RED NARROWS LANDSLIDE
US-6 SPANISH FORK CANYON
M.P. 192.9

GOING THE EXTRA MILE

GEOTECHNICAL SECTION

Utah Department of Transportation - 4501 South 2700 West - Salt Lake City, UT 84119-5998

GEOTECHNICAL DIVISION REPORT

RED NARROWS LANDSLIDE
US-6 SPANISH FORK CANYON
M.P. 192.9

PREPARED BY:
UDOT GEOTECHNICAL DIVISION
SALT LAKE CITY, UTAH

November 15, 1995

FIELD TRIP REPORT
GEOTECHNICAL SECTION

TO: Merrill Jolley, Maintenance Engineer, Region 3
THRU: Ed Keane

FROM: L.A. Heppler
DATE: November 14, 1995

PROJECT: Red Narrows Landslide
LOCATION: US-6 Spanish Fork Canyon

PIN.: --
CID: --

M.P. 192.9 **COUNTY:** Utah

MEET AT: US-6 MP 192.9 **DATE:** November 14, 1995 **TIME:** 9:00 a.m.

PURPOSE/SITUATION: Site visit for the removal of unstable material east of slide area; as recommended in Field Trip Report, November 6, 1995; Area B, Figure 1.

GEOLOGIC FORMATION: The unstable material is composed of unconsolidated colluvium with a thin (1 to 2 foot) thick tufa deposit "capping" the colluvium.

ATTACHMENTS: See attached photographs and Field Trip Report, November 6, 1995, including figure 1.

COMMENTS: On November 14, 1995 at 9:00 a.m. Region 3 mobilized a track hoe, the necessary support equipment, and the traffic control support to bring down the unstable material in a controlled, safe and restrained manner. The track hoe built access up to the unstable material and cautiously removed the "tufa cap rock" and undercut the toe which caused the release of the saturated material in Area B. The material came down at 11:35 a.m. (See photos page 1). The support equipment then removed the debris.

FURTHER INVESTIGATION: The slide areas appear to be small and the priority area of concern has been remediated. The region from Area B to Area C (Figure 1) will have the potential for mass movement as long as water is saturating the natural ground. Several different observations can be specified about the source of the water.

1) Water is coming in from above - see photo page 2.
2) Tufa deposits indicate a possible deep seated spring source and water could be coming directly into hillside.
3) Water could be collecting behind the self sealing tufa deposits and building up pressure.

Several different approaches or options to the problem could be implemented.

1) Track the water coming into the areas from above by using dye.
2) Monitor seismic activity for ground vibration. Several "micro slides" were noted as trains passed by, possibly adding to the liquification potential of the saturated soil.
3) Define subsurface contacts either through drilling or geophysical survey.
4) Accumulate the surface water coming into the area with collection basins and pipe the water past the cut slopes.
5) Horizontal dewatering holes might be warranted if water is coming from a spring source.
6) Removal of tufa deposits might allow water to migrate through the ground.

Some or all of the suggested approaches could be implemented, but a meeting with the Regional Engineer and maintenance personnel should occur to formulate further investigations.

Area A and B before Area B was released

Area A and B after Area B was released

Area B after release

Open Crack above Area B
before release

Flowing water and Erosion above
Area C

Area of Railroad tracks covered by
the toe of the slide (After cleanup)

FIELD TRIP REPORT
GEOTECHNICAL SECTION

TO: Merrill Jolley, Maintenance Engineer, Region 3 **FROM:** L.A. Heppler
THRU: Ed Keane **DATE:** November 6, 1995
PARTICIPANTS: Leslie Heppler, Loren Rausher

PROJECT : Red Narrows Landslide **PIN:** --
LOCATION: US-6 Spanish Fork Canyon **CID:** --
M.P. 192 9 **COUNTY:** Utah

PURPOSE/SITUATION: Site Investigation of recent debris slide.

GEOLOGIC FORMATION: Late Cretaceous - Early Tertiary North Horn conglomerate is in fault contact with the Tertiary aged Flagstaff formation. The landslide material is composed of unconsolidated colluvium and tufa deposits.

ATTACHMENTS: See attached sketch (Figure 1)

COMMENTS:
On Friday, November 3, 1995 at approximately 11:00 a m a debris slide came down on to US-6 at mile post 192 9. This area is saturated with water; and water can be considered the driving mechanism for the slide The water is migrating along shale layers above the slide area. The water is heavily saturated with minerals and possibly slightly geothermal. Numerous tufa deposits have been deposited from the water. The water precipitates the tufa deposits, self sealing the area, and then seeping around the tufa deposits. The tufa deposits are precipitated upon the sandstone and are precipitated on the valley fill colluvium Three areas of concern have been delineated on figure 1

The area that slid on November 3 (Area A, Figure 1) is heavily saturated with water, currently seeping out of the scarp Above the scarp, an old road bed, from power line construction, is collecting the water and saturating the ground below. The slide is approximately 100 feet wide and has a scarp 120 feet high. The material that has been removed consists of colluvium that was probably covered with a superficial layer of tufa The face of the scarp appears to be rock and further slumping in the near future from this scarp is unlikely.

