



TRC1002

**Evaluation of High Performance Curing  
Compounds on Freshly Poured Bridge  
Decks**

Sarah Tamayo

Final Report

2012

Arkansas State Highway & Transportation Department

**Transportation Research Committee**

# **Final Report**

## **TRC 1002**

EVALUATION OF HIGH PERFORMANCE  
CURING COMPOUNDS ON FRESHLY  
POURED BRIDGE DECKS



# **Final Report**

## **TRC 1002 Evaluation of High Performance Curing Compounds on Freshly Poured Bridge Decks**

By

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Conducted in Cooperation with the U.S. Department of Transportation  
Federal Highway Administration

February 2012

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## Introduction Chapter 1

Shrinkage cracking is a critical factor affecting the durability of concrete bridge decks. On their own, these cracks are not typically large enough to compromise the structural integrity of the bridge deck, but the presence of these cracks does allow potentially corrosive substances to enter the interior of the bridge deck.(Poole, 2005) Accelerating deterioration of the concrete and reinforcement, thus reducing the life span of the bridge.

The four main types of shrinkage cracks that occur in concrete are autogenous, plastic shrinkage, drying, and carbonation. Autogenous shrinkage cracks are caused by the consumption of water during the hydration process. Drying shrinkage cracking takes place when water is lost from hardened concrete. Carbonation shrinkage occurs when carbon dioxide and a hydroxide or oxide within the concrete paste reacts to form a carbonate. Plastic shrinkage cracking occurs when water is lost from the surface of freshly poured concrete pavement. This research will focus on plastic shrinkage cracking and is a continuation of the laboratory work completed in TRC 0603.

Plastic shrinkage cracking is the most common type of cracking to occur in concrete pavement. These cracks may manifest in two different forms. The first form of cracking is large, shallow, well-spaced, parallel cracks. The second form of cracking that occurs is a shallow, fine, map cracking pattern. The map type cracking pattern is difficult to see on concrete where tining has been introduced. (Poole, 2005)

Curing compounds can help reduce the amount of shrinkage cracking. Selection criteria for curing compounds can include water retention, pigments, drying time, amount of solids, volatile organic compounds, coating, and viscosity.(Poole, 2005)

Standard curing compounds typically require the addition of water throughout the curing process. The additional water is typically added through the application of wet burlap, insulation blankets, or misters to keep the surface of the concrete hydrated. Though wet burlap or insulation blankets are typically used, their installation process is labor intensive and time consuming.(Cable, Wang, & Ge, 2003) Newer, high performing curing compounds (HPCC) may reduce the amount of shrinkage cracking in bridge decks as well as eliminating the need for the burlap, insulation blankets and misters. These HPCC, also referred to as shield-forming curing compounds, can be lithium-based, and do not require the same curing process as standard curing compounds.

Chemical admixtures are the most common uses of lithium in the construction industry. Lithium compounds such as ( $\text{Li}_2\text{CO}_3$ ,  $\text{LiOH}$ ,  $\text{Li}_2\text{SO}_4$ ) are used in the formulation of set accelerators for calcium-aluminate-cement concrete. Lithium hydroxide monohydrate ( $\text{LiOH}\cdot\text{H}_2\text{O}$ ) and lithium nitrate ( $\text{LiNO}_3$ ) have been used to control alkali-silica reaction in Portland cement concrete.(Thomas, 2007)

## **Literature Review Chapter 2**

Numerous factors affect the occurrence of plastic shrinkage cracking in concrete pavement. Plastic shrinkage cracks occur when water evaporates from the surface of freshly placed concrete faster than it is replaced by bleed water from below. These cracks normally occur in flatwork but may occur in beams and footings. Other factors that can affect plastic shrinkage cracking include water-cement ratio, fines content, member size, admixtures and building practices on-site.(Uno, 1998)

The two major factors that affect plastic shrinkage cracking is time of application of the curing compound and the type of curing compound or system used. Time of application of a standard curing compounds or HPCC is a critical factor affecting the plastic shrinkage cracking of a structure. Application of curing compounds should occur when bleeding is completed and the pavement initially sets. At that time, the surface sheen of the concrete will be dissipated.(Poole, 2005)

One newer type of product that has been developed is evaporation reducers. These products were developed to address conditions where evaporation rates are considered excessive. By frequently applying large quantities of evaporation reducers, the concrete is able to maintain the necessary water for the curing process. The application process for evaporation reducers is similar to that of curing compounds. The evaporation reducers are comprised of film-forming compounds in a water emulsion. The frequency of application is dependent on the application rate, evaporation rate of bleed water, and the bleed rate of concrete. A typical value for the application rate is 0.2 kilograms per square meter. Manufacturers of these products claim a fifty-percent reduction in evaporation.(Poole, 2005)

The Iowa Department of Transportation completed a study in 2003 that looked at three curing compounds: 1645-White, 1600-White, and 2255-White. Both 1645-White and 1600-White met ASTM specification Type 2 Class A and are both water based curing compounds. The third curing compound, 2255-White, met the ASTM specifications for Type 2 Class B and was a resin-based curing compound. All three of the products were produced by the W.R. Meadows Company. The study had five different test sections, including 600 linear feet of: 1645-White single application, 1645-



White double application, 1600-White double application, wet curing, and 2255-White single application. A sixth test section included 20 linear feet with no curing materials applied. Data collected during the curing process included concrete temperature, moisture content, conductivity, permeability, air temperature, wind speed, relative humidity, and cloud condition. The project concluded that the 2255-White, the resin based curing compound, was less desirable due to the difficulties in handling and distributing. From the results of the conductivity test, it was concluded that the most effective material was the wet cure followed by the double application of 1645-White. The temperature control of the surface concrete with the curing methods showed that the wet curing was the most effective followed by the 2255-White.

The Hawaii Department of Transportation (HDOT) has used THE CURE from Sinak Corporation, a lithium-based curing compound. HDOT has used this HPCC on all of their concrete construction with great reported results. HDOT stated that “when applied properly, THE CURE was found to produce a much cleaner surface than standard curing compounds”. Very little, if any, dirt or mold was found to adhere to the concrete with little cure-related cracking.

Florida State University (FSU) conducted research evaluating the performance of three different curing methods. The three methods used were lithium-cured, sodium silicate cured and air cured. The concrete for the project was supplied by a local batch plant and had a design strength of 4,000 psi. The curing process took place inside a FSU laboratory, where three industrial fans were used to produce high evaporation rates. A total of five concrete slabs, three measuring 6 ft x 6 ft x 6 in and two measuring 6 ft x 6 ft x 4 in, were used in the evaluation of the curing treatments. Slab one

(6 ft x 6 ft x 4 in) was treated with lithium-cure six hours after casting the slab. Slabs two (6 ft x 6 ft x 6 in) and three (6 ft x 6 ft x 4 in) were permitted to be air cured. Slab four (6 ft x 6 ft x 6 in) was cured using sodium silicate thirty minutes after casting. Slab five (6 ft x 6 ft x 6 in) was treated with lithium-cure thirty minutes after the slab had been cast. All slabs were instrumented to monitor moisture content, relative humidity, and temperature throughout the curing process.(Tawfig & Armaghani, 2011)

A micrographic evaluation was conducted on all five slabs after the conclusion of the curing process. No cracks were observed on slab five, the slab cured with the Lithium curing compound thirty minutes after casting. Slab one, which was treated with the lithium-cure six hours after casting, did contain microscopic cracking. The two air-cured slabs developed cracking throughout the surface. These cracks, many of which were visible with the naked eye, started appearing early in the curing process. Slab five maintained the highest moisture and humidity levels for the greatest period of time. The sodium silicate slab, slab 4, maintained the second highest moisture and humidity levels.(Tawfig & Armaghani, 2011)

The report concluded that the lithium and silicate curing compounds reacted with the free  $\text{Ca(OH)}_2$  at the surface of the pavement, and thus created a protective layer that extended the hydration on the surface of the pavement. The report also concluded that "Lithium cure will most likely mitigate, if not eliminate plastic and drying shrinkage cracking in newly cast concrete slabs and decks". The use of lithium-based curing compounds helped to maintain the moisture and temperature during the curing of concrete, which allows the hydration process to continue over an extended time period. (Tawfig & Armaghani, 2011)

## **Work Plan Chapter 3**

The primary objective of this research project was to determine if HPCCs can reduce plastic shrinkage cracking when compared to standard curing methods. Testing of the HPCC was conducted on freshly placed bridge decks that were monitored to determine the effectiveness of the HPCC in reducing shrinkage cracks. The work plan was divided into three tasks. Task one included conducting a literary review on HPCC. Task two identified suitable bridges to field test the HPCC, which was identified in task one. Task three was the construction and treatment of the bridge decks with the HPCC. The bridges were divided into two sections, a control and a test section. The control sections were cured using standard methods, which were already being used per the Department's current construction specifications. This included using a regular curing compound and covering the pavement with burlap to maintain surface moisture. On the test section the HPCC was used as a finishing aid prior to tining and application of a curing compound after the tining process, which was applied per the manufacturer's specifications. For the seal coat on the bridge decks the control sections were treated with boiled linseed oil and the test sections were sealed using the HPCC. Atmospheric conditions including temperature, relative humidity, wind speed and the evaporation rate were monitored and recorded during the bridge pour and during the curing process. Both the control sections and test sections were manually surveyed for shrinkage cracking. The secondary objectives of this project were to determine if HPCCs are more economical than standard curing methods and easier to use than standard curing compounds. THE CURE from Sinak Corporation was chosen as the HPCC for evaluation on this project.

## Site Location and Construction Information Chapter 4

There were four bridges evaluated as part of this research project. Three of the bridges are located in Southwest Arkansas and the fourth bridge is located in Northeast Arkansas. The projects were selected in an attempt to try and include all climatologically relevant conditions in Arkansas. However, due to time constraints, a bridge deck pour during winter conditions was unavailable. It was hoped that there would be high evaporation rates during the bridge deck pours; unfortunately, the highest evaporation rate obtained during the project was 0.3 lb/ft<sup>2</sup>/hr.

The first of the four bridges is located in Hope Arkansas on Highway 278 overpass of Interstate 30. The job number for the project was 030350. The westbound lanes were poured a year prior to the research project and were not included in this project. The test section included the two eastbound lanes and center two-way left turn lane (TWLTL) and was placed on September 2, 2009. The total length of the bridge is 288 ft and the width of test section for this bridge is 35 ft. The western halves of the eastbound lanes were cured using the HPCC and the eastern halves were cured using traditional methods. The average ambient air temperature was 63°F with a deck temperature of 70°F. The humidity at the time of the pour was 78% with a wind speed of 0.8 mph. The average evaporation rate during the pour was 0.02 lb/ft<sup>2</sup>/hr. There were no problems reported during the placement of the bridge deck.

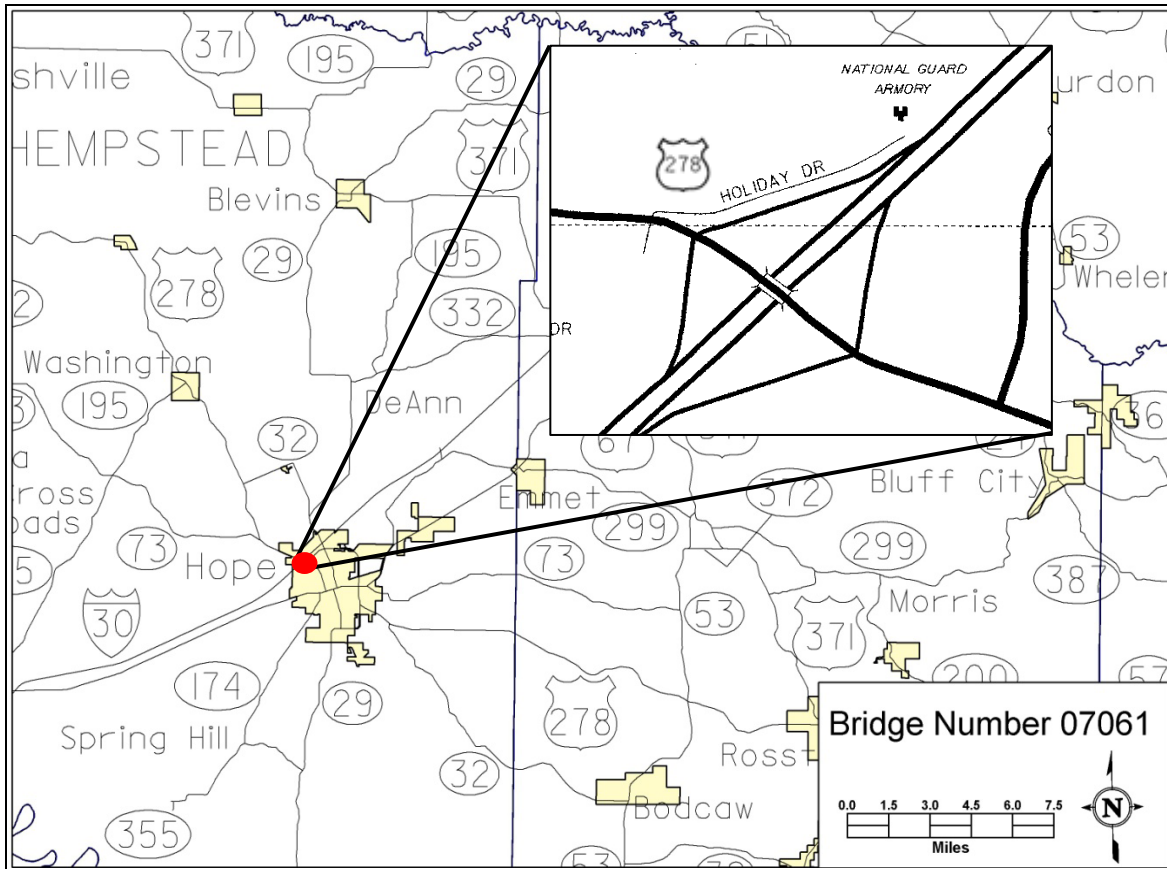


Figure 1 Location of bridge; Hope, Arkansas

The second of the four bridges is located in Texarkana, Arkansas on 19<sup>th</sup> Street over Highway 245. The job number for the project was 030341. The bridge deck was placed on September 2, 2009. The total length of the bridge is 248 ft with a width of 38 ft. The west half of the bridge was cured using the HPCC and east half was cured using traditional methods. The average ambient air temperature was 74°F with a deck temperature of 83°F. Humidity at the time of the pour was 52% with a wind speed of 4.5 mph. The average evaporation rate during the pour was 0.085 lb/ft<sup>2</sup>/hr. During the application of the HPCC, an excess amount was sprayed on the deck and some ponding occurred.

