Gravel Prospecting by Use of Aerial Photographic Interpretation

R. J. KASPER, Geologist, North Dakota State Highway Department

●DUE TO A rapidly diminishing aggregate supply as compared with a greatly increased highway construction program, the North Dakota State Highway Department has found it imperative to expedite the rate of prospecting through the utilization of available scientific methods. Presently, the sciences of geology, aerial photographic interpretation, and geophysics are being combined as a research unit for the reconnaissance and exploration of sand and gravel deposits situated in an economically important location to the interstate highway system.

PHYSIOGRAPHIC SETTING

North Dakota can be divided into three various provinces on the basis of the physically characteristic land forms contained by each (Figure 1).

The easternmost province in the state, known as the Red River Valley, takes its physiographic name from the Red River, which incidentally forms the eastern boundary of North Dakota. However, the implied river valley, given to understand by the name, is not actually a river valley but more properly the remnant lacustrine plain of ancient Glacial Lake Agassiz. The portion of the plain lying within North Dakota is 30 to 40 miles wide thinning at its southern end to approximately 10 miles. Along the west-

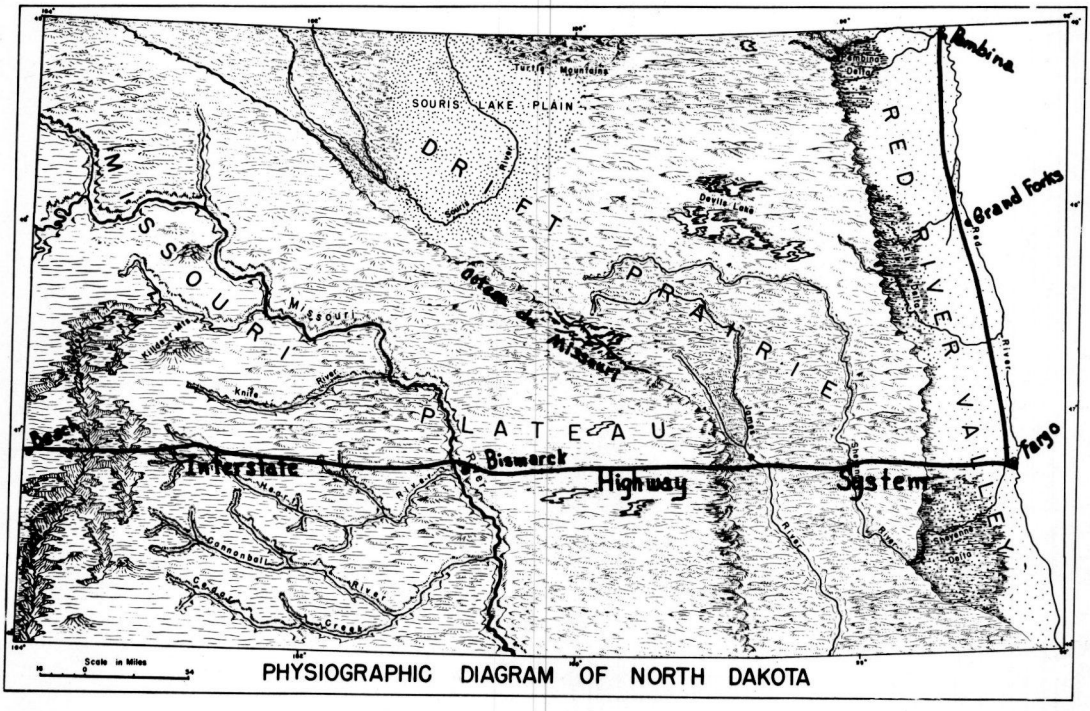


Figure 1.

