State of Illinois
DEPARTMENT OF PUBLIC WORKS AND BUILDINGS
Division of Highways
Bureau of Research and Development

DRILLED-HOLE LIME TREATMENT OF FILL

Final Report

by
R. H. Mitchell

A Research Study

by

Illinois Division of Highways
in Cooperation with
U.S. Department of Transportation
Federal Highway Administration
Illinois Division

March 1971

DRILLED-HOLE LIME TREATMENT OF FILL

ABSTRACT

This is a final report of a study of drilled-hole lime treatment of existing fill to stabilize slumping before widening and resurfacing. The study tested the theory that dry hydrated lime tamped in holes drilled at five-foot centers in both shoulders would stabilize the fill sufficiently to support the added width and weight.

The objective of prompt treatment of fill to permit immediate rehabilitation was met quite successfully. However, the widening strip has settled in local areas.

Laboratory tests of soil samples taken near the lime-filled holes one and three years after treatment indicated little strength gain and continued to indicate seasonably high moisture contents. Apparently a greater contact area between the soil and the lime is needed for uniform stabilization than was provided by the drilled holes at five-foot spacing as used in this study.

SUMMARY

This report relates a demonstration-type study in which an old embankment was given a drilled-hole lime treatment for stabilization before widening and resurfacing. The old fill was the approaches to bridges over the Big Muddy River and Pond Creek on Route Ill. 148 north of Herrin. The treatment was accomplished by a State of Illinois, Division of Highways Day Labor crew from mid-April through May 1964.

The drilled-hole method was chosen because of the possibility it offered for quick, deep stabilization with a minimum of disturbance to traffic on the route. There appeared to be immediate improvements that aided the reconstruction, but subsequent localized settlements along the widening strips during succeeding years indicated insufficient uniformity of load carrying capacity.

Laboratory tests of soil samples taken in the spring before and in years after treatment revealed little change of moisture content, compressive strength, or calcium ion content of undisturbed soil. The five-foot spacing of holes apparently did not provide sufficient lime-soil contact for full utilization of the lime's strength gain capability.

DRILLED-HOLE LIME TREATMENT OF FILL

INTRODUCTION

The drilled-hole lime treatment that is the subject of this report was applied prior to pavement widening and resurfacing in a gumbo-like fill area with a long history of slumping and pavement settlement. The fill was constructed in 1932-1934 in a bottomland area from adjacent borrow pits using draglines and bottom-dump wagons. As was the practice at that time, the fill was water-soaked to induce settlement.

The drilled-hole lime treatment was accomplished by a State of Illinois, Division of Highways Day Labor crew from mid-April through May 1964. The base widening and bituminous-concrete resurfacing that followed were constructed later in the year by a private contractor.

The drilled-hole lime treatment was chosen because of the possibility it seemed to offer for quick stabilization with a minimum of disturbance of traffic on the route as compared with alternate mixing methods. Increased strength of soil was anticipated adjacent to holes, and the improved vertical drainage was expected to aid in the stabilization of the fill by faster dry-out.

Because of the present limitations of knowledge of the effectiveness of the drilled-hole lime treatment as a means of fill stabilization, an experimental program including a control section was established for the planned construction operation to add to the information available regarding this treatment.

The objective of prompt treatment of the fill to permit immediate rehabilitation was met quite successfully; however, the widening strip has settled in a few local areas. Follow-up laboratory testing of soil samples taken near the lime-filled holes at one year and three years has indicated little strength gain and

has continued to indicate seasonally-high moisture contents.

The construction area consists of the fill approaches and one mile of fill between the bridges over Big Muddy River and Pond Creed (Figures 1 and 2).

The north end of the fill (142+00 to 152+40), which previously had been reconstructed to a 22-foot width with an 8-inch PCC base course and 3-inch I-11 surface course, was selected as a comparison section.

Another comparison area selected was the next upstream highway fill for Route Illinois 149 across the Big Muddy River floodplain. The higher portions of this fill showed evidence of occasional subsidence similar to that of the test area. Other portions of this fill had the shoulders widened and strengthened by selected borrow and mechanical stabilization in 1954.

