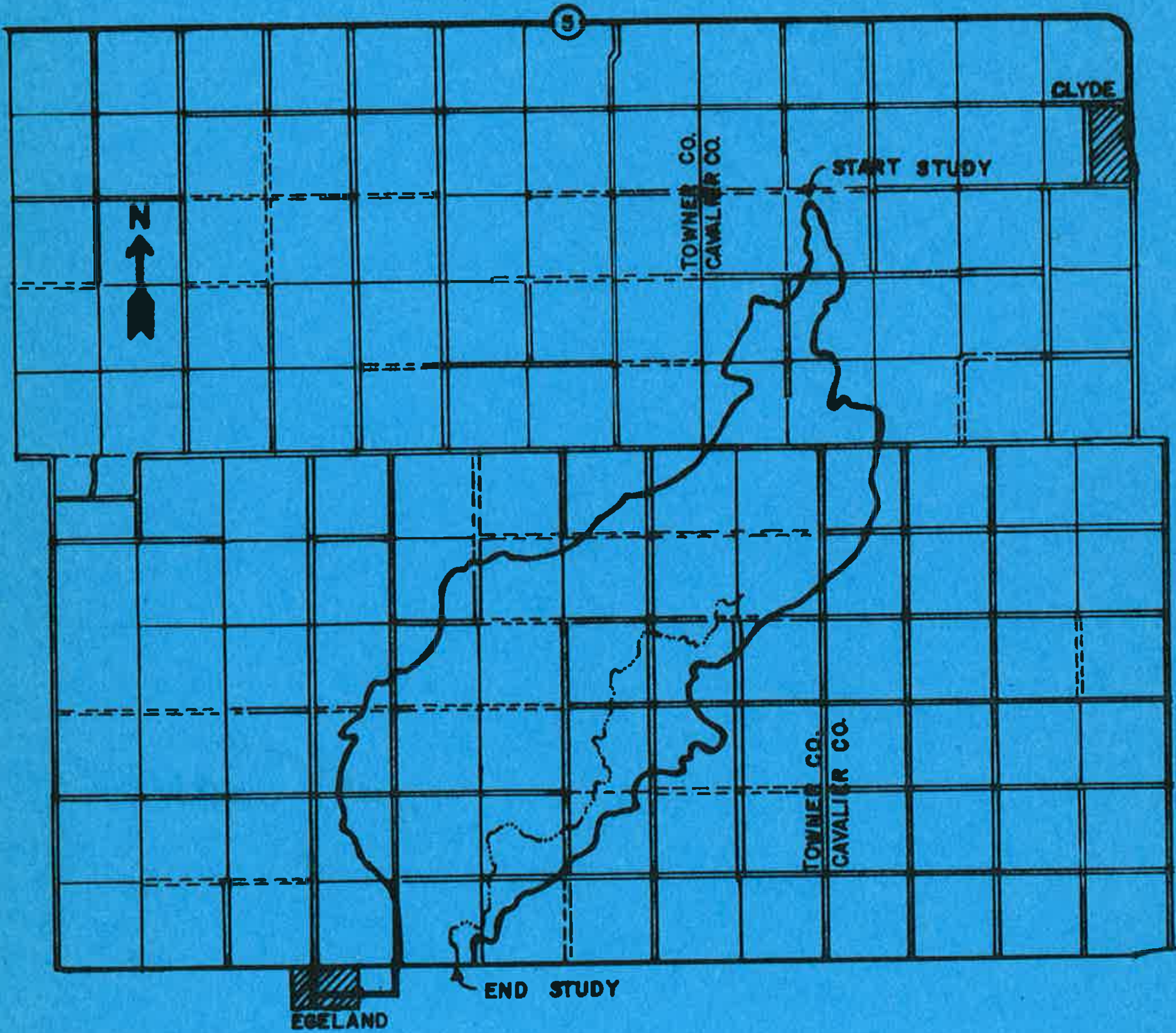
PRELIMINARY ENGINEERING REPORT

TWIN HILL TOWNSHIP FLOOD STUDY

SWC PROJECT NO. 1745



NORTH DAKOTA
STATE WATER COMMISSION

MAY 1982

PRELIMINARY ENGINEERING REPORT

TWIN HILL TOWNSHIP FLOOD STUDY
SWC PROJECT #1745

MAY, 1982

North Dakota State Water Commission
State Office Building
900 East Boulevard
Bismarck, North Dakota 58505

PREPARED BY:

RANDY GJESTVANG
Assistant Investigation Engineer

SUBMITTED BY:

DAVID A. SPRYNCZYNATYK, P.E.
Director of Engineering

APPROVED BY:

VERNON FAHY, P.E.
State Engineer

Prepared for the
Towner County Water Resource Board

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I. INTRODUCTION

In August of 1981, the North Dakota State Water Commission entered into an agreement with the Towner County Water Resource Board. This agreement, shown in Appendix A, requested that a hydrologic analysis be made of the coulee northeast of Egeland. Figure 1 shows the general location of the study area.

Originally, the agreement requested that an investigation be conducted to determine the downstream effects of increasing the capacity of the crossing located between Sections 10 and 11, Township 160 North, Range 65 West (See Plate 1). All channel and crossing capacities were to be determined for the study area. A report summarizing the adequacy of the crossings and recommending improvements was to be presented. However, in November of 1981, Twin Hill Township replaced several of the culverts within the study area. The hydrologic analysis, necessary to determine the size of the culverts that would adequately handle the flow, had not been completed.

For this reason, it was necessary to modify the intent of the original agreement. The study was changed to an analysis of the replaced culverts. It was not possible to analyze the adequacy of the original culverts. This report contains the results of the modified hydrologic study. The capacity and adequacy of the new crossings were determined based on the estimated runoff from various frequency storms. Maps, showing the land area inundated behind each crossing, are included for various frequency storms. If the crossing was not adequate, the culvert size required to alleviate the problem is presented.

DESCRIPTION OF AREA

A drainage area of 20.4 square miles was analyzed. The coulee is an intermittent stream which is a tributary of the Mauvais Coulee. Approximately 17.6 river miles of the coulee were within the study area. On the average, the channel slopes are at a rate of 6.3 feet per mile.

As shown in Figure 1, the study area is located in the east-central portion of Towner County, in north-central North Dakota. The study starts in the upper portion of the drainage area in Section 20, Township 161 North, Range 64 West, and extends downstream to the south boundary of Section 5, Township 159 North, Range 65 West. (See Plate 1)

This area is located in the Central Lowland Province (Fenneman, 1938, p. 559) and the Drift Prairie as designated by Simpson (1929, p. 4). Soil composed of loam to clay loam glacial till predominates in this area. The topography consists of many low irregular shaped hills and poorly drained depressions.