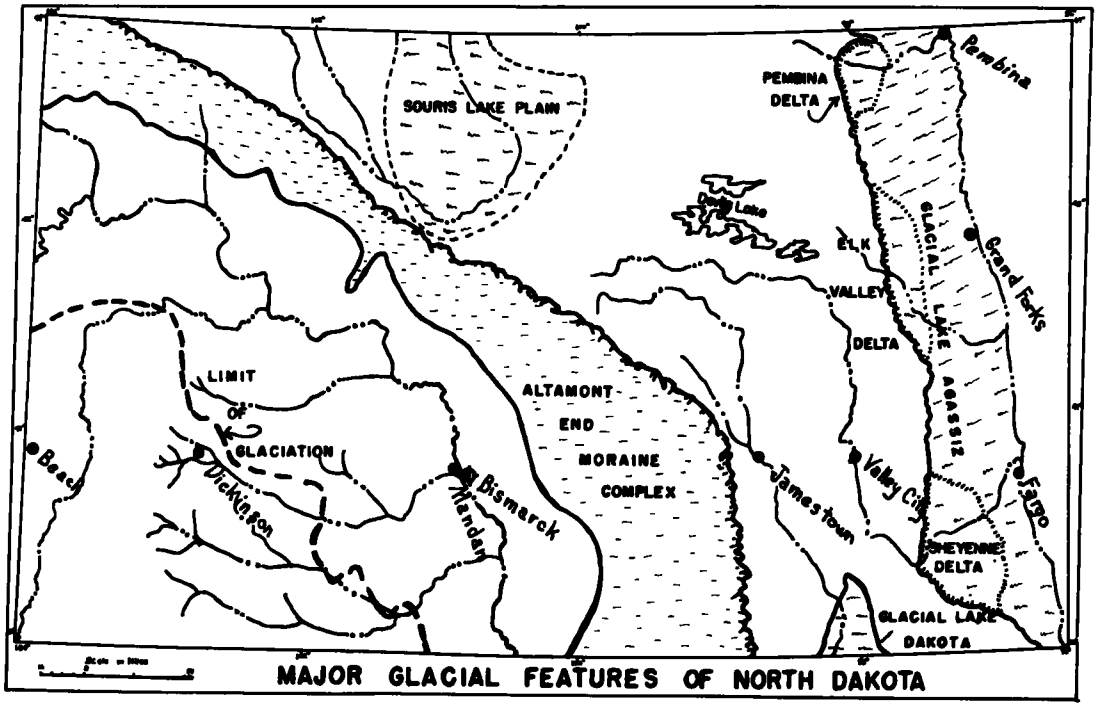
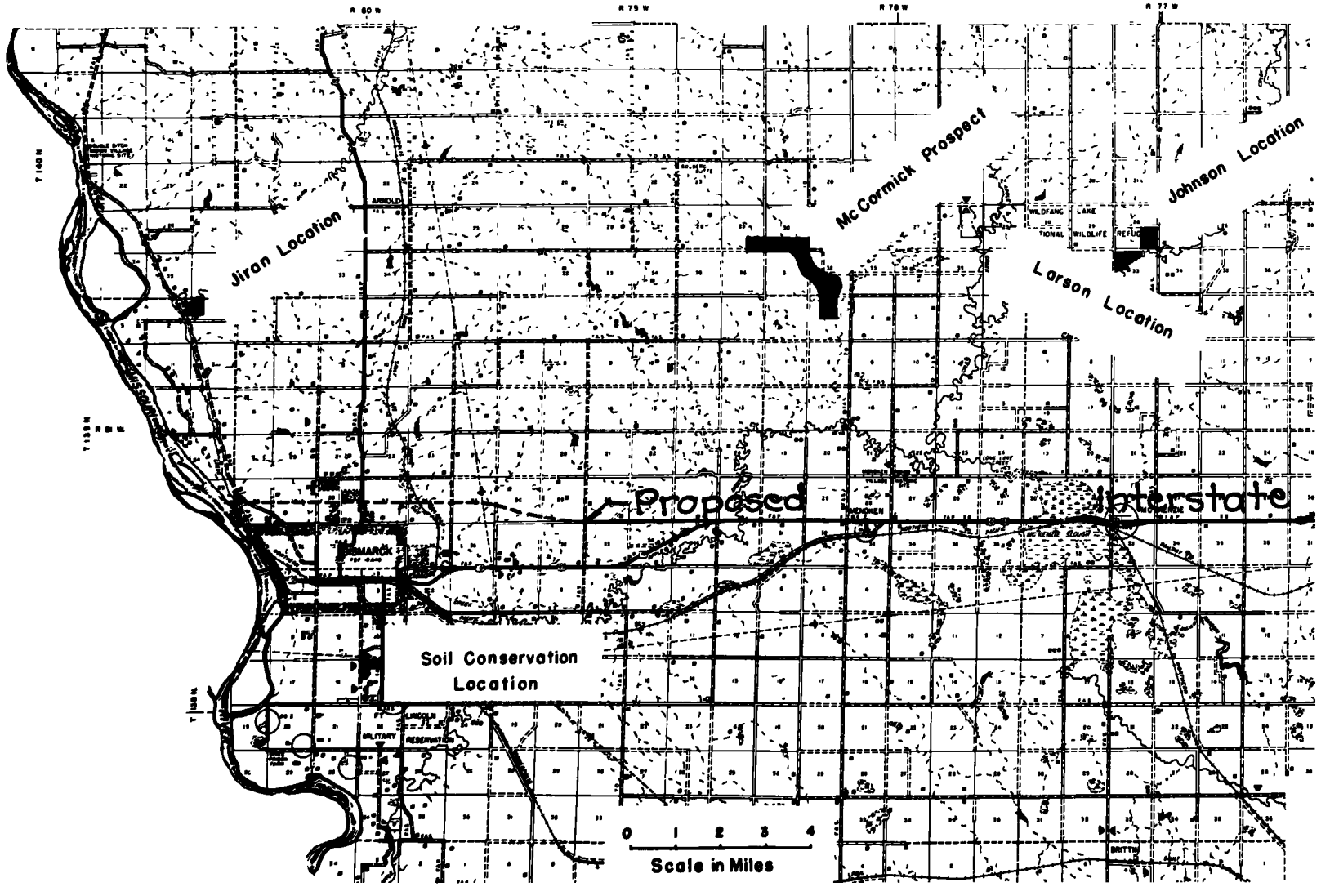


