

**EXPERIMENTAL PROJECT
USE OF SHREDDED TIRES
FOR LIGHTWEIGHT FILL**

**FHWA Experimental Project No. 1
DTFH-71-90-501-OR-11**

Post-Construction Report

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16. Abstract <p>Shredded rubber tires have been used as lightweight fill in repair of a landslide that occurred under a highway embankment in mountainous terrain on Highway US 42 (Oregon State route #35). The force driving the slide was decreased by removing the soil embankment and replacing it with a lighter weight embankment constructed with shredded tire chips. The tire embankment has a three-foot-thick compacted soil cap on the top and side-slopes and supports a conventional aggregate base and asphalt pavement. 5800 tons of shredded tires were used - approximately 580,000 tires. Cost of the tires delivered to the site was \$30/ton reduced by a \$20/ton reimbursement from Oregon DEQ; net \$10/ton (\$7/yd³). Cost of placing and compacting the tires was \$8.33/ton (\$5.85/yd³). Total cost of the tire fill at final in-place density was \$18.33/ton (\$12.87/yd³). Surface monuments, settlement plates, and slope inclinometers have been installed to monitor the performance of the embankment.</p> <p>Shredded tire chips were transported to the project site in "live-bottom" trailers from vendors located 150 to 200 miles from the project. The trailers each carried 28 tons of tires. The tire chips were placed and compacted in three-foot lifts using a D-8 dozer. Density (unit weight) of the tire chips was on the order of 30 pcf when "loose" in the haul vehicle, 45 pcf compacted in-place, and 52 pcf when compressed under the soil cap and pavement. The 12.5-foot-thick section of compacted tire embankment compressed 20 inches (13.4%) under the capping load. Few construction problems were encountered. Exposed wires in the tire chips caused tire punctures on dump trucks.</p> <p>Pavement surface deflections were measured using a falling weight deflectometer. Deflections were twice as great as would be expected of the same pavement over an earth embankment. Vibrations similar to those felt when standing on a bridge can be felt by a person standing on the embankment when a heavy truck crosses it.</p>					
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DISCLAIMER

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Abstract

Shredded rubber tires have been used as lightweight fill in correction of a landslide that occurred under a highway embankment in mountainous terrain on Highway US 42 (Oregon State route #35). The force driving the slide was decreased by removing the soil embankment and replacing it with a lighter weight embankment constructed with shredded tire chips. The tire embankment has a three-foot-thick compacted soil cap on the top and side-slopes and supports a conventional aggregate base and asphalt pavement. 5800 tons of shredded tires were used - approximately 580,000 tires. Cost of the tires delivered to the site was \$30/ton reduced by a \$20/ton reimbursement from Oregon DEQ; net \$10/ton (\$7/yd³). Cost of placing and compacting the tires was \$8.33/ton (\$5.85/yd³). Total cost of the tire fill at final in-place density was \$18.33/ton (\$12.87/yd³). Surface monuments, settlement plates, and slope inclinometers have been installed to monitor the performance of the embankment.

Shredded tire chips were transported to the project site in "live-bottom" trailers from vendors located 150 to 250 miles from the project. The trailers each carried 28 tons of tires. The tire chips were placed and compacted in three-foot lifts using a D-8 dozer. Density (unit weight) of the tire chips was on the order of 30 pcf when "loose" in the haul vehicle, 45 pcf compacted in-place, and 52 pcf when compressed under the soil cap and pavement. The 12.5-foot-thick section of compacted tire embankment compressed 20 inches (13.4%) under the capping load. Few construction problems were encountered. Exposed wires in the tire chips caused tire punctures on dump trucks.

Pavement surface deflections were measured using a falling weight deflectometer. Deflections were twice as great as would be expected of the same pavement over an earth embankment. It may be that the larger deflections have larger-than-normal radii. Vibrations similar to those felt when standing on a bridge can be felt by a person standing on the embankment when a heavy truck crosses it.

EXPERIMENTAL PROJECT
USE OF SHREDDED TIRES FOR LIGHTWEIGHT FILL

INTRODUCTION

The use of shredded tires for lightweight fill represents a very new technology. There are many questions to be answered regarding the construction and performance of this type of structure. The objective of this experimental evaluation was to provide information to help answer the following questions:

1. Is lightweight fill constructed of shredded tires effective in stabilizing a landslide or soft ground problem?
2. What special construction problems are associated with shredded tire embankments?
3. Can construction methods (details) be improved?
4. What is the density of the shredded tire chips:
 - a. during haul ("loose density")?
 - b. following compaction in an embankment?
 - c. following loading with "capping embankment" and pavement?
5. Will shredded tires in embankments undergo continuing long-term compression?
6. Will pavement over shredded tire embankments be subject to abnormal distress?
7. Are shredded tire fills cost-effective?

BACKGROUND

The United States has an estimated 2 billion scrap tires stockpiled around the country. Another 240 million tires are discarded each year. Disposal of waste tires is one of the country's most pressing environmental problems.

Beginning in 1986, the Minnesota Department of Forestry has demonstrated the feasibility of using shredded tires as lightweight fill in embankment construction over soft ground. Use of shredded tires as lightweight fill also has application on landslide correction projects.

