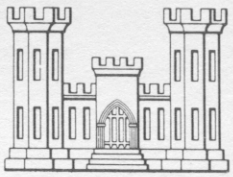
MISSOURI RIVER

ANALYSIS OF TEMPERATURE EFFECTS ON STAGE-DISCHARGE RELATIONSHIP IN A MISSOURI RIVER REACH NEAR OMAHA



FEBRUARY 1977

U. S. ARMY ENGINEER DIVISION, MISSOURI RIVER
CORPS OF ENGINEERS
OMAHA, NEBRASKA

M.R.D. Sediment Series

NO. 15

This report presents the results of a cooperative study undertaken by the US Army Corps of Engineers and Dr. H. W. Shen, Professor of Civil Engineering at Colorado State University. The report is a continuation of the Channel Regime Studies started in 1966 to investigate factors affecting the stage-discharge relationship on the Missouri River. This study was conducted under the general supervision of Alfred S. Harrison and Warren J. Mellema of the Missouri River Division, Corps of Engineers.

I. INTRODUCTION

A. Statement of the Problem

The U.S. Army Engineer District, Omaha (1967, 1968, 1969) reported "a pronounced correlation between water temperature, shifts in the stage-discharge relationship and bed roughness forms" in the Missouri River near Omaha (between Missouri River Mile 609 to 616).

The main purpose of this study is to analyze these field data using currently available methods such as those proposed by Einstein and Barbarossa (1952), Simons and Richardson (1966), Lovera and Kennedy (1969), Alam and Kennedy (1969), Taylor and Vanoni (1972a, 1972b), Vanoni (1974) and others. The scope of this study also includes the following three purposes: (1) to describe the significant factors influencing the shift of the rating curve; (2) to provide criteria for the prediction of this shift, if possible; and (3) to comment on the relationship between the shift and river navigation.

B. Description of the Study Reach

The location of this reach is between Missouri River Mile 609 to 616 near Omaha, as shown in Plates 1 and 2. The main data collection section is in a relatively straight reach with a top width of about 700 feet, depending on the flow conditions. Both banks are protected securely by riprap.

The dashed line in Plate 1 shows the general location of the river thalweg. The flow is concentrated along the right bank near the Ak-Sar-Ben Highway Bridge, crosses over to the left bank near Mile 614.1 and then crosses back to the right bank in the vicinity of the South Omaha Bridge (Mile 612). From this location throughout the remainder of the study reach (Mile 609), the flow hugs the right bank as the river proceeds around a rather sharp bend. Plate 2 is an aerial photograph of the reach; Omaha is on the left.

The controlled flow of the Missouri River at Omaha varies generally from between 30,000 to 35,000 cubic feet per second (cfs) during the navigation season from mid-March to mid-November and from 7,000 to 10,000 cfs during the winter period. However, the flow discharge was kept at about 64,500 cfs during September 23 to November 18, 1975, because of unusually high flows into the river.

