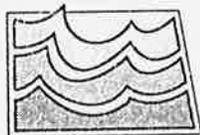
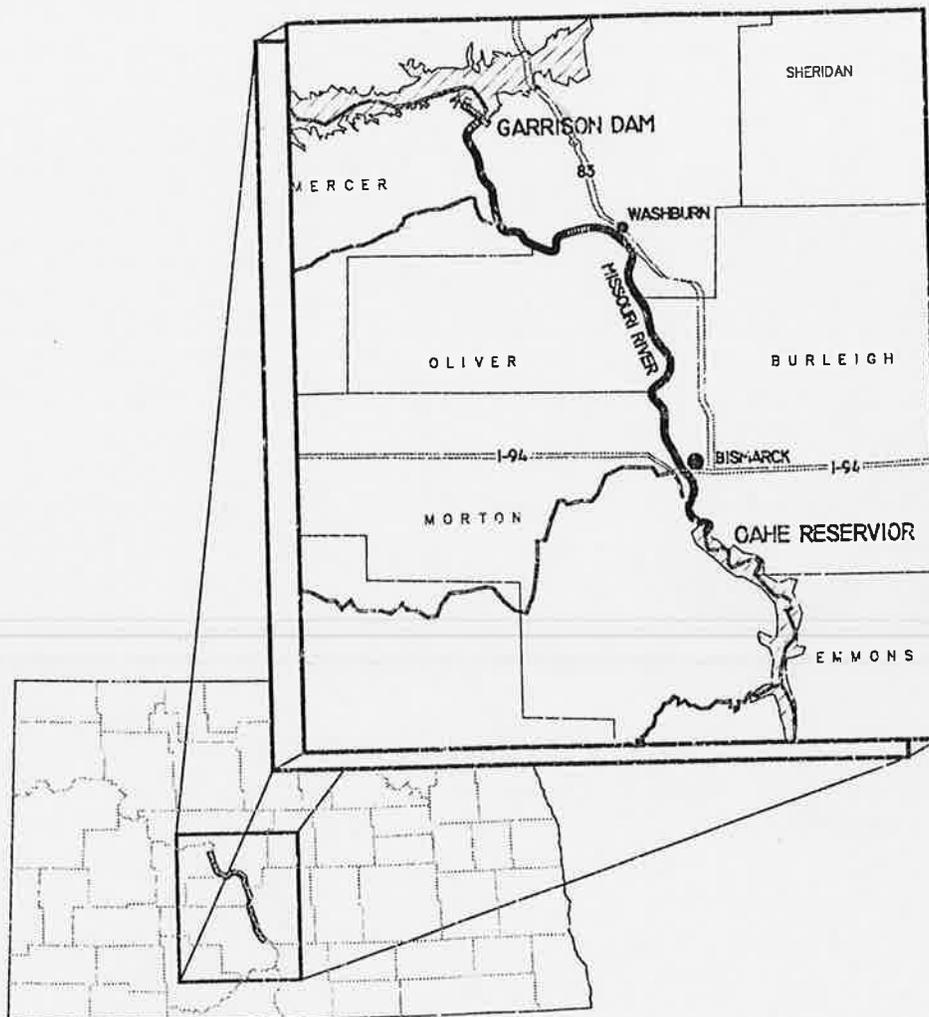


MISSOURI RIVER BANK EROSION GARRISON DAM TO LAKE OAHE

Project No. 576



**NORTH DAKOTA
STATE WATER COMMISSION**

December 1997

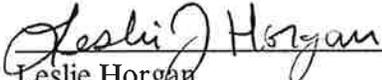
MISSOURI RIVER BANK EROSION
GARRISON DAM TO LAKE OAHE

SWC Project #576

December 1997

North Dakota State Water Commission
900 East Boulevard
Bismarck, ND 58505-0850

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Missouri River Bank Erosion
Garrison Dam to Lake Oahe

North Dakota State Water Commission
Project Number: 576

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APPENDICES

Appendix A - Section 33
Appendix B - Aerial Photos of Identified Sites

I. INTRODUCTION

This report was prepared by the North Dakota State Water Commission (SWC) at the request of the Burleigh, Oliver, Morton, Mercer, McLean Joint Water Resource District (B.O.M.M.M) to provide a rated listing of Missouri River bank erosion sites and to provide documentation of the process used to create the list. The report also provides cost estimates and justification to protect the erosion sites.

II. JUSTIFICATION

Bank erosion along the Missouri River has been a continuing problem since closure of the main stem reservoirs. Since completion of the Missouri River main stem reservoirs, the building process of high floodwater of the past are now non-existent, halting the rebuilding of bottom lands. Only low sandbars reaching to upper levels of the currently fluctuating river are formed. Therefore, the present bank erosion results in the permanent destruction of bottom lands, widening of the riverbed, and a continuing net loss of land [Photos 1 and 2].

The river is controlled by the Corps of Engineers and serves as a conveyance channel between the reservoirs. The Corps admits the dams have changed the flow regime of the Missouri River. They acknowledge that the changes have resulted in widening of the channel and a net loss of high bank lands. While bank erosion occurred before the dams, due to accretion there was no net loss of land. The hydropower operations at Garrison Dam and the clear water released from the dam have caused a substantial increase in the net loss of land. In addition, the high flows of the last several years, especially the extremely high flows this past summer, have increased the erosion rate significantly.

Jay A. Leitch and LeRoy W. Schaffner in *Economic Activity Associated With the Garrison Diversion Unit in 1984* stated, "Total acreage lost to Missouri River bank erosion between Garrison Dam and Lake Oahe through 1983 was 2,447 acres. Assuming 28 percent was dryland cropland, 17 percent was potentially irrigated cropland, 35 percent pasture, 15 percent woodland, and 5 percent other nonincome producing would result in \$614,514 in gross business volume and \$196,333 in personal income foregone in 1984." These losses have continued to increase and accumulate since the completion of the main stem reservoirs. Most of the land being lost is agricultural land causing a continuing economic loss to the state. Another economic loss is the reduction in property tax revenues for the land that is lost to erosion. The annual and cumulative economic losses will continue to increase as land is lost.

The siting of irrigation pumps [Photo3] along the Missouri River has been restricted because of bank erosion. The bank erosion discourages and in some cases prevents the irrigation of adjacent land. Only a few farmers along the river are fortunate to have pump sites located on naturally hard banks or where a bank stabilization project has been constructed. Additional bottom lands would be irrigated if the banks were protected from erosion.

The river is causing erosion in some areas of natural hardwood forests [Photos 4 and 5]. These areas are the few remaining along the Missouri River. Woodlands are rare in the state of North Dakota as well as other prairie states occurring mainly along rivers. Many of the forests are already lost due to past logging and farming and due to the inundation of the pools of the main stem reservoirs on the Missouri River.

Soil eroded from the banks settles out of the water in the upstream reaches of the reservoirs forming deltas. These deltas reduce storage in reservoirs, raise the water table of adjacent land, and can cause ice jams and flooding during the fall freeze and the spring thaw. Reducing erosion rates would slow delta formation.

Bank erosion along the Missouri River continues to cause problems [Photo 6]. The problems will continue to occur and accumulate if no action is taken, causing ever increasing economic impacts. The Corps of Engineers has stated that bank erosion, unless halted, will gradually transform the present river into a wide area of sandbars, channels, and islands occupying most of the valley floor between bluffs. Photo 7, an aerial photograph of river mile 1334, depicts this situation. The future condition of the river as described by the Corps will make boating, fishing, and withdrawal of water for off-river uses almost impossible. Stabilization efforts should not be viewed solely as an effort to protect adjacent lands but also as an effort to protect the river.

Section 33 of the Water Resource Development Act of 1988 amended Section 9 of the Flood Control Act of 1944. Section 33 (Appendix A) directed the Secretary of the Army to undertake such measures, including maintenance and rehabilitation of existing structures, which the Secretary determines are needed to alleviate bank erosion and related problems associated with reservoir releases along the Missouri River between Fort Peck Dam, Montana, and a point 58 miles downstream of Gavins Point Dam, South Dakota. The Corps of Engineers has used the funds appropriated under Section 33 to repair a number of existing structures, to build non-traditional structures, and to purchase sloughing easements on eroding land. Unfortunately, the Corps has not alleviated the major problem. The Corps maintains that any structure constructed under Section 33 must be economically justified. The test they apply to determine economic justification is if the land can be purchased for less than the cost to protect the land. This test does not consider that if land is purchased by the Corps and allowed to erode it is destroyed. The test neglects the economic impact of destroying the land.

III. INSPECTION

The bank erosion sites listed in this report were identified during field inspections. The State Water Commission, B.O.M.M Joint Board, Missouri River Adjacent Landowners Association, and the Citizens for River Front Preservation conducted the inspections on August 14 and 28, 1997. The August 14, 1997, inspection was conducted from Garrison Dam to Bismarck (river mile 1390 to 1313). The August 28, 1997, inspection was conducted from Bismarck to the headwaters of Lake Oahe (river mile 1313 to 1303). Figure 1 shows the inspected area.



PHOTO 1



PHOTO 2



PHOTO 3



PHOTO 4



PHOTO 5



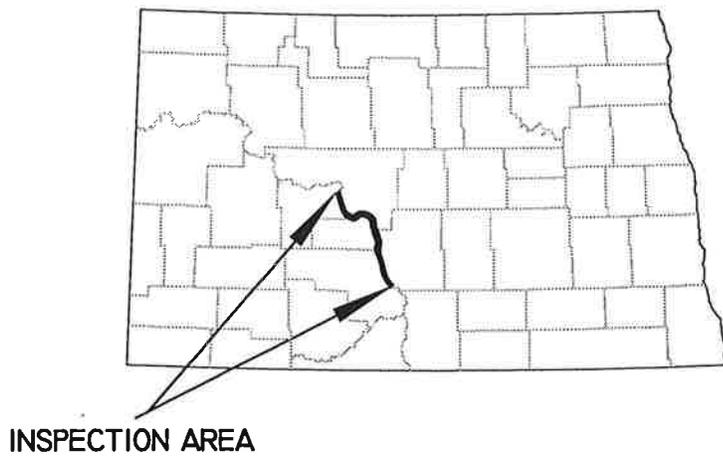
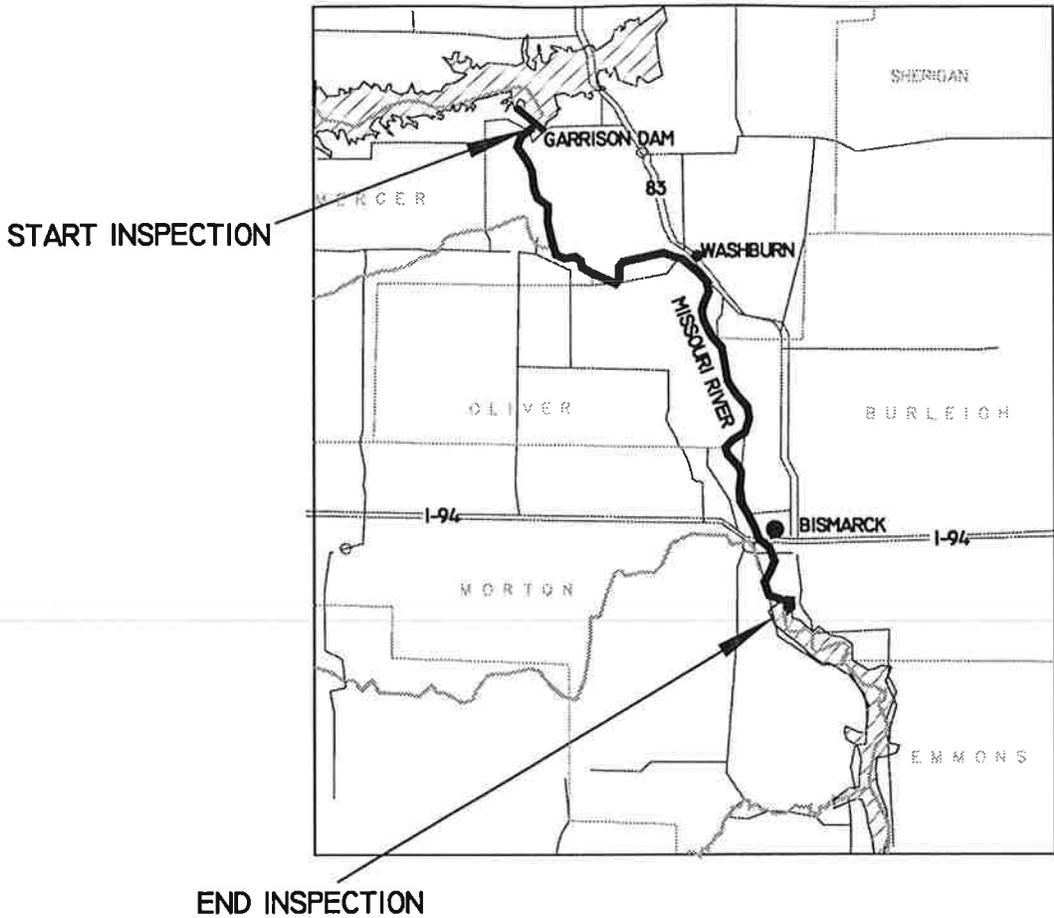
PHOTO 6

PHOTO 7



Aerial Photograph of Missouri River
River Mile 1334

FIGURE 1
MISSOURI RIVER EROSION
INSPECTION AREA
SWC # 576



LOCATION MAP

Inspection data was gathered for each site based on the following inspection criteria:

1. Rate of streambank erosion;
2. Adjacent land use;
3. Environmental resources at risk;
4. Cultural resources at risk; and
5. Potential for future streambank erosion.