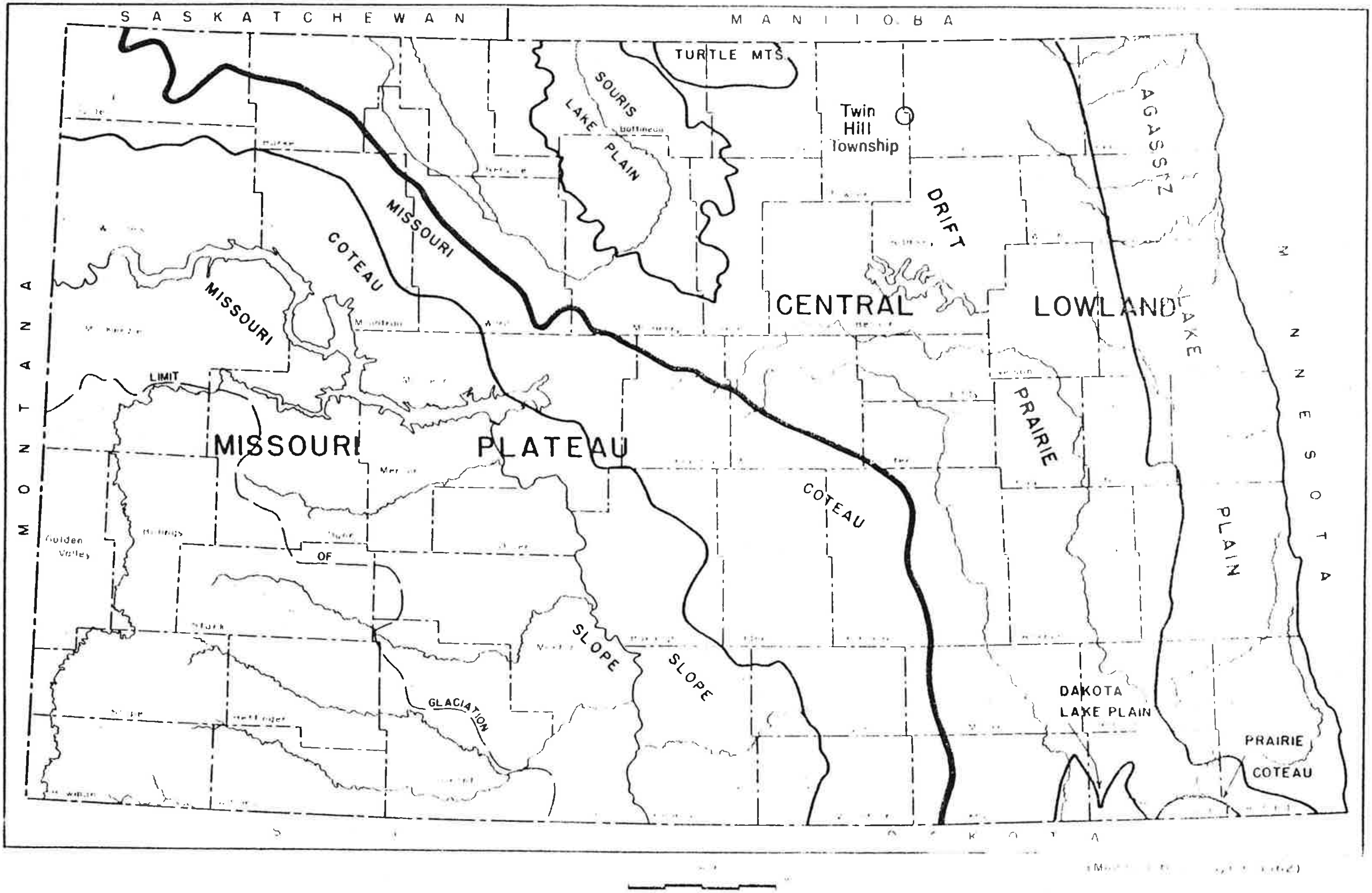

Figure I — LOCATION OF TWIN HILL TOWNSHIP STUDY AND PHYSIOGRAPHIC PROVINCES OF THE AREA

II. HISTORICAL BACKGROUND

In September of 1980, the Towner County Water Resource Board received a complaint from Harold Campbell. He claimed that the roadway between Sections 10 and 11 in Township 160 North, Range 65 West acted as a dam during high flows. Approximately 30 acres of land is inundated during periods of heavy rainfall. Water spills over into the undrained low areas that are south and east of the crossing. Flooding has occurred in this area in 1975, 1979, and 1980.

After conferring with the State Water Commission, a 36 inch CMP was installed alongside the existing 48 inch CMP at this site. David Barrett and his mother, Mildred Barrett, became concerned over this installation. They own land immediately downstream in Section 10 and 15 of Township 160 North, Range 65 West. They were concerned that the capacity of the two 36 inch C.M.P. between Sections 10 and 15 was not as great as the capacity upstream. During high flow conditions, water could back up into a slough area on their property. Because no outlet is available for this slough area, valuable farmland could be flooded. In order to determine the adequacy of these crossings, the Towner County Water Resource Board requested the State Water Commission to perform a hydrologic analysis of the area.

Twin Hill Township installed a culvert at the Barrett crossing, as well as several other crossings along the coulee, during November of 1981. A hydrologic analysis of the study area had not been completed at that time.

III. ENGINEERING ANALYSIS

STUDY PROCEDURE

The hydrology of the study area was analyzed using the TR-20 program developed by the U.S. Soil Conservation Service. It was used to determine the peak elevations, peak inflow, and peak discharges of various frequency storms. The program formulates a mathematical, hydrologic model of the watershed. This is based on the following data: the amount of rainfall, rainfall distribution, soil type, land use, and the hydraulic characteristics of the stream channels and drainage area.

The study area consisted of 20.4 square miles. It was divided into five sub-basins in order to obtain more accurate results from the TR-20 program. This program was run assuming that no structures were present on the channel. Therefore, the results obtained will be for a channel with no obstructions along its path.

Cross sections were taken at several points along the coulee. A roughness coefficient (n) was determined according to the surface roughness and type of vegetative growth present at each cross section. The slope, n-value, and the dimensions of the channel were input into an open channel program utilizing Manning's formula. Channel capacities at 1/2 foot intervals were determined for each cross section.

The land area is comprised of glacial till with numerous depressions and hills. Several of these depressions do not contribute to the inflow of the coulee. Unless extensive drainage practices have been incorporated, some portions of the watershed have ponding occurring over as much as 30% of the area. A reduction in the effective runoff was made in order to account for this storage capacity. A general land use description of the area is as follows:

Row Crops	45%
Fallow	25%
Small Grain	20%
Pasture	5%
Farmsteads and Roads	5%

An inventory was taken of each crossing in the study area (See Table 1). The numbers encircled on Plate 1 show the location of these crossings. The size and invert elevations of the culverts were obtained. Roadway elevations were also taken at these points.

All the sub-basins, from the TR-20 analysis, were further divided according to the area contributing to each crossing. Flows from each area were estimated by using the data from the TR-20 computer model. Conditions at each crossing were then analyzed by flood routing the coulee flow through the study area. This analysis was done for various frequency events.

Starting from the upstream end of the drainage area, inflow received at the first crossing consists solely of runoff from its contributing area. This inflow was flood routed through the crossing. Inflow received at the next crossing consists of the runoff from its contributing area, plus the discharge from flood routing the upstream crossing. This inflow was then flood routed through the crossing. Continuing downstream, this process was repeated for each crossing.

Inflow conditions at each crossing are dependent on the capacity of the upstream crossing. Quadrangle maps with a five-foot contour interval were used to determine the area inundated by back water from each crossing. It was assumed that the texas crossings would not significantly back up water.

TABLE 1

CULVERT INVENTORY

Crossing Number	Legal Description S-T-R	Description	Pipe Length (FT)	Invert Elevation (MSL)	Road Elevation (MSL)
1	20,29-161-64	18"CMP	30	1593.0	1597.0
2	31,1-161,160-64,65	36" CMP	40	1578.4	1582.7
		36" CMP	40	1578.3	
3	1,2-160-65	30" CMP	22	1573.8	1577.7
		Texas Crossing		1575.2	
4	2,11-160-65	36" CMP	20	1567.0	1570.7
		24" CMP	20	1567.3	
5	10,11-160-65	24" CMP	48	1557.7	1563.0
6	10,11-160-65	48" CMP	46	1556.4	1561.7
		36" CMP	48	1555.1	
7	10,15-160-65	48" CMP	42	1549.4	1554.6
		36" CMP	41	1548.5	
8	15,22-160-65	48" CMP	42	1542.8	1548.3
		36" CMP	42	1543.8	
9	21,22-160-65	48" CMP	35	1542.4	1548.2
		36" CMP	38	1543.3	
10	21,28-160-65	48" CMP	34	1535.2	1541.3
		36" CMP	34	1536.5	
		24" CMP	36	1536.9	
11	14,15-160-65	36" CMP	38	1552.4	1558.0
12	15,22-160-65	36" CMP	40	1544.6	1550.3
		24" CMP	28	1546.0	
13	28,33-160-65	48" CMP	50	1526.1	1531.9
		36" CMP	50	1526.0	
		36" CMP	34	1526.9	
14	32,33-160-65	Texas Crossing		1524.2	
15	32,5-160,159-65	3.7' x 6' RCP	53	1518.3	1525.4
		3.7' x 6' RCP	53	1518.1	
16	5-159-65	5' x 5.3' RCP	30	1516.0	

STUDY RESULTS

Results from the TR-20 computer program show that floods occurring with a frequency of 10, 25, 50, and 100 years were slightly larger when caused by rainfall than by spring runoff. Results of the program provided an inflow hydrograph for each of the five sub-basins.