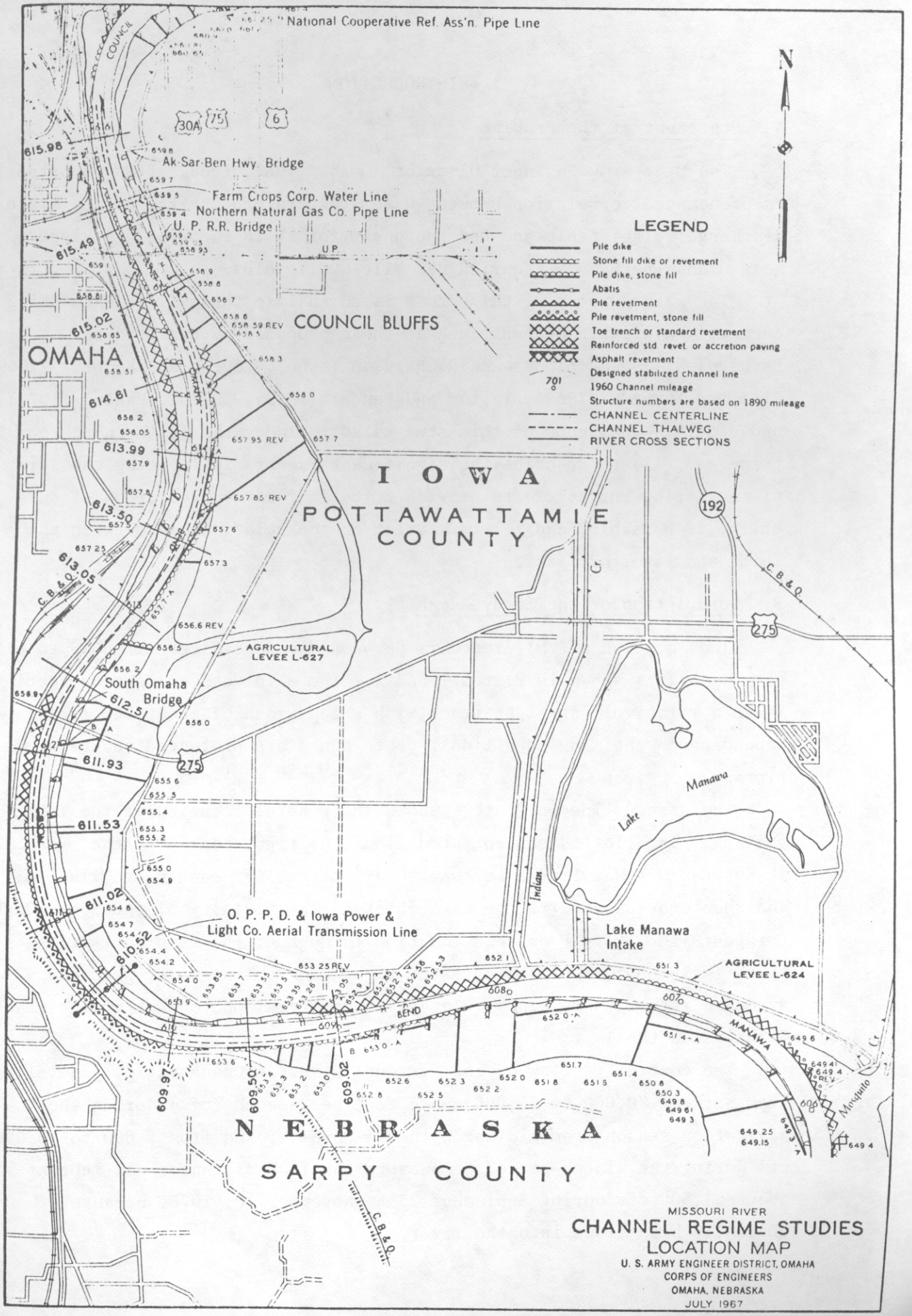


Plate 1. Location of Study Reach

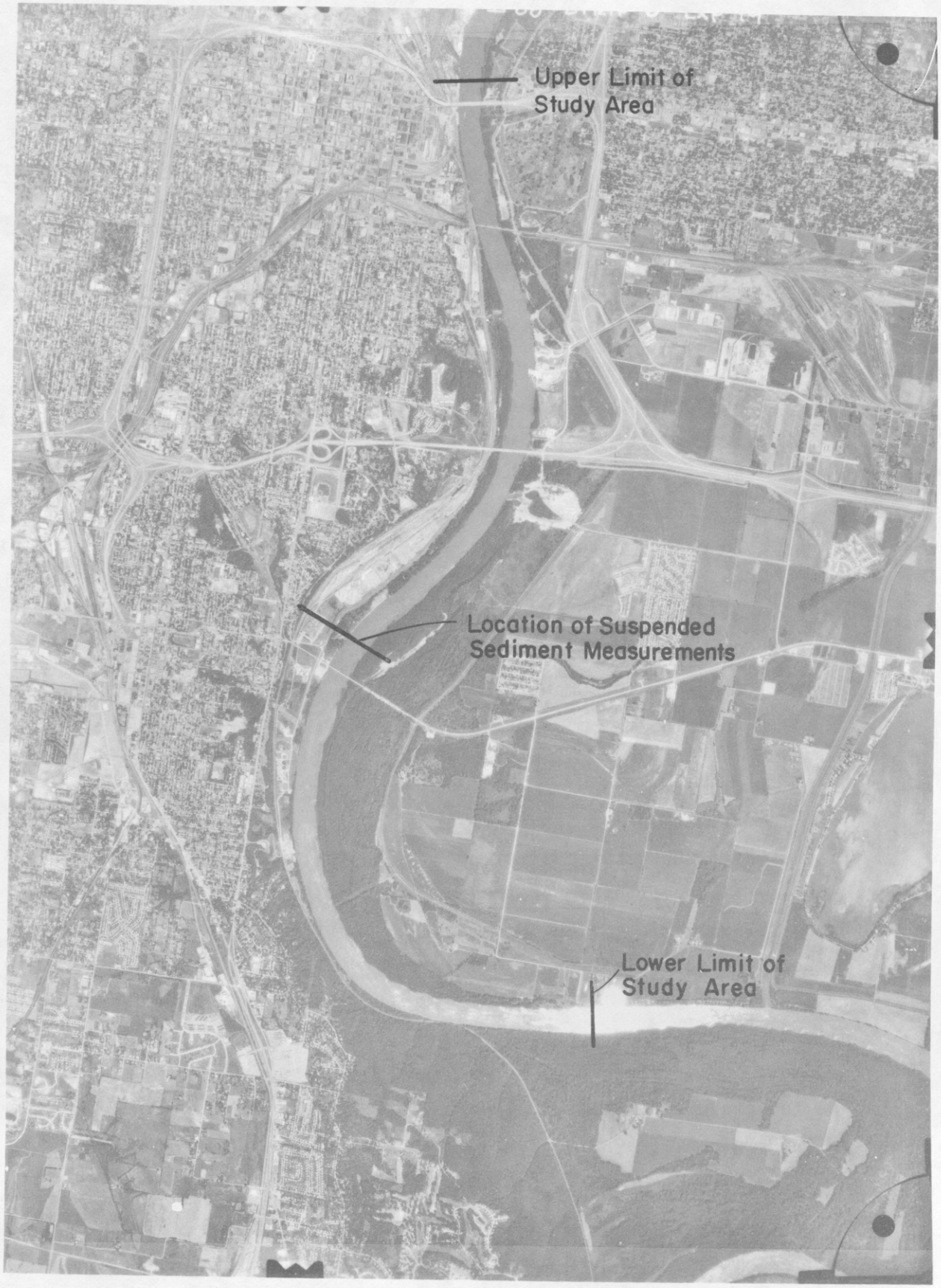


Plate 2. Aerial View of Missouri River Study Reach

C. Data Collection

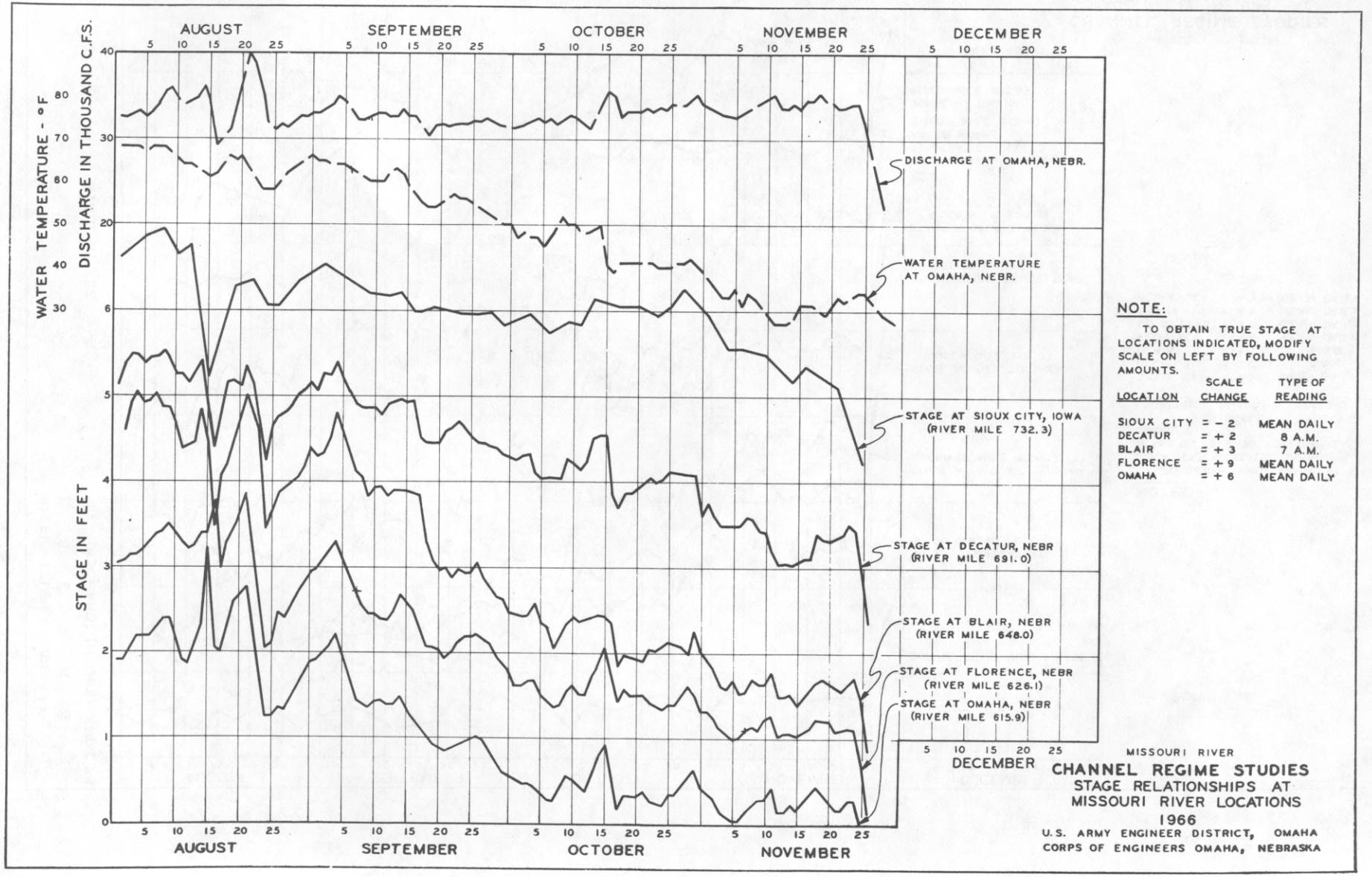
All data were collected by personnel from the U.S. Army Corps of Engineers. Data collected for 1966, 1967, 1968, 1969 and 1975 include the following:

1. Water surface profiles - measurements obtained at one-half mile intervals throughout a 7 mile reach.
2. Water temperature throughout measurement period of September through mid-December.
3. Discharge measurements.
4. Channel cross sections at one-half mile intervals.
5. Longitudinal soundings of bed profile along the river thalweg at 3 locations in the channel.
6. Bed material samples in the study reach.
7. Suspended point samples at 3 to 5 verticals, at 5 to 7 locations (depths) in each vertical, from which sand loads for each grain size fraction were computed.
8. Velocity measurements at locations of point samples.
9. Stage at the Omaha U.S. Geological Survey measurement station throught the measurement period.