In addition, each site was identified by river mile and left or right bank. Left or right bank is identified by looking downstream, generally the left bank is the east side of the river.

The inspection resulted in the identification of 36 bank erosion sites. The inspection did not include gathering of data to the level necessary to complete a preliminary design. For example, the length of the site was estimated not measured and the depth of the river was not measured at each site. The purpose of the inspection was to identify erosion sites and gather data to allow the sites to be ranked. Further data will need to be gathered on any sites that move forward towards being protected.

IV. EVALUATION OF INSPECTION DATA

Overview

The evaluation of the inspection data was accomplished through a rating system. Aerial photographs from December 3, 1995, the Corps of Engineers Bank Protection Status maps, and drawings that show Missouri River bank alignment in 1950, 1975, and 1984, 1985, or 1986 were used to evaluate erosion rates. The bank alignments on the drawings were traced from aerial photographs for the respective years.

The rating system used for the evaluation process was applied to each inspection criteria. However, environmental resources at risk and cultural resources at risk were combined in the other criteria.

A rating between 0 and 10 was assigned for each site and each criteria. The ratings were assigned based on the standards represented in Table 1.

TABLE 1
Standards For Rating Assignment

| CRITERIA | RATING | |
|--|-------------|------------|
| | 0 | 10 |
| Rate of Stream Bank Erosion | Low | High |
| Adjacent Land Use | Low Value | High Value |
| Potential for Future Streambank erosion | Low | High |
| Other (Environmental/Cultural Resources at Risk) | Not Present | Present |

The rating data was compiled in Table 2. In addition to rating data, the table contains the following:

1. Site name
2. River mile
3. Bank (left or right when facing downstream)
4. Estimated site length
5. Cost for each site

The length of the sites was estimated from the aerial photographs and drawings. The total cost is discussed in Section V, Cost Estimates for Reinforced Revetment. The table presents the sites in order of rating. The total rating for each site is the sum of the ratings for each criteria.

Rate of Streambank Erosion

A rating between 0 and 10 was assigned for each site. The standard for rating assignment was 0 for a low rate of erosion and 10 for a high rate of erosion. Table 3 is a detailed presentation of the standard for rating assignment.

**Table 2
Missouri River Erosion Site Rating Table**

| Site Number | Site Name* | River Mile | Bank | Rate of Streambank Erosion | Adjacent Land Use | Potential for Streambank Erosion | Other** | Total | Site Length*** (feet) | Cost**** (\$) |
|-------------|-----------------------|------------|-------|----------------------------|-------------------|----------------------------------|---------|-------|-----------------------|---------------|
| 1 | Cornatzer | 1336 | Right | 4 | 5 | 6 | 6 | 21 | 7,000 | 1,000,000.00 |
| 2 | State Prison Farm | 1310 | Left | 6 | 3 | 5 | 5 | 19 | 4,200 | 600,000.00 |
| 3 | Weisgarber | 1357 | Right | 6 | 5 | 7 | 0 | 18 | 3,500 | 500,000.00 |
| 4 | Ness | 1365 | Left | 6 | 5 | 7 | 0 | 18 | 2,100 | 320,000.00 |
| 5 | Fox Island | 1312 | Left | 6 | 5 | 5 | 0 | 16 | 3,000 | 400,000.00 |
| 6 | Wetstein | 1333 | Right | 4 | 8 | 4 | 0 | 16 | 4,500 | 600,000.00 |
| 7 | Belohlavek | 1304 | Right | 6 | 4 | 6 | 0 | 16 | 4,000 | 600,000.00 |
| 8 | Suchy | 1308 | Right | 5 | 5 | 6 | 0 | 16 | 2,200 | 340,000.00 |
| 9 | Tweeten | 1362 | Right | 4 | 4 | 2 | 5 | 15 | 900 | 180,000.00 |
| 10 | Peterson | 1375 | Left | 4 | 4 | 6 | 0 | 14 | 5,100 | 720,000.00 |
| 11 | Grannis | 1378 | Right | 4 | 5 | 5 | 0 | 14 | 1,800 | 260,000.00 |
| 12 | Burlington Northern | 1318 | Right | 3 | 3 | 2 | 5 | 13 | 500 | 100,000.00 |
| 13 | Price | 1355 | Right | 3 | 8 | 2 | 0 | 13 | 3,400 | 480,000.00 |
| 14 | Wachters | 1325 | Right | 3 | 5 | 5 | 0 | 13 | 1,200 | 200,000.00 |
| 15 | Price | 1334 | Right | 4 | 5 | 4 | 0 | 13 | 4,100 | 600,000.00 |
| 16 | Suchy | 1309 | Right | 5 | 5 | 2 | 0 | 12 | 2,200 | 340,000.00 |
| 17 | Dinius | 1320 | Left | 4 | 4 | 4 | 0 | 12 | 2,000 | 300,000.00 |
| 18 | Opheim | 1339 | Left | 2 | 5 | 5 | 0 | 12 | 1,400 | 200,000.00 |
| 19 | Russel | 1377 | Right | 2 | 5 | 5 | 0 | 12 | 800 | 160,000.00 |
| 20 | Flinn | 1346 | Left | 3 | 5 | 4 | 0 | 12 | 4,900 | 680,000.00 |
| 21 | Basin Electric | 1372 | Left | 4 | 4 | 4 | 0 | 12 | 3,000 | 400,000.00 |
| 22 | Cullen | 1362 | Right | 6 | 4 | 2 | 0 | 12 | 2,500 | 400,000.00 |
| 23 | ND Game & Fish | 1356 | Right | 4 | 4 | 3 | 0 | 11 | 2,300 | 360,000.00 |
| 24 | Kunudtson | 1360 | Left | 4 | 5 | 2 | 0 | 11 | 2,600 | 400,000.00 |
| 25 | Unknown | Unknown | Left | 4 | 4 | 2 | 0 | 10 | 1,300 | 200,000.00 |
| 26 | Sibley Island Estates | 1305 | Left | 4 | 3 | 3 | 0 | 10 | 3,700 | 540,000.00 |
| 27 | Lahman | 1306 | Left | 2 | 4 | 4 | 0 | 10 | 2,000 | 300,000.00 |
| 28 | Lange | 1337 | Left | 2 | 4 | 4 | 0 | 10 | 3,300 | 460,000.00 |
| 29 | United Power | 1370 | Right | 4 | 3 | 2 | 0 | 9 | 2,000 | 300,000.00 |
| 30 | Mork | 1324 | Right | 3 | 4 | 2 | 0 | 9 | 2,700 | 400,000.00 |
| 31 | Yunker | 1351 | Left | 2 | 4 | 3 | 0 | 9 | 2,900 | 400,000.00 |
| 32 | Peterson | 1331 | Left | 3 | 4 | 2 | 0 | 9 | 900 | 180,000.00 |
| 33 | Simons | 1333 | Left | 2 | 4 | 2 | 0 | 8 | 1,200 | 200,000.00 |
| 34 | Shroeder Heights | 1340 | Left | 2 | 4 | 2 | 0 | 8 | 1,700 | 240,000.00 |
| 35 | Oster | 1385 | Right | 2 | 5 | 1 | 0 | 8 | 600 | 120,000.00 |
| 36 | Nostdahl | 1380 | Left | 2 | 2 | 3 | 0 | 7 | 800 | 160,000.00 |

*The site name is the landowner in most cases. The ownership was determined from county atlas and has not been verified.

**Other includes Cultural Resources at Risk and Environmental Resources at Risk

***The site length was estimated during the river inspection and from aerial photography. Actual length varies.

****For sites with length of 1,000 feet or less, the cost estimate for reinforced revetment was determined by estimating the cost at \$200 per linear foot of site. Where sites were greater than 1,000 feet, the revetment was segmented leaving unprotected gaps of 500 feet between segments of 1,000 feet revetment. The most downstream segment of the revetment for each site may be less than 1,000 feet depending on the total length of the site and the potential segmentation. The cost estimates for reinforced revetment for sites greater than 1,000 feet were determined by estimating the cost at \$200 per linear foot of reinforced revetment.

Don Hoop
~~1,500~~
~~25~~

Table 3
Standards for Rating Assignment
Rate of Streambank Erosion

| Rate of Erosion (Feet/Year) | Rating |
|--------------------------------|---------|
| Greater than 20 | 8 to 10 |
| 15 to 20 | 6 to 8 |
| 10 to 15 | 4 to 6 |
| 5 to 10 | 2 to 4 |
| 0 to 5 | 0 to 2 |

Rates of erosion were estimated through a comparison between aerial photographs from December 3, 1995, and drawings that show Missouri River bank alignment in 1950, 1975, and 1984, 1985, or 1986.

Adjacent Land Use

A rating between 0 and 10 was assigned for each site. The standard for rating assignment was 0 for land use of low value, and 10 for land use of high value. Table 4 is a detailed presentation of the standard for rating assignment.

Table 4
Standards for Rating Assignment
Adjacent Land Use

| Land use | Rating |
|--|---------|
| Farmland (Irrigated) | 8 to 10 |
| Farmland (Crops) | 6 to 8 |
| Residential/Commercial/Wooded | 4 to 6 |
| Grassland (Pasture/Grazing) | 2 to 4 |
| No Development Potential (Undeveloped) | 0 to 2 |

Land use was observed and noted during field inspections. Aerial photographs from December 3, 1995, were also used to determine land use.

Potential for Future Erosion

A rating between 0 and 10 was assigned for each site. The standard for rating assignment was 0 for land with a low potential for future erosion and 10 for land with a high potential for future erosion. Due to the dynamic nature of the Missouri River, it is impossible to predict future erosion with a large degree of certainty. Each site was assigned a rating based on engineering judgement. The major factor considered during the evaluation was the sites proximity to one or more of the following:

- River bends
- Straight river reaches
- High bluffs
- Bottom lands
- Sand bars
- Existing bank protection structures

Data collected during the field inspections was used to aid evaluation of the potential for future erosion. Aerial photographs from December 3, 1995, were also used in the evaluation.

Other (Environmental/Cultural Resources at Risk)

A rating between 0 and 10 was assigned for each site. The standard for rating assignment was 0 when no environmental and cultural resources were at risk and 10 when environmental and cultural resources were at risk. Due to the dynamic nature of environmental and cultural resources, a detailed standard for rating assignment was not used. Each site was assigned a rating based on the analyst's judgement. The evaluation was simplified because 32 of 36 sites did not have any known environmental or cultural resources at risk and were therefore assigned a rating of 0. The sites with environmental and cultural resources at risk included:

1. Site 1
2. Site 2
3. Site 9
4. Site 12

A native hardwood forest is located at site 1. A rating of 6 was assigned for site 1. An eagle's nest is located at site 2. A rating of 5 was assigned for site 2. An eagle's nest is located at site 9. A rating of 5 was assigned for site 9. A railroad line is located next to site 12. The potential for derailment as a result of erosion poses the danger of an environmental disaster if a toxic chemical were spilled into the river during a derailment. A rating of 5 was assigned for site 12.

