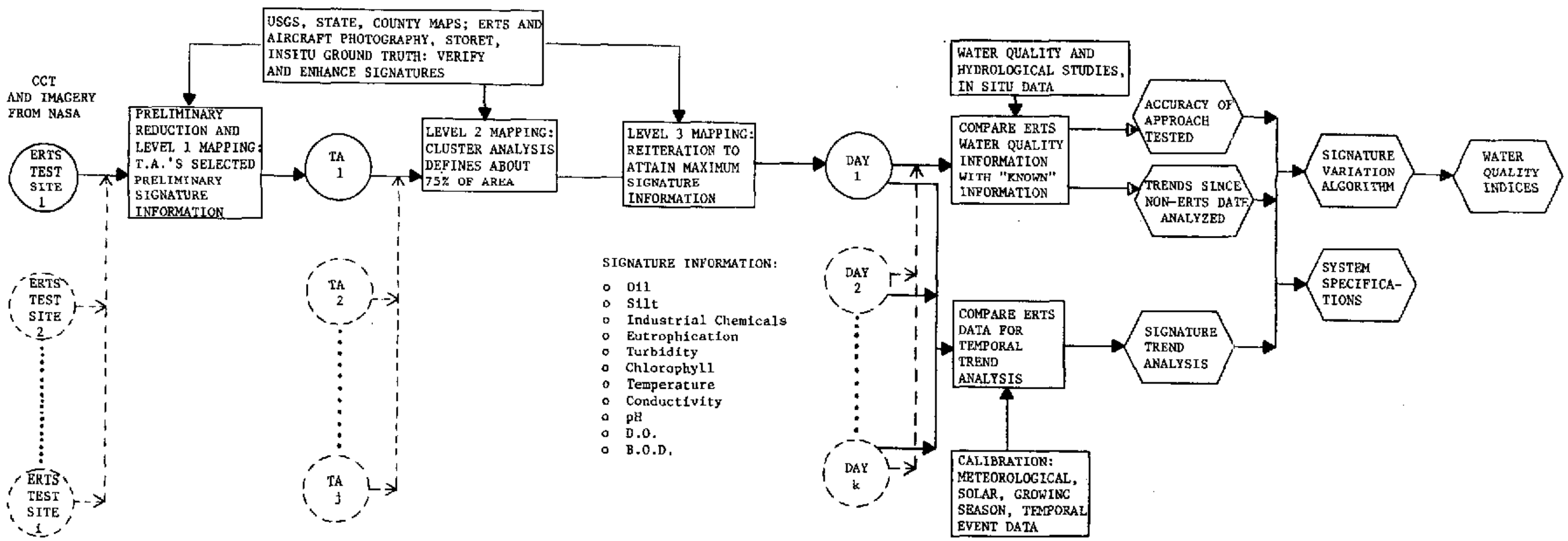


FIGURE 4

DATA ANALYSIS PLAN: WATER QUALITY

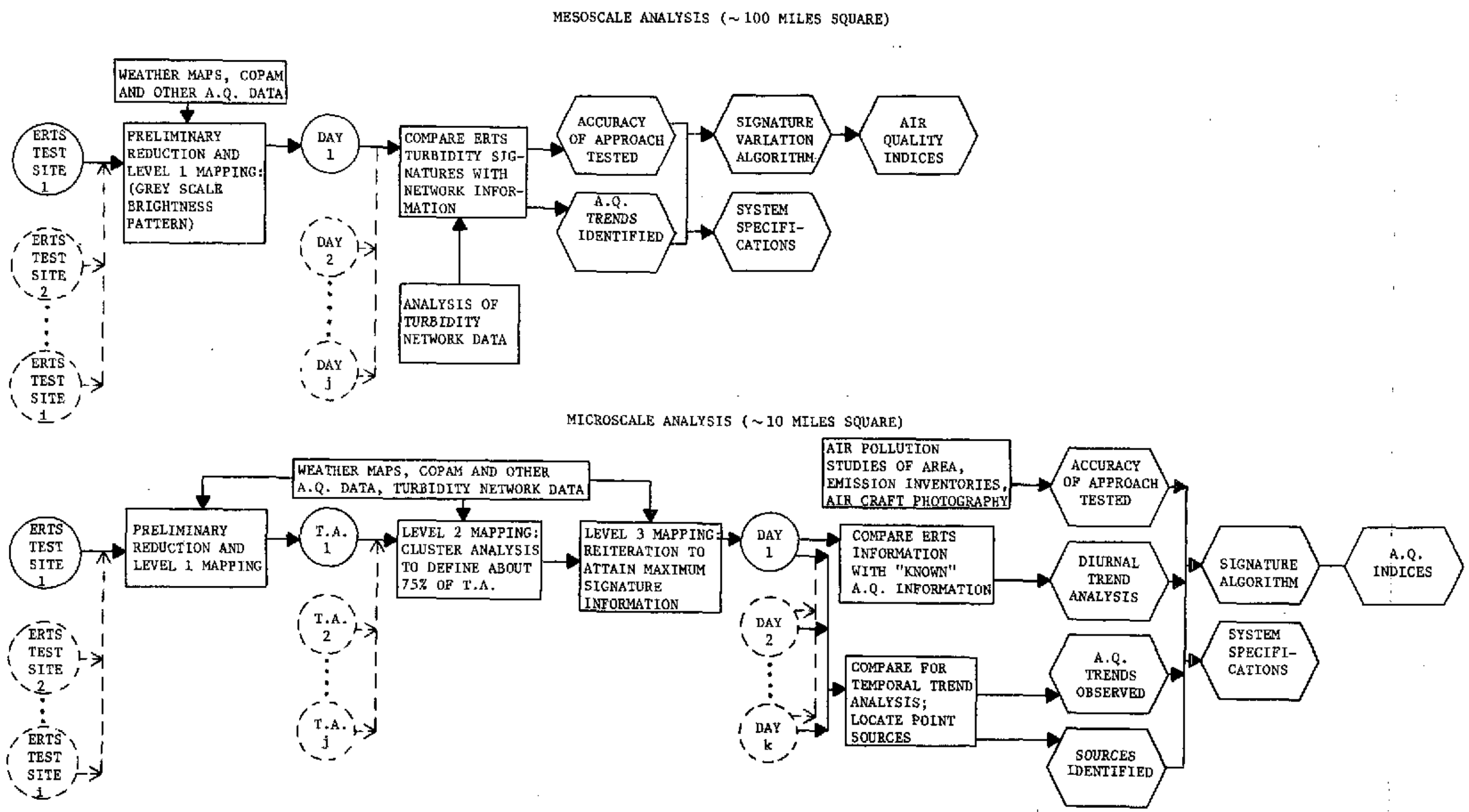


FIGURE 5

ERTS-1 DATA ANALYSIS PLAN: AIR QUALITY

2.2 Land Use-Harrisburg Site

2.2.1 1 August 1972 Land Use Analysis - Site 1

The land use analysis for 1 August 1972 (1009-15244) as reported by MITRE in the first Type II Report was performed in order to checkout existing software and to try classification of the Harrisburg area without the aid of photo-interpreters or imagery other than ERTS.

It was found that a supervised classification could identify 85-90 percent of the area. The remaining areas were then subjected to cluster analysis, or unsupervised classification. This resulted in only 3-4 percent remaining unclassified.

Once land areas where classified, there existed problems in naming categories. Some of the targets such as water and forest were easily identified. After that most categories were only generally named. This was in part due to the fact that it is not easy to distinquish or name categories from their signatures. The USGS maps were of limited use since they did not go into the detail required. It was found that ground or aircraft information would have been helpful. The final digital maps for this effort were based on eleven signatures. The breakdown of categories is given in Table 5.

The results of this digital test run of ERTS-1 data pointed up the need for ground information or underflights to be used to interpret the maps. The USGS 7-1/2 minute quad maps do not provide the detail needed and in most cases were out-dated for rapid transitions areas. Because of this, the use of USGS maps alone to support ERTS-data-based mapping became inadvisable.

TABLE 5

SUMMARY OF CLASSIFICATIONS FOR 1 AUGUST 1972, SITE 1

Category Name	Count	Percent
Forest 1*	6990	9
Rail	1431	2
River	6691	8
Grass 1*	1908	3
Urban	2253	3
Grass 2*	10123	12
Forest 2*	10723	14
Roof	247	0
Suburb	27872	22
Highway	3824	4
Creek	1936	2
Open Land	10098	13
Building	3088	4
Other	2850	4

*Forest 1 and Forest 2 classify coniferous and deciduous trees. Grass 1 and Grass 2 classify fields or overgrown areas.

2.2.2 11 October 1972 Land Use Analysis - Site 1

The development of the 11 October 1972 land use maps followed the method of analysis discussed in our Data Analysis Plan (DAP). Intensity maps (N-MAP) were produced using 3, 5, and 10 gray scale levels. Using the map with 10 levels it was found that major geographical features (rivers, creeks, islands) and some highways could be identified. Additional areas were located by projecting U-2 photos on the map.

Next uniformity maps (U-MAP) were run. Only large uniform areas were chosen as target areas. Not all areas could be named since they were not near any major geographical feature. These areas were named X_1 through X_n. A statistical analysis (STATS) was then run on these target areas and signatures were developed.

In parallel the photo-interpreter had chosen areas from the U-2 photos that were thought to be good training areas. The unsupervised classification program (D-CLUS) or cluster analysis was run on these areas. Such areas included runway, quarry and many other small targets.

Once signatures were developed for all categories, MITRE began a process of condensing signatures. Classes were condensed by producing distance of separation tables from the classification program D-CLASS. The rules to condense signatures became: (a) combine any signatures whose distance of separation is less than approximately 1.0, providing they are of the same type (i.e., forest with forest, but not forest with field) or (b) combine if one or both is an unknown (X_1 through X_n). Signatures were combined in all cases by taking a weighted mean. Some cases occurred where one signature X was close to signature Y, Y was close to signature Z, but X and Z were not close enough to be combined. A subset table of distance of separation was constructed for these signatures and they were combined as closely as possible.

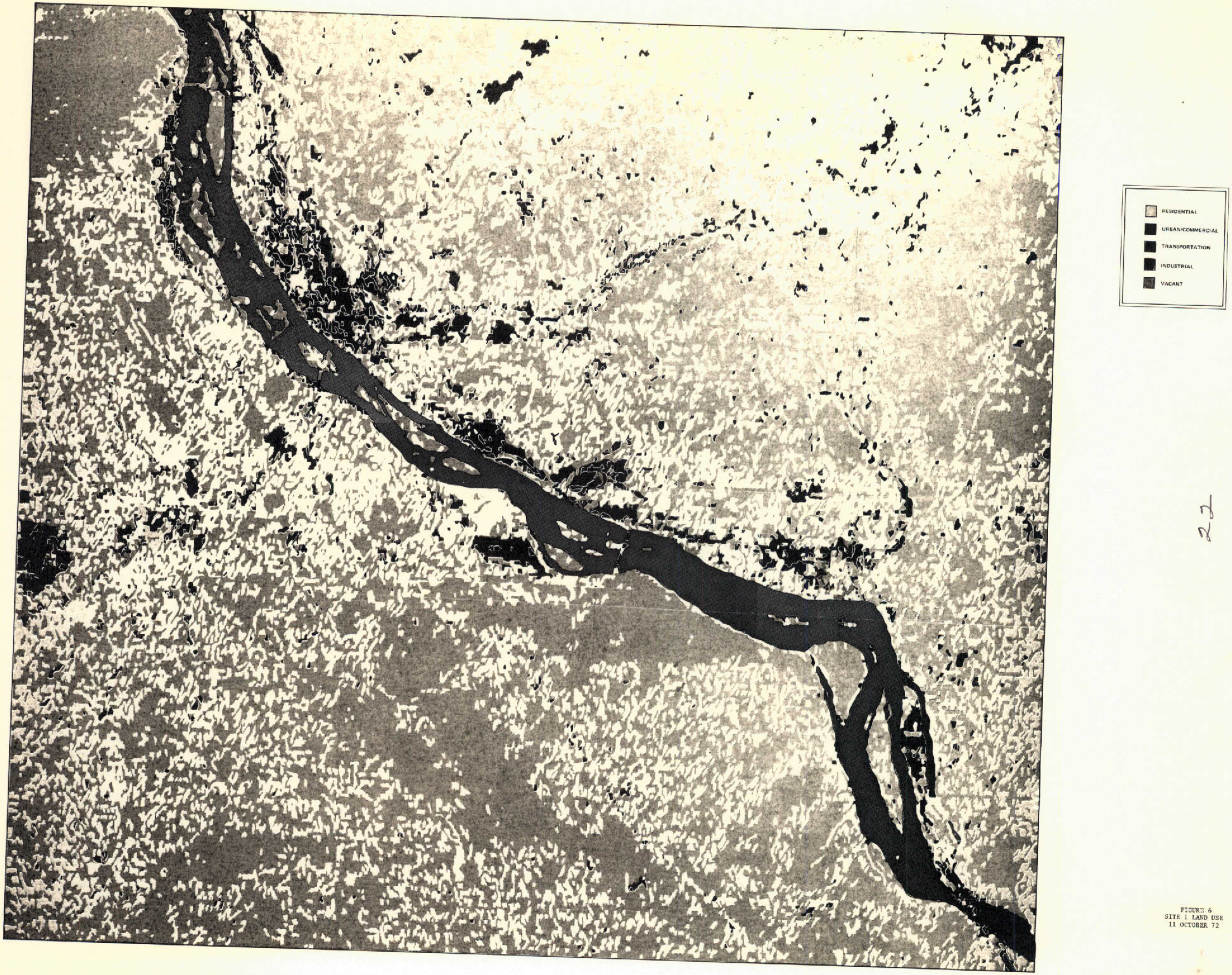
Confusion seemed to arise especially around the Condoguinet Creek area between suburban and field, and in Harrisburg with the railroad and industry signatures. This could not be resolved at this time and the areas were assigned confusion symbols for mapping.

As a result of these manipulations 56 distinct land use signatures remained. It was clear that many still described the same land use feature. Consequently artificially different categories were merged and assigned the same symbol for mapping. The final map, Figure 6, contains 17 distinct categories.

In order to discover the validity of these categories it became necessary to check the ERTS information with ground information. Section 2.2.4 goes into further detail in this area.

While this checking was being performed on the 11 October 1972 map, GSFC was redoing this image to correct for striping (See Section 2.4.2). These corrected tapes along with the decision to change our analysis in search of a quicker means encouraged us to re-do the October 11th land use map.

An intensity map was run for the same scene using every other line and element, i.e., in increments of 2. This was then compared with U-2 photos by use of the Zoom Transfer Scope (ZTS) at USGS/McLean. Using



22

FIGURE 6
SITE 1 LAND USE
11 OCTOBER 72

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the ZTS we were only able to cover small areas (approximately 20 x 30 pixels) before we had to adjust the image due to the fact that the computer maps have inherent distortions. Areas were outlined from the U-2 photo which best represented the categories we hoped to define. Cluster analyses were then run on these areas to develop signatures. Signatures that were found for like areas ie., two agriculture plots, were combined until we had 6 categories (13 subcategories).

Figure 7 is the land use map from the corrected tapes. The Susquehanna River is easily mapped as is both the Condoguinet Creek and Swatara Creek (designated by W). The symbol I (industrial) describes urban areas as well as large building or warehouses. Besides mapping out the industrial sections of Harrisburg, symbol I also identifies the New Cumberland General Depot south of Harrisburg State Airport, the U.S. Naval Reservation Supply Depot, and the Power Plant on Three Mile Island.

The transportation categories, T, identify runways, railroad marshalling yards, and streets in newly developed areas. The residential, R, category describe three types of suburban areas. Finally the category called denuded takes into account fields, agriculture areas and bare areas.

Confusion has occurred between our creek signature and the railroad signature. Our ground information is such that we can not tell if there is possibly sediment, low vegetation, or water in the yards which would give a true response for the creek classification.

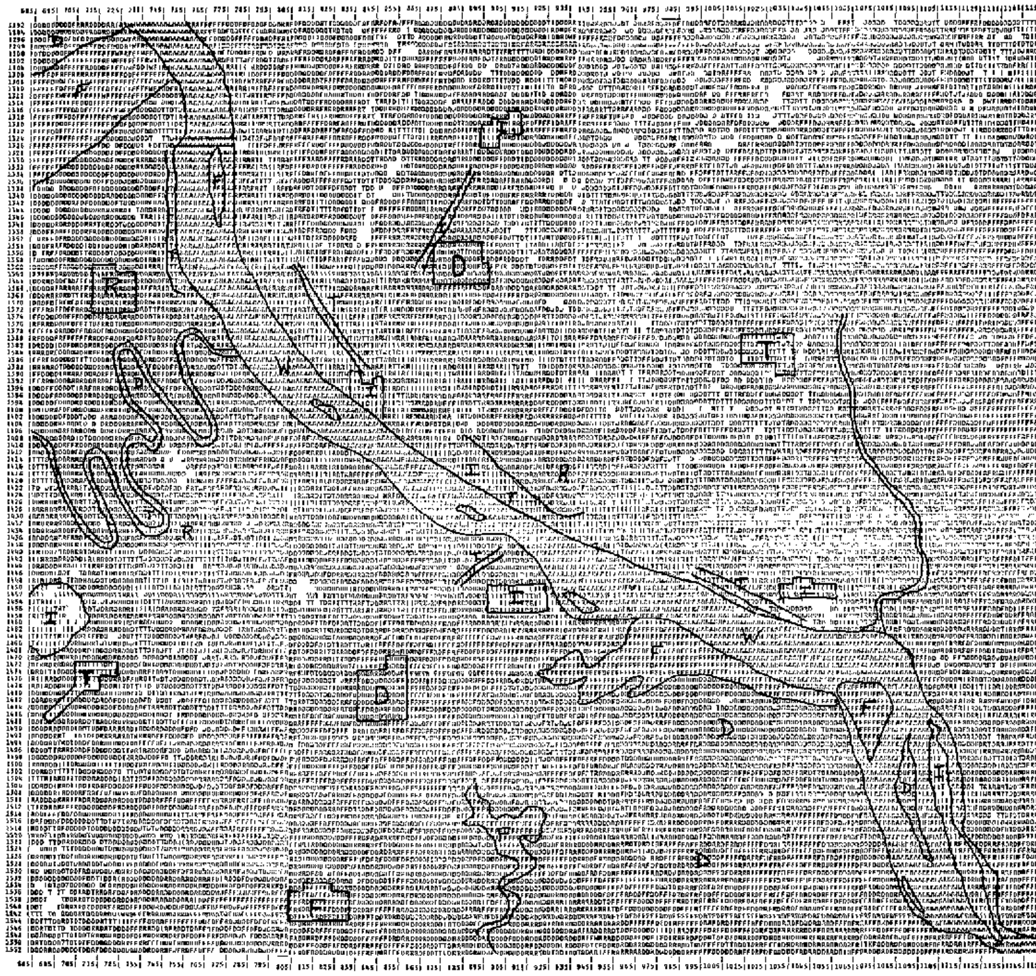

FIGURE 7
CLASSIFICATION MAP OF SITE 1
USING EVERY OTHER PIXEL
11 OCTOBER 1972

The map developed using every other line and element (2 x 2) when compared with the original 11 October 1972 map showed no loss in resolution. We have still been able to pick up such small features as islands and a bridge crossing the northern part of the Susquehanna River.

On the whole this method provides a less expensive and quicker way to produce digital maps of our test areas. For example a 2 x 2 intensity map of an area 250 lines and 450 elements can be processed for around $15.00 and printed out for around $4.00. If we had used a 1 x 1 map, the processing cost would be around $30.00 and the connection time for printout would be $16.00. Of course, the amount saved varies with the computer program used; however there will always be some saving, and our maps still have sufficient resolution to identify our target areas.

2.2.3 <u>9 January 1973 Land Use Analysis - Site 1</u>

The next date for our land use analysis was 9 January 1973. An intensity map (N-MAP) of this area shows no distinct pattern for reflectance, ie., it was hard to pick up such noticable features as the river, creeks, and island. Once we did determine our exact location we classified the area using the signatures for 11 October 1972. This proved to be completely infeasible and so we started developing new signatures for the January image.

The most obvious difference between signatures to date has been water. For 11 October 1972 we needed just one signature to classify the river and one for the creeks. For January we still have one for the creek but we now need three to describe the river.

TABLE 6

RIVER WATER SIGNATURES

	Ch. 4	Ch. 5	Ch. 6	Ch. 7
11 October 1972	19.46	10.50	6.88	1.14
	19.55	12.96	1.81	1.70
9 January 1973	22.33	17.39	11.33	2.55
	21.36	15.93	9.89	1.96

Part of the difference in the January signatures can be explained by ice in the river; the other might be the water turbidity.

We have had no problem re-classifying industrial areas and the transportation categories. Our analysis has now centered on developing signatures for trees, bare area and suburbs which will not be confused with each other. The analysis however, has not been completed in time for inclusion in this report. With the help of some additional analysis efforts; however, the confusion between classes should be corrected and the area classified shortly.

2.2.4 Correlation of ERTS 11 October 1972 Data with Tri-county Regional Planning Commission (TRC) Ground Truth Data for the Harrisburg Test Site

Because one overall objective of the MITRE investigation is to develop land use trend information useful to local, regional, and state planners, an important part of the Continuing Analysis Phase has been dedicated to demonstration that ERTS-1 Data will be a potentially valuable complement to land use information obtained from conventional sources at the local level. Showing a significant correlation between the current ERTS-1 land use analysis and the existing land use information now available to the state, regional, and local planners, is the first essential step in demonstrating the usefulness of ERTS data as an input to the land use planning process. Showing that the ERTS data can be made available to provide land use updates more frequently than conventional means, and with less expenditure of resources, will demonstrate that ERTS is not only a useful tool, but a cost effective one as well.

In reports of the results of other ERTS-1 land use related investigations reviewed to date, correlation is generally accomplished by defining aerial photography and maps produced from photography as ground truth, and checking the results of ERTS imagery interpretation and digital analysis techniques against this ground truth. In most cases, the scale employed has been very large (1:250,000), and the land use classifications have therefore necessarily been generalized. Several examples are the work of John Place, USGS, analyzing land use in the Phoenix Quadrangle in Arizona[1], Simpson and Lindgren at Dartmouth College classifying land use on a state-wide basis in New England[2], and Ernest Hardy at Cornell University classifying a 6,300 square kilometer area in New York state[3]. While these and similar investigations are of

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[1] Place, John L., "Change in Land Use in the Phoenix Quadrangle, Arizona, Between 1970 and 1972," Symposium of Significant Results Obtained from ERTS-1 (NASA, Washington, D. C., 1973) pp. 899-906.

[2] Simpson and Lindgren, "Land Use of Northern Megalopolis," ibid. pp. 973-980.

[3] Hardy, Ernest, "ERTS Evaluation for Land Use Inventory," Report No. NASA-CR-133139 of 13 June 1973 (NASA, Washington, D. C.).

unquestionable value, and verification of ERTS analysis against macro-scale ground truth appears to yield high correlation, the MITRE land use investigation has sought a more specific focus for metropolitan land use analysis. As Alexander indicates in his report of ERTS application in the CARETS area[4], ERTS results will not only be useful in Federal, state, and large regional land use classification as anticipated, but his analysis also shows level of classification in some areas which can prove useful to local planning staffs in smaller, more specific metropolitan areas. MITRE has therefore applied ERTS land use analysis techniques in two test sites at a scale of approximately 1:24,000 and is now correlating the results with the actual land use data presently employed by planners in the area of the test sites. Success in this effort demonstrates that ERTS is not only a valuable tool for a synoptic appraisal of present land use and trends over large areas, but is a source of timely complementary information for land use planning at specific local levels as well.

An approximately 18 mile square area in Test Site 1, centered on the Harrisburg, Pennsylvania metropolitan area, was selected for detailed ERTS-derived land use analysis and correlation with the best available local land use studies. Working at first with the ERTS coverage of 11 October 1972 (frame 1080-15185), land use category signature development has proceeded according to the Data

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[4]Alexander, Robert, "Land Use Classification and Change Analysis Using ERTS-1 Imagery in CARETS," op. cit., pp. 923-930.

Analysis Plan[5]. The minimum area interpreted is approximately one acre, as compared, for example, to about 60 acres for the Cornell University analysis referenced earlier.