The use of shredded tires for lightweight fill (or as "standard" fill) provides the significant benefit of utilizing a troublesome

waste product (scrap tires) in a beneficial highway engineering application. Further, the present commercial uses for scrap tires utilize only a small portion of the amount stockpiled and generated annually in the U.S. The use of shredded tires in embankments offers the potential benefit of disposing of large volumes of tires in short sections of highway. For example, the use of an asphalt-rubber pavement overlay utilizes only about 3600 tires per mile of 2-lane road while a mile of 2-lane embankment 20-feet high would utilize about 5 million tires (one tire equals approximately one cubic foot loose bulk density before compaction).

THE OREGON SLIDE CORRECTION PROJECT

The slide that ODOT corrected is at mile point 59.3 on Highway U.S. 42 (Oregon Hwy. 35, Coos Bay - Roseburg), approximately 25 miles west of Roseburg, Oregon as indicated on Figure 1. The slide occurred in a newly-constructed 15-foot-high highway embankment and the slide block extends approximately 150 feet beyond the toe of the embankment to a small creek (Shields Creek) running parallel to the highway.

The first indications of a possible landslide problem were pavement cracks which appeared in September, 1989, shortly after construction of new embankment that raised the previous highway embankment 4 feet and widened it about 20 feet. More definite slide symptoms, as shown in Figures 2 and 3, appeared early in 1990. The original ground underneath the embankment is gently sloping. The slide is a block slide riding on an old slip plane of an ancient slide. Although the old slip plane had "healed" and had enough strength to support the original 11-foot-high embankment, the additional load of the new construction was sufficient to activate the portion of the ancient slide between the highway and the creek. The head scarp of the new slide is at approximately the centerline of the highway. Figure 4 is a plan drawing of the slide.

DESIGN OF SLIDE CORRECTION

Geotechnical analyses indicated that an effective correction scheme would be removal of some of the embankment weight by replacement with shredded tires and use of the excavated embankment soil to construct a counterbalance berm between the embankment toe and the creek. The weight of the counterbalance acts as a force resisting the movement of the landslide.

The design called for removal of 8,500 cubic yards of earth embankment to be replaced with shredded tires. (Final tire volume was 8,260 cubic yards.) The weight of soil removed was approximately 12,800 tons compared to 5,800 tons of shredded

tires used as replacement. An estimated 580,000 tires were used. Details of the design are shown on Figures 5, 6 and 7.

A drainage blanket consisting of 12 inches of free-draining rock between two layers of geotextile was placed beneath the shredded tire embankment and beneath the counterbalance in order to prevent the groundwater table from rising into the embankment. Three 10-foot-deep french drains which outlet into Shields Creek were located beneath the blanket to enhance the subsurface drainage. The tire chips would have served as a good drainage medium without the rock blanket, but the Oregon DEQ required the rock blanket so the tire chips would not be submerged.

ENVIRONMENTAL (GROUNDWATER) CONSIDERATIONS

A laboratory study has been completed for the Minnesota Pollution Control Agency (MPCA) "to evaluate the compounds which are produced by exposure of tires to different leachate environments." One of the recommendations in the report of that study (2) is "that the use of waste tires be limited to the unsaturated zone in a roadway ...". The Oregon DEQ used the recommendations in the report as a basis for evaluating and approving the slide correction design. That is why a rock drainage blanket was required below the tire fill.

At this time there are differences of opinion regarding the need for controlling contact between tires and groundwater. Some question the conclusions and recommendations of the MPCA report and believe that the threat to the environment due to tire leachate is virtually nil. Much of the data in the MPCA report could be used to support such an opinion.

Geisler, et. al. (1) describe the use of shredded tire fill in submerged applications in Minnesota. They used a lightweight shredded tire embankment to successfully cross soft organic wetland soils that had failed under the load of an earth embankment. They also used shredded tires to cross a peat swamp. They single out wetlands applications as being a particularly suitable for shredded tire applications. The extremely low buoyant weight of rubber makes it especially beneficial as lightweight fill when submerged.

We recommend that additional research be conducted regarding the chemical stability of shredded tires in submerged conditions. Monitoring of groundwater quality in the vicinity of full-scale embankments would be particularly valuable.

CONSTRUCTION WITH SHREDDED TIRES

The embankment construction was completed in two stages to allow traffic on one half of the embankment while the other half was under construction. The construction steps are listed briefly on Figure 7 and more completely in Attachment A. Figures 8, 9, and 10 show the embankment under construction.

TRANSPORTING TIRE CHIPS TO THE PROJECT

Shredded tires were brought to the site from four different vendors, located 150 to 250 miles from the project: one in Salem, Oregon, two in the Portland Oregon area, and one in Winlock, Washington. They were transported in trailers capable of carrying 28 tons of tires; approximately 80 cubic yards "loose weight." The tires would "shake down" or "pack" to about 60 cubic yards during the trip to the project site. The trailers were "live-bottom" trailers capable of "self-unloading" at a stockpile near the project. Some tilt trailers were also used (Figures 11 and 12).

The cost of transportation from vendor to stockpile was \$10-per-ton which is equivalent to approximately \$7-per-cubic-yard at final in-place density.