D. Shift of the Stage-Discharge Relationship

The variations of stage, river discharge and water temperature with time at different stations for years 1966 to 1968 are shown in Plates 3, 4 and 5. These figures were taken from U.S. Army Engineer District, Omaha (1969). Plate 6 shows the change in stage, discharge and water temperature for a station at Missouri River Mile 615.02, about 0.8 mile upstream from Omaha (Mile 615.9), for the year 1975. Although river discharges were held approximately constant between August (or September) and November (or December) of each year, the stage dropped steadily when the temperature descreased. Table 1 briefly summarizes these changes. In 1969, discharge was not held constant as in the other years.

Typical bed profiles for summer and early winter are shown in Plate 7.



NOTE:

TO OBTAIN TRUE STAGE AT LOCATIONS INDICATED, MODIFY SCALE ON LEFT BY FOLLOWING AMOUNTS.

LOCATION	SCALE CHANGE	TYPE OF READING
SIOUX CITY	= − 2	MEAN DAILY
DECATUR	= + 2	8 A.M.
BLAIR	= + 3	7 A.M.
FLORENCE	= + 9	MEAN DAILY
OMAHA	= + 6	MEAN DAILY

MISSOURI RIVER

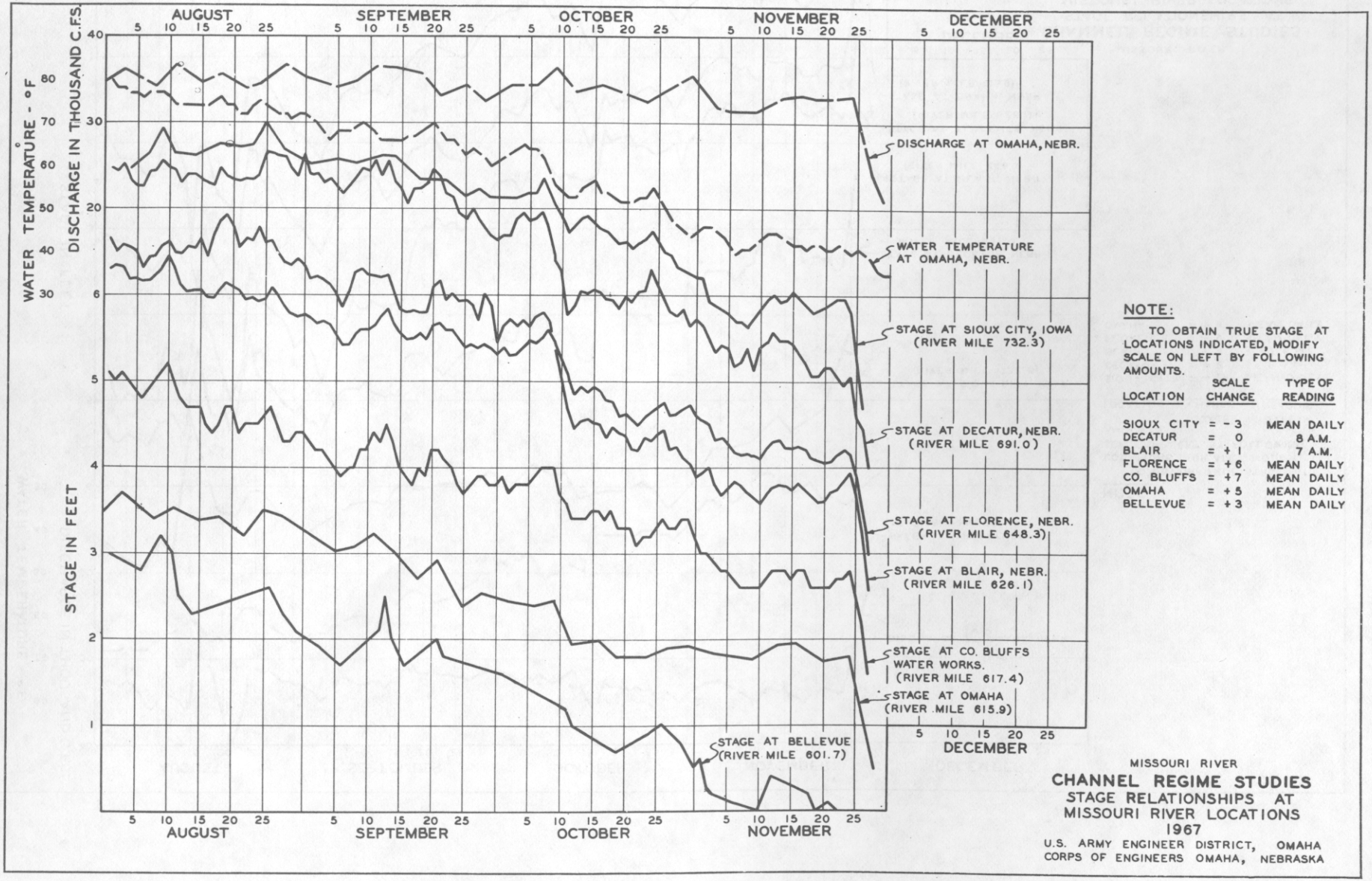
CHANNEL REGIME STUDIES

STAGE RELATIONSHIPS AT MISSOURI RIVER LOCATIONS

1966

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

Plate 3



NOTE:

TO OBTAIN TRUE STAGE AT LOCATIONS INDICATED, MODIFY SCALE ON LEFT BY FOLLOWING AMOUNTS.

LOCATION	SCALE CHANGE	TYPE OF READING
SIOUX CITY	= - 3	MEAN DAILY
DECATUR	= 0	8 A.M.
BLAIR	= + 1	7 A.M.
FLORENCE	= + 6	MEAN DAILY
CO. BLUFFS	= + 7	MEAN DAILY
OMAHA	= + 5	MEAN DAILY
BELLEVUE	= + 3	MEAN DAILY