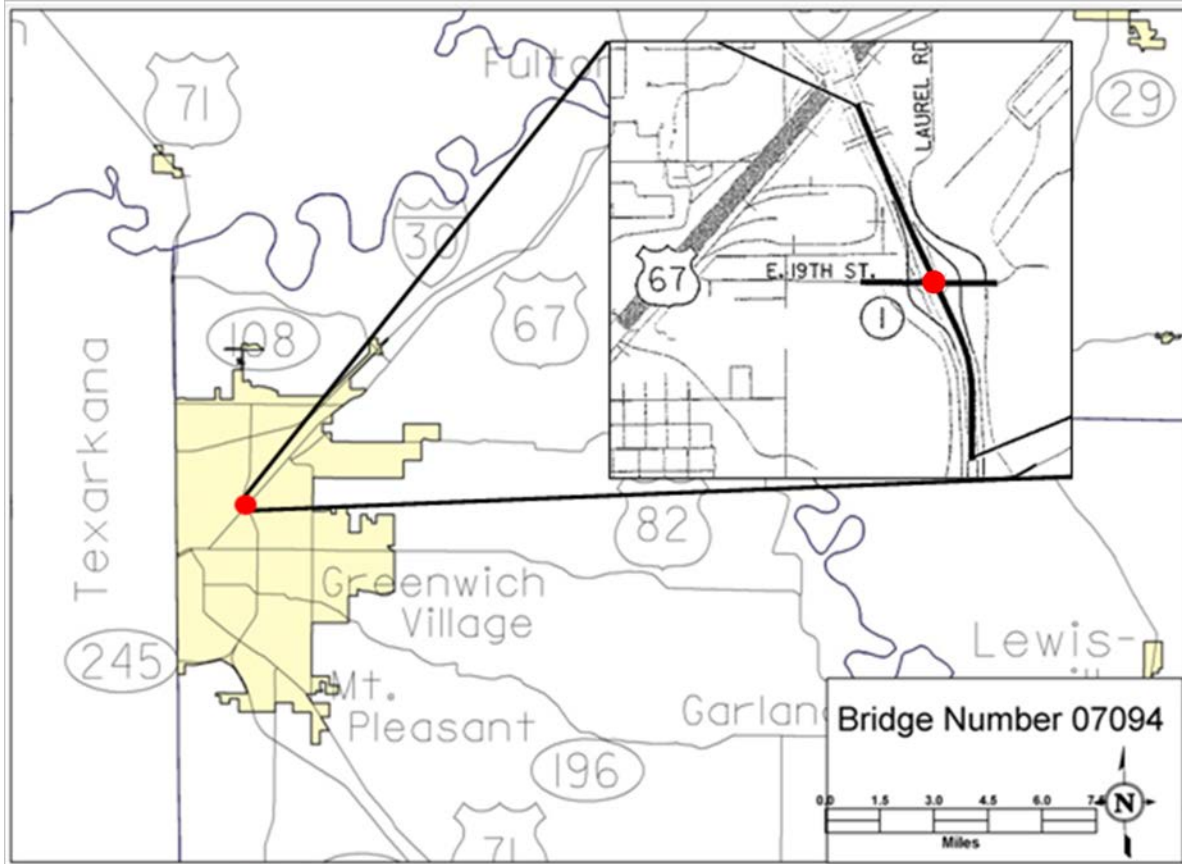


Figure 2 Location of bridge; Texarkana, Arkansas

The third of the four bridges is located in Pocahontas, Arkansas on Highway 67 over Marr's Creek. The bridge deck was placed on March 31, 2010. The job number for the project was 100608. The total length of the bridge is 150 ft with a width of 58 ft. Due to the size of the bridge deck, the whole deck was treated with the HPCC. The average ambient air temperature was 80°F with humidity being 33% at the time of the pour and a wind speed of 20 mph. The average evaporation rate during the pour was 0.3 lb/ft<sup>2</sup>/hr. There were no problems noted during the placement of this bridge deck.

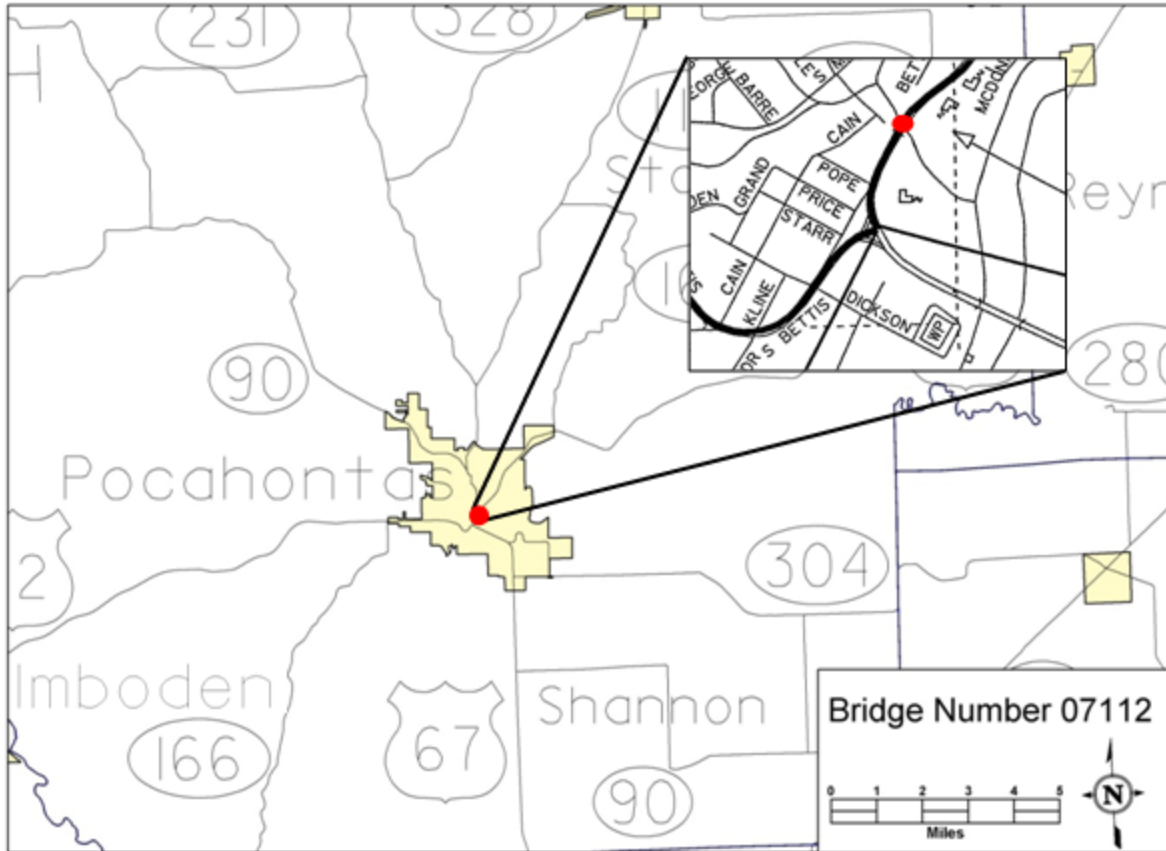


Figure 3 Location of bridge; Pocahontas, Arkansas

The fourth and final bridge is located in Prescott, Arkansas on Highway 67. The bridge was built as a railroad overpass. The job number for the project was 030322. The bridge deck was placed on August 19, 2010. The total length of the bridge is 338 ft with a width of 40 ft. The western half of the bridge deck was treated with HPCC and the eastern half was treated with standard curing practices. The average ambient air temperature was 83°F with a deck temperature of 89°F. The humidity was at 65% at the time of the pour with a wind speed of 1.41 mph. The average evaporation rate during the pour was 0.054lb/ft<sup>2</sup>/hr. A concrete retarder, Daratard 17, was ordered to compensate for expected high temperatures, half way through the pour, the amount of

retarder was reduced because of unseasonably cool weather. This caused the second half of the deck to cure before the first half of the deck. No other problems were noted.

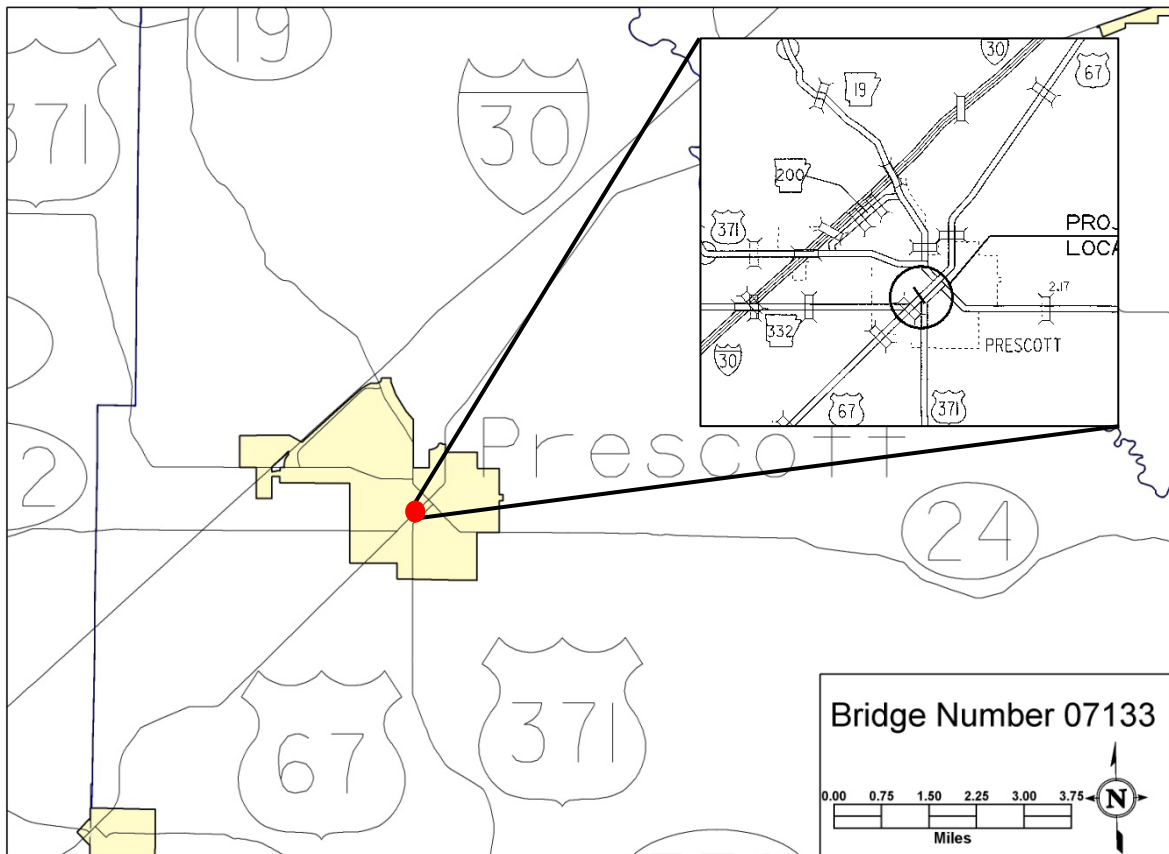


Figure 4 Location of bridge; Prescott, Arkansas

## Post Construction Site Evaluation Chapter 5

Distress surveys were completed on all four of the bridge decks. Each of the bridge decks had three distress surveys completed the first distress survey was completed shortly after the bridge deck had been placed, the second distress survey was completed approximately a year after the bridge deck had been completed and the final survey was completed early 2012. Once the distress surveys were completed, the total crack length for the control section and the HPCC section were calculated and compared.



### 5.1 Job Number 030350; Hope, Arkansas

The bridge deck in Hope was completed on September 2, 2009. The first of the three distress surveys was conducted on October 28, 2009. At the time of the first distress survey, the last 20 feet on the control section was covered with equipment. Therefore, the last 20 feet of the control section was not evaluated in the distress survey. The total length of cracking on the HPCC half of the bridge deck was 277 feet. The total length of cracking measured on the control section was 300 feet. Due to the equipment on the bridge deck, a comparison of the cracking between the two sections was not completed.

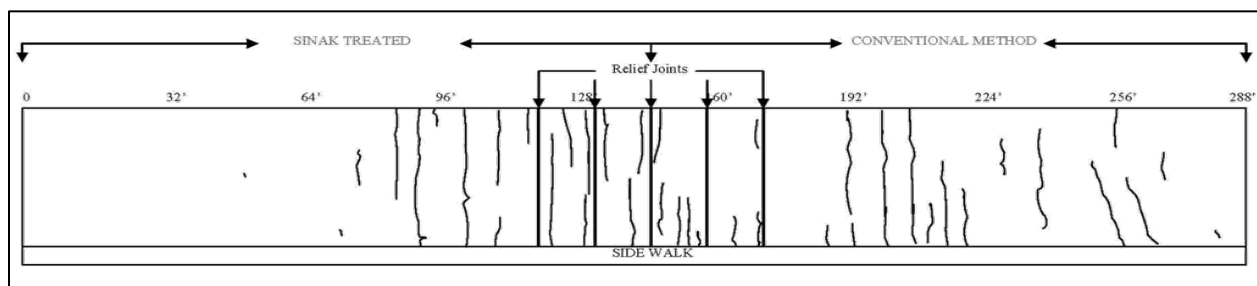


Figure 5 First Distress Survey of Job Number 030350

The second distress survey for job number 030350 was completed on January 14, 2010. The HPCC total crack length measured 672 feet and the total crack length for the control section was 1,190 feet. At the time of this distress survey there was approximately a 44% reduction in cracking with the HPCC when compared to the control section. The third and final distress survey was completed in two parts the first part, the westbound lanes, was surveyed on February 16, 2012 and the second part of the distress survey was completed on March 7, 2012. The HPCC section had 1,750 linear feet of cracking where the control section had 2,654 feet of linear cracking. The

reduction in cracking was approximately 34 percent when comparing the HPCC section to the control section.

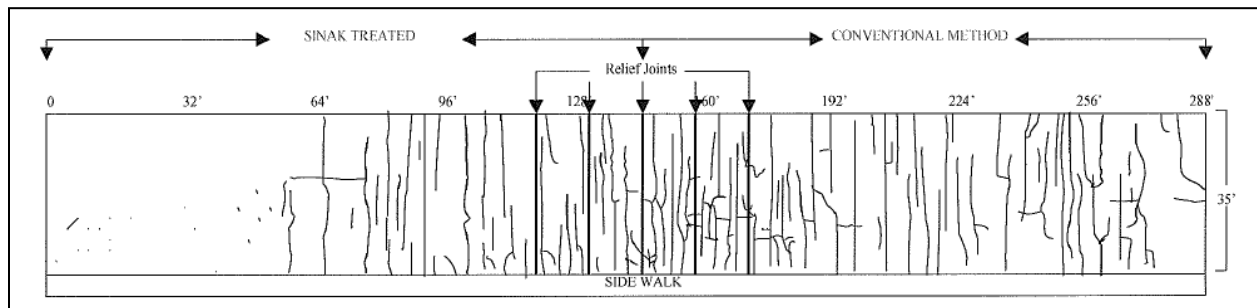


Figure 6 Second Distress Survey of Job Number 030350

### 5.2 Job Number 030341; Texarkana, Arkansas

The bridge deck in Texarkana was completed on September 2, 2009. The first distress survey was completed on November 12, 2009. In the areas where ponding had occurred during the application of the HPCC, the surface of the concrete became soft and is indicated by the elongated circles in the distress survey. With the final application of the HPCC several months later, the softer areas did seem to harden. At the time of the first distress survey, there was a total crack length of 173 feet on the HPCC half of the deck and 301 feet of total crack length on the control sections. There was approximately a 43% reduction in the HPCC section when compared with the control section. Due to time constraints the distress survey was not completed a year after placement of the bridge deck. The second survey was completed in two parts. The first part was completed on February 21, 2012 and the second part was completed on March 22, 2012. The total linear feet of cracking for the HPCC half was 1,402 linear feet and the control section had 1,608 linear feet of cracking. There was a 13% reduction in cracking when comparing the HPCC to the control section.