The second area of concern is directly east of the slide (Area B, Figure 1). This block will probably come down in the near future. The toe is currently undercut and the head scarp has a six inch wide crack. It is recommended that this area should be brought down mechanically before mother nature brings it down at an inconvenient time.

The third area of concern is west of the slide (Area C, Figure 1). This area has a large volume of water and field evidence of previous ancient small slides. The water source from the drainage is derived from the drainage to the east and is cross cutting the hillside and draining into Area C. At this time the area is stable, but the area should be monitored for cracking and care should be taken not to under cut the toe of the area

FURTHER INVESTIGATION: Meet with Regional Engineer and maintenance personnel on site to formulate further investigations The slide areas appear to be small, but drill holes would confirm the field observations Horizontal dewatering holes might be warranted looking North

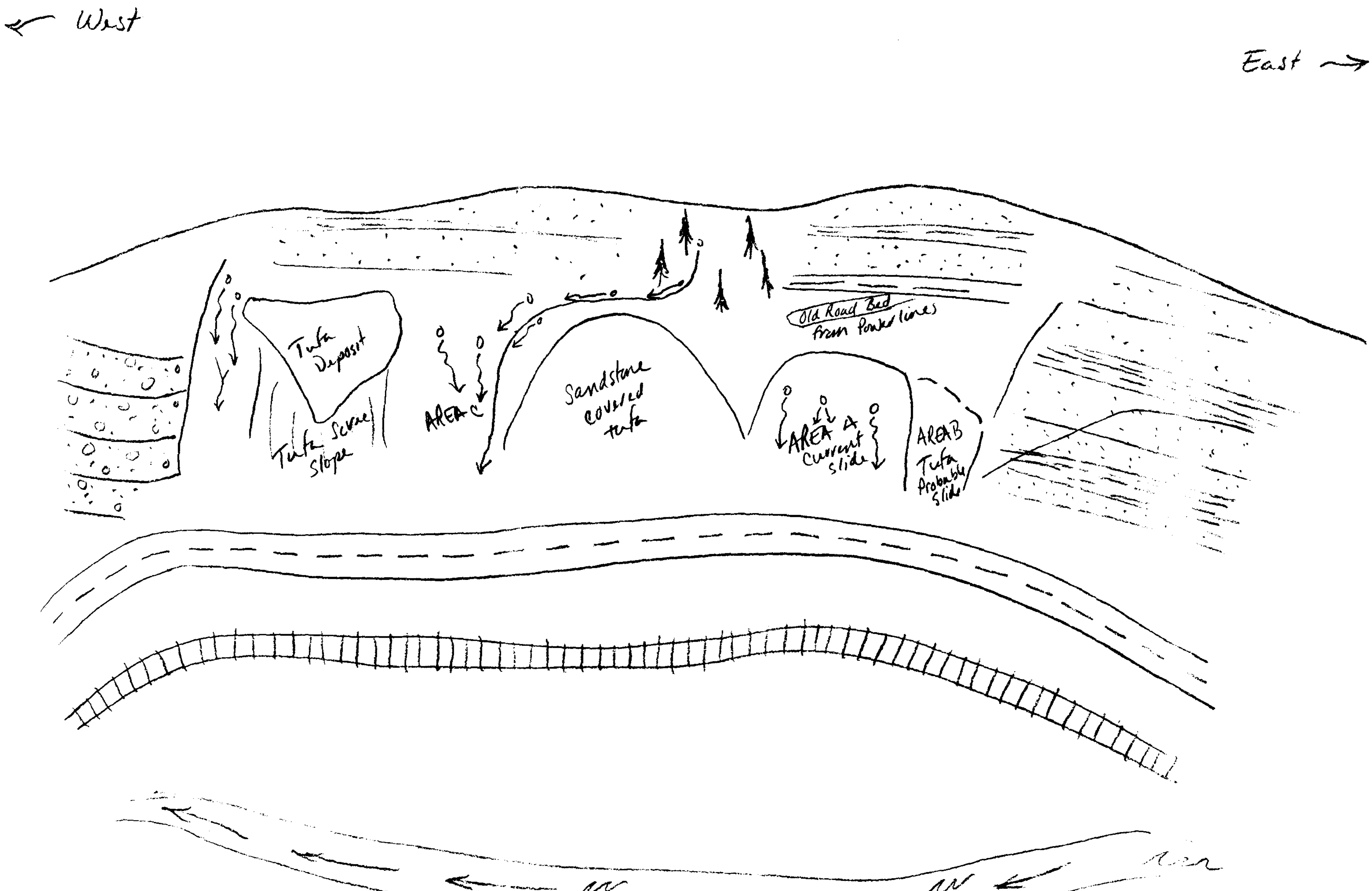

FIGURE 1

SOUTHERN PACIFIC LINES

REPORT

W-7033-02

Landslide Site Reconnaissance
Milepost 673.6
Spanish Fork Canyon, Utah

November 1995

Southern Pacific Lines
1860 Lincoln Street
Denver, Colorado 80295

SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS
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SHANNON & WILSON, INC.
GEOTECHNICAL AND ENVIRONMENTAL CONSULTANTS

SEATTLE
HANFORD
FAIRBANKS
ANCHORAGE
SAINT LOUIS
BOSTON

November 9, 1995

Mr. John Mathews
Southern Pacific Lines
1860 Lincoln Street
Denver, Colorado 80295

RE: LANDSLIDE SITE RECONNAISSANCE, MILEPOST 673.6, SPANISH FORK CANYON, UTAH

Dear Mr. Mathews:

At your request, Mr. William Hultman, an engineer from Shannon & Wilson, Inc. visited the site of a recent landslide along the Soldier Creek in Spanish Fork Canyon, Utah, see Figure 1. The slide is located at Mile Post 673.6 on the north side of the Southern Pacific Lines (SP) main line and Highway 6 as shown on Figures 2 and 3. The purpose of the site visit was to assess the stability of the existing landslide debris and to identify potential risks to the railroad from future landslide activity in the immediate vicinity. Mr. Hultman arrived at the slide area at about 4 p.m. on 4 November, 1995 and met with Mr. Paul Crespin, (SP Roadmaster) and Mr. John Mathews (SP Division Engineer). On 5 November he performed a detailed reconnaissance of the slide and surrounding area.

Slide Description

We understand that the slide occurred on Friday morning, November 3, 1995, at about 10 a.m. and originated in the highway cut slope on the north side of Highway 6 as shown on Figure 3. The railroad was reportedly cleared of slide debris by the afternoon on 3 November 1995 and train service through this area resumed at approximately 4 p.m.