Peak water elevations and the amount of water backed up behind each crossing were determined for various frequency events. As shown in Table 2, no roadways are overtopped during a 10 year event. Table 3 shows that crossings 4, 11, and 13 will be overtopped during the 25-year event. Several roadways will be overtopped by the 50 and 100 year events (See Tables 4 and 5).

It is questionable whether the water would reach the elevation calculated for crossing 13. Its upstream area has no set drainage pattern. The runoff could spread out over a large area, slowing its arrival at the crossing. Also, several roadways must be crossed. This would reduce the peak flow and delay its arrival to the crossing. Due to these conditions, the roadway probably wouldn't be overtopped until the 50 year event occurred. The peak water elevation for the 10 and 25 year events may be about 0.5 foot less than the calculated values.

Water surface elevations were calculated for both sides of the crossings. The difference in these elevations represents the depth of water backed up by the structure.(See Tables 2 through 5). A water surface profile was not developed for the entire length of the channel. An insufficient number of cross sections were obtained to accurately evaluate the flat land area bordering the coulee. Also, the purpose of the study was to evaluate the adequacy of the crossings.

Tables 2 through 5 also show the number of acres inundated during the 10, 25, 50, and 100 year events. As shown in Plates 2 through 9, a fairly large

TABLE 2
FLOOD ROUTING RESULTS
10 YEAR EVENT

Crossing Number	Legal Description S-T-R	Roadway Elevation (msl)	Head Water Elevation (msl)	Area Inundated (acres)	Storage (acre-feet)	Tailwater Elevation (msl)	Change In Elevation (ft.)
1	20,29-161-64	1597.0	1595.3	4	5	1593.3	2.0
2	31,1-161,160-64,65	1582.7	1580.6	22	74	1580.2	0.4
4	2,11-160,65	1570.7	1570.4	7	20	1569.0	1.4
6	10,11-160-65	1561.7	1559.3	13	32	1556.7	2.6
7	10,15-160-65	1554.6	1552.2	25	75	1550.2	2.0
8	15,22-160-65	1548.3	1546.7	39	48	1546.0	0.7
9	21,22-160-65	1548.2	1546.0	2	2	1544.1	1.9
10	21,28-160-65	1541.3	1538.6	28	69	1536.9	1.7
11	14,15-160-65	1558.0	1557.3	38	102	1554.3	3.0
12	15,22-160-65	1550.3	1548.2	35	98	1546.0	2.2
13	28,33-160-65	1531.9	1530.3	139	284	1528.4	1.9
15	32,5-160-159-65	1525.4	1521.3	116	160	1521.1	0.2
16	5-159-65		1521.1	15	45	1518.6	2.5

TABLE 3
FLOOD ROUTING RESULTS
25 YEAR EVENT

Crossing Number	Legal Description S-T-R	Roadway Elevation (msl)	Head Water Elevation (msl)	Area Inundated (acres)	Storage (acre-feet)	Tailwater Elevation (msl)	Change In Elevation (ft.)
1	20,29-161-64	1597.0	1596.6	6	8	1593.3	3.3
2	31,1-161,160-64,65	1582.7	1581.6	32	104	1580.5	1.1
4	2,11-160-65	1570.7	1570.9*	15	37	1569.3	1.6
6	10,11-160-65	1561.7	1560.0	15	38	1557.0	3.0
7	10,15-160-65	1554.6	1553.2	32	95	1550.5	2.7
8	15,22-160-65	1548.3	1548.1	67	92	1546.7	1.4
9	21,22-160-65	1548.2	1546.7	3	3	1544.2	2.5
10	21,28-160-65	1541.3	1539.5	36	86	1537.3	2.2
11	14,15-160-65	1558.0	1558.2*	52	139	1555.1	3.1
12	15,22-160-65	1550.3	1549.3	46	126	1546.2	3.1
13	28,33-160-65	1531.9	1532.1*	197	380	1528.9	3.2
15	32,5-160,159-65	1525.4	1522.7	197	321	1521.8	0.9
16	5-159-65		1521.8	17	56	1518.9	2.9

* Roadway overtopped

TABLE 4
FLOOD ROUTING RESULTS
50 YEAR EVENT

Crossing Number	Legal Description S-T-R	Roadway Elevation (msl)	Head Water Elevation (msl)	Area Inundated (acres)	Storage (acre-feet)	Tailwater Elevation (msl)	Change In Elevation (ft.)
1	20,29-161-64	1597.0	1597.1*	7	10	1593.9	3.2
2	31,1-161,160-64,65	1582.7	1581.9	34	117	1580.6	1.3
4	2,11-160-65	1570.7	1570.9*	15	42	1569.6	1.3
6	10,11-160-65	1561.7	1560.3	23	49	1557.0	3.3
7	10,15-160-65	1554.6	1553.5	34	100	1550.5	3.0
8	15,22-160-65	1548.3	1548.7*	79	117	1547.8	0.9
9	21,22-160-65	1548.2	1547.8	4	5	1544.7	3.1
10	21,28-160-65	1541.3	1540.4	43	104	1537.6	2.8
11	14,15-160-65	1558.0	1558.3*	54	146	1555.4	2.9
12	15,22-160-65	1550.3	1550.6*	59	159	1546.7	3.9
13	28,33-160-65	1531.9	1532.6*	213	433	1529.5	3.1
15	32,5-160,159-65	1525.4	1523.5	243	468	1522.3	1.2
16	5-159-65		1522.3	18	66	1519.1	3.2

*Roadway overtopped

TABLE 5
FLOOD ROUTING RESULTS
100 YEAR EVENT

Crossing Number	Legal Description S-T-R	Roadway Elevation (msl)	Head Water Elevation (msl)	Area Inundated (acres)	Storage (acre-feet)	Tailwater Elevation (msl)	Change In Elevation (ft.)
1	20,29-161-64	1597.0	1597.2*	7	11	1594.8	2.4
2	31,1-161,160-64,65	1582.7	1582.8*	43	143	1580.9	1.9
4	2,11-160-65	1570.7	1571.2*	20	54	1569.8	1.4
6	10,11-160-65	1561.7	1560.8	36	102	1557.1	3.7
7	10,15-160-65	1554.6	1553.9	37	108	1550.7	3.2
8	15,22-160-65	1548.3	1549.0*	85	134	1548.3	0.7
9	21,22,160-65	1548.2	1548.3*	4	6	1544.8	3.5
10	21,28-160-65	1541.3	1541.1	49	119	1537.8	3.3
11	14,15-160-65	1558.0	1558.6*	58	155	1556.1	2.5
12	15,22-160-65	1550.3	1551.1*	64	175	1547.2	3.9
13	28,33-160-65	1531.9	1533.0*	226	477	1530.1	2.9
15	32,5-160,159-65	1525.4	1524.3	290	692	1523.0	1.3
16	5-159-65		1522.9	20	77	1519.2	3.7

* Roadway overtopped

area is inundated by some crossings. This is due to the flat topography of the land upstream from these crossings. The duration of flooding would be short, as this water would soon be discharged through the crossing.

It is difficult to determine the elevation at which water will spill over into a low area. This region consists of a rolling topography and slight changes in elevations are not evident on a contour map. However, it is evident that a few undrained areas would be flooded during the less frequent events. It is not feasible to design the crossings to prevent this from occurring.

A crossing's capacity is dependent on the dimensions of the culverts as well as their invert elevation. A greater head of water will produce a larger discharge through the culvert. Therefore, both the culvert's dimensions and invert elevation are required before the capacity of a crossing can be determined. Unfortunately, before revisions were made to the crossings, this data was obtained only for crossing 7. Table 6 compares the conditions before and after revisions were made for this crossing.) Data collected for the remaining crossings show the elevations after installation of the additional culverts only. Therefore, no evaluation can be made on how the crossing improvements affected flows in the coulee.