When the first complete classification of the Harrisburg area based on ERTS data was completed (See preceding Sections), the next step was to develop the structures for evaluating the results against the land use data available from local planners. The basic source of ground truth, as determined early in the investigation in consultation with Commonwealth of Pennsylvania and local planners, has been the Tri-County Regional Planning Commission (TRC) directed by Mr. Oliver Fanning. The Commission has planning responsibility for the counties of Cumberland, Dauphin, and Perry and is headquartered at Harrisburg. From continually updated tax maps and spot field surveys, TRC compiles acreage by land use for all municipalities in the tri-county area according to the following categories:

- Residential
- Industrial
- Transportation Terminals
- Transportation Facilities
- Retail
- Wholesale and Storage

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[5] Riley, et. al., Data Analysis Plan WP-10209 (McLean, Va.: The MITRE Corporation, February 1973).

- Services
- Public and Semi-Public
- Vacant

From these data, generalized color-coded land use maps are prepared for the entire area. Figure 8, reproduced with the permission of Mr. Fanning, is an example of a currently available area-wide land use map. It is these two sources--the TRC acreage tabulations by land use category, and the land use maps--that form the basis of ground truth for testing the land use classification information analyzed from the ERTS data.

In order to structure a valid basis for comparison of ERTS and TRC results, two conditions were essential. First, both ERTS coverage and ground truth data must cover precisely identical geographic areas; and secondly, ERTS land use signature categories must be defined as exactly as possible to coincide with TRC categories. The first task, then, was to project the boundaries of all municipalities surveyed by TRC onto the digital thematic map of land use symbols produced by analysis of ERTS MSS data tapes. Although some difficulties were encountered with the inherent distortion of computer output maps this was compensated for and a corrected acetate overlay of municipality boundary lines was produced from a 1:24,000 state plane coordinate map of the area provided by TRC. It was found that 18 municipalities of Dauphin and Cumberland Counties lay completely within the area of the ERTS-derived land use map, so these were selected as the area for testing ERTS correlation. The 18 municipalities, with TRC land use acreage,

FIGURE 8
TRI - COUNTY LAND USE MAP
FOR HARRISBURG AREA

are shown in Table 7. Once the correlation test area was selected, the boundary overlay and the ERTS-derived land use map were used for a manual tabulation of ERTS land use symbols for each municipality and for the total area. Results of the tabulation are shown in Table 8. The final step to achieve geographical identity was to convert the ERTS symbol counts to acres so that comparisons could be made with the TRC data. At the 1:24,000 scale employed in the ERTS data analysis, each symbol (pixel) is equivalent to approximately 1.094 acres,[6] with small additional corrections (calculated by MITRE to be a factor of about 0.013) necessitated by variance from nominal orbit of the spacecraft and variance of distance between the spacecraft and Test Site 1 attributable to the oblateness of the earth. It was felt that a simplified method of symbol-to-acre conversion determination was warranted for this analysis. Accordingly, the boundaries of the 18 municipalities and the total area were planimetered for total acreage, so that the ratio of planimetered acreage to total ERTS symbol counts would yield an average factor for converting ERTS symbol counts with categories and for each municipality. The data for the conversion calculation are shown in Table 9.

Having achieved a reasonably common geographical basis for comparing ERTS and TRC land use data, MITRE then found it necessary to define ERTS and TRC land use categories as precisely as possible so that valid

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[6] Goddard Space Flight Center, ERTS Data Users Handbook, Document No. 71 SD 4249. (Each Pixel is 56 meters x 79 meters).

TABLE 7
SITE 1 LAND USE ACREAGE COMPARISON

MUNICIPALITY	SOURCE	LAND USE CATEGORY: URBAN	RESIDENTIAL	TRANSPORTATION	VACANT	TOTAL (DIFFERENCE)
1. CAMP HILL	ERTS	105	742	12	537	1396
	TRC	200	1224	9	227	1659
						(- 263)
2. EAST PENNSBORO	ERTS	241	2034	688	4175	6638
	TRC	202	2695	274	2714	5884
						(+ 754)
3. HARRISBURG	ERTS	1694	1439	432	1366	4932
	TRC	1114	2043	329	1531	5016
						(- 84)
4. HIGHSPIRE	ERTS	101	220	11	187	519
	TRC	61	305	4	163	533
						(- 14)
5. HUMMELSTOWN	ERTS	59	349	3	465	876
	TRC	118	524	86	439	1165
						(289)
6. LEMOYNE	ERTS	164	340	14	512	1027
	TRC	265	521	39	247	1072
						(- 45)
7. LOWER ALLEN	ERTS	209	2303	69	3477	6088
	TRC	354	2643	88	3896	6980
						(- 898)
8. LOWER SWATARA	ERTS	611	2843	267	5030	8752
	TRC	75	1095	427	4890	6488
						(+ 1246)
9. MIDDLETOWN	ERTS	193	511	19	506	1229
	TRC	133	953	82	359	1538
						(- 209)
10. NEW CUMBERLAND	ERTS	39	575	1	468	1083
	TRC	44	1086	13	212	1356
						(- 273)
11. PAXTANG	ERTS	17	107	-	141	265
	TRC	24	172	2	74	272
						(- 7)
12. PENBROOK	ERTS	26	158	-	99	282
	TRC	55	270	1	57	382
						(- 100)
13. ROYALTON	ERTS	12	85	2	95	195
	TRC	3	91	1	141	236
						(- 41)
14. SHIREMANSTOWN	ERTS	-	103	1	58	165
	TRC	7	197	5	22	230
						(- 65)
15. STEELTON	ERTS	422	237	78	242	979
	TRC	491	340	30	251	1111
						(- 132)
16. SWATARA	ERTS	614	2834	154	4441	8044
	TRC	1127	3413	746	4049	9335
						(- 1291)
17. WEST FAIRVIEW	ERTS	16	58	2	80	153
	TRC	9	138	1	34	181
						(- 28)
18. WORMLEYSBURG	ERTS	21	246	18	183	467
	TRC	30	257	1	66	353
						(+ 114)
TOTAL AREA (DIFFERENCE)	ERTS	4542	15182	1271	22060	43092
	TRC	4309	17970	2135	19380	43795
		(+ 233)	(- 2788)	(- 864)	(+ 2680)	(- 703)

*TRC: TRI-COUNTY REGIONAL PLANNING COMMISSION, HARRISBURG, PA.

TABLE 8

ERTS - 1 PIXEL COUNTS AND CALCULATED ACREAGE FOR THE

FOUR COMPARISON CATEGORIES, BY MUNICIPALITY

	URBAN		RESIDENTIAL		TRANSPORTATION		VACANT		TOTAL	
	PIXELS	ACRES	PIXELS	ACRES	PIXELS	ACRES	PIXELS	ACRES	PIXELS	ACRES
1.	95	105.2	670	741.7	11	12.2	485	536.9	1261	1396.1
2.	218	241.3	1837	2033.6	170	188.2	3771	4174.5	5996	6638.2
3.	1530	1693.7	1300	1439.1	390	431.7	1234	1366.0	4455	4932.1
4.	91	100.7	199	220.3	10	11.1	169	187.1	469	519.2
5.	53	58.7	315	348.7	3	3.3	420	464.9	791	875.7
6.	148	163.8	307	399.8	13	14.4	462	511.4	930	1029.6
7.	189	209.2	2080	2302.6	62	68.6	3141	3477.1	5499	6088.0
8.	552	611.1	2568	2842.8	241	266.8	4544	5030.2	7905	8751.7
9.	174	192.6	462	511.4	17	18.8	457	505.9	1110	1228.9
10.	35	38.7	519	574.5	1	1.1	423	468.3	978	1082.7
11.	15	16.6	97	107.4	-	-	127	140.6	239	264.6
12.	23	25.5	143	158.3	-	-	89	98.5	255	282.3
13.	11	12.2	77	85.2	2	2.2	86	95.2	176	194.9
14.	-	-	93	103.0	1	1.1	52	57.6	149	165.0
15.	381	421.7	214	236.9	70	77.5	219	242.4	884	978.7
16.	555	614.4	2560	2833.9	139	153.9	4012	4441.3	7266	8044.2
17.	14	15.5	52	57.6	2	2.2	72	79.7	138	152.8
18.	19	21.0	222	245.8	16	17.7	165	182.7	422	467.2
T	4,103	4,542.0	13,715	15,182.5	1,148	1,270.8	19,928	22,060.3	38,923	43,091.8

TABLE 9

RELATIONSHIP OF ERTS - 1 PIXEL COUNT TO

PLANIMETERED ACREAGE IN TEST SITE 1

MUNICIPALITY	PLANIMETER ACREAGE	ERTS COUNT
1. CAMP HILL	1355.9	1261
2. EAST PENNSBORO	6290.5	5996
3. HARRISBURG	5045.4	4455
4. HIGHSPIRE	521.4	469
5. HUMMELSTOWN	908.8	791
6. LEMOYNE	1006.9	930
7. LOWER ALLEN	6412.1	5499
8. LOWER SWATARA	8288.2	7905
9. MIDDLETOWN	1287.4	1110
10. NEW CUMBERLAND	1068.7	978
11. PAXTANG	272.6	239
12. PENBROOK	287.7	255
13. ROYALTON	189.0	176
14. SHIREMANSTOWN	159.9	149
15. STEELTON	1170.5	884
16. SWATARA	8126.2	7266
17. WEST FAIRVIEW	207.2	138
18. WORMLEYSBURG	493.4	422
TOTAL COUNTS, TEST SITE 1	43091.8	38923

$\therefore$ ERTS-1 PIXEL TO ACRE CONVERSION FACTOR:

$$\frac{43091.8}{38923.0} = 1.107$$

classification comparisons could be made. This has proven to be a complex and difficult task. The main problem was that the TRC data were apparently classified more on an administrative basis, whereas the ERTS data is based on the different spectral characteristics within the test area. For example, tax information and surveys enable TRC to classify land uses such as retail, wholesale and storage, services, and public and semi-public facilities. For these uses in the test site, ERTS data are amenable to the development of signatures which indicate building complexes at perhaps several density levels, but ground truth is clearly required to discriminate between public buildings and private commercial buildings. On the other hand, since TRC relies heavily on tax maps for land use data, farmland and all other land not developed for residence, commerce, industry or transportation is put into the general category of "vacant." In these areas classified vacant by TRC, ERTS data analysis had signatures for the categories of river, creek, forest, field and denuded area. As the TRC staff has stated, the more specific description and quantification of vacant land by ERTS will add valuable information for the planning of future development in the presently vacant areas.

Following discussions with the TRC staff to determine what specific uses were included in their nine categories, and analysis of the signature information derived from ERTS data, it was determined that five common categories would best serve for the comparison of land use acreage. The five common categories are as follows:

1. <u>Industrial</u> - includes all ERTS signatures for industrial and the

total TRC industrial category.

2. Urban - includes the ERTS signatures for urban area and the TRC categories for retail, wholesale and storage, services, and public and semi-public.
3. Vacant - includes the total TRC vacant category and the ERTS signatures for forest, field, and denuded area (TRC did not include river and creek area in their land use acreage).
4. Transportation - includes the ERTS signatures for transportation (railroads and paved runways) and the TRC categories of transportation facilities and transportation terminals.
5. Residential - includes the total TRC residential categories and the ERTS signatures for suburbs.

After several preliminary comparisons were made using these five common categories, it was found that ERTS signatures in the urban and industrial categories were frequently confused. Apparently the present state of analysis is not adequately developed to discriminate consistently between building complexes which are commercial/institutional and those which are industrial in use. Consequently, the industrial and urban categories were merged as urban for correlation purposes, as shown in Table 7.

With a common geographical basis established and reasonably common category definitions determined, all the TRC and ERTS data were re-tabulated into the four correlation categories. When this was completed, an initial scan of the results showed one major discrepancy and several smaller anomolies. The major problem was that for nearly every municipality and for the test site as a whole, the ERTS total acreage for all categories was over 30 percent greater than the TRC total acreage. A re-calculation by planimeter of the total acreage in each municipality and in the total test site confirmed that the ERTS totals were correct, and that TRC totals were low by fully one-third. Obviously some category or categories of land use in the area were not being included in the TRC counts. The smaller anomolies affected the apportionment of acreage among particular municipalities and could very possibly have been the result of annexations or other boundary changes not reflected on the map used for projecting the boundaries of the 18 municipalities. In any event, no explanation for the discrepancies was apparent in the planning studies and other data provided by TRC, so a conference was held in Harrisburg to discuss the problems point by point with the TRC staff.

The conference with the TRC staff was very valuable, both for clarifying discrepancies and for providing an opportunity to review ERTS land use analysis progress with individuals who will be the ultimate users of the information developed. On the first question regarding a possible 30 percent or more acreage undercounting by TRC, the answer was forthcoming after a review of the methods used by TRC in gathering land use data. Because acreage was computed from parcels listed in tax records and maps, sidewalks, streets, highways and rights-of-way generally were not counted in any category as part of total land use by TRC. The planning staff estimated that the streets, sidewalks, and highways for the area under consideration would amount to about 30 percent of total acreage. Since the ERTS data analysis had minimum interpretation resolution of about one acre, streets, sidewalks, and highways were incorporated into the broader land use category signatures in the ERTS results. Apportioniong the street, sidewalk, and highway acreage among the TRC categories, then, would allow a valid basis of comparison of the ERTS and TRC data.

Unfortunately, only the 1967 land use data and maps already on hand were available, and these gave no indication of right-of-way acreage. (The TRC offices are located on Front Street adjacent to the Susquehanna River, and the disastrous flooding caused by Hurricane Agnes in June 1972 destroyed all more recent data, which included street and highway surveys as well as updated land use.) Some individual municipalities could provide estimates of annual amounts of paving materials used on rights-of-way, but there was apparently no reliable way of determining how the acreage was apportioned among the urban, residential, transportation, and vacant categories. In general, the TRC staff agreed that nearly all of the right-of-way acreage should be allocated to the urban and residential categories, since rights-of-way were included in the transportation category, and probably less than one percent of the vacant category would be comprised of streets, sidewalks, and highways. The problem, then, became how most reasonably to allocate the right-of-way acreage (about 10,000 acres) between the urban and residential categories.

The solution ultimately arrived at, and concurred in by Commonwealth of Pennsylvania and TRC planners, was to apportion the acreage between the two categories by a coefficient for the urban and for the residential categories which would result in the optimum statistically significant apportionment for all 18 municipalities and for the total test area. The specific method used to reconcile the difference was a University of California multiple linear regression analysis package[7], which in summary computed the sequence of 18 regression equations to arrive at the best fit for all 18. The results of the computation are shown in Figure 9. These results show that increasing urban acreage by a factor of 2.09320 and increasing residential acreage by a factor of 1.79877, while leaving transportation and vacant acreage unchanged, will result in the best allocation of street, sidewalk, and highway acreage between the urban and residential categories for all 18 municipalities.

To ensure that this allocation procedure was not only statistically significant, but realistic in terms of the actual proportion of right-of-way acreage in metropolitan areas, a meeting was held with officials of the Urban Planning Division of the Department of Transportation in Washington. Their studies and analysis generally confirm that heavily developed downtown areas of cities (which would conform to the urban category definition) will have about 50 percent of their surface area in streets, sidewalks, and highways. MITRE's calculations show that 52 percent of urban acres consisted of right-of-way acreage. The residential category would be comprised of a lesser percentage of right-of-way acreage, and the allocation computations show 44 percent for this category. Further information obtained at a later date from Harrisburg city officials via

[7] Dixon, W. J., ed., BMD - Biomedical Computer Programs (University of California Press, 1968), pp. 233-257.

VARIABLES IN EQUATION

VARIABLE	COEFFICIENT	STD. ERROR	F TO REMOVE
(CONSTANT	0.0)		
URBAN 2	2.09320	1.78487	1.3753 (2)
RESIDL 3	1.79877	0.44922	16.0337 (2)

SUMMARY TABLE

STEP NUMBER	VARIABLE ENTERED	VARIABLE REMOVED	MULTIPLE R	RSQ
1	RESIDL 3		0.8972	0.8050
2	URBAN 2		0.9058	0.8205

FIGURE 9

EXERPT OF RESULTS FROM REGRESSION ANALYSIS COMPUTATION

Commonwealth of Pennsylvania planners also corroborated the finding that street, sidewalk, and highway acreage made up about 50 percent of the land in the city, which further indicates that the statistically derived coefficients of 2.09320 and 1.79877 are reasonable in terms of the actually occurring proportion of right-of-way acreage in metropolitan areas. In the absence of any actual acreage data for the 18 municipalities in the test area and with virtually no other means available for measuring how many acres of streets, sidewalks, and highways should be apportioned to each land use category, MITRE's method of allocation is considered valid for arriving at a common acreage basis for correlation testing.

The several other discrepancies discussed at the conference with the TRC staff were also clarified, and a detailed description of the corrections required may be found in MITRE Corporation Memorandum D22-M-1835 of 6 August 1973. In general the corrections fell into three main categories:

1. Boundary change among the 18 municipalities that were reflected in TRC acreage tabulations but not on older maps which were used to project the boundaries onto the ERTS computer maps.
2. Classification by TRC of one large airport and several large parks as public land, which caused their acreage to be merged incorrectly with the urban category for comparison purposes. These acres were subsequently reassigned to the transportation and vacant categories, respectively.
3. Human error in manual symbol counting and planimetering in

several smaller municipalities with very irregular boundaries. These errors were minor and are considered to have been averaged out over the total 18 municipality test area.

All of the above corrections and adjustments were made to the basic data, including the allocation of the approximately 10,000 right-of-way acres to the TRC urban and residential categories for each municipality. Table 7 shows the category-by-category, municipality-by-municipality comparison of ERTS and TRC land use acreage. As expected, correlations are much better for the total test area than for any of the individual 18 municipalities.

Table 10 shows the summary of correlations for the entire test area including all 18 municipalities. With the exception of the transportation category, the ERTS acreage compares very closely in all areas, and the overall quantitative skill score, as indicated, is 85.0 percent. One reasonable explanation of why the transportation category does not show a higher correlation has since been provided by TRC. The TRC transportation acreage counts include bus and truck terminal buildings in addition to railways and airports. Because Harrisburg is a major highway transshipment point for New York, Philadelphia, Baltimore, Washington, and points west, there are a large number of truck terminals in the test area. These terminal buildings, depending on their size and location, would probably be classified by ERTS as urban, with large open parking areas classified as vacant. If a method is found for accurately quantifying the required adjustments, then the ERTS urban acreage can be reduced, transportation and vacant increased, and the

TABLE 10

COMPARISON OF ERTS - 1 WITH TRC* SURVEY DATA

TEST SITE 1

	URBAN	RESIDENTIAL	TRANSPORTATION	VACANT	TOTAL TEST SITE
TRC DATA (ACRES)	4309	17970	2136	19380	43,795
ERTS DATA (ACRES)	4542	15182	1271	22060	43,092
ACRES IN DISAGREEMENT	+ 233	- 2788	- 865	+ 2680	6,566
PERCENT AGREEMENT	94.6	84.5	59.5	86.2	85.0

* TRI-COUNTY REGIONAL PLANNING COMMISSION (HARRISBURG, PA.)

[redacted]

skill score as a result would be higher. In any event, in light of the requirement for using 1967 acreage data and a 1965 land use base map for ground truth, in addition to the requirement to adjust the ground truth for the inclusion of street, sidewalk, and highway data, the results clearly are significant enough to show that ERTS data analysis does provide a new tool for accurate land use inventory on a local metropolitan scale. It should also be noted that, with average annual population increase of about one percent[8] since 1967, no major changes are expected in the TRC data used as current ground truth.

2.3 Continuing Data Analysis - Land Use in the Wilkes-Barre/Scranton Area

When the initial correlation between ERTS analysis and TRC land use ground truth had been satisfactorily determined for the Harrisburg test area, the next step in Phase III was to apply to Test Site 2 the land use analysis techniques which had been developed and refined in Test Site 1. This part of the Phase III effort has now been underway for about one month. The procedure employed thus far in Test Site 2, which includes the Wilkes-Barre and Scranton area along the upper Susquehanna River, was first to generate an intensity map of the 11 October 1972 frame (1080-15183) at the scale of 1:48,000 for orientation and to familiarize analysts with the general features of the area (See Figure 10). The next step was to run the D-CLASS

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[8] Tri-County Regional Planning Commission, Population (Harrisburg, 1972).

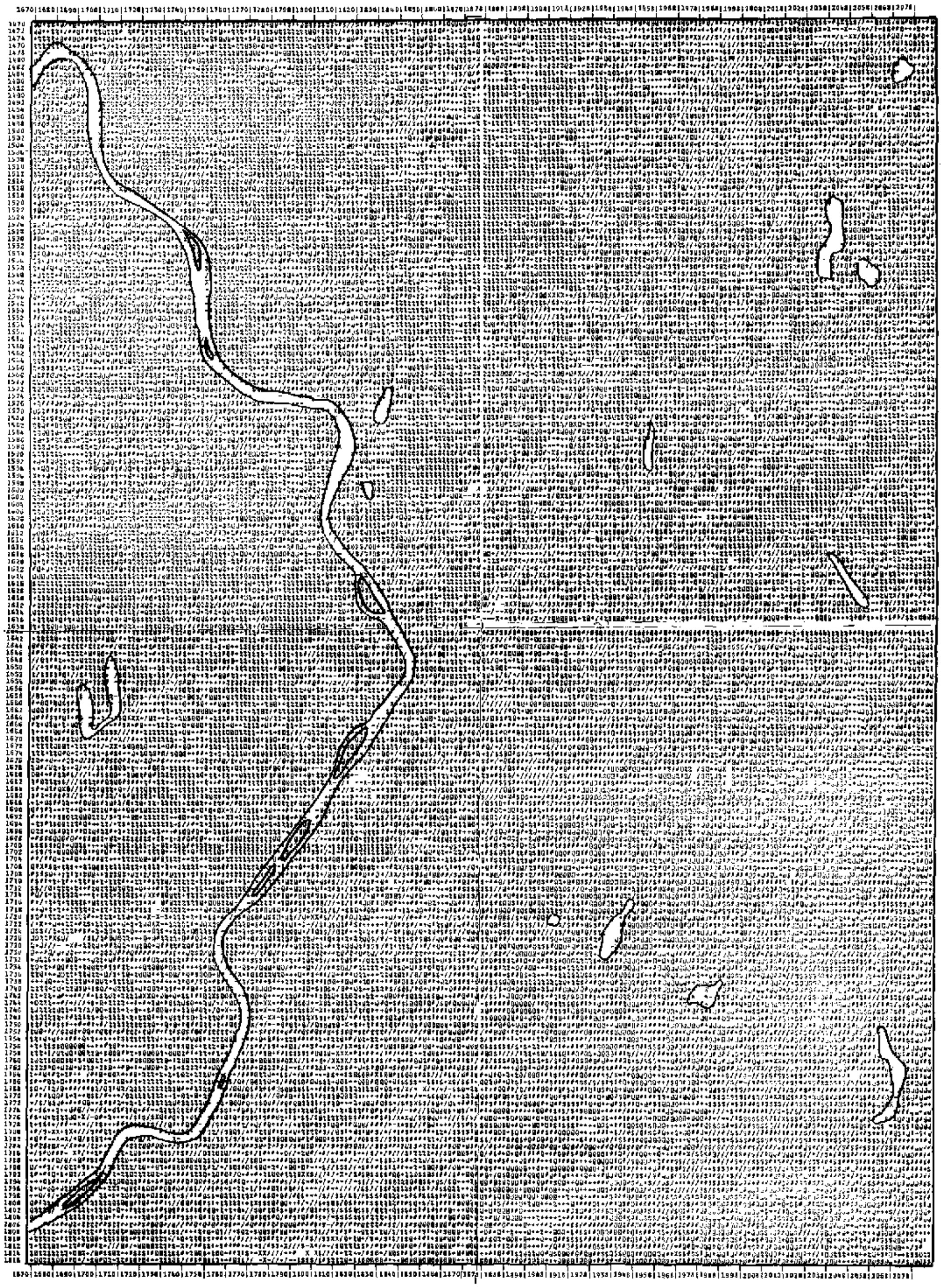

FIGURE 10
INTENSITY MAP FOR SITE 2
11 OCTOBER 1972

program (described in the Data Analysis Plan) using the optimum signature information which had been developed in the Harrisburg test area for 11 October. Initial checks were made with the Zoom Transfer Scope to determine the correlation of the ERTS digital map with the available ground truth. In this case the ground truth consisted of USGS quadrangle maps of the area, January 1973 U-2 photography, and a number of local land use maps and planning documents dated from 1960 through 1972. The application of the Harrisburg signatures to Test Site 2 was generally very successful for the river, urban/industrial, residential, field, and forest categories. However, two difficulties were encountered. First, although the Wilkes-Barre Wyoming Valley Airport was correctly identified by the ERTS analysis, the somewhat larger Wilkes-Barre/Scranton airport at Avoca was confused with several other categories. Secondly, the Harrisburg signature information for denuded areas did not result in the generation of the strip mine symbol for all the areas where the U-2 photography showed strip mines existed. In consideration of the short time remaining before the second Type II Report was required, and of the fact that strip mines were the most prominent features in Test Site 2 except for the Susquehanna, it was decided to concentrate efforts on development of reliable strip mine signatures and to leave the airport problem for later analysis.

