Use of the Kelsh Plotter in Geo-Engineering and Allied Investigations in Kansas

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• THE USEFULNESS of aerial photography for highway engineering can be fully recognized when all possible qualitative information and quantitative data are extracted for the completion of the design and construction of a proposed highway project. Repeated observations and study of the photography by qualified personnel is necessary to accomplish this end. Information obtained from the photography in meeting these objectives culminates in the form of survey notes, geological reports, materials inventories and surveys, and in other engineering reports of various types.

In a given area, different engineering organizations would require essentially the same type and amount of field information to design and construct a project. Consequently, many of the engineering field procedures are relatively standard throughout the United States and the world. There are areas, however, where differences in investigation policies are employed with a great deal of success.

In years past, the practice of obtaining detailed geological information to be used in the design, construction, and maintenance of highways has been adopted as a routine operation in Kansas. Since the establishment of the State Highway Commission's Photogrammetry Section in 1958, this operation has advanced into the photogeology field which in turn has branched out into many of the related fields of photographic interpretation. In essence, the newer fields of photogrammetry and photographic interpretation have been recognized by the Kansas Highway Commission as an essential method of investigation.

It is the purpose of this paper to present some of the procedures and techniques used in Kansas in an attempt to obtain full employment of available aerial photography and the conditions that exist to which these procedures have been adapted. The process of acquiring a variety of field data for any particular project often involves the use of the same photogrammetric techniques. It is difficult to separate the close interrelationship of the types of information. This paper has attempted to separate the general areas with the understanding that in practice they are frequently combined into one operation.

KANSAS GEOLOGY

In general, the rock formations of Kansas can be described as of sedimentary origin with a nominal amount of structure dip to the west. A generalized composite section of outcropping geological formations in Kansas would range from Mississippian cherty limestone exposed in the extreme southeast corner of the State to recent alluvial deposits found along most of the major stream valleys.

The eastern one-third of the State is made up predominantly of Pennsylvanian and Permian interbedded limestone and shale. The northeastern corner of this area is overlain by Pleistocene glacial deposits.

Progressively younger beds are encountered to the west. Cretaceous shales, sandstones, and limestones dominate the terrain of the central portion of the state. In the south portion of this area, these formations are overlain by silt and sand of Quaternary age.

The western one-third of the State is characterized by continental deposits of sand, gravel, and silt of Tertiary age capped in many areas by Pleistocene silt.

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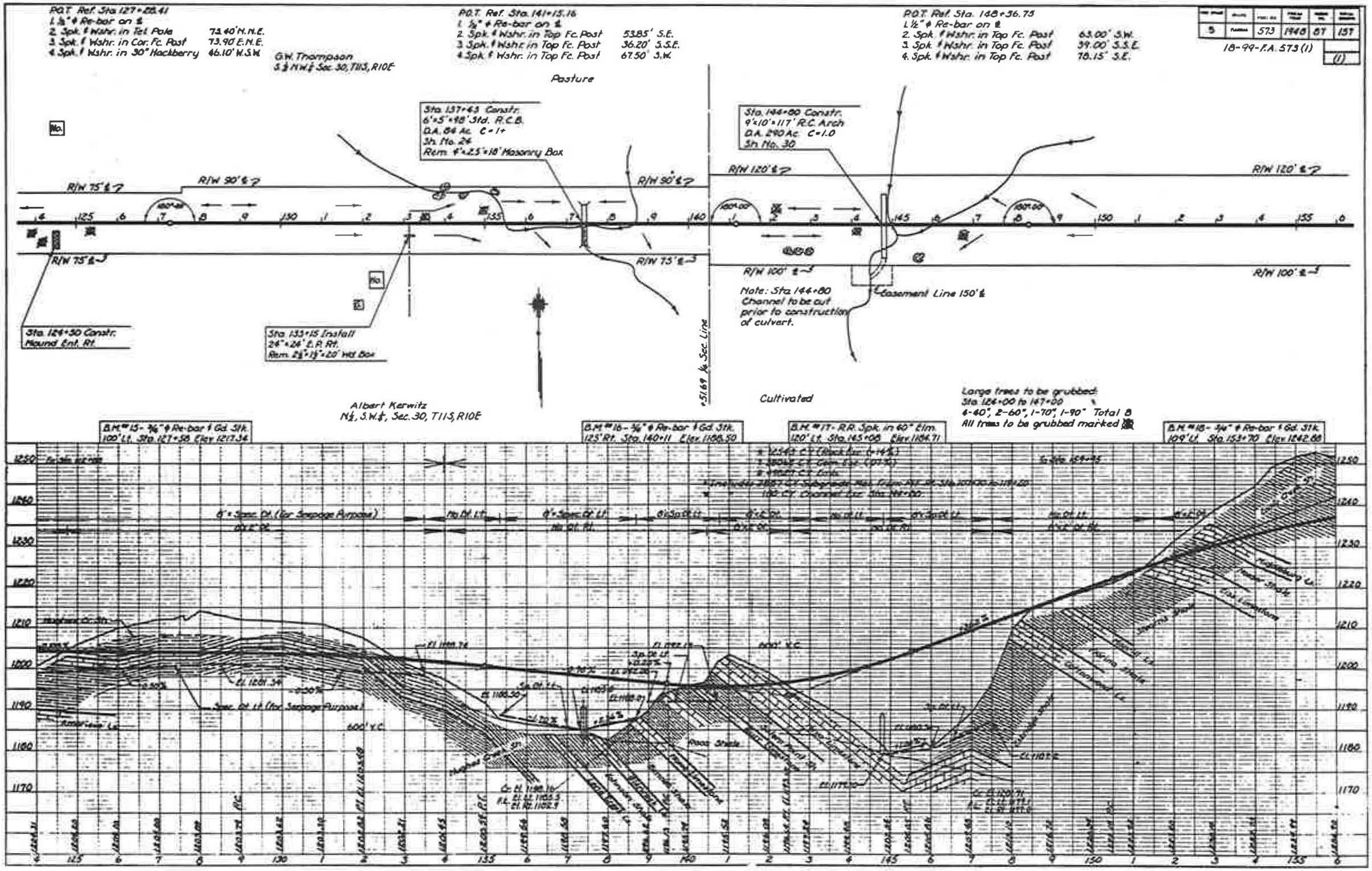
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6'×5'×48' Std. R.C.B.
D.A. 84 Ac. C=1+
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Rem. 4'×2.5'×18' Masonry Box
Sta. 144+80 Constr.
9'×10'×117' R.C. Arch
D.A. 290 Ac. C=1.0
Sh. No. 30
R/W 75' ℄
R/W 90' ℄
R/W 120' ℄
R/W 100' ℄
Note: Sta. 144+80
Channel to be cut
prior to construction
of culvert.
Easement Line 150' ℄
Sta. 124+50 Constr.
Mound Ent. Rt.
Sta. 133+15 Install
24"×24" E.P. Rt.
Rem. 2½'×1½'×20' Wd. Box
¼ Sec. Line
Cultivated
Albert Kerwitz
N½, S.W.¼, Sec. 30, T11S, R10E
Large trees to be grubbed:
Sta. 124+00 to 147+00
4-40", 2-60", 1-70", 1-90" Total 8
All trees to be grubbed marked
B.M. #15 - ¾" ϕ Re-bar ϕ Gd. Stk. 100' Lt. Sta. 127+58 Elev. 1217.34
B.M. #16 - ¾" ϕ Re-bar ϕ Gd. Stk. 125' Rt. Sta. 140+11 Elev. 1188.50
B.M. #17 - R.R. Spk. in 60" Elm 120' Lt. Sta. 145+08 Elev. 1184.71
B.M. #18 - ¾" ϕ Re-bar ϕ Gd. Stk. 109' Lt. Sta. 153+70 Elev. 1242.88
6" Spec. Dt. (for Seepage Purposes)
Spec. Dt. Lt. (for Seepage Purposes)
600' V.C.
Pooe Shale
Hughes Cr. Sh.
Americus Ls.
Stearns Shale
Eskridge Shale
Grenola Ls.
1250
1240
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1200
1190
1180
1170
125
130
135
140
145
150
155

Figure 1.

Inasmuch as the Mississippian System is represented in Kansas by only a very small area, very little photographic interpretation work has been accomplished in sediments of this age. There, a further description of these beds has been omitted.

The geological formations of Pennsylvanian age are characterized by predominantly thick interbedded limestone and shales. These beds tend to thin to the west. Most of the shales thicken southward toward the Oklahoma border and many of the limestones either wedge out or grade into shale or sandstone in this direction. Reef development has also caused local thickness variation in many of these formations. Photogrammetric and photographic interpretation techniques have been used quite successfully in rock formations of this age; however, accurate and sometimes abundant ground information is necessary to cope with the local variations that may be encountered.

The Permian formations, which with the Pennsylvanian formations comprise the eastern one-third of the State, include evenly stratified predominantly marine deposits in the lower part of the section and irregularly bedded, mainly nonmarine deposits in the upper part. In the lower portion of the section, limestone beds, many of which are distinguished by abundance of flinty chert, form persistent benches or escarpments, among which the Kansas Flint Hills are most prominent. These escarpments are readily adaptable to photogrammetric and photographic interpretation techniques. The nonmarine deposits in the upper portion of the section are too erratic and inconsistent to be mapped by these procedures. Much information, however, can be obtained concerning ground-water conditions, material deposits, etc., by photographic interpretation.

Rocks of Cretaceous age are predominantly of marine origin in the upper portion of the section and of continental origin in the lower. Soft, thin limestone of late Cretaceous age is easily discernible on aerial photographs and have been mapped by using photogrammetric techniques. Sediments of continental origin (early Cretaceous age) cannot be mapped by photogrammetric methods but much information concerning the type and extent of the deposit can be ascertained from stereoscopic examination of aerial photography.

The remainder of the surface geology of Kansas is composed of Tertiary Continental stream deposits located in the western one-third of the State. These deposits are overlain in many areas by a wide assortment of fluvial and eolian deposits of varying thickness of Quaternary age. These beds cannot be mapped on the Kelsh plotter because of their great thickness, absence of an "index" bed, and their inconsistent nature. Photographic interpretation techniques have been utilized in the detection of construction material deposits and ascertaining the aerial extent of these sediments.

USE OF GEOLOGICAL INFORMATION IN DESIGN OF KANSAS HIGHWAYS

In Kansas the geological conditions rarely dictate the location of a new alignment. These conditions must be known, however, so that the designer can formulate a successful design.

It is the job of the highway geologist to provide the designer with this information. By use of a variety of augers, core drills, and penetrometers, the highway geologist obtains all pertinent geological information and presents it in report form. The characteristics of each geological formation that will be encountered is presented in terms of stability, excavation classification, and ground-water conditions.

The geology is plotted on the centerline profile and cross-sections of the proposed project. Figures 1 and 2 show a standard highway plan and profile sheet and a corresponding set of cross-sections. The designer then has a picture of the natural conditions on which he is to design a road or structure.

One of the most important pieces of information obtained through geological survey is the quantity of rock excavation that will be encountered on a given project. This information is not only of value to the designer but to the contractors who will be bidding on the project. Not only will the contractor know the quantity of rock that will be encountered, but he will have some idea of how it can be worked. This helps the contractor to determine a more accurate and consequently lower bid. Swell and shrink factors for each formation will enable the designer to adjust the grade line for greater economy in excavation. This information is also required in determining the balances

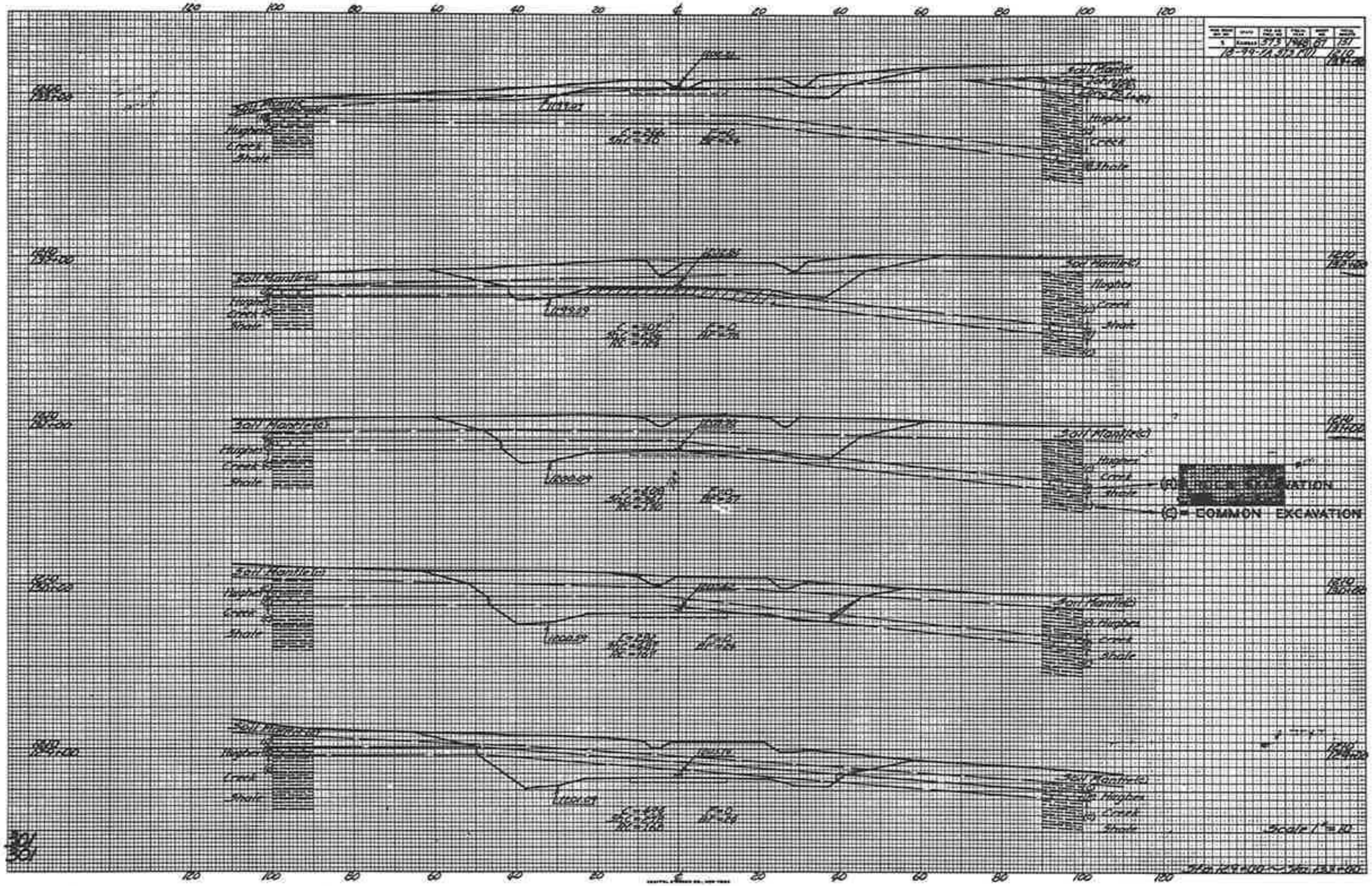


Figure 2.

between cut and fill or the necessity for borrow pits or waste areas. Where bedrock is encountered, additional excavation of the undesirable material (subgrade) will be recommended and the need for additional selected material for backfill will be specified.

If ground-water problems are encountered during the geological survey, the geologist recommends and designs underdrains to cope with the problem. The underdrain design includes the name and elevation of the aquifer, gradient of the drain, and the location and elevation of the outlet.

The stability of geological formations encountered in cut areas is presented in form of backslope gradient recommendations.

Bridge foundations studies are performed by subsurface geologists to provide information concerning depth and type of bedrock, and to recommend type and length of piles and/or types of footings. This information is used by the bridge designer to help select the most feasible bridge site, to formulate the design of the bridge, and to help estimate the cost of the structure.

Detection, prevention, and maintenance of slide areas; special ditch recommendations; channel change recommendations; and determination of sources of good construction materials are other problems that may also be worked by the highway geologist.

ADAPTABILITY OF KANSAS GEOLOGY TO KELSH PLOTTER TECHNIQUES

Because of the flat lying and consistent nature of the different geological formations, the geology of Kansas lends itself to geological field investigations. For the same reasons it lends itself to photographic interpretation and measurement and, therefore, is the key to many methods and techniques currently utilized in photo-geology investigations as used in the Kansas Highway Commission.

Both the geological field investigations and the photo-geological investigations rely on relatively consistent and discernible geology. Both methods acquire the same type of information. The field investigations are more detailed and more exhaustive in nature.

Another similarity of the two methods is the need for a geological bed or beds to correlate the geology in one area to another. The difference in the correlation procedures that the field and photo-geologist uses lies in the choice of different identifying characteristics of the correlation bed. Whereas the field geologist might use fossils, joint spacing, fresh bed color, weathered bed color, calcium content, thickness, and the relative position of the bed, the photo-geologist might use relative tone as depicted on the aerial photograph, relative position, topographic expression, joint patterns, vegetative cover, drainage pattern, and other markings that he might find peculiar to that bed.

Besides being consistent and relatively flat-lying, one of the main characteristics of Kansas geological formations which is conducive to photogrammetric measurements is that an abundance of "index" beds are available. An index bed could very well be called a correlation or reference bed that is prominent, fairly consistent, and discernible on aerial photographs. In areas adapted for this work, index beds can be located in each local area. There are some index beds that extend over a large part of the State and are subsequently described. Figures 3 and 4 show the Ft. Riley rimrock index bed in Cowley County and Geary County which are 120 miles apart.

In each area that is worked the index bed is a reference point within the geological section that is being mapped. The photo-geologist must either measure the section that will be encountered on the project in the field or obtain reliable measurements from old projects that have been worked in close proximity of the proposed project.

By having these thicknesses, the elevations of the geological formations not discernible on the aerial photograph can be accurately obtained. Subsequent to this operation, the geology can be plotted on centerline profiles and cross-sections. A figure in the Wyandotte County K-5 Report enclosed herein (Fig. 15) shows a cross-section of an area in Wyandotte County where the geology was mapped on the Kelsh plotter. If the project is over several miles long, or if the geology is inconsistent, the section may have to be measured several times along the proposed route so as to detect any lithology or thickness change in the formations.

Figure 3. Ft.Riley limestone "rimrock" index bed in Cowley County, Kans. (scale: 1:13,500).

The Kelsh plotter can be used for mapping purposes in formations in the Pennsylvanian, Permian, and Cretaceous systems. Usually several prominent index beds are located within each system.

A great deal of literature pertaining to Kansas geology has been published by the State Geological Survey of Kansas. This information combined with the data accumu-

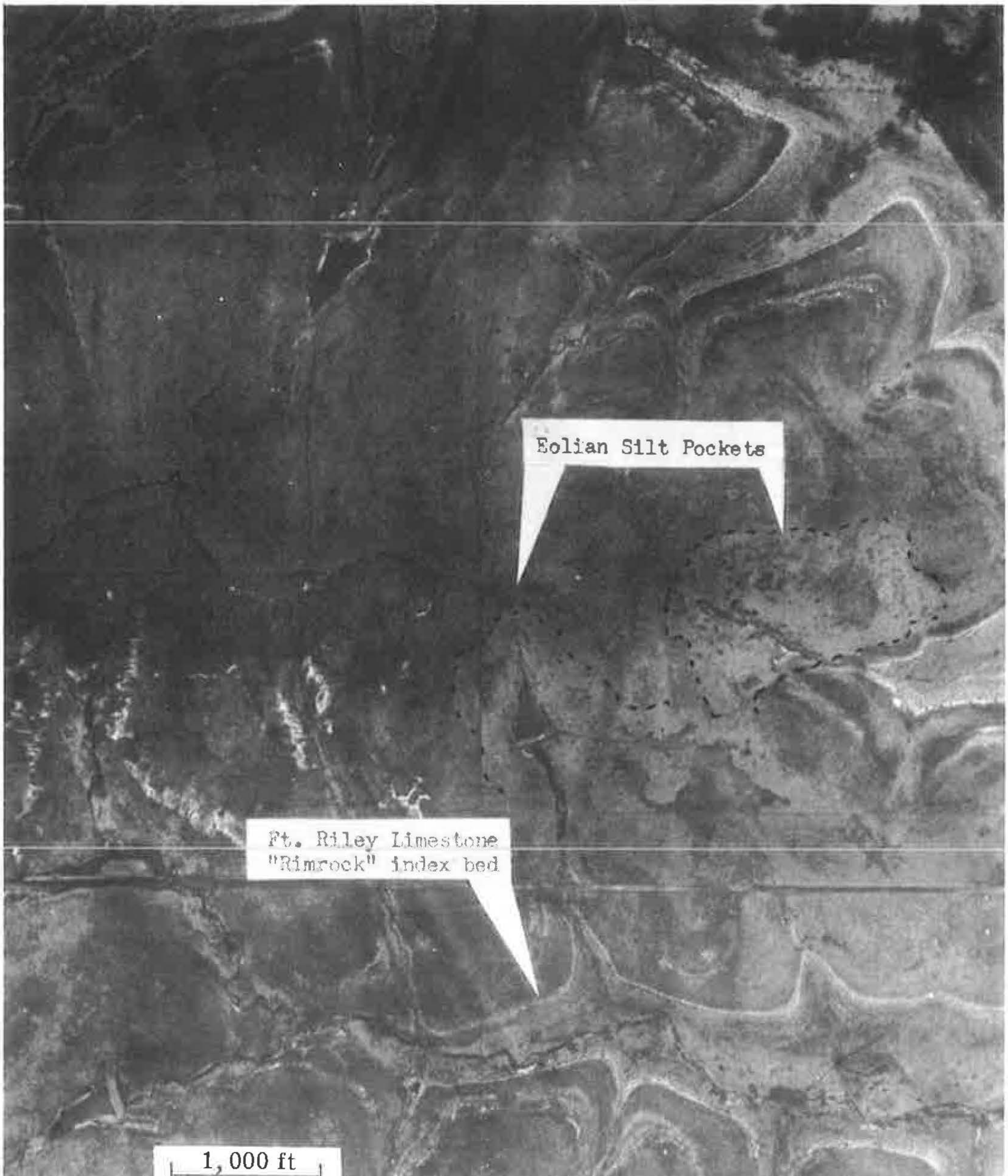


Figure 4. Ft. Riley limestone "rimrock" index bed in Geary County, Kans.; eolian silt pockets detected by gully characteristic s and tone variation (scale: 1:12,000).