CONSTRUCTION

Two typical cross sections of the completed test area are included as Figures 3 and 4. Hydrated lime was tamped into holes drilled in the shoulders at 5-foot centers. The outer row of 12-inch diameter holes in each shoulder was established 10 feet from the old pavement edge. Other rows of holes were drilled 5 feet from the edge and at the pavement edge with the holes of adjoining rows in a diagonal pattern. For 150 feet each way from the two bridges, 6-inch holes 39 inches deep were made by star drill and auger through the pavement near the center of each lane and at the centerline of the pavement at 5-foot intervals (Figure 5). The depth of holes in the outside row in the shoulders ranged from 2 1/2 to 27 feet. Their depths were determined by depth of fill plus approximately 1 foot. This depth was easily recognized by a layer of black high-organic muck from the buried topsoil and humus of the swampy timbered area. The other rows of holes in the shoulders were 39 inches deep.

All holes were backfilled immediately after drilling with powdered hydrated lime. The lime was tamped with a pole and covered with a conical mound of clayey peelings from the auger. It was noted that 100 pounds of lime were required to fill each 6-foot hole where the crew was working with Day Labor's drill 245A, a hydraulically operated Sterling Engineering and Manufacturing Company's Model GO (Figure 6), on the 5-foot fill on the west shoulder north from the Pond Creek bridge. This drill could be power-adjusted to either side or center-rear of the truck. Reports indicate that 600 tons of hydrated lime were used to treat the 1.5 miles of fill at a cost of $58,000. All lime used on the project was manufactured by Mississippi Lime Company, of Alton, Illinois, and supplied under the trade-name Peerless.

Other major items of equipment used on the job were:

(1) A chain drive, cable-lift Williams Hole Digger, Model PD-H2, with a 26-foot reach

(2) A chain-drive, chain-lift Williams Hole Digger, Model ADE-3, with an approximate 26-foot tower on a truck

(3) A star drill on tractor-mounted Schramm air hammer

The drilling crews at first had difficulty getting the augers to shed the wet clay. This problem was helped by dusting hydrated lime on the auger and into the hole while drilling as shown in Figure 7.

The cone-shaped piles of clayey auger peelings over the lime-filled holes (Figure 8) showed considerable granulation and settlement into the holes following several heavy rains during the last two weeks of April. When the wheels of a motor patrol were run down the rows of settled piles, the excess soil was pressed into the holes or spread to near the original elevation with slight ridging and rutting.

The predominant soil types of the fill and adjoining borrow areas are Okaw silt loam and Colp silt loam. There are bands of Beaucoup silty clay loam at the bridge approaches where the fill is highest.

EVALUATION

A condition survey of the existing pavement was made in April 1964, from Station 140+00 to 233+00. The previously reconstructed section between 140+00 and 152+40 was selected as a comparison section for the reason that the improvement had not included lime treatment. However, the earlier decision not to extend the reconstruction without lime treatment beyond 152+40 was based on the recognition that the higher fill south of that point had a greater requirement for stabilization. The tabulation of cracking and patching for the determination of the Present Serviceability Index at the beginning of the work in April 1964, was divided into the subsections of original construction Sections 129 and 129X for comparisons of fill height and distress. The roughness indexes from roadometer tests made on May 5, 1964, indicated several subsections of higher fill to have over 300 inches of roughness per mile, a completely unsatisfactory degree of roughness. This degree of roughness, combined with the severe cracking and patching, determined several P.S.I.'s of less than 1.0 and a few that were negative values.

A post-reconstruction roadometer test in January 1965, following resurfacing gave roughness indexes of near normal to slightly rough for new resurfacing averaging 79 inches per mile. November 1966 recordings revealed only slight changes in the traffic wheelpaths over the old slab. The 3-foot widening strips have been tested to evaluate their settlements compared to wheelpaths over the old slab. The raw data on field sheets appear to be significantly rougher over the widening strips.

A condition survey made in June 1965, revealed no signs of distress severe enough to lower the P.S.I. The only reflection cracking was for 35 feet over the longitudinal joint of the southbound lane between the old pavement and the widening strip on the west side of the Pond Creek bridge.

A condition survey made in October 1966, showed occasional settling of the widening strip and the accompanying longitudinal joint reflection crack but little else to lower the P.S.I. value. The treated section showed reflection cracking over 11.7 percent of the total length of widening joint and noticeable settlement of 4 percent of the widening strip. The comparison section on Route Illinois 149 showed reflection cracking over 12.5 percent of the total length of widening joint but no noticeable settlement of the widening strip. The comparison section between 140+00 and 152+40 with its full-width construction had no cracking or settlement.