One goal of the strip mine signature analysis has been to develop, if possible, distinct signatures for active mining areas, inactive mines, and reclaimed mines. Because inactive and reclaimed mines would be at least partially overgrown, confusion was anticipated with forest and field categories; but it was nevertheless felt that a distinct signature for active strip mines should be obtainable. The first effort, therefore, was directed toward active strip mines.

The major problem in identifying active strip mines appears to be the difficulty in obtaining current ground truth to locate those mines which are presently active, since ground truth that is only one or two years old may show active mining where in fact the area is presently overgrown. From the files of the Pennsylvania Bureau of Mines in Harrisburg, MITRE was able to obtain from permit data the location of several areas where strip mining had been requested. These areas were located on the quadrangle maps, and a cluster analysis was run on the 11 October data. As a result of the cluster analysis, several potential signatures were determined and a classification program was run for a portion of the test area using the Harrisburg signatures and the new possible strip mine signatures. The resulting computer map properly located some of the symbols for the mine signatures, but there was also considerable confusion with forest, field, and denuded areas. A rechecking of the ground truth with officials in the Wilkes-Barre/Scranton area revealed one potential source of analysis problems. The strip mine permit information which was used to pinpoint active strip mines in fact only shows where mining may be carried on, not where operations are actually underway. Much like zoning maps which show what land use is permitted but not necessarily what exists, the permit information was determined to be inadequate in itself to use as ground truth.

Contact has since been made with officials of planning groups in the test area, Pennsylvania Power and Light Company representatives, and coal company representatives to obtain the required up-to-date ground truth on currently active mining areas, to supplement the large land use data base already on hand. Since it may be a matter of weeks before this new information is received, however, it was decided to proceed with the mine signature analysis via another approach. A uniformity map was generated for the entire test area to ascertain the uniformity of the areas believed to be strip mines based on the quadrangle maps and U-2 photography. Statistical analysis programs were run on several uniform areas to develop the mine signature with the smallest standard deviation. The signature information developed was then applied to another portion of the test area not previously analyzed, but believed to have a concentration of strip mines. The result was classification of 69 percent of the small area as strip mines, which appeared to correspond to the percentage of strip mines shown on the maps and photography of the same small area. To map and check the extent and location of strip mining, a digital map was then generated for the entire test site, using only the symbol for water, for orientation, and the new possible strip mine symbol. The results of the mapping are shown in Figure 11. The new signature information produced very separate and distinct groupings of the strip mine category throughout the test site. Very high

FIGURE 11
CLASSIFICATION MAP FOR SITE 2
SHOWING WATER AND MINES

agreement of the order of 80-90 percent was found in comparing the ERTS strip mine areas with the USGS maps and U-2 photography.

One additional means of checking the results of ERTS analysis was available. Another ERTS-1 investigator had analyzed a frame of 11 October 1972, adjacent to MITRE's Test Site 2, and had reported developing four signatures for the culm banks which are found throughout the area.[9] The culm banks are nearly always co-located with strip mines and MITRE's strip mine category definition included the banks, so if the signature information used to identify culm banks were applied to MITRE's Test Site 2 the same areas should appear as mines as when the MITRE strip mine signature was used. The test was made, and the area included by the four signatures coincided very closely with that classified by MITRE's one strip mine signature, as well as with the ground truth. Consequently, the new strip mine signature information was accepted as a valid classification and was added to the list of signatures developed in the Harrisburg test area. The full listing of signature information is shown in Table 11.

The final result achieved up to the time of this report was a computer land use map produced by applying the new strip mine signature and all the Harrisburg signatures to the Wilkes-Barre/Scranton test site. The map is shown in Figure 12, with major land used outlined. Work is presently underway to identify the Wilkes-Barre/Scranton Airport,

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[9] Borden, et al. "Identification and Mapping of Coal Refuse Banks and Other Targets in the Antracite Region." Symposium of Significant Results Obtained from ERTS-1, (Washington, D.C.: NASA 1973)

TABLE 11

SITE 1 SIGNATURES APPLIED TO SITE 2

CATEGORY	SIGNATURES FOR ALL FOUR CHANNELS				MAP SYMBOL
	CHANNEL 1	CHANNEL 2	CHANNEL 3	CHANNEL 4	
RIVER	19.46	10.50	6.88	1.14	W
CREEK	21.20	13.40	15.60	7.00	W
RUNWAY	32.33	30.33	38.33	19.83	T
RAIL	25.19	18.88	18.21	7.79	T
FOREST	19.80	11.06	28.12	17.69	F
SUB 1	25.50	19.10	20.45	9.10	R
SUB 2	23.27	16.18	30.18	16.64	R
SUB 3	25.46	19.04	27.73	14.04	R
DENUDED	22.17	14.83	33.33	20.67	D
INDUSTRY	25.74	19.52	21.49	9.75	I
AGRICULTURE	25.32	20.09	29.50	16.36	D
MINE*	20.93	15.00	14.47	5.73	*
FIELD	23.84	17.13	30.48	17.13	D

*THE MINE SIGNATURE WAS DEVELOPED SPECIFICALLY
FOR THE WILKES-BARRE/SCRANTON AREA

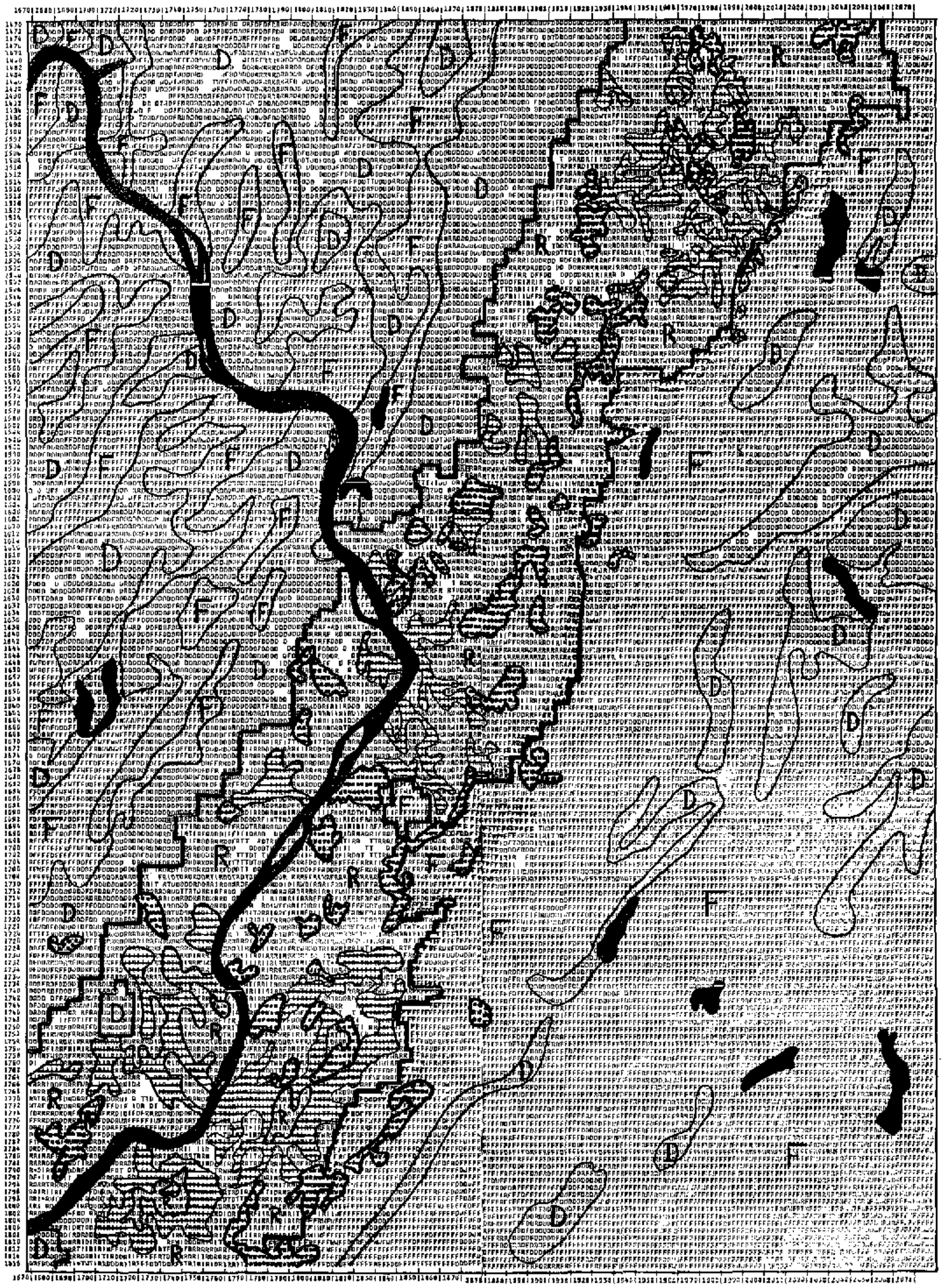

FIGURE 12
SITE 2 LAND USE
11 OCTOBER 1972

apply the full land use analysis to other coverage dates, and obtain more current ground truth for correlation of the ERTS results.

2.4 Water Quality Analysis

2.4.1 Susquehanna River Indices

MITRE's water quality parameters' effort was shifted back to the Susquehanna River after it had been determined that the Potomac River data was not usable due to striping (See Section 2.4.2). The test areas that had been chosen along the Susquehanna River are the following:

TABLE 12

SUSQUEHANNA RIVER WATER QUALITY TEST AREAS

Test Areas		River Mile
1	River Mouth at Chesapeake Bay	0
2	Conowingo Dam	10.1
3	Above Holtwood Dam	26.6
4	Safe Harbor Dam, Conestoga Creek Mouth	32.6
5	Marietta	45.2
6	Above Swatara Creek Mouth	57.2
7	Harrisburg, Conodoguinet Creek Mouth	67.6
8	Juniata River Mouth	81.5
9	Fishers Ferry	109.0
10	Sunbury	121.5

Signatures were developed for each test area by using cluster analysis (D-CLUS). These signatures were then input into the classification program (D-CLAS). A distance of separation table, which identified categories similar enough to be represented by one mean signature, was generated. If the distance of separation between two categories was less than 1.0 quanta, then the signatures for those categories were combined by taking a weighted mean. This procedure resulted in five signatures being developed ranging from most turbid water, category 1, to cleanest water, category 5 (See Table 13). Only MSS channels 4, 5, and 6 were used since channel 7 had no water quality variation information of value.

TABLE 13

WATER SIGNATURES

CATEGORY	CHANNEL 4	CHANNEL 5	CHANNEL 6
1	20.97	13.18	8.54
2	19.49	11.62	6.65
3	18.57	9.99	4.93
4	17.79	10.00	8.32
5	17.58	9.46	6.23

Each of our test areas was then classified with the above signatures, thus mapping out water quality along the Susquehanna River. Figures 13, 14, 15, and 16 are test areas 1, 4, 5, and 9 respectively. For all water quality maps only the River is shown; all land is blanked out. The River mouth (Figures 13) has generally clean water throughout (category 3 with some category 5 showing up). Along the water bank we pick

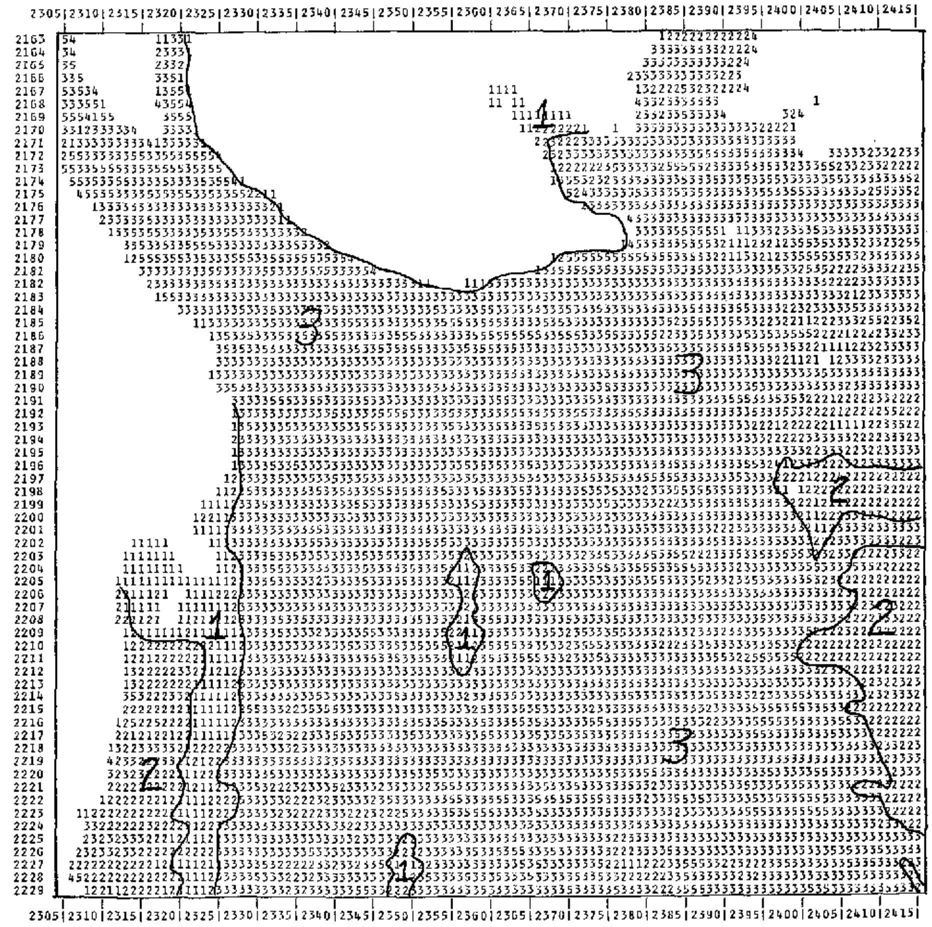

FIGURE 13
WATER QUALITY AT
SUSQUEHANNA RIVER MOUTH
11 OCTOBER 1972

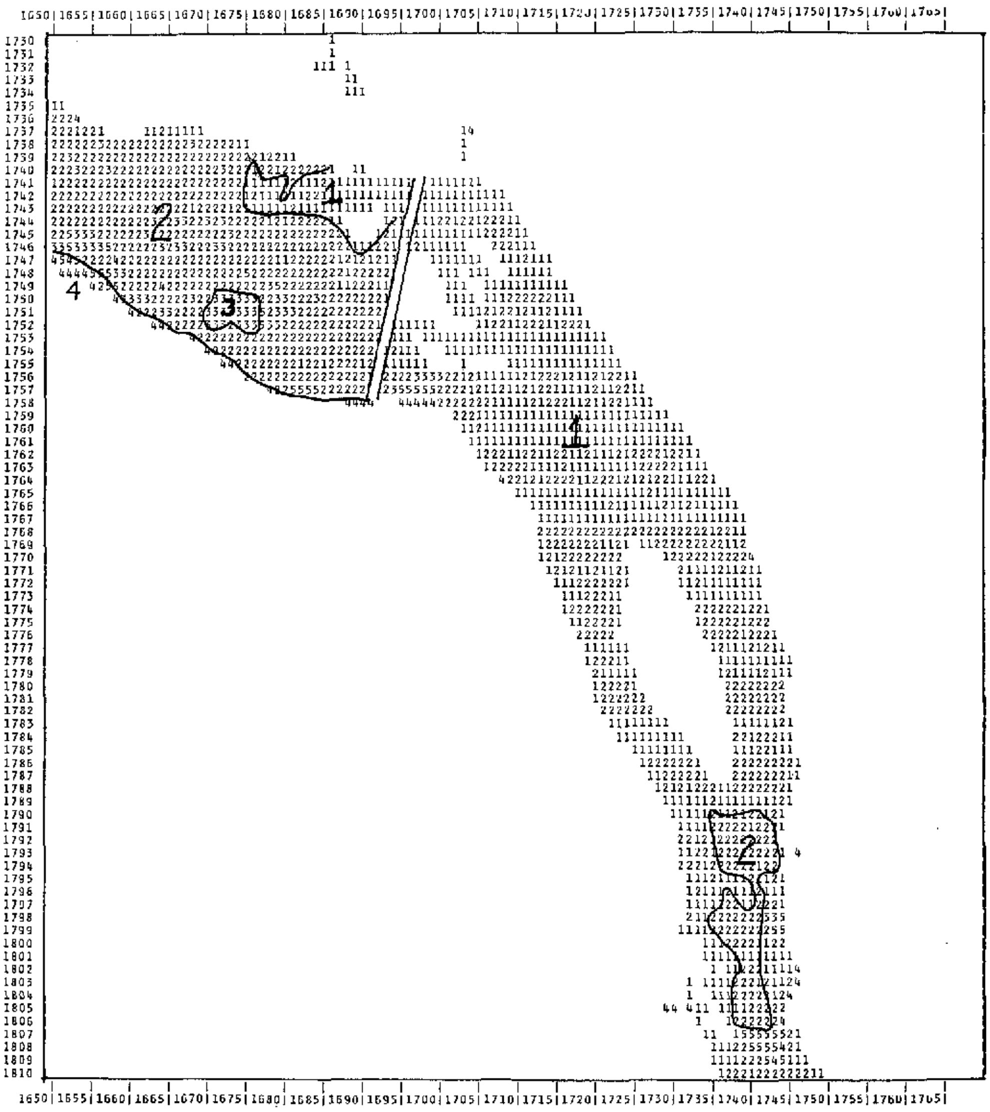

FIGURE 14
WATER QUALITY AT SAFE
HARBOR DAM AREA
11 OCTOBER 1972

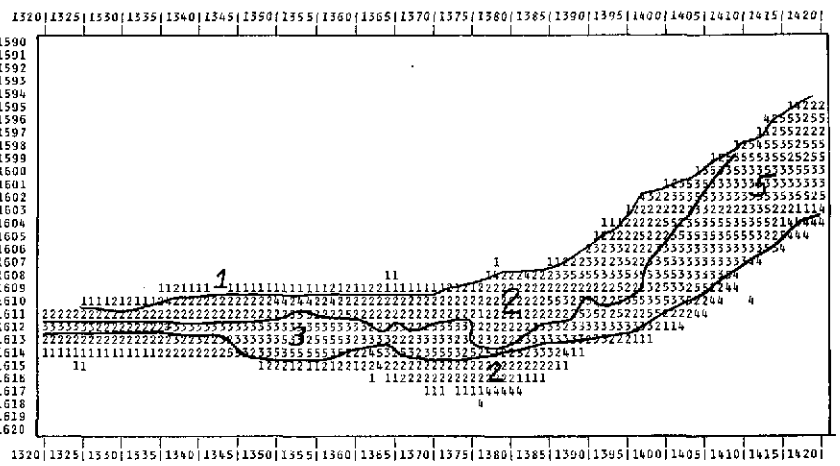

FIGURE 15
WATER QUALITY AT MARIETTA
11 OCTOBER 1972

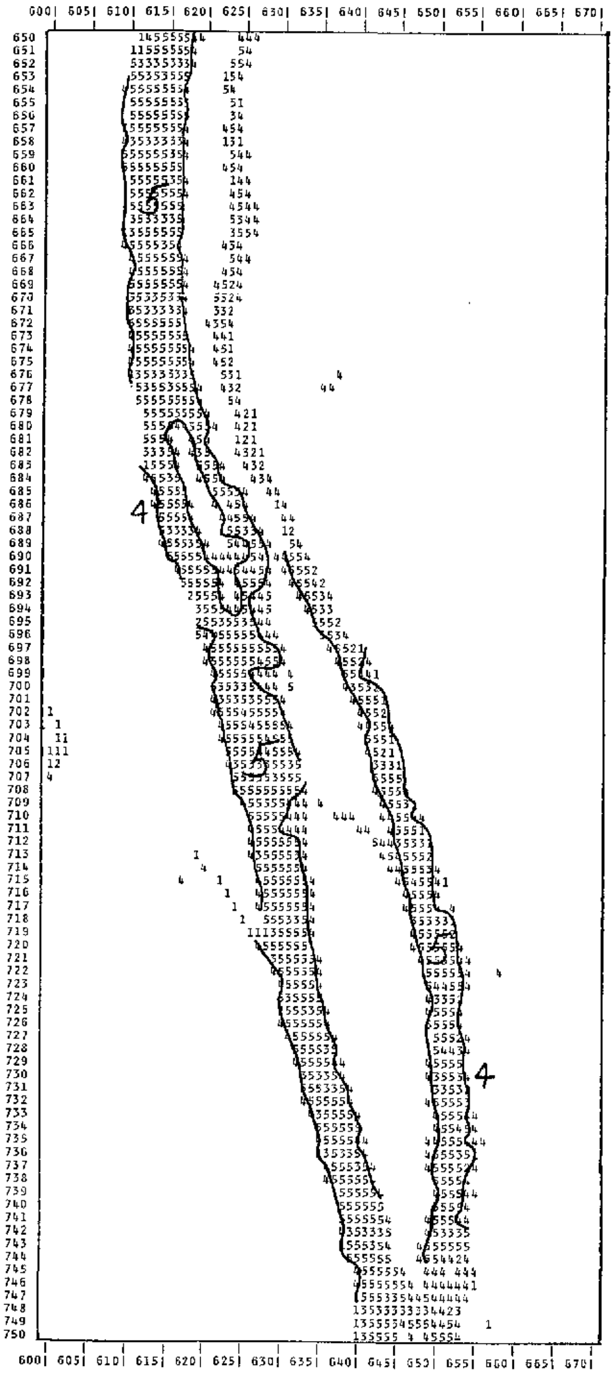

FIGURE 16
WATER QUALITY AT FISHERS FERRY
11 OCTOBER 1972

up more turbid water. The areas of turbid water showing up in the middle of the map are probably sandbars.

The Safe Harbor Area (Figure 14) is the most turbid as shown by the predominant mapping of categories 1 and 2. Marietta (Figure 15) has clearer water with a stretch of category 3 and 5 in the center. Fishers Ferry (Figure 16) shows a large amount of category 5 implying a lower level of turbidity in this Area. Category 4 has been showing up along the shoreline in several of the test sites implying surface water drainoff with some silt loading.