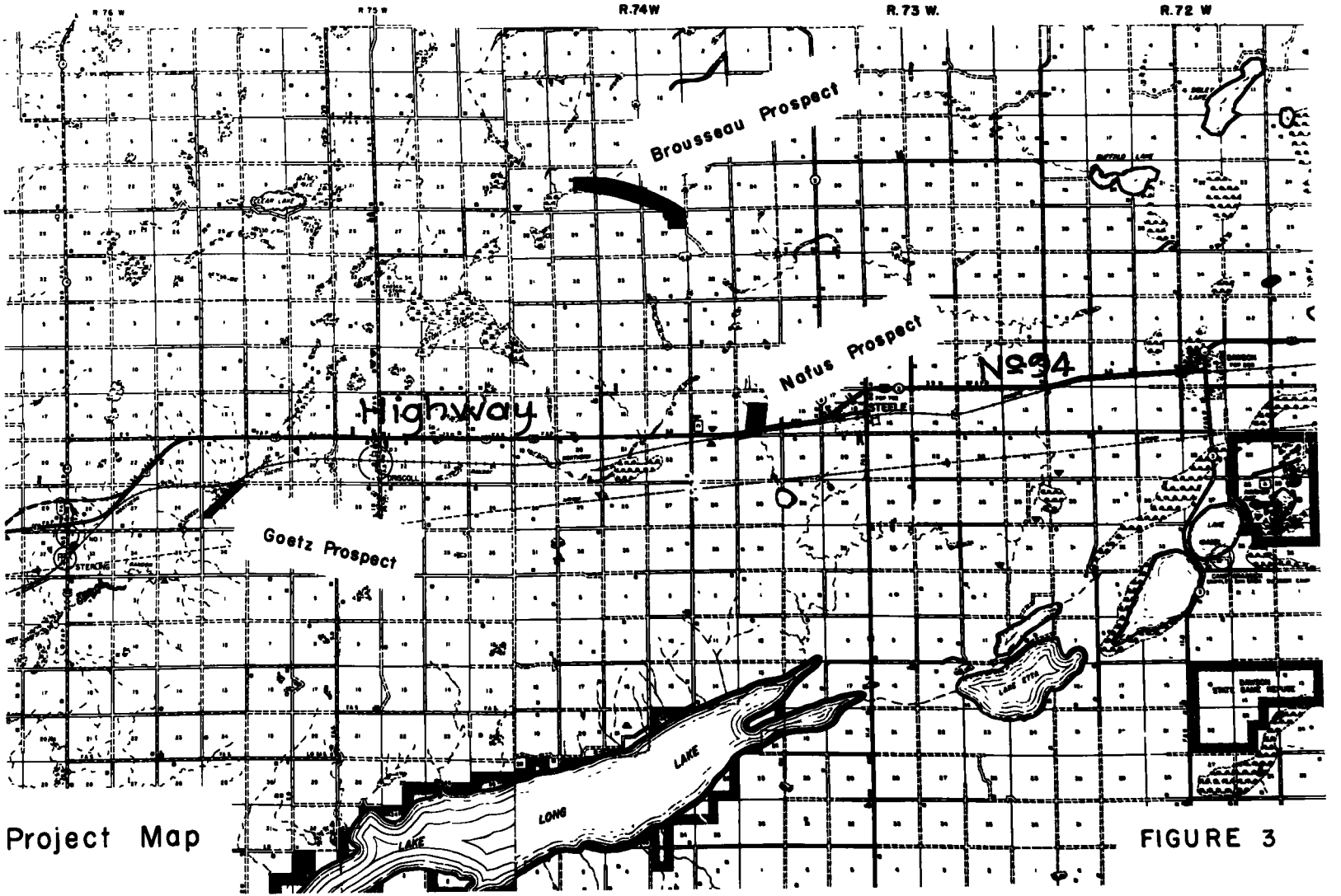
Figure 2.