The slide debris consisted of brown, slightly sandy, clayey, SILT, with minor amounts of rock fragments ranging in size from small gravel to boulders. Based on Mr. Hultman's discussions with the SP personnel, the slide debris was saturated and behaved as a fluid mixture of soil and rock (mud flow) after the cut slope failed. It is our understanding that the majority of the slide debris mud flow moved over the highway and accumulated on the railroad main line tracks. After the slide occurred, railroad personnel estimated that the highway was covered with approximately three feet of slide debris, and that the double

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track main line was covered by approximately 15 feet of debris. Railroad personnel estimated that approximately 90 linear feet of the highway and main line tracks were blocked by the debris. Based on our field measurements made on 5 November, we estimate that the slide involved about 2,000 cubic yards of material.

At the time of our site visit, the highway and railroad were cleared of debris and the drainage ditch at the toe of the cut slope had been reestablished. The length of the slide at the base of the cut slope is 80 feet long, measured east-west along the highway, and extends approximately 100 feet up the hill, measured from the assumed pre-existing toe of slope to the head scarp. The crest of the head scarp is approximately 55 feet vertical above the highway pavement. A generalized plan view and ground surface profile of the slide area are presented on Figures 2 and 3, respectively. These figures were developed from pace and hand-level surveys referencing existing site features and have a level of accuracy implied by the survey method used.

The existing ground surface in the area of the head scarp ranges from near vertical to overhanging. Slide debris on the lower portion of the slide area slope at 30 to 35 degrees measured from the horizontal. Sandstone of the North Horn Formation crops out in the upper half slide and top of rock is located about 12 feet below the crest of the head scarp. The sandstone was observed in the eastern two-thirds but not in the western one-third of the slide area. Numerous seeps were observed in the slide area, and we estimated that the total combined flow at 20 to 50 gallons per minute. Seeps were observed throughout the vicinity of the slide, with the largest seeps observed in the upper portion of the slide at the contact of the sandstone and overlying soil.

During our reconnaissance we observed a section of the cut slope along the east flank of the existing slide that has moved but not traveled with the main body of the slide. This slide mass is still hanging above the highway and railroad. Tension cracks are visible at the top of this slide mass that intersect the existing head scarp. This slide mass is approximately 27 feet wide (measured along the highway), and has an estimated volume of about 500 cubic yards. Seepage was observed on the soil surface along both flanks and along the toe of slope.