Data collected during the field inspections was used to aid the analyst's judgement. Aerial photographs from December 3, 1995, were also used in the evaluation.

V. COST ESTIMATES FOR REINFORCED REVETMENT

The purpose of this report is to identify bank erosion sites and to rank the sites to provide a basis for determining the sites to gather additional information for preliminary design. Due to the limited scope of this study the cost estimates are based on a \$200 per foot cost of eroding bank. This is a typical cost of a Corps of Engineers bank erosion structure. The actual cost may be significantly different depending on the actual length of bank protected, the height of the bank above the waterline, the depth of the river, and the geometry of the bankline.

For sites with length of 1,000 feet or less, the cost estimates for bank stabilization were determined by estimating the cost at \$200 per linear foot of site. Where sites were greater than 1,000 feet, the revetment was segmented leaving unprotected gaps of 500 feet between segments of 1,000 feet revetment. The most downstream segment of the revetment for each site may be less than 1,000 feet depending on the total length of the site and the potential segmentation. The cost estimates for reinforced revetment for sites greater than 1,000 feet were determined by estimating the cost at \$200 per linear foot of revetment. Table 2 contains a listing of the cost estimates for each site. These cost estimates are very preliminary and are presented to illustrate the scope of the problem. Each site will need to be investigated further to determine actual costs and the best method of dealing with erosion at each site. The use of 1,000 foot revetments with 500 foot gaps is a tool for estimating cost and is not meant to represent a preliminary design, the actual structure would likely have smaller revetments and gaps that would total 2/3 protected and 1/3 left unprotected.

The reach length from Garrison Dam to Lake Oahe is 87 miles. Therefore, there are 174 miles of riverbank. At present, approximately 52 miles (30 percent) of riverbanks are protected, while 105 miles (60 percent) of riverbanks are not considered in danger of erosion. The remaining 17 miles (10 percent) of riverbanks are identified in this report as endangered by erosion. The total estimated cost for reinforced revetment for the 17 miles of riverbanks is \$13,640,000.

VI. SUMMARY

This report documents the process used to create a rated listing of Missouri River bank erosion sites. Table 2 presents the rated listing of Missouri River bank erosion sites. The data used to create the rated listing was obtained during field inspections. The evaluation of the field data was supplemented by review of aerial photographs and drawings. Table 2 contains a listing of cost estimates for each site. The total estimated cost for reinforced revetment for all sites is \$13,640,000. Bank erosion along the Missouri River continues to cause personal and business income losses, property tax revenue losses, irrigation pump site losses, natural hardwood forest losses, delta formation, and associated impacts to adjacent land. These losses will continue to mount until the Corps of Engineers mitigates the impacts being caused by the operation of Garrison Dam as directed in Section 33 of Water Resource Development Act of 1988.

REFERENCES

- Economic Activity Associated With the Garrison Diversion Unit in 1984, Agricultural Economics Report No. 190, Leitch and Shaffner, North Dakota State University, Department of Agricultural Economics, 1984.
- Missouri River Streambank Erosion Study Garrison Dam to Lake Oahe North Dakota, U.S. Army Corps of Engineers, Omaha District, July 1985.
- Summary Report of Feasibility Studies Missouri River South Dakota, Nebraska, North Dakota, Montana, U.S. Army Corps of Engineers, Missouri River Division, Omaha District, September 1989, Revised 1990.

APPENDIX A

Section 33 of the Water Resources Development Act of 1988 Pub. L. No. 100-676, Section 33, 102 Stat. 4013 (1988)

SEC. 33. MISSOURI RIVER BETWEEN FORT PECK DAM, MONTANA, AND GAVINS POINT DAM, SOUTH DAKOTA AND NEBRASKA.

Section 9 of the Act entitled "An Act authorizing the construction of certain public works on rivers and harbors for flood control, and for other purposes", approved December 22, 1944 (58 Stat. 891), is amended by adding at the end thereof the following new subsection:

"(f) The Secretary of the Army is directed to undertake such measures, including maintenance and rehabilitation of existing structures, which the Secretary determines are needed to alleviate bank erosion and related problems associated with reservoir releases along the Missouri River between Fort Peck Dam, Montana, and a point 58 miles downstream of Gavins Point Dam, South Dakota, and Nebraska. The cost of such measures may not exceed \$3,000,000 per fiscal year. Notwithstanding any other provisions of law, the costs of these measures, including the costs of necessary real estate interests and structural features, shall be apportioned among project proposes¹ (sic) as a joint-use operation and maintenance expense. In lieu of structural measures, the Secretary may acquire interests in affected areas, as the Secretary deems appropriate, from willing sellers."

1. This apparent typographical error "proposes" rather than "purposes" was made in the conference committee report on the bill and subsequently carried over to the statute itself.