ern edge of this extremely flat lying physiographic plain, an escarpment rises quite abruptly to heights of 200 to 500 ft above the valley floor. This escarpment is physiographically significant, in that it forms both the western edge of the Red River Valley and the eastern edge of the Drift Prairie, which is the next physiographic province to the west.

Contained within the boundaries of the Drift Prairie is a gently undulating through rolling to hilly topography consisting of both stratified and unstratified glacial drift deposits. Much of the past history of continental glacial advancements is revealed throughout the Drift Prairie by numerous irregular moraines, undrained kettle lakes, and broad outwash plains. Similar to the western edge of the Red River Valley, the western edge of the Drift Prairie is also distinguishable by an escarpment referred to geologically as the Coteau du Missouri or the "Hills of the Missouri." The Coteau du Missouri is in reality a series of terminal moraines lying on the eastern edge of the Missouri Plateau. This series of moraines is called the Altamont End Moraine Complex (Figure 2).

The Missouri Plateau province embraces nearly half of North Dakota; its eastern extremity is marked by the Coteau du Missouri, while the western extent within the state is drawn by the state's western boundary line. The plateau is divided by the Missouri River into two very distinct topographic features. West of the river, the plateau forms a wide plain distinguished by thinly vegetated, broad to very steeply eroded slopes, while the eastern plateau's portion is much more gradual, due to a more or less resistant cover of glacial drift and dense vegetation.


Jiran Location
McCormick Prospect
Johnson Location
Larson Location
Proposed Interstate
Soil Conservation Location
0 1 2 3 4
Scale in Miles



Project Map

FIGURE 3

GEOLOGIC SITUATION

The superficial geology within North Dakota cannot assert itself to be the parent body from which aggregate deposits in the state have been derived. North Dakota can best be thought of as transitional zone where sand and gravel were transported by different agents from varying directions. Those agents of erosion most involved in the conveyance of material from its source to its present depositional locality are glacial flow and stream flow.

During the Pleistocene epoch of geologic time, the Kansan and the Wisconsin glaciers uprooted rock material and debris largely from the Canadian Shield region and transported it both interglacially and subglacially to its various depositional localities. The unstratified drift material of the earlier Kansan glacier was dispersed over all but the southwestern portion of North Dakota, while the Wisconsin drift did not reach beyond the Altamont End Moraine Complex. Upon the ablation and final recession of each glacier, stratified drift deposits of sand and gravel were developed by the melt water re-working the unstratified drift material. Some of the more notable stratified drift deposits encountered and processed for highway sand and gravel needs within the state are kames, outwash terraces, eskers, crevasse filling, kame terraces, and deltaic deposits formed at the intersection of smaller glacio-fluvial streams with larger major streams.

Glacial topography is recognizable over most all of the state, except in western and southwestern regions where it is largely in absentia. Within this non-glaciated region, aggregate material possibly owes its origin to streams flowing from source rock areas and depositing sand and gravel in flood plains, which were later dissected so as to leave terrace remnants.

PROCEDURE FOR GRAVEL SEARCH IN A LIMITED CRITICAL AREA

The area extending approximately 50 miles eastward from Bismarck and 10 miles on each side of and paralleling present US 10 (Figure 3) was the first area designated for aerial photographic research under the new gravel search program in connection with the interstate highway system. This area lies within the eastern portion of the Missouri Plateau and is partially covered by the Altamont End Moraine Complex.