The slide area is bordered on the east by a near-vertical outcrop of interbedded sandstone and mudstones of the North Horn Formation and on the west by a massive tufa deposit.

The regional geology in the vicinity of the slide is presented on Figure 4. The overall slope of the ground surface upslope from the head scarp forms an angle of about 33 degrees from horizontal. This slope is covered by a dense growth of live oak and other vegetation. Seepage was observed on this slope near the western flank of the slide. Isolated outcrops of conglomerate were observed on the slope above the slide area, but it was not possible to determine if the outcrops were in place or float material. Tension cracks were not observed up slope from the head scarp which indicates that the slide is currently not progressing up slope. However, depending on the groundwater levels, depth to rock, and engineering properties of the soil, it is our opinion that the slide will likely progress upslope with time.

A bench is located about 50 feet above the crest of the head scarp. Numerous seeps were observed on the upslope side of this bench. These seeps provide a source of water to the slide area but do not account for all the seepage observed in the slide area. We observed numerous seeps in the surrounding area, particularly to the west of the slide. Based on our observations and our interpretation of the local geology, we believe that additional water is entering the slide area through fractures within the underlying rock mass.

Cause of Sliding

Our site reconnaissance revealed no conclusive evidence to explain why the cut slope failed. However, our reconnaissance and discussions with railroad personnel revealed two factors that may have contributed to the sliding and the type of sliding at this site: personal accounts indicating that the slide debris was saturated and behaved as a mud flow, and our observations of continuing seepage in the slide area. Changes in the groundwater system may have been caused by an increase of groundwater input into the soil mass or by a decrease of drainage from the soil mass. Slope stability of marginally stable slopes may also be influenced by changes made to the slope geometry, such as removing material from the toe of the cut slope. We understand that prior to sliding, ditch work was performed along the toe of the cut slope. It is possible that prior to ditching, the saturated cut slope was marginally stable, and that minor excavation at the toe of the cut slope was sufficient to initiate sliding.

Conclusions

Based on our interpretations of site conditions, we have identified two potential impacts to the railroad from future landslide activity resulting from the present conditions at the site. Our primary concern is the stability of the section of the cut slope on the east flank of the existing slide area. In our opinion, this section of the cut slope is marginally stable and failure is imminent. However, in its present drainage condition, we do not believe that the slide debris from this section of the slope will result in a mud flow which would potentially reach the railroad track. However, if changes are made to the slope geometry, or if there is an increase in moisture content in the soil mass, then the potential for impacting the railroad will increase. Our second concern is the progression of the landslide upslope from the existing head scarp of the slide. Although we believe that the impact to the railroad from migration of the scarp up slope is small, we have not explicitly assessed the slope stability in this region because the subsurface conditions in this region of the slope are not known. However, we expect that there will be at least minor sloughing of the soil above the sandstone as the soil fails back to a more stable slope geometry.