The shredded tire suppliers were:

- 1) Western Recovery
1650 Industrial Drive, Salem, OR 97303
- 2) RMAC PO Box 301008
12245 NE Whitaker Way, Portland, OR 97230
- 3) Tire Recyclers Inc.
583 N. Military Road, Winlock, WA 98596
- 4) Waste Recovery Inc.
8501 N. Borthwick, Portland, OR 97217

PLACEMENT AND COMPACTION

After a sufficient stockpile was accumulated, shredded tires were brought from the stockpile to the construction site in 10-yard dump trucks and dumped at one end of the 350-foot-long correction excavation. It was not practical to drive the dump trucks over the in-place shredded tires because exposed wires sticking out of the shredded tire "chips" punctured the tires of the hauling vehicles.

The tire chips were spread and compacted by a D-8 dozer. At least 3 "full-coverage" compaction passes were specified for each

3-foot lift of tires. (A full coverage pass is a pass during which at least one track of the dozer passes over every portion of the lift surface being compacted.) Attempts to compact the tires with a D-6 Dozer were observed to be less effective than compaction by the D-8.

The specified compaction method was selected based on successful results achieved during similar construction in Minnesota using the same method (1).

The most effective method of compaction with the dozer proved to be the use of a "grid" coverage pattern with the dozer making a full-coverage pass while travelling back and forth the length of the lift followed by a full-coverage pass while travelling back and forth the width of the lift and continuing to alternate the travel direction on successive passes.

During compaction by the D-8, the shredded tire material tended to "push-out" or "bulge-out" on the sides of the embankment under construction. Due to the staging scheme of the construction, one side of the embankment under construction was always confined against the other half of the highway embankment which was in-place and carrying traffic. This was advantageous in that dressing of the slope was only necessary on the unconfined side.

An attempt was made to compact the material by "squirring" the dozer, that is, turning the dozer in-place with the tracks turning in opposite directions and then reversing the turn direction in an alternating pattern. This technique was not effective, tending to loosen the fill rather than compacting it.

A VERTICAL CUT

During the Phase-2 construction of the north half of the embankment, a vertical cut was made in the shredded-tire portion of the Phase-1 embankment. This vertical cut, with a maximum height of approximately 8 feet, stood under traffic without any observable distress during the 28 days required to build the Phase-2 embankment. The fact that this vertical cut through the tire chips was able to stand unsupported for several days illustrates the high internal shear strength of the compacted tire chips due to friction and interlock. Close up photographs of the vertical cut are shown in Figure 13.

SLOPE CONSTRUCTION

Final trimming of the 2:1 slope of the shredded tire embankment could not be effectively accomplished with a dozer. A dozer attempting to trim the slope surface would loosen the material on the surface resulting in a rough, uncompacted slope.

The desired embankment slope was achieved by over-building the slope approximately 1 foot horizontally and then trimming it back with a Cat 235 excavator sitting on top of the tire embankment. The excavator trimmed the slope with a bucket that had a "thumb" on it. (The excavator could be observed "rocking" considerably on the flexible embankment as its center-of-gravity shifted during the boom moves associated with the trimming operation.)

SOIL CAP CONSTRUCTION

A three-foot-thick soil cap (vertical thickness) was specified for both the top and the south slope of the embankment. A separation geotextile was placed between the shredded tires and the soil.

The south (right) slope of the embankment had a height of approximately 10 feet above the embankment toe berm. On this slope, the soil cap was placed and compacted in horizontal lifts with a horizontal width of approximately 10 feet resulting in a vertical thickness of about 5 feet. Four feet of the width was temporary widening to provide sufficient width for the Stage-2 traffic, and it was removed after completion of Stage 2. The tire fill along the north (left) boundary of the embankment was quite thin and the edge of the fill was constructed with a very shallow slope. The soil cap on this side was constructed as an extension of the soil cap on the top of the tire fill.

The soil cap over the top of the shredded-tire fill was placed in a conventional manner using standard lift thicknesses of no more than 8 inches and compaction to 95 percent of maximum density as determined by "Standard Proctor," except for the first lift which was compacted to 90 percent as specified for that lift. In general, the contractor did not experience difficulty in obtaining the specified compaction using an Ingersoll-Rand LD 150 compactor on the native clayey silt soil.

During compaction of the first 8-inch lift of soil over the top of the tire fill, the earth cap was deflecting ("bouncing") significantly, but 90 percent compaction was achieved with normal compactive effort. With each additional lift of capping soil, aggregate base, or asphalt, the deflections became progressively smaller.

Due to the flexibility of the surface of the shredded-tire fill, the joints between panels of the geotextile placed on top of the tires had a greater-than-normal tendency to separate as the first lift of soil cap was placed. In order to overcome this tendency, brass "hog-ring" clips were used to pin the joints together. The panel edges were overlapped 12 inches as normally specified and then the clips were added at 6-foot intervals along the joints. This method was very effective in preventing joint separation.