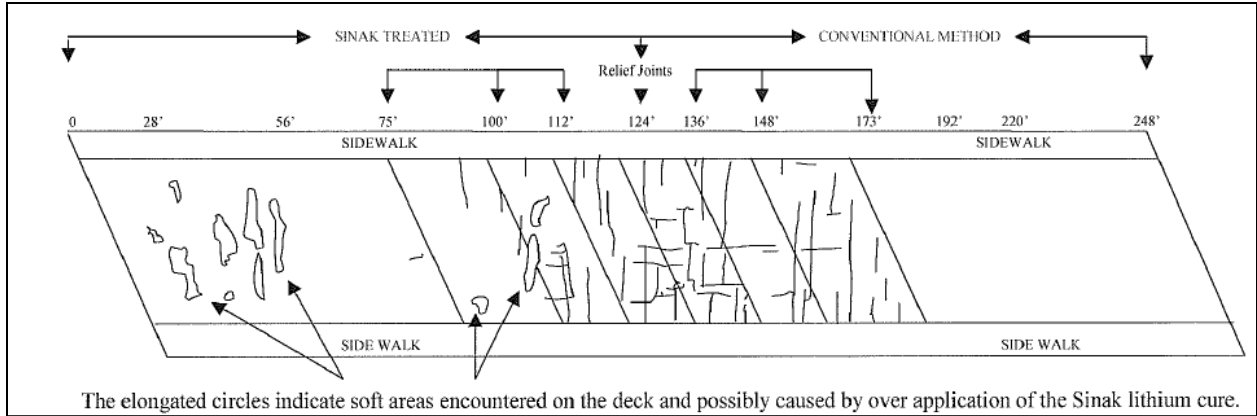


Figure 7 First Distress Survey of Job Number 030341

5.3 Job Number 100608; Pocahontas, Arkansas

The bridge deck in Pocahontas was placed on March 31, 2010. Since the entire bridge deck was treated with the HPCC, there is no comparison for this bridge. The first distress survey was completed on June 16, 2010 with a total crack length of 236 linear feet. The second distress survey was completed on August 25, 2010 with a total crack length of 1,208 linear feet. The third and final distress survey was completed on February 27, 2012 at which time the bridge deck had a total crack length of 2,485 linear feet.

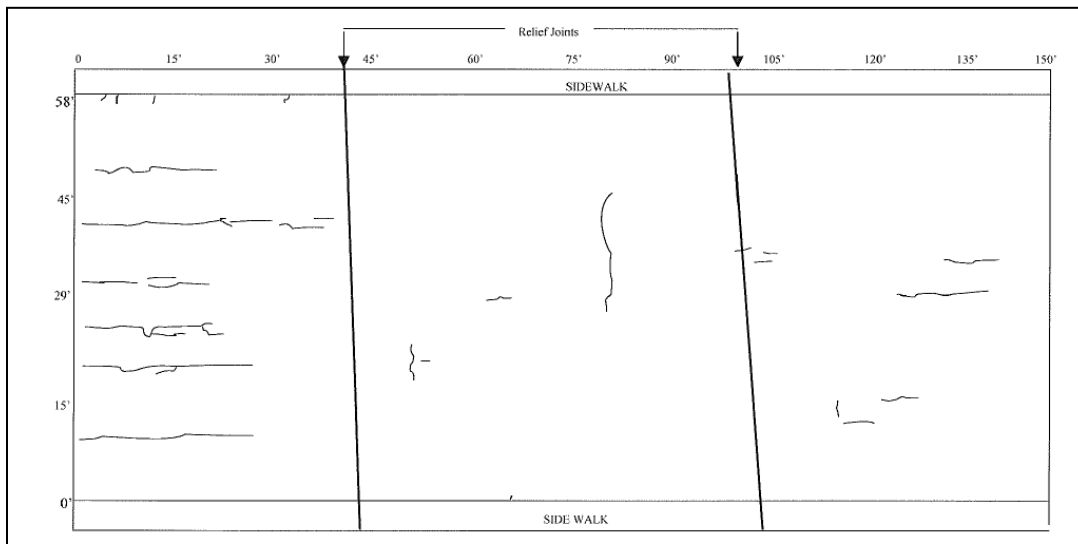


Figure 8 First Distress Survey of Job Number 100608

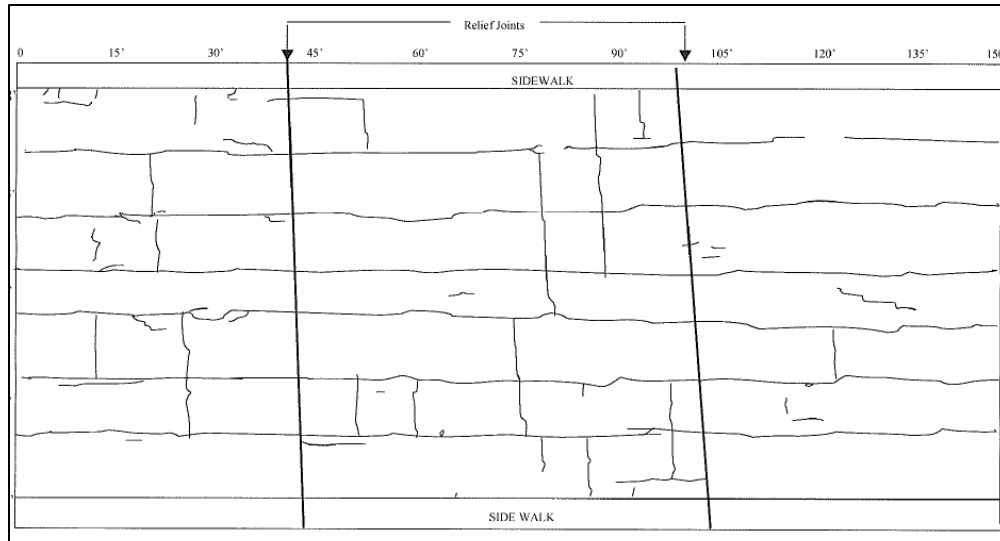


Figure 9 Second Distress Survey of Job Number 100608

#### 5.4 Job Number 030322; Prescott, Arkansas

The final bridge in the project was Job Number 030322 near Prescott, Arkansas. The bridge deck was placed on August 19, 2010 and the first distress survey was completed on October 20, 2010. There were 265 linear feet of cracking on the HPCC section of the deck and 327 linear feet of cracking on the control section. The HPCC section had a reduction in cracking of approximately 19% when compared to the control section at the time of the survey. The second distress survey was completed on March 24, 2011. The total crack length on the HPCC section was 906 linear feet and was 1,137 linear feet on the control section. This showed a reduction in cracking on the HPCC section of approximately 20% when compared to the control section. The third and final distress survey was completed on March 6, 2012. The control section had 1,978 linear feet of cracking where the HPCC section had 1,709 linear feet of cracking. The amount of cracking on the HPCC section of the bridge deck was reduced by approximately 14% when compared with the control half of the bridge deck.

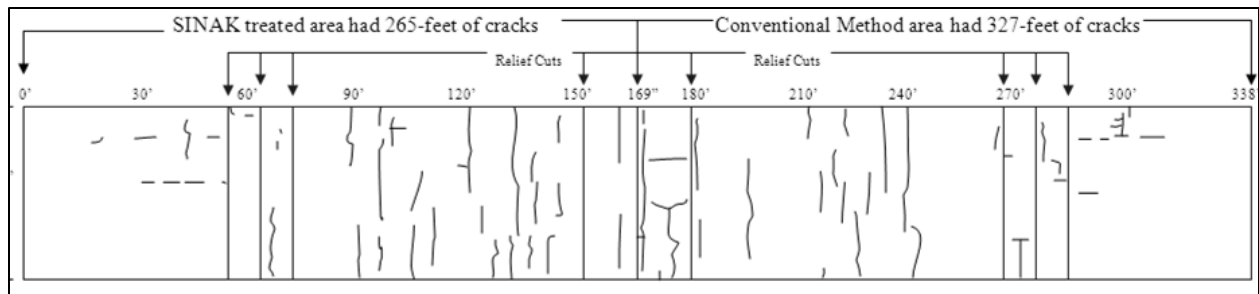


Figure 10 First Distress Survey of Job Number 030322

## Discussion of Results Chapter 6

Several factors need to be compared when determining if HPCCs are a viable option for replacing the standard curing methods. The first is the performance of the HPCC on all three of the bridges where the HPCC was used side by side with the standard curing compound. This is broken into two components, reduction in plastic shrinkage cracking and reduction in total cracking. As defined in chapter one, plastic shrinkage cracking occurs when water is lost from the surface of freshly poured concrete pavement. The initial distress surveys completed during the project are an evaluation of the reduction of the plastic shrinkage cracking. The subsequent distress surveys are an evaluation of the total reduction of cracking on the bridge decks. The cracks which form after the initial cracking may be a mixture of autogenous cracking, drying cracking, carbonation cracking, building practices, movement of the bridge deck, or member size.

The second factor that needs to be examined is the ease of use when compared with the standard curing treatments. Standard curing compounds require additional supplies such as wet burlap and moisture-adding devices. This standard method also requires additional labor for the placement of the burlap and monitoring of the bridge

deck until the curing process has finished. The HPCC does not require any additional supplies or labor.

The last factor that needs to be evaluated is the economic feasibility of the HPCC. The standard curing compound costs 11 cents per square foot with labor and applying burlap costs approximately 25 cents per square foot. The HPCC studied costs 10 cents per square foot and does not require burlap or extra water for the curing process. In order to seal the bridge deck, the standard treatment is to apply boiled linseed oil, which costs 12 cents per square foot. The cost of using the HPCC as the sealer is 13 cents per square foot without any additional costs for labor.

## **Conclusions & Recommendations Chapter 7**

### Conclusions

On all three of the bridges evaluated in this project, the HPCC outperformed the standard curing compound. For plastic shrinkage cracking, the HPCC outperformed the standard curing compound by 19% to 43%. For total cracking, the HPCC outperformed the standard curing compound by 14% to 34%. Since additional supplies and labor are required with standard curing compounds and are not required with the HPCC, the HPCC is easier to use, but the HPCC application rate does need to be monitored. With the inclusion of labor and supply costs, the HPCC is economically feasible when compared with the standard curing compound.

### Recommendations

Since evaporation rates during the project were not considered to be high, continued monitoring of bridge decks placed during conditions with high evaporation

rates is recommended to further verify the results obtained in this study. Allowing this product to be used on a case by case basis with a special provision will allow for the additional verification needed at the higher evaporation rate. An over-application of the HPCC can possibly cause soft areas to form in the surface of the pavement. This problem does need to be investigated further. To avoid in over application of the HPCC maintaining the manufacturer's application rate is recommended.

## References

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Uno, P. J. (1998). *Plastic Shrinkage Cracking and Evaporation*. ACI Materials Journal Tilt no. 95-M34.



# Appendix A

Distress Survey

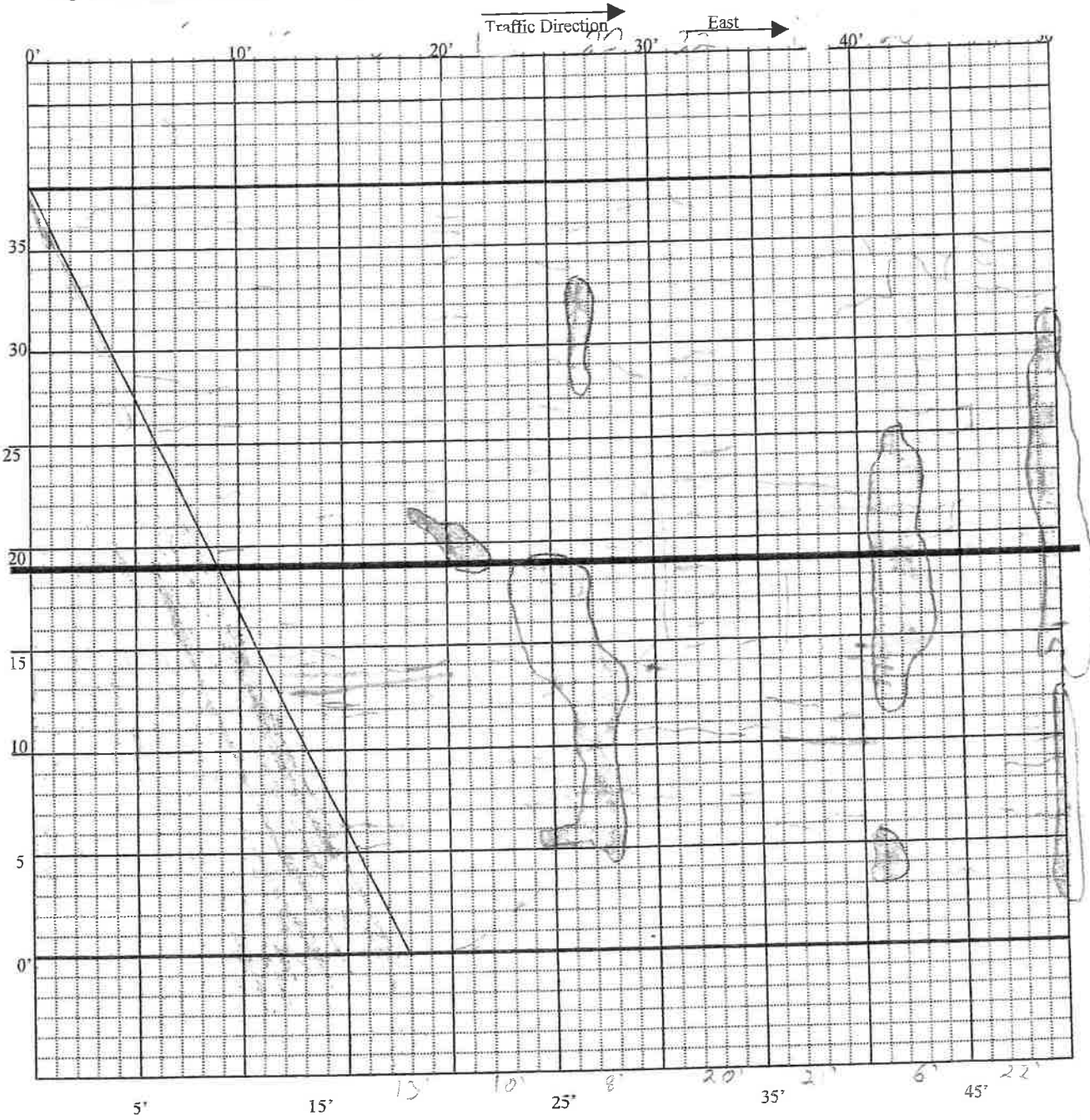
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Surveyor: Mark Greenwood, T.A., Ayo, White