Recommendations

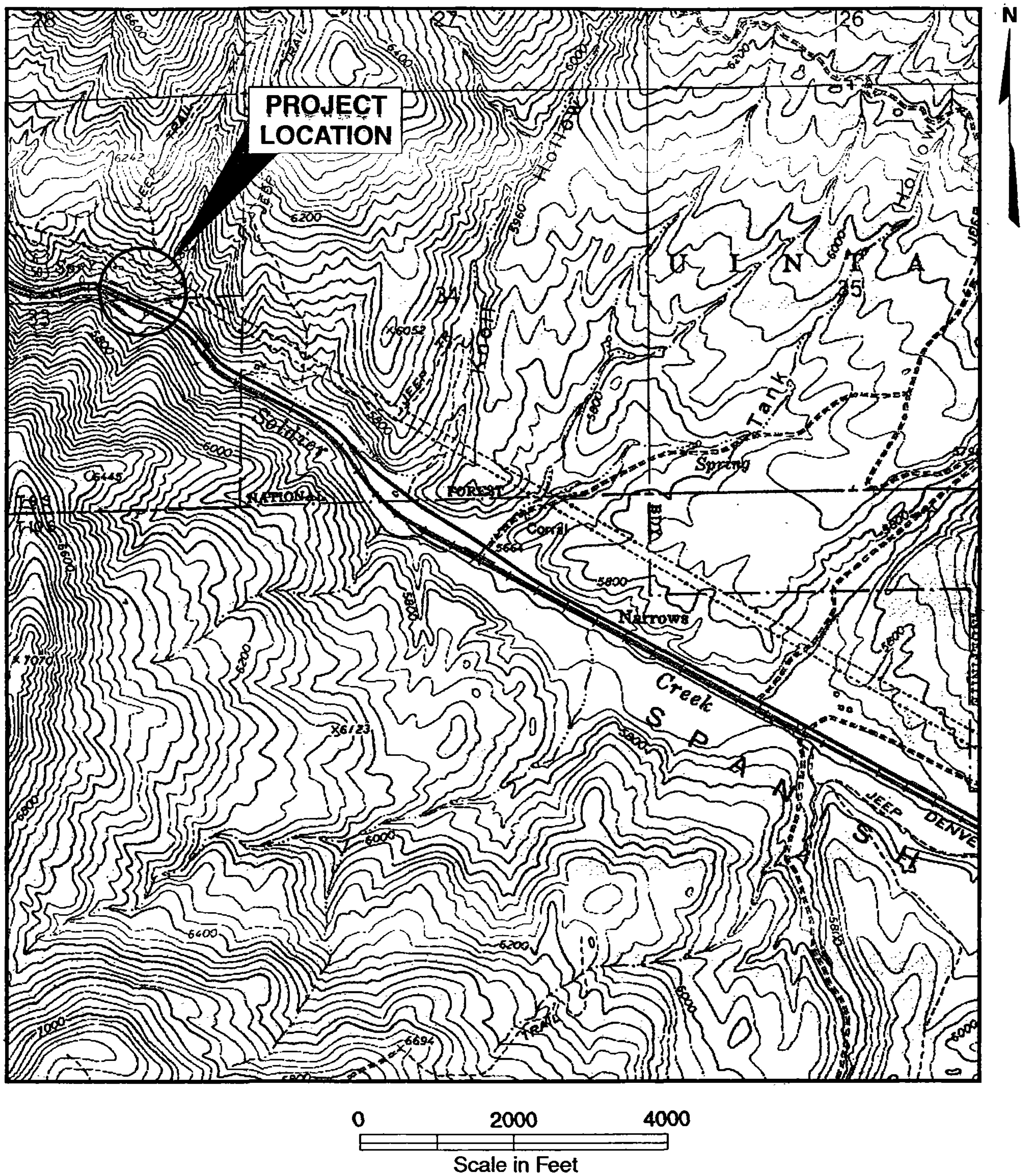
Based on our site reconnaissance and our interpretation of existing site conditions we recommend the following:

1. that the Utah Department of Transportation remove the potential slide material on the eastern flank of the existing slide.

2. that the Utah Department of Transportation assess the potential for progression of the existing slide up slope and to submit their report to Southern Pacific Lines for review and comment.