TABLE 6
COMPARISON OF ORIGINAL AND EXISTING CONDITIONS
CROSSING 7

	Culverts	Return Period Years	Headwater Elevation (msl)	Area Inundated (acres)	Storage (acre-feet)	Tailwater Elevation (msl)	Change In Elevation (ft.)
Original Conditions	2-36" CMP	10	1552.4	26	81	1550.2	2.2
		25	1553.7	35	102	1550.4	3.3
		50	1554.0	37	110	1550.5	3.5
		100	1554.5	41	122	1550.6	3.9
Existing Conditions	1-48" CMP 1-36" CMP	10	1552.2	25	75	1550.2	2.0
		25	1553.2	32	95	1550.5	2.7
		50	1553.5	34	100	1550.6	3.0
		100	1553.9	37	108	1550.7	3.2

IV. SUMMARY AND CONCLUSIONS

The intent of this report was to discuss the adequacy of the existing culverts within the study area and to determine the area inundated behind each crossing. A hydrologic analysis was performed for the 20.4 square mile area northeast of Egeland. For several frequency events, the coulee flow was flood routed through each crossing. Conditions at each crossing were obtained from these results.

The major concern was the amount of land inundated by water backed up behind the crossings. If the water level became high enough, it could spill over into depressions having no outlets. This was the reason for concern at crossing 7. Tables 2 through 5 show the peak water elevations and amount of area inundated for the 10, 25, 50, and 100 year events at each crossing. As shown on Plates 2 through 9, the existing culverts cause a fairly large area to be inundated behind some crossings, due to the flat topography. However, this flooding would only occur for a short period of time. The crossings have an adequate capacity, which ensures that this excess water would quickly be discharged downstream. Also, no farm buildings would be located below the high water levels. Therefore, it is apparent that few flooding problems would be caused by water backing up behind the crossings. Although some depressions will be flooded during rare occurrence storms, it is not feasible to design for these conditions.

Secondary roads of the type found in the study area are generally designed for a ten year event. Within this study area, no road will be overtopped during the ten year event. Only three of the roadways will be overtopped during the 25 year event.

As shown in Table 6, it is evident that replacing a 36 inch CMP with a 48 inch CMP should improve the conditions at crossing 7. The reduction in headwater elevation will decrease the likelihood of water spilling into undrained depressions. Because revisions were made on the remaining crossings before invert elevations could be obtained for the old culverts, it is difficult to determine whether conditions were improved by these revisions. However, the same type of results should be expected at these crossings as at crossing 7.

The increased discharge rate at crossing 7, due to revisions in pipe size, can adequately be handled by the downstream crossings. Although some flooding will occur at all crossings during the 50 and 100 year events, it is the conclusion of this study that the existing culverts can adequately handle the normal expected flow. Therefore no further modifications are required.