APPENDIX B

**AERIAL PHOTOS
OF
IDENTIFIED SITES**

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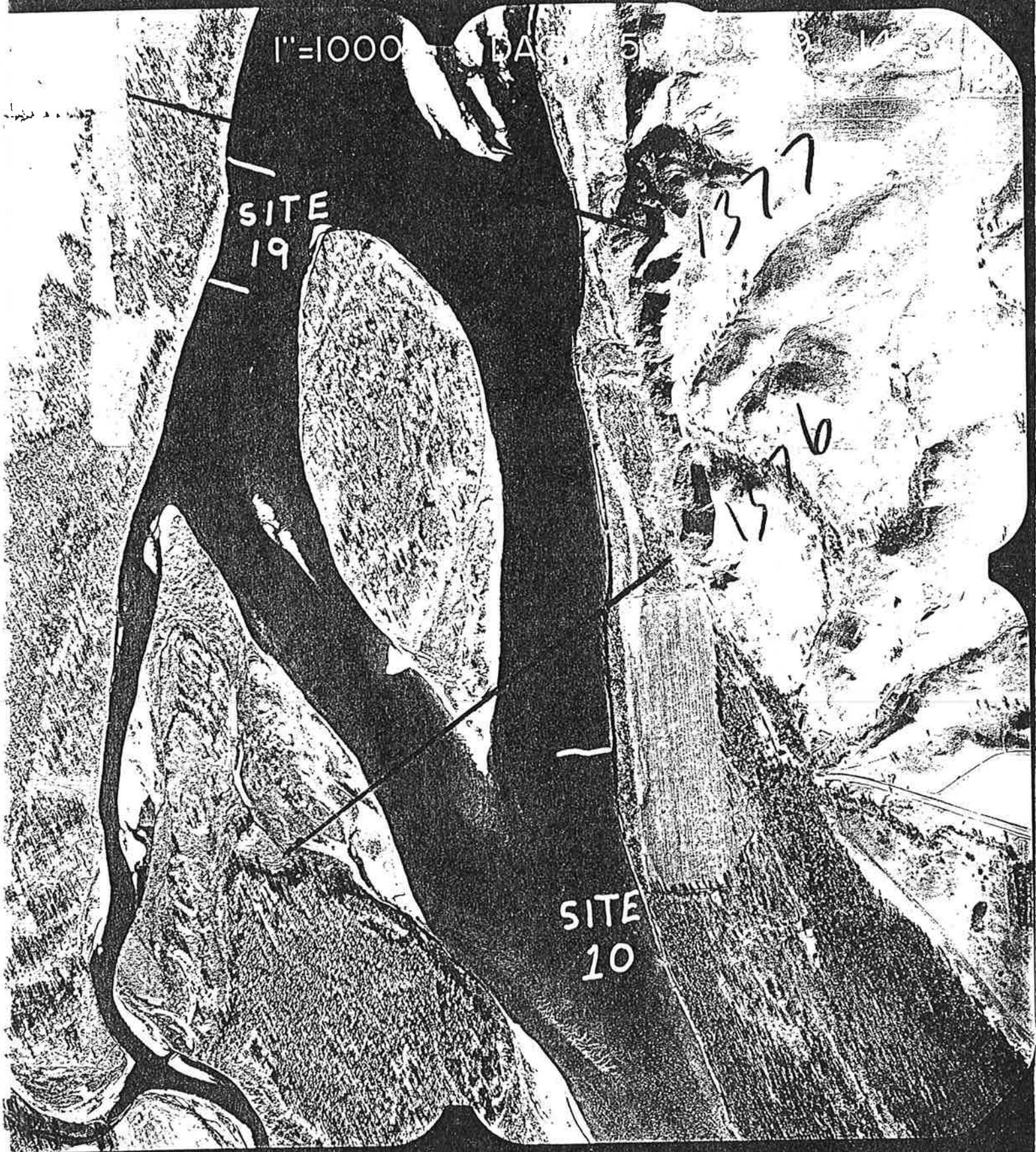
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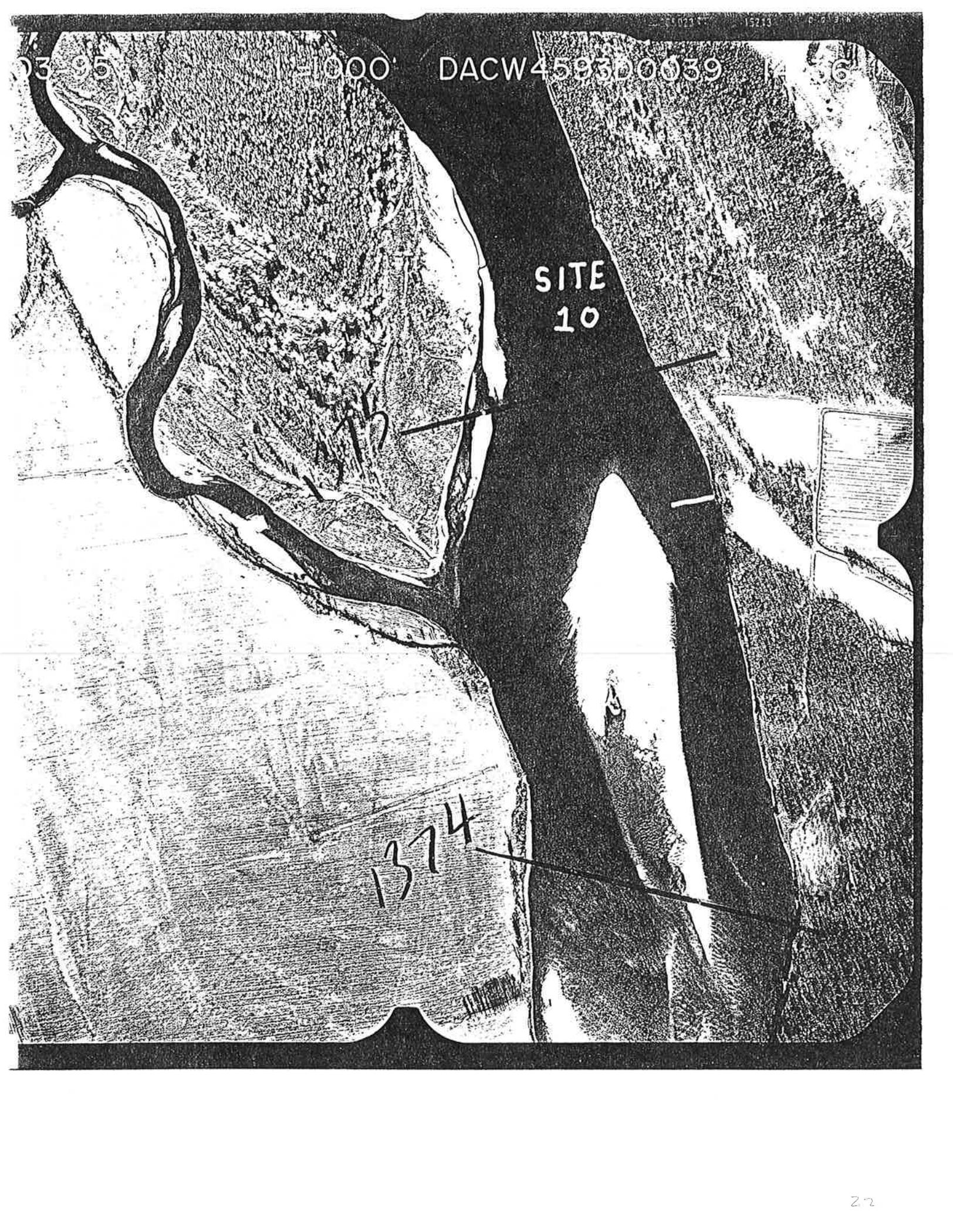
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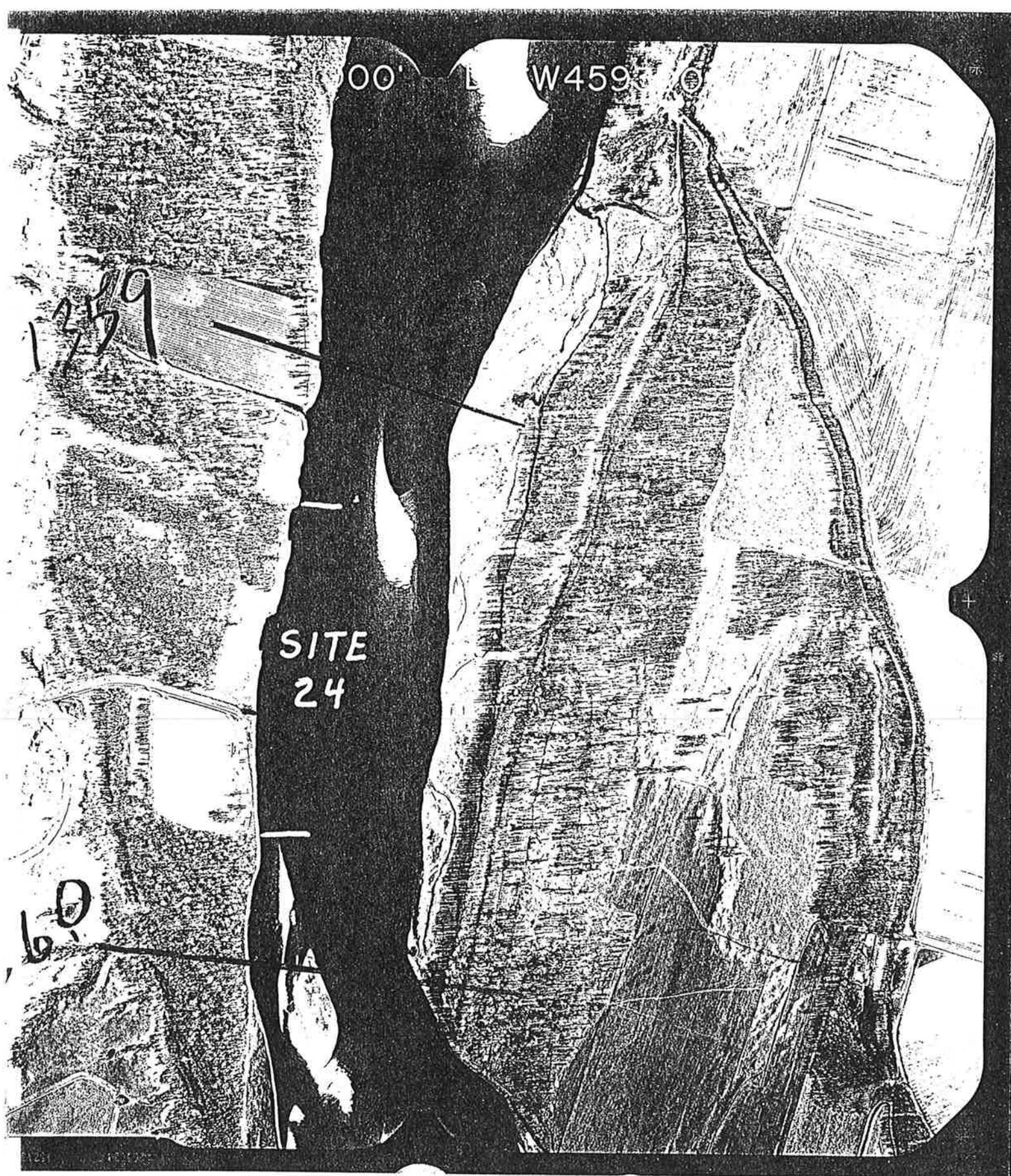