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Date: 3-22-12

Begin Sta \_\_\_\_\_ End Sta \_\_\_\_\_



Project No. 030341

Project Name: East 19<sup>th</sup> St. Bridge

Surveyor: Mark Greenwood, *Taylor, White*

Station \_\_\_\_\_

Route: \_\_\_\_\_

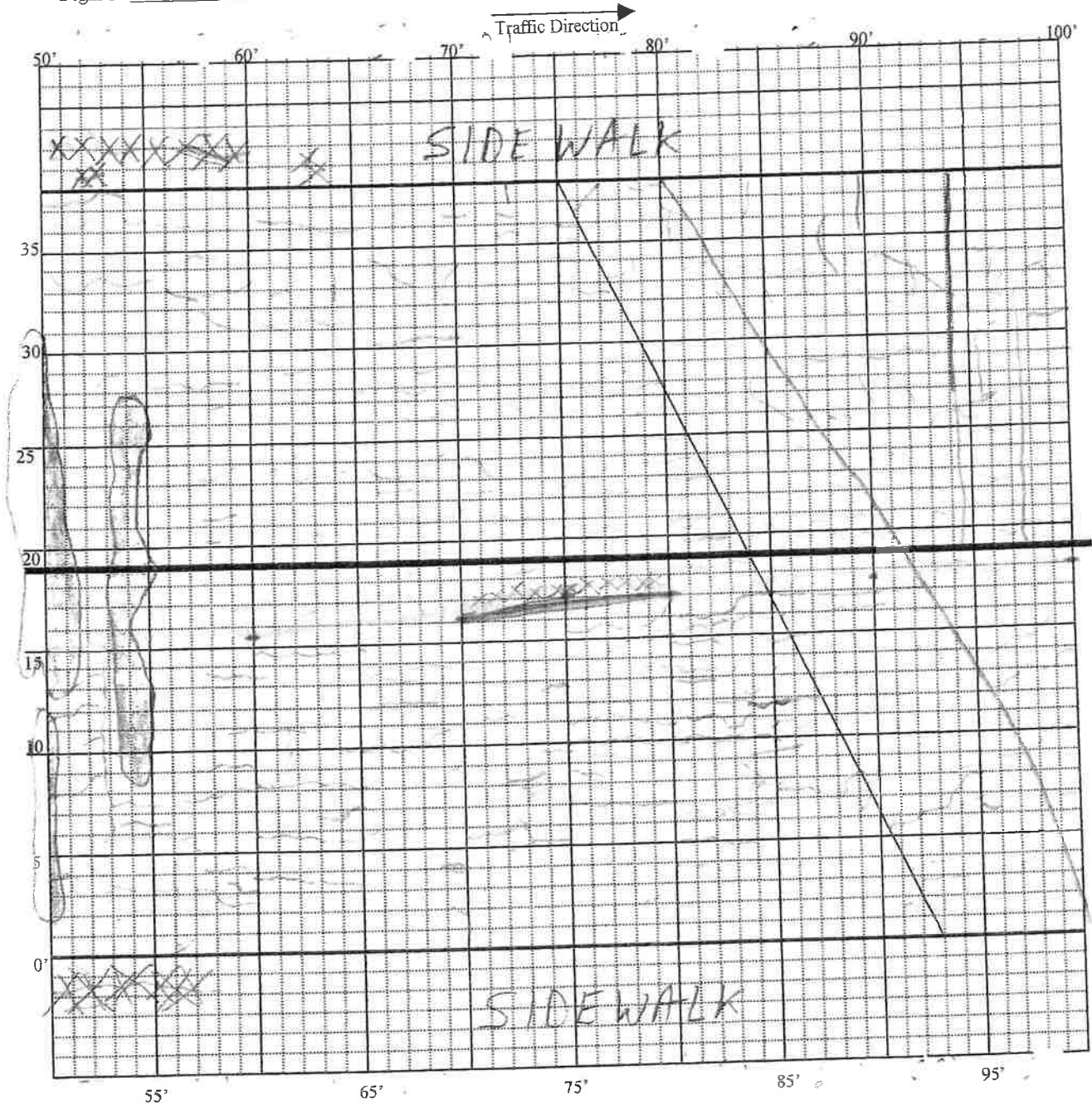
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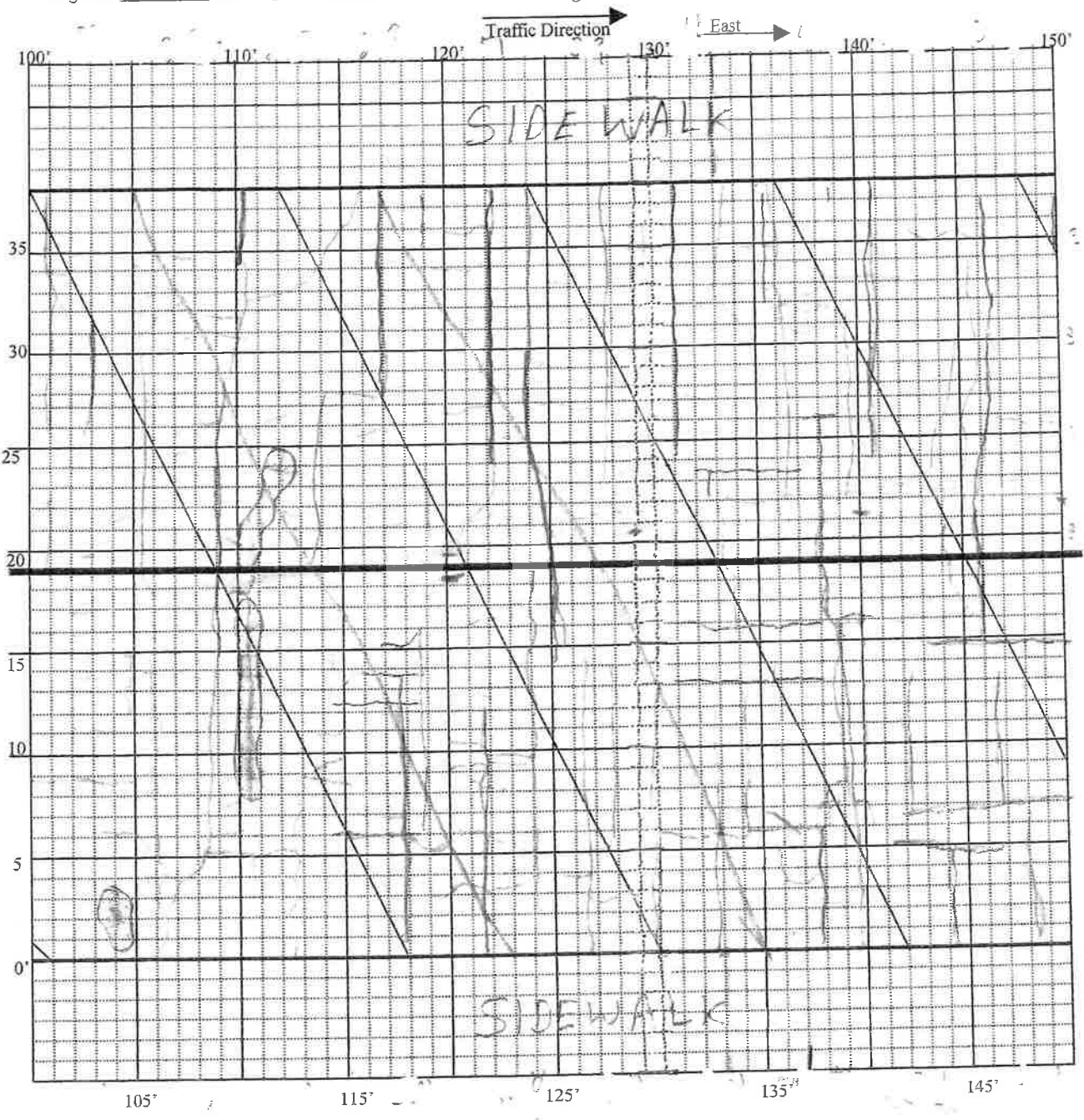
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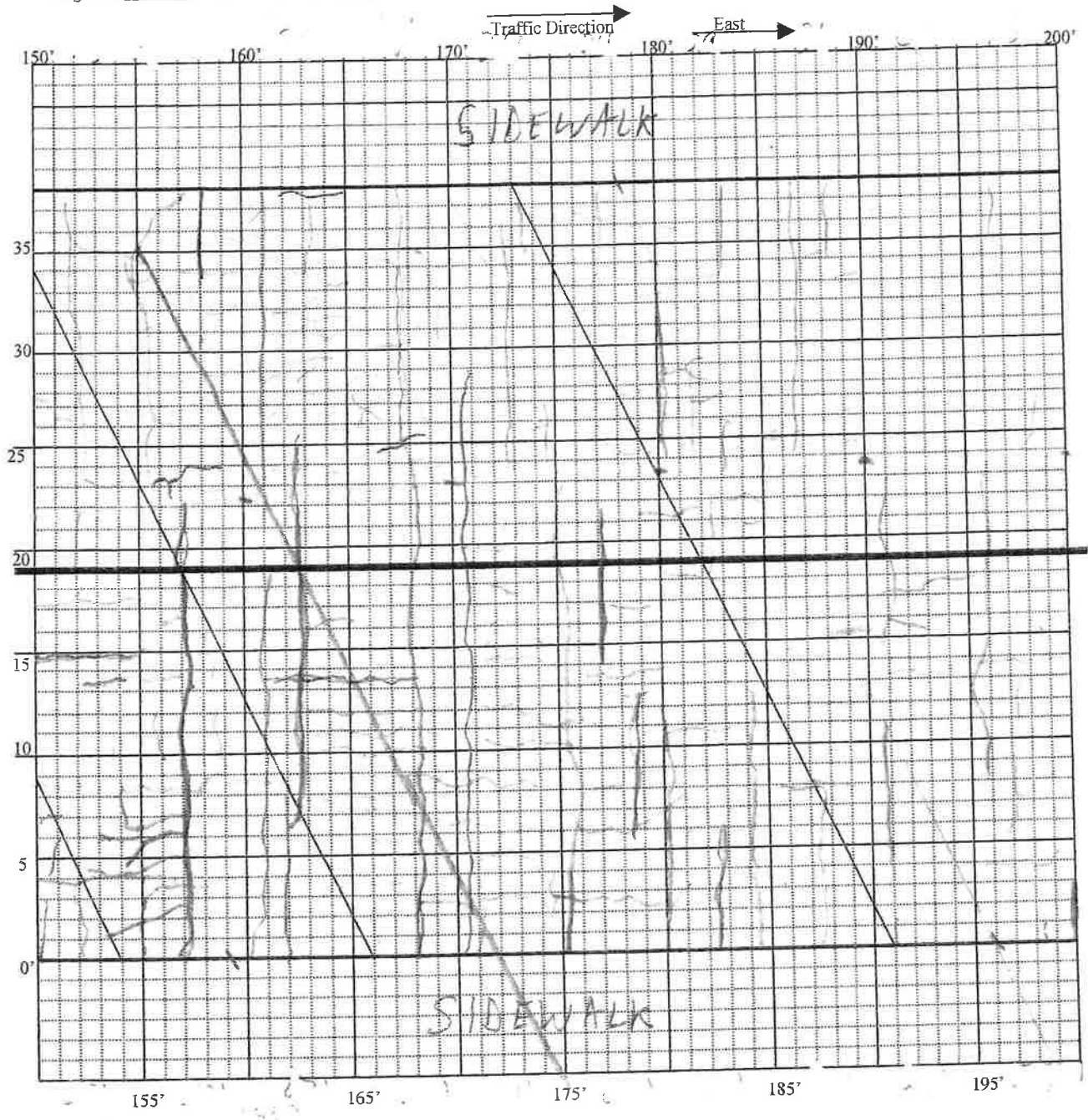
Project No. 030341 Project Name: East 19<sup>th</sup> St. Bridge Surveyor: Mark Greenwood *Township, White*

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Begin Sta \_\_\_\_\_ End Sta \_\_\_\_\_ 660+27 683



Project No. 030341 Project Name: East 19<sup>th</sup> St. Bridge Surveyor: Mark Greenwood  
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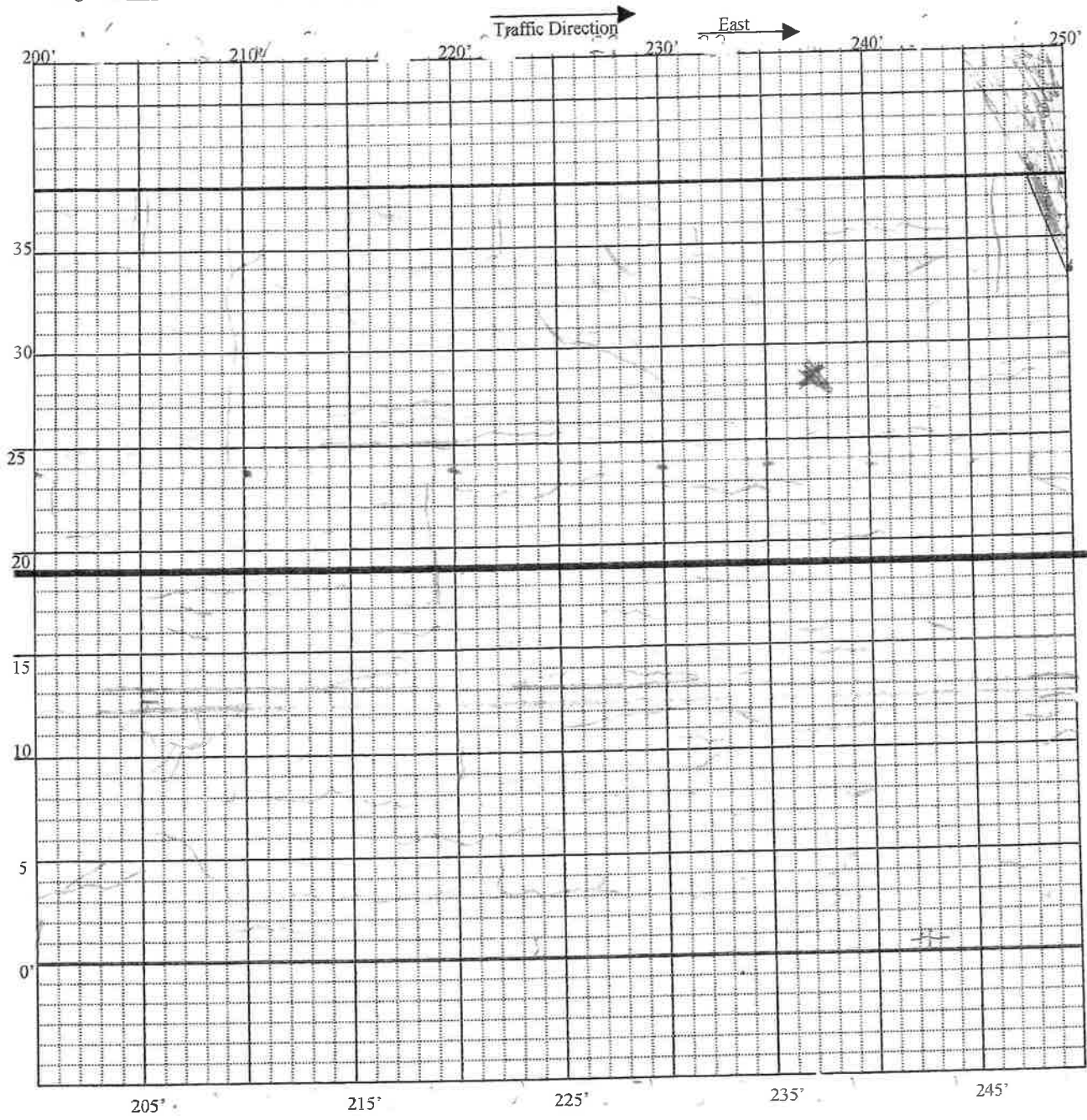




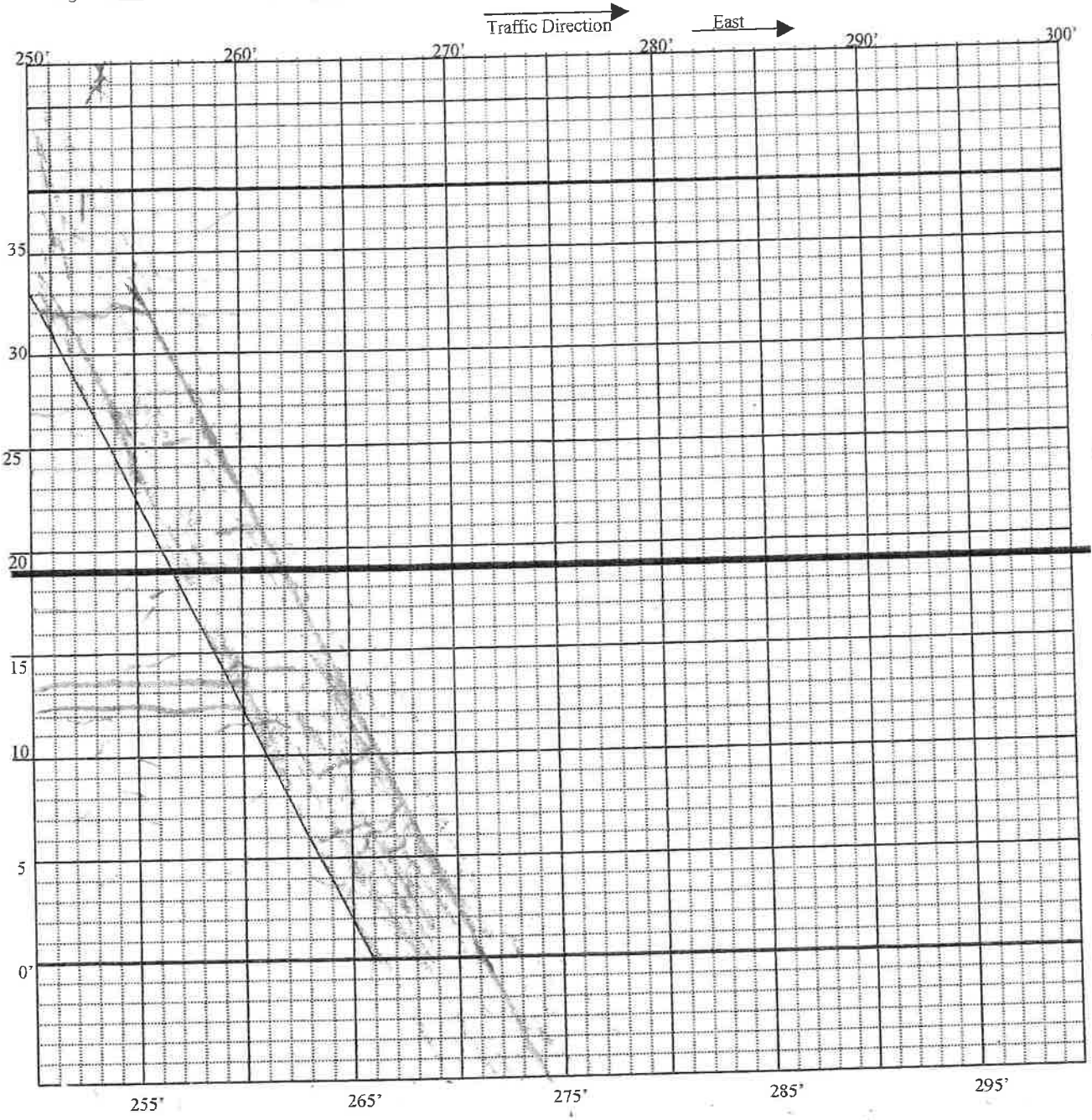
Project No. 030341 Project Name: East 19<sup>th</sup> St. Bridge Surveyor: Mark Greenwood *Tampa, FL*