An index of water quality was then computed for each test area as follows:

$R_{i,j,k}$ = Reflectance in (mw/cm^2-ster) from Channel (k) of Water Type (i) in Test Area (j)

$a_{i,j}$ = Percent Area of Water Type (i) in Test Area (j)

$A_j = \sum_{i=1}^{n} a_{i,j}$ = Percent Area of All Water in Test Area (j)

$\alpha_{i,j} = \frac{a_{i,j}}{A_j}$ = Percent Area of Water Type (i) in All Water in Test Area (j)

$\rho_{i,j} = \frac{1}{m} \sum_{k=1}^{m} (R_{i,j,k}) \cdot (\alpha_{i,j})$ = Average Reflectance of Test Area (j) for Water Type (i) in (mw/cm^2-ster)

$P_j = \sum_{i=1}^{r} \rho_{i,j}$ = Water Quality Index for Test Area (j)

Figures 17 show the water quality indices for our 11 October study; note Safe Harbor which has the highest index of turbidity also shows up

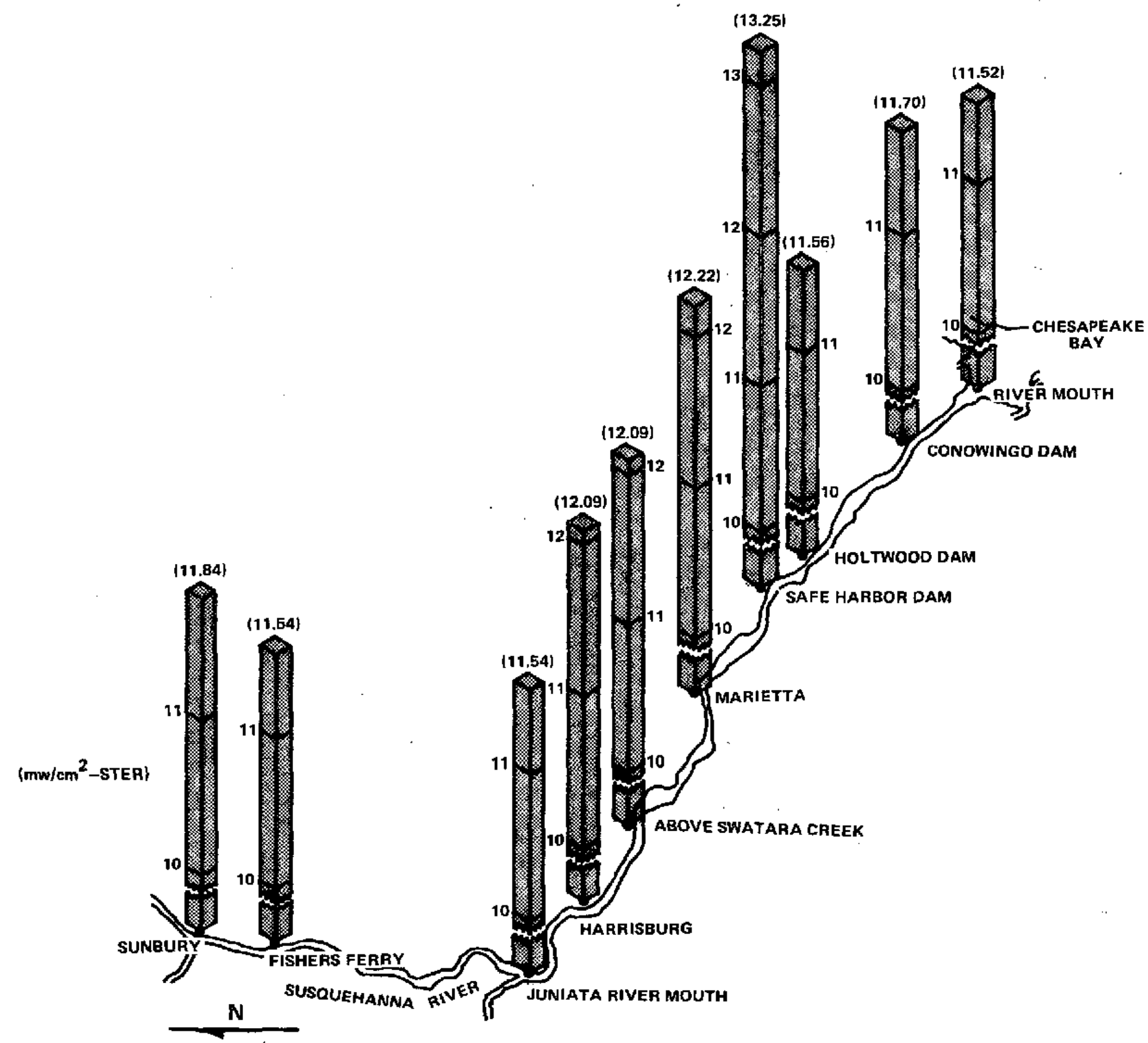

FIGURE 17
WATER QUALITY INDICES ALONG SUSQUEHANNA RIVER, 11 OCTOBER 1972

most turbid on the Channel 4 image, Figure 18.

Figure 19 shows the percent of each water type present in each test area. A look at Safe Harbor reveals that there is no clear water (i.e., type 4 or 5) in this area. Another interesting area is Sunbury: although there is a larger percentage of type 5 and 4 water there, the water quality index is higher than that computed for the Juniata River mouth. This is due to the equal percentages of types 1, 2, and 3 present (33% total) in the water which contribute to raising the index. Each of the remaining test areas can be analyzed in the same manner. We believe, however, that the water quality index, rather than percent of water type, gives a total description of the water and can be used more directly to classify water quality along the Susquehanna River.

With ERTS-1 we have been able to determine a range of turbidity, but it is only with in-situ water information that these levels can be quantified into physical units. In order to acquire this water information, Mr. Reed at USGS/Harrisburg was contacted. The only water quality station which USGS maintains along the Susquehanna River from the mouth to Sunbury is at Harrisburg, and they had turbidity readings for 1 October 1972 and 31 October 1972. In order to reach a reading for 11 October 1972, interpolation of available data was made by USGS. At Harrisburg the east bank of the river was estimated to have a sediment level of 12-15 micrograms/liter, and the west bank of 9-11 micrograms/liter. These readings imply that the east side of the river is more turbid. This conclusion conflicted with our results from Harrisburg, Figure 20, which shows the dirtier

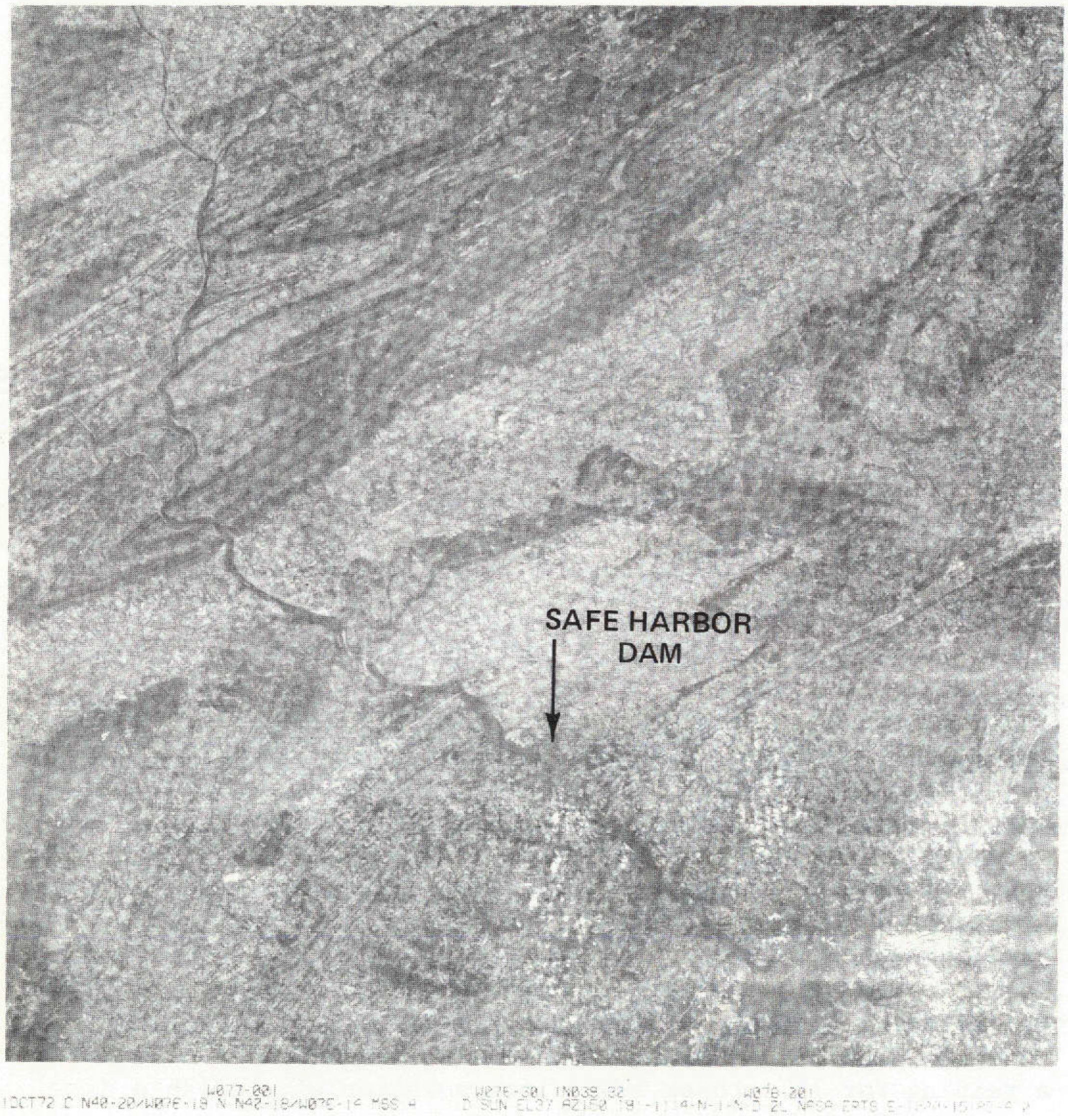

FIGURE 18
ERTS-1 IMAGE, CHANNEL 4
11 OCTOBER 1972

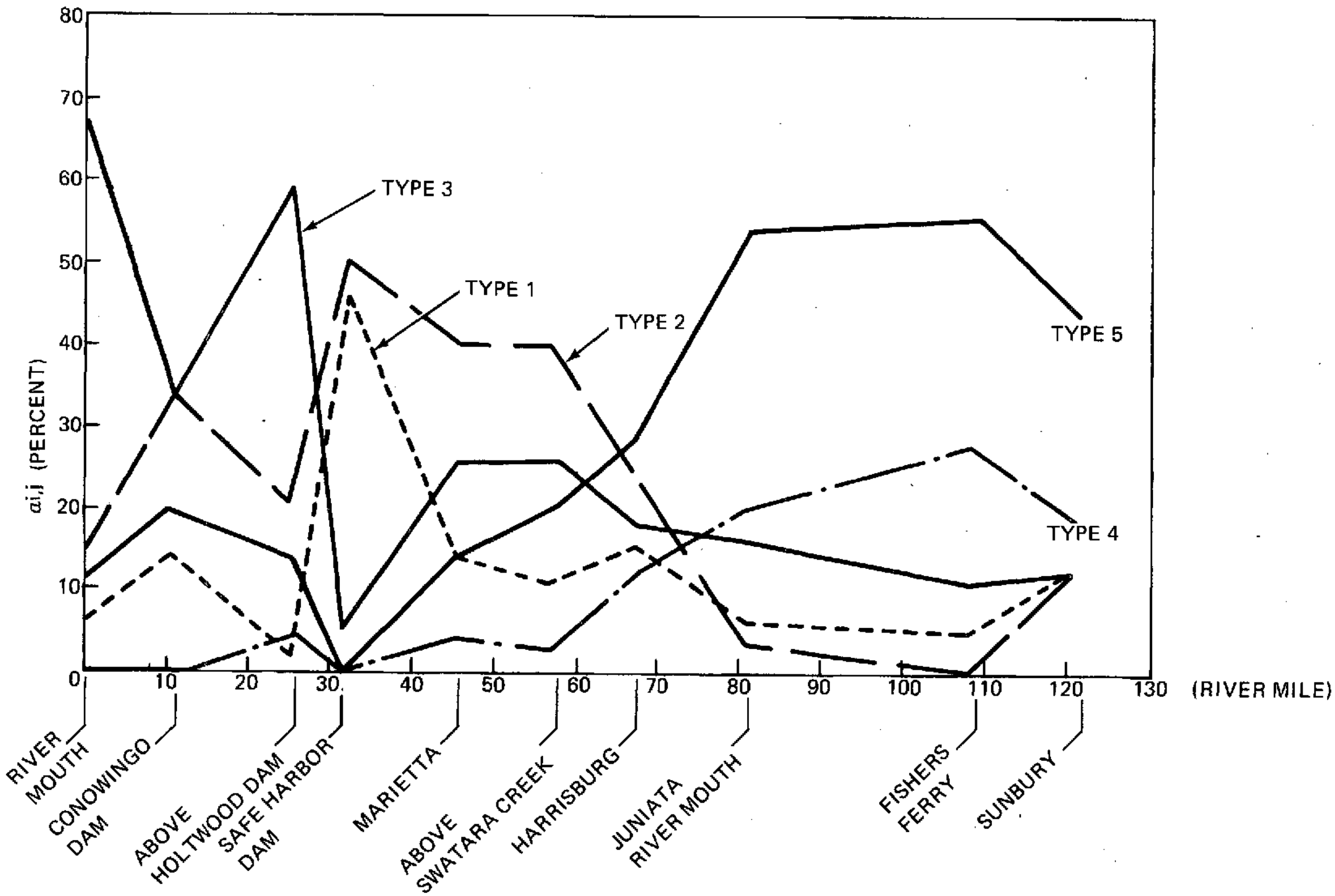

FIGURE 19
TYPES OF WATER QUALITY ALONG SUSQUEHANNA RIVER, 11 OCTOBER 1972

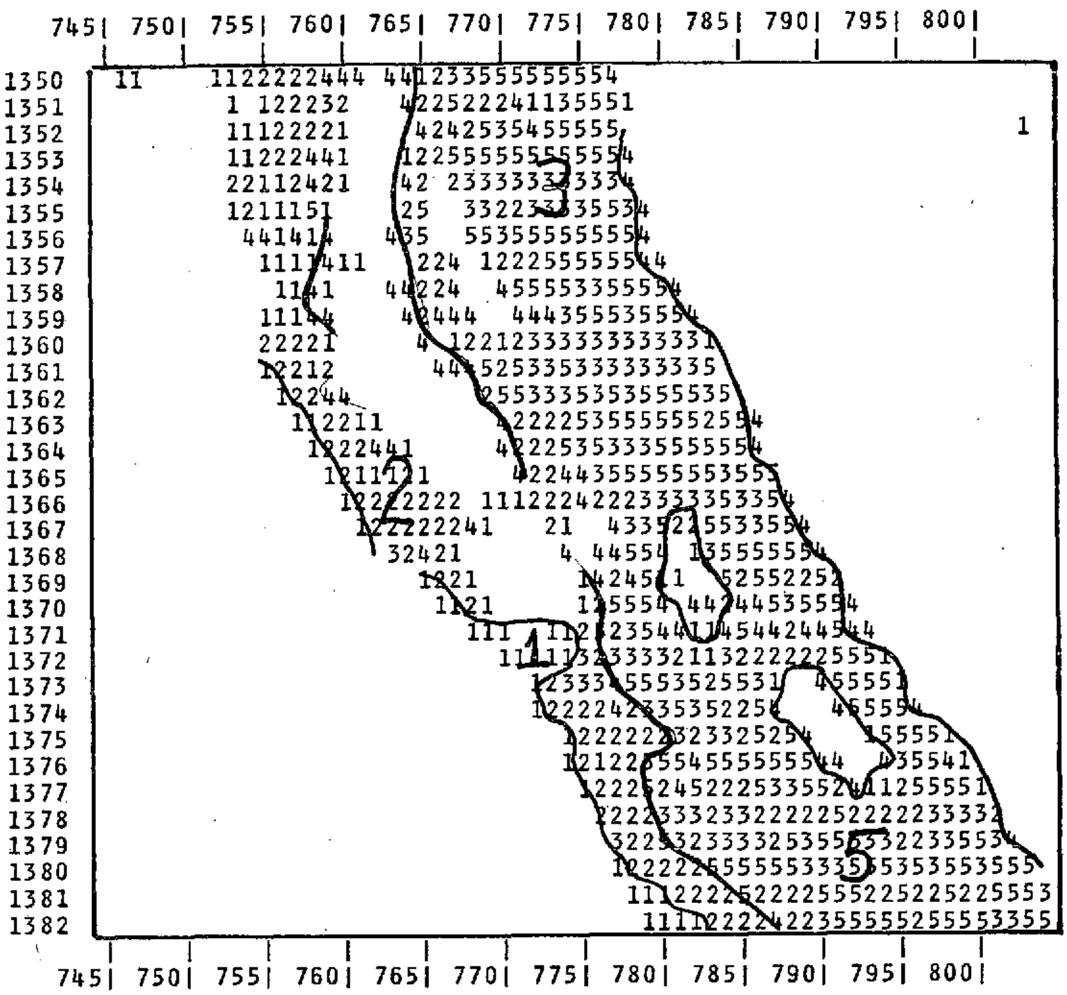

FIGURE 20
HARRISBURG WATER QUALITY
11 OCTOBER 1972

water to be along the west bank. At this point Mr. Reed (USGS) was again contacted. He stressed that they (USGS) did not have data close enough to 11 October 1972 to give us very substantial help. Therefore, Mr. Reed stated that we should not overvalue his figures; rather we should give preference to our own findings.

Thus we conclude that we have been able to classify multi-levels of relative turbidity (indices) along the Susquehanna River as outlined in our Data Analysis Plan, (DAP). Such indices are of value to river basin personnel interested in the relative dynamics of the stream, even though physical levels may not be quantifiable.

2.4.2 <u>Potomac River Striping Analysis</u>

MITRE's first training area for the identification of water quality parameters was centered along the Potomac River. The ERTS-1 imagery for 11 October 1972 shows a large plume of turbid water from the Washington area to south of Quantico, Virginia. Also visible are several gradations of water caused by merging streams. Since both of these conditions were easily recognized, it was felt that water classification of this area could be done with minimum time and effort.

The first intensity map (N-MAP, an RMS of all of the reflectance channels) of the area showed several types of water within the boundaries of the Potomac, especially around Quantico, and this was chosen as the site for developing signatures of water quality. A cluster analysis was run using a sample size of 150 pixels and a critical distance of 4.5. The resulting map, Figure 21, displays the levels of turbidity from IV, high turbidity, to I, clearest water.

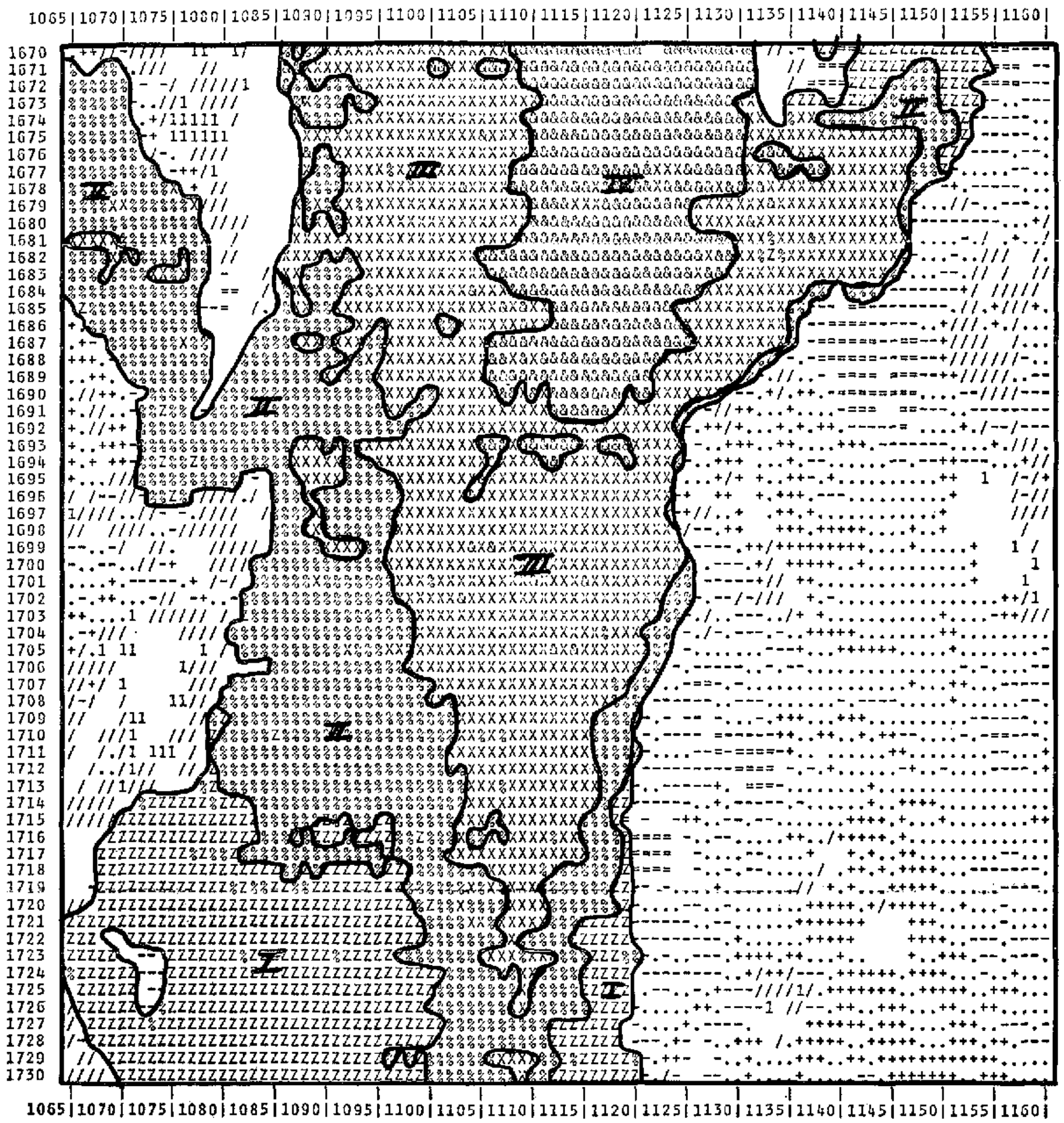

FIGURE 21
QUANTICO WATER QUALITY – FOUR LEVELS
11 OCTOBER 1972

With the success that was encountered at Quantico, it was decided to investigate other areas along the Potomac where the plume can be seen in the imagery. In particular the following were selected:

TABLE 14

POTOMAC RIVER TEST AREAS

TEST AREA	RIVER MILE
Popes Creek	42.0
Cedar Point	49.0
Maryland Point	56.4
Clifton Beach	61.7
Quantico	67.5
Mason Neck	79.0
Fort Hunt	86.0
Wilson Bridge	90.8
Hains Point	94.7

Using a supervised classification program the signatures from the Quantico analysis were applied to Clifton Beach and Maryland Point. At both points, however, only a single water category could be identified though these new sights were less than 12 miles down stream. Since this contradicted what could be seen from the images, it was decided to change the limiting parameters of the cluster analysis of Quantico and develop new signatures.

With the critical distance reduced to 1.0 and the sample size expanded to include 900 pixels, six categories of water were identified. Figure 22 shows the breakdown with VI representing the most

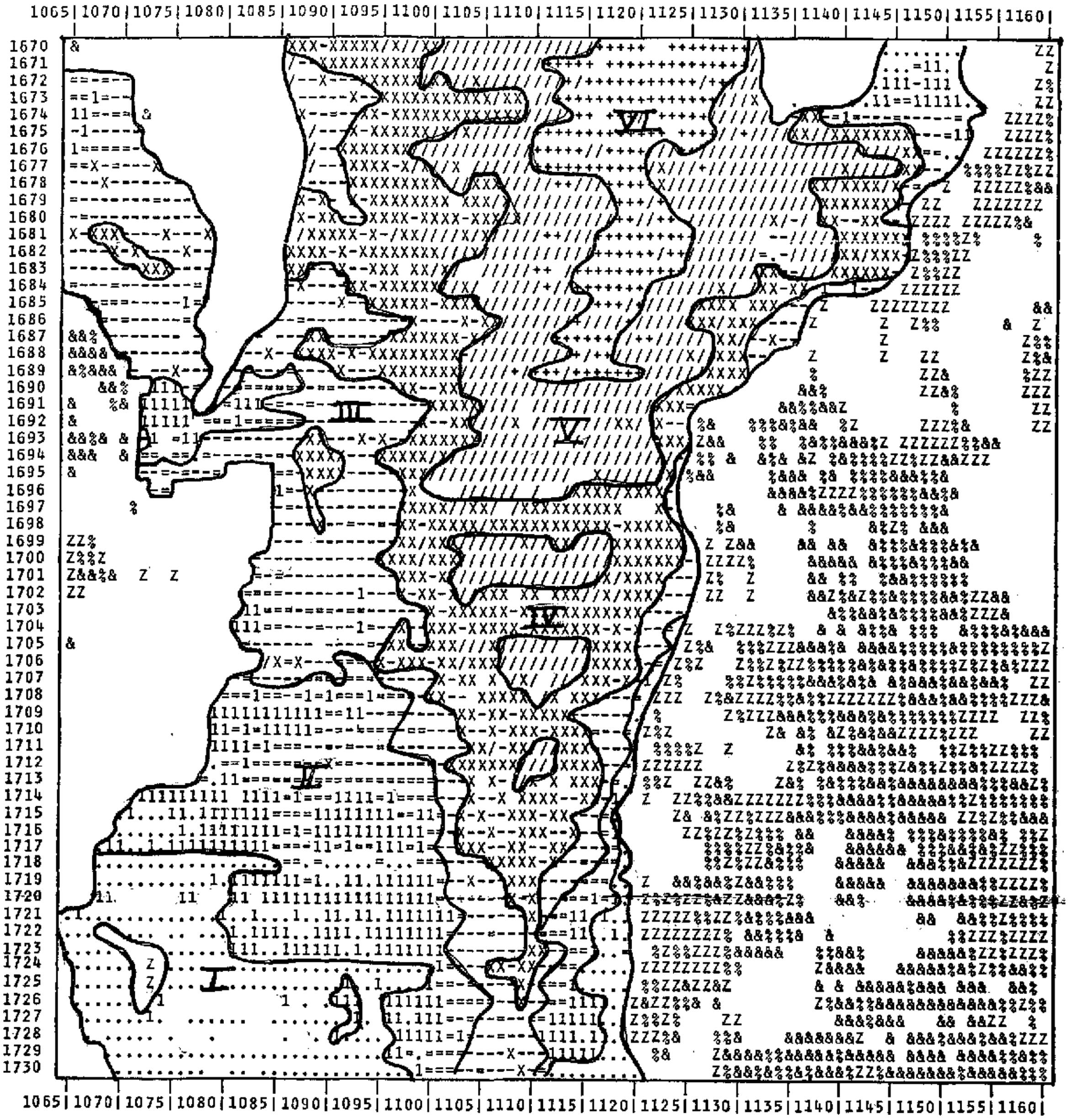

FIGURE 22
QUANTICO WATER QUALITY – SIX LEVELS
11 OCTOBER 1972

turbid, decreasing to level I which is again the clearest water. Despite this refinement of the signatures, the application to Clifton Beach and Maryland Point still resulted in the classification of just one water category.