In 1968 and 1969 the Roadometer tests and observations indicated that the uneven subsidence of the resurfaced widening strips had continued substantially. Corrections required approximately 4,000 square feet of leveling cold mix material from 1 to 3 inches thick. This distress was concentrated on the higher fill portions. During August 1969, following some heavy rains, there was continued massive slumping and outward movement of a portion of the east shoulder north of the Big Muddy River bridge. This further slippage along a slide plane, noticed and repeatedly repaired over a twenty-year history, did not appear to have been affected by the drilled holes or the lime treatment unless the affect has been to delay somewhat.

Soil test data were processed from Shelby tube samples taken at representative locations of the fill and borrow area in February 1964, prior to the treatment. These samples at various profile depths showed moisture contents ranging from 24 to 41 percent and unconfined compressive strengths ranging from 0.8 to 4.1 tons

per square foot. Wet weights ranged from 97 to 129 pcf. LL values in the upper 3 feet of fill ranged from 49 to 73, and PI values from 30 to 52 prior to lime treatment. Follow-up sampling near the same location in May 1965, approximately 12 months after lime stabilization, yielded values of somewhat greater wet density and average moisture contents 3.5 percent higher. Compressive strengths averaged lower (1.0 vs 2.0 tons per square foot), and LL and PI values averaged approximately 5 points lower. Spring rains prior to collection of follow-up data in May 1965, may account for higher moisture contents than those measured in February 1964. Further testing was planned on a winter and spring basis.

Calcium ion content tests of soil samples taken prior to and a year after treatment reveal little change due to lime migration during the first year after treatment. Gradation, bearing ratio, and swell tests were conducted on soil taken from the high fill area prior to treatment but have not been repeated on soils taken following treatment.

CONCLUSION

The objective of prompt treatment of the fill area to permit immediate widening of the pavement and shoulders was met successfully. Localized settlements that have occurred in the widening strip show the treatment not to have been completely successful as a stabilization procedure. Apparently, a greater contact area between the soil and the lime is needed than was provided by the 5-foot spacing of drilled holes which was used in this study.