TEMPORARY SURFACING

In order to allow for compression of the tire fill under traffic loads, permanent asphalt pavement was not placed on the project for several weeks following completion of the embankment. Temporary surfacing was constructed on the top of the aggregate base of the Phase 1 embankment during construction of Phase 2 and also on the Phase 2 surface for a specified three-week-minimum waiting period and while waiting for suitable weather to allow placement of permanent pavement. An asphalt prime coat surface was placed on the Phase 1 aggregate base surface on September 14, and with weekly maintenance, performed reasonably well for the two months prior to permanent paving. A temporary surface of compacted asphalt pavement grindings placed on the Phase 2 half of the embankment in October required daily maintenance. The pavement grindings may have performed better if they had been exposed to warmer weather to soften them and facilitate binding.

PERMANENT ASPHALT SURFACING

The pavement design is 8 inches of asphalt concrete over 21 inches of aggregate base. Due to compression of the tire fill during construction of the pavement, it is estimated that 23 inches of aggregate base were placed in order to reach design grade.

To date, 6 inches of asphalt have been placed. The final 2 inches will be placed in the summer of 1991.

COMPRESSION UNDER SOIL AND PAVEMENT CAP

The shredded tire fill was constructed to a elevation 12 inches above the design elevation for top-of-tire-fill in anticipation of "compression" of the tire fill during placement of the overlying soil cap and pavement. This anticipation of compression was based on the 10 percent compression observed in a similar embankment (9 feet of tire fill under 4 feet of soil cap) constructed in Minnesota and reported by Geisler, Cody, and Niemi (1).

Data from the settlement plates and from monuments on the surface of the pavement indicate that the thickest portion of the shredded-tire fill (approximately 12.5 feet thick) compressed 13.4 percent during construction as follows:

1. 16 inches during placement of 3 feet of soil cap,
2. 2 inches during placement of 23 inches of aggregate base, and

3. 2 inches during 3 months of traffic and placement of 6 inches of asphalt concrete.

CONSTRUCTION CHALLENGES

SHREDDED TIRE CHIPS QUALITY CONTROL

The nature of the tire chips varied among the four vendors supplying material. Attachment B is a "specification" (with commentary) for the shredded tire material. Some of the material delivered to the site departed from the specifications with:

1. excessive exposed wire (from cords and belts),
2. tire chips with both sidewalls attached,
3. tire chips that exceeded the maximum size of 24 inches, and
4. occasional extraneous material including: tires which had not been through the shredder, wheel rims, and miscellaneous debris.

However, less than 25 cubic yards of material was judged unsuitable and sorted out of the 17,000 cubic yards (loose measure) delivered to the site. Typical examples of tire chips delivered are shown in Figures 13 and 14.

The oversized tire chips were used in the embankment. Visual inspection revealed that virtually all of the tire chips which were too large or had both sidewalls attached had multiple holes through the body of the chip and were, in effect, "porous". It is estimated that less than 2 percent of the chips were in these two categories. These oversize chips caused no problems during placement and compaction.

Apparently the shredding machine of the first vendor had dull cutters and tended to expose more than the specified maximum allowable amount of wire in approximately 5 percent of the chips. These chips were also used in the embankment since the exposed wire was not considered detrimental to the function of the chips as fill, and the drainage blanket beneath the fill protects against contact of the groundwater table with any corrosion developed on the exposed wire. Examples of these "poorly shredded" tire chips are shown in Figure 14.

Control of the material quality was difficult without an inspector at the source location (at the vendor). The deliveries were made by independent truckers, often in the middle of the night. Had a significant portion of the material been unsuitable

for use in the embankment, an inspector at the source would have been necessary.

PUNCTURING OF DUMP TRUCK TIRES

Because of the quantity of tire chips with relatively long wires exposed on the edges, it was not possible to route rubber-tired vehicles such as dump trucks over the tire fill without chip wires penetrating the vehicle tires and sometimes puncturing them. Chips in the stockpile area punctured a few tires, and even the chips that fell off the trucks along the haul route caused a minor problem. Tighter quality control of the chip material might reduce, or possibly eliminate, this problem.

MISCELLANEOUS

The dump trucks with tail gates had some difficulty in dumping the tire chips. The chips tended to hang up on the tail gate during dumping.

Some people have expressed concern that a shredded tire embankment is subject to destruction by fire. Once the shredded tires are in place and covered with the earth cap, there is no danger of combustion. During construction, normal caution should be used to avoid starting any fires in the stockpiled tires or in embanked tires that have not yet been capped with soil.

UNIT WEIGHT OF SHREDDED TIRE FILL

Measurements were taken to facilitate computation of the density (unit weight) of the shredded tire material in several different conditions: as-loaded in the haul vehicles at time of loading and after a long haul, as-compacted prior to placement of a soil cap, immediately following placement of a soil cap, and after a "settlement" period of 3 months with a soil cap, aggregate base, and a temporary surfacing in place and carrying traffic.

LOOSE DENSITY

The average loose density (unit weight) in the haul vehicles was determined by weighing three trucks empty and loaded and physically measuring the load volume by profiling the top of the load relative to the bottom of the trailer. Two trucks were measured immediately after the loading operation and one truck was measured after a 40-mile haul. One truck was measured from each of three different vendors.