3. that the Utah Department of Transportation install a drainage system in the bench up slope from the slide to divert water away from the slide area.

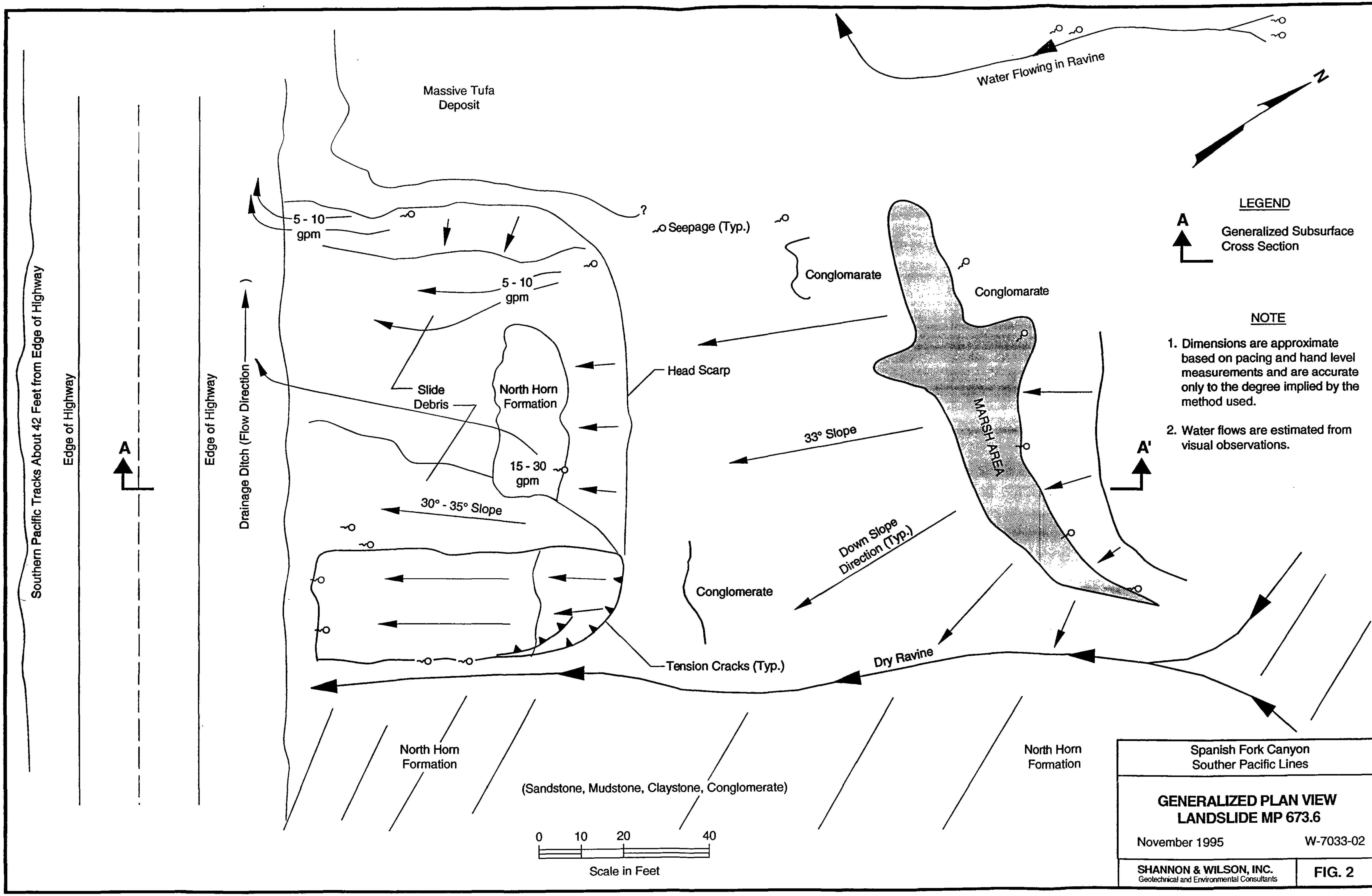
4. that until items 1, 2, and 3 are completed to the railroads satisfaction, install a slide fence between the railroad and Highway 6. The slide fence should be designed so that a mud flow such as that which occurred recently will trigger the system and warn approaching trains that the track is obstructed. Specifically,