Initiation of the program began with the compilation of all data relative to the subject of sand and gravel. All of the available published geologic literature was gathered. A complete volume of the U. S. Geological Survey ground water studies pertaining to North Dakota was acquired from the U. S. Geological Survey. The Bureau of Reclamation furnished drilling reports of subsurface geology in areas sited for future governmental projects. Drilling records were obtained from private companies for areas that they had explored. Most of the relatively few soil survey studies and topographic maps for areas in North Dakota were obtained from Government agencies. Although little of the foregoing subject matter gathered pertained directly to the immediate area undergoing research, it aided most beneficially in establishing a basic operating concept. Direct assistance was received from the Division of Physical Research of the Bureau of Public Roads in formulating a narrowed more experienced approach.

A complete coverage set of aerial photos of North Dakota had been previously obtained by the North Dakota State Highway Department and was

made available for the research program. The total given project under observation east of Bismarck was divided into its respective townships and then each undertaken as an individual study. In the course of actual study and interpretation of these individual areas, both the over-all terrain and drainage patterns were given special emphasis. Within a few short weeks of full time aerial photographic study and ground operations, an exceptionally interesting geologic depositional area was discovered. The selected area lying within four miles of the proposed interstate highway site just north of Bismarck would, if aggregate material were found, be of definite economic importance to the project. The prospect was selected on the basis of a comparatively narrower stream valley at its point of intersection with the Missouri River Valley than the width of the valley farther up-stream. The narrower, more youthful mouth, suggested a possible channel change or re-routing due to some blocking agent such as