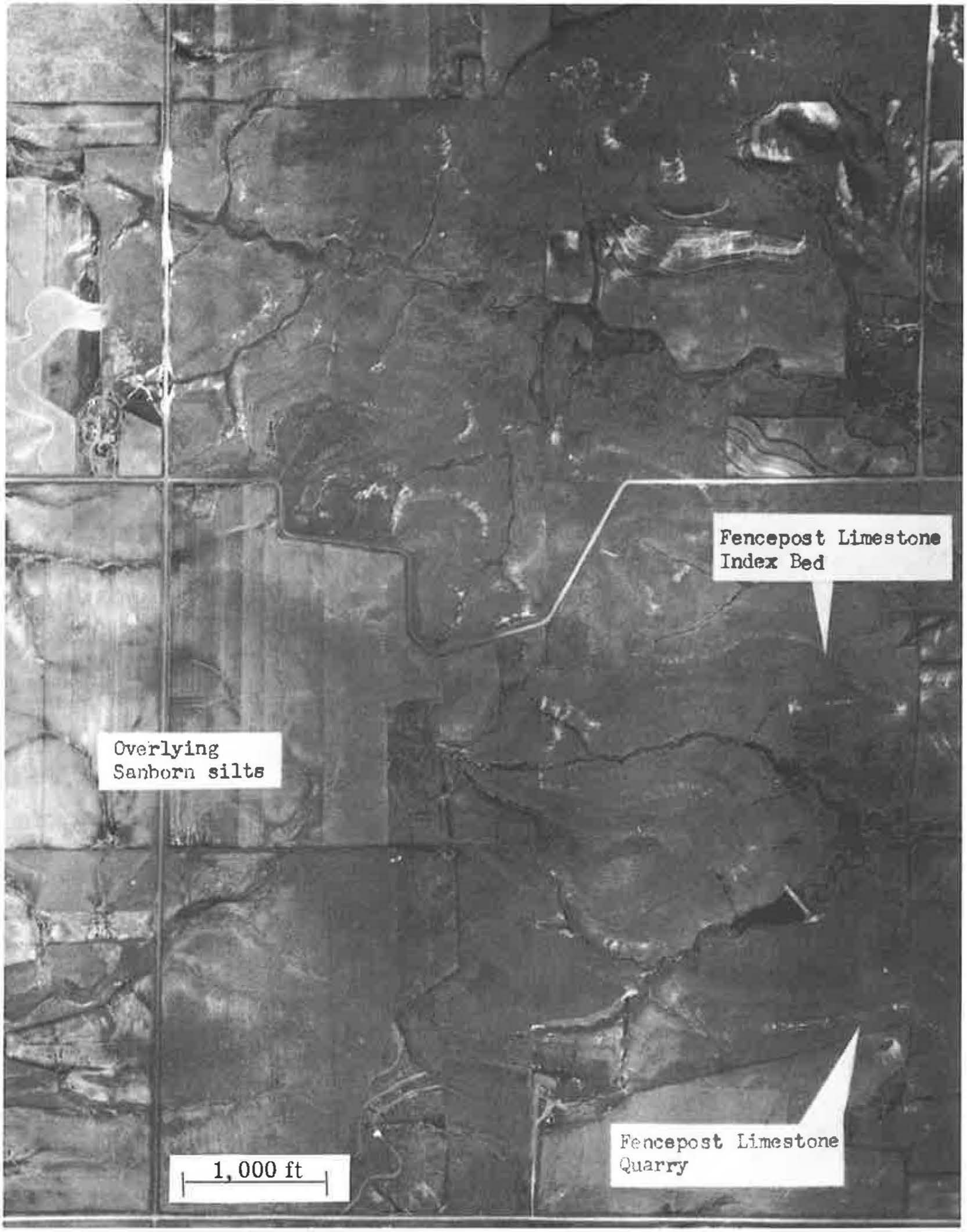


Figure 5. Fencepost limestone index bed in Lincoln County, Kans.; white band below fencepost limestone caused by band of thin chalky limestone; overlying Sanborn silts are being farmed in this area (scale: 1:12,000).

lated in the Geology Section of the Kansas Highway Commission has provided the photographic interpreter with a rich library of general and detailed information about Kansas geology. As in any other photographic interpretation activity, this "ground" information has been a tremendous aid in developing and implementing the mapping procedures currently being used.

INDEX BEDS AND TARGETS FOR GEOLOGY

An index bed can be described as a reference or correlating bed with consistent characteristics in color, thickness, and topographic expression which make it readily identifiable on aerial photography. In mapping procedures, these beds are used as a

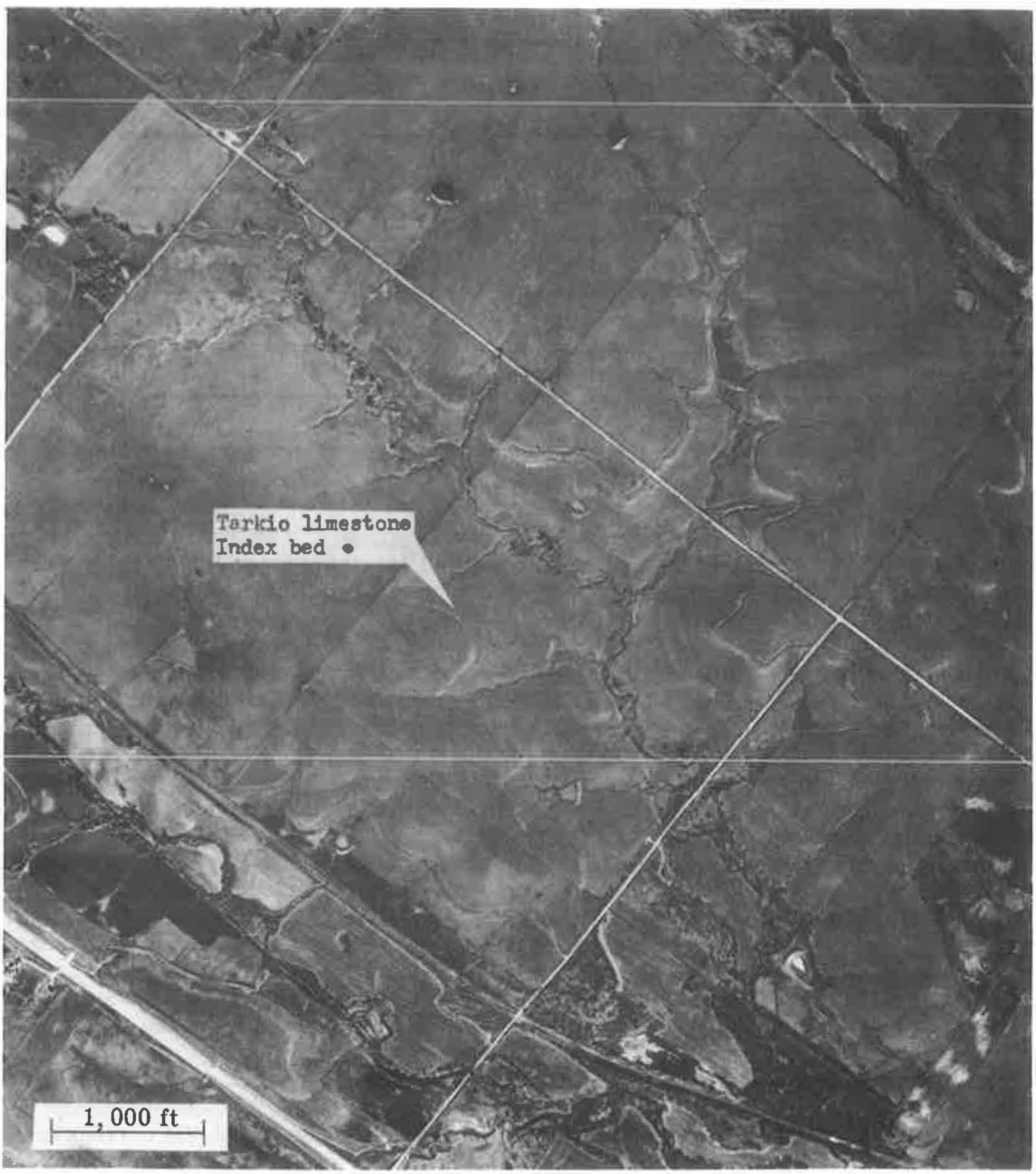
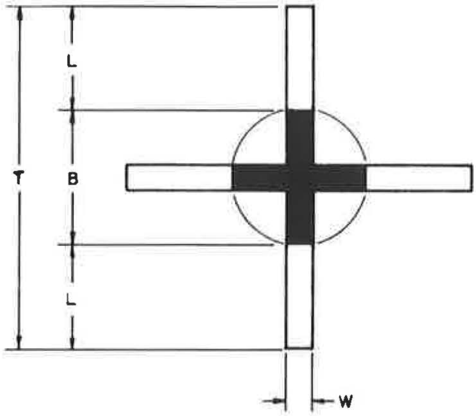


Figure 6. Tarkio limestone index bed in Jackson County, Kans. (scale: 1:12,000).



HORIZONTAL CONTROL TARGET

MINIMUM DIMENSION				
FLIGHT HEIGHT	DIMENSION T IN FEET	DIMENSION L IN FEET	DIMENSION B IN FEET	DIMENSION W IN INCHES
900	4.00	1.50	1.00	3.00
1200	5.00	2.00	1.00	4.00
1500	6.00	2.25	1.50	5.00
1800	7.00	2.50	2.00	6.00

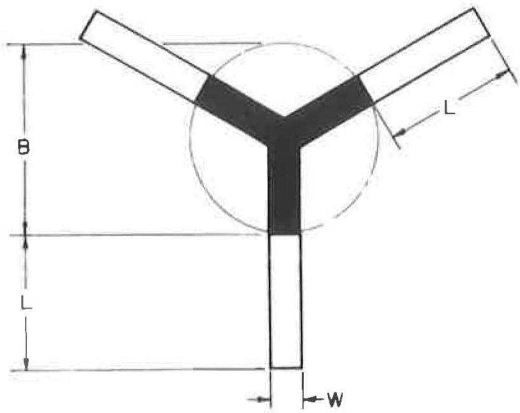
Figure 7.

"datum" from which the elevations of underlying and overlying formations are obtained by measurements on the Kelsh plotter. Some of the more prominent index beds in Kansas are subsequently described.

The fencepost limestone bed is a key index bed that is used in central Kansas. The limestone is located on top of the Pfeifer shale member, Greenhorn limestone, Colorado group, Gulfian series, Cretaceous system. Even though the thickness of this bed is approximately 0.5 to 0.8 ft, there are several features of this rock and the surrounding bedrock which identify this bed on aerial photography. Usually this bed helps to form escarpments on ledges that are typical of Greenhorn topography. A distinct vegetation change occurs at the geological contact of the fencepost limestone and surrounding bedrock which gives a banding appearance. This limestone has been quarried extensively throughout this area and the old quarry scars distinctively mark this ledge or rock. Figure 5 shows the fencepost limestone in Lincoln County, Kans.

The Ft. Riley rimrock is a very extensive bed geographically in eastern Kansas. The rimrock occurs in the lower portion of the Ft. Riley limestone member, Barneston limestone, Chase group, Wolfcampian series, Permian system. The main factor that identifies this bed on aerial photographs is its massive characteristics which make it stand out from the overlying and underlying thin bedded and relatively soft limestone. Figure 4 shows the rimrock in Geary County, Kans.

The Tarkio limestone is a prominent limestone in the upper portion of the Pennsylvanian system. This limestone belongs to the Nemaha subgroup, Wabaunsee group, Virgilian series, Pennsylvanian system. It is used as an index bed in the northeastern part of the State. This bed is relatively thick in this area and has thick overlying and underlying shales. This sequence of formations gives rise to a prominent topographic



VERTICAL CONTROL TARGET

MINIMUM DIMENSIONS			
FLIGHT HEIGHT	DIMENSION W IN INCHES	DIMENSION L IN FEET	DIMENSION B IN FEET
900	3.00	1.50	1.00
1200	4.00	2.00	1.00
1500	5.00	2.25	1.50
1800	6.00	2.50	2.00

Figure 8.

expression which can be easily discerned on aerial photography. Figure 6 shows the limestone in Jackson County, Kans.

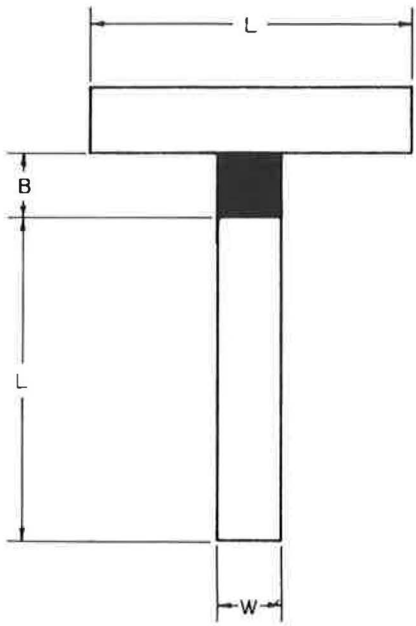
The most favorable index beds are the limestones that are underlain and overlain by thick shale formation. This is true of the three examples previously mentioned with the exception of the Ft. Riley rimrock which is located within a softer limestone formation.

Other geological formations, which are equally consistent in character and easily located on the ground but are difficult to identify on aerial photography, also cover certain large areas of the State.

During the field work which precedes the flying of photography, targets are placed to identify points of reference for the measurement of distance and elevations. If there are no index beds when these targets are laid, the geologist can also mark key geological formation to obtain adequate geological control.

Figure 7 shows the type of target used for horizontal or distance control. In Figure 8, the vertical or elevation control target is shown. The type of target used specifically for the control of geology will generally have a different shape from the horizontal or vertical control target to make them more easily identifiable. The usual shapes used in Kansas are the T, the L, the V, and the ↓. Figures 9, 10, 11, and 12 give the general dimensions of these targets.

The T-target is usually placed so that the cross-bar lies along the strike of the bed. The L-target is used in a similar manner with the shorter leg of the L running parallel



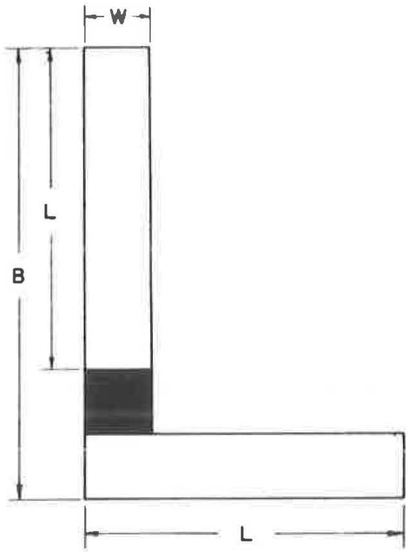
GEOLOGY T TARGET

MINIMUM DIMENSIONS			
FLIGHT HEIGHT	DIMENSION W IN INCHES	DIMENSION L IN FEET	DIMENSION B IN FEET
900	3.00	1.50	1.00
1200	4.00	2.00	1.00
1500	5.00	2.25	1.00
1800	6.00	2.50	1.00

Figure 9.

to the strike of the bed. The V- and the arrow ↓-target are placed so that the apex of the target is on the geological contact. Because the control beds being flagged are limestone formations, the targets are usually placed or tied down in the shale formation directly below or above the control bed. The main reason for this is that the shale beds provide a better medium in which to tie the target. If the targets were placed on the limestone, the light color of the limestone beds would blend with the color of the targets. Consequently, if the targets are tied in underlying shales, the arrows will be pointed upslope, the T-target will be upright, and the L and V will be inverted. The opposite will be true if the targets are tied in overlying shales.

The targets are placed intermittently along key beds. Measurements of the geological sections may be made at some target points in the field or are obtained from previous geological reports. When an index bed is covered by overburden, the depth of overburden can be determined at the target point. As each target is laid, the geological contact is noted.



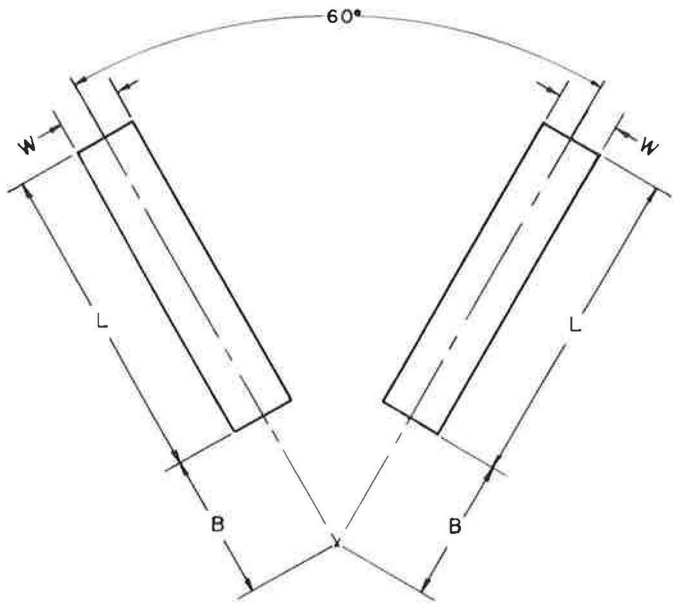
GEOLOGY L TARGET

MINIMUM DIMENSIONS			
FLIGHT HEIGHT	DIMENSION W IN INCHES	DIMENSION L IN FEET	DIMENSION B IN FEET
900	3.00	1.50	2.25
1200	4.00	2.00	3.33
1500	5.00	2.25	3.66
1800	6.00	2.50	4.00

Figure 10.

Many times photogrammetric pass points or points of elevation may be selected to coincide with field geology control points and thus serve two purposes. When this occurs, the normal elevation target is used and a note is made to indicate this point as a geological reference. By sending the geologist to the field with the field control survey crew, much field work can be coordinated and the additional geological control points then require little additional field work.

The use of several types of targets has the distinct advantage of pin-pointing several index horizons in any specific area. The symbol of the target becomes a key for the photographic interpreter and the Kelsh plotter operator as the various horizons are studied and plotted. To illustrate the use of the various targets, a series of geological horizons were located and marked. The area was then photographed. A sample of the photography is shown in Figure 13. This photography can now be used to determine the elevations and local structure of the geology and to determine the effect of the geology as related to the construction, and in this case, maintenance of the existing facility. The lower portion of Figure 13 is a geological column of the same forma-



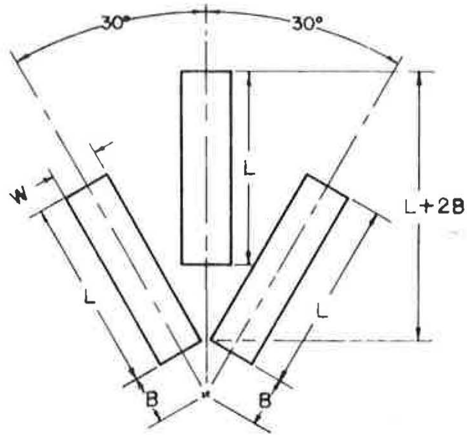
GEOLOGY V TARGET

MINIMUM DIMENSIONS			
FLIGHT HEIGHT	DIMENSION W IN INCHES	DIMENSION L IN FEET	DIMENSION B IN FEET
900	3.00	1.50	1.00
1200	4.00	2.00	1.00
1500	5.00	2.25	1.00
1800	6.00	2.50	1.00

Figure 11.

tion. With this information, the correlation and the characteristics of the various horizons are generally known.

With the use of targets and index beds, geological structural contour maps and geological profiles and cross-sections can be produced with a great deal of accuracy. The field targets produce permanent reference markings on the photography for the photographic interpreter. The inherent characteristics of key beds and the field markings of these and allied beds result in good control and assist in the production of final maps which give not only the topography, contours, and land use but also the geological structural contour map, possible material sources, problem areas caused by ground water, seepage zones, and slide areas, and some indication of the quantity of rock and shale which could be encountered in the area.



GEOLOGY V ARROW TARGET

MINIMUM DIMENSIONS			
FLIGHT HEIGHT	DIMENSION W IN INCHES	DIMENSION L IN FEET	DIMENSION B IN FEET
900	3.00	1.50	1.00
1200	4.00	2.00	1.00
1500	5.00	2.25	1.00
1800	6.00	2.50	1.00

Figure 12.

GEO-ENGINEERING PROBLEMS AND USE OF PHOTOGRAPHIC INTERPRETATION AND KELSH PLOTTER

The use of the Kelsh plotter, photographic interpretation, and field investigations can be applied to a variety of engineering problems. Usually each investigation will not be restricted to one problem, but will extract pertinent information concerning any situation or condition that may exist. With each problem, however, changes in the methods of attack, procedures, and form of report are usually made to fit the needs and to improve the methods. To indicate best some of the procedures used, certain typical examples of the uses made in Kansas of these tools are given.