NOTE

Map adapted from USGS topographic map of Mill Fork, Utah quadrangle, dated 1967.

Spanish Fork Canyon Southern Pacific Lines
VICINITY MAP
November 1995 — W-7033-02
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants — **FIG. 1**



Spanish Fork Canyon
Souther Pacific Lines

GENERALIZED PLAN VIEW
LANDSLIDE MP 673.6

November 1995 W-7033-02

SHANNON & WILSON, INC.
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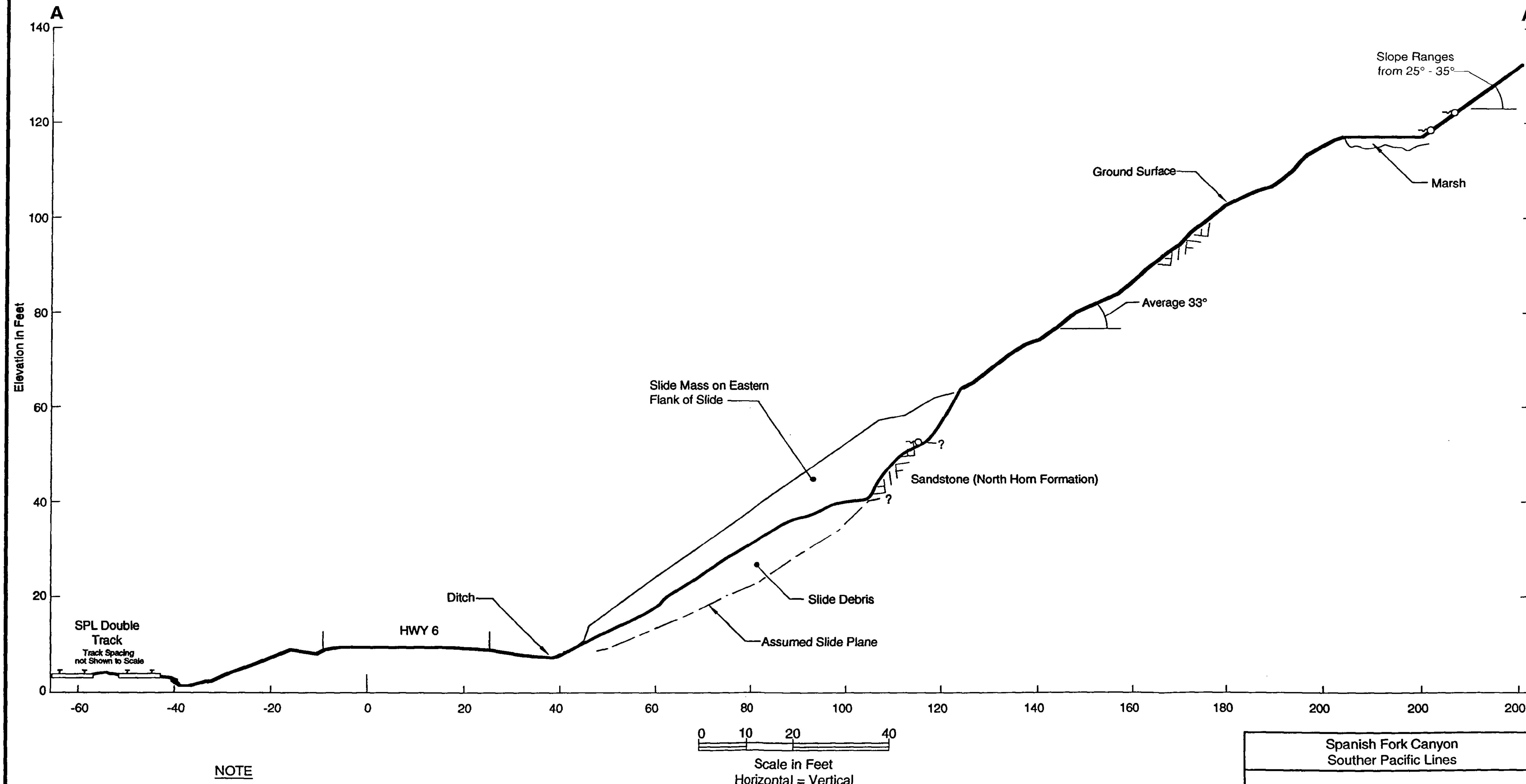
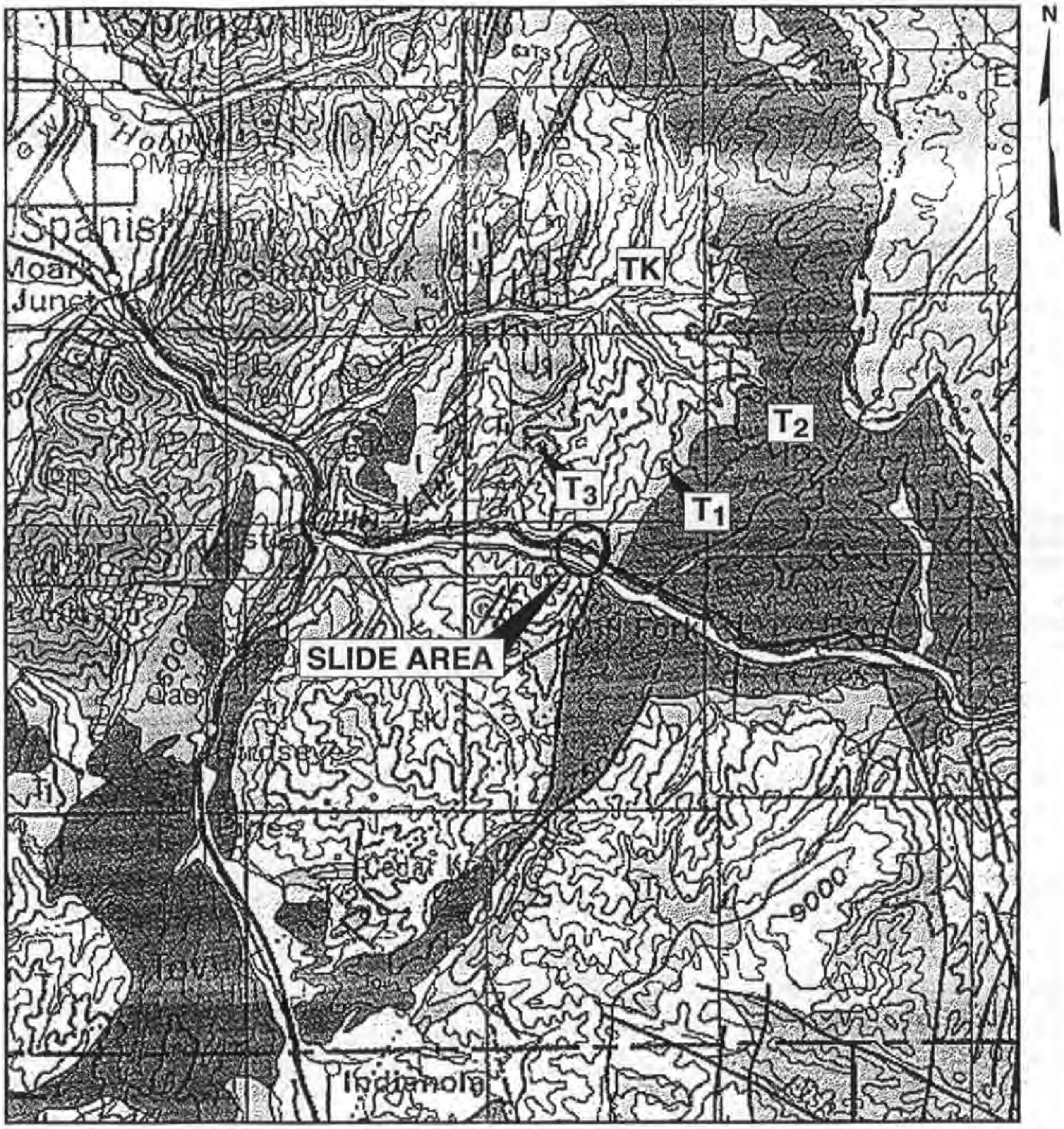
FIG. 2