The next attempt to uncover the reasons for our problems was to vary the MSS channels that would supply input for the programs. It is generally held that channels 4 and 5 are better for water investigation. So a cluster analysis for Quantico was run for channel 4 alone and for channels 4 and 5. The results when applied to Clifton Beach were the same as above, i.e., only one level where several levels could be seen in the MSS image.

At this point the image was rechecked at Clifton Beach as was the original 4-channel intensity map of the Potomac scene. It was found that the gradations of water seen on the image were evident on the intensity map at Quantico but not at Clifton Beach. Therefore, separate MSS channel intensity maps of Clifton Beach were run to see if the turbidity would show up in the smaller population. Figure 23 and 24 are MSS channels 4 and 6 respectively.

Analysis of these maps showed no horizontal (east-west) turbidity pattern, but did show a vertical (north-south) six line pattern. A closer study of the maps pointed to the possibility that the poor results were due to this every sixth line striping. A cross-check with the images, this time looking specifically for striping, proved this to be quite evident in each channel and throughout each image. Since the striping intensity changes were of the same order as the turbidity in the east-west direction, the striping had to be eliminated.

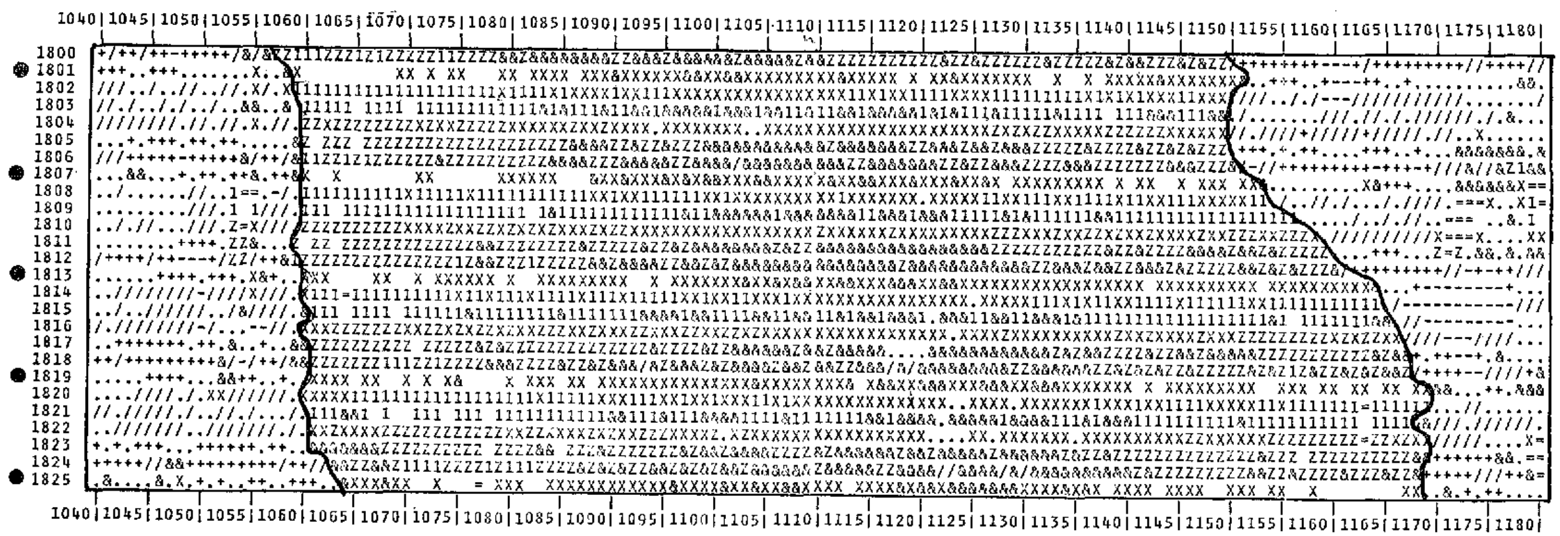

FIGURE 23
CLIFTON BEACH CHANNEL 4
INTENSITY MAP WITH STRIPING

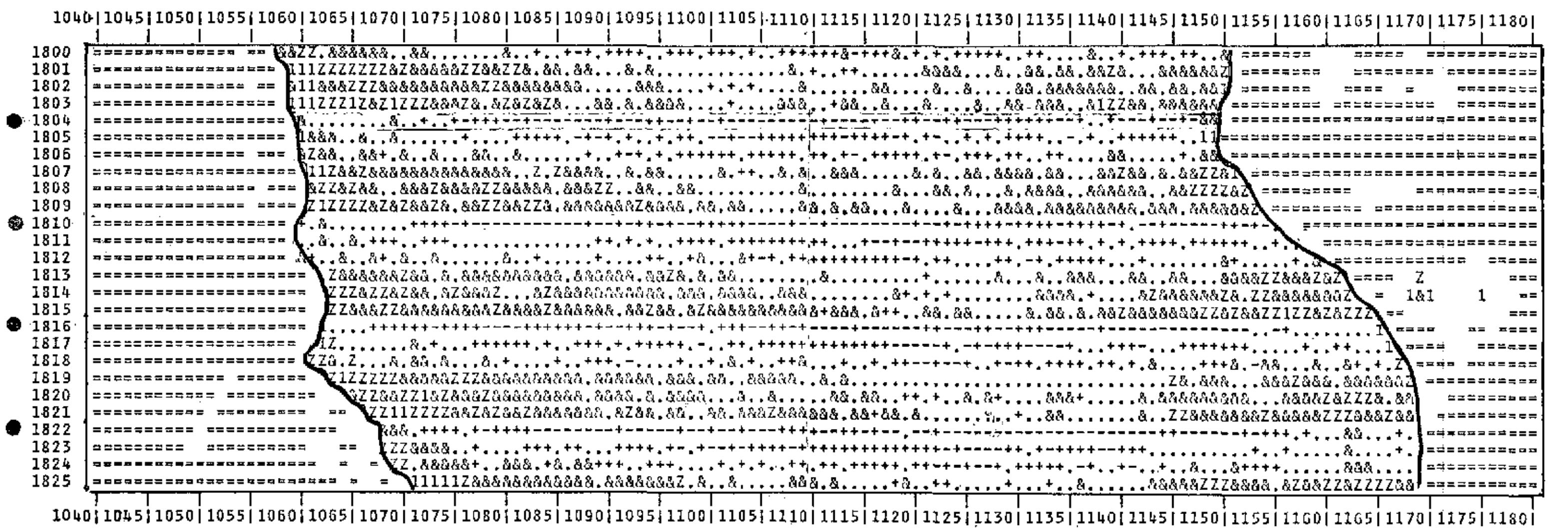

FIGURE 24
CLIFTON BEACH CHANNEL 6
INTENSITY MAP WITH STRIPING

In order to overcome the problem, suspect lines were discarded using the separate channel intensity maps (those indicated by a dot (•) in Figures 23 and 24). The intensity program was then rerun on the reduced population. This produced a small improvement in the map with two categories of water being identified. However, the improvement was overshadowed by the fact that three out of every five lines of the population had been eliminated. This method, therefore, proved to be completely impractical because much of the turbidity information was also being discarded.

At this point a check with NDPF User Services caused the problem to be referred to Mr. Robert Feinberg. Mr. Feinberg had knowledge of software that was being developed by GE to correct the striping and he agreed to have MITRE's tapes reprocessed. It was decided that both the Potomac scene (1080-15192) and the Harrisburg, Pennsylvania area (1080-15185) would be redone; the latter being our prime test area for water quality and land use.

While the reprocessing was being done, it was decided to run separate MSS channel intensity maps of Quantico. The purpose was to develop signatures, from the reduced population, which could be compared to signatures, from the tapes with striping and the corrected tapes. However, the same problem that arose with Clifton Beach was encountered, that is, losing too much of the population for the results to be considered worthwhile. It was decided to wait for the corrected tapes before we would do any other analysis for water.

Waiting proved to be both long and costly. We had noticed the striping showing up in our digital maps on 21 March 1973. Our decision to stop our water analysis came on 26 March 1973 after consultation with Mr. Feinberg at GSFC. We received the corrected tapes on 7 May 1973. The first intensity maps that were run, however, a distinction between water and land was not possible. Mr. Feinberg was again contacted and on 14 May 1973 MITRE received acknowledgment that the tapes had been processed incorrectly and that they had to be redone. Shortly after this, a discussion was held also with Mr. Saul Portner and Mr. Paul Heffner of GE to discuss the exact nature of our problem. It was decided that a third set of tapes should be generated and these were received on 15 June 1973.

Once the new tapes were received, an intensity map of the Quantico, Virginia area was run. There was difficulty in locating this test area; therefore, another intensity map covering a larger area was run. It was found that for all data on the new tapes there is an 84 line shift from the old tapes. Therefore any comparison of the Quantico maps run with the uncorrected tapes to those maps from the new tapes should not be affected by the difference in line number.

With our test area properly located, separate channel intensity maps were run for Quantico (Figure 25). We could still see the striping in this map (suspect lines indicated by a dot, (•)) and in the other three channels also. At this point a meeting was arranged with Mr. Saul Portner and several other GE engineers, who had worked on the software to correct this problem. Mr. Portner had run intensity maps covering the Susquehanna River mouth which did not show striping. (Figures 26, 27, and 28, channel 7 not included). Unfortunately, we only had digital maps covering the Potomac River and therefore could not directly compare outputs. In trying to help us solve our problem, Mr. Portner focused on Table 15 accompanying Figure 25. Mr. Portner informed us that the data are only good within the limits of ± 1 quanta, and that our choice of limits less than ± quanta was too much of a demand on the ERTS data. Mr. Portner suggested that we widen our limits for the intensity mapping, and then we should have no further problems with striping.

Our first attempt to correct the data involved running intensity maps for the Susquehanna River Mouth (Figures 29, 30, and 31). Within the above criteria, these maps showed no striping. We then proceeded to start again on the Potomac River (Figures 32, 33, 34, and 35 are intensity maps of channel 4-7 respectively). Once again striping showed up clearly in all but channel 5 (channel 5 has a bad line, i.e. 1804). Mr. Portner was again contacted about our findings. He agreed to run a GE program, similar to our intensity mapping, on this area; these are included as Figures 36, 37, 38, and 39 (channels 4-7 respectively). These maps also show striping, but it appears within the constraints of ±1 quanta, and therefore the data are considered usable by GE.

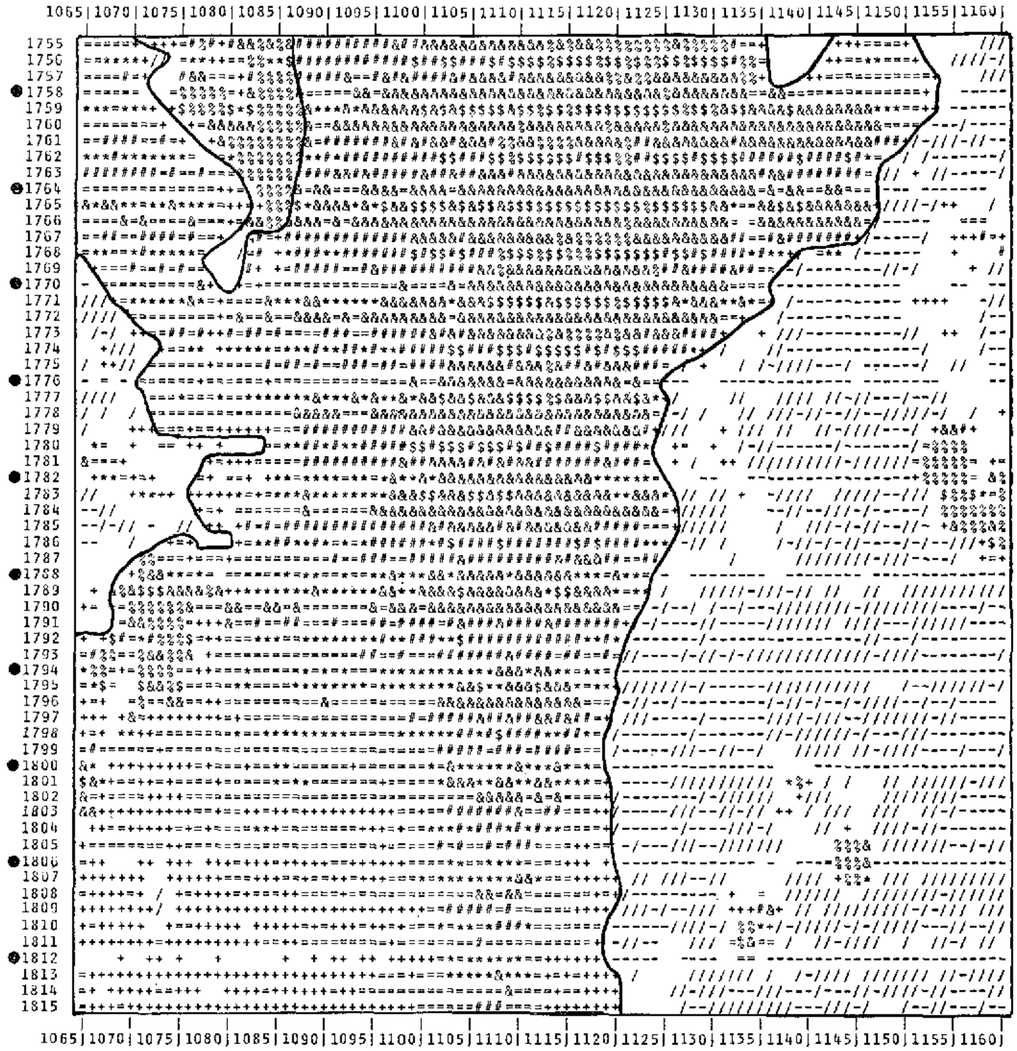

FIGURE 25
QUANTICO CHANNEL 4
INTENSITY MAP, IMPROVED TAPES

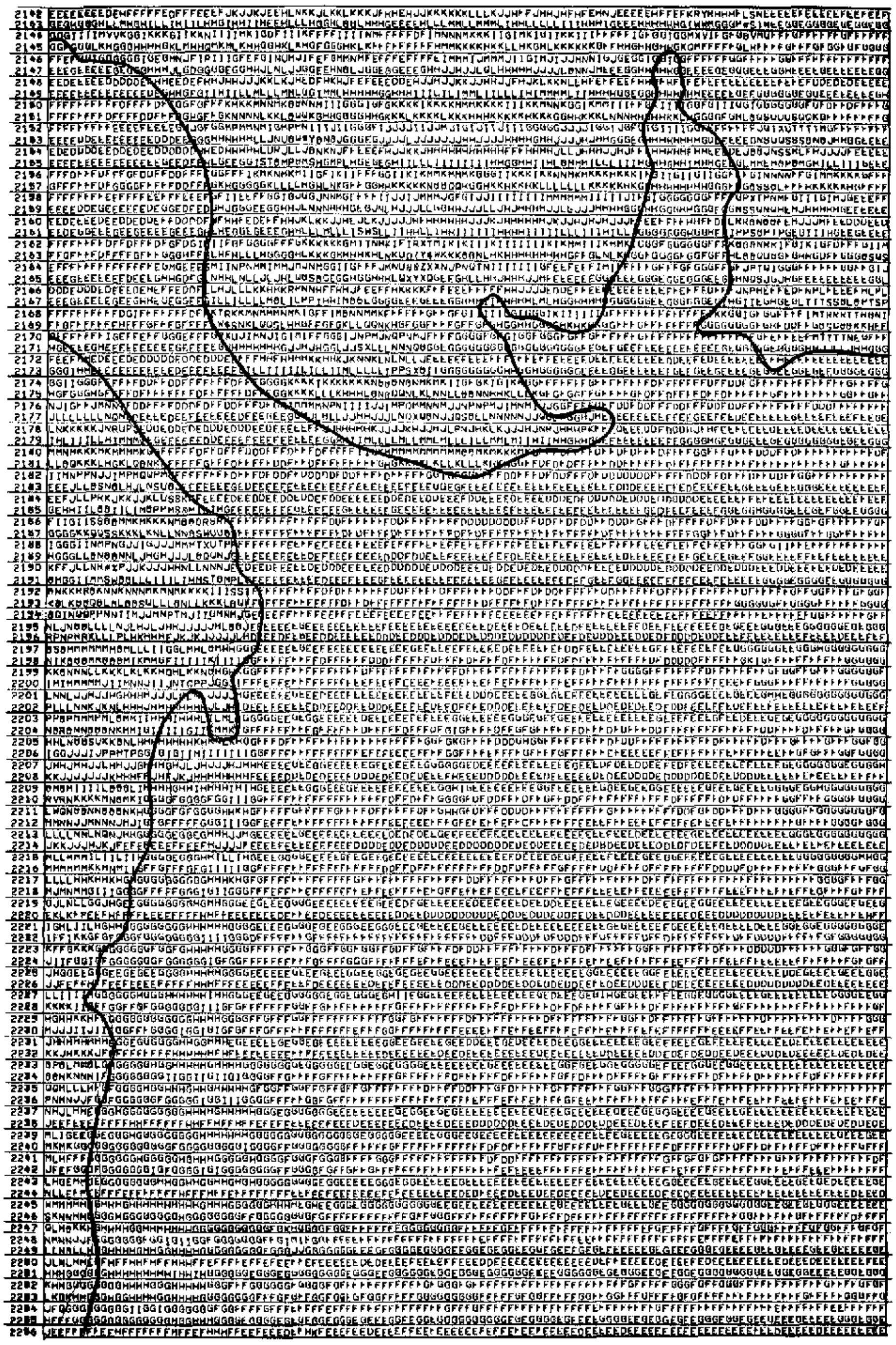

FIGURE 26
SUSQUEHANNA RIVER MOUTH
GE's CHANNEL 4 INTENSITY MAP

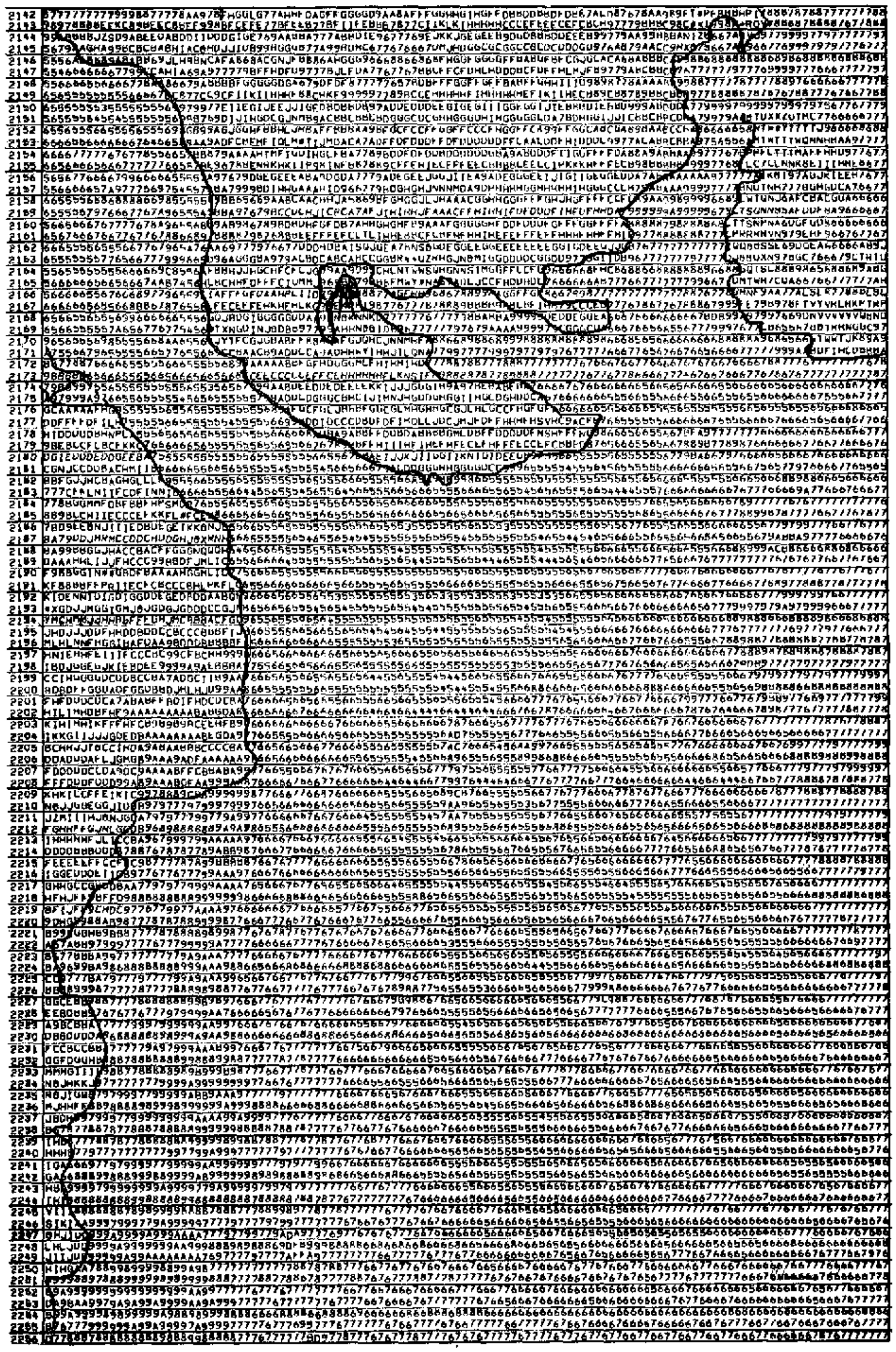

FIGURE 27
SUSQUEHANNA RIVER MOUTH
GE's CHANNEL 5 INTENSITY MAP

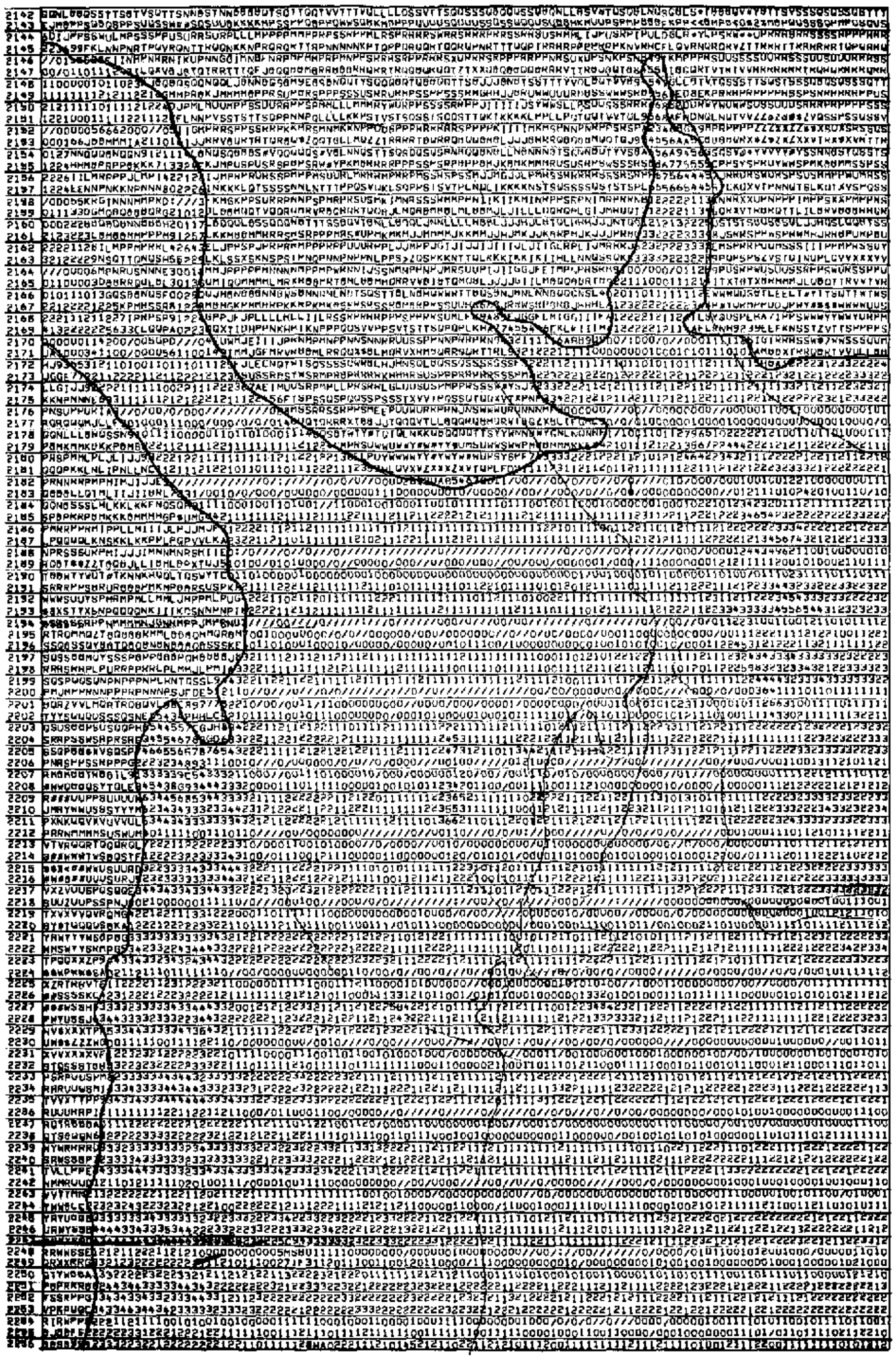

FIGURE 28
SUSQUEHANNA RIVER MOUTH
GE's CHANNEL 6 INTENSITY MAP

TABLE 15

SUMMARY TABLE FROM
INTENSITY MAP OF QUANTICO

SYMBOL	LIMIT	COUNT	PERCENT	QUANTA* LEVEL
-	15.0	767	13	19
/	16.0	705	12	20
	19.0	563	10	24
+	21.0	560	10	27
=	22.2	1006	17	28
*	23.0	380	6	29
#	24.0	554	9	31
¢	25.5	908	16	33
$	26.0	206	4	34
%	100.0	207	4	128

*Not printed out by computer - this is Quanta Level for appropriate limit shown.