Feasibility Reports and/or Route Selection

Using small-scale photography, the possible locations of proposed highway improvements are made. This photography is then studied in detail to determine all important information possible to select the proper route or alternatives. After a proposed route or routes have been selected, the centerline of the route is located on the ground. Field crews, besides making initial line measurements, determining property ownership, locating and tying section or property corners, sizing and determining existing structure features, sizing and counting trees and allied functions, also target the line and photogrammetric pass points. Working with the survey crew, a geologist places

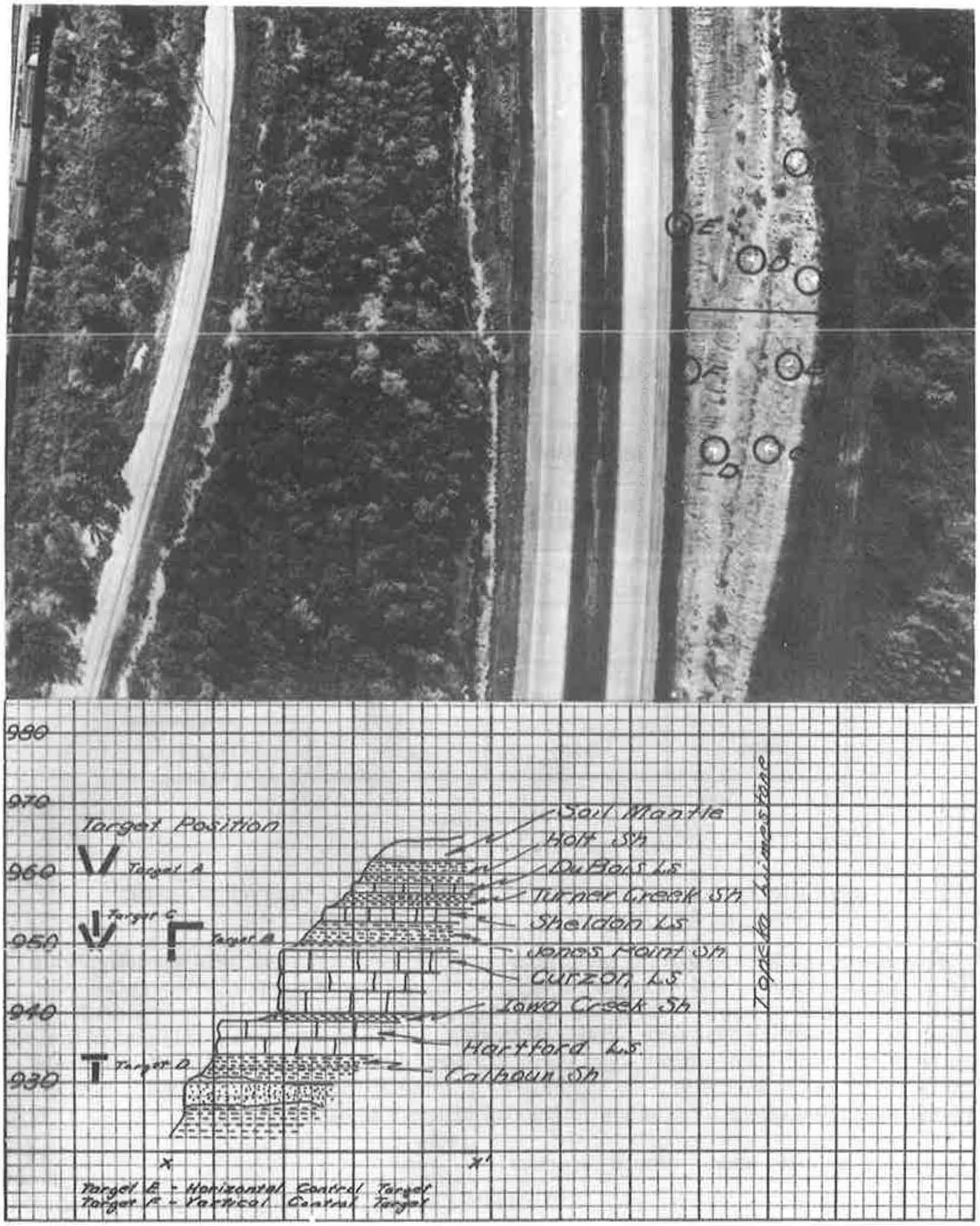


Figure 13. Geology targets on backslope of Highway 24 in Shawnee County, Kans.; lower geological column depicts formations present and corresponding targets.

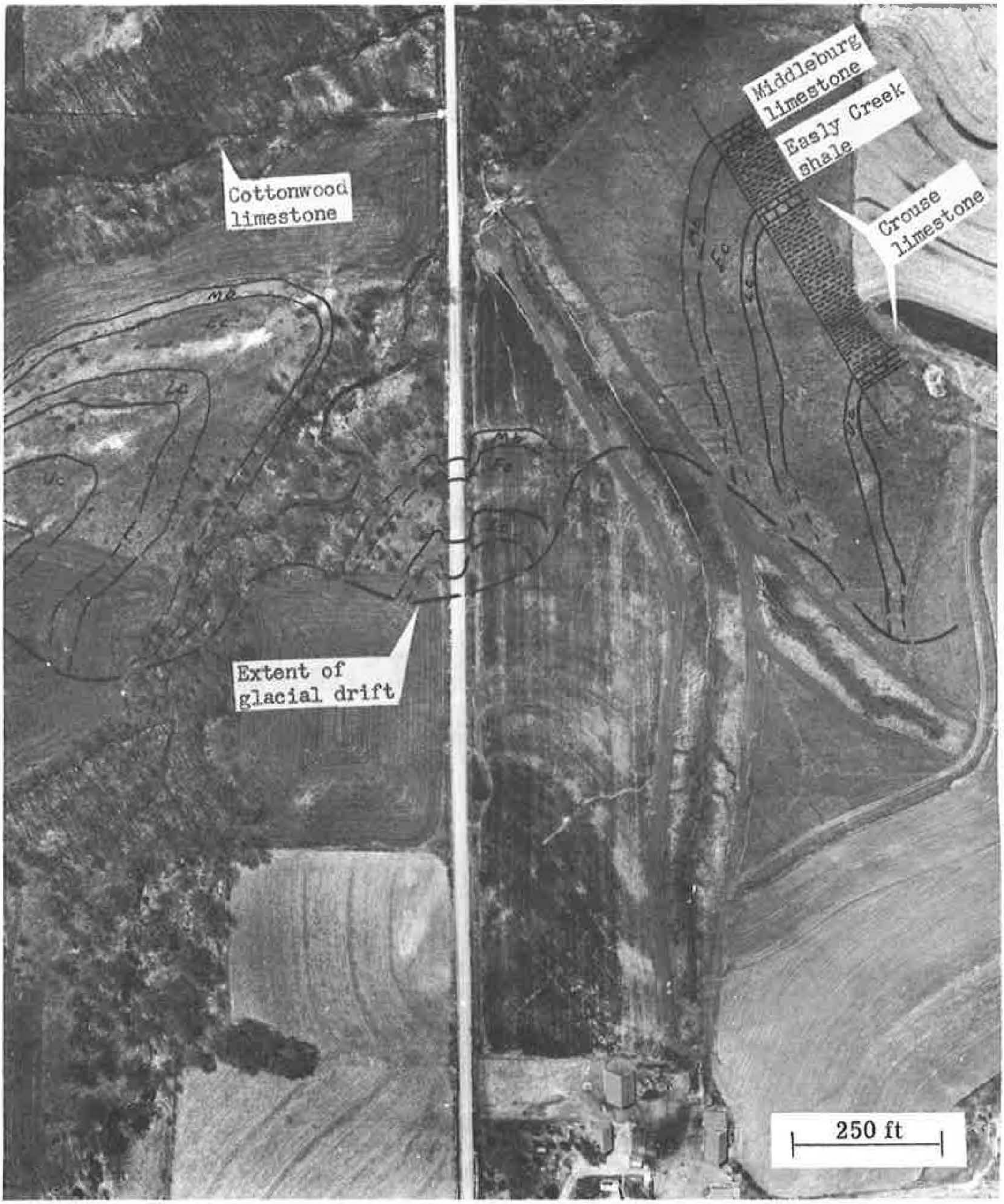


Figure 14. Interbedded limestone and shale capped by glacial drift in Brown County, Kans.; approximate boundary shown was located by use of topographic expression, land use, gully configuration, and tone variation; shows anularity of gully where bedrock is encountered; limestone formations denoted (scale: 1:3,000).

targets on selected geological horizons and usable index beds. If a project is surveyed by normal field survey methods, the areas which, from the initial study, seem to be possible sources of problems are specifically marked by the geologist. The route is then flown and photographed. This photography is used to determine one or more of the following items:

1. Rock and common quantities (estimate).
2. Ground-water conditions and problems.
3. Rights-of-way real estate requirements.
4. Unstable areas.

In April of 1962, a highway improvement was proposed for a portion of North Kansas City, Kans., in Wyandotte County. Route alternatives were selected. One alternative, the longest route, was located to the south of the Wyandotte County Lake and the other was placed north of the lake between the dam site forming the lake and an existing railroad. There was some doubt as to the feasibility of placing a roadway in the latter location and a special investigation was requested.

Existing photography was studied to plan the most feasible and economical way of conducting the investigation. Because of the extreme conditions of the area, it was decided to make the investigation using photogrammetric measurements and photographic interpretation analysis.

The area was characterized by interbedded Pennsylvanian limestones and shales capped with Pleistocene loess. The relief of the area can be described as severe with a 200-ft vertical change in elevation in 600 ft of horizontal distance. Trees, brush, and undergrowth was extremely heavy. The most crucial problems existed in the area around the Wyandotte County Lake.

It was decided to target the area around the dam using vertical control and geology control targets. The photo-geologist accompanied the survey crew in the field and laid all geology targets. A contour map was prepared and geological cross-sections were plotted from elevations and distances measured with the Kelsh plotter. This work and the findings of the investigation were presented to the Special Assignment Engineer in the report contained in Appendix A. This report serves as an example of a typical report presenting information obtained through photographic interpretation and photogrammetric procedures as used in Kansas.

In May 1961, a project was proposed to improve a county road between the small cities of Morrill and Sabetha, Kans., located in Brown County in the northeastern portion of the State. Two alignments were selected and choice of route was based in part on the geo-engineering aspect of each line. The Photogrammetry Section was assigned the problem of providing profiles of each alignment and a preliminary geo-engineering survey.

The geology of the area can be described as interbedded Permian limestone and shales capped in many locals be glacial drift of Pleistocene age. The topography of the area can be described for the most part as hilly.

Targets were laid by the Photogrammetry Section personnel for both alignments. No geology targets were laid because of the existence of identifiable and discernible geology. The photo-geologist spent one day in the field to familiarize himself with ground conditions.

Profiles were plotted for both alignments with measurements taken from the Kelsh plotter. Elevations were taken on selected geological formations. The thickness of the various geological formations were taken from a previous project that was worked in the area. A great deal of interpretation was required to ascertain the bedrock-glacial drift contact. Figure 14 shows bedrock capped with glacial drift along one of the proposed alignments. The geology of each alignment was plotted on the respective profiles. Seep areas were noted and stationed to the centerline. Figure 15 shows a seep area in glacial drift which traverses the proposed centerline.

After all of the interpretation and plotter work was accomplished, a preliminary geo-engineering report was presented to the location engineer. An abridged edition of the actual report pertaining to this problem is presented in Appendix B.

Figure 15. Seep area in glacial drift in Brown County, Kans.; an indication of sand and gravel deposit that may require special attention during field investigation (scale: 1:1,500).

During the early stages of planning Interstate 435 in Kansas City, Johnson County, Kans., the Geology Section of the Kansas Highway Commission was requested to provide information pertaining to the amount of right-of-way that would be required on the preceding project. This information is usually presented after the routine geological field investigation is completed. This type of information would provide the type of

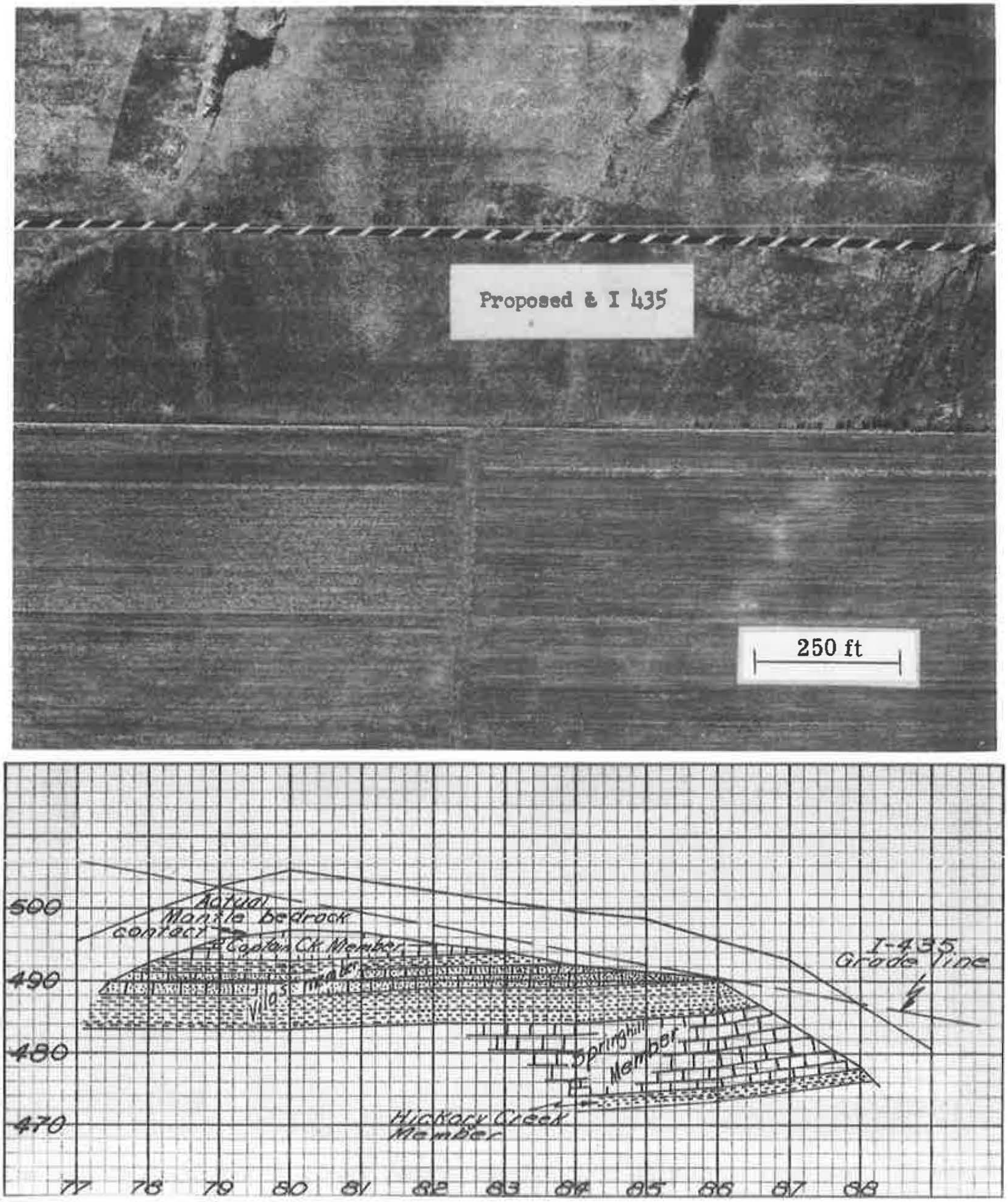


Figure 16. Interstate 435 proposed centerline and profile depicting existing geology and gradeline; photographic analysis indicated only common excavation would be encountered in cut.

material that would be encountered and recommendations as to backslope gradients. This in turn would provide the right-of-way engineer with the width of right-of-way that would be required.

Because this information was requested in advance of the routine field investigation, a photo-geologist was requested to obtain this information through photographic interpretation procedures.

The area was characterized by interbedded limestones and shales capped with a varying thickness of transported material. The proposed alignment traverses open fields, wooded areas, and suburban housing developments.

The centerline of the proposed project was plotted on existing photography. Photography with a scale of 1:3, 000 and 1:12, 000 was used for interpretation purposes. Topographic expression, gully analysis, land use, photographic tone, and knowledge of the local area were used to complete the investigation. Figure 16 shows a portion of the centerline on an aerial photograph. The material was predicted to only a depth that would cover the gradeline elevation. The lower portion of Figure 16 shows the results of the investigation and the actual geological profile as plotted from the subsequent geological field investigation.

SLIDE AREA INVESTIGATIONS

From the study of small-scale photography and from a knowledge of the characteristics of certain geological formations and the ground-water conditions, slide areas or the possibility of slide areas can be ascertained. Prevailing conditions may keep certain forces in equilibrium and slides may not exist in some areas while these same areas may be subjected to slides when large cuts are developed through certain geological horizons. When slides are apparent or when conditions exist that indicate possible slide problems, the areas are further studied from lower controlled photography.

Slides have also developed along existing construction. These areas have also been assigned for study by photogrammetry and photographic interpretation using the Kelsh plotter for the maintenance studies needed for the stabilization of such areas. The methods of control, the factors of detection and maintenance, and the use of Kelsh measurements are best discussed by the following examples.

Detection of Slides

In the spring of 1959 the preliminary field data for Interstate 70 west of Salina, Kans., was being collected. During this process the final alignment of the proposed project was being made in Ellsworth County, Kans. Once the alignment had been established, the geology field crews began their investigations. Several severe slides were encountered in the early part of their investigations.

The geology of the area consisted of Cretaceous chalky limestone and shales underlain by Graneros shale, an unctuous clayey shale that has a high percentage of montmorillonite. The Graneros shale is underlain by the Dakota formation. The fencepost limestone index bed mentioned previously capped most of the ridges and was used extensively throughout the investigation as a reference bed. Most of the slides occurred in the Graneros shale. When this formation forms the steep sided canyons and escarpments, numerous slides occur as the result of gravity and ground-water action. A few slides also occur in the underlying Dakota formation.

To get a complete picture of the relationship of the proposed centerline and slide areas in this area, aerial photographs were used to detect and map all slides, establish the centerline proximity to these slides and map the geological formation in which the slides were occurring.

Topographic expression, photographic tone, and a knowledge of the geology of the area were used to complete the photographic interpretation investigation.

The result of this investigation is shown in Figure 17 which depicts a portion of the realignment which subsequently took place. Figure 18 is a stereogram of a portion of the area that was investigated. The new alignment which was selected on the basis of these findings avoided the more severe areas and in most cases approached the Graneros shale escarpment at right angles to avoid any slide slope situations.

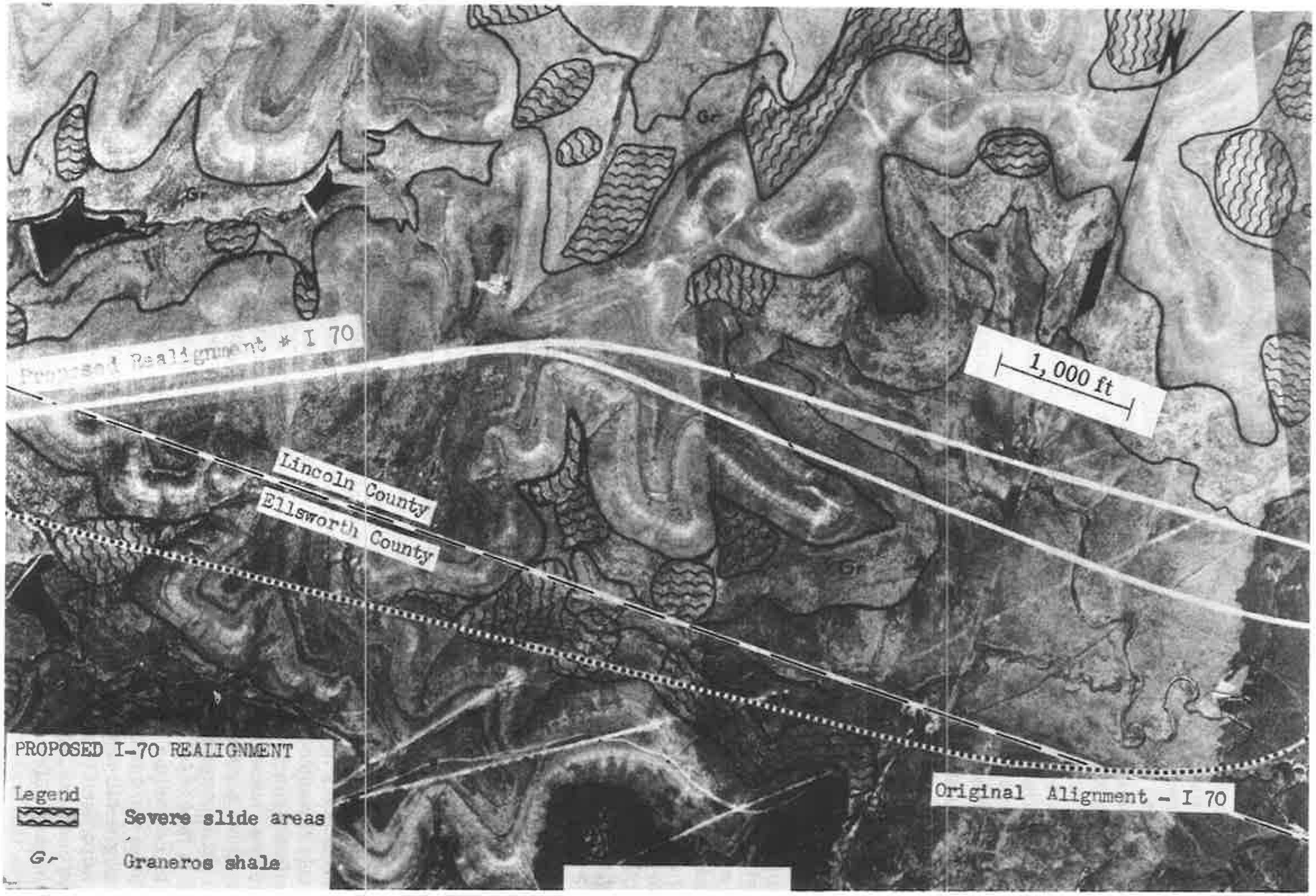

Proposed Realignment # I 70
1,000 ft
Gr
Lincoln County
Ellsworth County
Original Alignment - I 70
PROPOSED I-70 REALIGNMENT
Legend
Severe slide areas
Gr
Graneros shale

Figure 17.