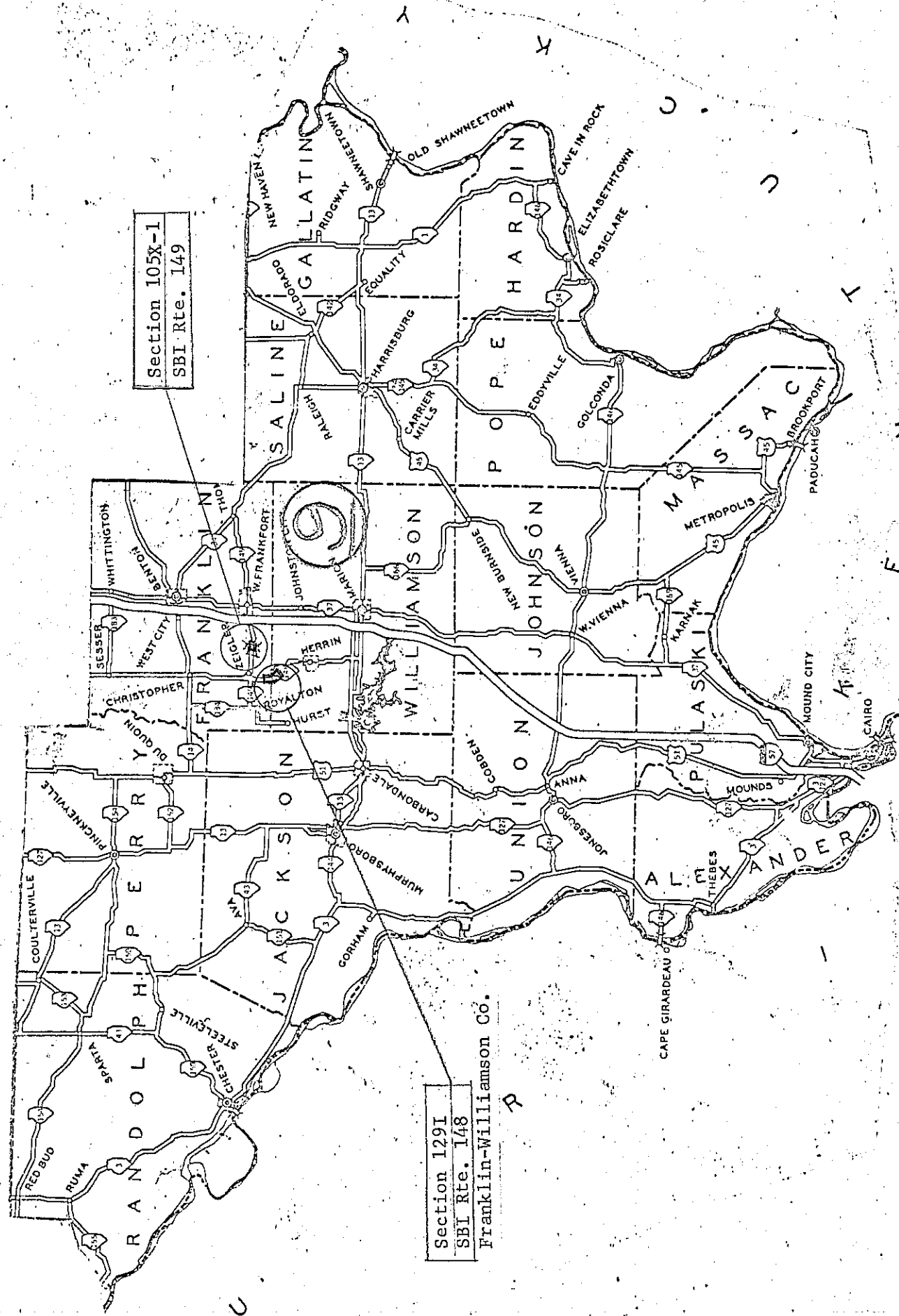


Figure 1. General Locations; Lime Stabilization of Fill and Comparison Sections.