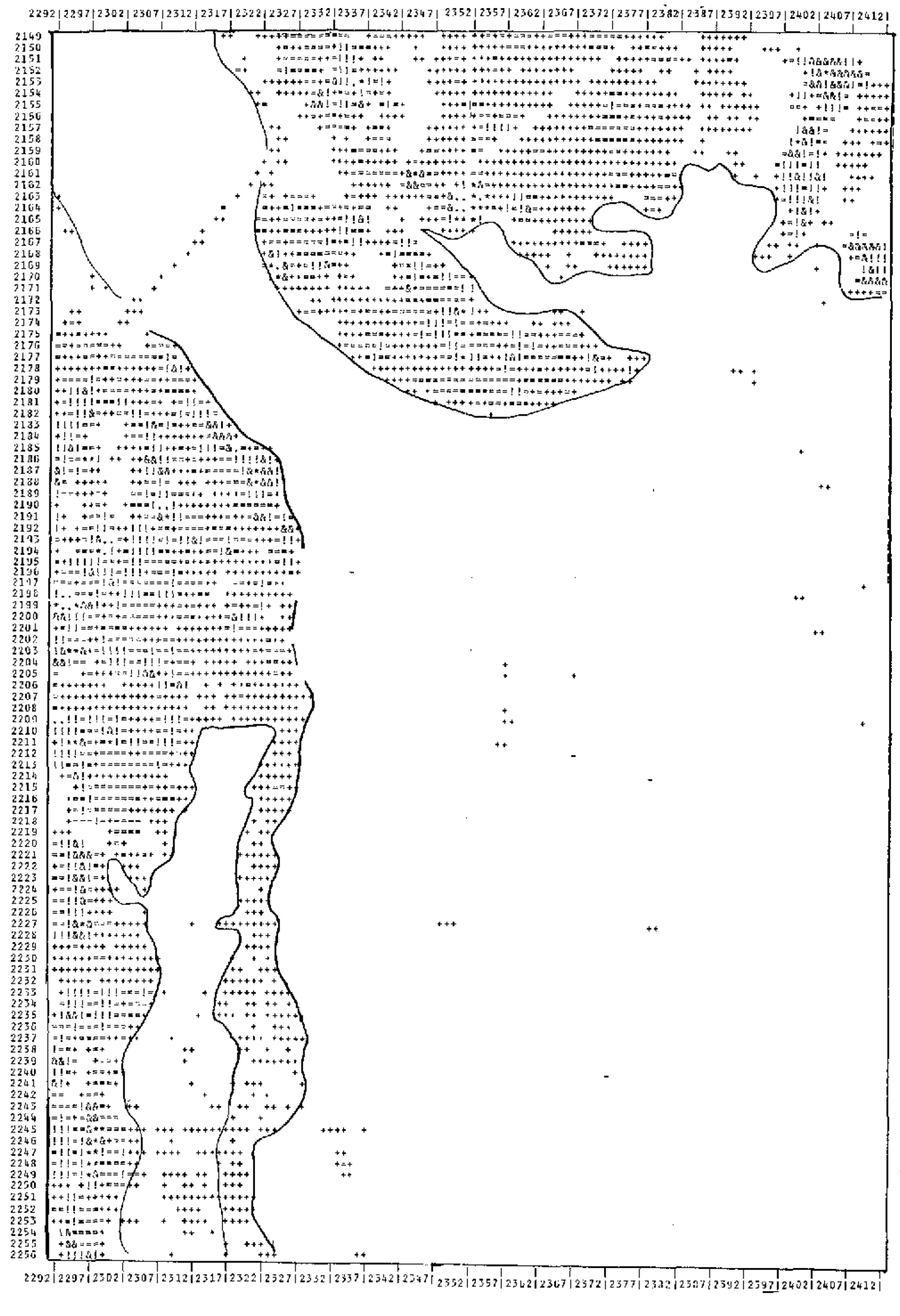

FIGURE 29
SUSQUEHANNA RIVER MOUTH
MITRE's CHANNEL 4 INTENSITY MAP

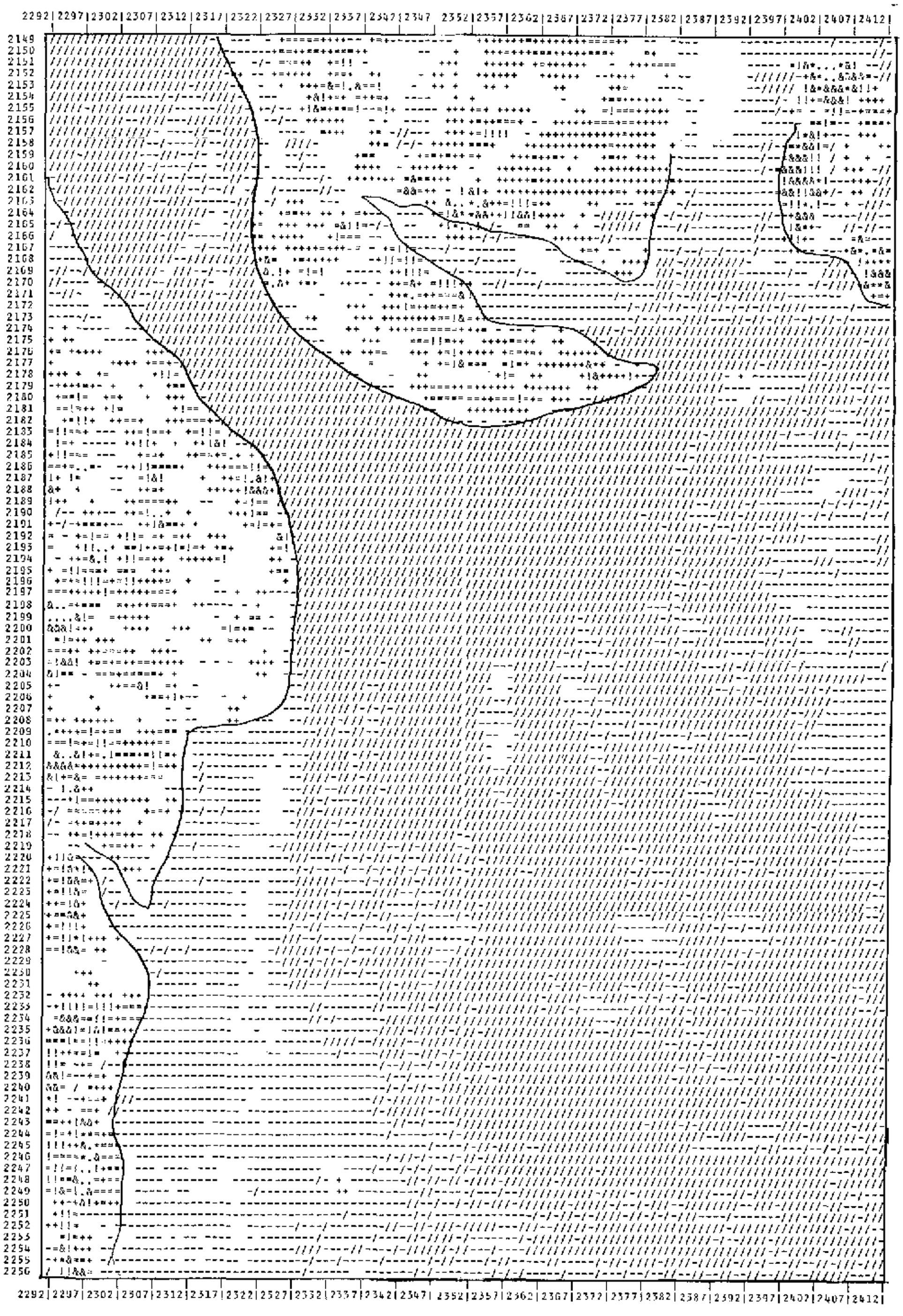

FIGURE 30
SUSQUEHANNA RIVER MOUTH
MITRE's CHANNEL 5 INTENSITY MAP

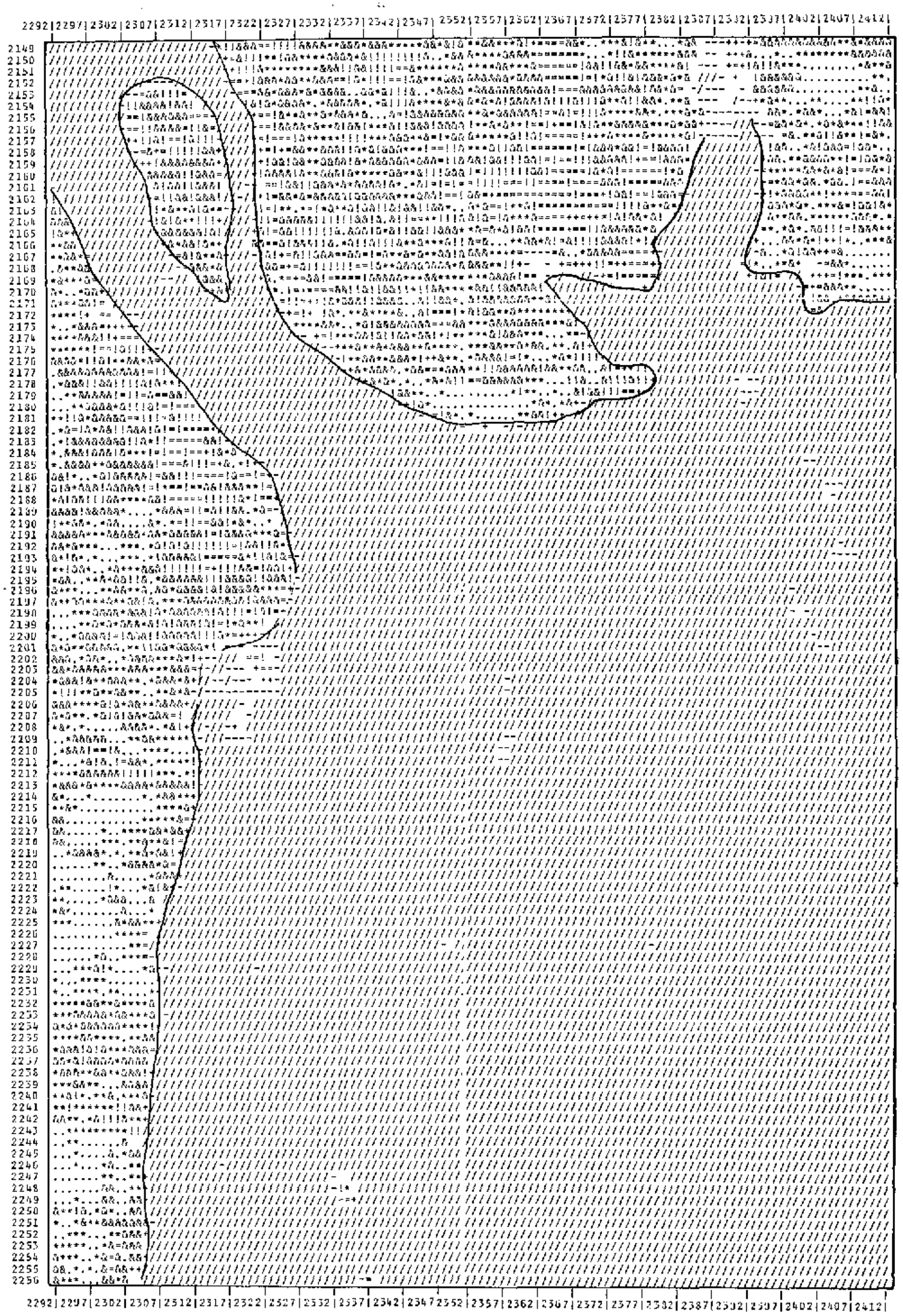

FIGURE 31
SUSQUEHANNA RIVER MOUTH
MITRE's CHANNEL 6 INTENSITY MAP

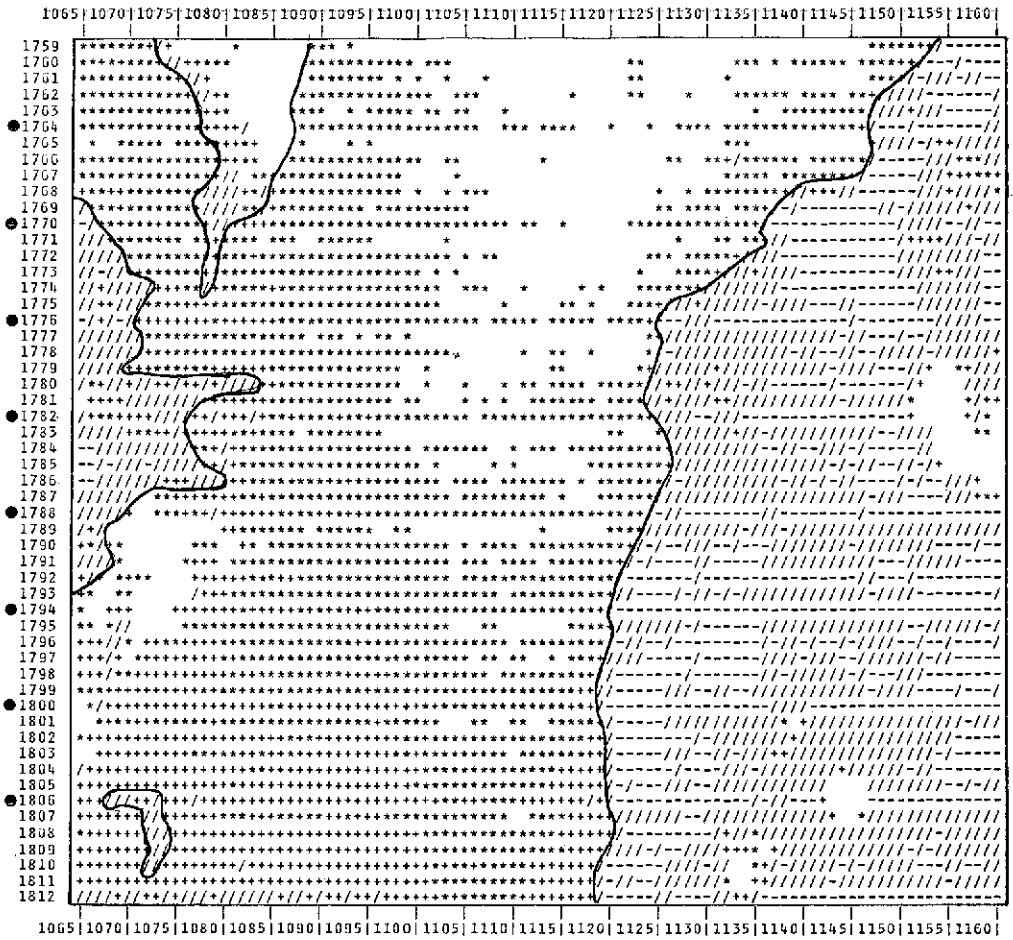

FIGURE 32
QUANTICO, MITRE's CHANNEL 4
INTENSITY MAP, IMPROVED TAPES

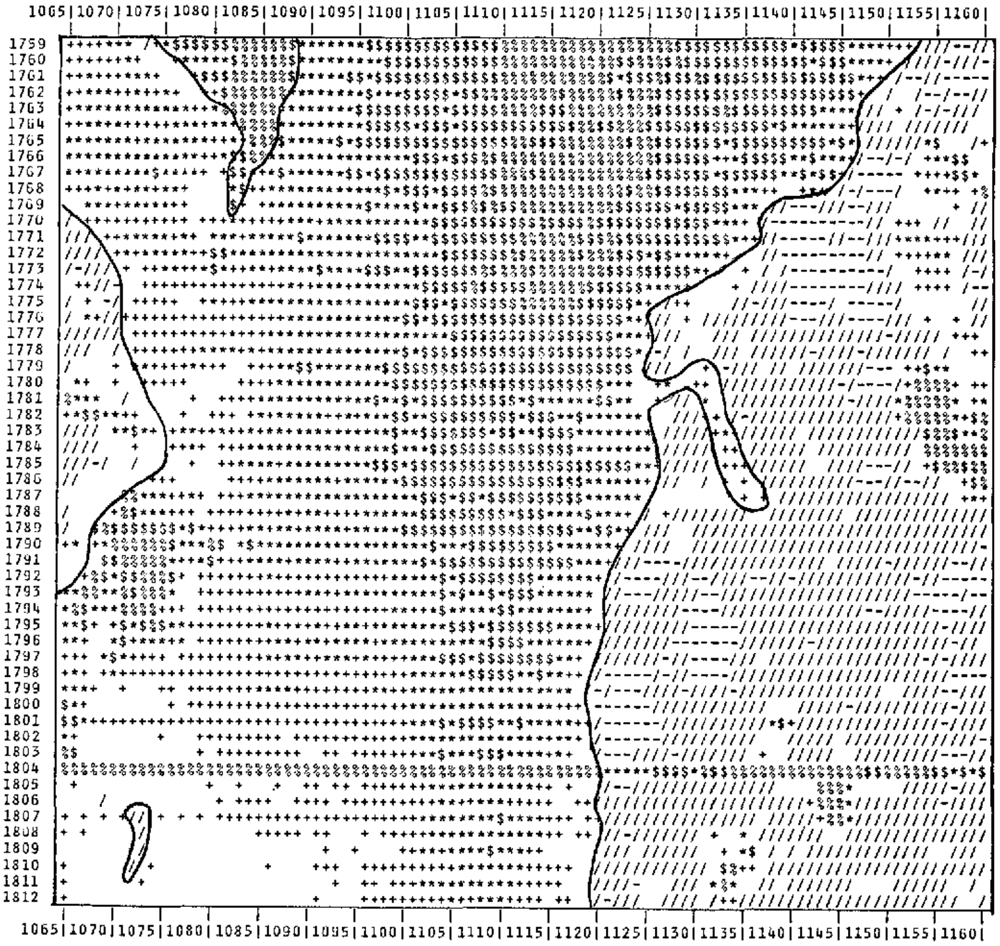

FIGURE 33
QUANTICO, MITRE's CHANNEL 5
INTENSITY MAP, IMPROVED TAPES

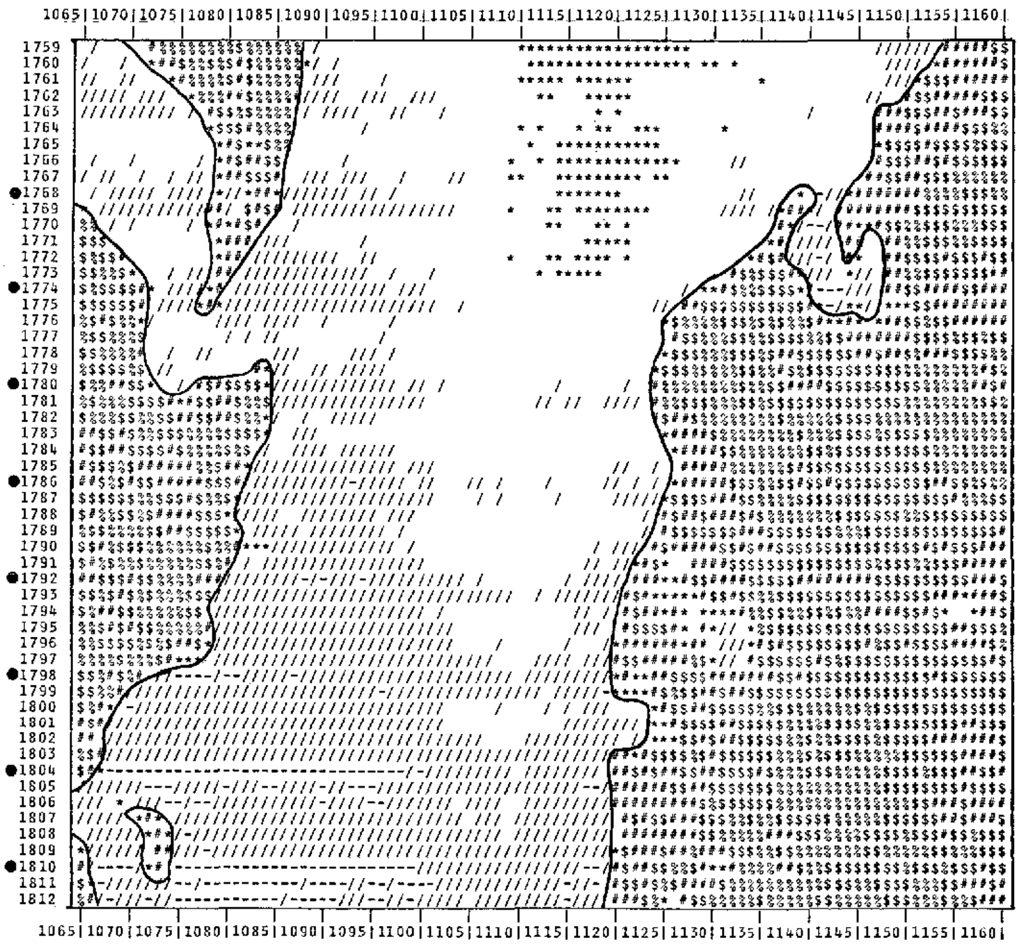

FIGURE 34
QUANTICO, MITRE's CHANNEL 6
INTENSITY MAP, IMPROVED TAPES

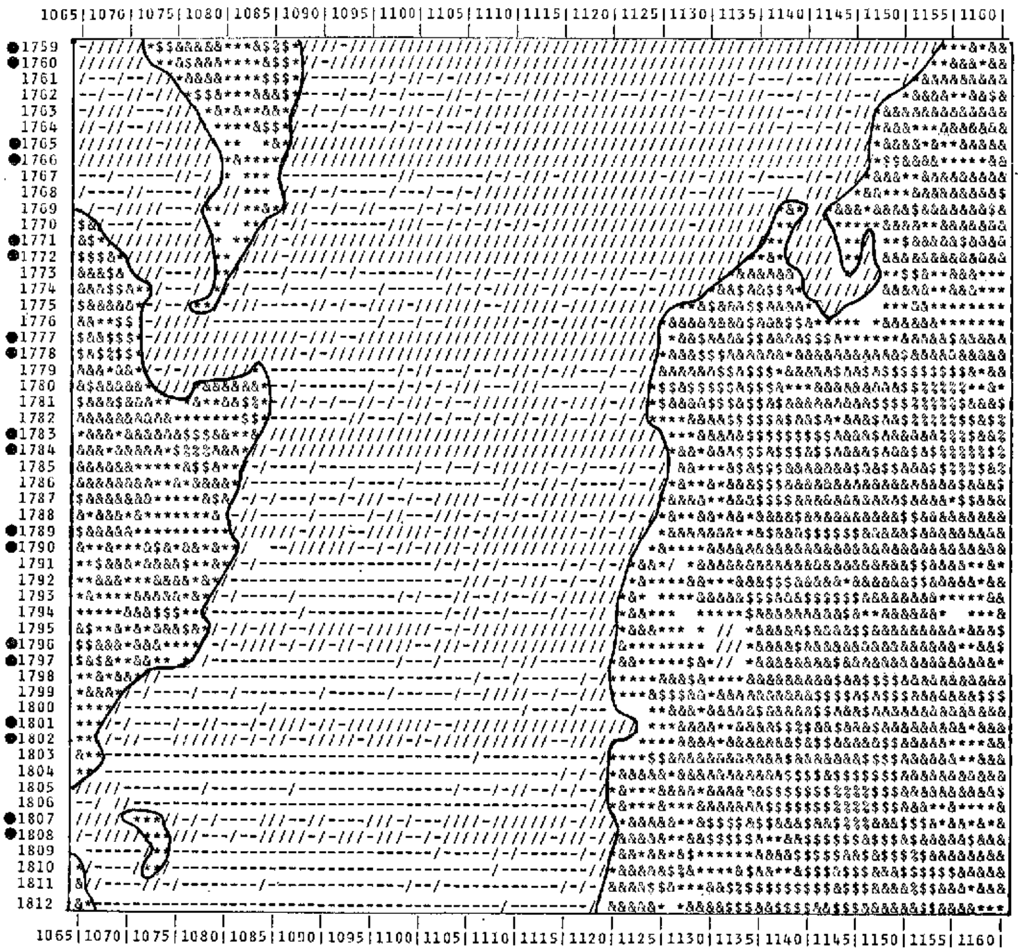

FIGURE 35
QUANTICO, MITRE's CHANNEL 7
INTENSITY MAP, IMPROVED TAPES

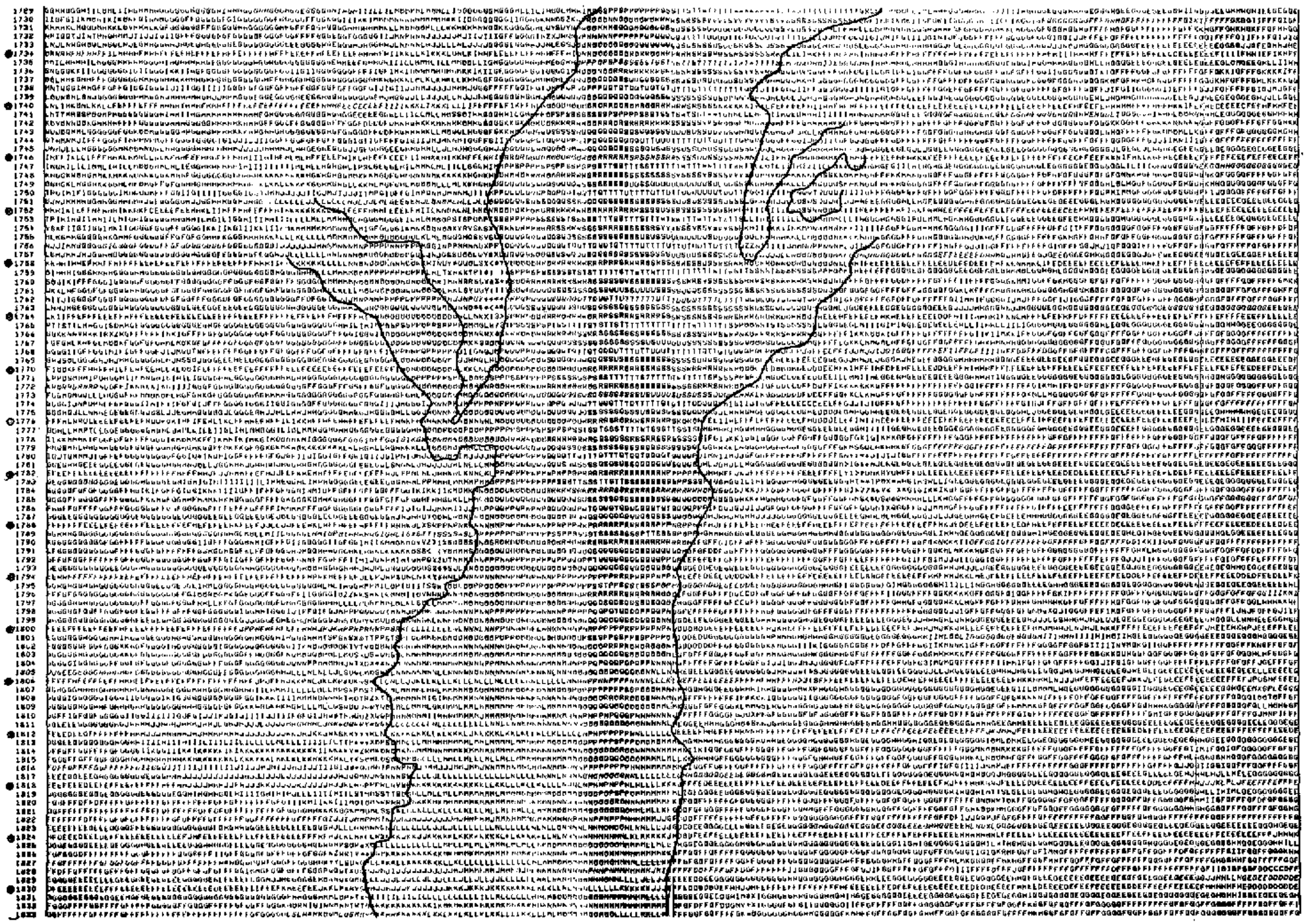

FIGURE 36
QUANTICO, GE's CHANNEL 4
INTENSITY MAP, IMPROVED TAPES

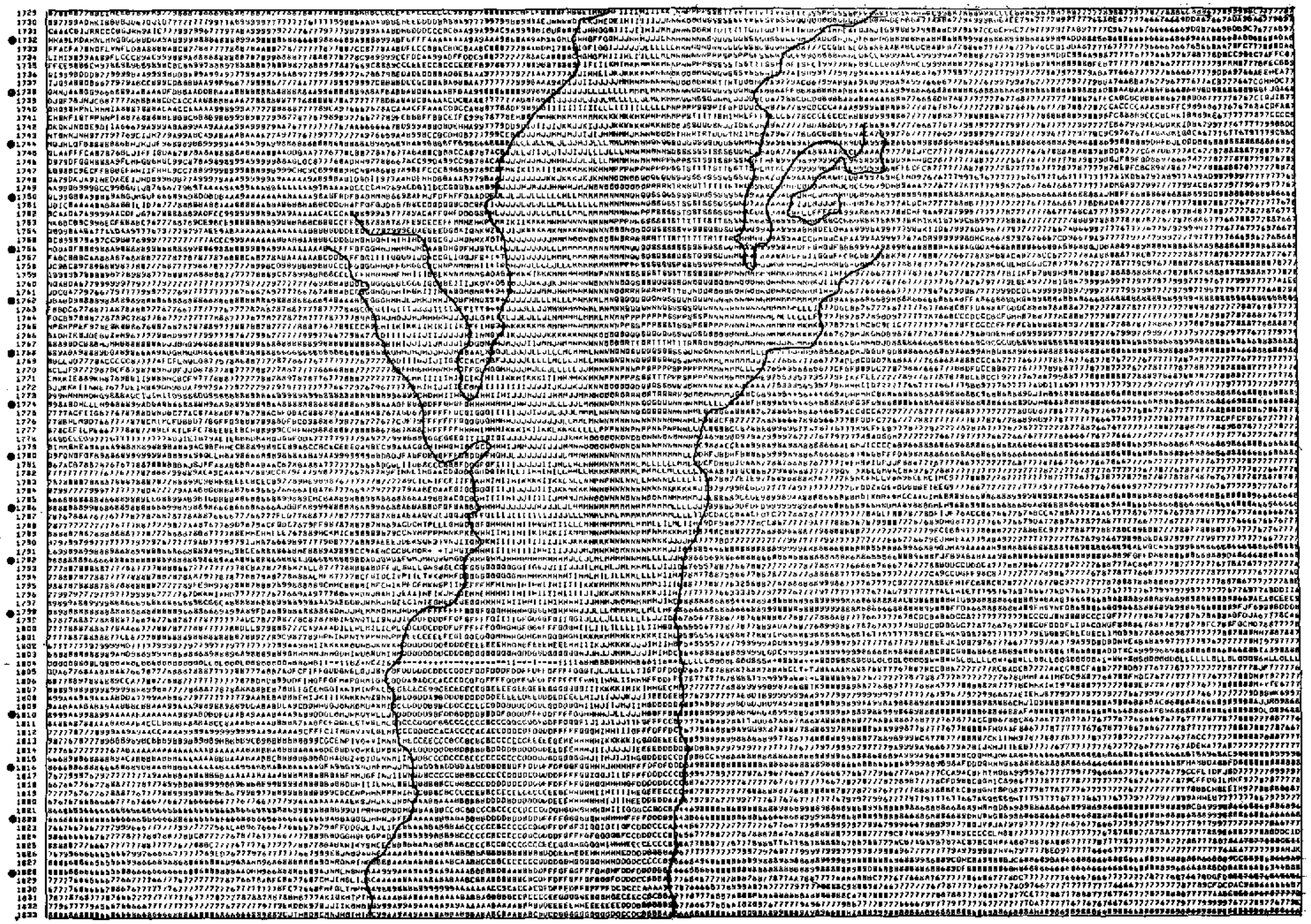

FIGURE 37
QUANTICO, GE's CHANNEL 5
INTENSITY MAP, IMPROVED TAPES
INTEN

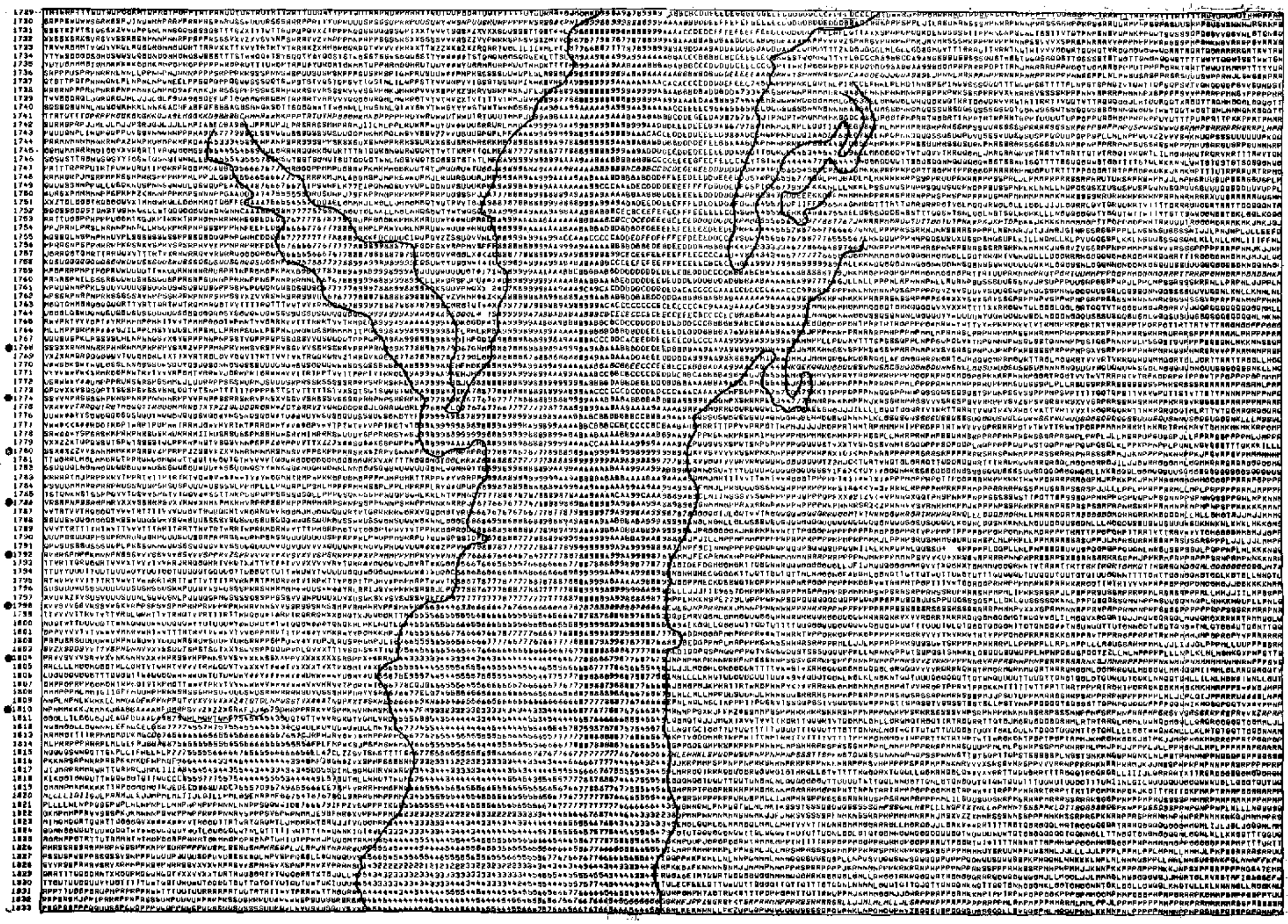

FIGURE 38
QUANTICO, GE's CHANNEL 6
INTENSITY MAP, IMPROVED TAPES

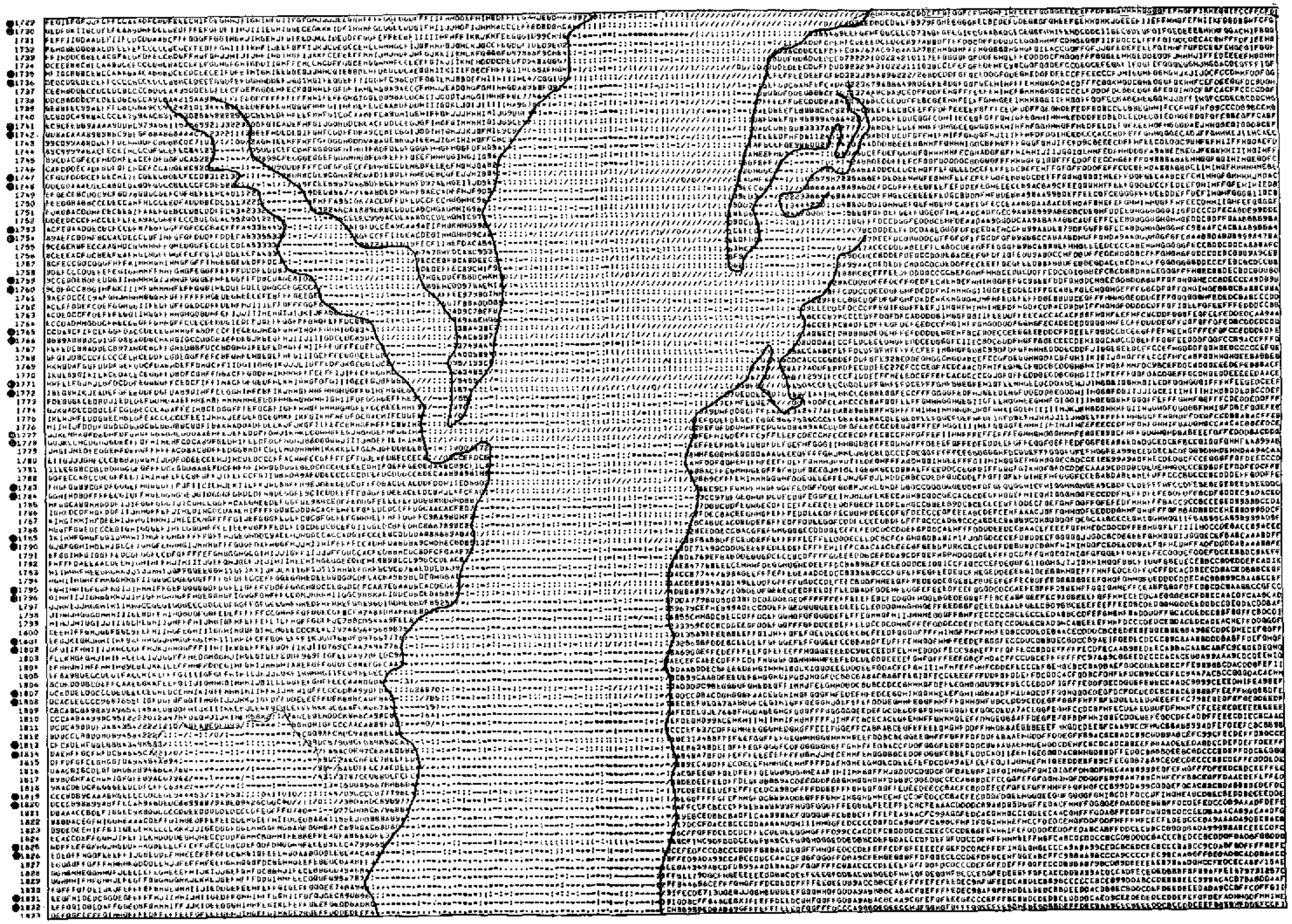

FIGURE 39
QUANTICO, GE's CHANNEL 7
INTENSITY MAP, IMPROVED TAPES

It has been found that both MITRE's and GE's maps for Quantico still show striping. We, therefore, believe the problem to be in the data and not inherent in our software or our use of it (i.e., our choice of limits). Therefore, the data as such are not useful for water quality analysis, and should be the focus of further study and correction at GSFC.

2.4.3 Special Quick Response Analysis - Water

During this reporting period, a special ERTS analysis request was received from Mr. Norman Melvin of EPA's Region III Headquarters in Philadelphia. Mr. Melvin was aware of MITRE's ERTS work on land use and water quality along the Susquehanna River, and when a special situation arose in west-central Pennsylvania requiring flood aftermath assessment, he asked MITRE to see if information was available from ERTS which would assist in the overall assessment.

Heavy rains (nine inches in 24 hours) had caused severe flooding on September 11, 1972, affecting the following rivers and creeks in Armstrong and Indiana counties:

Cush Cush

Rayne Run

Pine Run

Crooked Creek

Little Mahoning Creek

Plum Creek

A Federal Disaster Area was declared on September 25 for the following communities:

Marion Center

Prochester

Cherry Tree

Mather

Clymer

Stafford

Dickensonville

Home

Shillocketa

Plumville

Although the area was not in either of MITRE's test sites, MITRE agreed to examine ERTS coverage to determine if any coverage about the time of the flood would provide useful data for analysis of the area. The following are the results of the checks on all coverages of the area from September 1972 to January 1973.

1. September 7: Coverage was four days prior to the flood. Cloud cover acceptable.
2. September 25: Imagery showed excessive cloud cover over the area. Fourteen days after flood.