NOTE

Dimensions are approximate based on pacing and hand level measurements and are accurate only to the degree implied by the method used.

Spanish Fork Canyon Souther Pacific Lines
Generalized Profile A-A' November 1995 W-7033-02
SHANNON & WILSON, INC. Geotechnical and Environmental Consultants — **FIG. 3**



ROCK UNITS IN PROJECT AREA

- T_2 - Green River Foundation
- T_1 - Flagstaff Formation
- TK - North Horn Formation
- T_3 - Price River Formation

0 500,000 1,000,000

Scale in Feet

NOTE

Map adapted from Geologic Map of UTAH compiled by Leh, F HINES, dated 1980.

Spanish Fork Canyon
Southern Pacific Lines

GEOLOGIC MAP

September 1995 W-7033-02

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

FIG. 4

SHANNON & WILSON, INC.
Geotechnical and Environmental Consultants

Dated: November 9, 1995

To: Southern Pacific Lines
Attn: Mr. John Mathews

Important Information About Your Geotechnical/Environmental Report

CONSULTING SERVICES ARE PERFORMED FOR SPECIFIC PURPOSES AND FOR SPECIFIC CLIENTS.

Consultants prepare reports to meet the specific needs of specific individuals. A report prepared for a civil engineer may not be adequate for a construction contractor or even another civil engineer. Unless indicated otherwise, your consultant prepared your report expressly for you and expressly for the purposes you indicated. No one other than you should apply this report for its intended purpose without first conferring with the consultant. No party should apply this report for any purpose other than that originally contemplated without first conferring with the consultant.

THE CONSULTANT'S REPORT IS BASED ON PROJECT-SPECIFIC FACTORS.

A geotechnical/environmental report is based on a subsurface exploration plan designed to consider a unique set of project-specific factors. Depending on the project, these may include: the general nature of the structure and property involved; its size and configuration; its historical use and practice; the location of the structure on the site and its orientation; other improvements such as access roads, parking lots, and underground utilities; and the additional risk created by scope-of-service limitations imposed by the client. To help avoid costly problems, ask the consultant to evaluate how any factors that change subsequent to the date of the report may affect the recommendations. Unless your consultant indicates otherwise, your report should not be used: (1) when the nature of the proposed project is changed (for example, if an office building will be erected instead of a parking garage, or if a refrigerated warehouse will be built instead of an unrefrigerated one, or chemicals are discovered on or near the site); (2) when the size, elevation, or configuration of the proposed project is altered; (3) when the location or orientation of the proposed project is modified; (4) when there is a change of ownership; or (5) for application to an adjacent site. Consultants cannot accept responsibility for problems that may occur if they are not consulted after factors which were considered in the development of the report have changed.

SUBSURFACE CONDITIONS CAN CHANGE.

Subsurface conditions may be affected as a result of natural processes or human activity. Because a geotechnical/environmental report is based on conditions that existed at the time of subsurface exploration, construction decisions should not be based on a report whose adequacy may have been affected by time. Ask the consultant to advise if additional tests are desirable before construction starts; for example, groundwater conditions commonly vary seasonally.

Construction operations at or adjacent to the site and natural events such as floods, earthquakes, or groundwater fluctuations may also affect subsurface conditions and, thus, the continuing adequacy of a geotechnical/environmental report. The consultant should be kept apprised of any such events, and should be consulted to determine if additional tests are necessary.

MOST RECOMMENDATIONS ARE PROFESSIONAL JUDGMENTS.

Site exploration and testing identifies actual surface and subsurface conditions only at those points where samples are taken. The data were extrapolated by your consultant, who then applied judgment to render an opinion about overall subsurface conditions. The actual interface between materials may be far more gradual or abrupt than your report indicates. Actual conditions in areas not sampled may differ from those predicted in your report. While nothing can be done to prevent such situations, you and your consultant can work together to help reduce their impacts. Retaining your consultant to observe subsurface construction operations can be particularly beneficial in this respect.