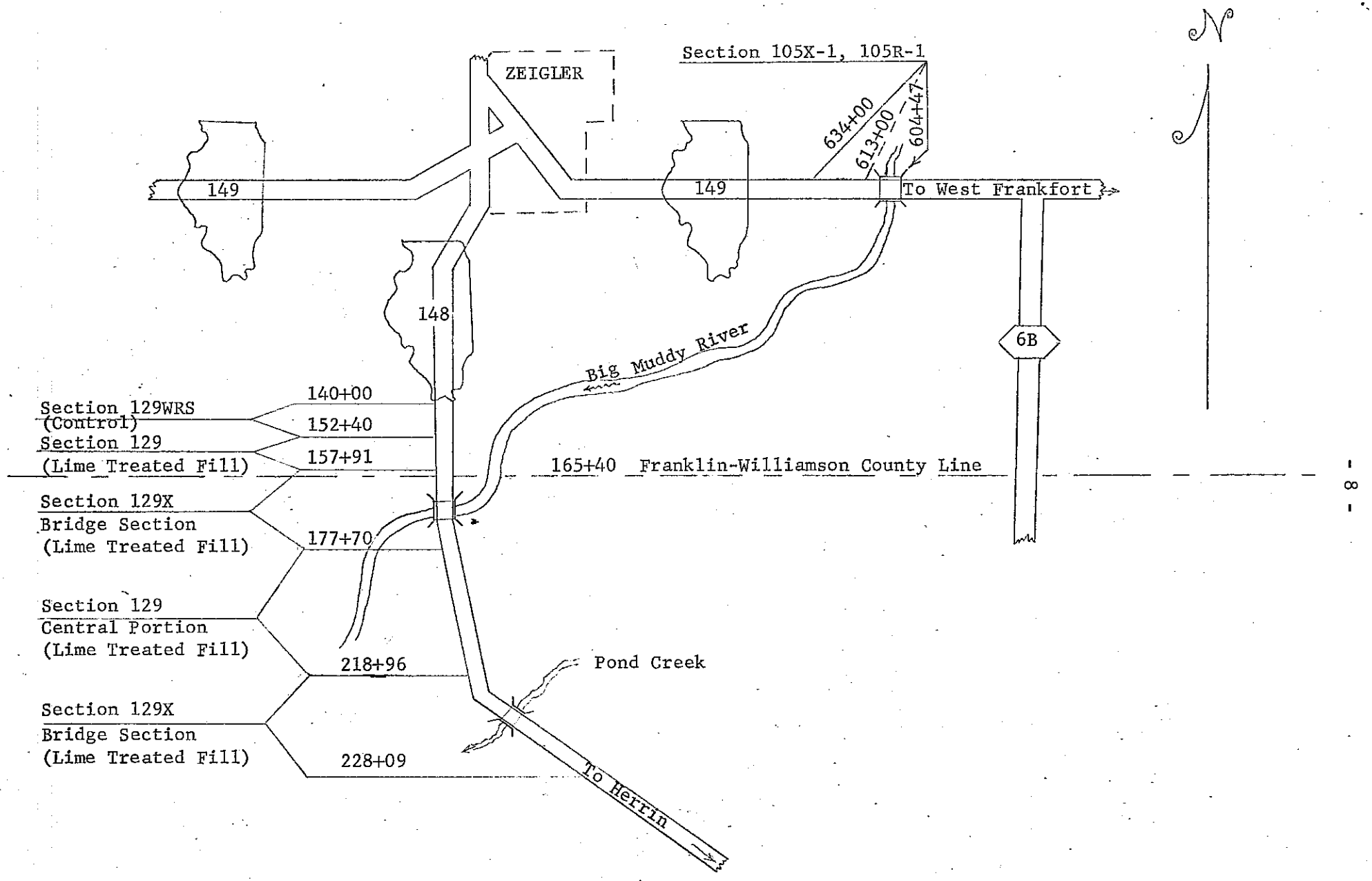
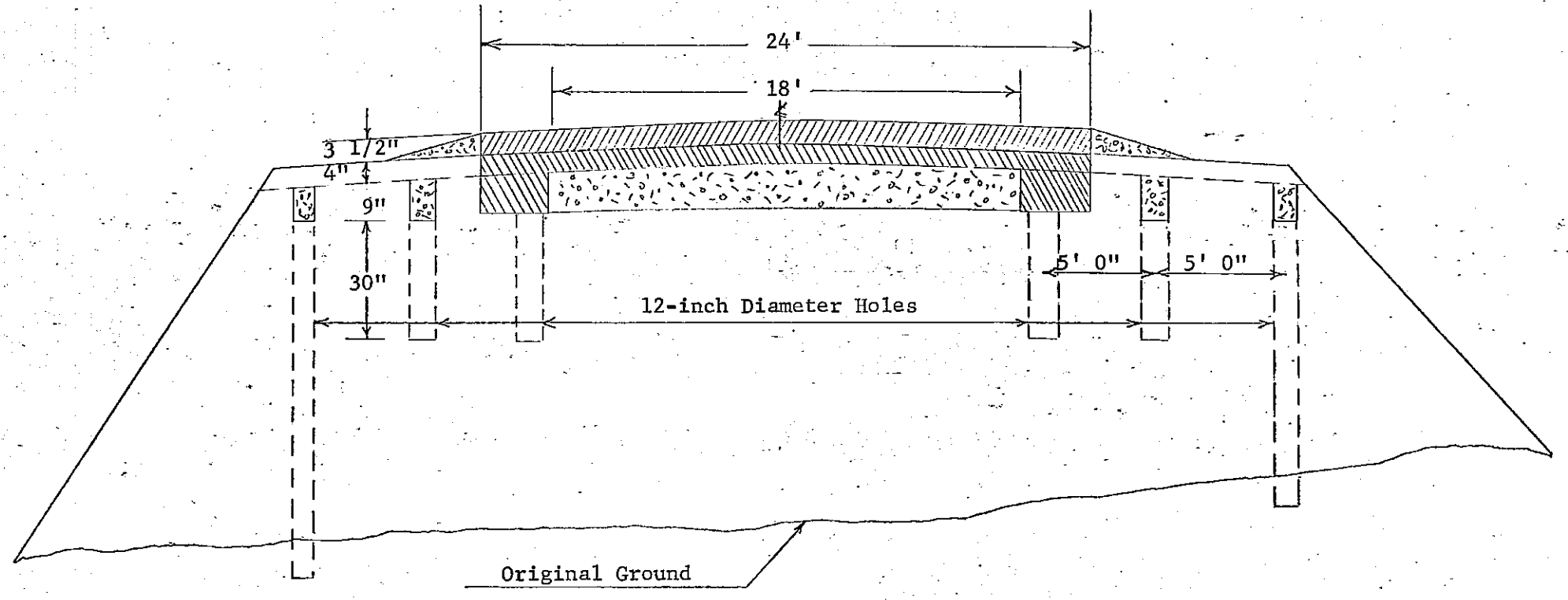


Figure 2. Subsection Locations: Drilled-hole Lime Stabilization of Fill.