3. October 13: Over 50 percent cloud cover over area of interest. Thirty-two days after flood.
4. October 31: Imagery showed excessive cloud cover over the area. Fifty days after flood.

5. November 18: Imagery showed excessive cloud cover over the area. Sixty-eight days after flood.

6. December 6: Imagery showed excessive cloud cover over the area. Eighty-six days after flood.

7. December 24: Imagery showed excessive cloud cover over the area. One hundred and ten days after flood.

8. January 11: Cloud cover acceptable over test area. One hundred twenty-nine days after flood.

Unfortunately, none of the coverages of flooded area could be considered useful for further analysis, primarily because of excessive cloud cover. The January coverage was acceptable on the basis of cloud cover, but was eliminated because of the length of time which transpired since the flood. Reports of investigations of flood inundation assessment indicate that about seven to ten days after flood crest is near the maximum elapsed time for identifying the high water mark, and after about 30-45 days indicators of plant stress caused by flooding have begun to fade.[10,11] It was concluded that although ERTS has a demonstrated capability for providing useful flood damage assessment information, the capability is dependent upon good cloud-free coverage within a reasonable time after flood crest. In this particular situation the required coverage was not available.

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[10] Hallberg, et al. "Application of ERTS-1 Imagery to Flood Inundation Mapping", Symposium of Significant Results Obtained from ERTS-1 vol. 1, Section A., Washington, D.C.: NASA 1973 pp. 745-753.

[11] Morrison, R. and Cooley, M. "Assessment of Flood Damage in Arizona by Means of ERTS-1 Imagery", ibid, pp. 755-760.

2.5 Air Quality Analysis

2.5.1 Further Results of Turbidity Analysis

The primary air quality analysis effort during the period of the first Type II report focused on determining the existence of correlation between the average grayness recorded by ERTS-1 over the Harrisburg test site with a calculation of turbidity based on reports from up to 16 Turbidity Network stations (located on the map of Figure 40). With only three ERTS coverages available at the time of the first report, the data nevertheless did show very good preliminary correlation. Since that time two more coverages, September 6, 1972 and January 10, 1973, have been analyzed and compared with turbidity data. The tabulated data are shown on Table 16, and Figure 41 is a graphic presentation of the results. Clearly the trend reported earlier has continued, and there appears to be a definite correlation between ERTS reported average grayness levels for Channel 4 and turbidity calculations. It is felt that further development of the investigation along these lines could potentially lead to the development of a reliable ERTS based system for monitoring meso- and macro-scale turbidity across large regions.