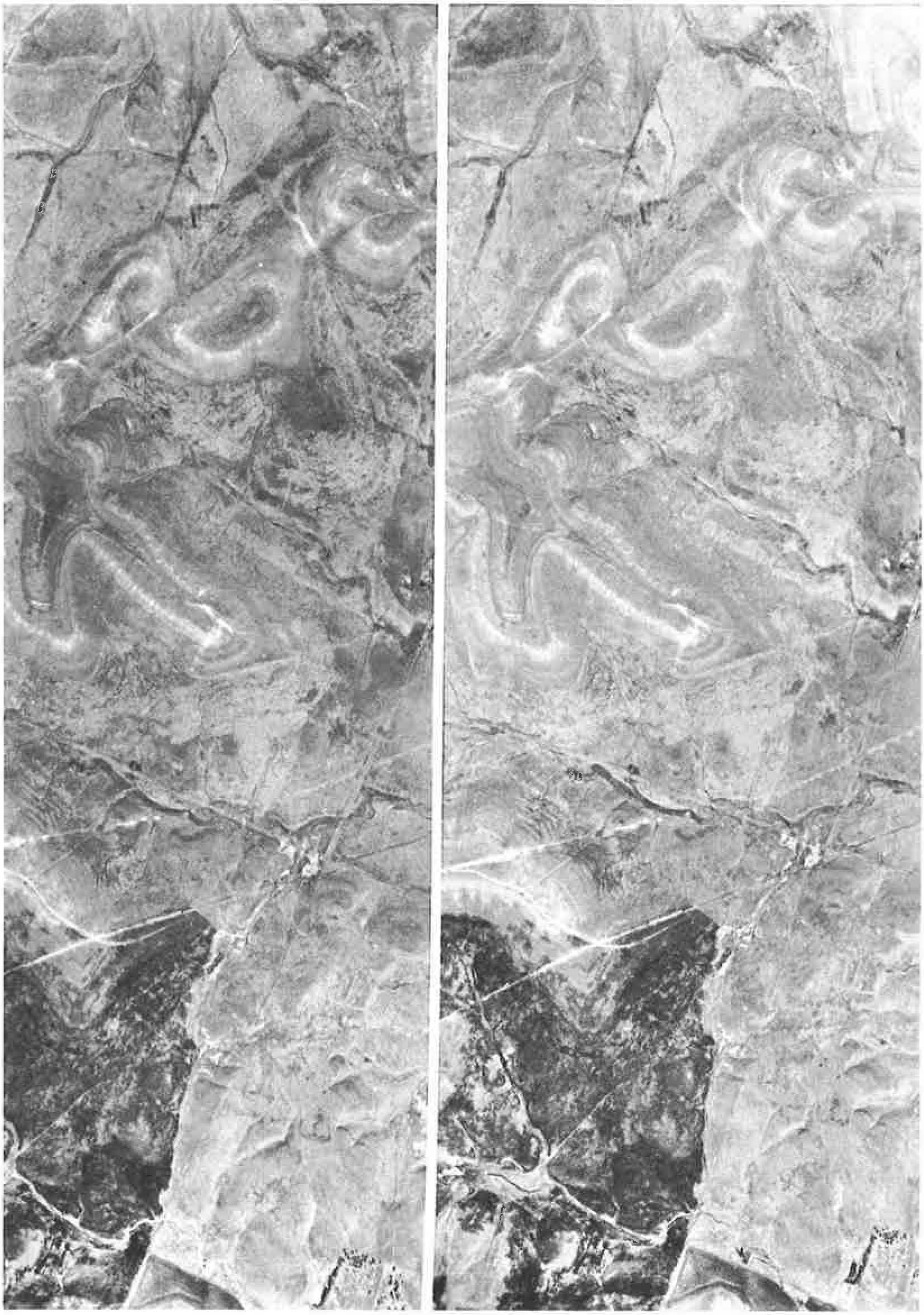


Figure 18. Stereogram of Greenhorn limestone and Graneros shale in Ellsworth County, Kans.; shows many slides that occur in the Graneros shale.

Slide Analysis

In July 1960, a slide occurred next to the Cedar Bluff Reservoir dam on State Highway 147 in Trego County, Kans. The Geology Section was requested by the Maintenance Department to investigate the slide and to provide information concerning the cause and to make recommendations as to the prevention of further slides in the area.

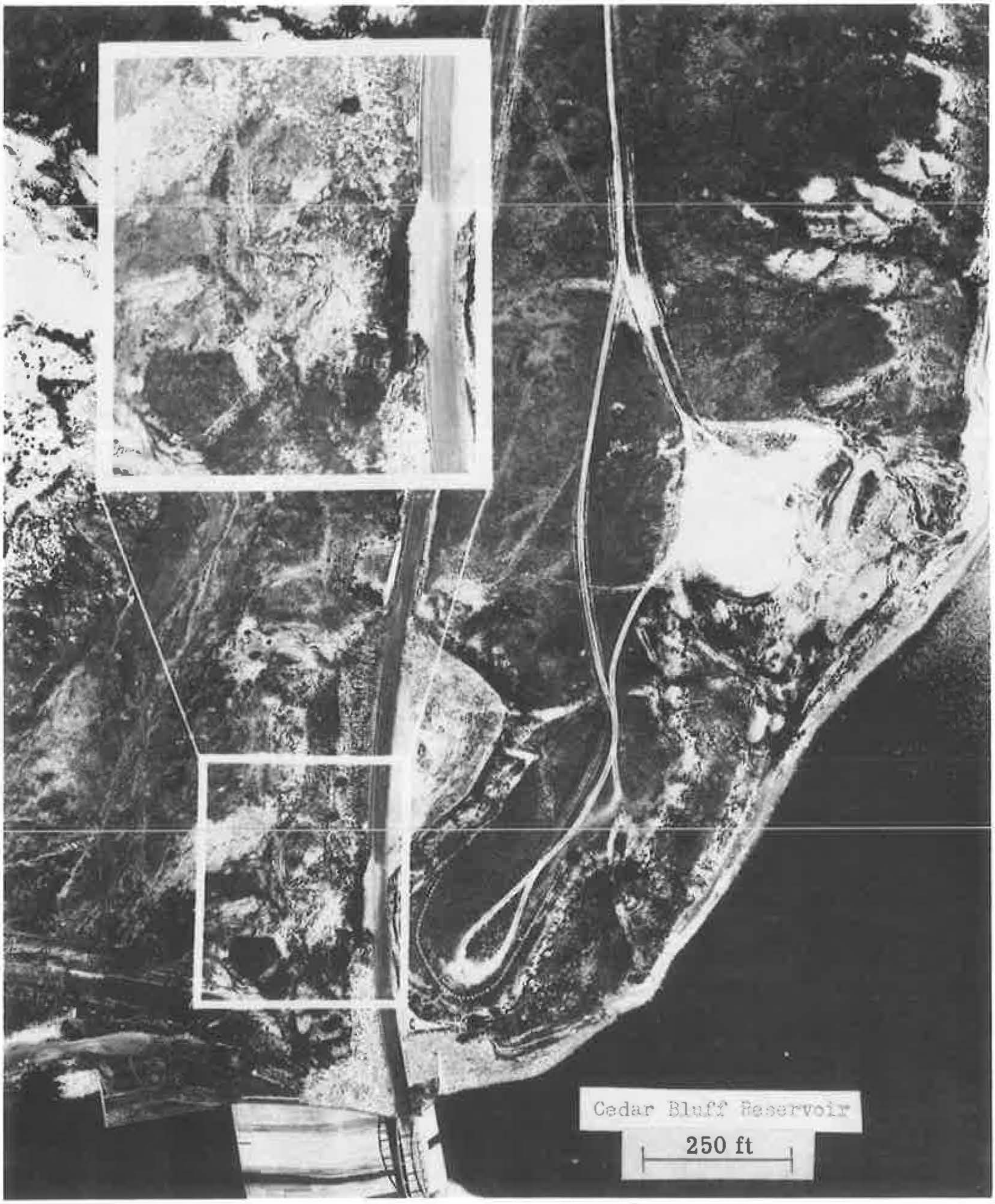
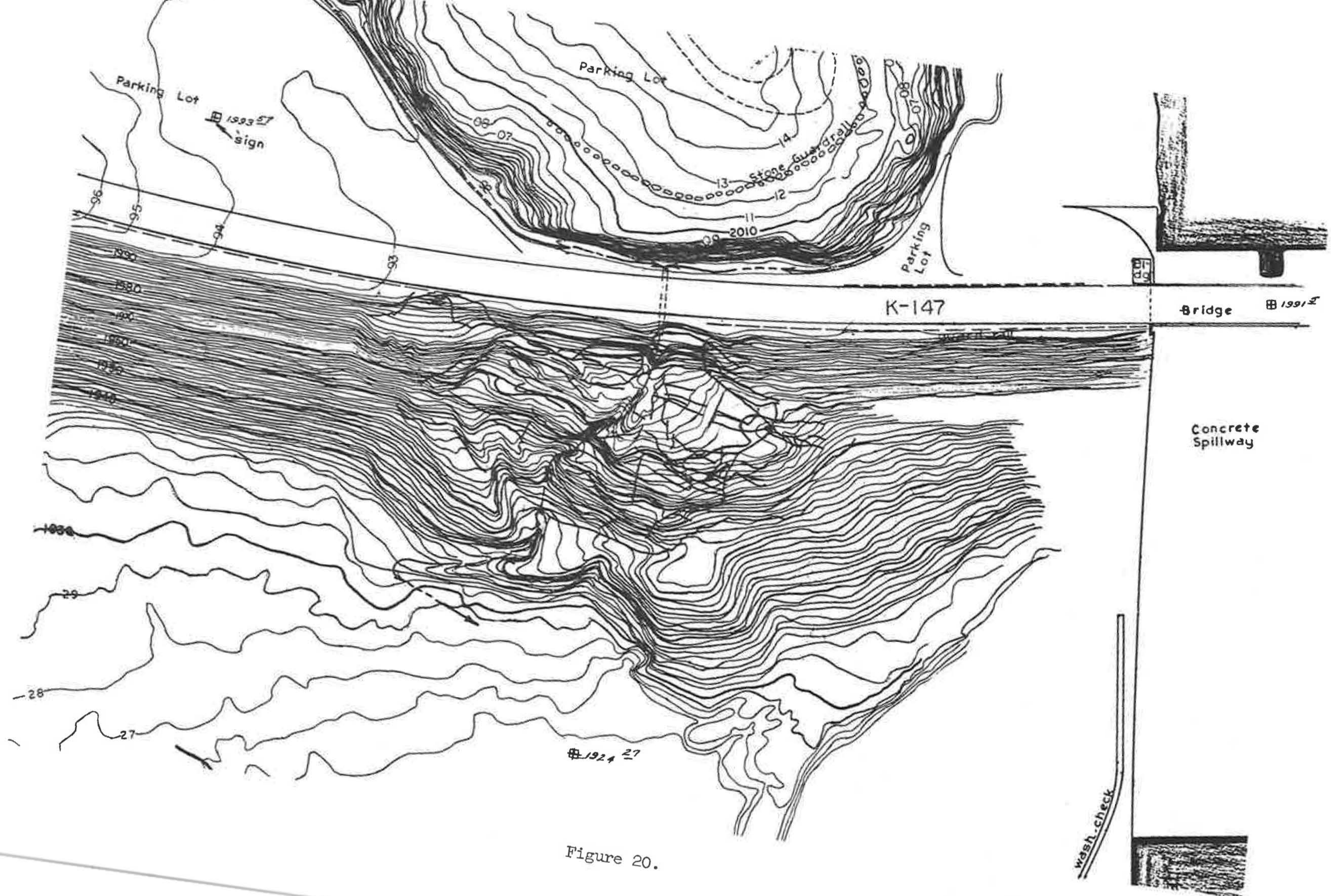


Figure 19. Cedar Bluff Reservoir in Trego County, Kans.; shows road slide on Kans. 147 (scale: 1:3,000).



Parking Lot
1993
sign
Parking Lot
Stone Guardrail
2010
Parking Lot
K-147
Bridge
1991
Concrete Spillway
1990
1980
1950
1940
29
28
27
1924
wash check

Figure 20.

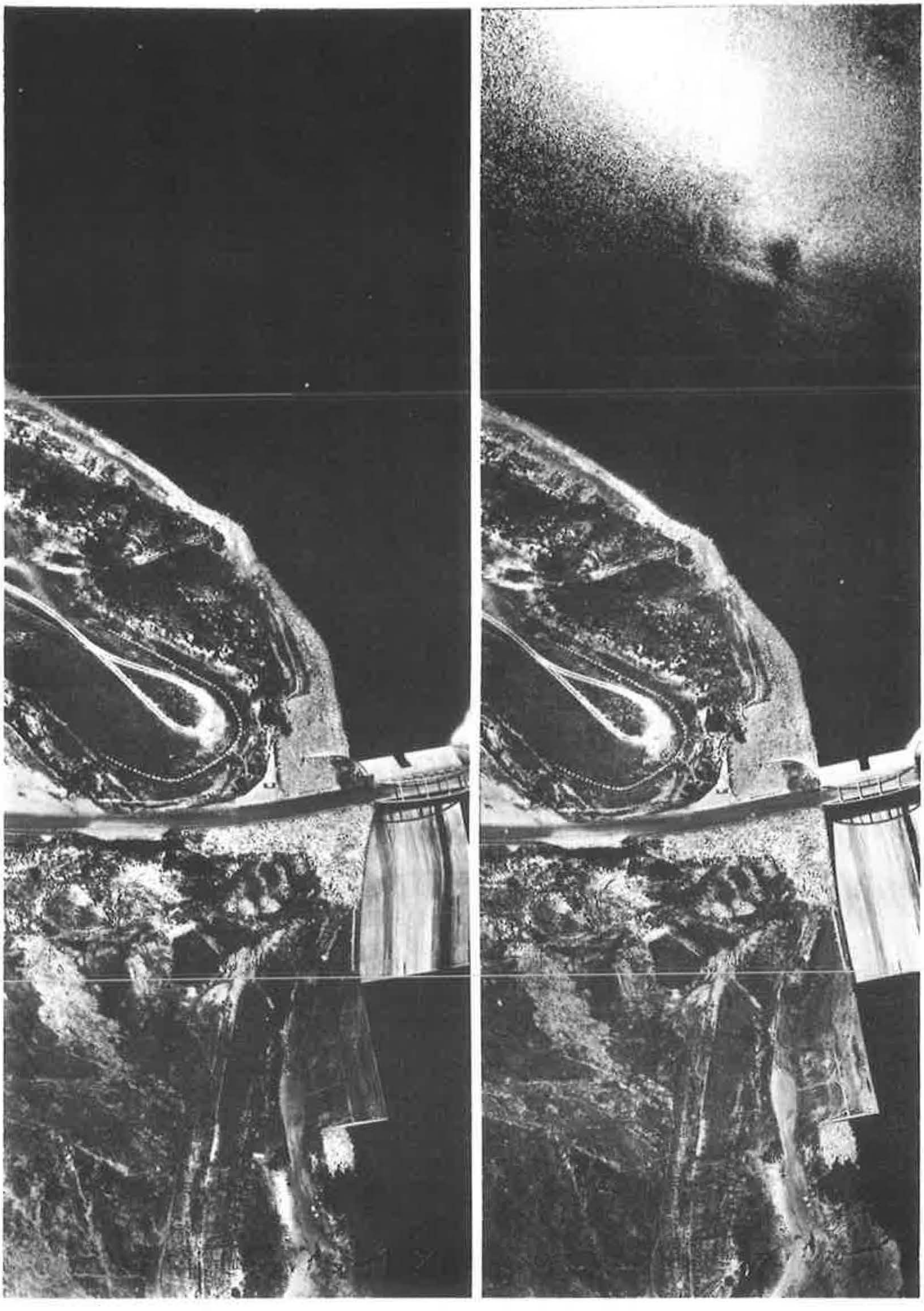


Figure 21. Stereogram of slide area along Kans. 147 in Trego County; contour map of this area produced on Kelsh plotter depicting location and elevations of slide planes.

The first step in such an investigation is the compilation of a contour map of the slide. This is normally compiled in the field.

At the request of the chief geologist, the Photogrammetry Section for the first time produced a contour map of a slide area.

Photo-control points were selected on existing photography and sufficient control obtained. No geology was mapped because the slide took place in one formation.

A photo-geologist and plotter operator mapped not only the slide area, but much of the surrounding area. This proved to be of great value in the final analysis because the amount of runoff of the immediate drainage area was the key to the cause of the slide. All slide planes were detected and mapped and other potential slides in the immediate area were indicated. Figure 19 is an aerial photograph of the area mapped and Figure 20 shows a portion of the contour map produced from this endeavor. Figure 21 is a stereogram of the slide area. This work was accomplished in one-fourth the time that would be required for a field crew and produced a map of larger scale which covered four times the area normally obtained through field investigations.

This information was presented to the chief geologist for further analysis.

HYDRAULIC AND HYDROGRAPHIC INVESTIGATIONS

Problems involving hydraulic and hydrographic principles occur in most any area where rainfall exists. These problems may be a part of other investigations or may be considered as the principal problem for which a solution is sought. The procedures here again vary with the problem, but measurements made with the Kelsh plotter coupled with photographic interpretation has resulted in the collection of data that allowed the solution to many hydraulic and hydrographic problems. Several specific examples again will show the use of the photogrammetric tools in the solutions of such problems as overflow problems, stream meander and erosion, silting, and drainage areas.

In the spring of 1962, the assistant bridge engineer of the Kansas Highway Commission assigned the problem of analyzing the cause and the extent of stream degradation on Turkey Creek at the crossing of State Highway 32 in Wyandotte County, Kans. In the early fall of 1961, this stream had scoured to such a point that the highway bridge had been undermined and the subsequent collapse of the structure resulted. Further sloughing of the stream banks occurred upstream adjacent to farmland after the structure collapsed. Many of the local residents felt that the Kansas Highway Commission was at fault and was liable for the loss of the farmland. This investigation was requested to determine the reasons for such stream action.

Five sets of aerial photographs dated 1941, 1954, 1959, 1961, and 1962 were used to study the stream activities for the past 21 years. The Wyandotte County Turkey Creek report depicts the stream configuration for each of these years. Figure 22 shows the highway structure condition immediately after the collapse. Appendix C gives an abridged edition of the report presented to the Bridge Section.

In the summer of 1962, a new alignment was being proposed for State Highway 32 near Bonner Springs, Wyandotte County, Kans. The new alignment crossed Wolf Creek two times within a few thousand feet. Figure 23 shows this relationship. To avoid the construction of two bridges a channel change is proposed. The assistant bridge engineer requested a photo analysis of the area to ascertain the probable damage that would be incurred on bridge structures in the area and surrounding farmland if the channel change was completed.

Two sets of photography dated 1941 and 1962 were used to study the stream migration pattern for the past 21 years. A contour map of the area in question was compiled on the Kelsh plotter and the photo-interpreter obtained specific elevations on structures, stream bed and surrounding terrain that might be affected by the channel change. An abridged edition of the report which was submitted to the Bridge Section is presented in Appendix D.

In the spring of 1959, the replacement of a structure over Bullard Creek in Clark County, Kans., prompted a study of the drainage area involved. Bullard Creek heads on the bank of the Cimarron River and highwater of the river flowed into the creek.

The northerly bank of the river was targeted and elevations of the targets were measured. Distances between targets were also measured to provide horizontal scale. A contour map was produced with hundreds of spot elevations. Although this map was being compiled by use of the Kelsh plotter, the photographic interpreter worked with the plotter operator to determine elevations at specific points in the area. Using the information from the Kelsh plotter and a series of photography covering the years 1937

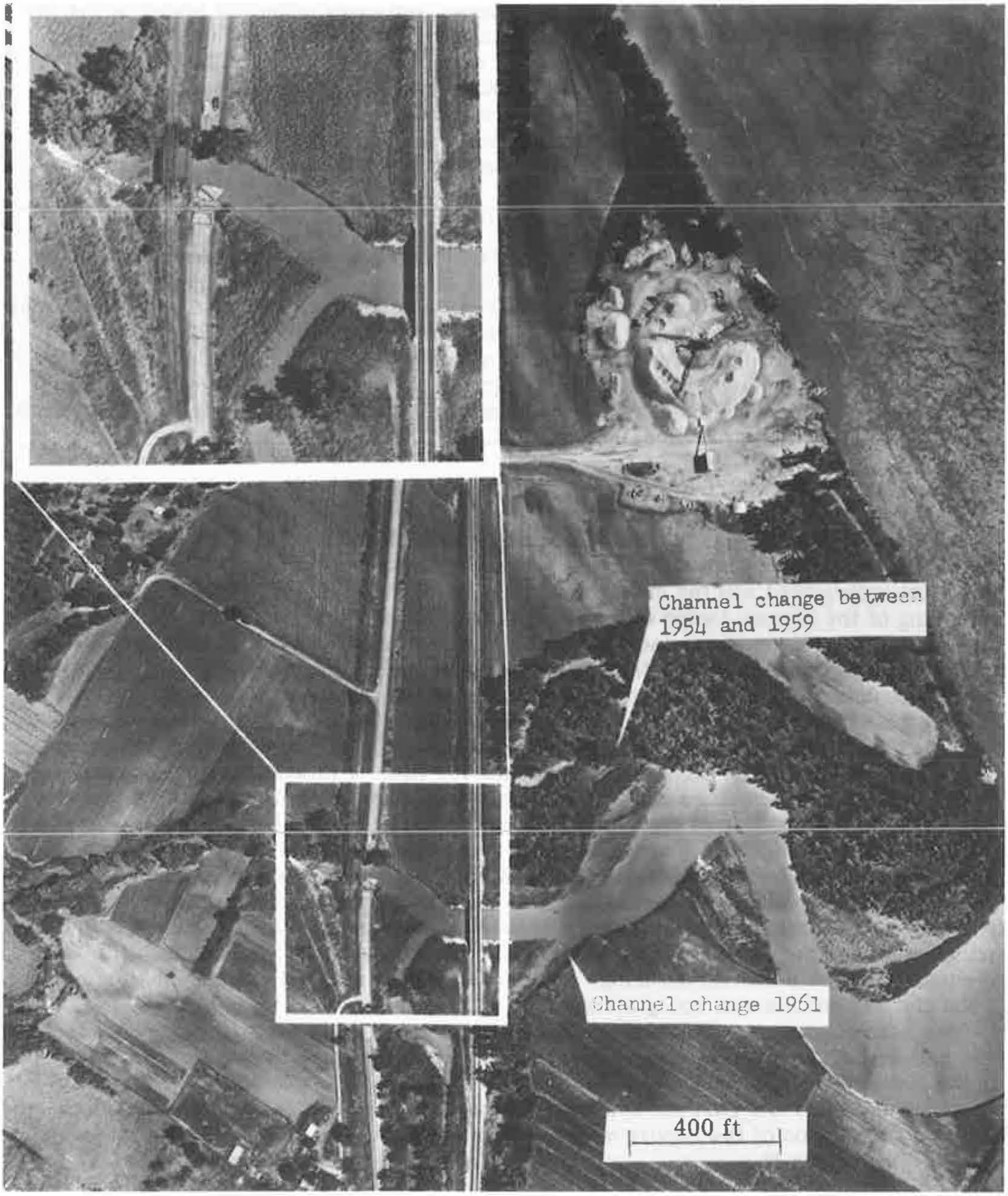


Figure 22. Bridge collapse as result of stream degradation on Kans. 32 in Wyandotte County (scale: 1:4,800).

through 1961, a stream migration study was completed and reported through a series of overlays. A photographic mosaic and a contour map were used in the presentation of the study.