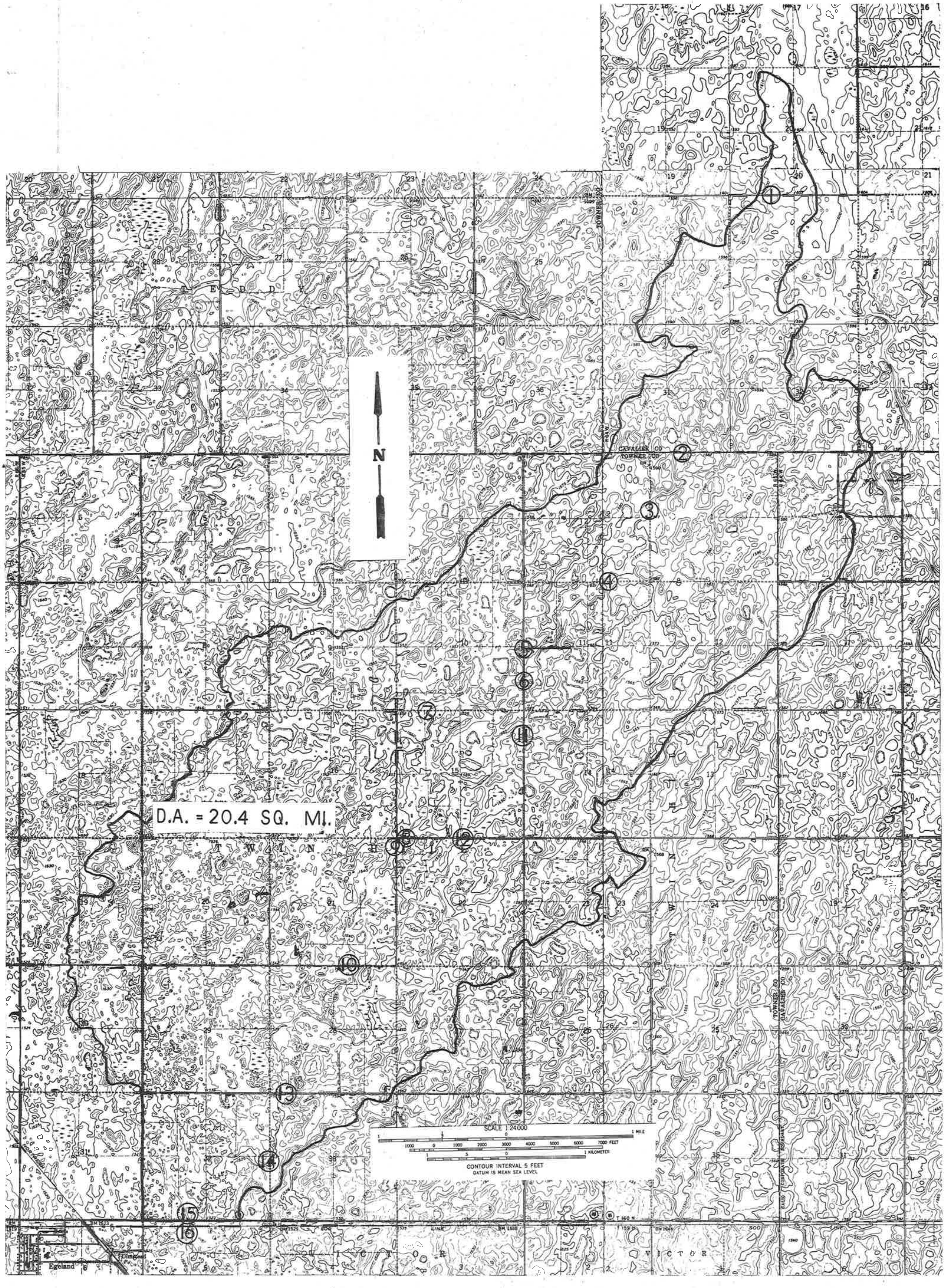

PLATE 1 - DRAINAGE AREA FOR TWIN HILL TOWNSHIP STUDY

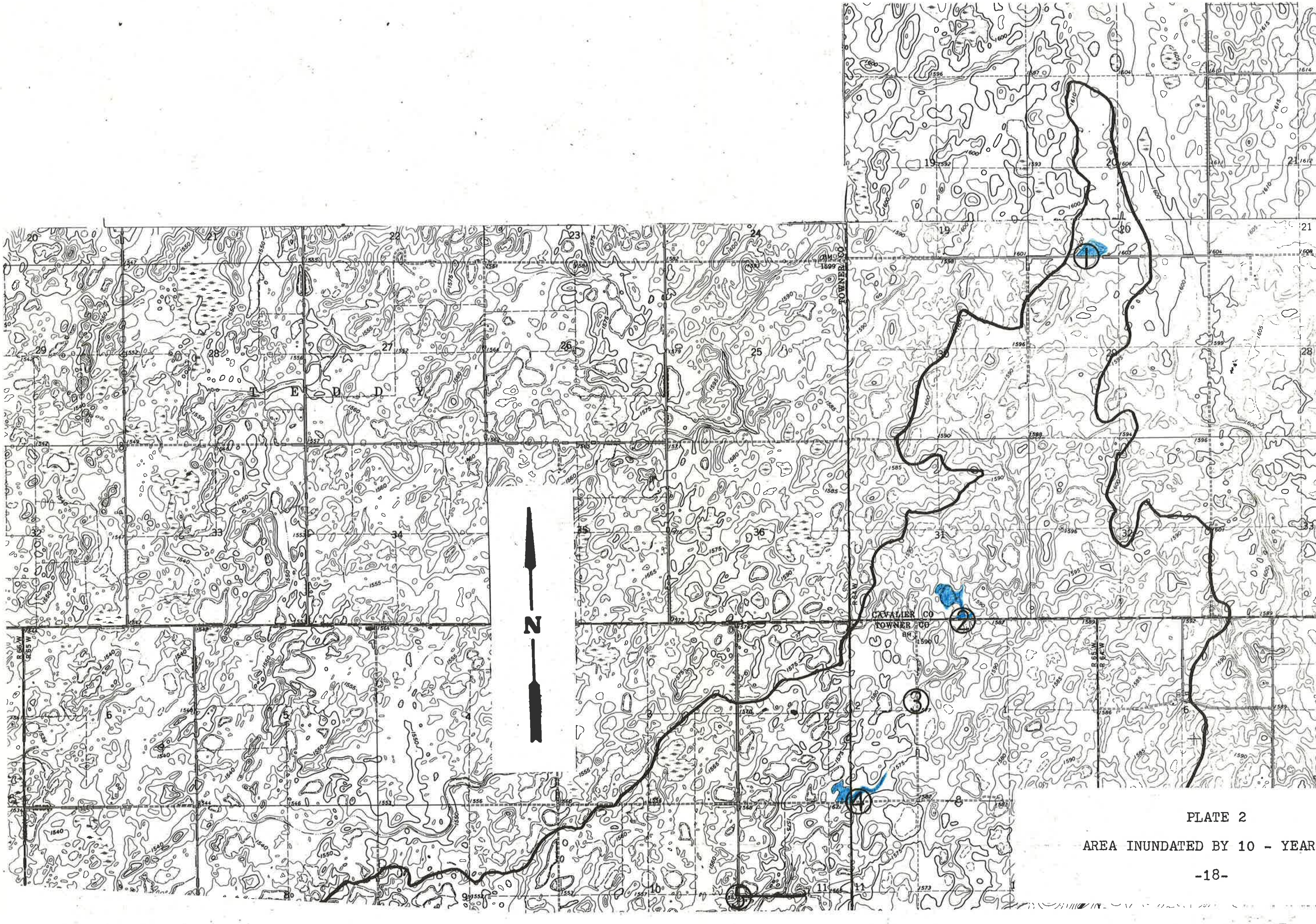

PLATE 2

AREA INUNDATED BY 10 - YEAR EVENT

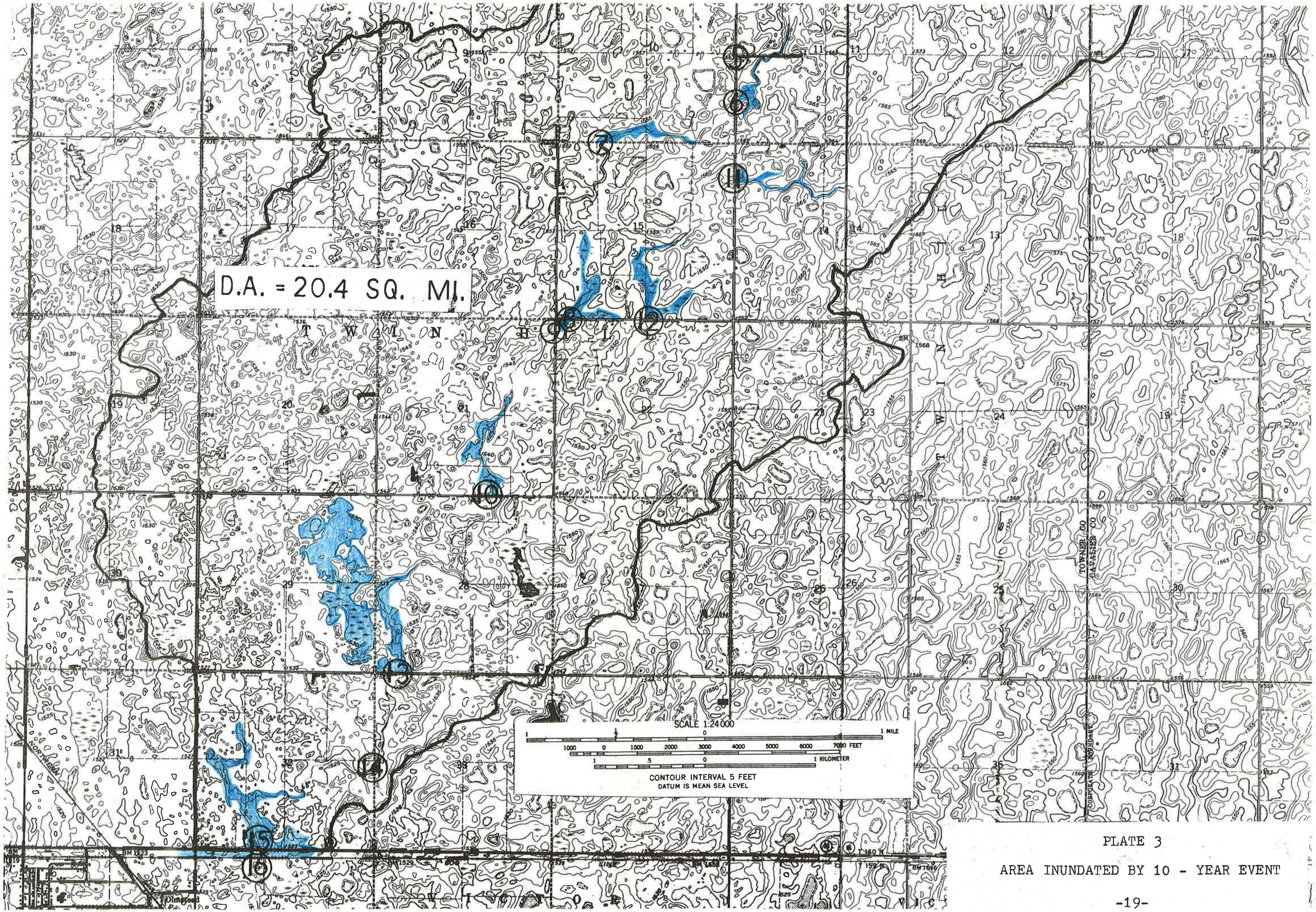

PLATE 3

AREA INUNDATED BY 10 - YEAR EVENT

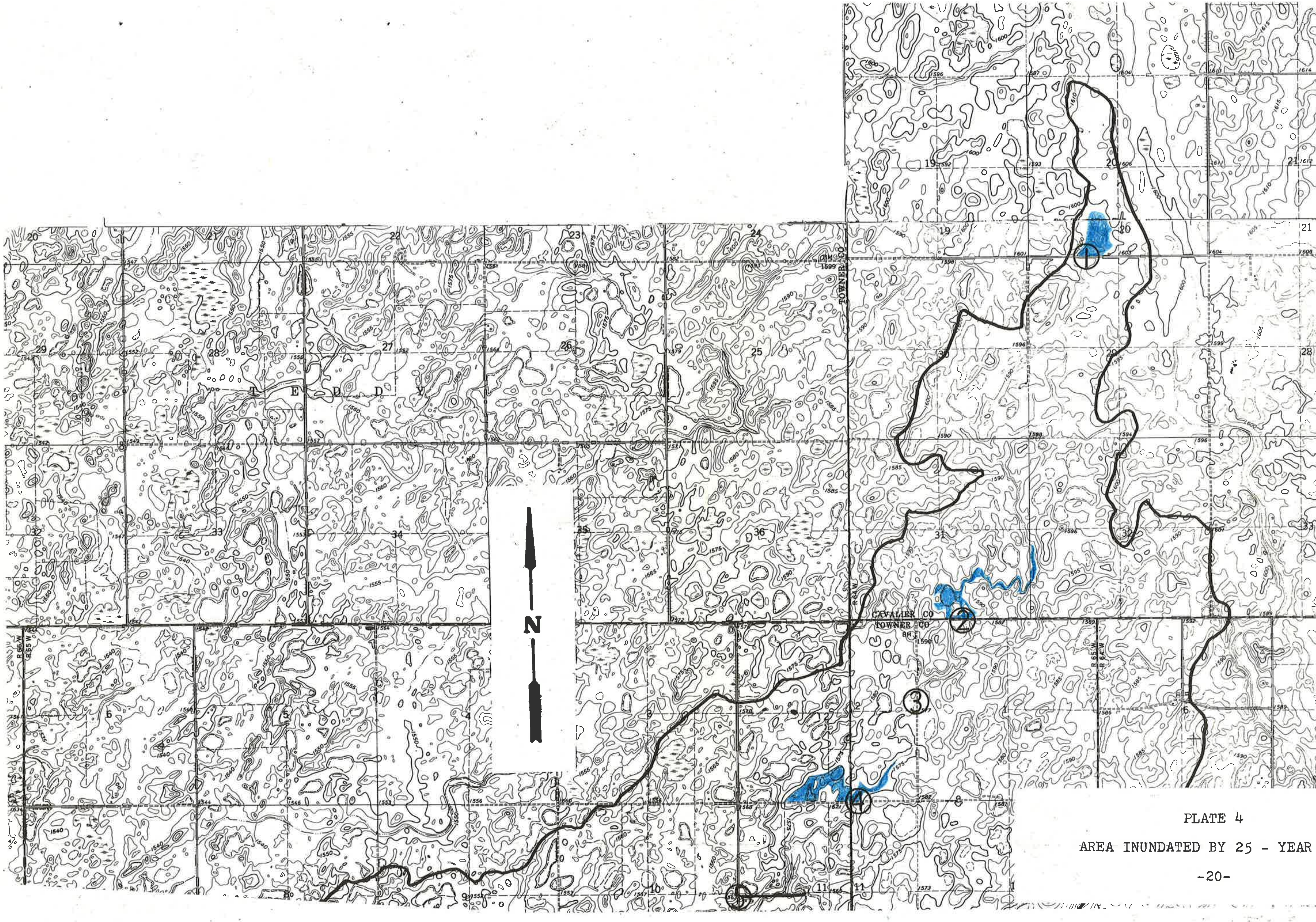

PLATE 4

AREA INUNDATED BY 25 - YEAR EVENT

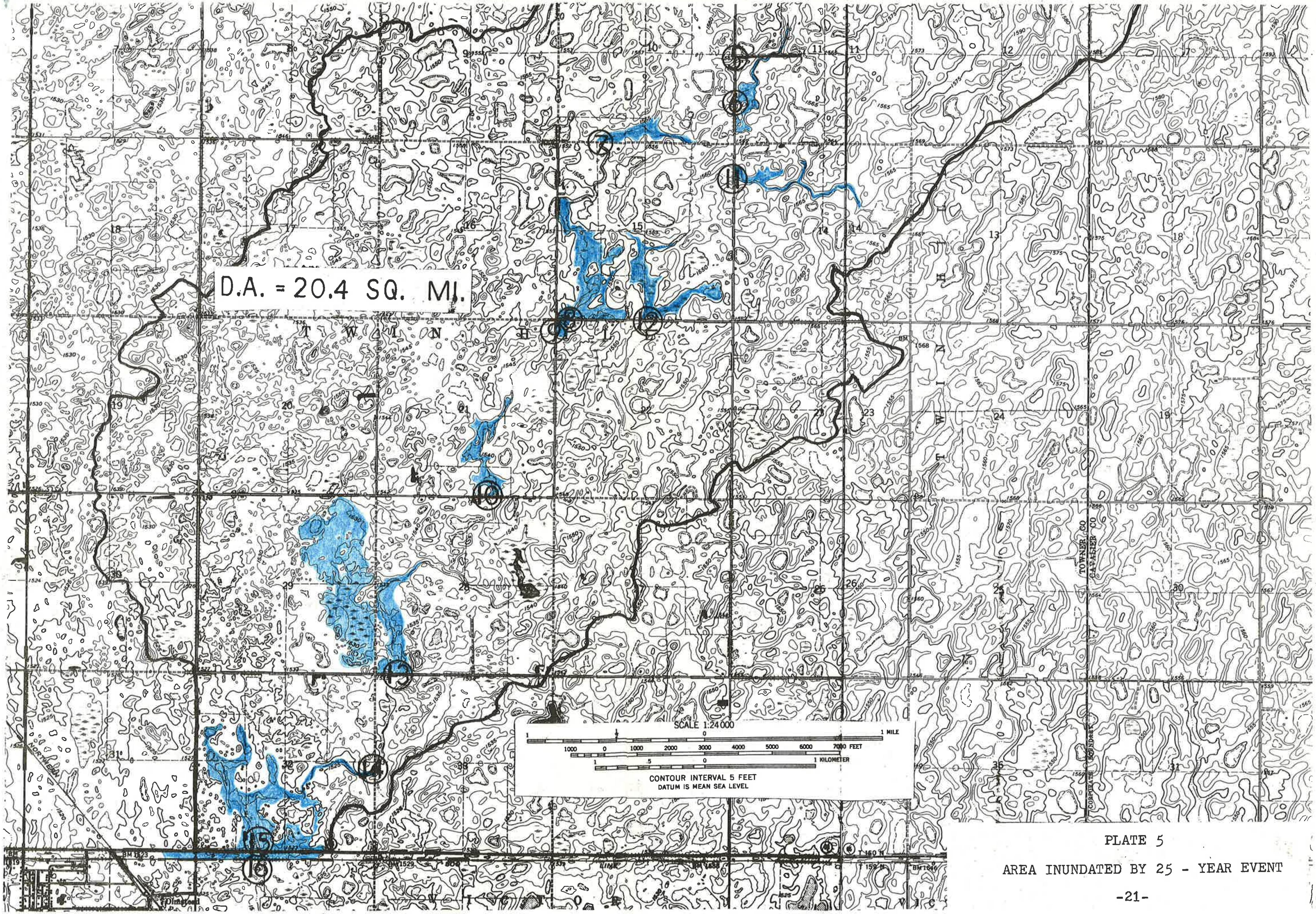

PLATE 5

AREA INUNDATED BY 25 - YEAR EVENT

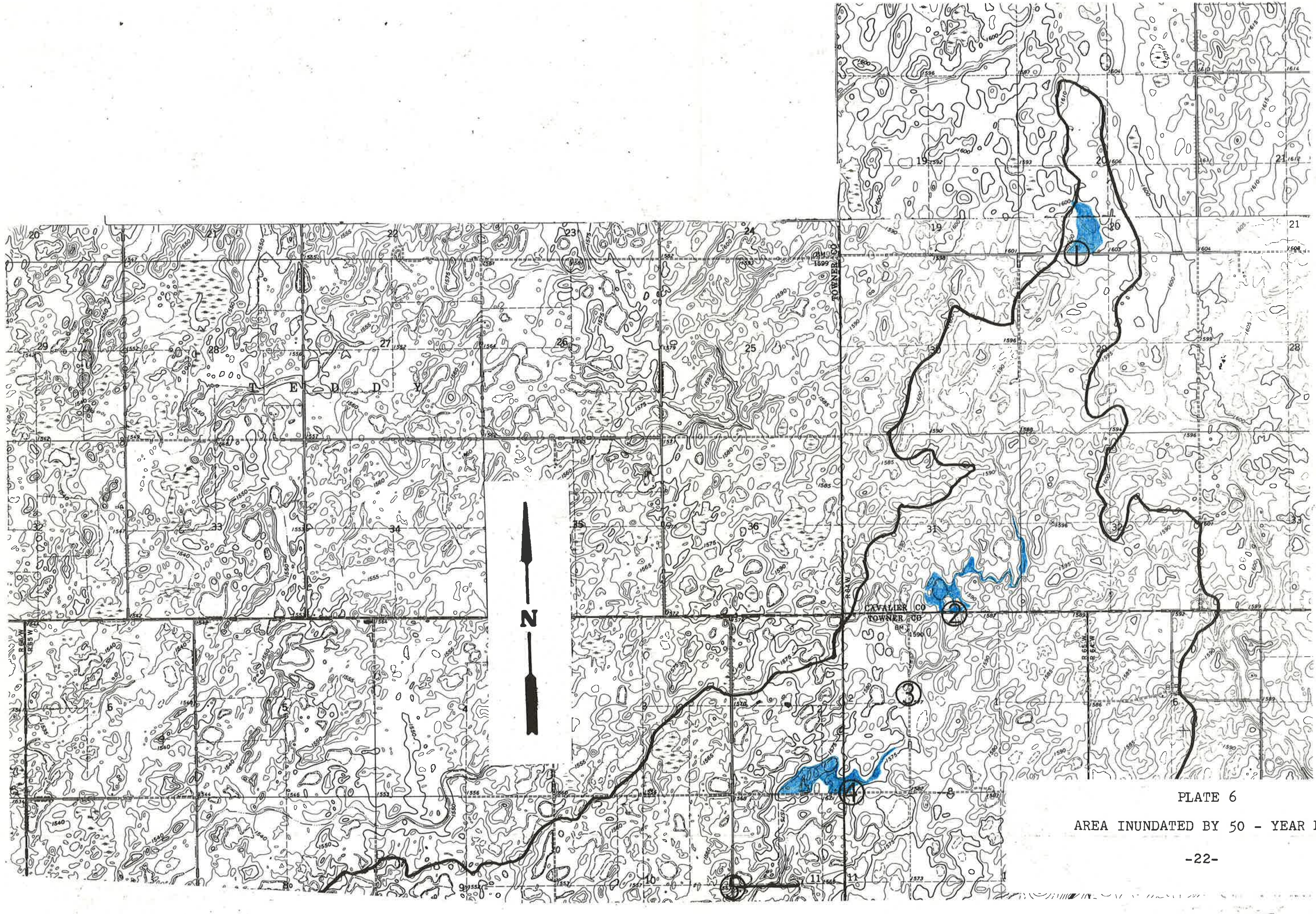

PLATE 6

AREA INUNDATED BY 50 - YEAR EVENT

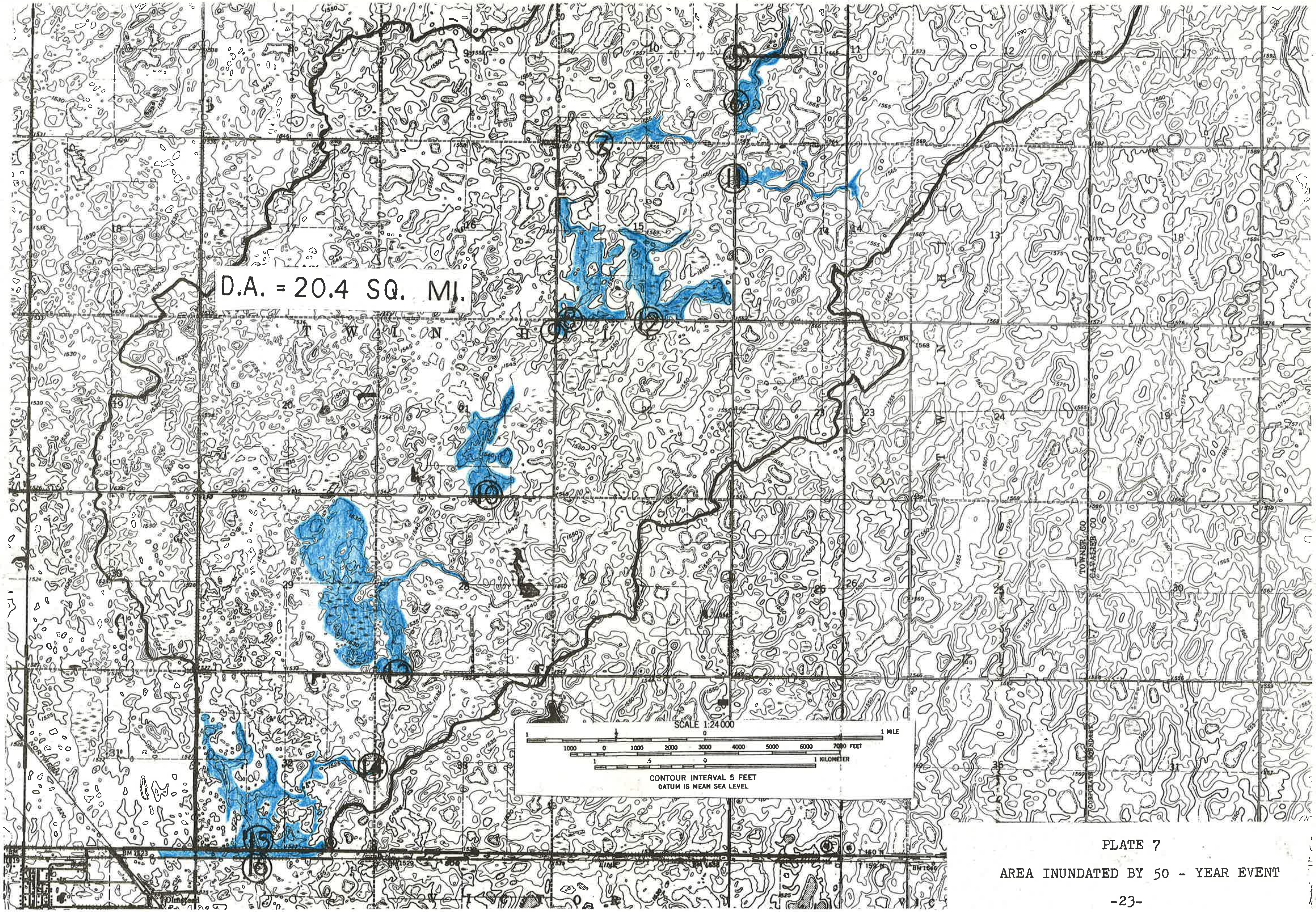

PLATE 7

AREA INUNDATED BY 50 - YEAR EVENT

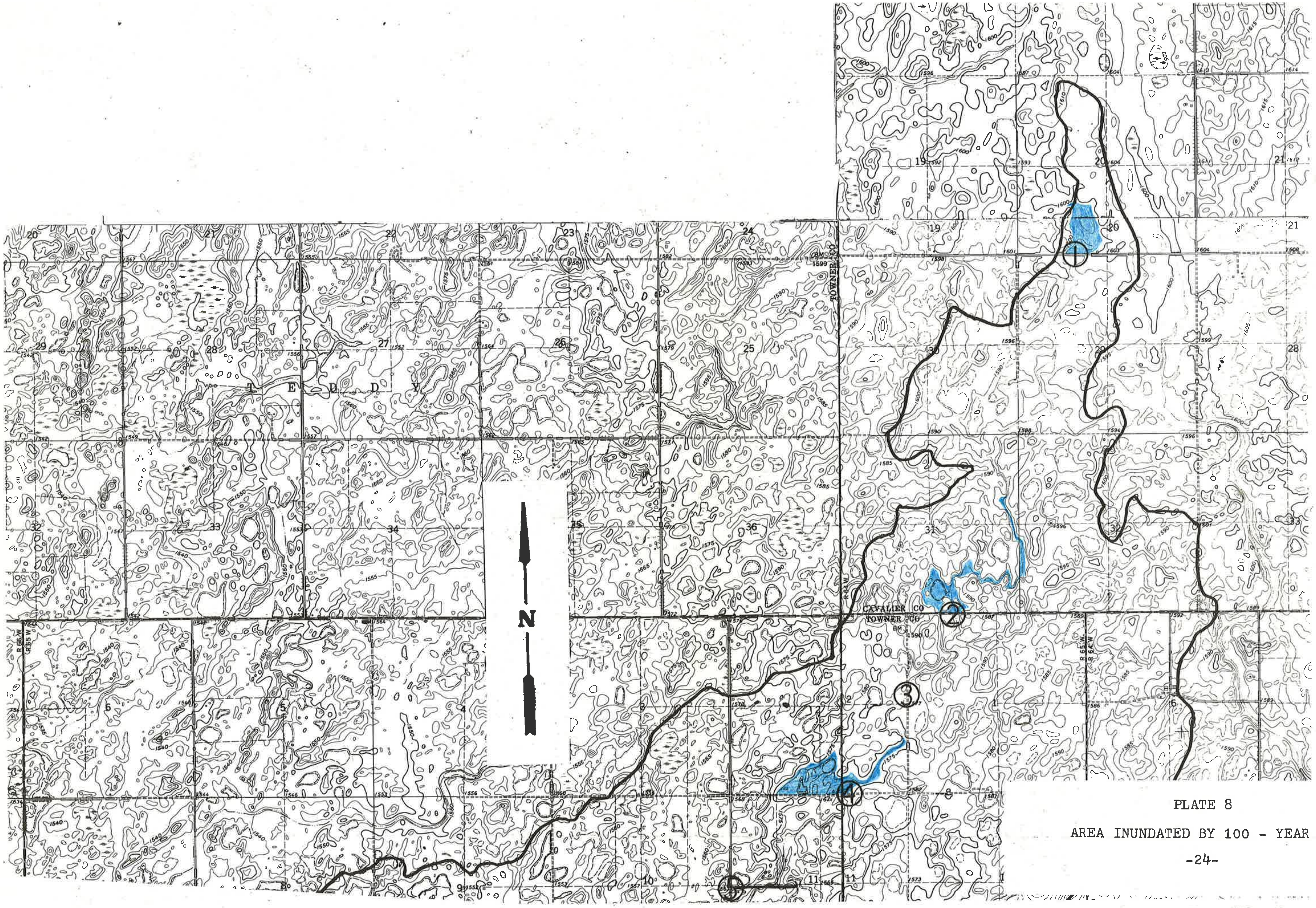

PLATE 8

AREA INUNDATED BY 100 - YEAR EVENT

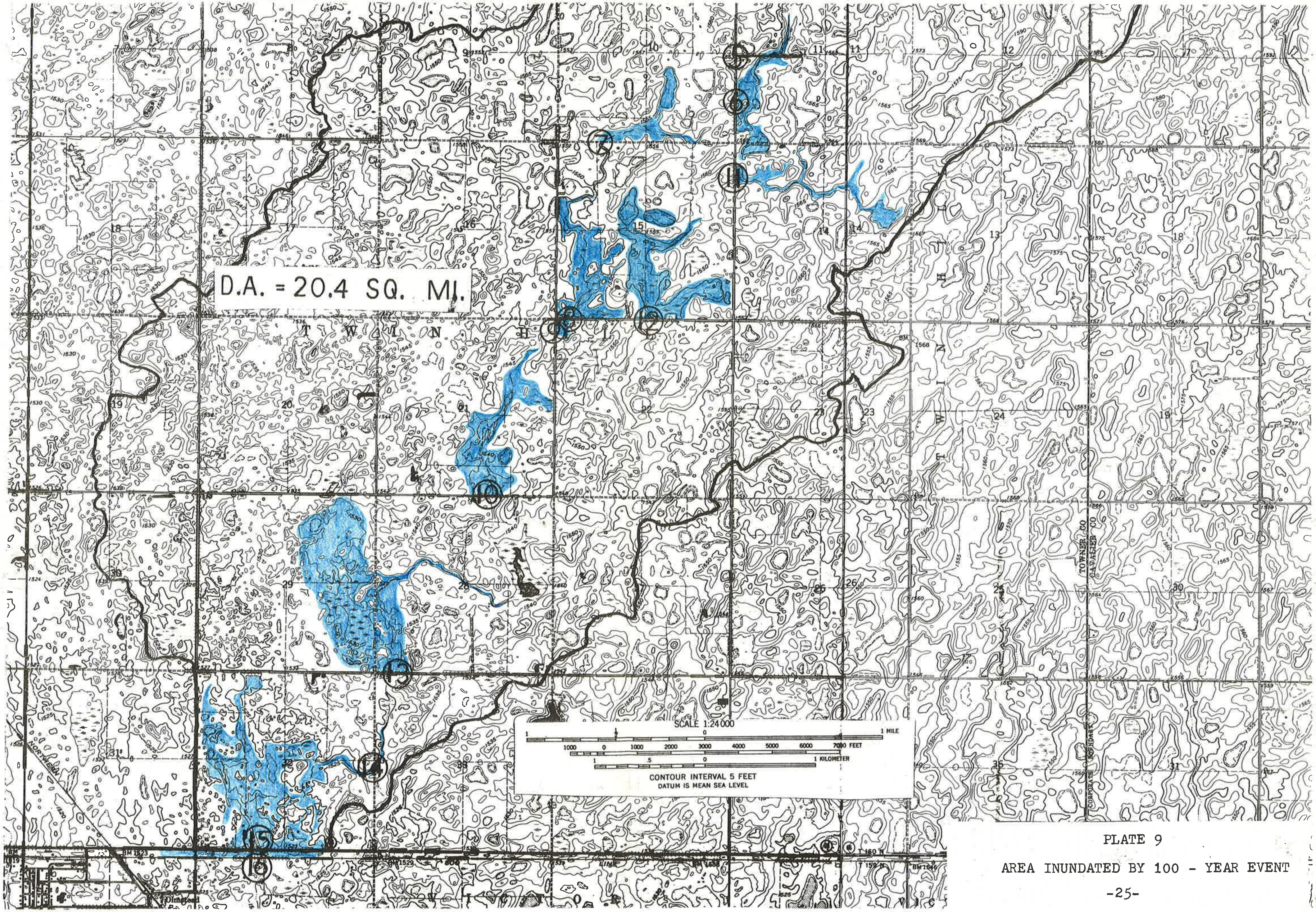

PLATE 9

AREA INUNDATED BY 100 - YEAR EVENT

APPENDIX A

Preliminary Investigation Agreement

SWC Project # 1745
August 4, 1981

A G R E E M E N T

Preliminary Investigation
by the
North Dakota State Water Commission

I. PARTIES

THIS AGREEMENT is between the North Dakota State Water Commission, hereinafter referred to as the Commission, acting through the State Engineer, Vernon Fahy; and the Towner County Water Resource Board, hereinafter referred to as the Board, acting through its Chairman, Warren Anderson.