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Begin Sta \_\_\_\_\_ End Sta \_\_\_\_\_

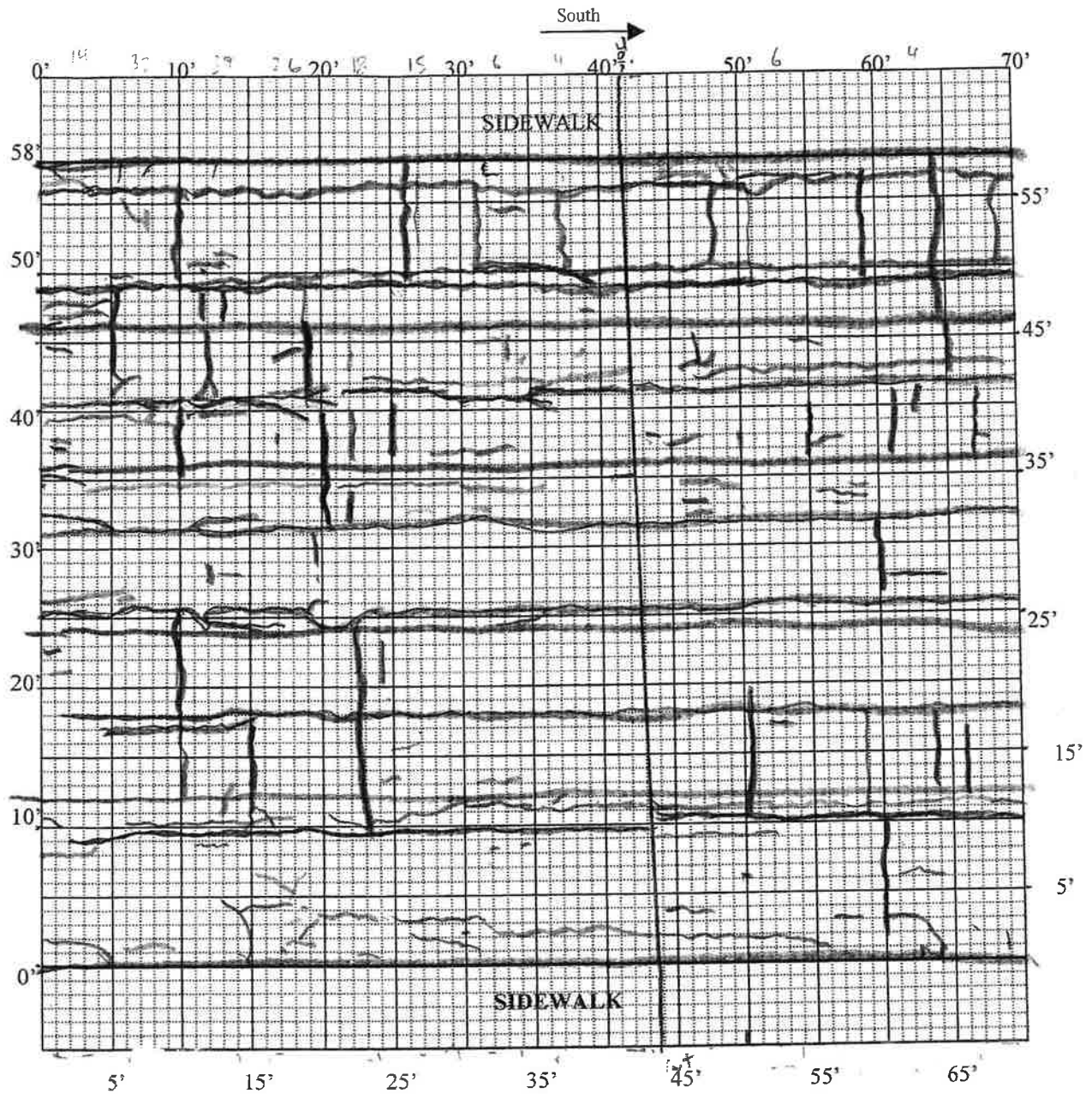


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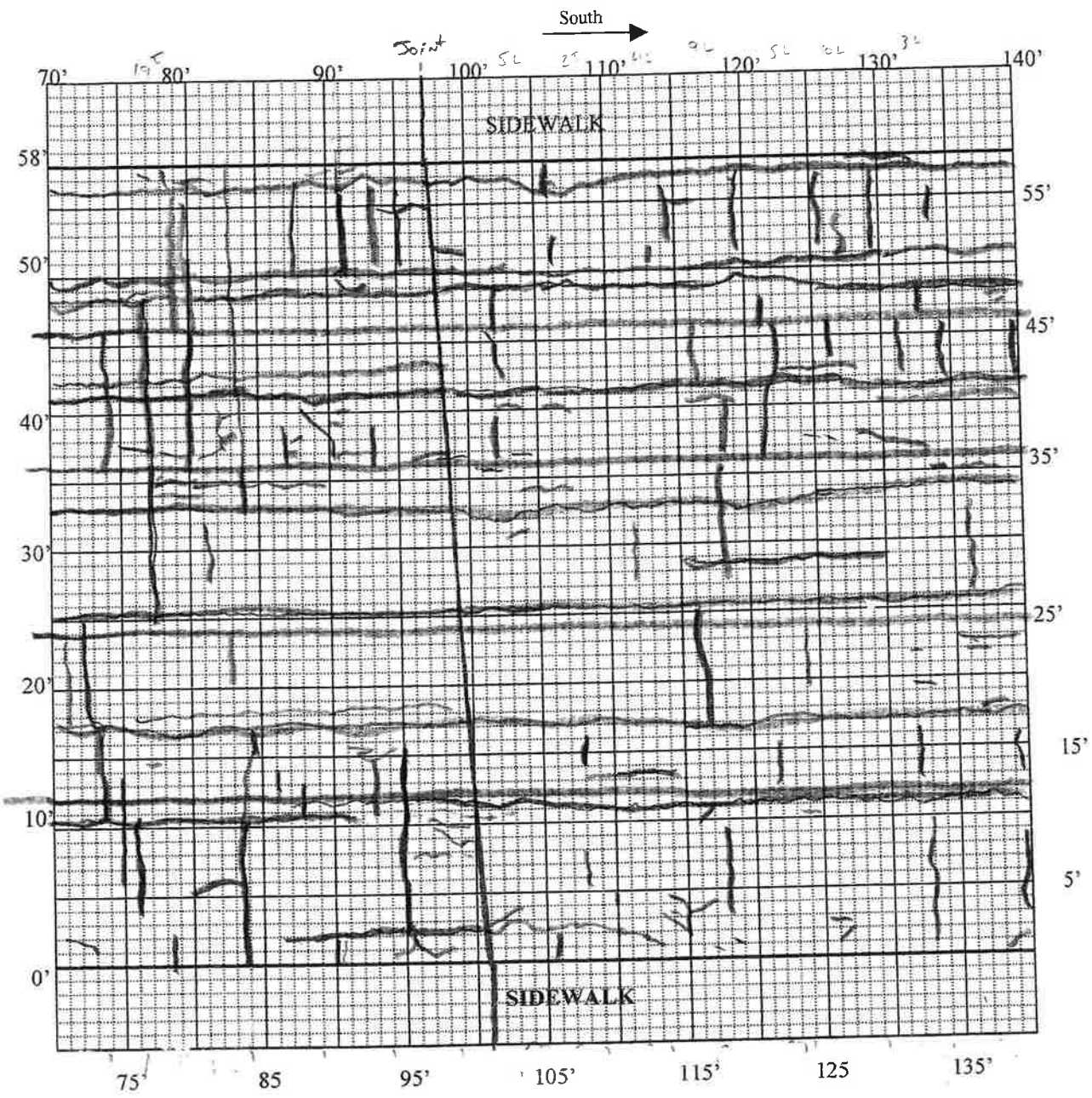
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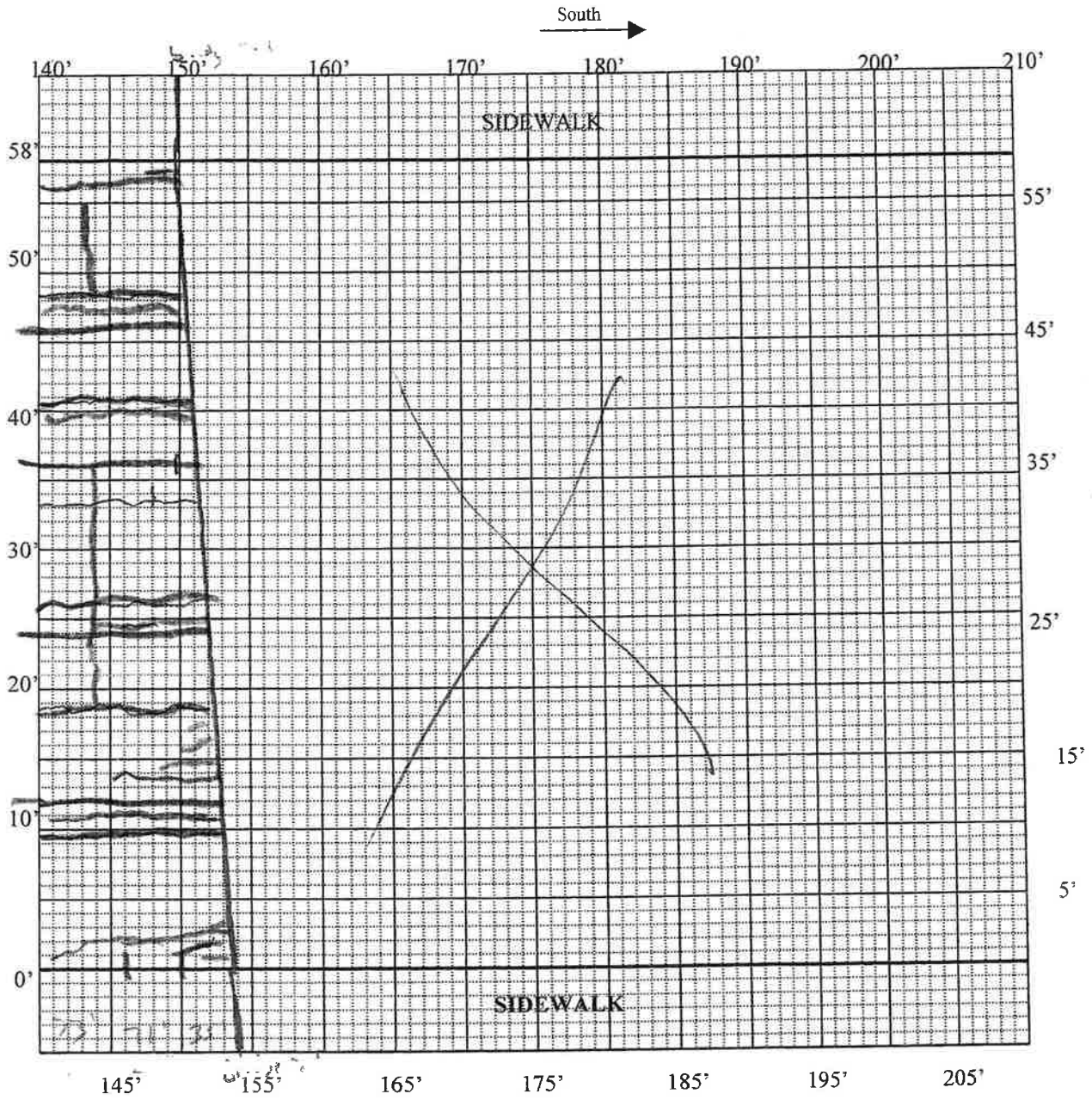




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Project No. 100608 Project Name: Marrs Creek Bridge Surveyor: Mark Greenwood ~~S. J. White~~ J. White  
Station \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: Pocahontas Date: 8-29-2010  
Begin Sta \_\_\_\_\_ End Sta \_\_\_\_\_

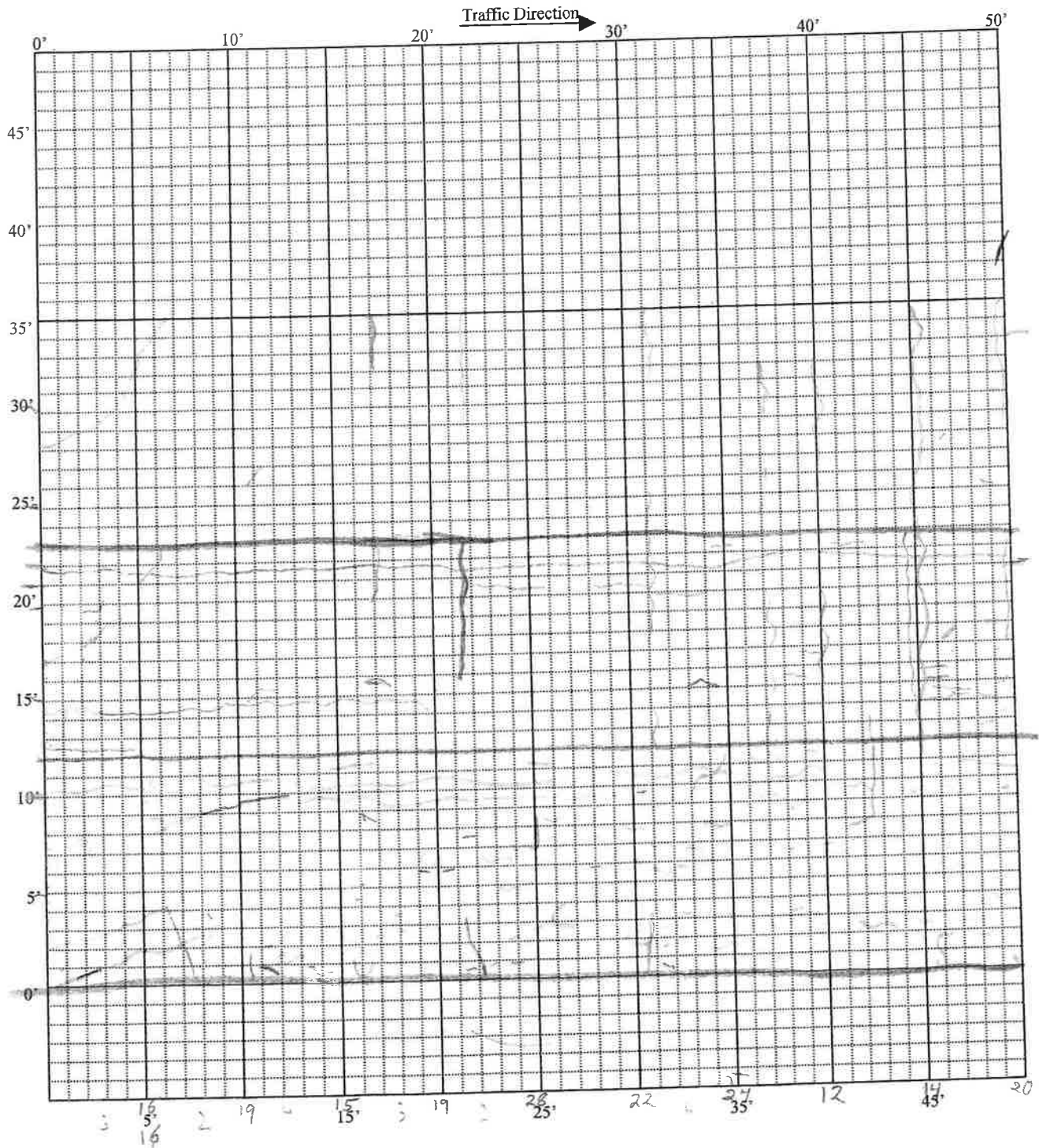


Project No. 030350 Project Name: I-30 E.B. Ramps - North (Hope) Surveyor: Greenwood, Tamara - W.H.L. 0-50