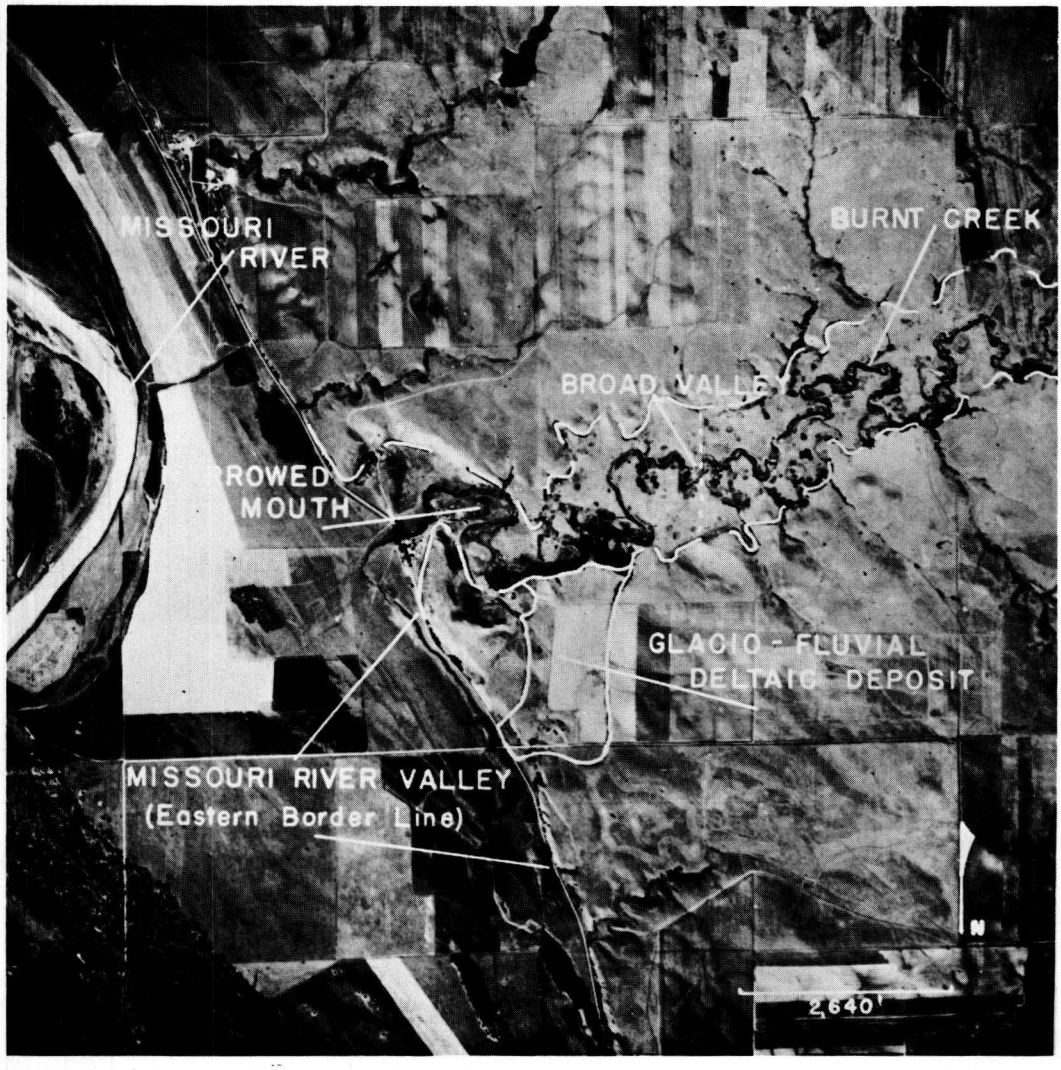


Figure 4. Aerial photograph of the Jiran Location displaying a glacio-fluvial deltaic deposit of sand and gravel.

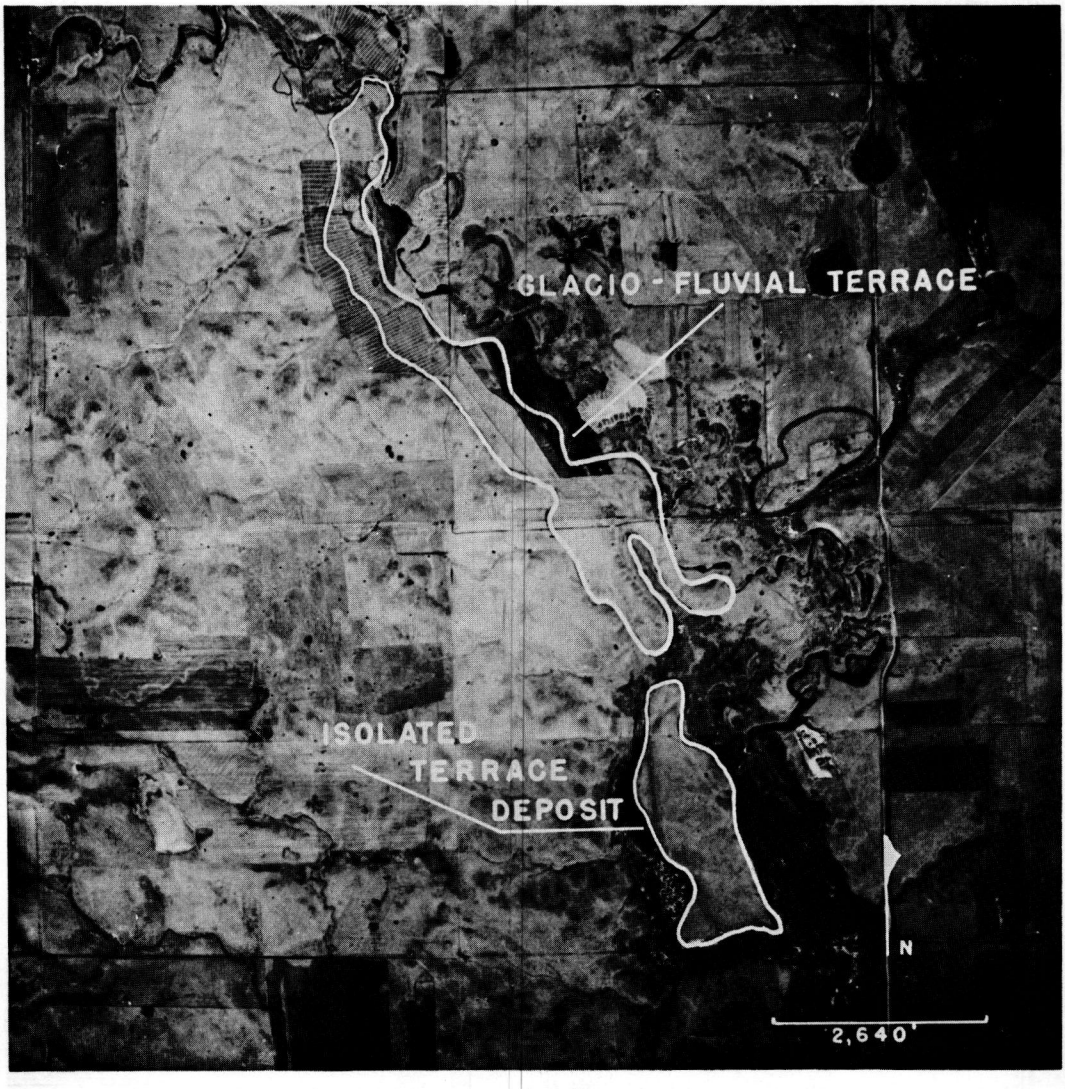


Figure 5. Aerial photograph of the McCormick Prospect displaying glacio-fluvial terrace deposits of sand and gravel.