The loose density of the shredded-tire material varied with the nature of the shredded product, how "coarse" the shred was, and also changed due to "packing" of the material during hauling. The following loose unit weights were measured:

1. 24 pcf Coarse material with many large chips as-loaded at Vendor #1. This material was apparently produced by a shredder with dull knives.
2. 30 pcf Material from vendor #2 with fewer large chips than material #1. This material was apparently produced by a shredder with sharper knives.
3. 33 pcf Material from vendor #3, similar to material #2, following a 40-mile haul. According to one of the drivers, this amount of "packing" was less than could be expected for the 150-mile haul.

The material that weighed 30 pcf at the time of loading is representative of the material intended by the material specification. It was produced by a shredding machine with reasonably sharp cutters. Our computations based on estimates by Geisler (1) of density and volume shrinkage during compaction indicate that the loose density of material used on a Minnesota project was 29 pcf. The 24 pcf density of "coarse" material should not be considered typical, but can occur in cases of marginal shredding machines. In computing the weight of tire chips that could be carried in a haul vehicle of a given volume, 24 pcf would be the lowest reasonable density to assume.

COMPACTED DENSITY

The compacted density (unit weight) was 45 pcf prior to loading with the soil and pavement cap.

The unit weight of the compacted tire fill was determined by dividing the entire weight of tires incorporated in the embankment by the total volume occupied by the tires at the end of compaction. The volume of tire fill was determined by cross-sections on 50-foot centers before and after tire placement and compaction. The settlement of the original ground under the weight of the tire fill was negligible, so no volume correction was necessary to compensate for settlement. This settlement was measured by two settlement plates under the thickest portion of the tire fill.

DENSITY UNDER LOAD OF SOIL AND PAVEMENT CAP

The density (unit weight) was 52 pcf following loading with approximately 3 feet of soil, 23 inches of aggregate base, and 6 inches of asphalt and after 3 months under traffic (ADT of 3750 with 20 percent trucks).

This unit weight was determined by adjusting the volume of compacted tires to compensate for the compression of the tire fill. The compression of the tire fill was estimated by using data from four settlement plates, two located on the top surface of the thickest portion of the tire fill and two directly below them at the base of the fill. The settlement was estimated to be directly proportional to the tire-fill thickness. The 20 inches of compression measured for the 12.5-foot thickness of fill established a compression ratio of 1.6 inches per foot of thickness or 13.4 percent.

Based on measurements of temporary surface monuments, we estimate that two inches of the settlement occurred during the first four weeks under traffic with the temporary pavement surface in place. Less than an inch of settlement occurred during the next two months.

ADDITIONAL DENSITY MONITORING

The settlement plates and surface monuments will continue to be monitored until December of 1991. A final report at that time will report any additional "compression" of the tire fill.

PERFORMANCE OF THE EMBANKMENT

In addition to the short-term "compression" or "settlement" performance reported above, we have made some qualitative observations of the embankment performance. We have also made dynamic deflection measurements on the pavement surface.

QUALITATIVE OBSERVATIONS

When a heavy truck travels over the shredded-tire embankment, there is a perceptible vibration. During Phase 2 construction, while traffic was carried by the temporary surfacing on the south half of the embankment (the thick half), an observer standing on the embankment during passage of a loaded log truck could note a vibration sensation similar to what one would feel standing in the middle of a long-span bridge. Following construction of the north half of the embankment, that vibration was noticeably reduced, but still easily perceptible.

A visible indication of vibration was also apparent during Phase 2 construction. Following excavation for Phase 2, the shredded tires in the south half of the embankment (constructed in Phase 1) formed an 8-foot-high, near-vertical face below the soil and base-rock cap (Figures 10 and 13). Some of the larger tire chips protruding from this face could be seen oscillating in response to the vibrations generated by the passage of a loaded log truck. Although actual measurements of this movement were not made, the magnitude was on the order of one inch or less for a chip protruding eight inches, and the frequency of the oscillation was on the order of five to ten cycles per second.

DEFLECTION TESTING

Deflection testing was conducted on January 7, 1991, 4 months after completion of the Stage 1 soil cap and aggregate base construction. Testing was done using ODOT's Falling Weight Deflectometer (FWD). The FWD is a non-destructive testing device which measures the pavement deflection under an impact load that simulates actual truck traffic loading. A 12-inch-diameter plate was used to apply the impact load to the pavement surface. Deflections were measured at three load levels ranging from 3,000 to 12,000 lbs. with sensors located at 0, 12, 24, 36, and 58 inches from the point of the load. The measured deflections were normalized to a standard 9,000 lb. load by linear interpolation.

The asphalt was cored and measured to be 6¼ inches thick at the time of the deflection testing.

The average deflection of the pavement over the rubber tire fill was approximately 0.020 inch compared to a typical deflection of 0.010 inch normally measured for a similar asphalt-and-aggregate-base pavement constructed over a conventional soil subgrade. The standard pavement overlay design method used by the Oregon Highway Division would call for an overlay of 5 inches of asphalt for an existing pavement with deflections of 0.020 inches. However, there is some question whether the standard overlay design procedure would be appropriate for the unusual subgrade condition of a shredded tire embankment. It is expected that, since the increase in dynamic deflection is apparently due to a deep layer (the tires), the deflection increase may have a large radius and cause less stress in the pavement than similar magnitudes of dynamic deflection with conventional embankment underlying the pavement.