Log Mile: \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: \_\_\_\_\_ Date: 2-16-12

Temp \_\_\_\_\_ °F  
Pvmt Temp \_\_\_\_\_ °F

Begin LM \_\_\_\_\_ End LM \_\_\_\_\_ Picture No \_\_\_\_\_ /Disc \_\_\_\_\_



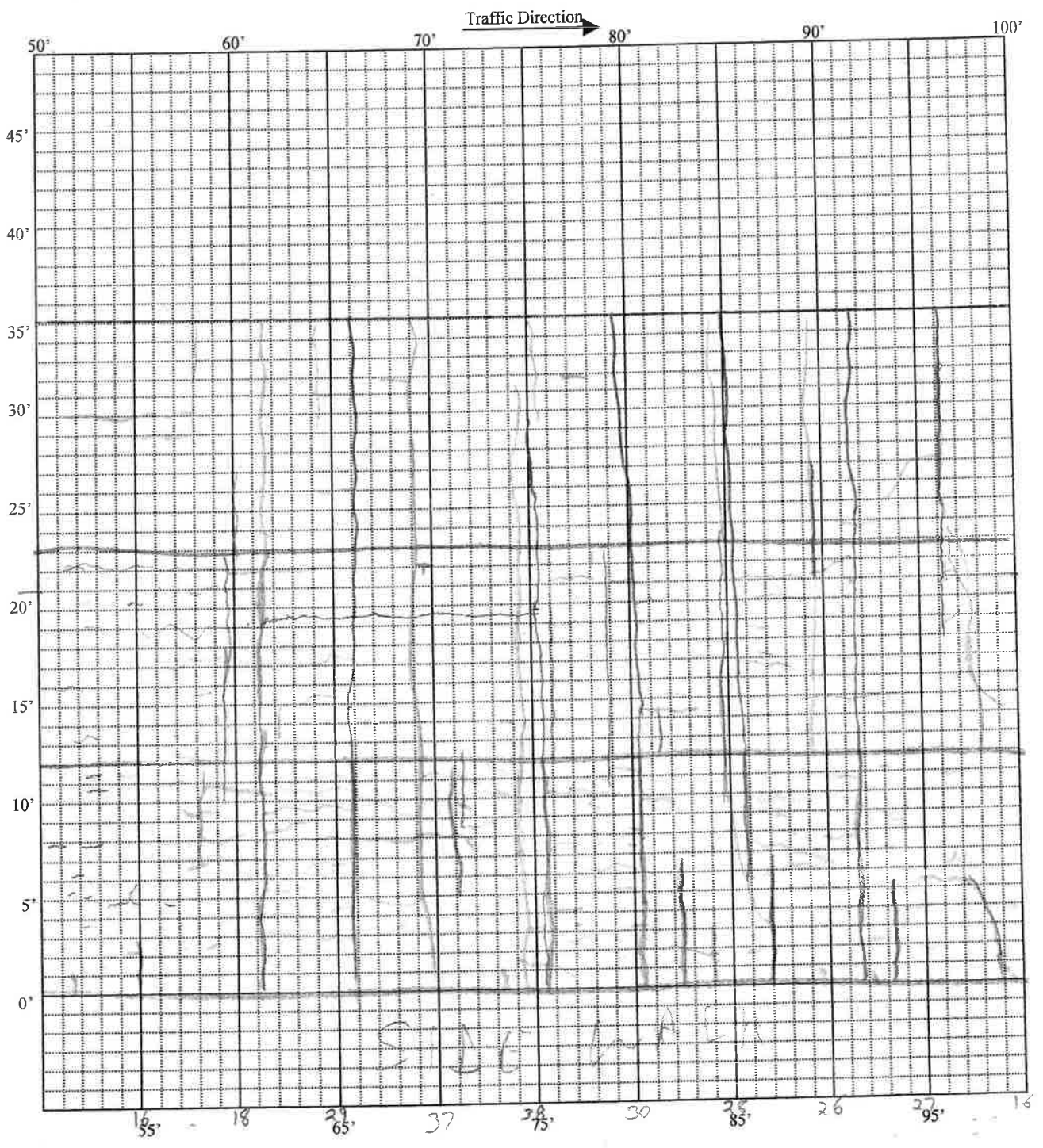


Project No. 030350 Project Name: I-30 EB Ramps - North (Hope) Surveyor: Greenwood, Tampa, White 50-100

Log Mile: \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: \_\_\_\_\_ Date: 1-14-2010

Air Temp \_\_\_\_\_ °F  
Pvmt Temp \_\_\_\_\_ °F

Begin LM \_\_\_\_\_ End LM \_\_\_\_\_ Picture No \_\_\_\_\_ /Disc \_\_\_\_\_

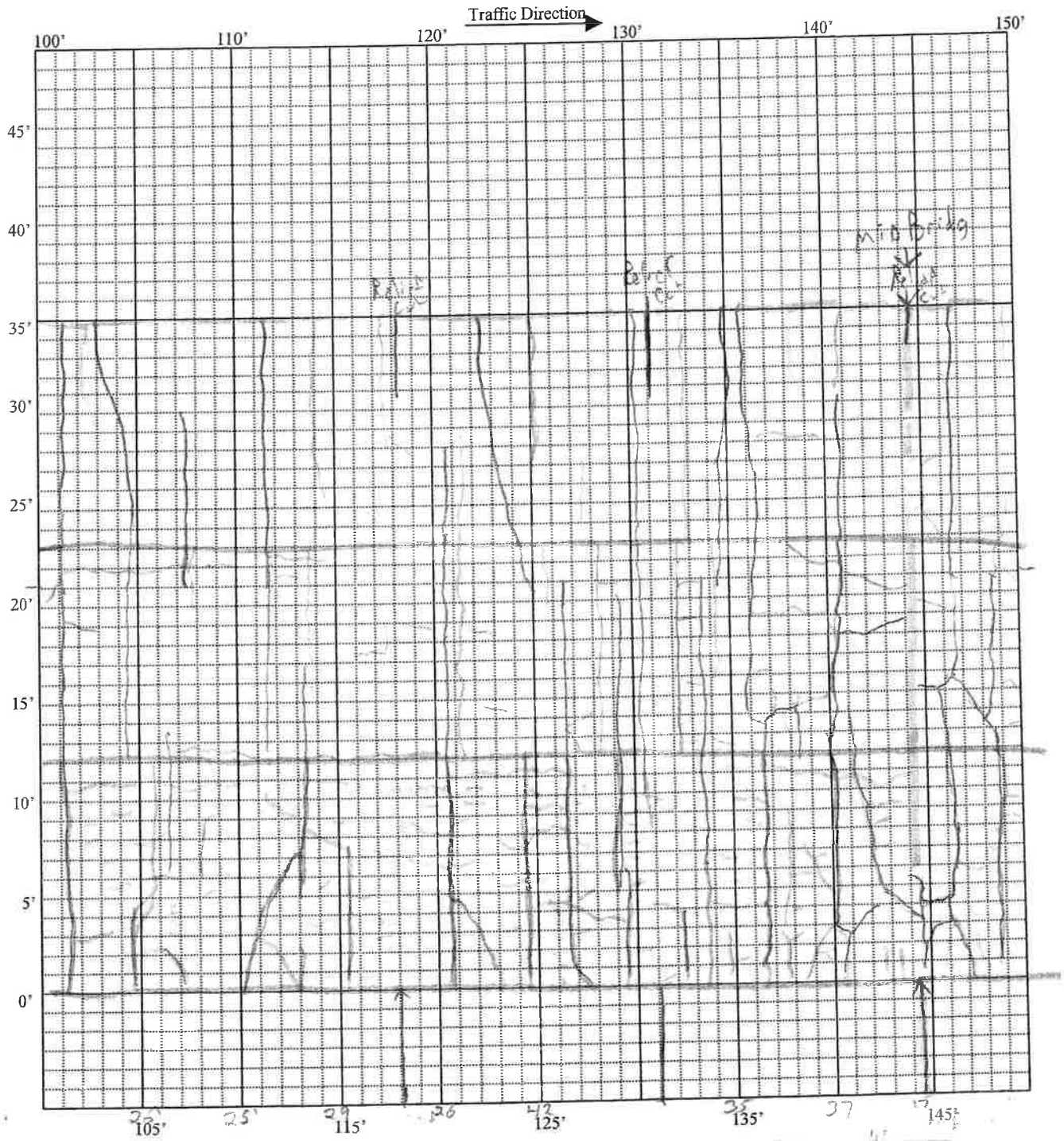


Project No. 030350 Project Name: I-30 EB Ramps - North (Hope) Surveyor: Greenwood, Tampa, Fla. 100-150

Log Mile: \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: \_\_\_\_\_ Date: 1-14-2010

Air Temp \_\_\_\_\_ °F  
Pvmt Temp \_\_\_\_\_ °F

Begin LM \_\_\_\_\_ End LM \_\_\_\_\_ Picture No \_\_\_\_\_ /Disc \_\_\_\_\_



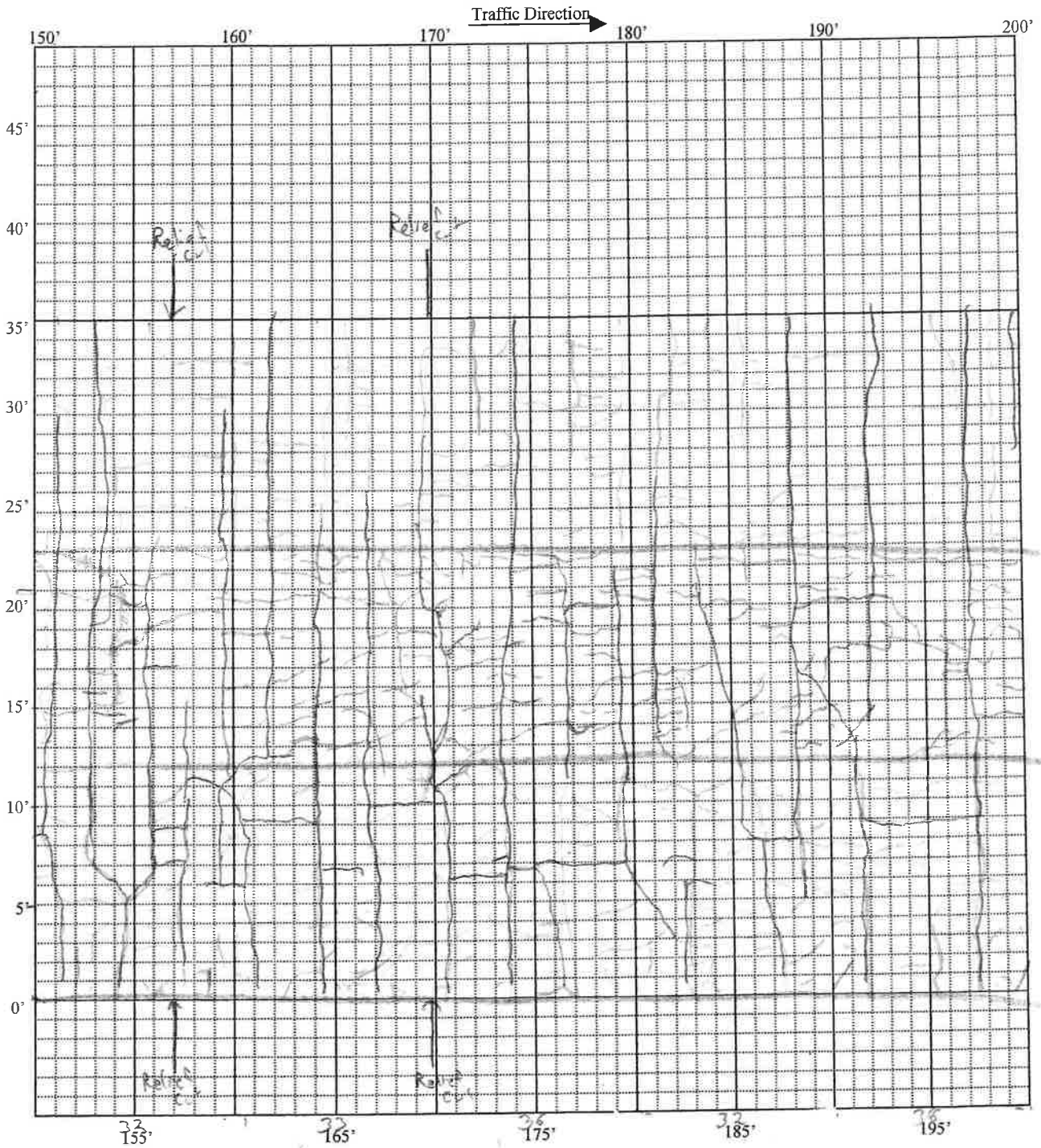
Project No. 030350 Project Name: I-30 EB Ramps - North (Hope) Surveyor: G. P. ... 150-200

Log Mile: \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: \_\_\_\_\_ Date: \_\_\_\_\_