TYPICAL SECTION NUMBER 1

Sta. 150+00 to 169+95
Sta. 177+45 to 220+41
Sta. 225+19 to 231+00



Bituminous Concrete - Subclass I-11

Bituminous Concrete - Subclass B-5

2.5' to 23.5' Hydrated Lime Backfill

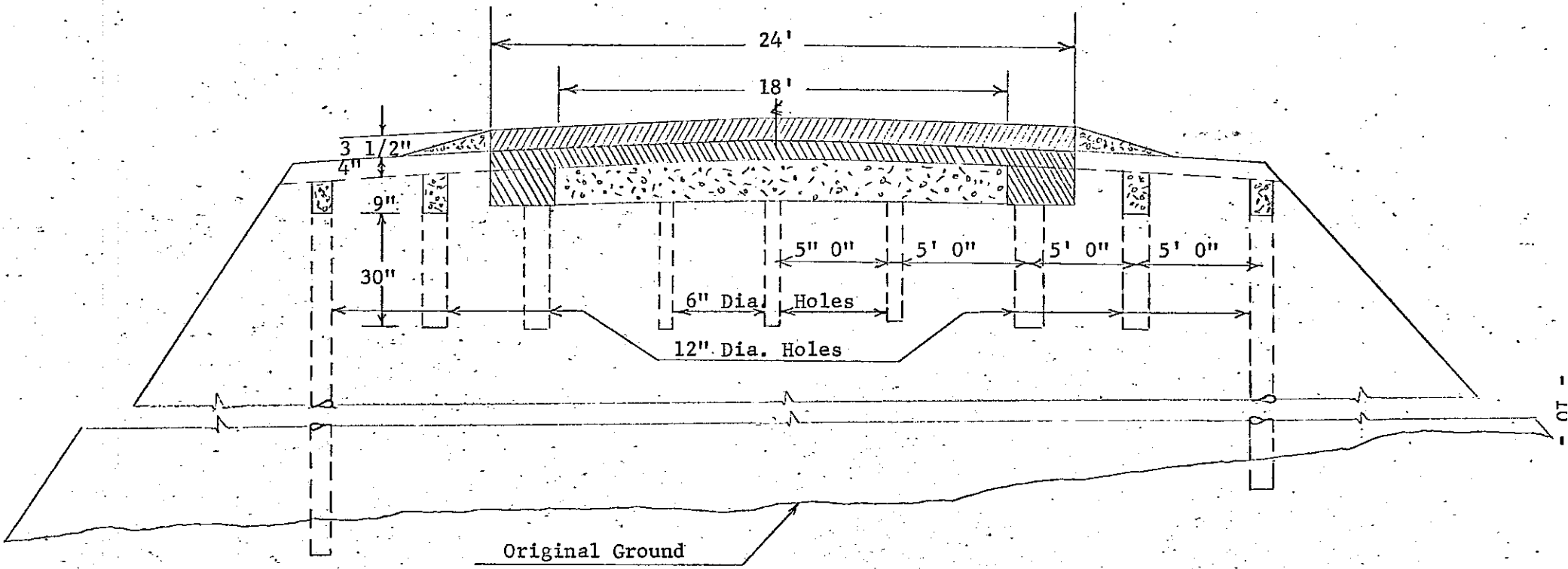
9" Earth Backfill

Note: All holes are on 5' centers and symetrical above centerline.

Figure 3. Design for most of fill.

TYPICAL SECTION NUMBER 2

Sta. 169+95 to 171+45
Sta. 175+95 to 177+45
Sta. 220+41 to 221+91
Sta. 223+67 to 225+19



Bituminous Concrete - Subclass I-11

Bituminous Concrete - Subclass B-5

15' to 26.5' Hydrated Lime Backfill

9" Earth Backfill

Note: All holes are on 5' centers and symmetrical about centerline.

Figure 4. Design for high fill at bridge approaches.

Figure 5. Pattern of holes star-drilled in pavement at bridge approaches preparatory to boring 6-inch diameter holes 39 inches deep for hydrated lime.

Figure 6. Day Labor's drill 245A was used on all 39-inch depth holes and others to 6-foot depth.

Figure 7. Drilling crew dusted hydrated lime into hole and an auger to aid in keeping the clay from sticking to auger. The previous hole is being tamped with lime backfill.

Figure 8. Cone-shaped piles of clayey auger peelings were made over the lime filled holes.