The pavement design for this project calls for a total of 8 inches of asphalt. The top 2-inch lift of asphalt pavement is scheduled for construction in fall of 1991. Additional deflection readings will be taken following construction of the top lift, and results will be given in our final report.

LONG-TERM PERFORMANCE

Subsequent reports will address the topics of long-term compression of the tire fill, success in stabilization of the landslide, and performance of the pavement over the embankment. The following instrumentation has been placed to monitor the long-term performance of the embankment.

INSTRUMENTATION

As mentioned above, four settlement plates have been installed. The plates are located in two pairs under the outside edge of pavement with one pair approximately 100 feet in from each end of the slide. Each pair has a plate at the bottom of the tire fill and a plate at the top of the tire fill. The plates are being used to measure any foundation settlement below the tires and any additional compression of the tire fill.

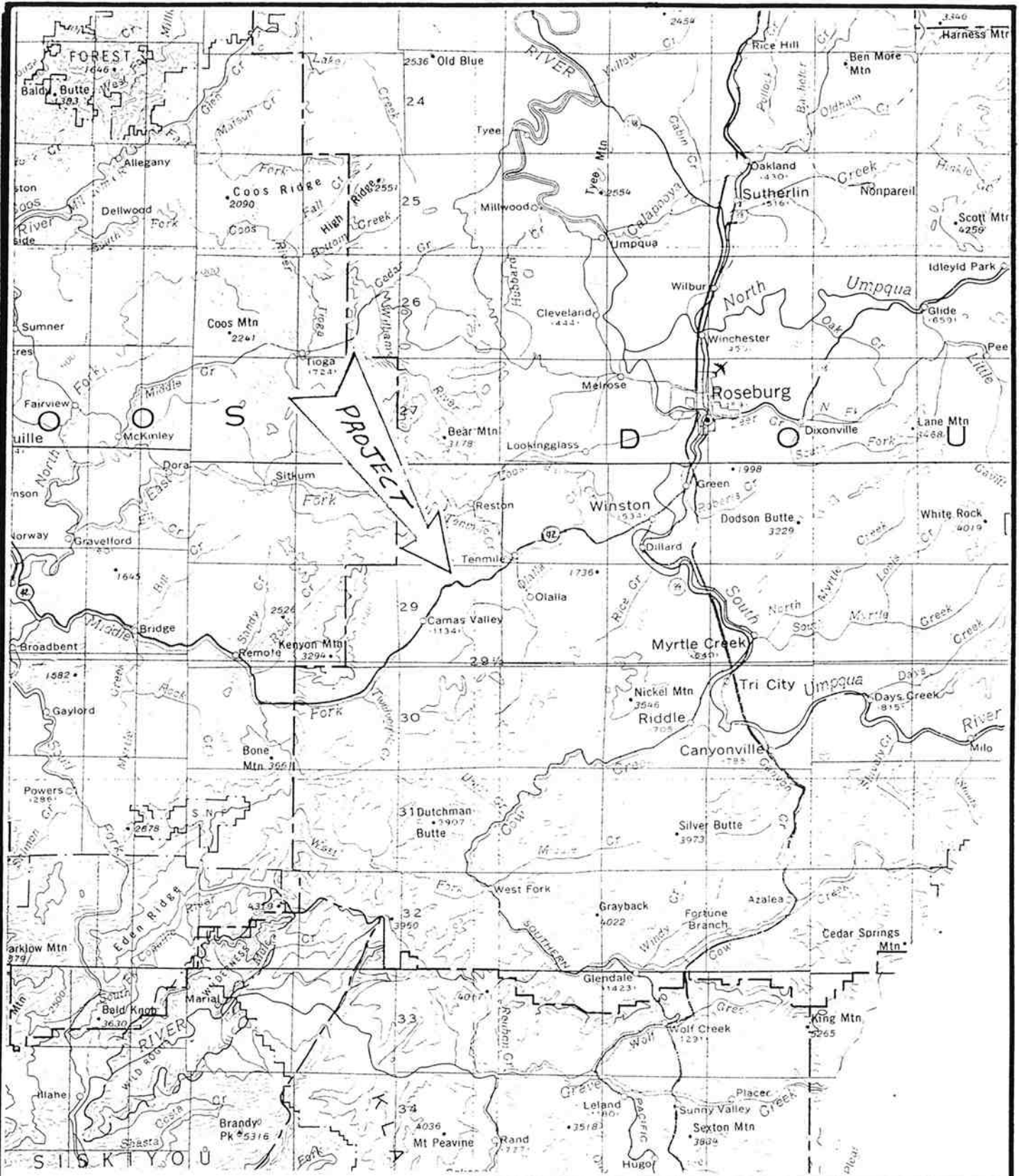
The settlement plate standpipes were temporarily buried in September following construction of the Phase-1 soil cap since they were in the detour path. They were re-exposed in November at the time of the asphalt paving construction.

Three lines of survey monuments have been installed running parallel to the centerline of the highway: one on the centerline, one on the shoulder, and one at the toe of the embankment. The monuments are installed on 50-foot spacing and extend to at least 50-feet beyond each end of the slide correction. The monuments are being used for monitoring of both horizontal and vertical movements.