glacial ice or sediment. Upon exploration and testing both north and south of the present mouth of Burnt Creek, a glacio-fluvial deltaic deposit of sand and gravel was located as shown in Figure 4. The Jiran Location, as this deposit is now referred to, contains 1,500,000 cu yd of sand and gravel. South of Bismarck at a distance of two miles a situation similar to the Jiran Location exists. Lying between the present channel of Apple Creek, which has a much larger watershed than Burnt Creek and the Missouri River channel, is a vast, deserted, glacio-fluvial deltaic deposit of sand and gravel. This deposit has for a number of years been under commercial and highway department production. Exploration and testing of a segment of the total depositional area on property belonging to the North Dakota Soil Conservation Service revealed an additional total of 2,600,000 cu yd of sand and gravel.

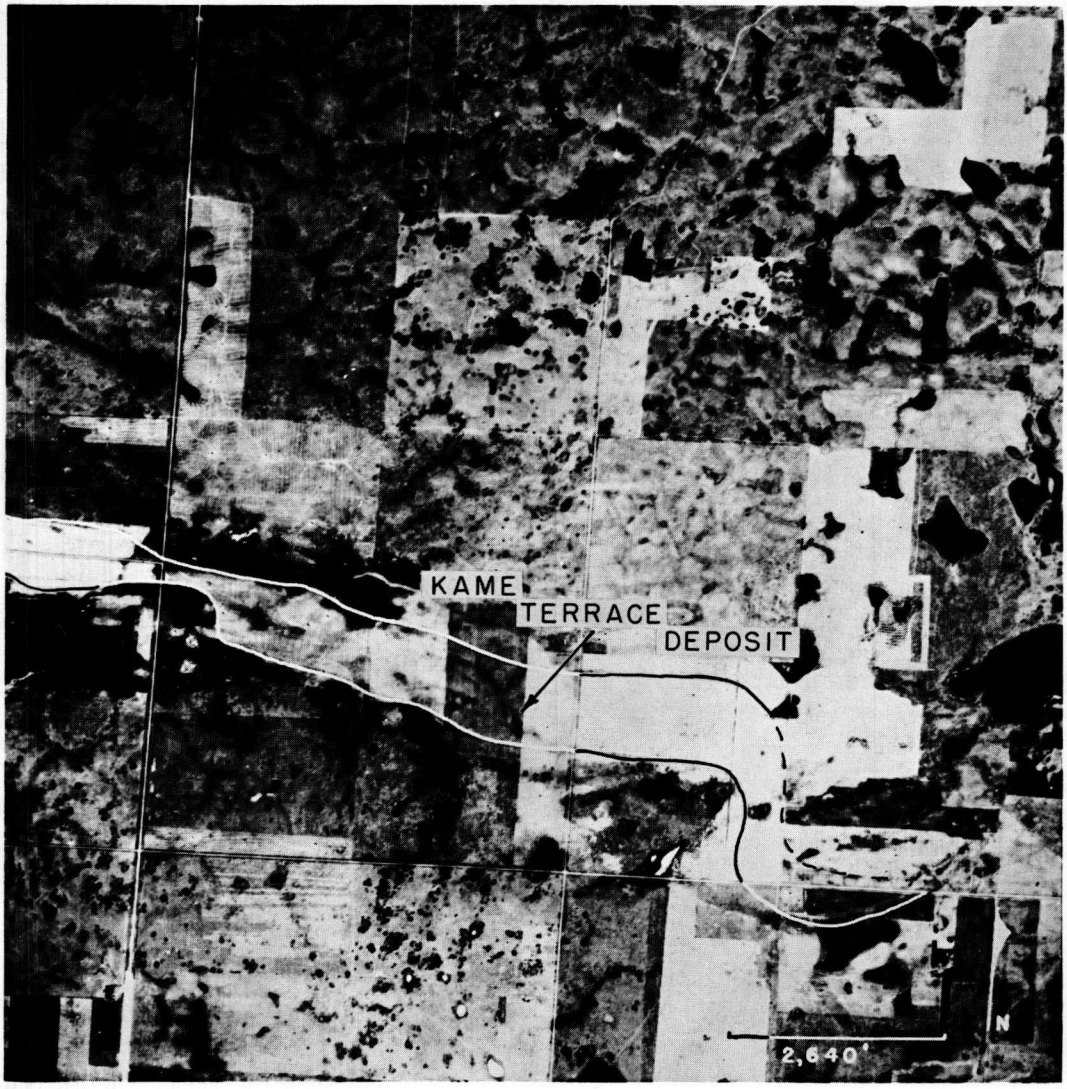


Figure 6. Aerial photograph of the Brousseau Prospect displaying a kame terrace deposit of sand and gravel.

While progressing eastward from Bismarck, special attention was given to present drainage patterns as well as to ancient glacial outwash channel markings. The areial photographs were of a most significant value in this typr of study in that sedimentational deposition points could be outlined much more clearly on the aerial photographs than could be done with months of tedious ground operations. Six glacio-fluvial terrace deposits were outlined by this procedure over the remaining extent of the project. For additional data on these aggregate locations refer to Table 1 and Figures 5 and 6.

FIELD OPERATIONS

Aerial photographs have played a key role in working out the solution to many problems in the field. Often times, reference must be made again

TABLE 1

PIT LOCATION DATA

Name	Location	Type Deposit	Estimated Quantity[1] (cu yd)	Remarks
Jiran Location	NE¼ Sec. 2 & NW¼ Sec. 1 T-139N, R-81 W	Glacio-fluvial deltaic	1,500,000	Drilled and resistivity test
Soil Conservation Location	NW¼ Sec. 15, T-138 N, R-80 W	Glacio-fluvial deltaic	2,600,000	Drilled and resistivity test
McCormicak Prospect	Sec. 25, T-140 N, R-79 W Sec's. 30, 31 & 32, T-140N, R-78W Sec. 5, T-139 N, R-78 W	Glacio-fluvial terrace	500,000	Preliminary test