Some of the drainage area under investigation included a small portion of the State of Oklahoma. No infiltration data were available to the Bridge Section to compute final

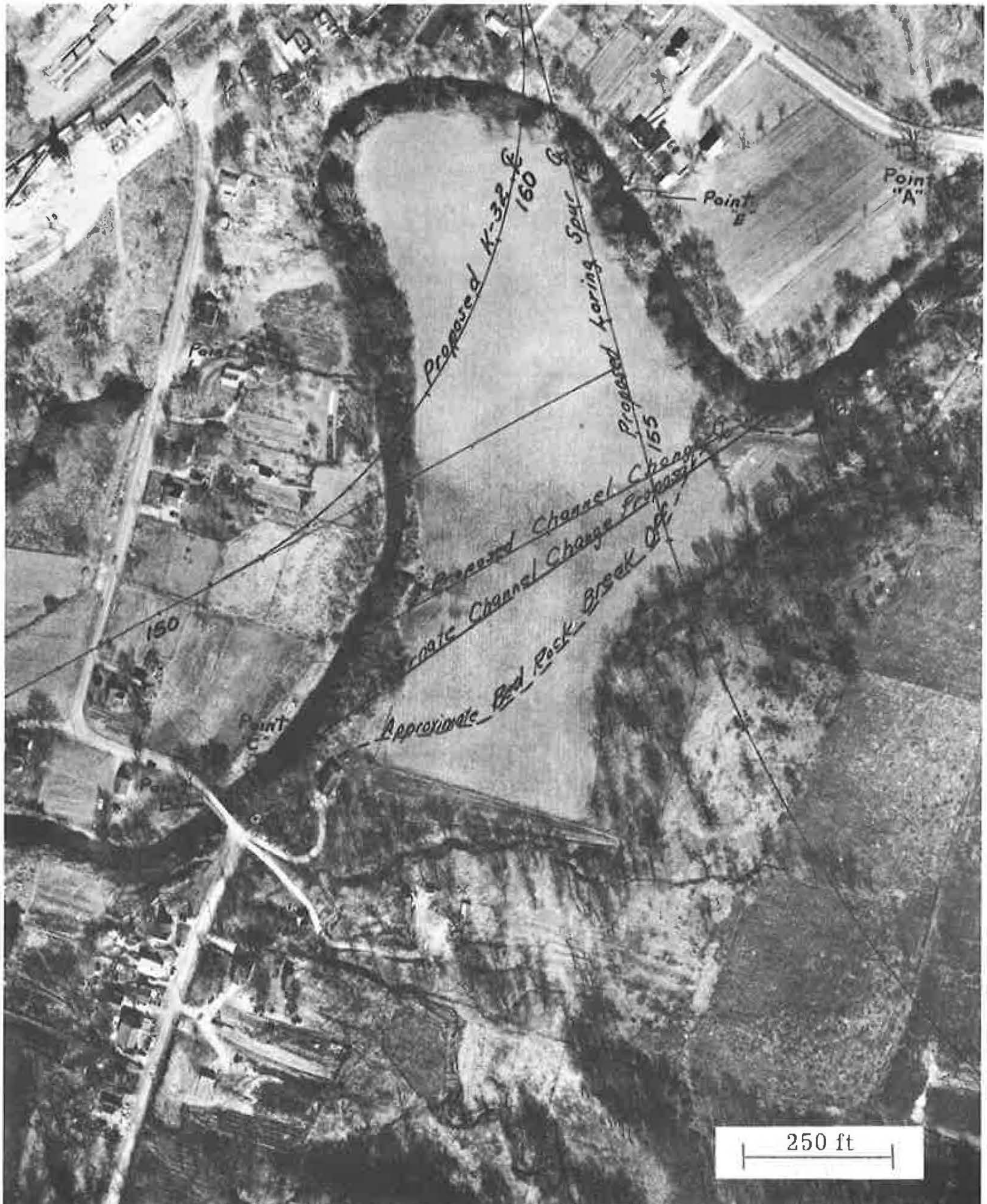


Figure 23. Proposed channel change on Wolf Creek in Wyandotte County, Kans. (scale: 1:3,000).

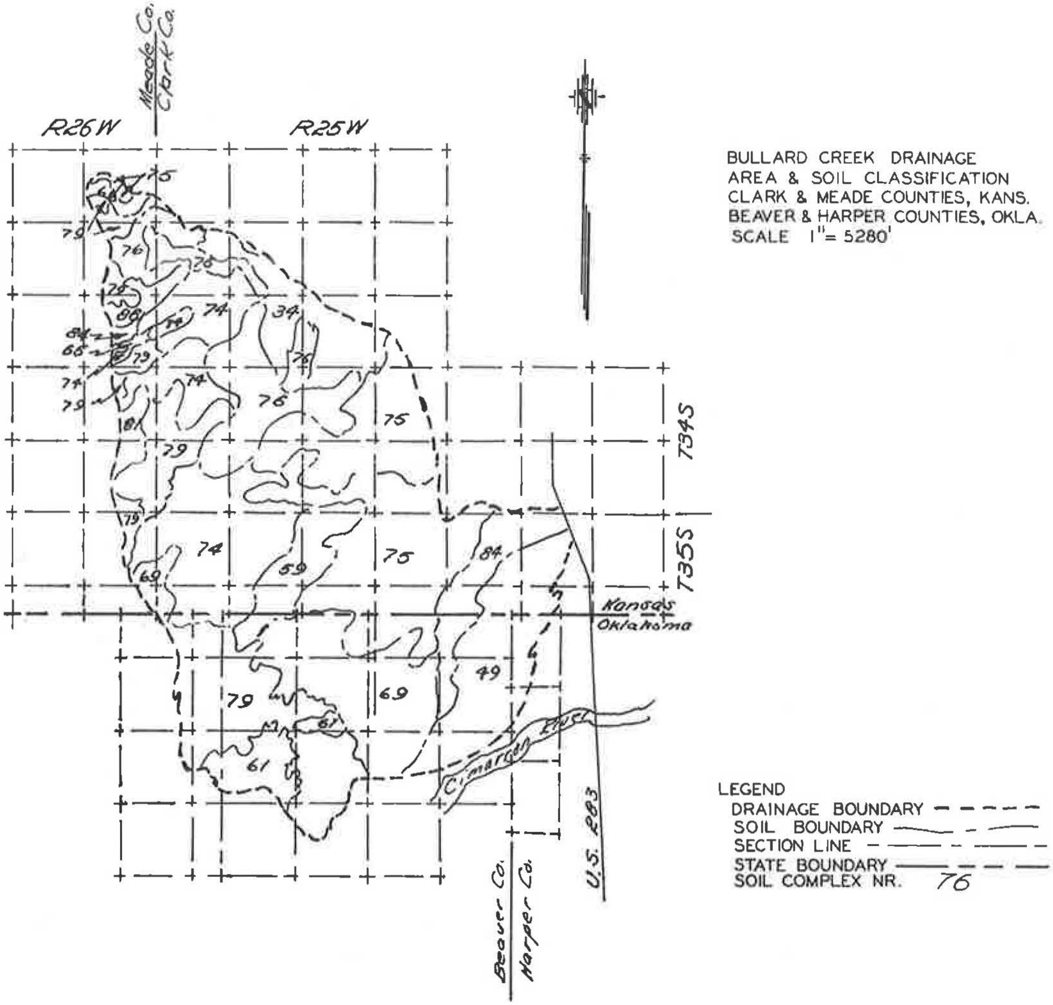


Figure 24.

run-off data. The photographic interpreter by using known infiltration data available in Kansas, mapped the soils in Oklahoma using the same type of classification system. Figure 24 shows a small-scale version of the completed soils map.

From the report of this study, it was obvious that overflow from the river had affected the amount of water carried by Bullard Creek on many occasions. It was also apparent that if the Cimarron River was to ever occupy the Bullard Creek channel, the sand carried by the Cimarron River would provide a source of sand which when transported by winds would be a threat to the nearby town of Englewood and surrounding farmland.

The USGS used the data thus reported to determine the amount of overflow expected for several cycles of time. Water run-off from the drainage area of Bullard Creek plus the overflow of the Cimarron River were combined to determine better the cross-section required for stream flow and in turn supplied the data to determine the size of the new bridge structure. This data also pointed to the possible reconstruction of a dike along the Cimarron to prevent overflow into the creek.

During the past two decades a series of dams have been built on some major Kansas streams by the Army Corps of Engineers and the Bureau of Reclamation. On many of

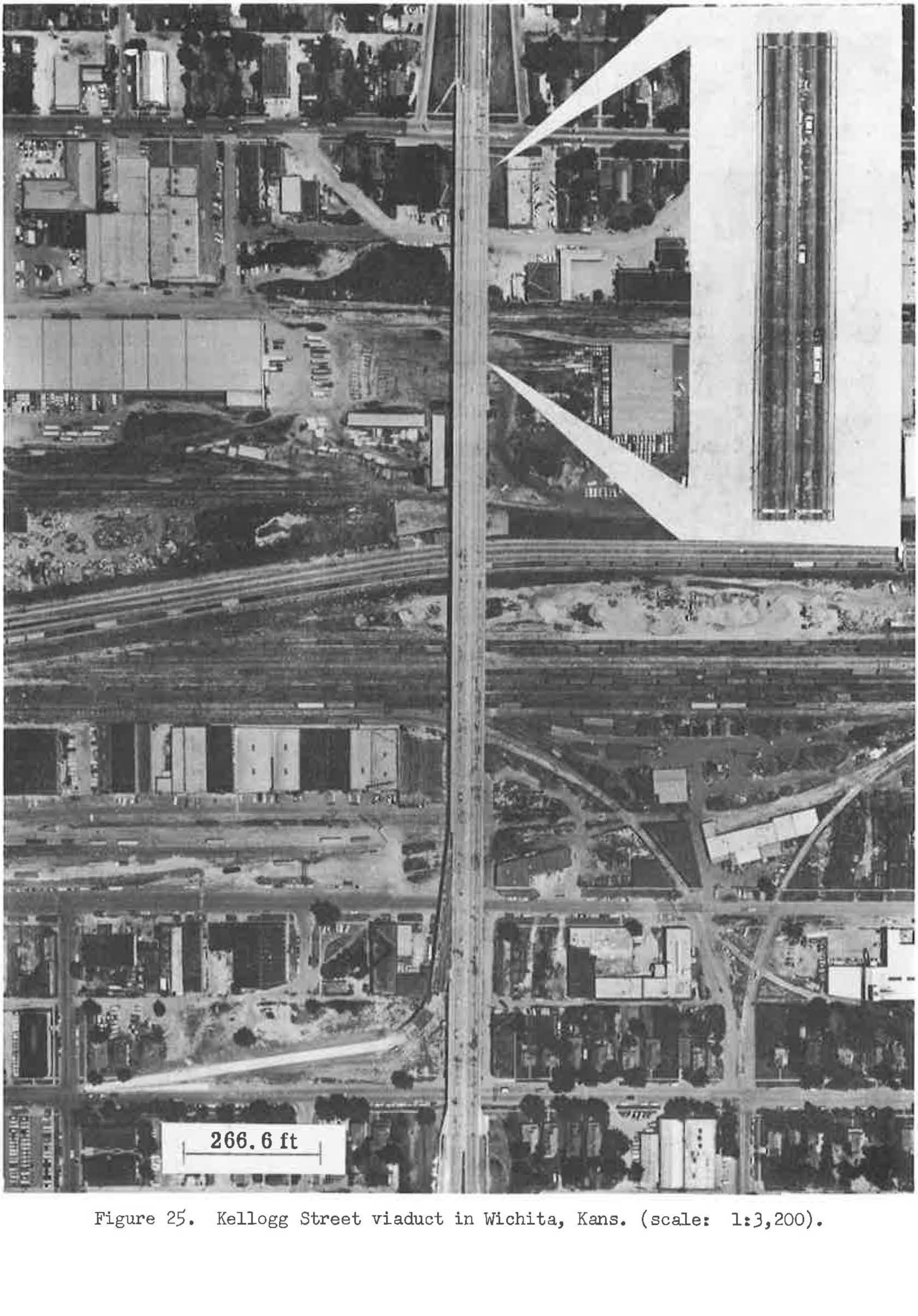


Figure 25. Kellogg Street viaduct in Wichita, Kans. (scale: 1:3,200).

these streams, the Highway Commission of Kansas has constructed and maintained bridges. Many of these bridges are located upstream from the dam of the reservoir. The silting of the channels at the bridge crossing have caused some concern. To keep abreast of the problem, aerial photography is being taken of all such areas and contour maps are to be compiled with the Kelsh plotter. Existing photography taken in past years is being studied by a photographic interpreter to determine the extent and rate of silting. This project is in the initial stages and will continue for many years.

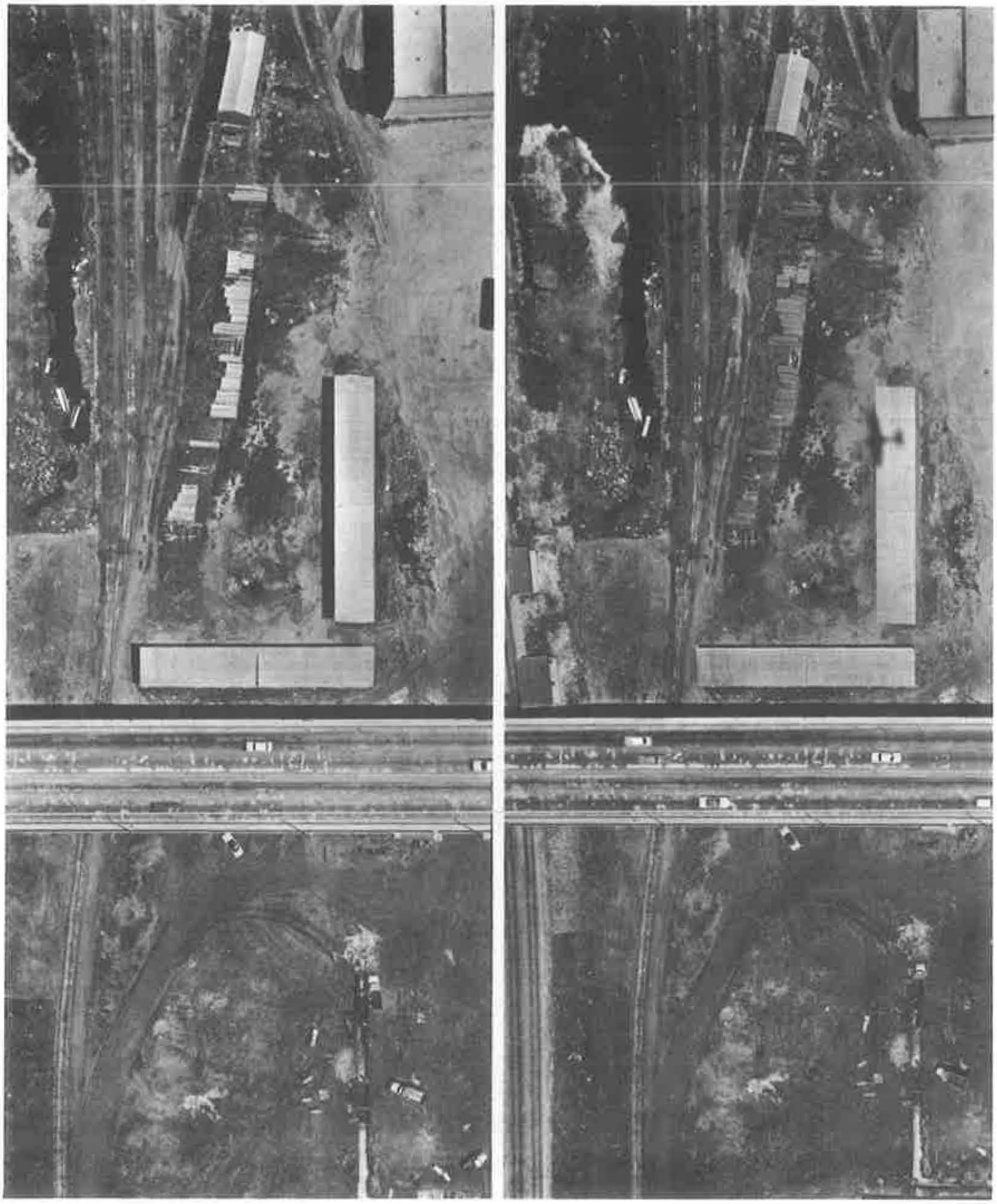


Figure 26.

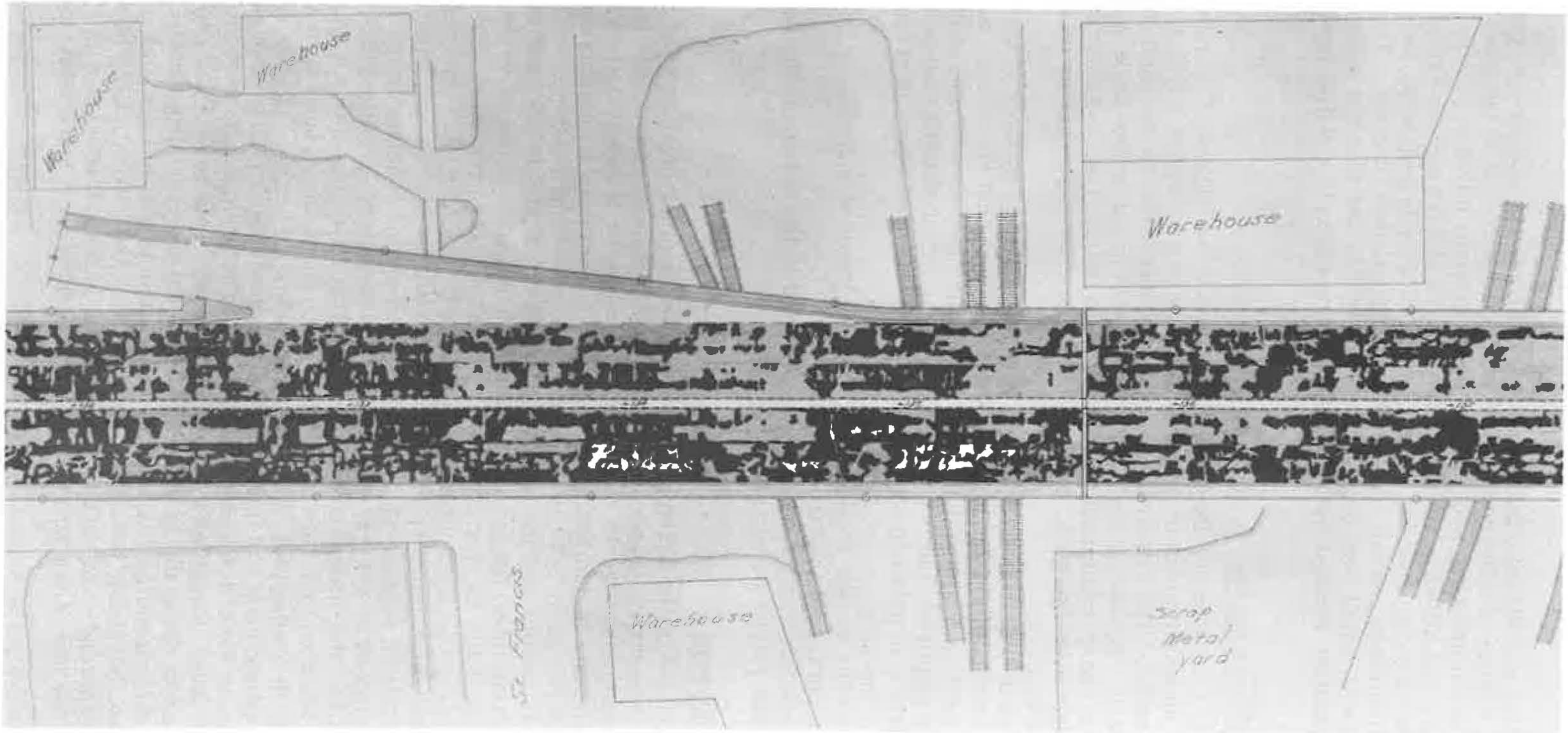


Figure 27. Stereogram of Kellogg Street viaduct deck; shows intricate deck pattern resulting from two generations of patches.

CONDITION SURVEYS

The Kelsh plotter and the information obtained through its use also played a part in several condition studies of construction projects. This tool, it is believed, would be cumbersome to use on projects involving the study of many miles of pavement. Bridges, intersections, and allied areas can, however, be studied as specific problems by this method. When a study covering several years of time is required, permanent control can be established and the area reflown at the desired interval. The study can thus be continued with small cost for control. To see the use that has been made of the method for condition surveys better, the following example and discussion are presented.

Bridge Deck Conditions Survey

In August 1961, the Research Department of the Kansas Highway Commission authorized the use of an epoxy-resin to improve the deck of a bridge in Wichita, Kans., on an experimental basis. The research engineer was interested in the condition of the original bridge deck. By having the condition of the original bridge deck available, new failures in the epoxy-resin could be traced as to origin; i.e., whether failures occurred on the original bridge deck, on the first generation of patches or on the second generation of patches.

To obtain a map of the original deck that could be overlain by later traces, the map had to be exact. The combination of the differences of ground elevations, aerial photography flight height, and stretching of the foils could give erroneous results. To obtain the exactness required, the mapping was accomplished on the Kelsh plotter. Permanent field control was obtained which can be used on future mapping projects of the same deck when necessary.

Figure 25 shows the bridge deck before the epoxy-resin was applied. Figure 26 is a stereogram of a portion of the structure (Fig. 27).