2.5.2 Redirection of Air Quality Effort

At a meeting at Goddard Space Flight Center with the ERTS Technical Officer on June 25, 1973, as discussed in Section 1.0, it was determined that time and resources would not be sufficient to continue the investigation in land use, water quality, and air quality at the prevailing level of effort for each area. Consequently, it was agreed that the bulk of the effort of Phase III would be directed toward land use analysis

TABLE 16

CALCULATED TURBIDITY AND GRAYNESS DATA

ERTS - 1 AVERAGE GRAYNESS (CH. 4)

1 August 1972	35.06	
6 September 1972	26.97	
11 October 1972	23.72	
16 November 1972	25.82	(Corrected to 20.1)
10 January 1973	19.15	

CALCULATED TURBIDITY FOR HARRISBURG TEST AREA

	Uncorrected	Pop. Corrected
1 August 1972	0.220	0.152
6 September 1972	0.165	0.142
11 October 1972	0.151	0.118
16 November 1972	0.072	0.038

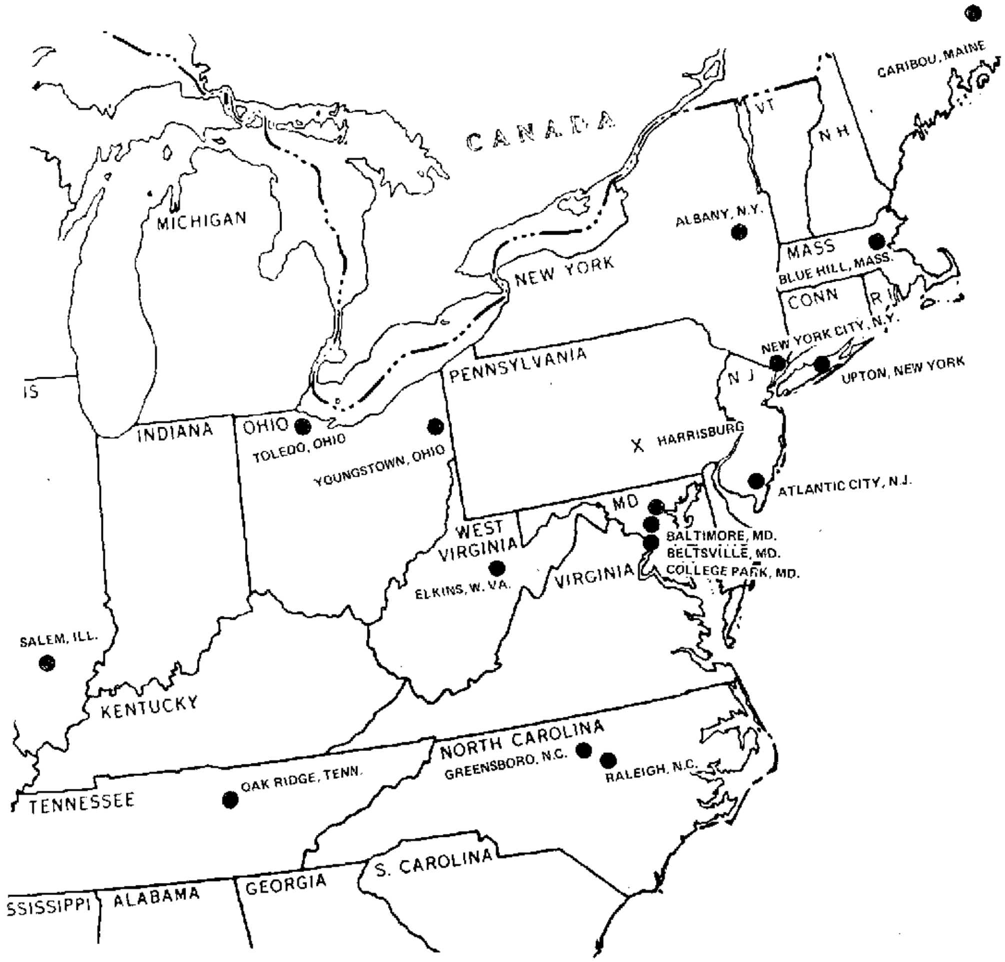
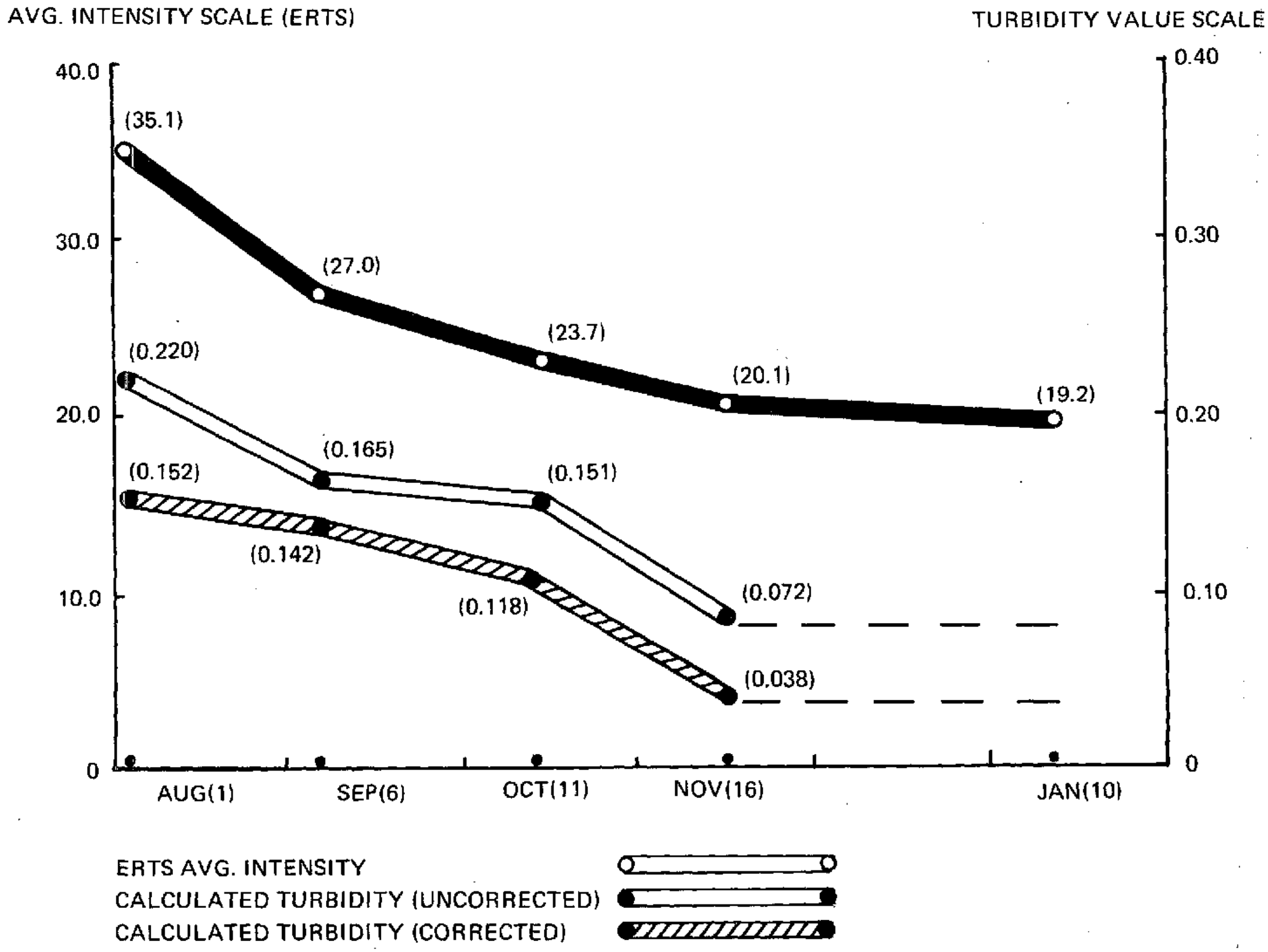


FIGURE 40
TURBIDITY NETWORK STATIONS
REPORTING DATA FOR THE MITRE ERTS-1 INVESTIGATION



COMPARISON OF ERTS-1 AVERAGE INTENSITY VARIATION WITH CALCULATED TURBIDITY VARIATION OVER THE HARRISBURG, PA. TEST SITE

FIGURE 41

in the Harrisburg and Wilkes-Barre-Scranton test areas. Water quality analysis was to receive second priority, with a concentration on Susquehanna River targets, and the air quality investigation was to continue only on a non-interfering basis with the land use and water quality efforts. The primary reason cited for de-emphasis on air was that of the three areas, it held the least promise of immediate useful environmental applications resulting from the investigation. There was also some question from the Technical Officer regarding (1) the validity of interpolating turbidity from 16 stations for the test site, rather than having a dedicated DCP (in this case, a Volz Sunphotometer station) in situ at the Harrisburg test site; and (2) the likelihood of heavy rains and resultant groundwater accumulations near the dates of ERTS coverage biasing the average grayness results. On the first point, MITRE's position was that interpolation from the existing Turbidity Network is an adequate method for investigating meso- and macro-scale turbidity trends, especially as compared to similar techniques successfully employed by the Weather Service in mesoscale weather analysis, and that the expense of adding a new station within the test site would not be justified on the basis of a small increase in the accuracy of the turbidity values. As regards the second point, only coverage dates where no rain had fallen in the test area for the preceding week were used for the ERTS calculations, thus negating recent rain effect on ground reflectivity. Additionally, only channel 4 was used for calculating ERTS average grayness values, and ground water effect on intensity values would be negligible in that bandwidth. Nevertheless, because of the priority of completing the land use and water quality investigations, it was agreed that air quality analysis would continue on a non-interfering basis with the other two areas.

Turbidity Network data has been requested for the dates selected for the continuing ERTS land use investigation, and ERTS/turbidity correlation analysis will proceed as time permits. Additionally, any point sources discovered in the course of the land use and water quality investigations are being analyzed as targets of opportunity.

2.6 Microscale Targets - Land, Air and Water

The microscale target areas selected for MITRE's ERTS-1 investigation are the following:

Holtwood Dam Lake

Conowingo Dam

Safe Harbor Lake

*Codorus Creek Lake

Brunner Island

Conewago Creek Mouth

Lime Kiln at Annville

*Harrisburg

*Susquehanna River-Sunbury to Maryland

Lancaster

York

*Swatara Creek Mouth

Conestoga Creek Mouth

*Juniata River Mouth

*Three Mile Island

A study was undertaken of these areas in order to determine targets for further investigation.

Images were available for 1 August 1972 (1009-15241), 6 September 1972 (1045-15243), 11 October 1972 (1080-15185), 16 November 1972 (1116-15192), 9 January 1973 (1170-15191), 10 January 1973 (1171-15245), and 9 April 1973 (1260-15195). However, only the October, November, January (1170-15191) and April images included all the target areas; the remaining dates cover those areas designated by asterisks, (*).

The dates that proved least helpful for our analysis were 16 November 1972, 9 January 1973, and 10 January 1973. The November 16th images were very hazy and most of the target areas are not visible in the Channels 4 and 5 images. For both January 9th and 10th the Susquehanna River is dotted with patches of ice, making it hard to identify turbidity caused by merging streams.

For the other images and dates the most productive was 11 October 1972. All along the river on this date water gradations are very evident especially in the Channel 4 image. This scene and date has been chosen for our water quality analysis (Section 2.4.1). Also on this day apparent point source smoke plumes have been detected. In accordance with the redirection of the air quality effort which included analyzing point source targets of opportunity (Section 2.5.2), these plumes were investigated in greater detail to determine their origin, and, if feasible, to develop signature information. Three distinct plumes were identified, and their origins were determined to be the Brunner Island power plant, the Annville lime kiln, and a large diffuse plume tentatively identified as originating at the Delmarva Power Plant near Delaware City, Delaware, (Figure 42). The smoke plume over Brunner Island has been chosen for closer analysis. This is being done on a noninterference basis with our land use and water quality study. Therefore to this date we have no conclusive evidence to report, since land use analysis has involved virtually a full time effort.

The only other target areas of interest for this reporting are (1) a small plume of turbid water flowing in the Susquehanna from Swatara Creek in August and (2) a plume from the Conodoguinet Creek in September.

As time permits other images will be studied for these target areas.

2.7 DCP Data Analysis

MITRE's efforts to obtain water information involved the implementation of two Data Collection Packages (DCP) along the Susquehanna River. Both DCP's were shipped on 20 November 1972 to Dr. Richard Paulson of the USGS/Harrisburg for implementation and management. At that time it was decided that the two DCP's would be dedicated to (1) the water quality station at Renovo and to (2) the water quantity station at Newport, Pennsylvania on the Juniata River. Philadelphia Electric Company data at Peach Bottom would be accepted for the dam basins on the Susquehanna River.

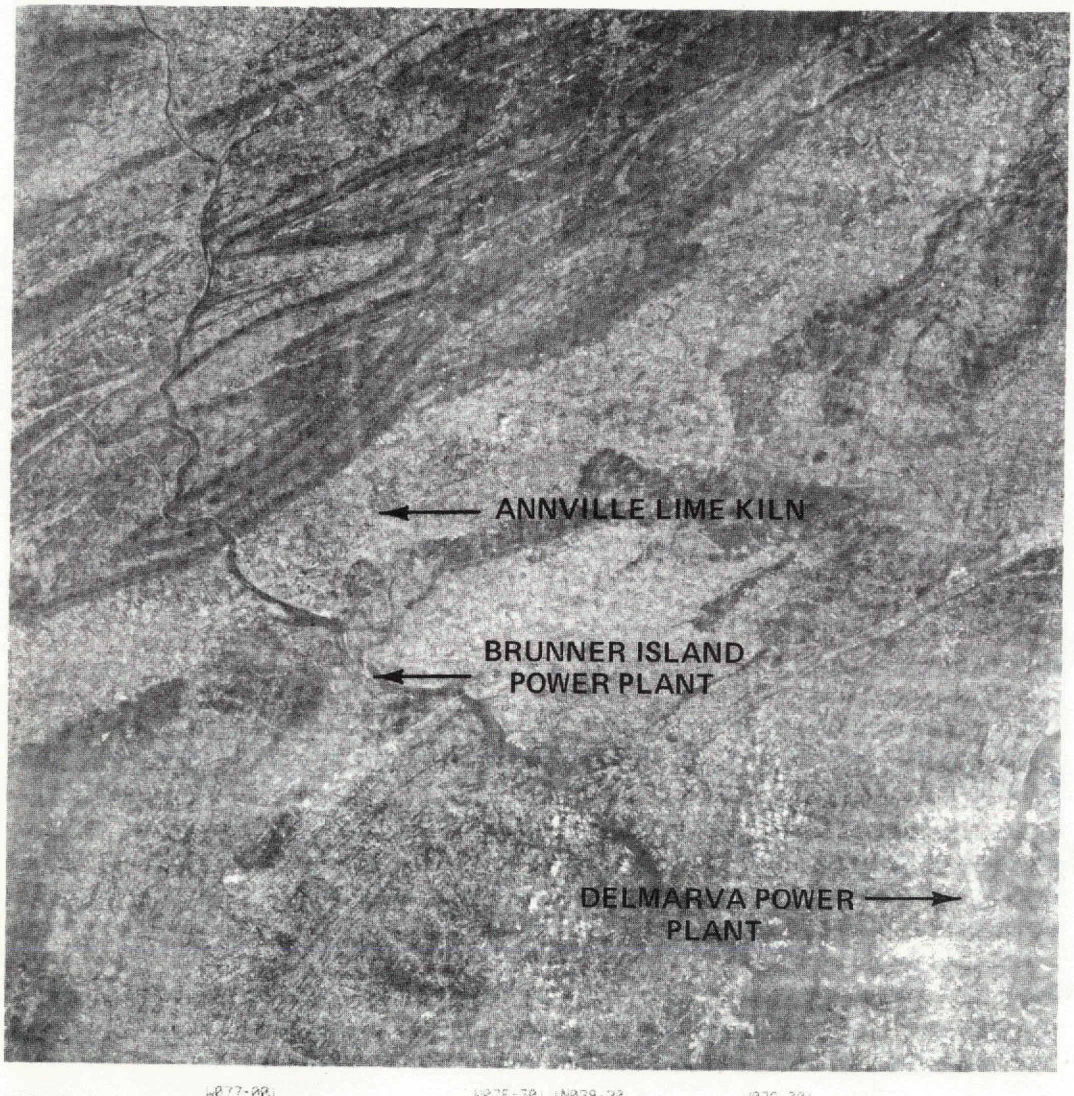


FIGURE 42
MICROSCALE AIR QUALITY TARGETS
11 OCTOBER 1972

To date a DCP has been installed in April 1973 on the West Branch of the Susquehanna River at Lewisburg, Pennsylvania and at Towanda, Pennsylvania on the East Branch of the Susquehanna River. Both are dedicated to recording water quantity at these points on the River. USGS and MITRE had reached a joint agreement in the placement and use of these stations. Subsequent changes made by USGS, see Appendix A, has degraded the use of these stations to MITRE's efforts in water quality analysis.

MITRE has been receiving output from 11 April 1973 to the present from the Lewisburg Station. The data are actually collected three times within the three minute intervals per pass. Only one of the three sets is recorded unless there is a significant change ($\pm$ 0.01 feet in stage height) in the information. There are approximately five readings recorded for each day for this station. Since the information MITRE has received is only water quantity not quality, this information is averaged further on a daily basis. The output from this DCP is included as Figure 43. These data have not proved to be useful (1) because of the DCP location out of our direct water test area (ie., Susquehanna River Mouth to Sunbury) and (2) the fact that the DCP is only recording water quantity.

MITRE's second DCP was set up on the Susquehanna River at Towanda, Pennsylvania, several months ago. This station has not operated properly and was returned to the USGS/Harrisburg office for a checkout and repairs. No data have been obtained from this DCP and it has been withdrawn from the Site. This DCP is expected to be reinstalled by 1 October 1973 at Towanda.

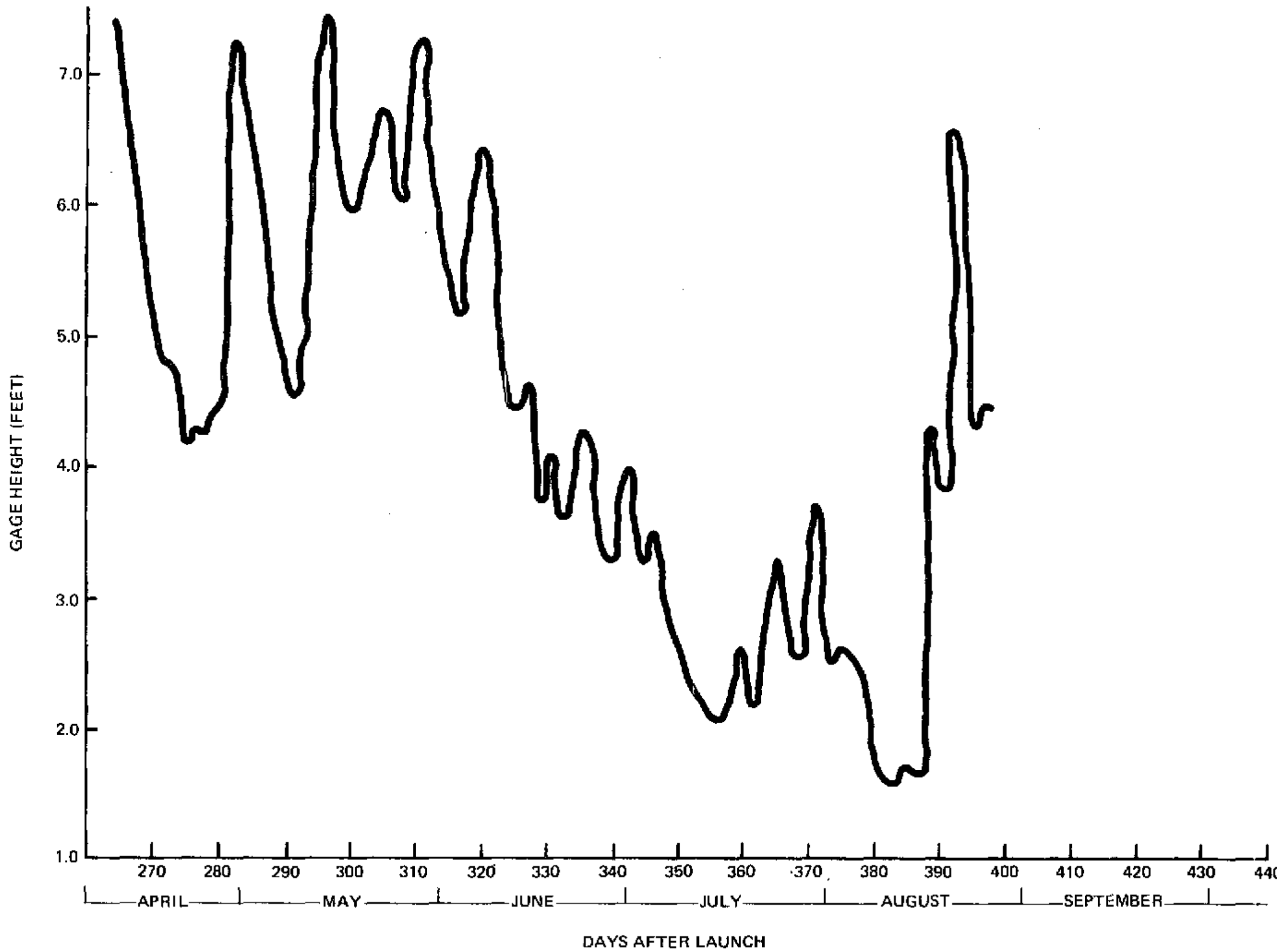


FIGURE 43
DATA FROM LEWISBURG DCP STATION

MITRE's other source for water quality information, i.e., Philadelphia Electric Company, has not followed through with the in-situ support promised initially. On February 6, 1973 data were sent by Fred N. Megahan, Assistant Chief Chemist, for 10 random dates from October 31, 1972 through December 24, 1972. MITRE's investigation of water quality parameters centered on data obtained for the 11 October 1972 overflight date (See Section 2.4.2). Data for January 1973 through March 1973 was promised but has not been received by MITRE. Contacts with this organization recently indicate that their data will be forthcoming for the Type III Report.

MITRE's attempt to get useful calibration information using DCP's along the Susquehanna River has proved futile. USGS, in setting up these stations as a water quantity sensing system aid, has produced information valuable for their purposes but of limited usefulness for our investigation.

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3.0 NEW TECHNOLOGY

There is no new technology development to be reported at this time.

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4.0 PROGRAMS IN NEXT REPORTING INTERVAL

The final four month effort will complete the Phase III - Continuing Analysis Phase - and will involve the following specific tasks:

1. Complete the processing of the following dates and targets such that land use once a season for four dates is covered.
   - Site 1
     - April 9, 1973, (1260-15195)
     - July 8, 1973, (1350-15190) - if time and resources permit.
   - Site 2
     - January 9, 1973, (1170-15184)
     - April 9, 1973, (1260-15184)
     - July 8, 1973, (1350-15183)
2. Continue to process mesoscale air quality indices derived from ERTS MSS and compare to Volz Sunphotometer data for as long as time and resources permit.
3. Compare signature trends for land use and develop algorithms for yearly variation.
4. Define the system (software and hardware) which can produce land water and air quality indices from ERTS MSS CCT's.
5. Develop and present cost-benefit arguments for the use of indices developed from ERTS data.
6. Produce the Type III Final Report.

7. Return processed computer products.

8. Break down and return the DCP equipment.

These above Tasks are to begin in September 1973 and continue through to the termination date of 31 December 1973, at which time the investigation objectives are expected to be achieved.

5.0 CONCLUSIONS

We have just completed the half way point in the final phase and any firm conclusions at this point would clearly be premature. Nevertheless, a brief discussion of potential conclusions may be useful here.

First, there is nothing that has been revealed in the analysis to date that would indicate that any of MITRE's stated objectives cannot be achieved. On the contrary, the early results in all three environmental areas - and in land use change particularly - have been most encouraging. The gross level to which air quality has been analyzed thus far in the investigation has potential for much refinement and enhancement toward the objective of developing at least mesoscale air turbidity indices. Likewise, difficulties involved in obtaining repeatable signatures for water turbidity levels on different river sections has been overcome and water quality indices have been developed.

No formal work has yet been completed on the second major objective of the investigation - developing specifications for an ERTS- type system for environmental monitoring. Nonetheless, nearly all of the effort and learning taking place in Phases I, II, and III is directly related to development of that final product, and the last several months of the investigation will formally concentrate on indices and specifications development.

As a general statement regarding potential conclusions, it appears at this time that the objectives set for the MITRE investigation will be achieved.

6.0 RECOMMENDATIONS

The primary recommendation for improved operation during Phase III analysis is the following:

- Make <u>both</u> ERTS-1 imagery and MSS CCT for MITRE's test sites on a given "good" date available simultaneously to the Principal Investigator.

The recommendation is made in the interests of having more good ERTS-1 data more expediently available for analysis during the period of the investigation. Experience has shown that only approximately 4.2% of the coverage of MITRE's test sites results in data products that are useful for further processing. This means only about four additional coverages can be expected during one year of observations (See Section 1.0). If imagery and MSS CCT's are not available at the same time, then several weeks (months sometimes) are irretrievably lost. To get maximum use out of available ERTS-1 data, and to process the data expediently so that other aspects of the investigation can go forward, MITRE needs to receive imagery and MSS CCT simultaneously for any given date of coverage.

The second recommendation to be made at this time is the following:

- NASA should establish, at the Goddard Spaceflight Center or some other appropriate location, a central library containing documentation of the various computer programs and digital analysis techniques applied to MSS data. The documentation in the library should be made available free of cost (or at some nominal fee) to all legitimate investigators.

The two main benefits of this recommendation are obvious: (1) costly and time-consuming duplication of MSS software development efforts can be avoided; and (2) a large catalog of existing methods and approaches is available to investigators for planning their experimentation. A great many valuable analysis programs have been developed, for example, by the Jet Propulsion Laboratory, the Environmental Research Institute of Michigan, the Laboratory for the Application of Remote Sensing (Purdue), the Pennsylvania State University, and others. It seems in the common interest of NASA and all investigators to share this wealth of accumulated information on the analysis of ERTS-1 and similar MSS data.

- De-striping software needs to be employed on all CCT's.

Striping, as discussed in section 2.0, inhibits the worth of the ERTS MSS data on certain targets such as water quality/turbidity and probably poisons the signatures of more complex targets such as land use. The knowledge of the limits of the MSS data (± quanta) should be made known for each frame so the experimenter does not overwork the poorer scenes needlessly.

- NASA should interest the users (State and local government) to produce uniform digitized land use libraries.

Uniform (at least 4-5 acre resolution) land use digitized libraries would aid the experimenter who in time could aid the

State preparing up-to-date land use inventories on a continuous and operational basis (Assuming an operational ERTS-like reconnaisance system exists).

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United States Department of the Interior

GEOLOGICAL SURVEY

July 3, 1973

Mr. Edward A. Ward
Environmental Systems
The Mitre Corporation
Westgate Research Park
McLean, Virginia 22101

Dear Mr. Ward:

This letter is to acknowledge the receipt and use of two Data Collection Platforms (DCP) from your Susquehanna River basin - ERTS project, that I have field installed and operated on stream gages in the Susquehanna River basin.

As you know, the Geological Survey has worked closely with the Susquehanna River Basin Commission in testing the potential use of the ERTS Data Collection System for streamflow warning and forecasting. In response to the need for such a warning system, which was demonstrated a year ago during the flood of Hurricane Agnes, we used your two DCP's and two additional DCP's I acquired from the EROS Program, to establish a skeleton data-relay system in the basin.

I am pleased to say that all your DCP's have been installed and currently all are functioning, although a problem with the stage recorder at Towanda has recently surfaced.

Your cooperation in permitting your two DCP's to be used on stream gaging stations, rather than one stream gage and one water-quality monitor, is appreciated.

Sincerely yours,

Richard W. Paulson
Hydrologist

Appendix A

USGS Letter Regarding DCP Stations