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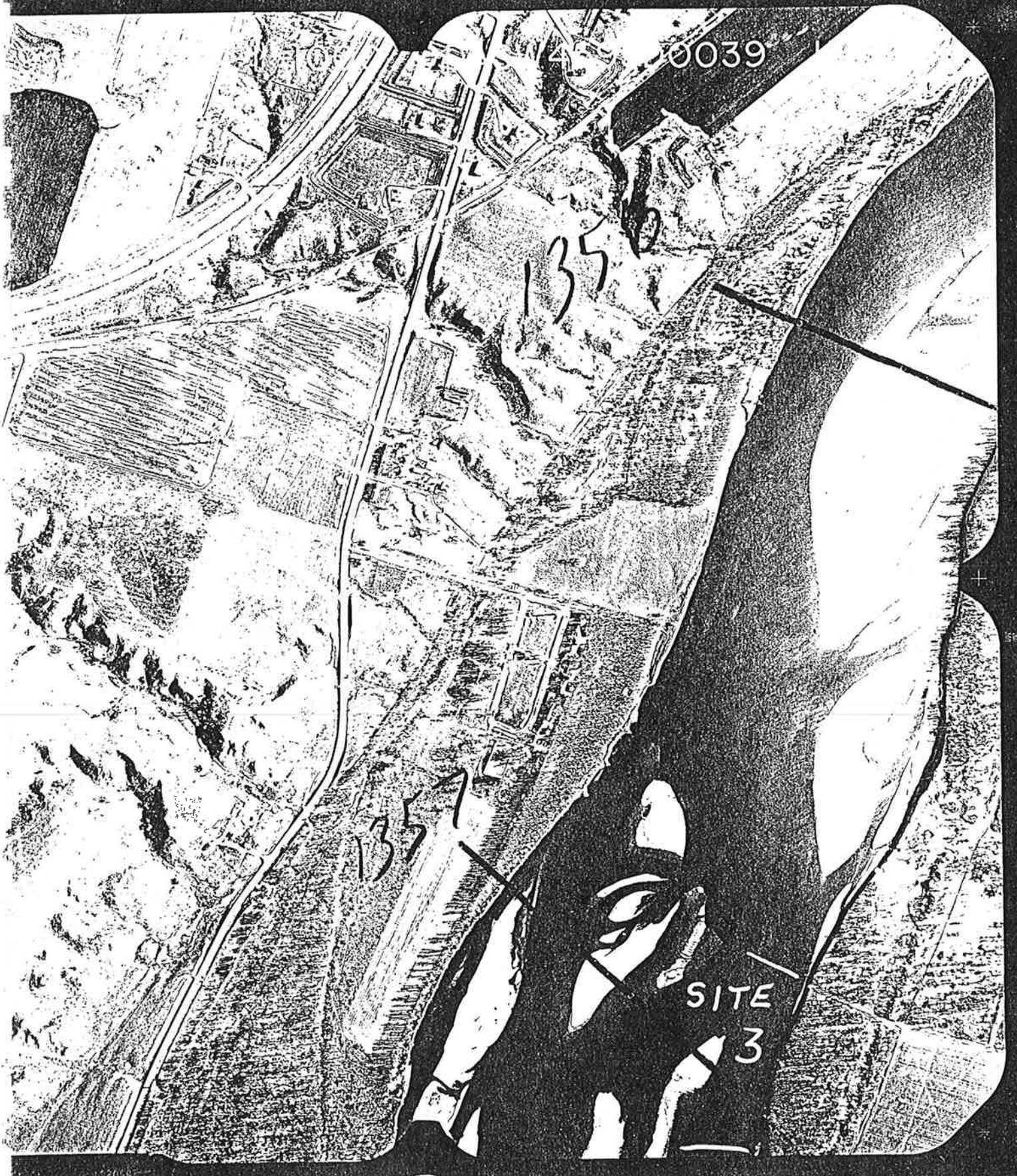
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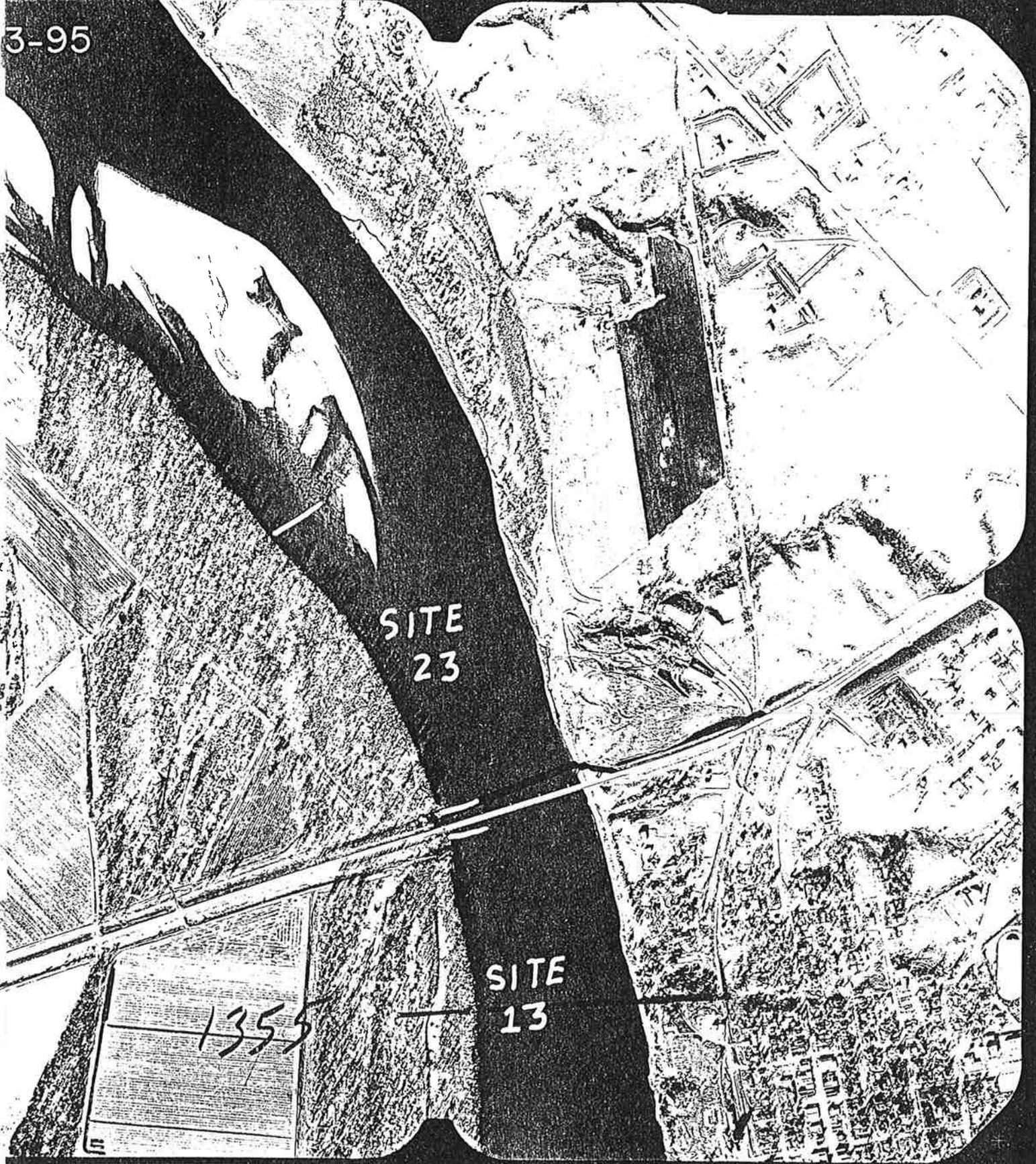
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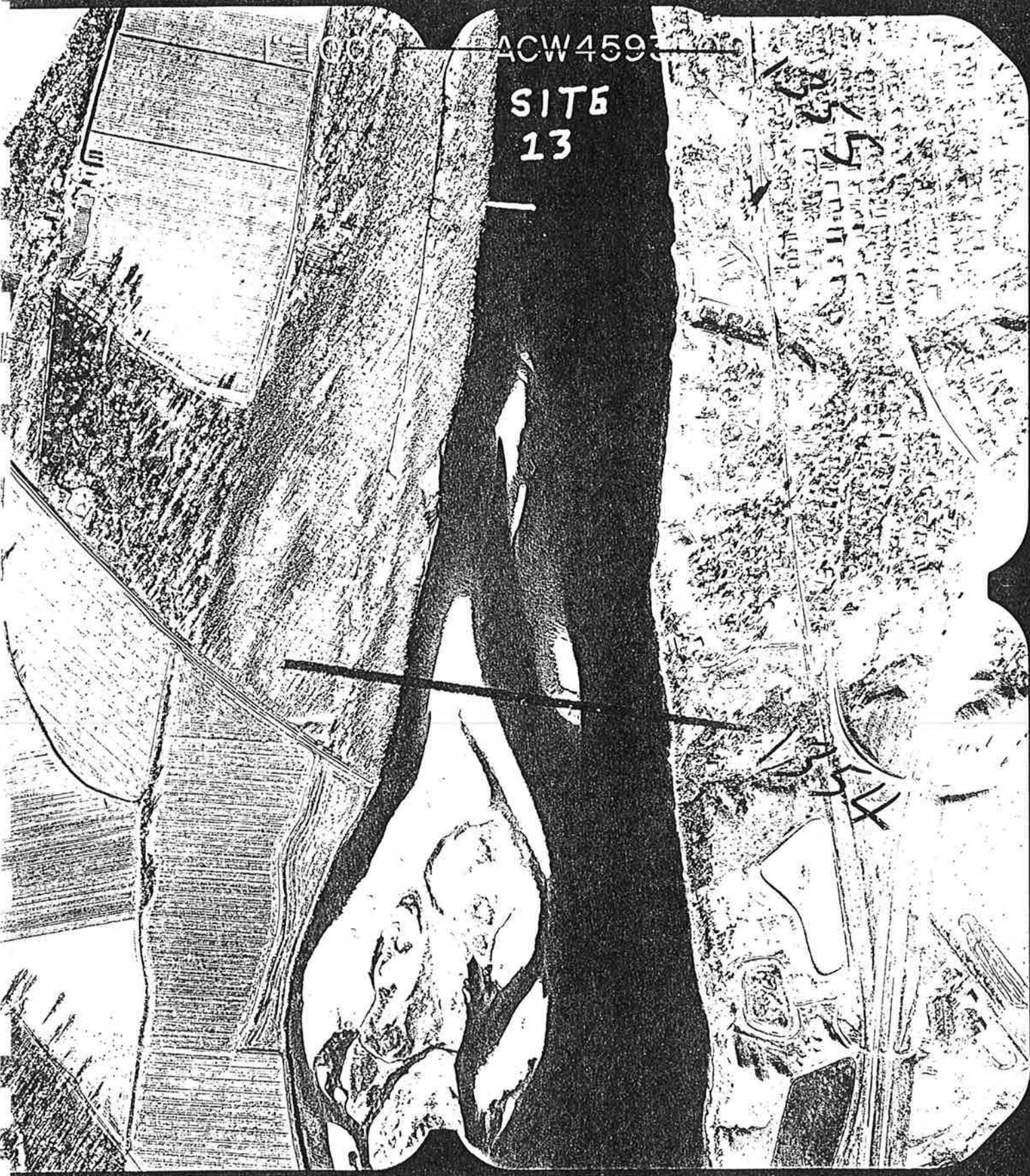
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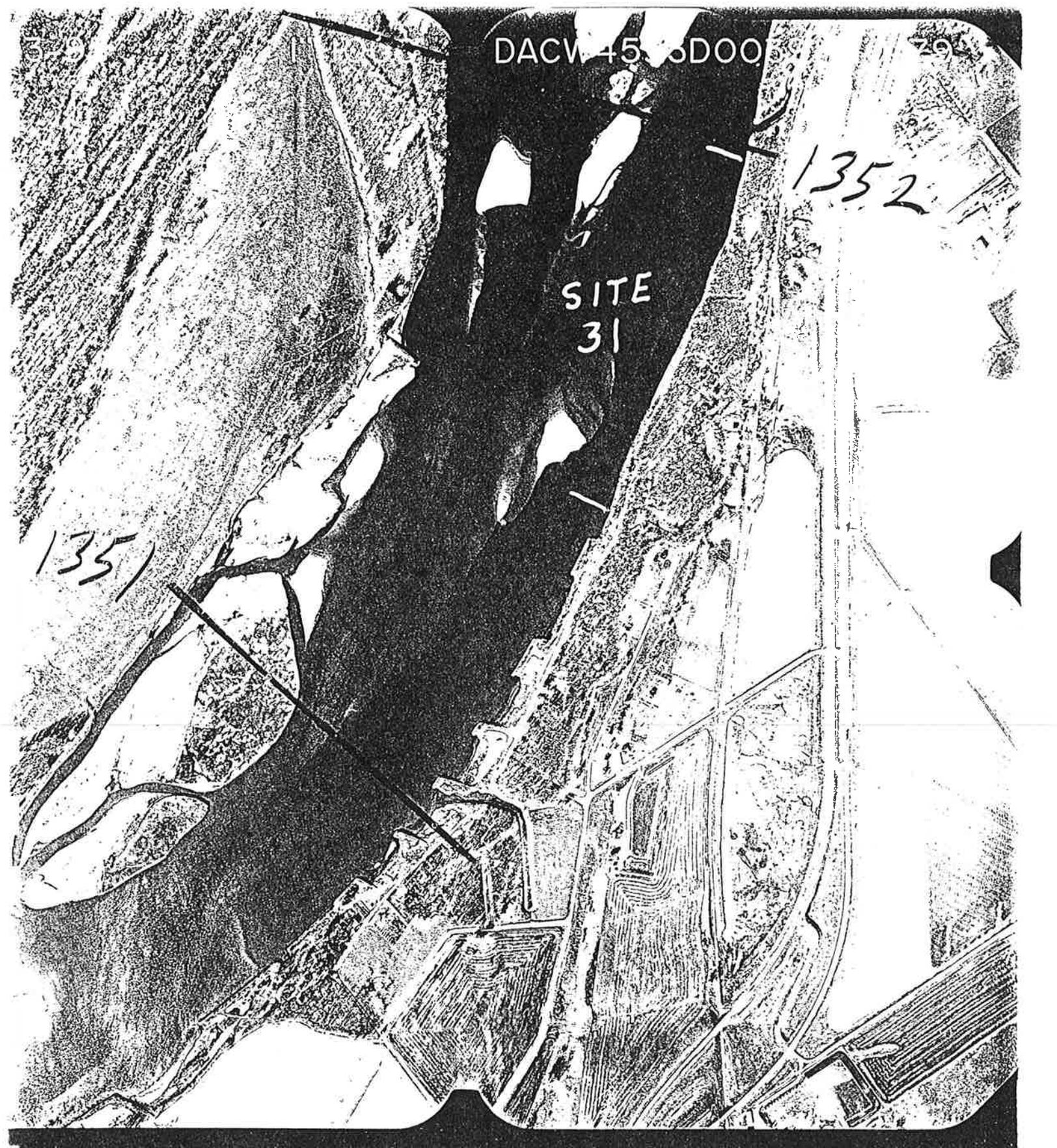