Appendix E gives information which was submitted to the research engineer along with the map for his reference and study.

Road Conditions Surveys

A very common use of the Kelsh plotter is that of mapping existing road interchanges. Construction changes, traffic analysis, accident rate studies, maintenance requirements and many other facets connected with highways and especially with intersections are continually in demand. Photography of certain intersections with permanent control can serve as a continuous study of any particular road intersection.

Changes in construction and the loss of old plans often initiate the first request for a new map of existing interchanges. As these requests were honored by the Photogrammetry Section of the Kansas Highway Commission, the usefulness of the maps and the allied photography became increasingly apparent. Photographic interpretation began to be employed and soon more information beyond the contour and topographic map was extracted from this photography. When the design and construction of highway facilities are conducted by several authorities such as cities, counties, turnpike authorities, and the like, the designs and engineering that have gone into any particular interchange may often be found at several sources. To combine such information is often best done by the remapping of the interchanges.

The Planning Department has found the photography used for this purpose a very handy tool in keeping the official maps up to date. The photography presents an accurate record of the interchange area on a specific date. This record has been a useful tool in the revision of maps and in the reporting of construction progress.

Photographic interpretation has not moved forward as fast in this field as in some of the allied areas, but it has been tried with success and will with time become another tool in determining road conditions on a local basis and coupled with the mapping that comes from the use of the Kelsh plotter will also present more information cheaper and faster.

ADVANTAGES AND DISADVANTAGES OF PROCEDURES

The advantages and disadvantages of the procedures and techniques discussed in this report do not pertain to any one particular job. The different factors affecting the reliability, the ease with which a project can be accomplished and the cost of each project will vary from project to project. Different problems are encountered on different projects and are solved in different ways. The most efficient method of operation or procedure herein reported may not be the best method because the techniques and methods are a continuously changing operation regardless of the amount of experience that has been accumulated by individuals or by the using organization.

The advantages of these procedures can best be described in the speed of accomplishment and the type of information that is obtained. In many instances, the information obtained can not be duplicated in the field. Stream study over a period of years can not be conducted in the field. This is a good example of the permanency with which an aerial photograph holds a record of the conditions of a particular item or area. Older aerial photography can easily be obtained from different Federal agencies.

Other information that is beneficial and sometimes required for the highway engineer can be acquired by routine field methods but would not be economically feasible. The survey of the bridge deck mentioned previously and the obtaining of preliminary geological information in a very inaccessible area serve as good examples. It took the plotter operator and photographic interpreter nine days to complete the reported bridge survey. It would require months, and maybe years, for a survey crew to obtain the same information and plot it on a base sheet.

Another big advantage of these procedures is that the analysis of the problem can take place during the time that the information is being compiled. If additional information is needed or more elevations required, this can be accomplished in a matter of minutes. In many cases complete problem areas are observed and studied or measured at the same time.

There is no doubt that engineers in Kansas now have information available that was unobtainable in prior years or was too expensive to acquire. This information in many cases helps to make better decisions which are substantiated by accurate findings and which may save millions of dollars in form of liability suits, and maintenance and construction costs.

The disadvantages of these procedures are those that are probably also encountered on other photogrammetric and photographic interpretation endeavors. The need of photography, the weather required for flying photography, the seasonal requirements for specific photographs, and field control requirements are all problems that must be accepted but are considered a part of the procedures just as chaining is considered a part of routine field surveying. Some disadvantages are inherent to these problems and involve natural covers, such as vegetation and soil mantle.

Areas of dense vegetation will eliminate or limit the number of elevation points that can be measured accurately. Soil mantle, whether transported or residual, also hampers the accuracy and the extent of detailed geological interpretation. Additional ground work is sometimes required. This is true also in areas where the geology is erratic.

In many cases, the lack of qualified personnel or, in many cases, interested personnel is a problem. Usually, with some formal training and with an interest in the procedures, geologist, soil scientists, and civil engineers can obtain good results from aerial photographic interpretation.

One of the big problems that any organization will encounter during the initial use of any new procedure or system is the lack of understanding of the new system. The people who are performing the work and who are using the results of the work should know the capabilities and the limitations of the system or procedures involved. The personnel who are performing the work should know what can be accomplished and how reliable the results are to be able to determine what projects can be worked. The personnel who request the work should know if the results will meet all requirements of the investigation.

Appendix A

WYANDOTTE COUNTY - K-5 REPORT

MAY 1962

MEMORANDUM TO: MR. H. O. REED, ENGINEER OF DESIGN
FROM: Mr. Virgil A. Burgat, Chief Geologist
By Alvis H. Stallard, Geologist I
Walter Fredericksen, Regional Geologist
SUBJECT: Preliminary Geology Report
Project No. 5-105 U-087-1 (3)
Wyandotte County

INTRODUCTION

The purpose of this report is to present a preliminary geo-engineering analysis of a prospective centerline of an alternate route of proposed route K-5 in Wyandotte County, Kansas. The information contained herein was compiled by photographic interpretation and by photogrammetric and field observations. A portion of the area under investigation was mapped on the Kelsh plotter at a scale of 50 feet to one inch with a 2-foot contour interval. This area is representative of the more severe areas that will be encountered on this project. Geological cross sections were plotted illustrating the geology and accompanying geo-engineering problems of the area. Only general terms are used in describing the problem areas since the magnitude of each problem will vary with the designed location of centerline. This report can best be utilized with the attached cross sections and diagrams.

The area under investigation is located in the S 1/2 Section 18 and NW 1/4 Section 20, T 10 S, R 24 E, in Wyandotte County. The prospective centerline runs from North 79th Street to present K-5 alongside the Missouri Pacific Railroad right of way and the existing county road in the area. The enclosed photographic mosaic depicts the county road, the railroad, and specific areas that were studied and mapped. [The size of the photographic mosaic prevents its reproduction in this paper. Figure 28 has been substituted which gives in part the information shown on the photographic mosaic.]

The geological units that will be encountered, if construction takes place in this area, are the Cherryvale Formation, Drum Limestone, Chanute Shale, Iola Limestone, Lane Shale, Argentine-Frisbie Limestone, Island Creek Shale, Farley Limestone, Bonner Springs Shale, and the Plattsburg Limestone. All of these geological units belong to the Pennsylvanian System. They are overlain by varying thicknesses of loess of Pleistocene Age.

The direction of drainage is to the north into the Missouri River Valley. Total relief of the area is 200 feet. An apparent dip of the geological units of 1-foot per 60 feet to the east was observed along the face of the valley wall.

Numerous springs were observed along the valley wall and will be discussed in detail in the geo-engineering aspects of this report.

GEO-ENGINEERING ASPECTS

The following presents information concerning different geo-engineering facets that should be considered.

Wyandotte County Lake Dam

This structure is included in the report due to its proximity to the proposed project. The northwestern abutment of the dam is included in the portion of the area that was mapped and cross section CC' [Figs. 29, 30 and 31] depicts the geology of this abutment. The dam can be observed in areas 2 and 3. [Fig. 28]

The dam was first constructed in 1936. Before construction was completed the central portion of the dam failed. This failure took place because of the following factors.

The dam was constructed on alluvial clays approximately 40 feet deep and was keyed into bedrock only by sheet pile. Also the drainage ditch leading from the spillway of the dam was placed parallel to the toe of the dam. No internal drainage of the dam was provided. Consequently the ground-water level of the immediate area rose to an excessive elevation into the dam proper. The combinational effects of ground water, weight of the dam and lack of support on the toe of the dam, and the fact that the dam

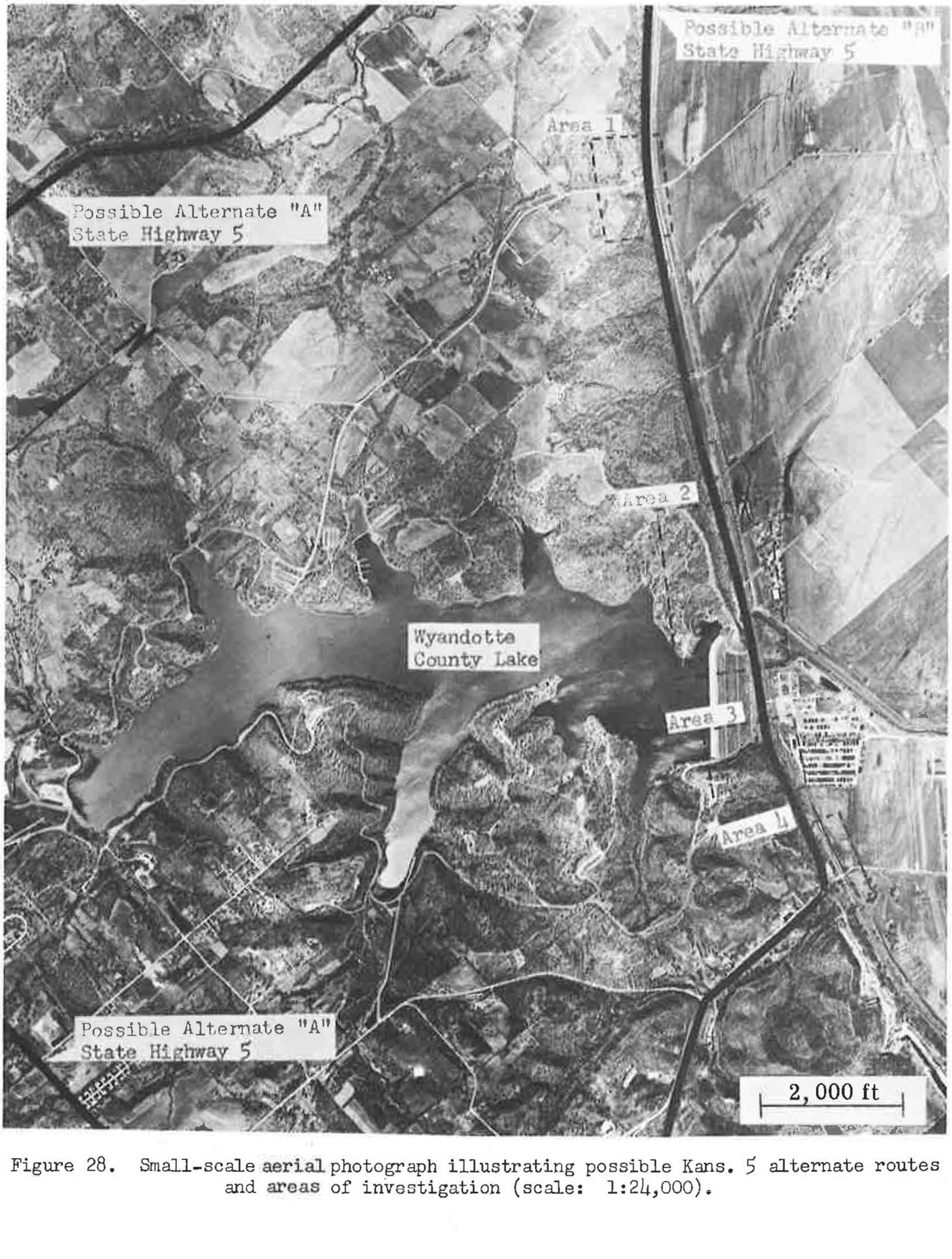


Figure 28. Small-scale aerial photograph illustrating possible Kans. 5 alternate routes and areas of investigation (scale: 1:24,000).

was not well keyed into bedrock, but rather setting on a clay foundation caused the central portion of the dam to fail. The slide plane was approximately 20 feet deep into the clay foundation of the dam.

Subsequently the Corps of Engineers reconstructed the dam. The base of the dam is now keyed into bedrock at varying elevations. The southeast abutment is keyed into the Wea Shale at an elevation of approximately 720 feet. The northwest abutment is keyed into the Block Limestone at an elevation of approximately 707 feet. The base of the dam is 140 feet wide at bedrock.

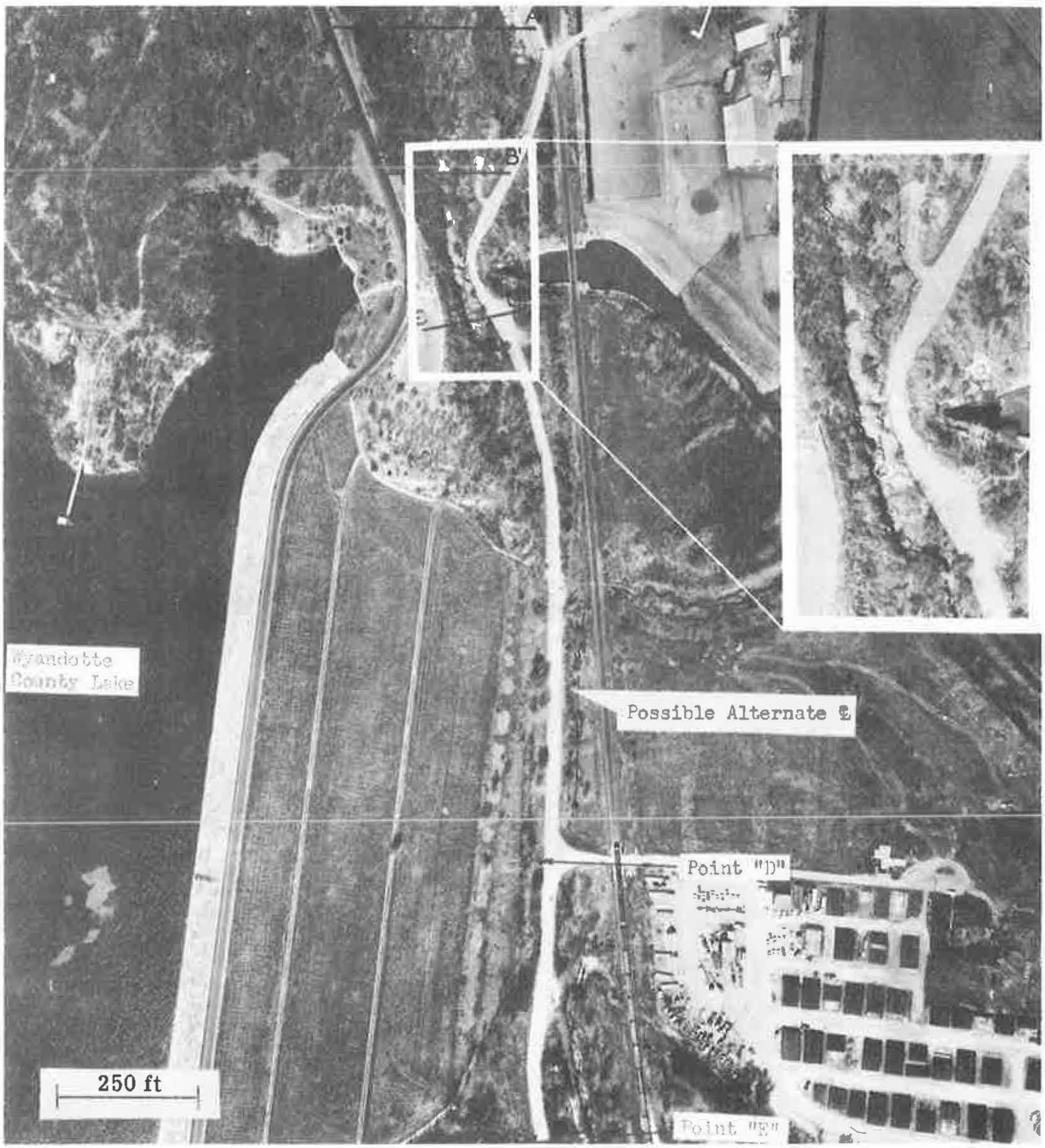
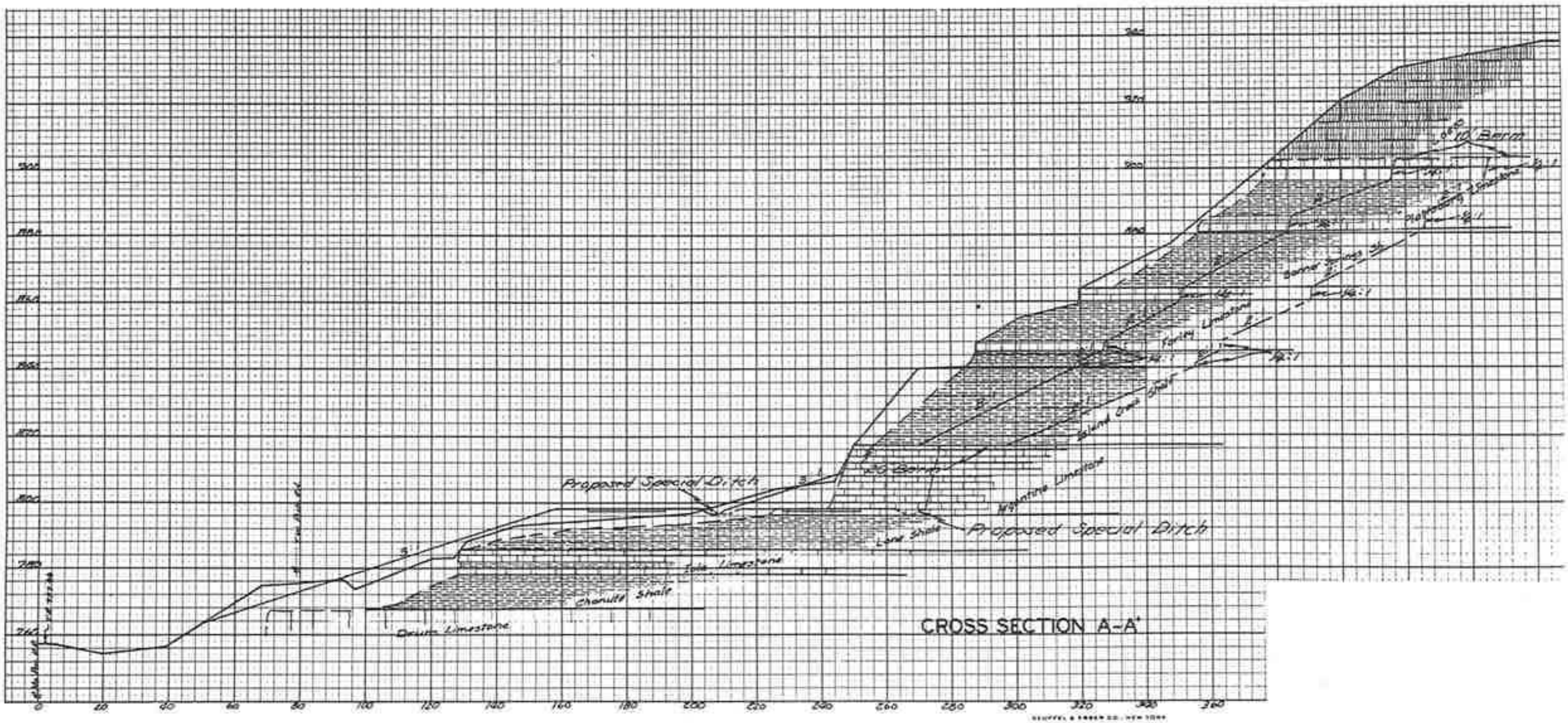


Figure 29. Wyandotte County Lake and possible alternate of Kans. 5 in Wyandotte County; possible alternate route would run approximately along the existing county road; geology targets encircled on inserted enlargement; geologic formations plotted on cross-sections along lines A-A', B-B', C-C' (scale: 1:3,000).



Proposed Special Ditch
20' Berm
10' Berm
Proposed Special Ditch
Lane Shale
Iola Limestone
Chanute Shale
Drum Limestone
CROSS SECTION A-A'

Figure 30.