Two plastic slope inclinometer tubes have been installed to measure the lateral stability of the embankment: one at the embankment toe, and one at 75 feet from the toe, toward the creek. The inclinometer tubes are located along the center cross-section of the slide and installed to a depth of 35 feet below the pre-construction ground surface. The inclinometer tubes are slotted to serve as observation wells for determination of groundwater level.

Instrumentation (slope inclinometers, settlement plates, and survey monuments) will be read on the following schedule by State personnel:

- a. Initial readings immediately after installation.
- b. Every 2-months for the first 6-months, i.e. @ 2, 4, and 6 months.
- c. Every 3-months for the next 6-months, i.e. @ 9 and 12 months.



PROJECT LOCATION



VICINITY MAP

SCALE: 1" = 8 MILES APPROX.



GEOTECHNICAL GROUP
Oregon State Highway Division

FIGURE NO. 1



LANDSLIDE DISTRESS: FEBRUARY 6, 1990

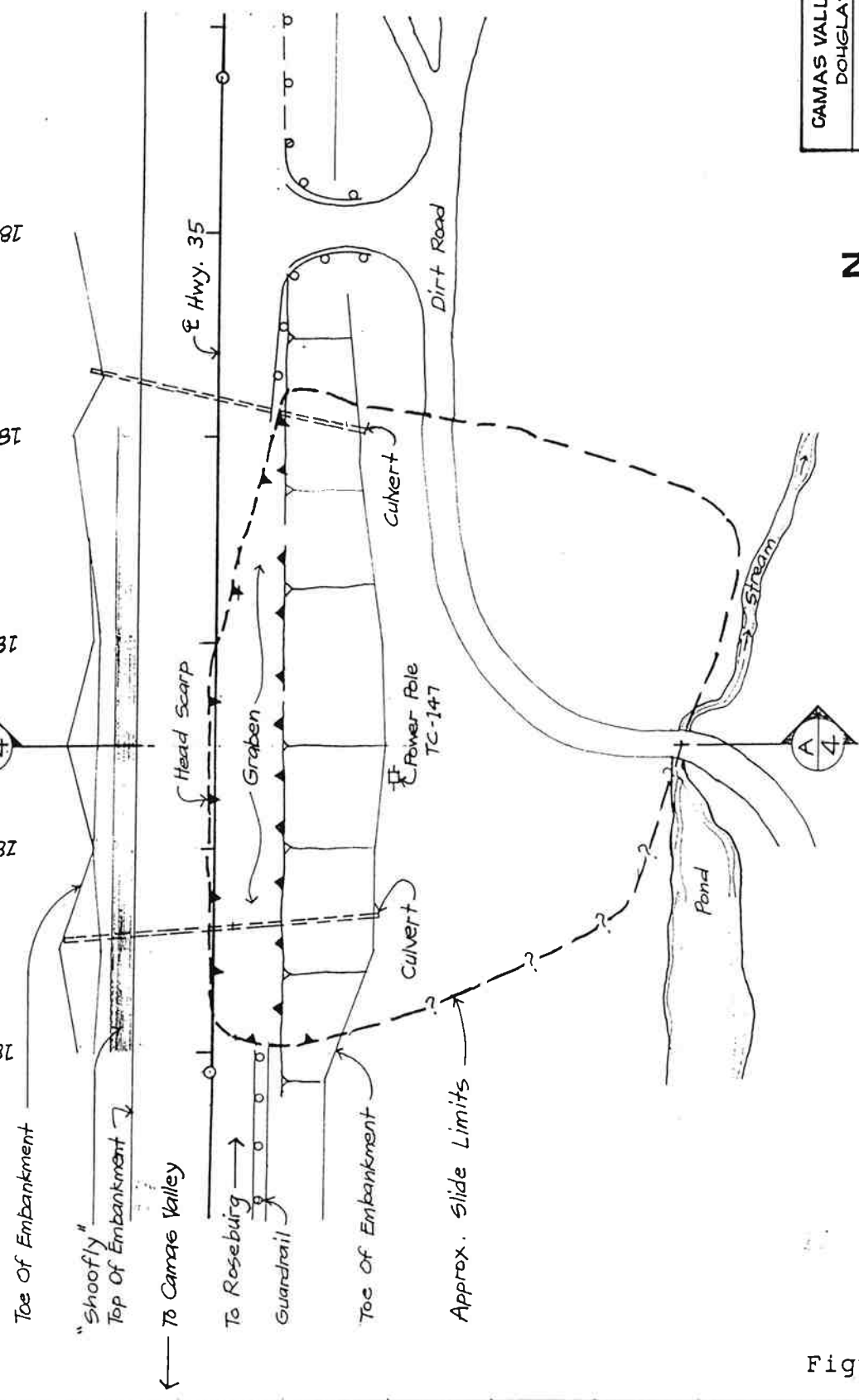
Figure 2



LANDSLIDE DISTRESS: MARCH 14, 1990

Figure 3

1863+00
1864+00
1865+00
1866+00
1867+00



Toe of Embankment
"Shoofly"
Top of Embankment
← To Camas Valley
To Roseburg →
Guardrail
Toe of Embankment
Approx. Slide Limits