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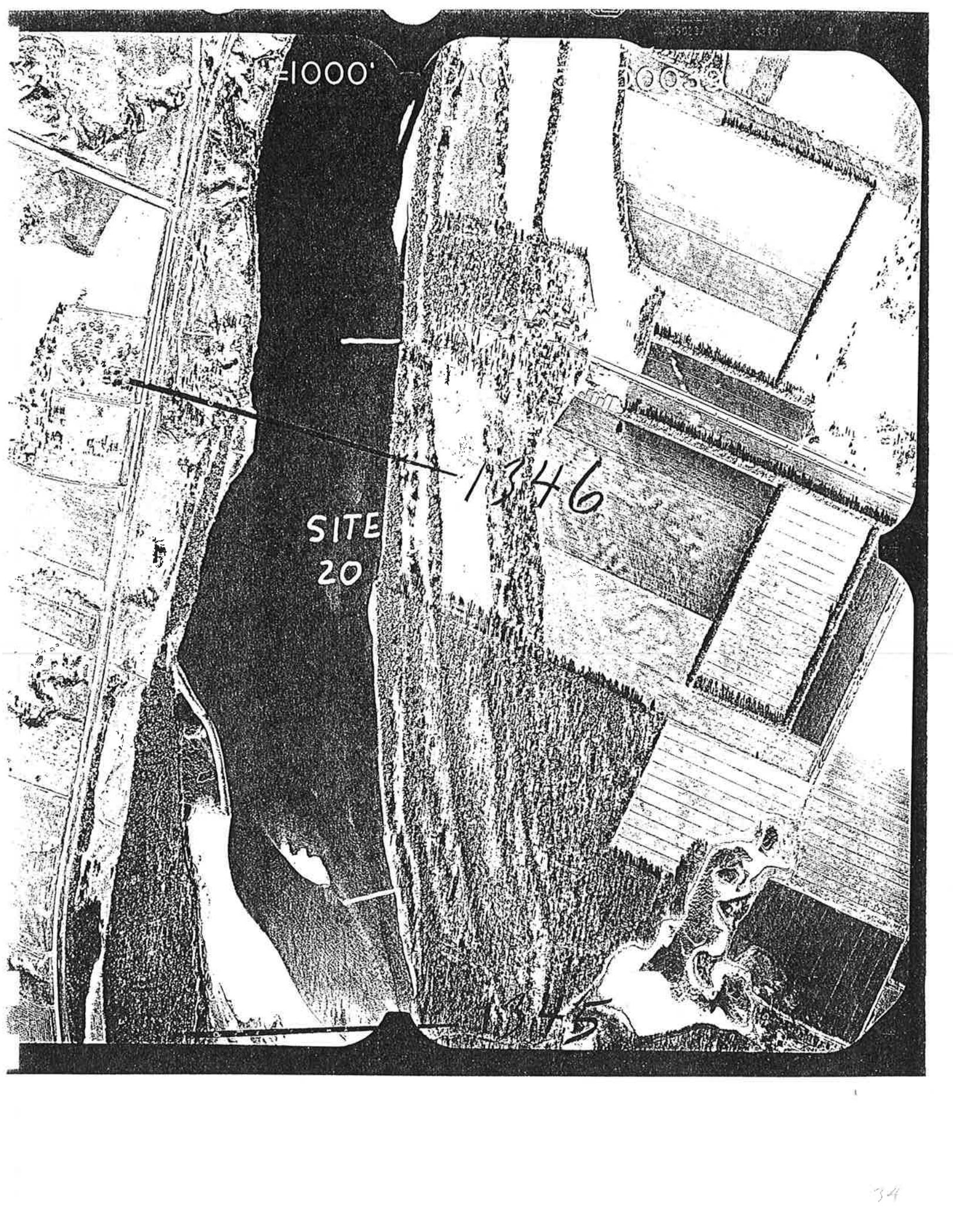
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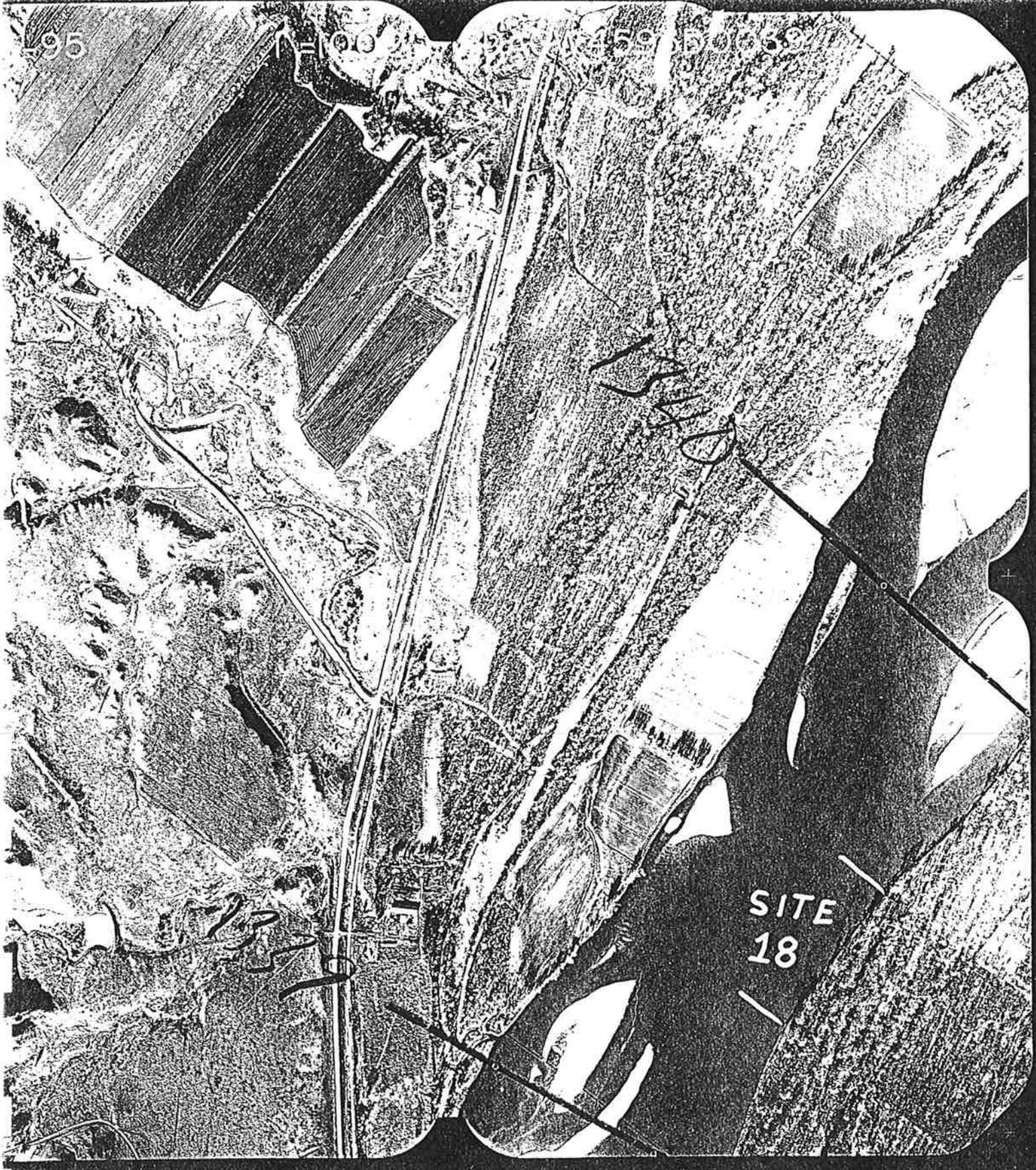
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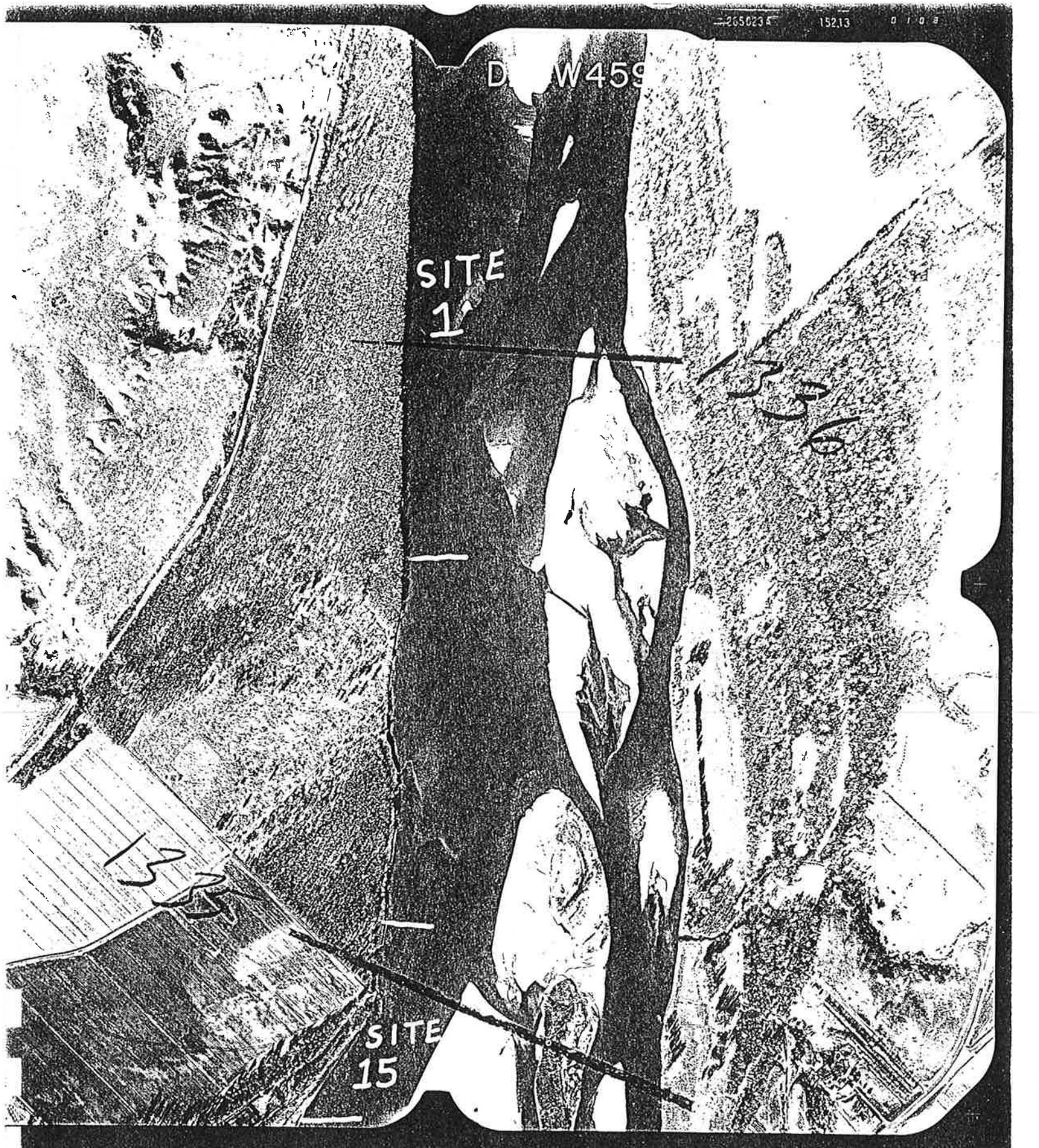
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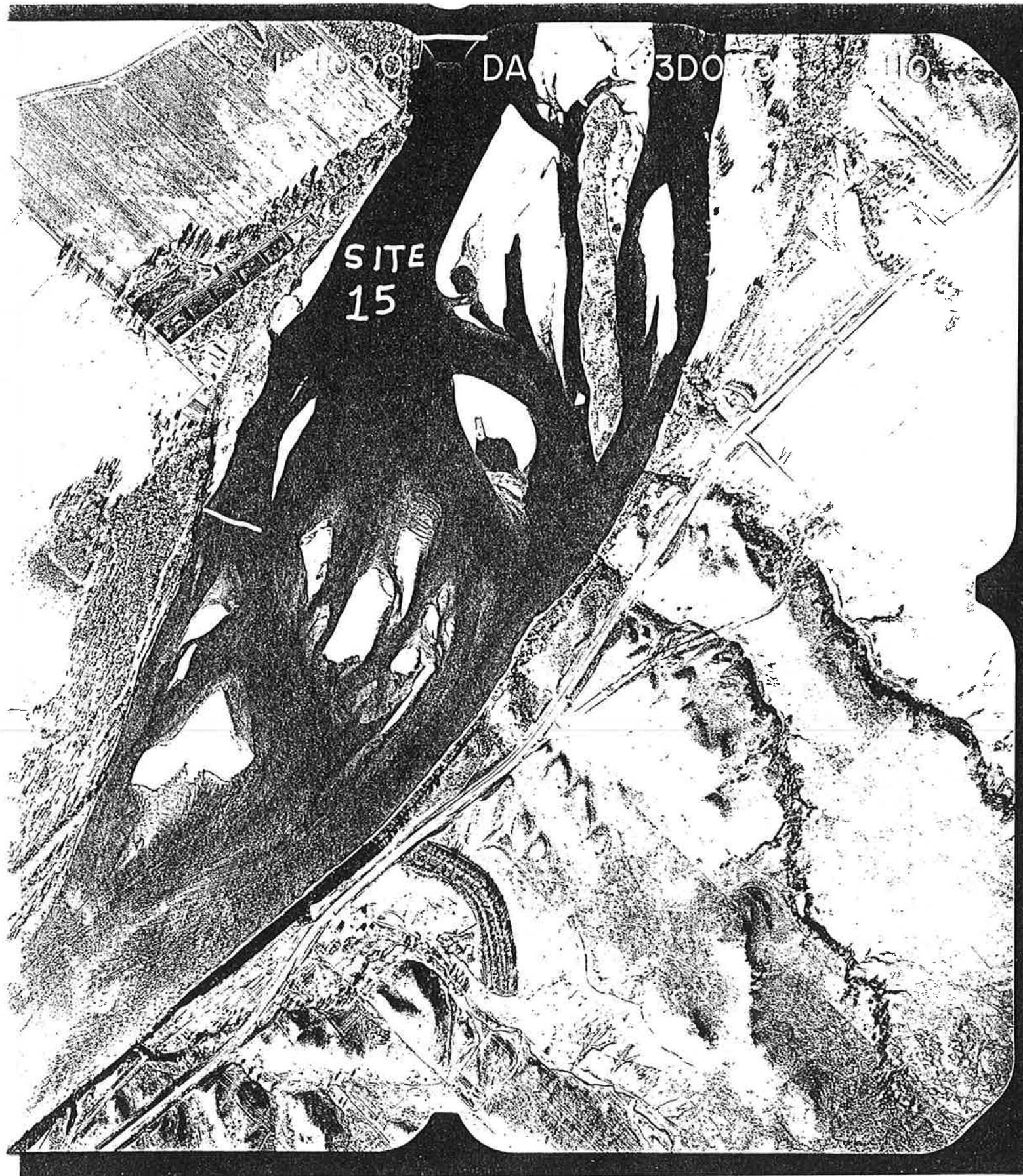