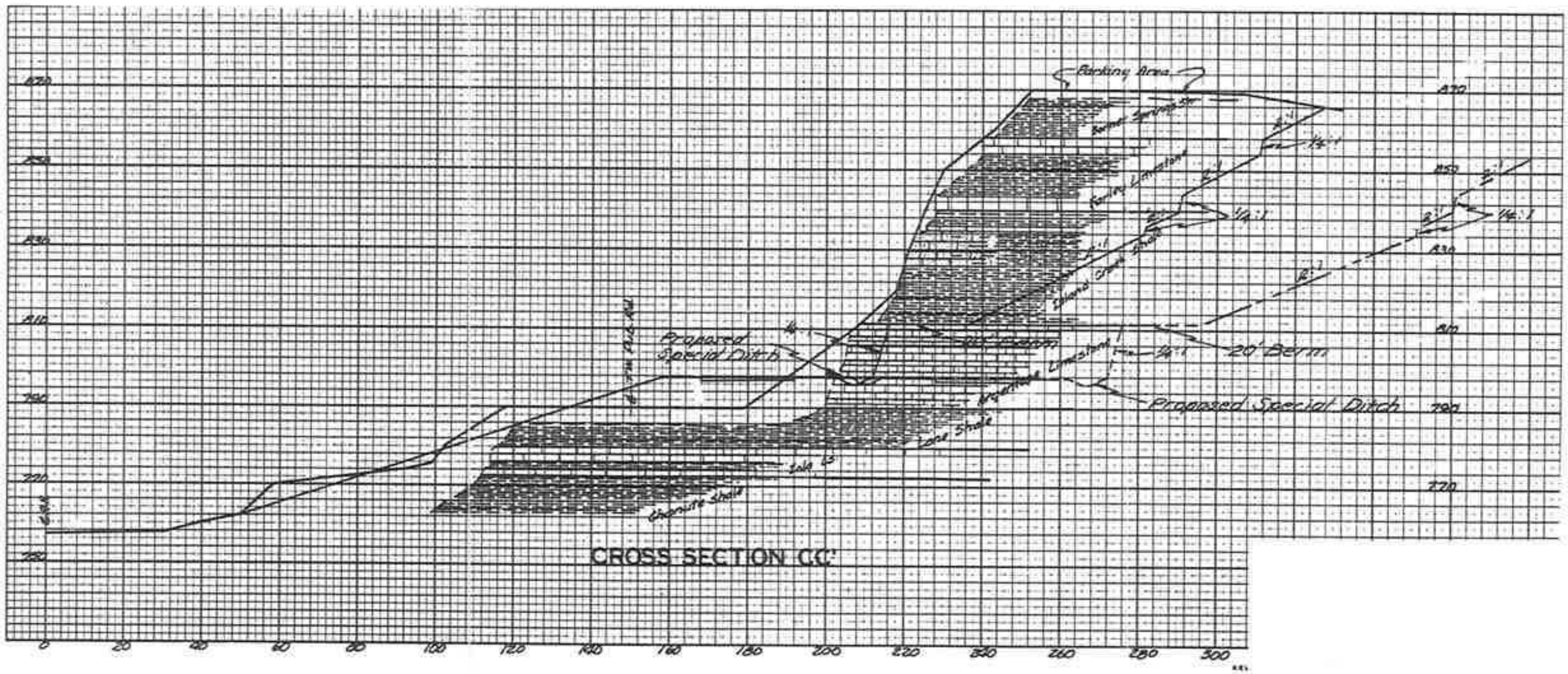
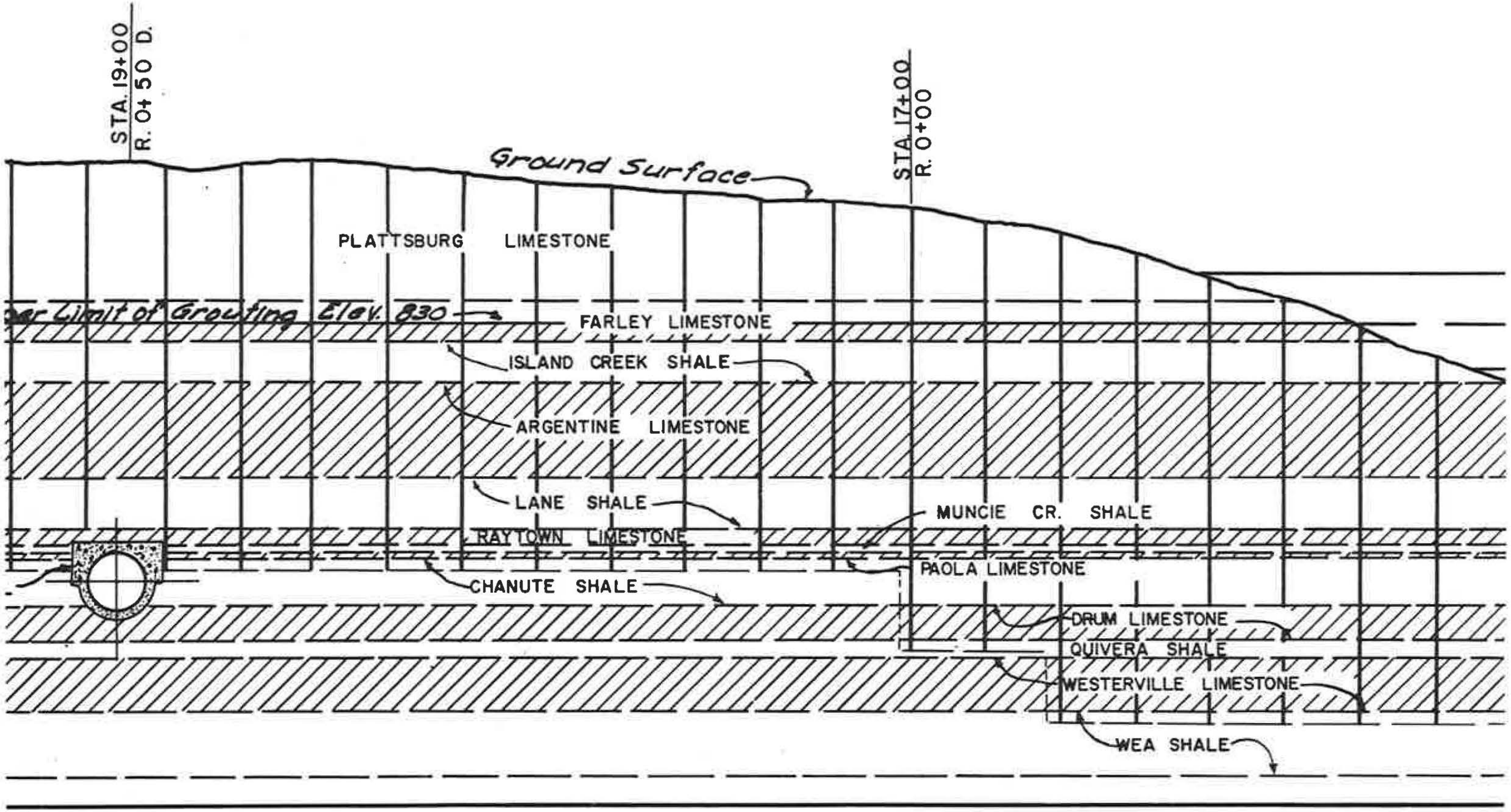

Parking Area
Proposed Special Ditch
Proposed Special Ditch
20' Berm
CROSS SECTION CC'
870
850
830
810
790
770
750
0
20
40
60
80
100
120
140
160
180
200
220
240
260
280
300

Figure 31.



LEFT ABUTMENT
SECTION ON ℄ OF GROUT HOLES

Figure 32.

Both abutments of the dam were excavated to bedrock. Due to the great amount of limestone present in the area, a great deal of seepage occurred at both abutments. Figure 32 is a portion of a diagrammatic profile of each abutment depicting the location and depth of grout holes which were drilled after the rolled earth fill of the dam was completed. Thirty-two grout holes were placed on the northwest (left) abutment of the dam extending over a horizontal distance of approximately 620 feet. This includes 200 feet of the dam and the area on both sides of the spillway. The southeast (right) abutment was grouted for a horizontal distance of 360 feet including 85 feet of the dam. The lower limit of the grout is at the top of the Wea Shale. [Fig. 32].

Tile drains were constructed in the dam to provide internal drainage of the dam. The drain outlet is located in the center of the dam near the toe. See Point "D". [Fig. 29]

A channel change has provided a spillway drainage ditch leading away from the dam instead of paralleling the toe of the dam.

There is a possibility that blasting of the bedrock in this vicinity will damage the grouting and worsen a now serious problem of seepage through the existing bedrock around the dam. Rock excavation requiring blasting can be anticipated if the proposed centerline is placed near the valley wall in this area.

Hydrology

Groundwater problems will be continuous in areas 2 and 3. They will be numerous in areas 1 and 4 [Fig. 28]. The main avenues of groundwater are at the base of the Argentine Limestone and the base of the Iola Limestone. This situation is made more severe since the general dip of the beds are to the east, thus feeding water away from the lake through the more fractured outcrop area of the rock.

This condition will tend to become more severe in future years as the groundwater solutions out larger cavities in the limestone which will carry larger quantities of water. This in turn will increase the solutioning capabilities of the water.

The source of water for most of the springs in this area is the Wyandotte County Lake; however, springs and seeps were noted in areas 1 and 4 [Fig. 28] which are probably quite independent of the lake source. No groundwater was noted above the Island Creek Shale. The lake's water level is maintained at an elevation of 830 feet which is within the elevation of the Island Creek Shale.

The Drum Limestone carries more water but at a lower elevation and in most cases the water seeps into the valley alluvium. This situation is a potential problem where the fill of the roadbed extends beyond the breakoff edge of this limestone.

Special ditches and underdrains would be needed in all four areas depicted on Figure [28]. Cross Sections AA' and CC' [Fig. 30 and 31] indicate that the present road is setting on the Drum Limestone and Iola Limestone respectively. This is not the case throughout the area as illustrated on cross section BB' [Fig. 32] where the road is setting on fill material. This is a particularly unstable condition since groundwater is running along the contact between the fill material and bedrock. If the proposed roadbed is located above these aquifers, special underdrains will be required to intercept the water. If the proposed roadbed is located below these aquifers, special ditches would be required to handle the runoff. Because of the position of the aquifers, it is possible that a given proposed roadbed level would encounter both conditions present and therefore would require both underdrains and special ditches.

Two separate domestic water supply systems have been built in the area under investigation. Cross section BB' [Fig. 33] depicts one at the base of the Argentine Limestone [See contour map for plan view]. This area is a catch basin approximately 120' × 60' constructed by the landowner. Gravel has been placed on a remnant of the Argentine Limestone (old quarry site), and plastic sheets have been placed over the gravel to prevent surface water from entering the basin. A pipe on the existing county road near cross section BB' is flowing water continuously from this basin. Another pipe depicted on the contour map carries water to the two farm sites located a few hundred feet north of cross sections AA' and BB'. This is the only source of water for these two farms.

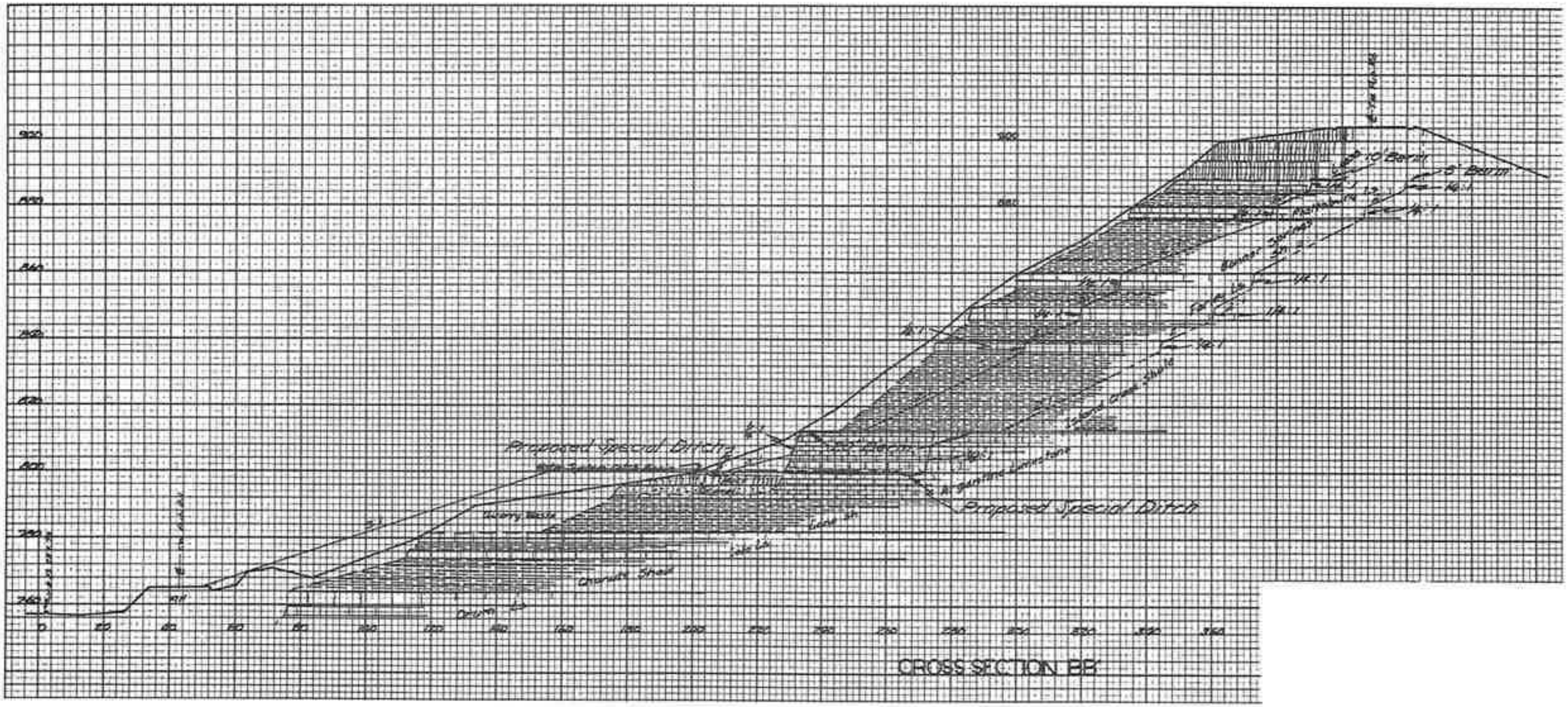

Proposed Special Ditch
Proposed Special Ditch
Chanute Shale
CROSS SECTION BB'

Figure 33.

Another small water system has its source at Point E [Fig. 29] at the present road elevation and the pipe runs northwest paralleling the existing road for approximately 250 feet, then crosses the road to the office of the pipe company located on the north side of the Missouri Pacific tracks. Both systems obtain water from the Argentine Limestone. If the proposed route is followed, these water systems will probably have to be relocated.

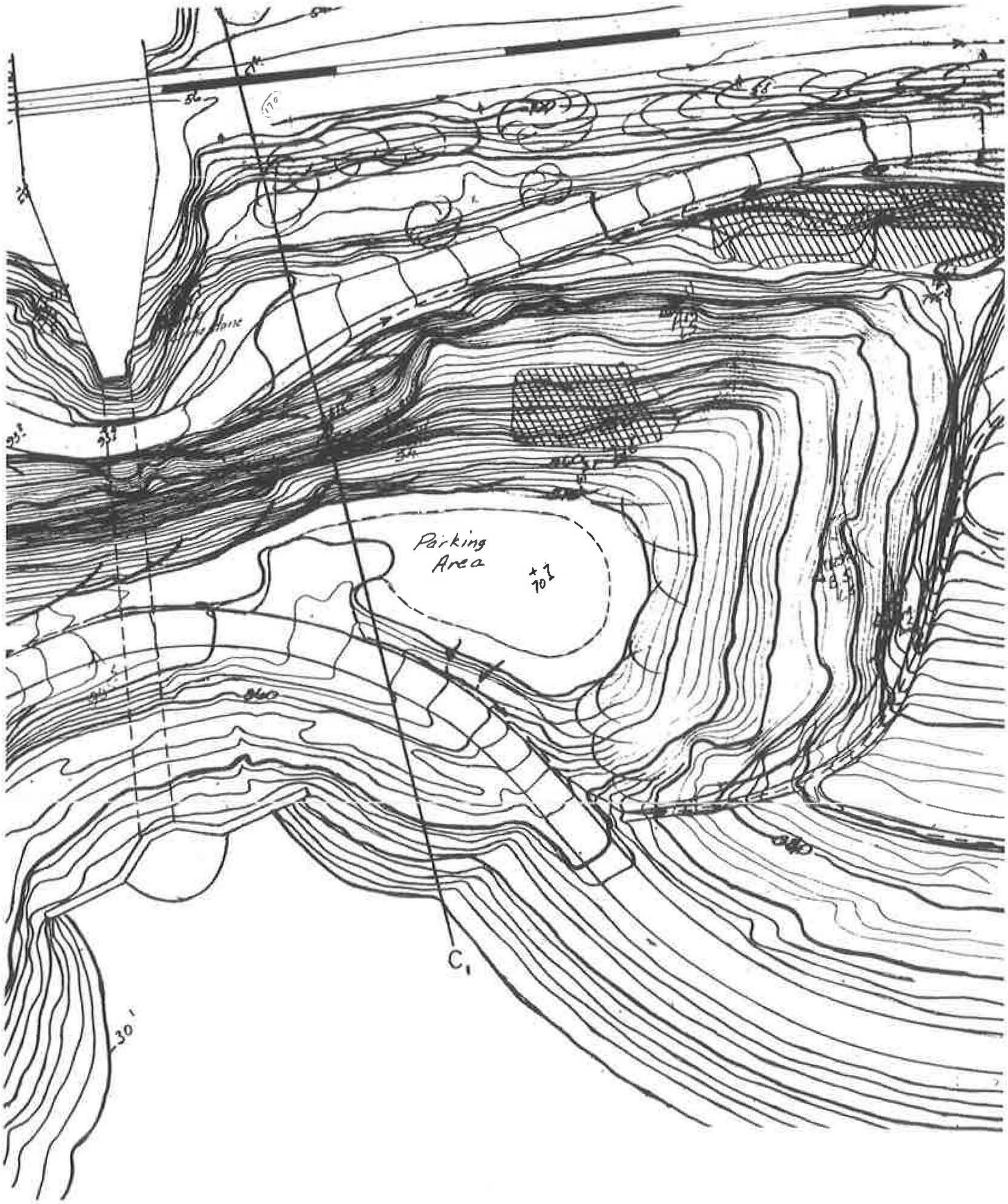


Figure 34.

Rock Excavation

In many areas only a small amount of real estate exists between the railroad right of way and the bluffs of the hill. If the road is placed at a low elevation (present road elevation or lower), rock excavation will be required to provide a sufficient amount of roadway for the proposed project. This is particularly true in the areas depicted. [Fig. 28] In area 2, the Argentine Limestone has been quarried and the existing bench could be used for a roadbed. However, this situation does not exist throughout the area.

Right of Way

If the road is placed at the present road elevation or lower, and rock is excavated, backslopes in the bedrock are suggested as follows: all shale is recommended to be on a 1:1 slope or flatter and the limestones on a 1/4:1 slope. With these recommendations, a 20-foot bench is suggested to be placed on the top of the Argentine-Frisbie Limestone and on top of the Farley Limestone. Thus considerable rock excavation would be required along the face of the existing slope. Also due to the extremely dense tree cover, a great deal of timber grubbing would be required in shaping the backslope.

An acute right of way problem will be encountered at the NW toe of the dam since only approximately 100 feet of real estate separates the dam and the railroad right of way. In area 4 the railroad has constructed their track adjacent to the south boundary of their right of way. Even though the railroad has a right of way 100 feet wide, none of their right of way exists beyond the south limits of the ballast in this area.

Slide Areas

Several slides were noted in this area. Two are depicted on the contour map. [Fig. 34] Mantle creep was noted on all steep slopes in this area. The general steep slopes and the groundwater conditions that exist in this area tend to make any given area a potential slide area. This condition would worsen with grubbing of the vegetation.

Flood Waters

The high water mark in the 1951 flood was approximately 575 feet which is over the existing road in areas 2 and 3.

SUMMARY

Regardless of the elevation of the proposed centerline in this area most of the problems and situations mentioned in this report cannot be avoided. From the geo-engineering point of view this area can be described as a rather difficult area for highway construction. If this area is selected for the proposed roadway, right of way will probably be required out at least as far as the top of the bluff, special ditches and underdrains will be necessary; at least two sources for domestic water systems will have to be relocated; extreme caution would be required during blasting operations to prevent the possibility of damage to the grout which was forced into the rock voids around the dam area; right of way would be scarce in areas where the Missouri Pacific Railroad right of way is near the valley wall and the toe of the existing dam; the backslopes would have to be very carefully constructed to prevent spall and slipouts; and unless all groundwater is intercepted and the anticipated increase of groundwater flow in future years is reckoned with, the maintenance of the finished roadway may prove to be a continuous and very expensive operation.

Appendix B

Abridged Edition

Preliminary Photo Geological Report, Brown County, Morrill to Sabetha Centerline Selection.

General Information

Two lines are being evaluated for the route location, Line A (north line) which is 5 miles long and Line B (south line) which is 6 1/4 miles long.

Both lines are located in similar topography. On Line A the relief varies from 1,116 feet in elevation to 1,285 feet in elevation, a difference of 169 feet. On Line B the relief varies from 1,140.5 feet in elevation to 1,322.5 feet in elevation, a difference of 182.0 feet.

Since no grade is available, only an estimate on the number of cuts is presented. It is estimated that Line A will have five major cuts of more than 10 feet in depth and five minor cuts less than 10 feet in depth. It is estimated that Line B will have one major cut and seven minor cuts. A more detailed analysis of the geo-engineering aspects is presented subsequently.

Regional Geology of the Area

The geological section that will be encountered on these projects will range from the Crouse Limestone Member, Council Grove Group, to the Cottonwood Limestone Member, Council Grove Group. Glacial till of Pleistocene Age caps most of the hills encountered on centerline, especially on Line B. The section thickness was obtained from field notes of Project 75-7 F 152-A which joins both centerlines of this project.

The general structure along centerline is a gentle west dip with a slight reversal of dip along the central portion of the project on Line A. Due to insufficient exposures of bedrock along Line B, a true representation of the structural geology cannot be presented.

Along Line A most of the high areas on the western half of the alignment are stabilized by bedrock. Usually the eastern slope of these hills consist of thick glacial till. Along Line B, all of the alignment consists of glacial till with the exception of approximately 2 miles of the central portion of the project where bedrock is exposed in lower areas.

Geo-Engineering Aspects

All cuts are referenced to centerline stationing. The characteristics of each geologic formation that would be encountered in each cut is described to help ascertain the excavation classification. Also all seep areas are located and their source determined to help evaluate general groundwater problems. [A detailed listing of these factors was given in the full report.]

Summary

A comparison of the two lines can only be presented in terms of estimates and potentials since the vertical location of the centerline grade will affect the amount of rock quantities and over-all grading quantities.

Ground relief is more erratic on Line A and consequently more major cuts of greater than 10 feet will be encountered. These cuts on the western half of this alignment will encounter rock excavation. These rock formations are encountered on construction Project 75-7 F 152-A which joins the west end of this project. From the experience encountered on this construction project, underdrains may be required in the same formations on the Morrill to Sabetha Line A alignment.

Even though Line B is the longer of the two lines, the relief is less erratic. Cuts will be less numerous and no rock excavation will be encountered except for the two small cuts previously mentioned.

Seep areas that are noted are present in glacial till on both lines.

Appendix C

Abridged Edition

Stream Migration Study of Turkey Creek, Wyandotte County, Kansas

Introduction

The purpose of this report is to present information obtained from a stream migration study of Turkey Creek in Wyandotte County, Kansas.