MISSOURI RIVER

CHANNEL REGIME STUDIES

STAGE RELATIONSHIPS AT MISSOURI RIVER LOCATIONS 1967

U.S. ARMY ENGINEER DISTRICT, OMAHA
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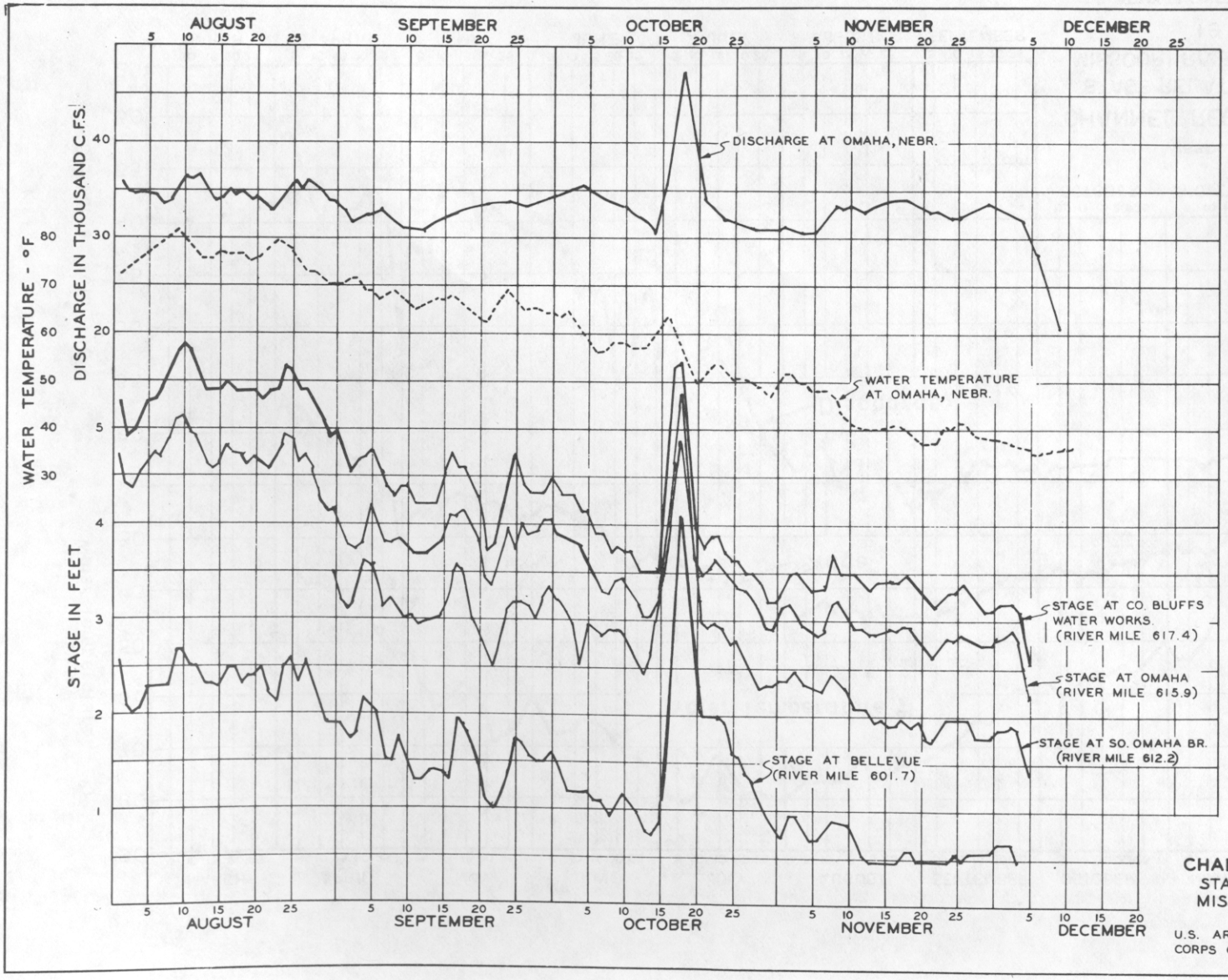
Plate 4



NOTE:

TO OBTAIN TRUE STAGE AT LOCATIONS INDICATED, MODIFY SCALE ON LEFT BY FOLLOWING AMOUNTS.

LOCATION	SCALE CHANGE	TYPE OF READING
CO. BLUFFS	= +6.5	MEAN DAILY
OMAHA	= +3.5	MEAN DAILY
BELLEVUE	= +1.0	MEAN DAILY
SO. OMAHA BR	= +3.5	MEAN DAILY