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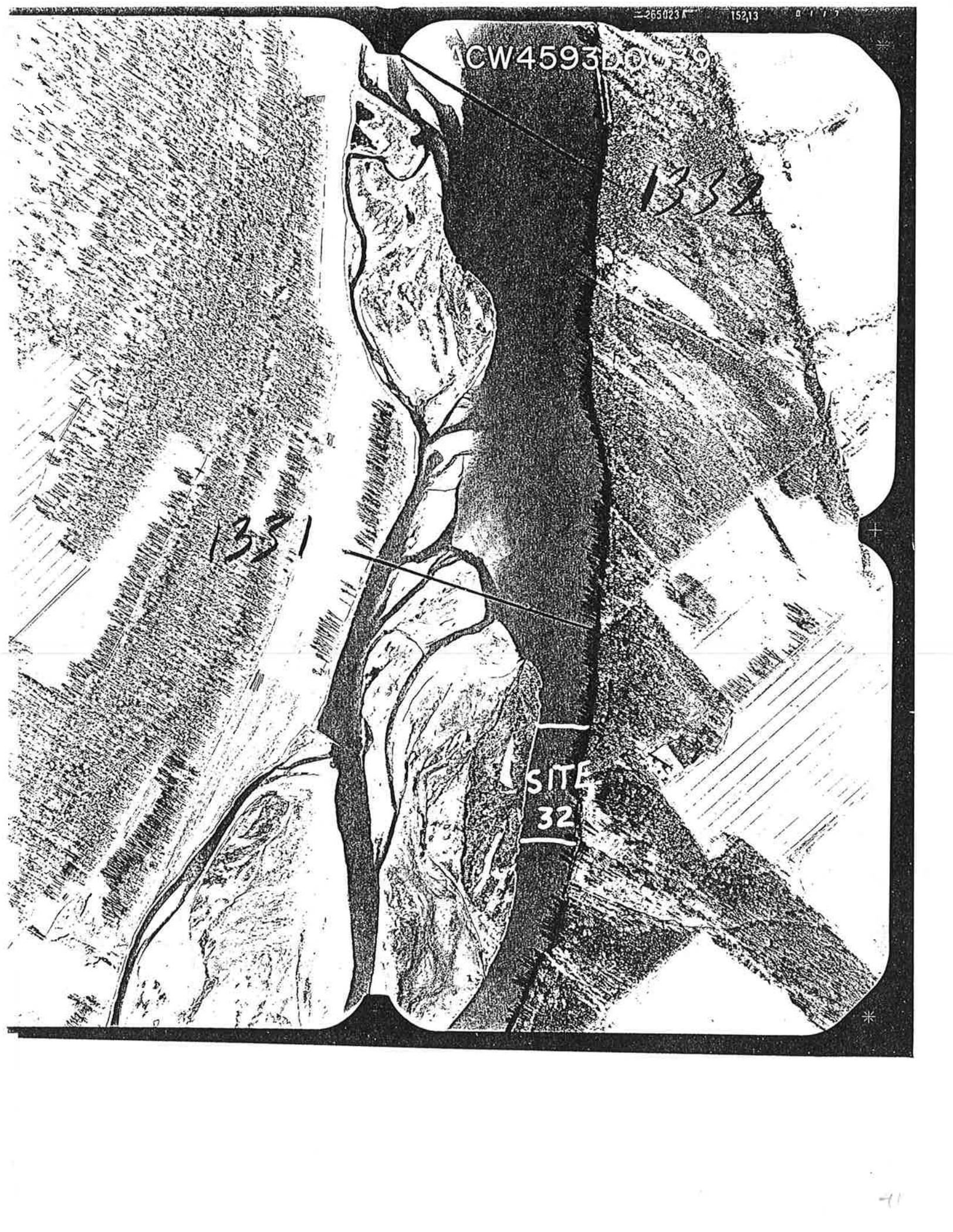
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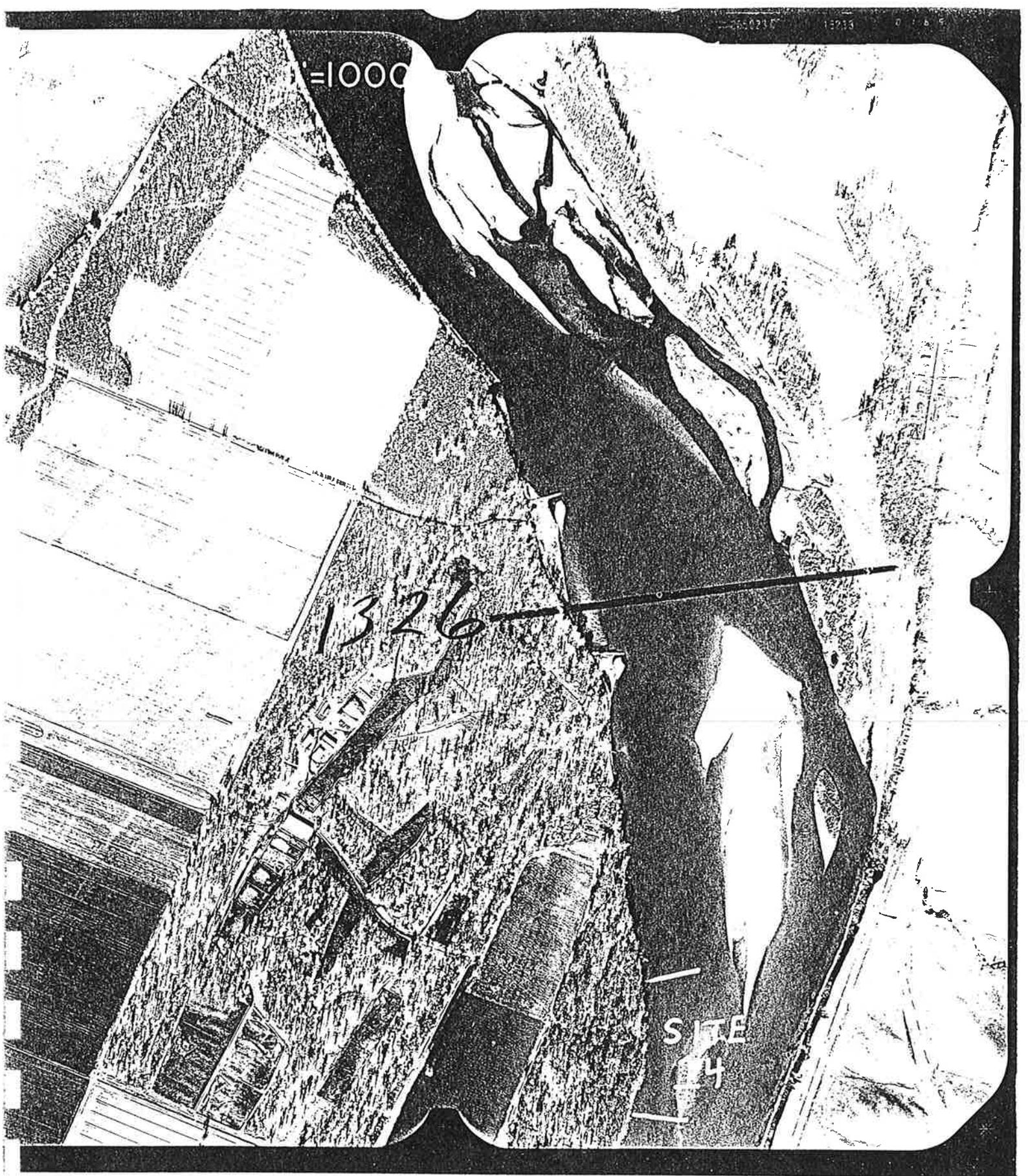
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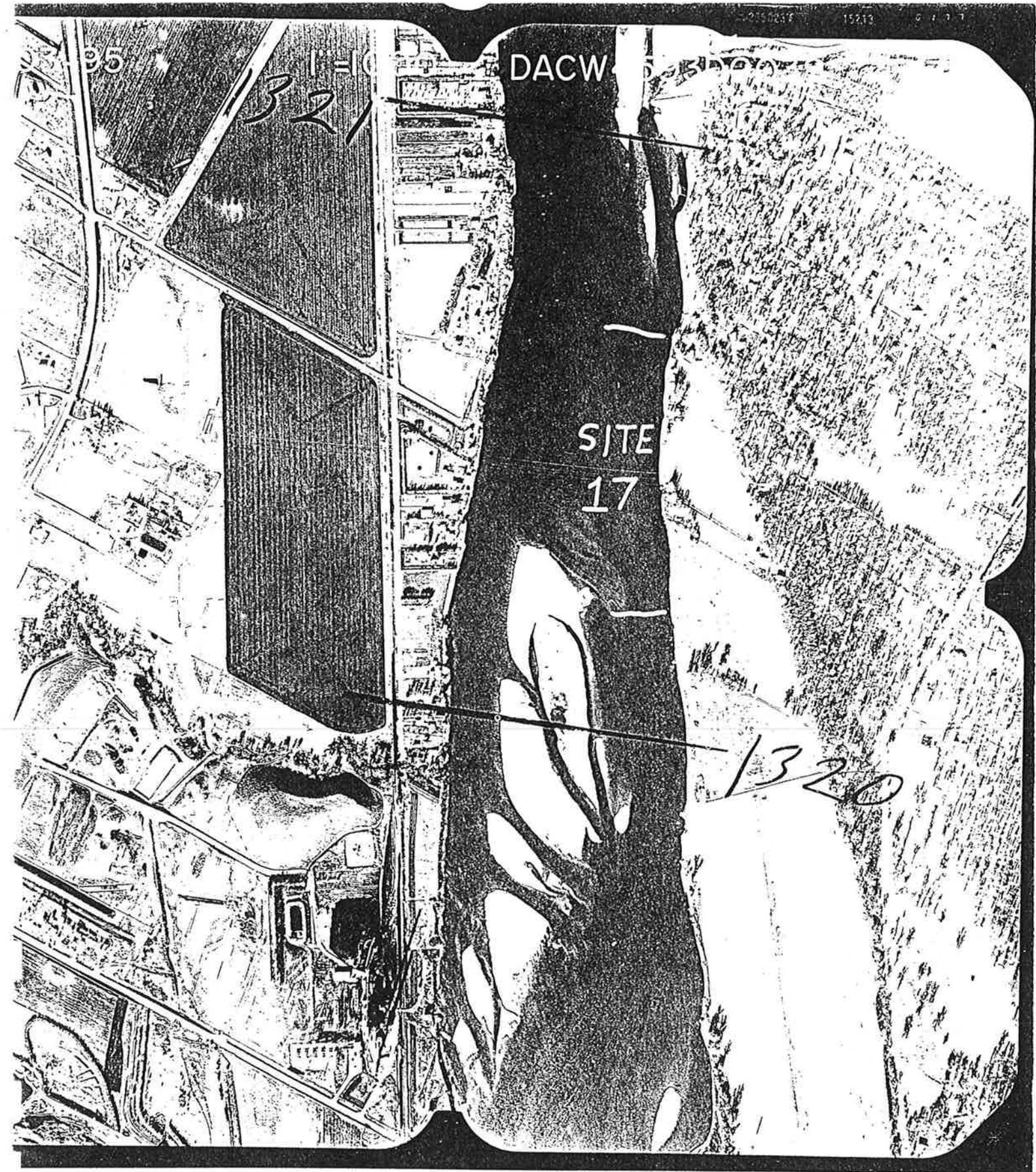
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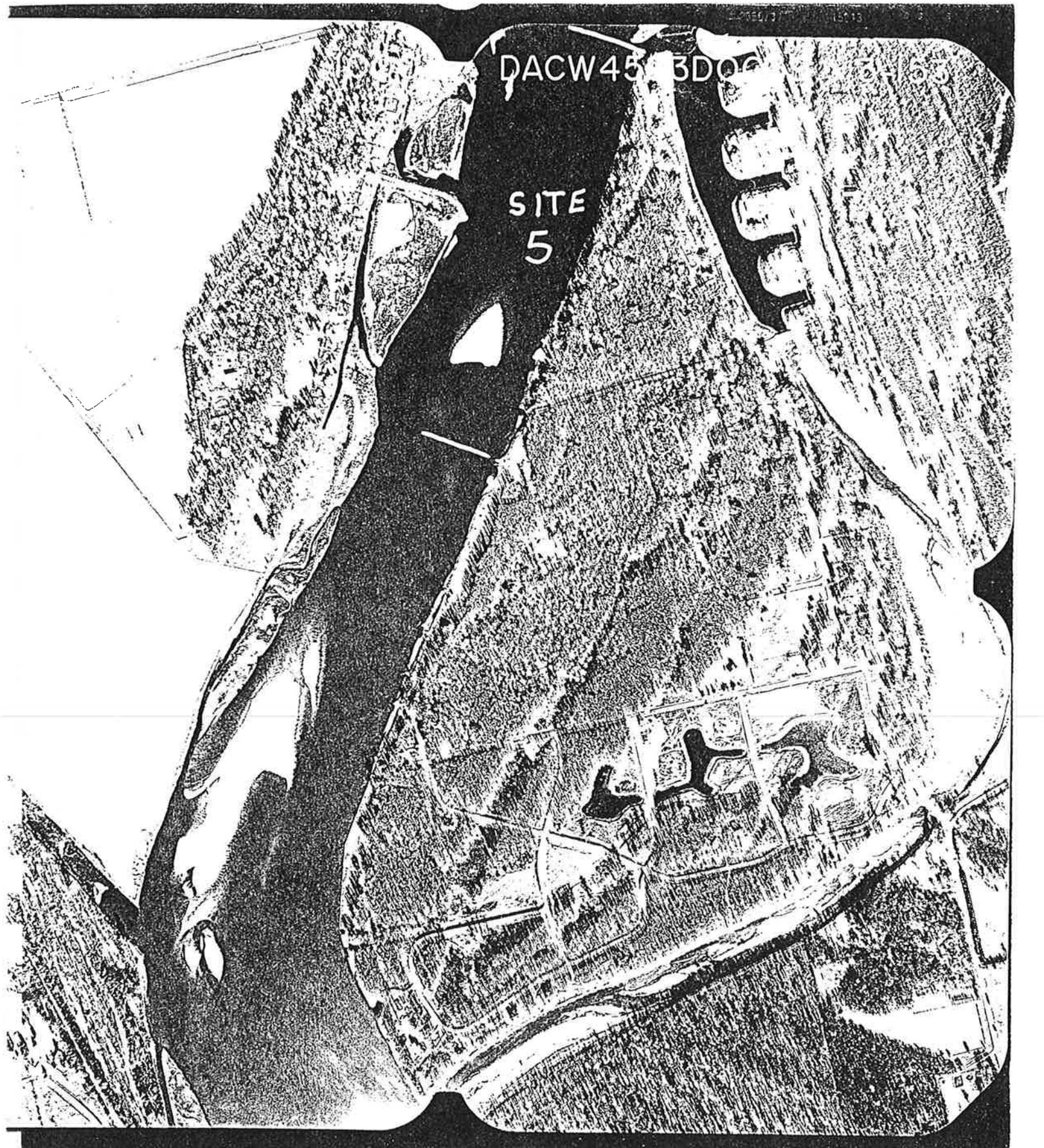
13198