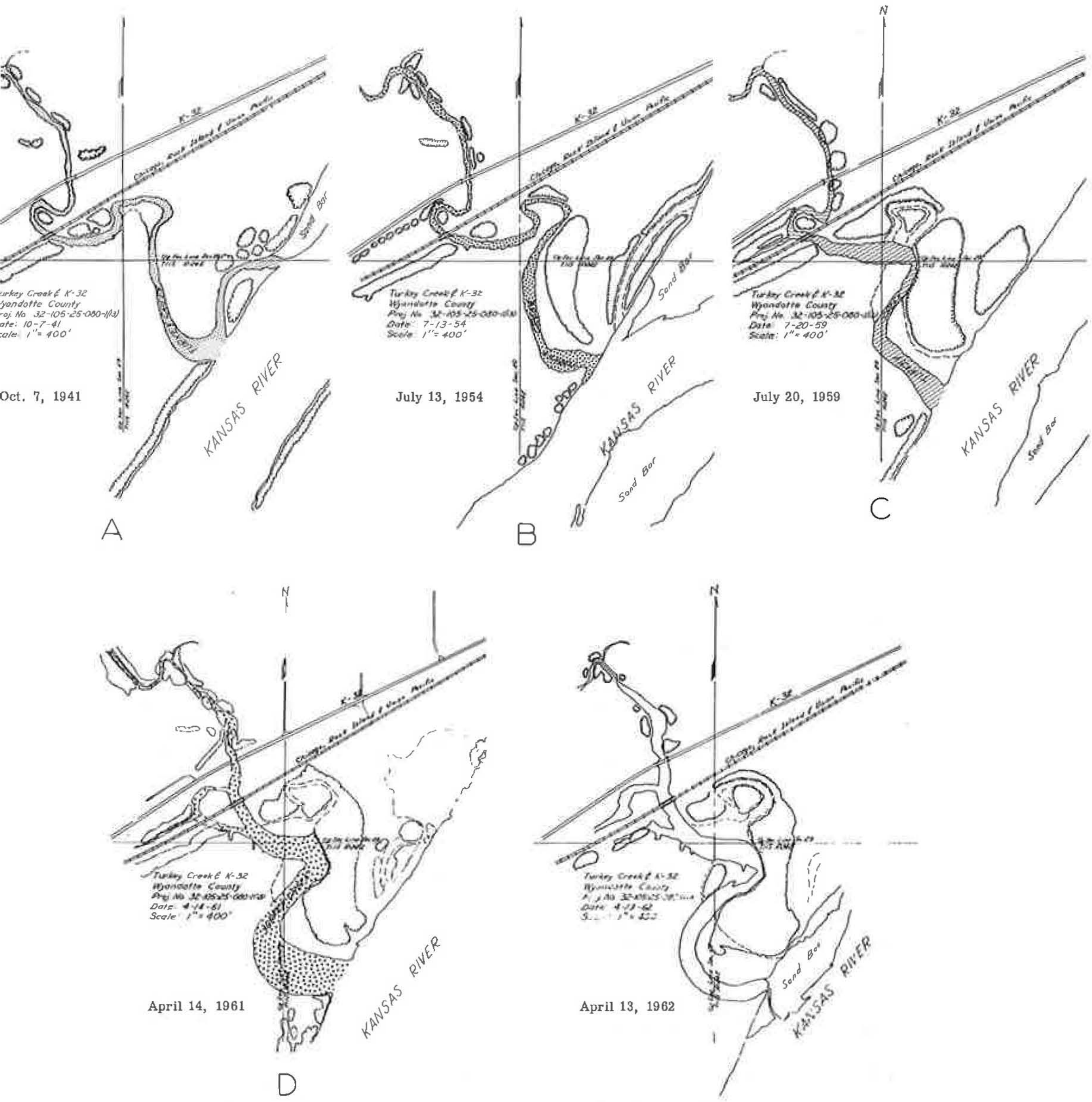


Figure 35. Stream migration patterns of Turkey Creek in Wyandotte County, Kans.

An opinion is herein presented as to the cause of the migration and the subsequent damage that is being incurred on the adjacent farmland.

A pictorial presentation of the stream's activity for the past 22 years is presented in graphic form in this report to supplement and to illustrate the author's opinion on the stream's development.

Five sets of comparable stereo photographs were studied. Stream configurations for each of the years are depicted on Figure [35]. The original illustrations were drawn to a scale 400 feet to 1 inch.

Field elevations taken during the month of August 1962, and elevations taken from the 1925 plans were used in this analysis. Stream profiles for each year studied are presented to illustrate and to supplement the author's analysis. The following photography was studied:

Photography	Scale of Photography	Date of Photography
AAA	1000 feet to 1 inch	7 Oct. 1941
AAA	1000 feet to 1 inch	13 July 1954
AAA	1000 feet to 1 inch	20 July 1959
SHC	400 feet to 1 inch	14 Sept. 1961
SHC	200 feet to 1 inch	13 April 1962

Procedure

By using elevations of a known date and data obtained through photographic interpretation procedures, the time and the extent of stream degradation and a prediction of future stream activities is presented in this report. By using photography of the area which was flown on the dates listed previously, the width of the stream at selected points and the extent of bank sloughing was studied. There appeared to be a close relationship between the width of stream, the sloughing and the degradation of the stream's bottom. Since the stream's banks can be measured for each of the years studied and the extent of sloughing can be observed for each of the periods, the stream degradation could be dated, located and correlated.

Table 1

Year	Extent of Detectable Sloughing
1941	Sloughing extends from mouth of stream to a point approximately 250 feet south of railroad bridge.
1954	No difference noted from 1941.
1959	Sloughing extends 160 feet north of railroad bridge.
1961	Sloughing extends 175 feet north of highway bridge.
1962	Sloughing extends 1,200 feet north of highway bridge.

Table 2
Width of Stream by Year

Year	Point A (420 feet north of stream's mouth)	Point B (250 feet south of railroad bridge)	Point C (200 feet north of highway bridge)
1941	120 feet	70 feet	30 feet
1954	200 feet (meander migration)	70 feet	30 feet
1959	145 feet	150 feet	30 feet
1961	60 feet (stream was at flood stage and width was estimated)	65 feet	50 feet
1962	60 feet	65 feet	60 feet

The main portion of the stream migration study pertains to the measurement and plotting of various meanders and reaches in the area under investigation. By studying the dated aerial photography of the same area, the amount of active lateral bank erosion and stream bed shift could be ascertained for the period of years between successive photographic coverage. The magnitude and the location of active stream degradation was ascertained by this procedure and consequently traced from one photographic year to the next. Known data on two man-made features [Turkey Creek channel changes dated 1954 and 1961] which affected the stream's flow, allowed the correlation of the degradation activity and these man-made features.

By using some known stream elevations taken in the year of 1925 (bridge plans) and stream bed elevations taken in 1962, the stream bed profiles were estimated for each photographic year based upon stream banks sloughing and migration evidence obtained from the stereoscopic study of the aerial photographs.

Conclusions

In essence, the erratic nature of Turkey Creek in the area of Highway K-32 bridge in Wyandotte County can be for the most part contributed to the two channel changes. Degradation of the stream bed at the bridge site has been of greater magnitude during the past four or five months and consequently the abutments of the old bridge are in immediate danger. Once the old bridge abutments are removed by erosive action only a short period of high velocity water could undermine the earth embankments on which the present bridge is sitting. Preventive maintenance of placing rock rip rap around and under the bridge has been implemented at the time this report was written.

Similar action would have probably occurred in years to come; however, the abrupt change in stream gradient accelerated the erosive action.

Stream degradation will continue in Turkey Creek especially upstream. Active sloughing of fields has been detected to the north of the highway bridge and will continue to do so in months to follow.

To date most of the degradation of the stream channel has been in a fine sandy loam or a very easily eroded material. This fact helps to explain the high rate of erosive action during the past three years. Approximately 200 feet upstream from the highway bridge, the stream is now cutting a much tighter more cohesive clay to silty clay. Consequently the rate of degradation will become slower upstream and will extend over a longer period of time.

Bedrock is approximately 10 feet below the stream bed at the bridge site, therefore a great deal of degradation will take place before an even more resistive material will be encountered.

From studying the present stream profile, a prediction that continued degradation in and around the highway bridge can be made. This will probably be due to stream adjustment downstream (stream channel is 5 feet higher at the bridge than at the river) and not necessarily a direct compensation of the abrupt change resulting from the two channel changes. It is believed that the majority of the degradation resulting from the two channel changes has already occurred at the bridge and is now more active upstream.

On future projects when channel changes are contemplated, it is suggested that an investigation be undertaken to ascertain soil conditions, gradient change and possible results of the change in terms of damage to real estate, highway structures and other property.

Appendix D

Abridged Edition

Stream Degradation Study of Wolf Creek and Proposed Channel Change, Wyandotte County, Kansas

Introduction

This report presents information pertaining to a stream degradation study of Wolf Creek and a proposed channel change near Bonner Springs, Kansas. The channel change is a portion of the proposed K-32 highway improvement in this area.

The information presented herein was obtained through photographic interpretation and field investigations. Photographs dated July 1941 and March 1962 with scales of 1:12000 and 1:3,000 respectively were used in this study.

General Information

The location of the proposed channel change is on a meander of Wolf Creek on the southwest edge of Bonner Springs, Kansas. The K-32 alignment crosses Wolf Creek at two points. The purpose of the channel change is to avoid the construction of two structures over this stream and to provide fill material for the proposed roadbed.

Figure [23] illustrates the location of the proposed channel change in relation to the proposed K-32 centerline.

The Wolf Creek valley is approximately 1500 feet wide at this point. The valley plain is made up of alluvial silts and clays (plastic index 20 to 42) with glacial clays capping the valley walls to the north and south. The valley is approximately 45 feet deep. Bedrock is exposed on both sides of the valley. The location of the bedrock "break off" on the south side of the valley may be an important factor in the final location of the proposed channel change.

Four bridges cross Wolf Creek in this immediate area. The Union Pacific Railroad crosses Wolf Creek near the mouth of the stream. Two county roads [Points A and B, Fig. 14] cross the creek several hundred feet upstream from the mouth of the stream. The present K-32 highway crosses Wolf Creek more than a mile above the stream's mouth.

Farmland is located on both sides of the present stream's channel in this valley.

At least two terraces are present, the lower one being the best farmland. The lower terrace is also more silty than the upper terrace and consequently is more vulnerable to erosive action.

Present Stream Condition

During the past 22 years Wolf Creek has been a stable stream; that is, no major migration tendencies were detected. The channel is essentially as it was in 1941. Currently, some degradation is taking place in the channel. Active sloughing or lateral bank erosion has been detected in many places along the stream's banks. Figure [14] depicts some of the areas of active sloughing. The stream bed profile depicted several sharp breaks which coincide with the areas of active degradation or where bedrock is being encountered in the stream bed.

Bridge Structures

As mentioned above, four bridges are present in the immediate area of the channel change. The Union Pacific Railroad bridge is located near the Kansas River, the elevation of which controls the base level of Wolf Creek. Recently rip rap has been placed around the bridge. The structure is such that much debris has and will collect at this point. The stream is degrading several hundred feet upstream at a point that active sloughing is taking place.

The county bridge located at Point "A" is relatively new and appears to be in good condition. It will be approximately 700 feet downstream from the end of the proposed channel change. Both abutments are setting on alluvial deposits. No active degradation or sloughing was detected near this structure.

The county bridge located at Point "B" is an older structure. The south abutment has been rebuilt of concrete and the north abutment is stone and is believed to be the original abutment. The bridge is setting on approximately 13 feet of alluvial silty clay with a plastic index of 14 to 20. One hundred feet downstream is a major break in the stream's profile [Point C, Fig. 23]. This is caused by loose rock that has been placed there probably during the reconstruction of the south abutment of the bridge. Active bank sloughing is present downstream from this point. Also active bank sloughing was detected approximately 400 feet upstream.

The K-32 bridge is located well over a mile upstream from the channel change site. The stream's channel encounters bedrock in two locations between the channel change site and this bridge and should any degradation take place as a result of the channel change, the bedrock will contain this activity.

Stream Degradation Study

The area of main concern in this study is the meander of Wolf Creek south of Bonner Springs near which the intersection of K-32 and the Loring spur will take place and the channel change is proposed. Figure [23] depicts the general relationship of the above. The proposed channel change would cut off the upper portion of this meander and would eliminate two bridge structures on the same; however, some form of drainage would have to be provided for approximately 50 acres drained by the gully depicted at Point "D" on Figure [23].

The fact that a slaughterhouse located at Point "E" [Fig. 23] empties sewage in the present Wolf Creek channel will present a sanitation problem since this point will be bypassed after the channel change is operational. If the channel change is completed, this problem will demand special consideration since the Highway Commission may be held liable for the resulting sanitation problem.

The channel change itself will cause detrimental effects on surrounding farmland and bridge structures. It is impossible to place a definite time element to this action but by observing the present condition of the stream channel and comparing it to the condition of the stream bed as a result of the channel change, it can be ascertained that some damage will be incurred. This is especially true where active lateral bank erosion is now taking place.

It is believed that such action will be at a slower rate than that of Turkey Creek [Wyandotte County, Memorandum dated September 1962] because of the more cohesive material and the presence of bedrock.

A major break in the original profile is present at Point "C" [Fig. 23]. This break is immediately downstream from the county bridge depicted as Point "B" on the enclosed illustration and immediately above the start of the proposed channel change. The break is caused by rock and rubble that has been placed in the stream at that point and is not a permanent condition. This was ascertained by limited drilling in this vicinity. Once the rock and rubble is removed by higher velocity water currents, the bridge in question would be in jeopardy. The channel change will shorten the channel by approximately 1,300 feet and consequently steepen the stream gradient immediately below the break in the stream bed profile at Point "C". The stream's meander is approximately 2,300 feet long with a 6-foot difference in elevation within this distance. The channel change will be approximately 950 feet long with the same 6-foot difference in stream elevation within its length. Unless there is some type of "check" in the resulting erosive action, the stream will degrade to a lower level (approximately 5 feet) at the site of this bridge which would, no doubt, cause the collapse of the structure. Sloughing of stream banks would result as far as 1,300 feet upstream where bedrock is encountered. The bedrock will tend to stabilize this condition. However, due to the increase in stream current velocity as a result of the channel change, there is a high probability that lateral bank erosion will take place above this point especially in areas where bank sloughing is now active.

Some scouring action may take place downstream as a result of the increase in velocity of the stream's current, but due to the proximity of the stream's mouth, this erosive action will not be of the same magnitude as similar action upstream.

From the information obtained from the soil survey, it can be surmised that the channel change as surveyed in the field is located near the break off of the bedrock. No detailed geological investigation has been accomplished.

The upper 15 feet of the material is a tight cohesive clay (glacial till) and the lower 15 feet is a less cohesive silty clay. This condition is conducive to the undercutting of the overlying clays. This condition exists in some areas along the present channel which helps to explain some of the present bank sloughing. Also with the presence of bedrock to the south, the stream degradation will be forced to the north in the silty clays which is a less resistive material than the bedrock. This will be especially true if the channel change is located at any one point on the break off of the bedrock. An approximate bedrock "break off" is depicted on Figure [23]. This line is generalized since no definite information could be obtained at this time. The break off will be further north at greater depths.

It is anticipated that bedrock will be encountered on the east end of the channel change and will be in alluvial deposits on the western end of the channel.

It is suggested that if the channel change is made, a detailed geological investigation be made to determine the exact break off of bedrock at the elevation at which the bottom of the channel change will be placed. Also it is believed that the channel change should be placed on bedrock for the entire length of the channel to stabilize the resulting scouring action and to prevent the stream action from cutting a new channel to the north if bedrock is encountered on only a portion of the proposed channel. This would entail moving the channel to the south on the western end of the proposed centerline as depicted on Figure [23] as an alternate line. This line may have to be curved to the south to encounter sufficient bedrock for this purpose. This should be done only if bedrock is present along the entire proposed centerline on the channel. Otherwise the resulting straighter stream channel will have a faster current veolcity and will have a greater scouring potential than the original proposal.

Appendix E

Abridged Edition

Condition Survey of the Kellogg Bridge Deck, Wichita, Kansas, by Photographic Interpretation Procedures

Introduction

The purpose of this report is to present the procedures and problems that were encountered during the process of delineating first and second generation patches on the Kellogg Street bridge deck in Wichita, Kansas. This study was accomplished for the Research Department of the State Highway Commission of Kansas in order to obtain a permanent record of the bridge deck condition at the time of the most recent photography.

Three sets of photography were utilized for interpretation purposes; two that were taken by the K-22 camera with scales of 38 feet and 56 feet to one inch and one set taken by the Wild RC-8 with a scale of 90 feet to one inch. Henceforth, this photography will be referred to as follows:

Set A	K-22	Scale 56 feet to 1 inch
Set B	K-22	Scale 38 feet to 1 inch
Set C	RC-8	Scale 90 feet to 1 inch

Date of Photography - August 1961.

Procedure

Initially, the mapping of the bridge deck took place on photographic enlargements (scale approximately 25 feet to one inch). A great deal of difficulty was encountered during this process and the anticipated accuracy of the finished product was below expectations.

In order to utilize Set C photography and be able to map at a large scale, it was decided to utilize the Kelsh plotter. Field control was run and additional control was obtained from the plans of the bridge. If the deck is to be mapped in the future, all control is filed in the photographic interpretation files.

Five stereoscopic models were required to obtain full coverage of the bridge deck.

The bridge deck was mapped at a scale of 20 feet to one inch. Different colors were used to depict the different generations of patches and the original bridge deck. Approximately nine days were required to complete the project with the Kelsh plotter.

Procuring Desired Photography

The initial problem was to obtain large scale photography. A scale of 25 feet to one inch was believed to be large enough for road condition surveys. The maximum scale that can be obtained with the State Highway Commission's Wild RC-8 (6" focal length) camera is 100 feet to one inch and still obtain good quality photography and be above the minimum legal flight height. In order to obtain the desired scale photography, the Photogrammetry Section borrowed a K-22 Air Force Camera and a 24-inch focal length cone from the Kansas Air National Guard. Using this focal length, the aircraft would have to fly a flight height of 600 feet which is above the minimum legal height to obtain photography at the scale of 25 feet to one inch. Through trial and error procedures, it was discovered that good quality photography can not be obtained at such low altitude because of image movement and limitations due to hyperfocal distance specifications of the 24-inch focal length cone. By conforming to the specifications of the cone, it was discovered that the minimum flight height for obtaining good quality photography was 1800 feet. At this height a 24-inch focal length camera would take photography at a scale of 75 feet to one inch compared to 100 feet to one inch that can be obtained by using the Wild RC-8 Camera. Since the K-22 photography is inferior to the RC-8 photography and only a minor difference exists in the scales, the latter was selected for interpretation purposes.

For a detailed account of the testing results of the cameras, the author makes reference to Photogrammetry Section's "Memorandum to the Files" dated 23 August 1961.

It is believed more tonal contrast can be observed with photography taken at noon or when the sun's rays are nearly normal to the bridge deck. Set B is the only group of photographs that were taken at approximately 12:00 noon. Set A was taken at approximately 10:30 a. m. and Set C was taken earlier in the morning.

Photography Sets A and B are blurred because of image motion and improper focusing of the lens. However, much information was derived from both sets of photography because of the larger scales and the better lighting conditions at the time the photography was taken.

Set C photographs are sharp and have good contrast but have smaller scale and poorer lighting conditions. This scale was too small to make a direct tracing of the patch system since the smaller patches were too small to be a mappable unit.

Photography Sets A and B were printed on glossy, single weight, paper while Set C was printed on semi-matte, single weight, paper. The glossy print is believed to be better for interpretation purposes. All three sets were used during the mapping process.

Photographic Interpretation

Initially it was thought the interpretation aspects would be a relatively simple operation if the photographs would depict the patch boundaries. Actually if the patches were clearly defined no interpretation would be necessary. The process would involve only the tracing of the patch boundaries from the photographs to the base map. Most of the patch boundaries are distinguishable but erroneous results can be obtained because of two reasons. (1) The first and some of the second generation patches have acquired a tone similar to that of the bridge deck through wear and "road scum". (2) The "road scum" acts as a blanket, thus covering up the patches' boundaries and form "pseudo" boundaries which depict the limits of the blanket. This is especially evident in the outboard lanes.

Three clues were utilized to detect and differentiate the "road scum" effects from the true patch boundaries. (1) The "pseudo" boundaries appeared more erratic and lacked the methodical pattern that the patch work system depicted. (2) The "pseudo" boundaries would often cross or extend through distinguishable patch boundaries. (3) The "road scum", while having a definite boundary at one point, would blend into the adjacent tone of the patches or bridge deck elsewhere.

Anticipated Accuracy

Accuracy of the completed product is contingent upon three factors. (1) The accuracy with which the Kelsh plotter was set up. (2) The placing of the floating dot on the Kelsh plotter by the plotter interpreter. (3) The selection of the patch boundary by the photographic interpreter.

Because of the amount of control that was available for the Kelsh plotter "set up", the inaccuracies resulting from the first factor would be nominal. It is believed inaccuracies resulting from the second factor would be insignificant as far as the overall accuracy of the map is concerned. The majority of the percentage of error present in the completed product can be attributed to the third factor. This is only true where the patch boundaries are not well defined on the aerial photographs. In essence, the inaccuracies of the completed map exist in areas where the patch boundaries are not clearly defined on the aerial photographs.

The author can not place a percentage reliability factor on the map since no true comparison of the actual bridge deck can be made. A verbal description of the accuracy of the finished product is presented giving approximate percentage values of the different sections of the bridge using the sections where the patches are clearly defined as a basis for comparison. Information from field notes was also used in the evaluation of the map's accuracy.

Outboard Eastbound Lane -	Two generations of patches. 1st Generation From the west abutment to Station 132 + 80, fair accuracy, at least 70% of the patches are accurately placed. Not all patches were detected. From Station 132+80 to Station 137+30, poor to fair accuracy, probably not more than 50% of patches accurately placed. Extreme difficulties in interpretation. From Station 137+30 to Station 140+15, same accuracy as first section. From Station 140+15 to east abutment, patch boundaries are accurately placed. 2nd Generation All patches are accurately placed.
Inboard Eastbound Lane -	One generation of patches. All patches are accurately placed.
Inboard Westbound Lane -	One generation of patches. All patches are accurately placed.
Outboard Westbound Lane -	One generation of patches. West abutment to Station 140+50, fair accuracy, at least 70% of patches are accurately placed. From Station 140+50 to east abutment, all patch boundaries are accurately placed.

Recommendations

If similar projects are to be undertaken in the future, the following recommendations are suggested:

1. Photography should be taken near noon time using the State Highway Commission's Wild RC-8 camera.
2. The Kelsh plotter should be utilized to map the patch boundaries.
3. Color photography should be utilized for interpretation purposes, if the project is as complex as the Kellogg Boulevard bridge deck.
4. All work should be continuous on such projects. This project was spread over a year's time. The full benefit of the field work was partially lost and each renewal of the project necessitated a review of work already accomplished.