II. PROJECT, LOCATION AND PURPOSE

The Board has requested the Commission to investigate the downstream effects of increasing the capacity of the crossing located between Sections 10 and 11, Township 160 North, Range 65 West, northeast of the City of Egeland. In conjunction with this request, the Commission, with the agreement of the Board, will study the unnamed coulee, determine its channel capacity, determine the crossing capacities, and define areas that will flood during various frequency flows. The study will start at the upper end of the drainage area in the SW¼ Section 5, Township 161 North, Range 64 West, and end at the south boundary of Section 5, Township 159 North, Range 65 West, which is about a mile east of the City of Egeland.

III. PRELIMINARY INVESTIGATION

Because there is concern about crossing capacities in the study area and the backwater flooding due to inadequate crossings and because the Commission is interested in attempting to define floodways along streams and drainage ways, the parties agree that further information is needed. Therefore, the Commission shall conduct a preliminary investigation consisting of the following:

1. Obtain field data for a hydrologic analysis of the study area and a water surface profile study.
2. Obtain an inventory of crossings in the study area and determine their capacities.
3. Complete a hydrologic analysis of the area to determine expected flows to evaluate channel and crossing capacities.
4. Determine the water surface profiles along the study area to show the effects of crossings and show areas subject to flooding.

5. Prepare a map showing the areas subject to flooding during various frequency storms.

6. Present a report discussing the adequacy of the crossings and how they could be improved. The report will also present the findings of the hydrologic analysis, crossing inventory and water surface profile study. Cost estimates will be made of any suggested improvements.

IV. DEPOSIT - REFUND

The Board shall deposit a total of $500.00 with the Commission to partially pay for the cost of the crossing inventory and the investigation of the effects of increasing the capacity of the crossing between Sections 10 and 11, Township 160 North, Range 65 West. Upon receipt of a request from the Board to terminate proceeding further with the preliminary investigation or upon a breach of this agreement by any of the parties, the Commission shall provide the Board with a statement of all expenses incurred in the investigation and shall refund to the Board any unexpended funds.

V. RIGHTS OF ENTRY

The Board agrees to obtain written permission from any affected landowner for surveys by the Commission which are required for the preliminary investigations.

VI. INDEMNIFICATION

The Board accepts responsibility for, and holds the Commission free from all claims and damages to public or private properties, rights, or persons arising out of this investigation but limited to claims and damages to public or private properties, rights, or persons located on or within other areas to be surveyed pursuant to this agreement. In the event a suit is initiated a judgment entered against the Commission, the Board shall indemnify it for any judgment arrived at or judgment satisfied.

VII. CHANGES TO AGREEMENT

Changes to any contractual provisions herein will not be effective or binding unless such changes are made in writing, signed by the parties and attached hereto.

Warren Anderson	David A Sprynczynatyk
WARREN ANDERSON, CHAIRMAN Towner County Water Rescource Board	For VERNON FAHY State Engineer
	15 OCT 81
DATE	DATE
	Dale L Frink
WITNESS	WITNESS