Air Temp \_\_\_\_\_ °F  
Pvmnt Temp \_\_\_\_\_ °F

Begin LM \_\_\_\_\_ End LM \_\_\_\_\_

Picture No \_\_\_\_\_ /Disc \_\_\_\_\_





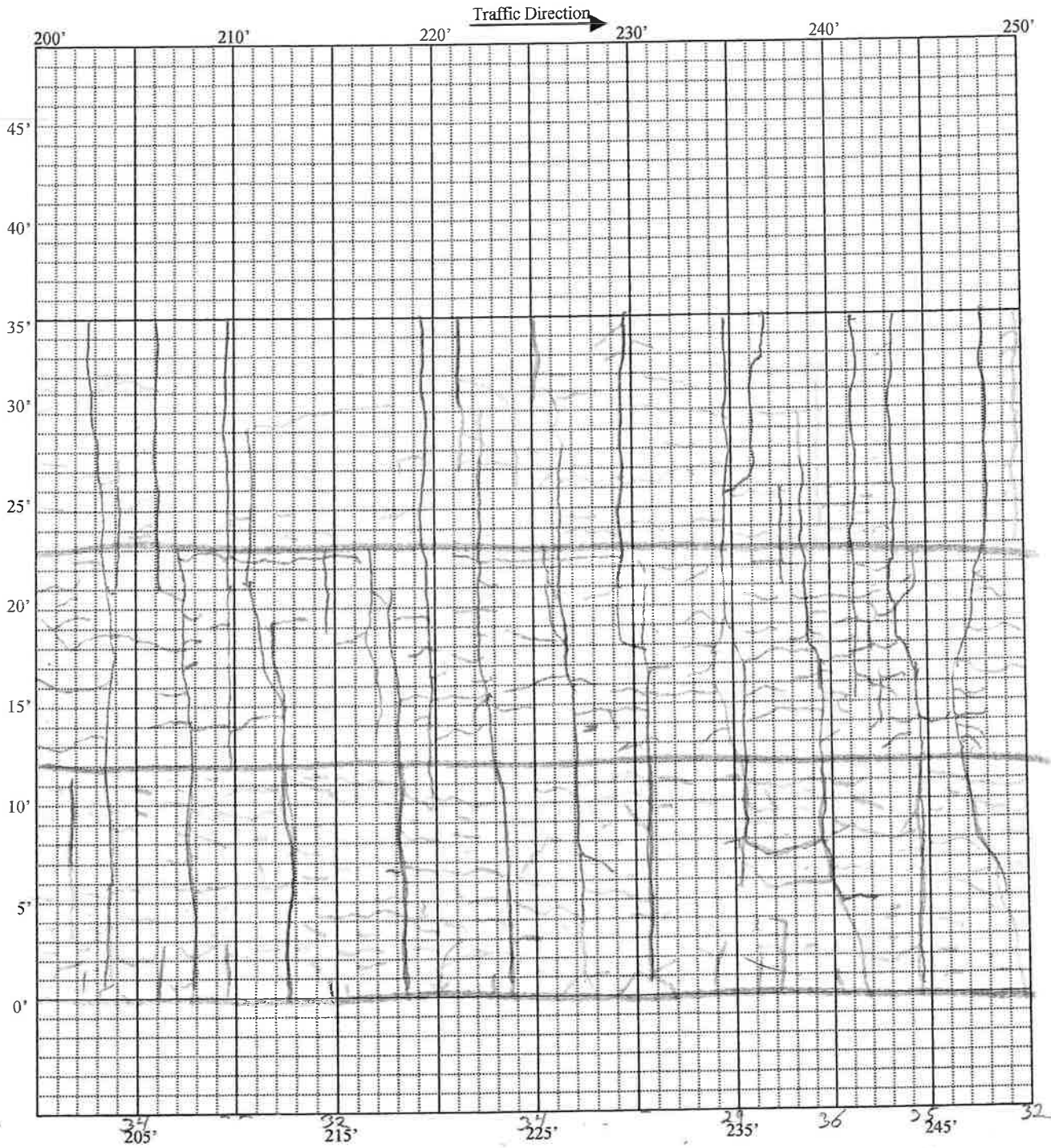
Project No. 030350 Project Name: I-30 EB Ramps - North (Hope) Surveyor: \_\_\_\_\_ 200-250

Log Mile: \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: \_\_\_\_\_ Date: \_\_\_\_\_

Air Temp \_\_\_\_\_ °F  
Pvmnt Temp \_\_\_\_\_ °F

Begin LM \_\_\_\_\_ End LM \_\_\_\_\_

Picture No \_\_\_\_\_ /Disc \_\_\_\_\_



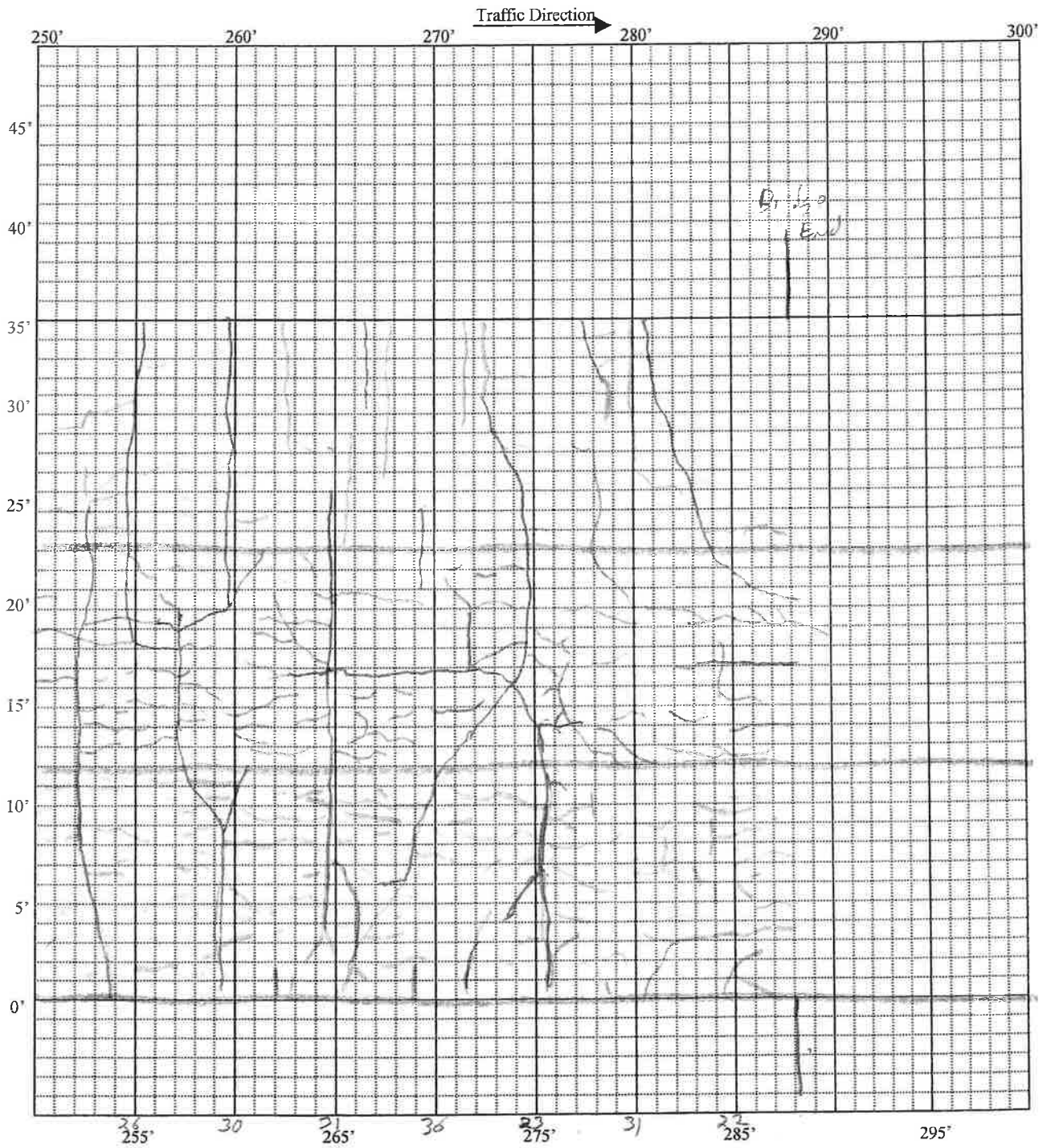
Project No. 030350 Project Name: I-30 EB Ramps - North (Hope) Surveyor: \_\_\_\_\_ 250-300

Log Mile: \_\_\_\_\_ Route: \_\_\_\_\_ Section: \_\_\_\_\_ Location: \_\_\_\_\_ Date: \_\_\_\_\_