MISSOURI RIVER

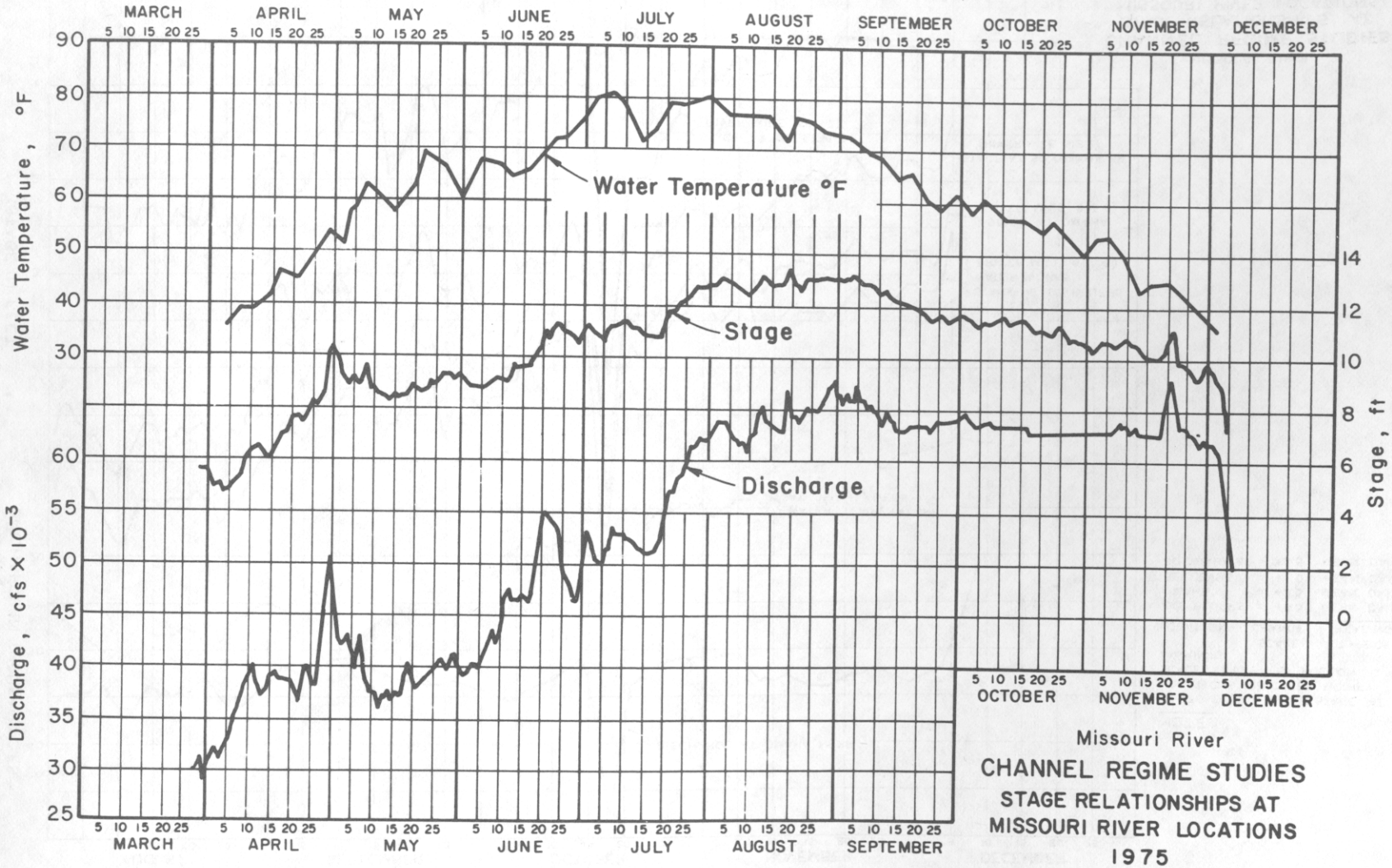
CHANNEL REGIME STUDIES

STAGE RELATIONSHIPS AT MISSOURI RIVER LOCATIONS

1968

U.S. ARMY ENGINEER DISTRICT, OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

Plate 5



Missouri River

CHANNEL REGIME STUDIES

STAGE RELATIONSHIPS AT MISSOURI RIVER LOCATIONS

1975

U.S. ARMY ENGINEER DISTRICT. OMAHA
CORPS OF ENGINEERS OMAHA, NEBRASKA

Plate 6

Table 1. Summary of Stage Shift at Omaha, Missouri River Mile 615.9

Date	Discharge (1000 cfs)	Approximate River Stage at Omaha (River Mile 615.9)	Water Temperature (Degrees F)
Sept. 8, 1966	32.1	2.7	71
Nov. 7, 1966	33.2	1.1	44
Aug. 21, 1967	34.1	3.3	72
Nov. 22, 1967	33.1	1.8	41
Aug. 6, 1968	34.0	4.7	78
Dec. 2, 1968	31.6	2.8	36
Sept. 23, 1969	53.8	5.6	61
Dec. 1, 1969	34.0	1.1	37
Sept. 23, 1975	64.4	11.6	60
Nov. 18, 1975	64.9	10.8	46