CAMAS VALLEY-MUNS CREEK DOUGLAS COUNTY	
SITE PLAN (EXISTING)	
HWY. 35 (Coos Bay, Roseburg) P. 56.0-61.8	DATE: Apr. 90
E.A. NO. C10653	DATE: Apr. 90
GEOTECHNICAL GROUP Oregon State Highway Division	
FIGURE 1 of 4	

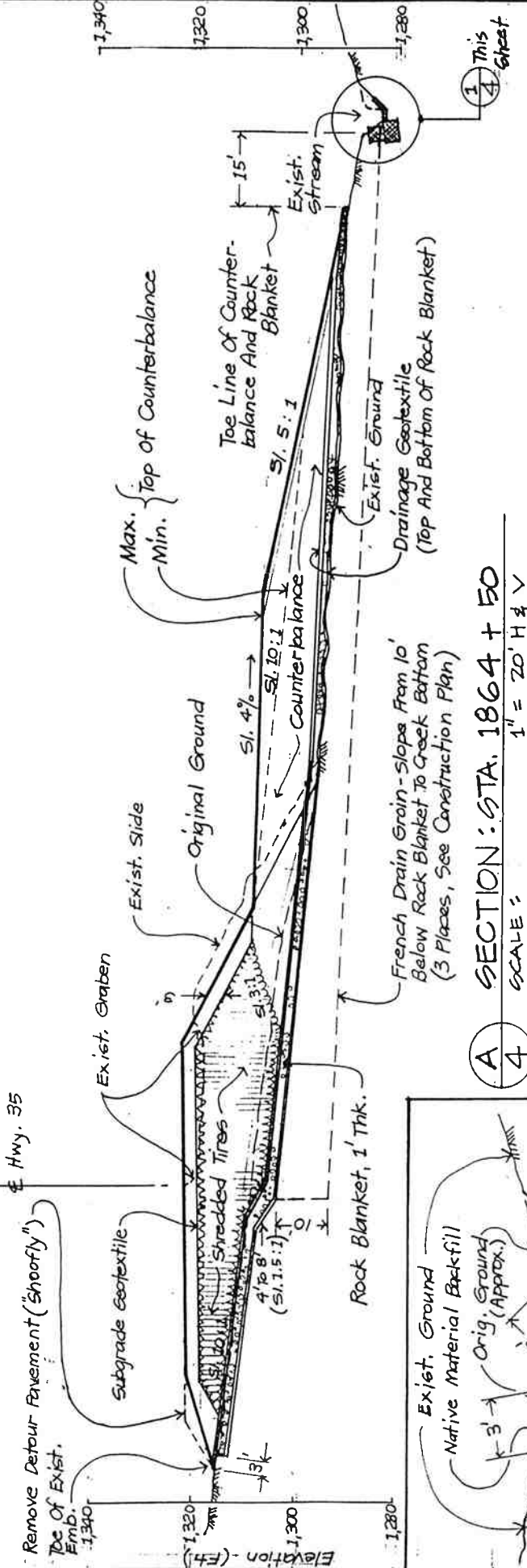


SLIDE PLAN (EXISTING)

SCALE: 1" = 50'

Figure 4

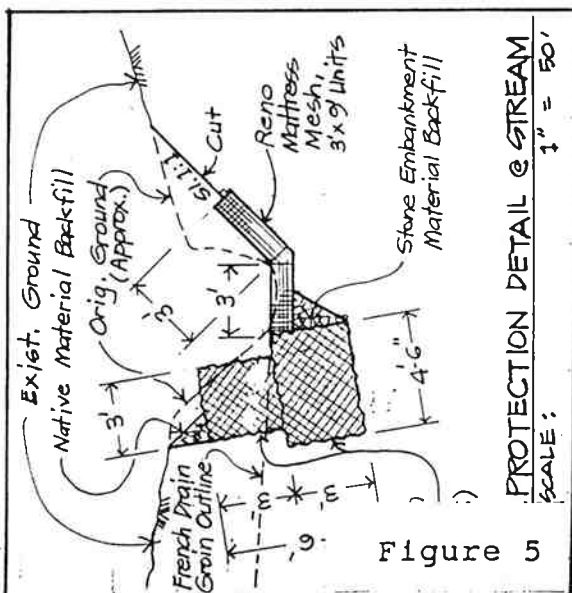
feet



A
4

SECTION: STA. 1864 + 50
SCALE: 1" = 20' H & V

NOTE:
See Figure 2 for SUGGESTED CONSTRUCTION SEQUENCING AND STAGING.



PROTECTION DETAIL @ STREAM
SCALE: 1" = 50'

CAMAS VALLEY-MUNS CREEK DOUGLAS COUNTY
SECTION: STA. 1864 + 50 AND DETAIL
HWY. 35 (Coo's Bay - Roseburg) M.P. 56.0-61.8
E.A. NO. C10.G.5.3 DATE: APR. 90
GEOTECHNICAL GROUP Oregon State Highway Division

FIGURE 4 of 4

Figure 5