Air Temp \_\_\_\_\_ °F  
Pvmnt Temp \_\_\_\_\_ °F

Begin LM \_\_\_\_\_ End LM \_\_\_\_\_

Picture No \_\_\_\_\_ /Disc \_\_\_\_\_

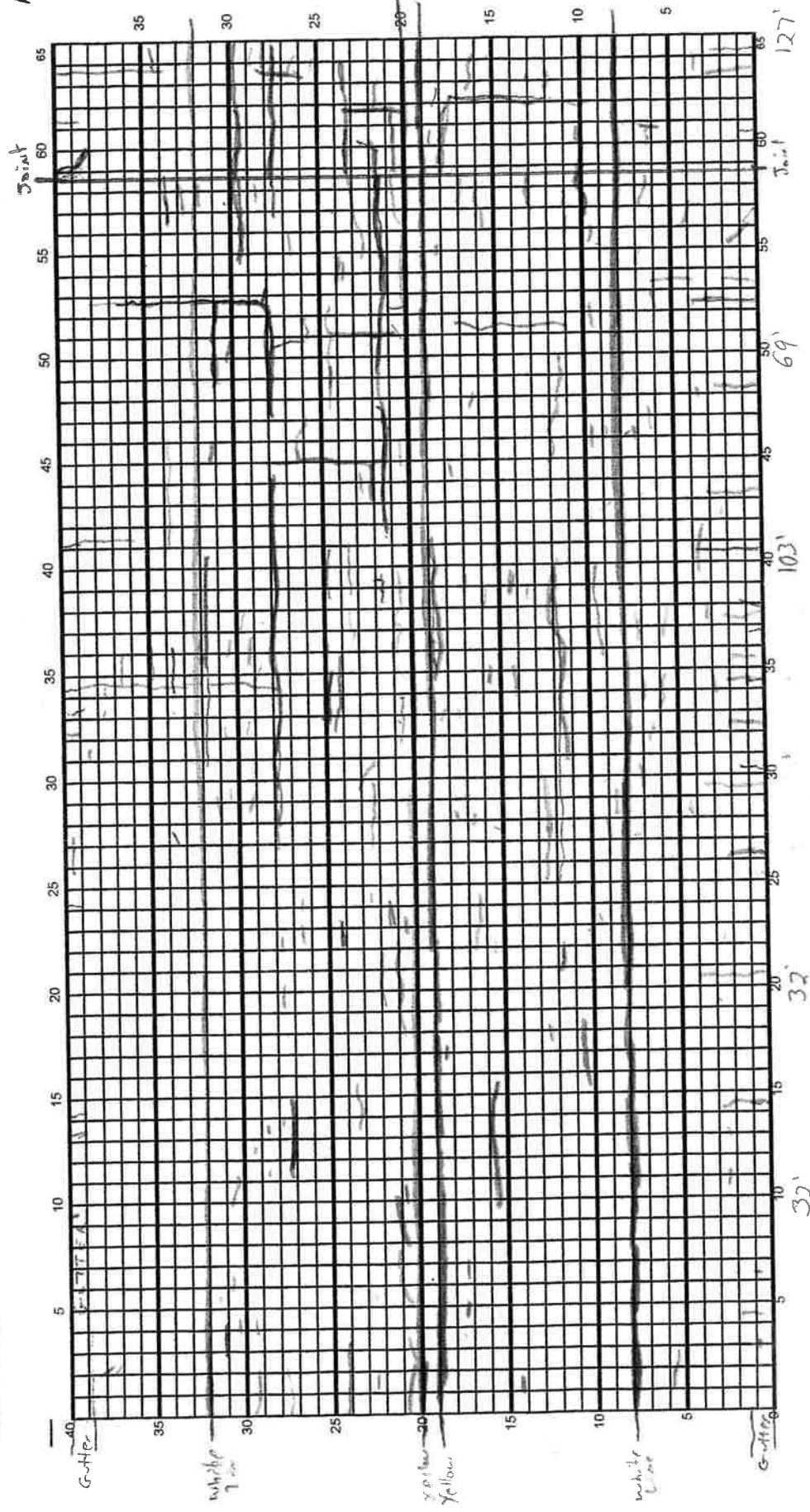




Project No. 03032Z  
Route 371, Sect. 5

Project Name US 67 & U.P.R.R. Bridge  
Location Prescott

Surveyor Mark G., Daniel S., Blake P., Rick S., Sarah T.  
Date March 6, 2012



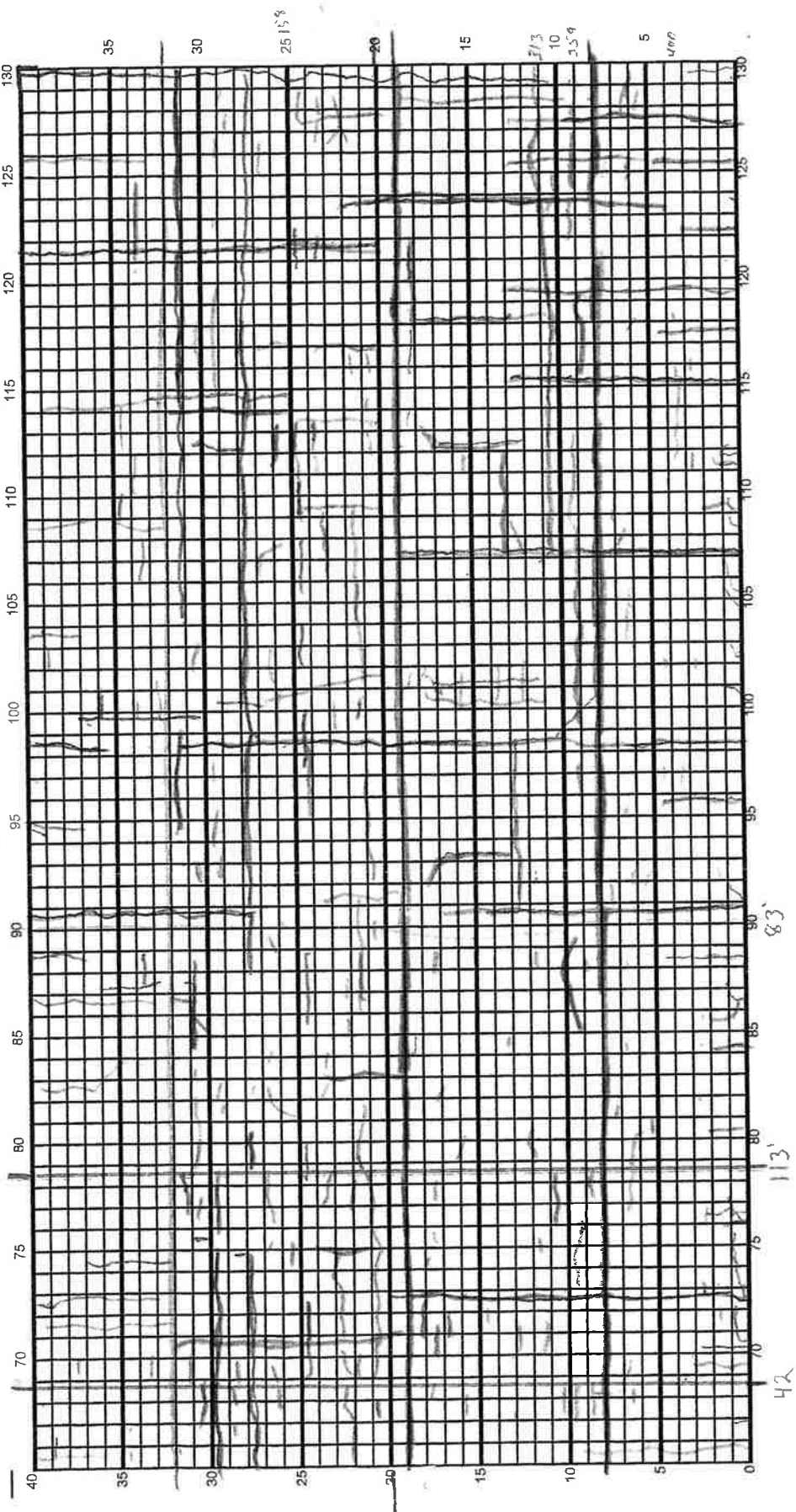
192

Project No. 030322  
Route 371, Sect. 5

Project Name US 67 & U.P.R.R. Bridge  
Location Prescott

Surveyor: \_\_\_\_\_

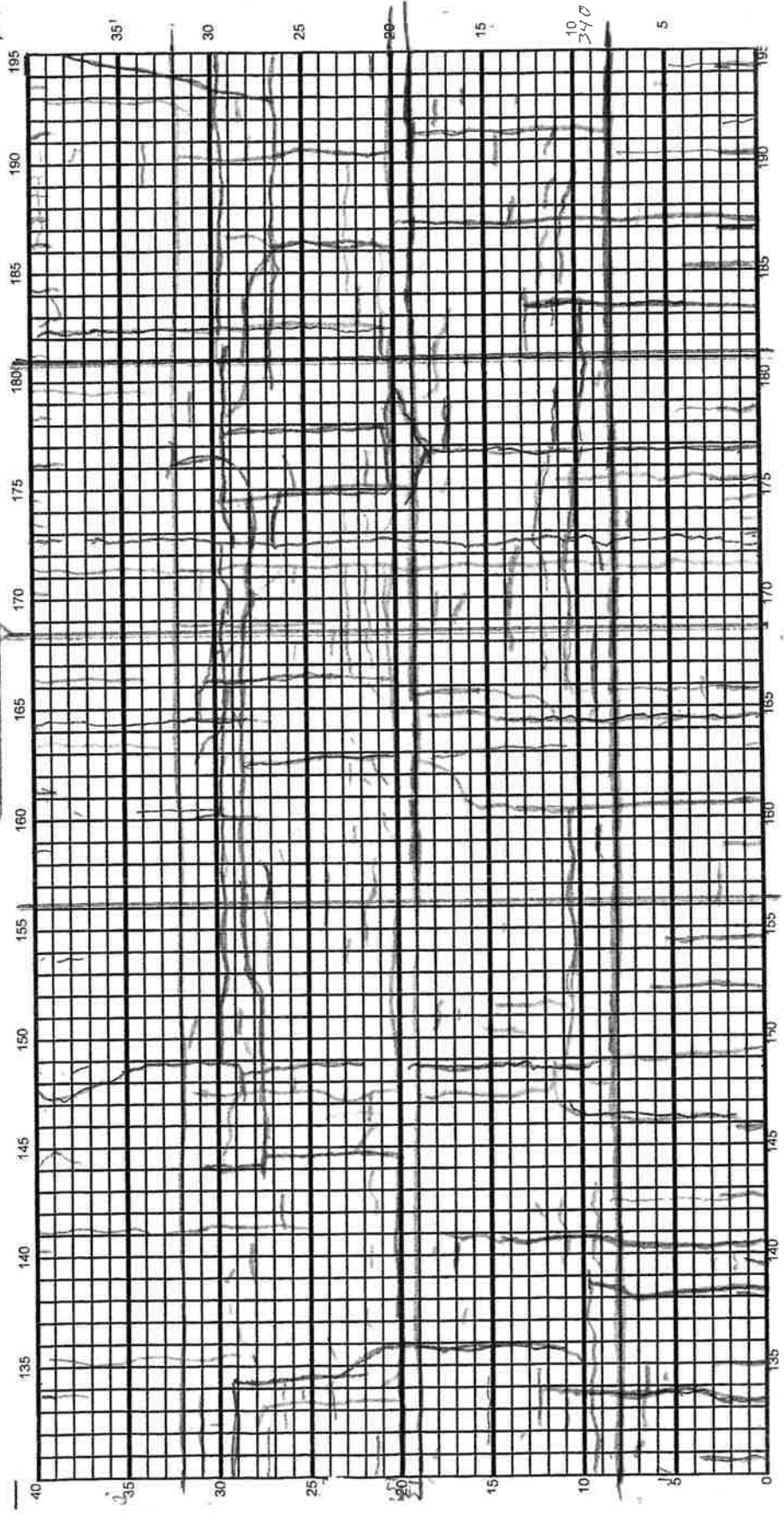
Date 3-24-2011

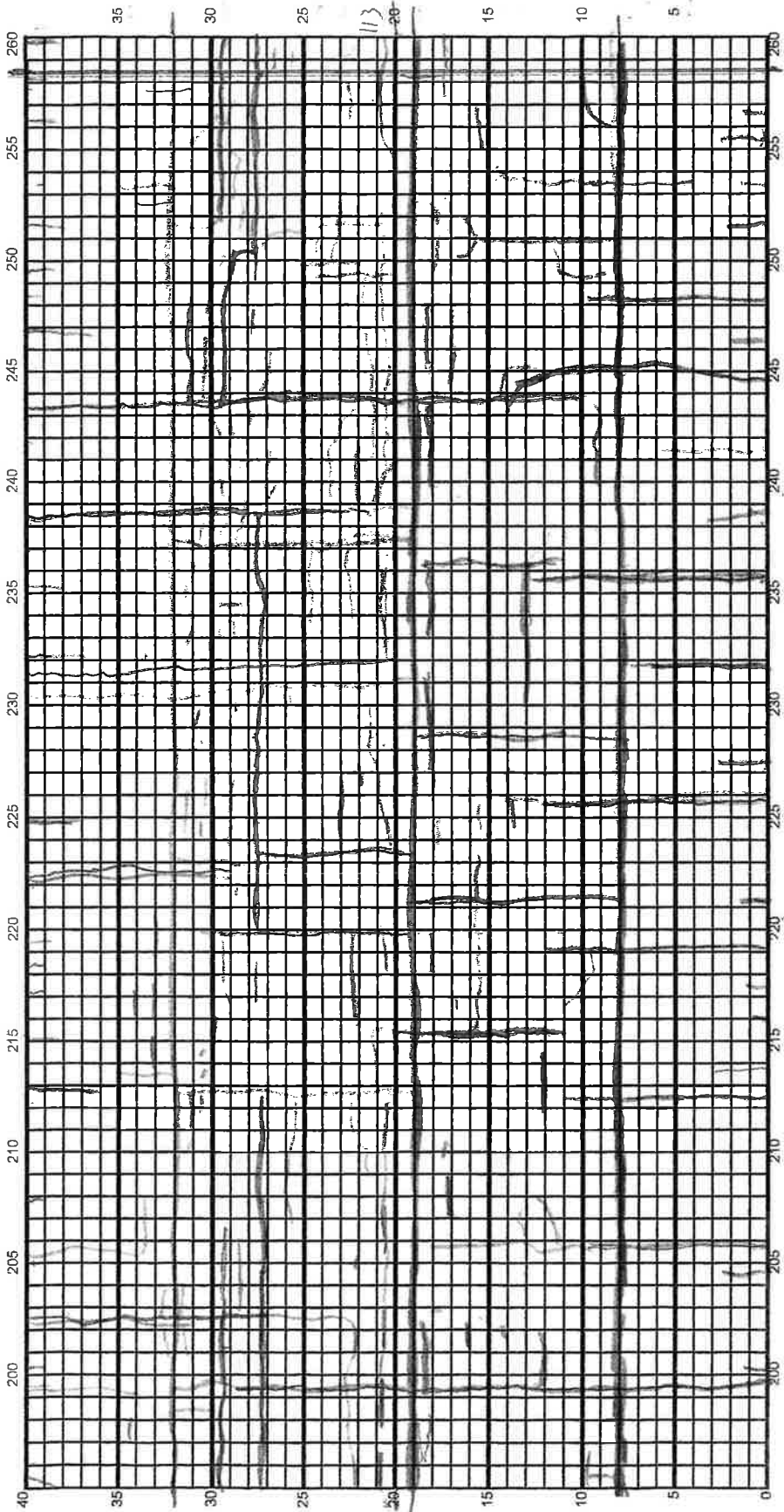
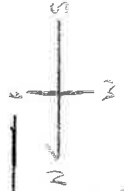


Project No. 030322  
Route 371, Sect. S

Project Name U.S. 67 & U.P.R.R. Bridge  
Location Pressed

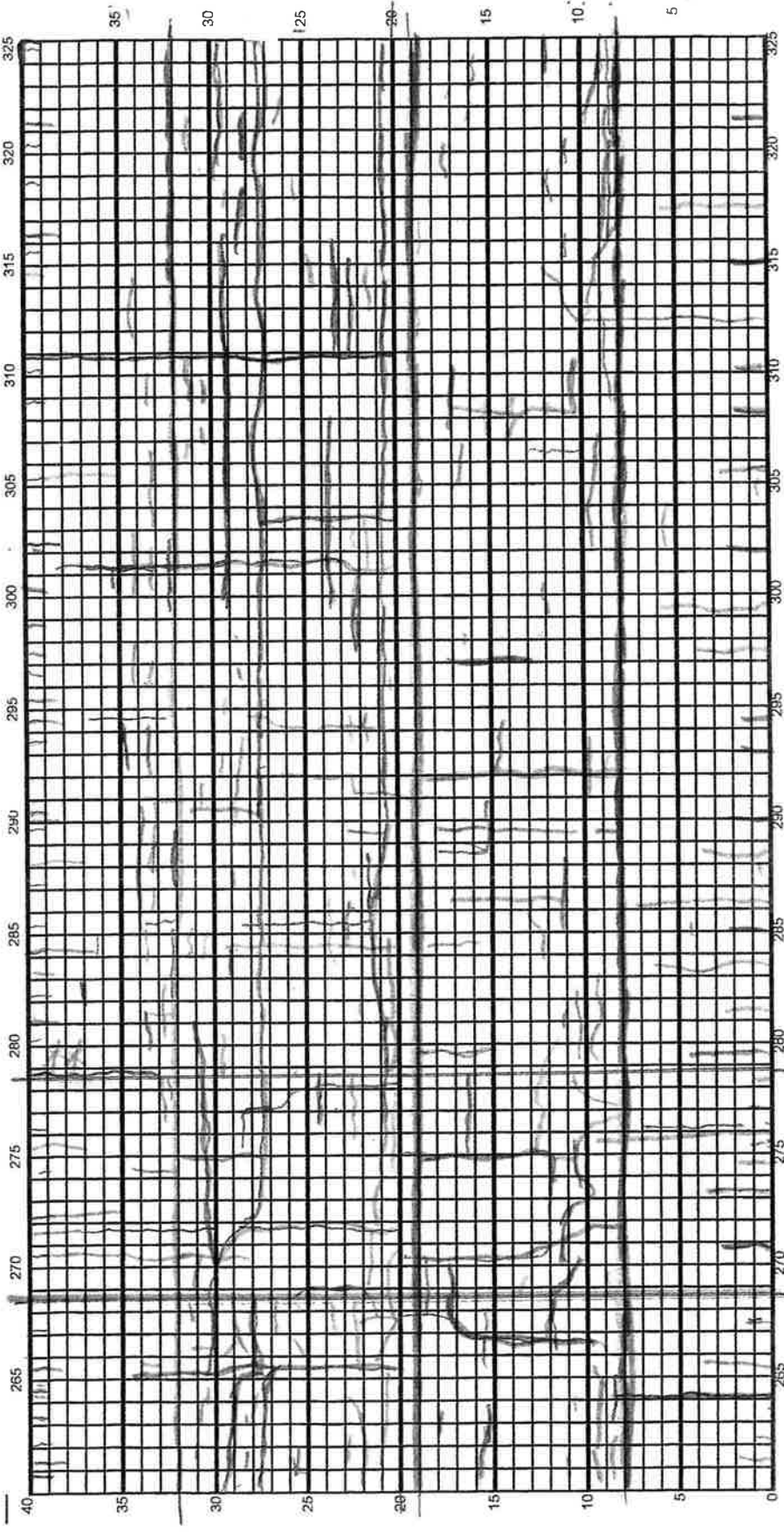
Surveyor Greenlee, T. White  
Date 3-24-2011





Project No. 030322      Project Name US 67 & D.P.R.R. Bridge      Surveyor STANLEY D. TAMAYO, Siskiyewski, Ukiah

Route 371, Sect. 5      Location Princeton      Date 3-24-2011

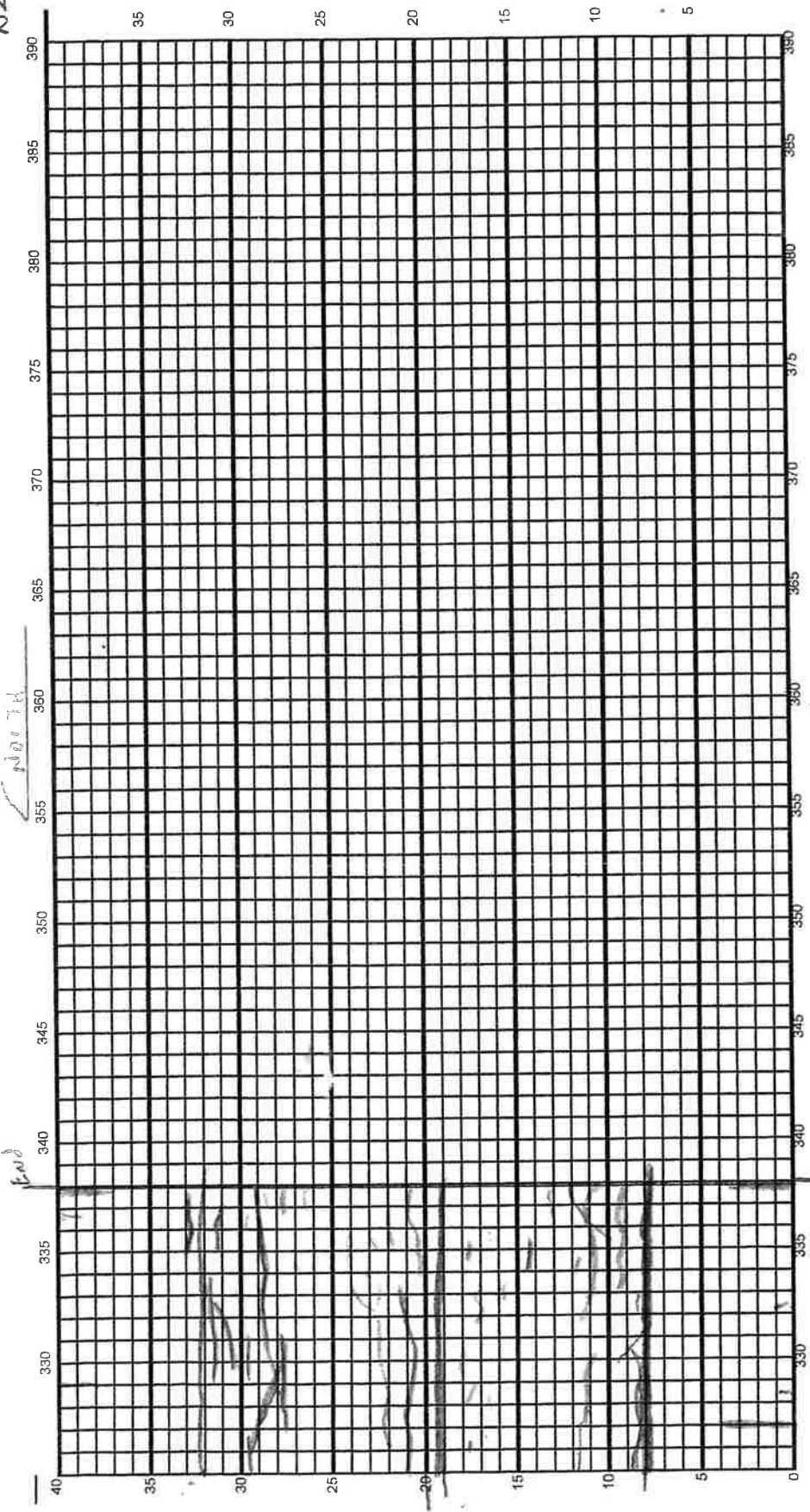




Project No. 030322  
Route 371, Sect. 5

Project Name US 67 & UPRR. Bridge  
Location Perseus

Surveyor Greenwood, Tamara, Suslovskii, White  
Date 3-24-2011



Perseus