Larson Location	NW¼ Sec. 33, T-140N, R-77W	Glacio-fluvial terrace	500,000	Drilled
Johnson Location	SE¼ Sec. 28, T-140N, R-77W	Glacio-fluvial terrace	700,000	Drilled
Goetz Prospect	N½ Sec. 25, T-139N, R-76 W	Glacio-fluvial terrace	350,000	Preliminary test
Brousseau Prospect	Sec's 20, 21, 22 & 27, T-140 N, R-74 W	Glacio-fluvial terrace	1,000,000	Preliminary test
Nafus Prospect	S½ Sec. 13, T-139 N, R-73 W	Glacio-fluvial terrace	100,000	Preliminary test

[1] Total quantity, 7,250,000 cu yd.

and again to the particular photos embodying prospective appearing areas in an effort to produce an exact geologic interpretation of sedimentation. The field party uses a compact assembly of aerial photographs, field chair and table, stereoscope, rule and masking tape in each site investigation.

After arriving at the field location designated on the aerial photograph, a small mobile drilling unit is positioned and a test boring made. Other probes are made to establish the location and the approximate average thickness of the deposit over the area.

At present, it is the policy of the department to test and determine the quality and quantity of a sand and gravel source by the use of a large power driven hydraulic auger but plans are for the future usage of earth resistivity equipment to assist in the field exploration. In July of 1957, the Division of Physical Research of the Bureau of Public Roads sent, at the request of the North Dakota State Highway Department, R. Woodward Moore, Head, Geophysical Explorations Section, to instruct departmental personnel in the use of such equipment. Both the Jiran Location and the Soil Conservation Location were traversed during the course of instruction. The resistivity survey was made before either of these locations had been drilled. It is interesting to note that similar quantities of sand and gravel were recorded by both procedures and that the earth resistivity method took very much less time and expense to arrive at approximately the same quantity of material as the drilling method. However, the analysis of material for quality will have to remain as a laboratory procedure.

ACKNOWLEDGMENT

This report is based on information developed in a study sponsored cooperatively by the North Dakota State Highway Department and the U. S. Bureau of Public Roads.