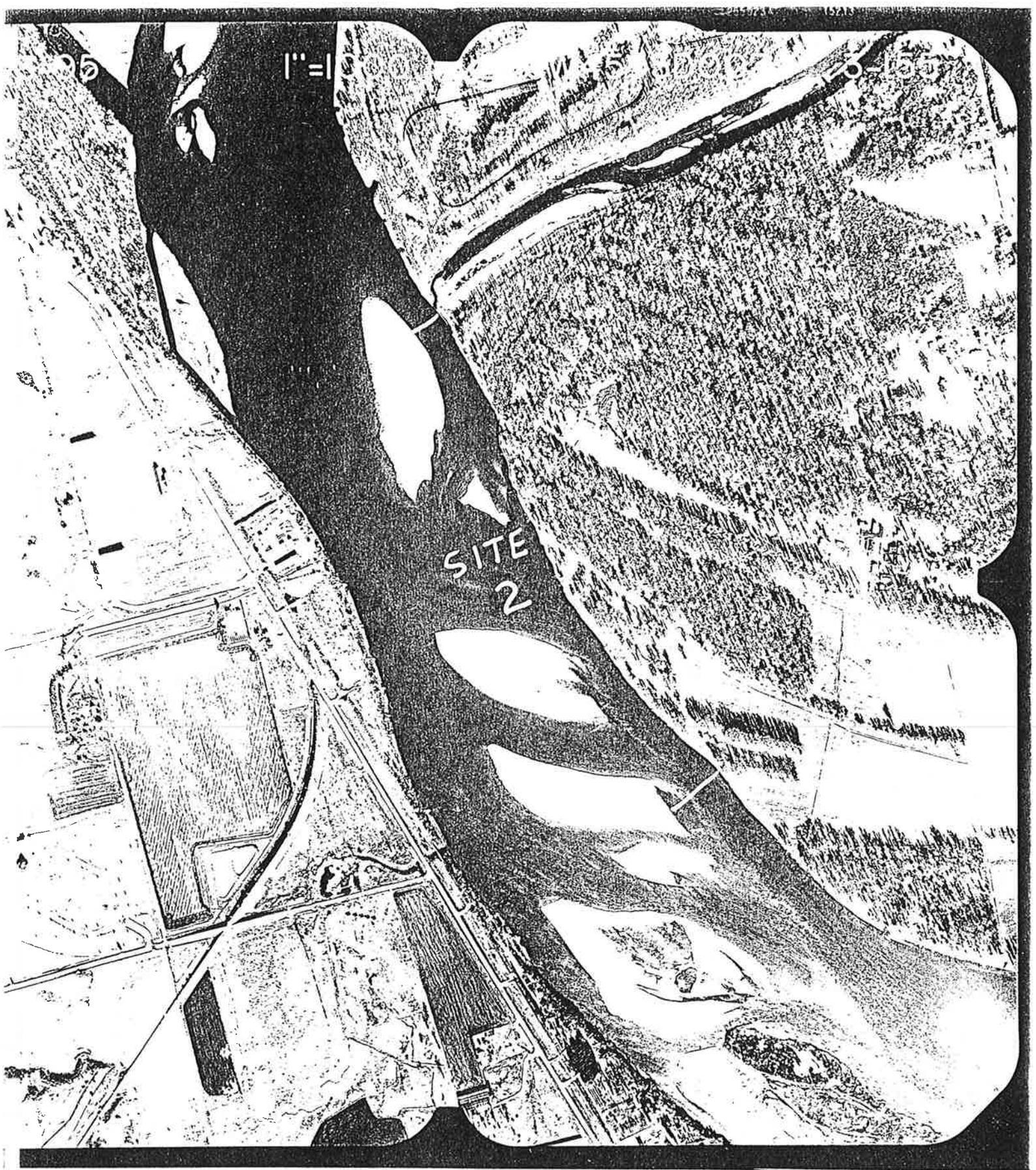
SITE
12

118

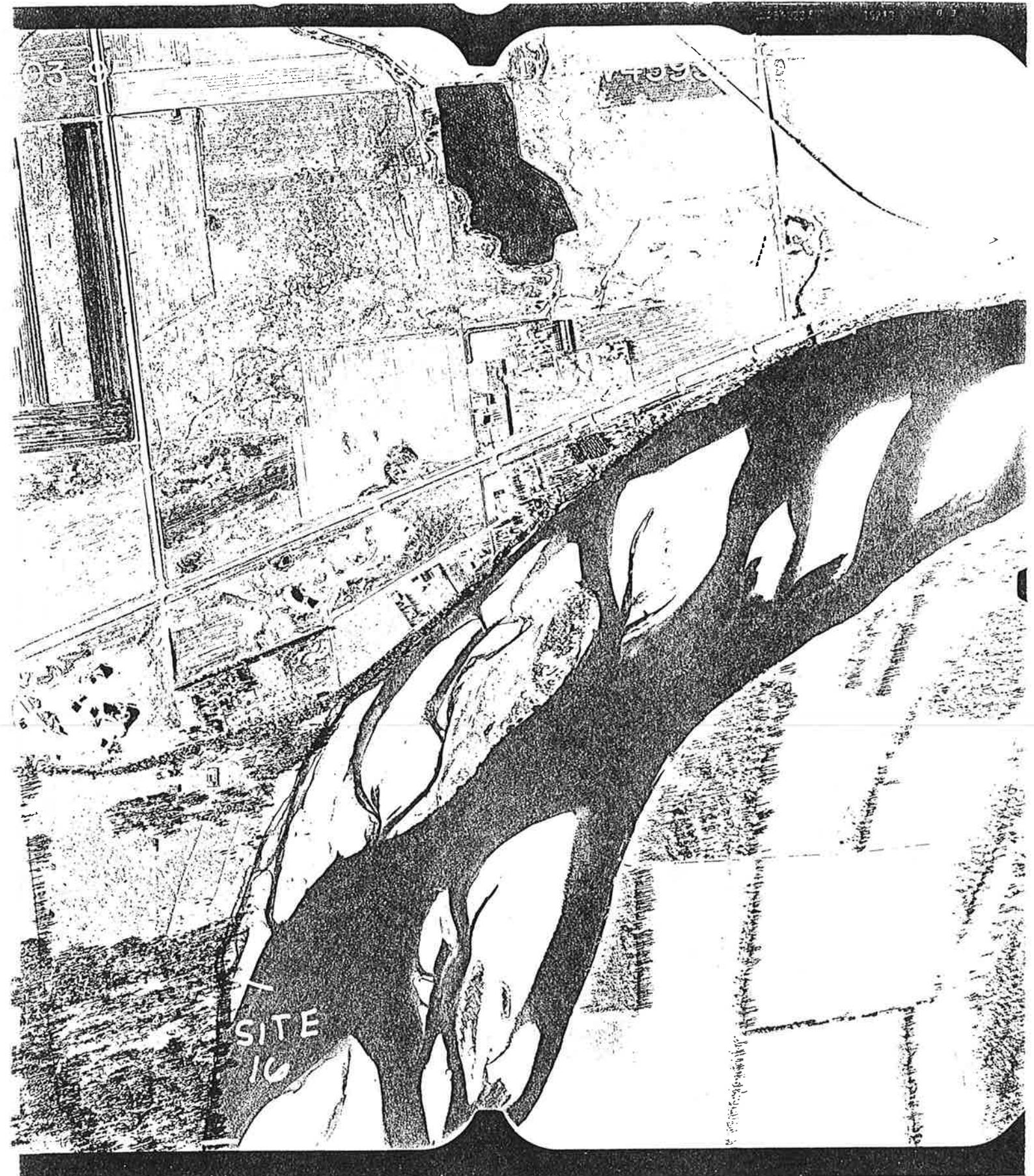
DACW45 3D06

SITE
5





SITE
2



SITE
16

1000'
SITE
16

DACW 93

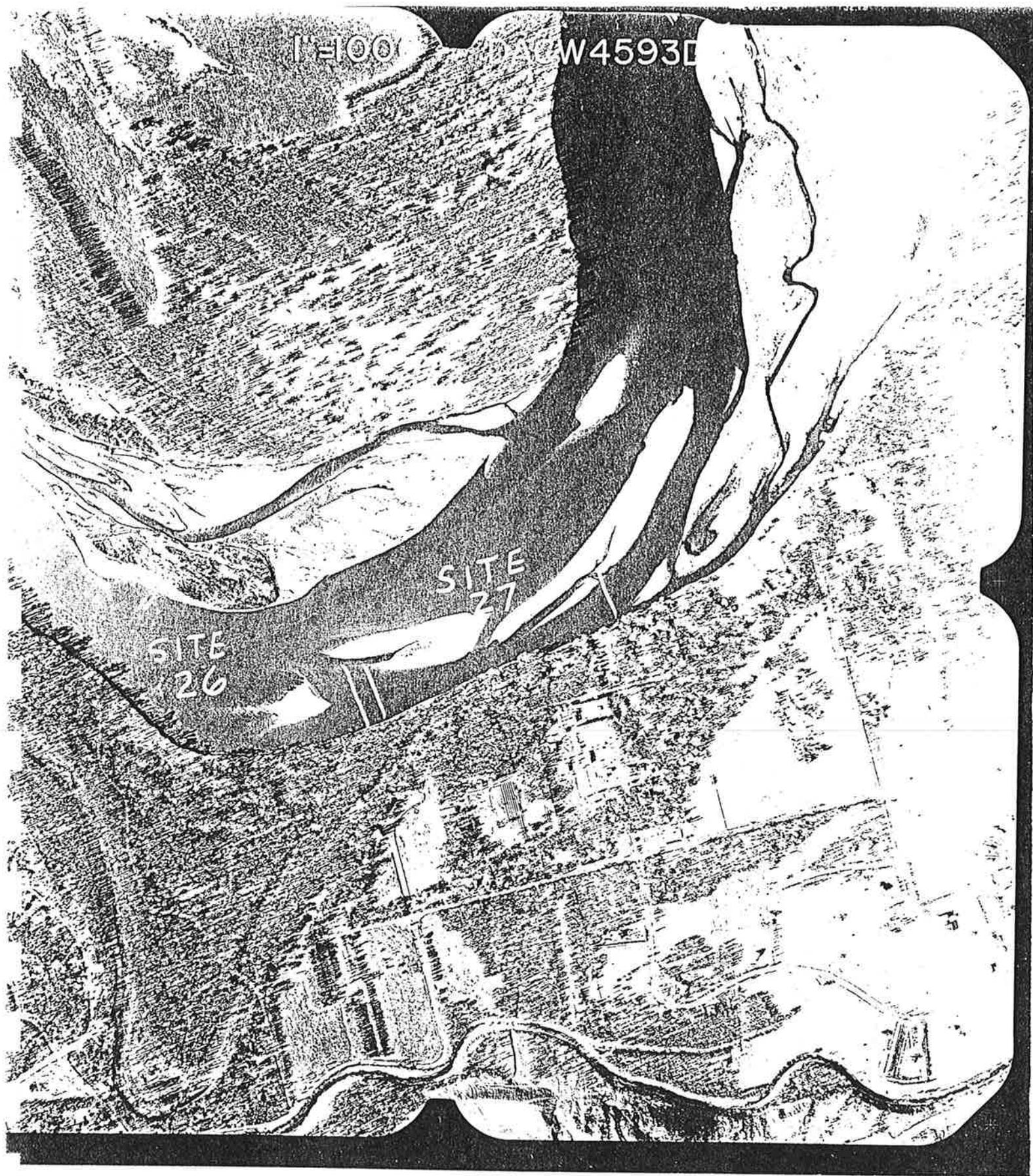
SITE
8

1:100

W4593D

SITE
26

SITE
27



1"=1000'

DAGW4593D9039

1-12

SITE
26

SITE
7

1"=100'
SITE
7

