Memorandum

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To: MR. DALE WIDNER - D02
Project Manager

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Date: May 25, 2021
File: 02-PLU-70-85.7/89.35
0218000068
Beckwourth Cap M

From: DEPARTMENT OF TRANSPORTATION
DIVISION OF ENGINEERING SERVICES
GEOTECHNICAL SERVICES – MS 5

Subject: **Geotechnical Memo- Pavement Cracking - Assessment and Recommendations**

The Office of Geotechnical Design North (OGDN) was requested by the Office of Maintenance Engineering by email on February 11, 2021 to assess anomalous roadway cracking on State Route 70 (SR70), in Plumas County, at postmiles (PM) 85.9, 87.5, and 89.35 as shown in Figure 1. A site meeting was performed with the local maintenance supervisor, Ms. Karen Partlow, and leadworker, Mr. Josh Dixon on April 13, 2020 to provide OGDN with specific local information and historical background. This memo provides the results of our field assessment and geotechnical recommendations for mitigation and repair.

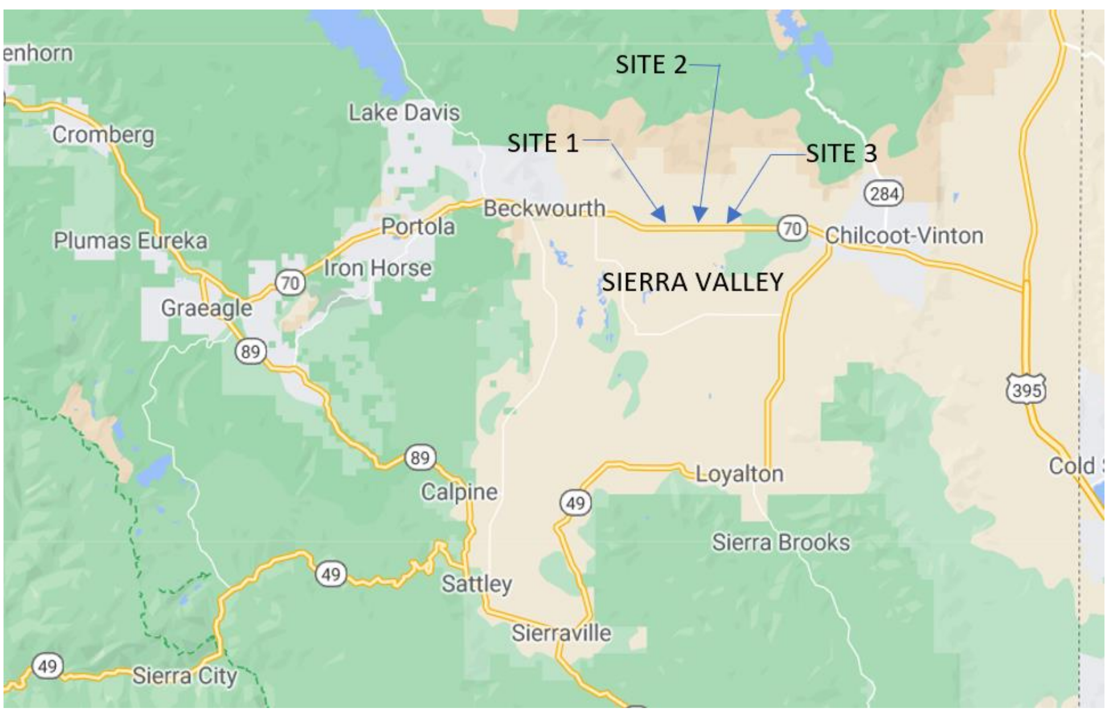

Figure 1. Map showing location of three sites on SR70 in Sierra Valley

The assessment herein is based on field observations, historic and chronological information provided by maintenance, published geologic and topographic maps, recent and historic aerial photographs, satellite and GPS geodetic data pertaining to subsidence collected and processed by Caltrans (2016) and the California Institute of Technology (December, 2016), and an online Department of Water Resources (DWR) Sustainable Groundwater Management Data Viewer (SMGA Data Viewer) that displays data on subsidence levels in the Sierra Valley into September 2019.

Field Observations and Background

Plan view sketches of the three sites are presented in figures 2, 3, and 4 below. According to maintenance the cracks began appearing at Site 2 (PM 87.5) and Site 3 (PM 89.35) about five years before, and about three years before at Site 1 (PM 85.9), and all have been getting progressively worse. During that time maintenance forces have applied several patches to the roadway surface to maintain the roadway for the travelling public.

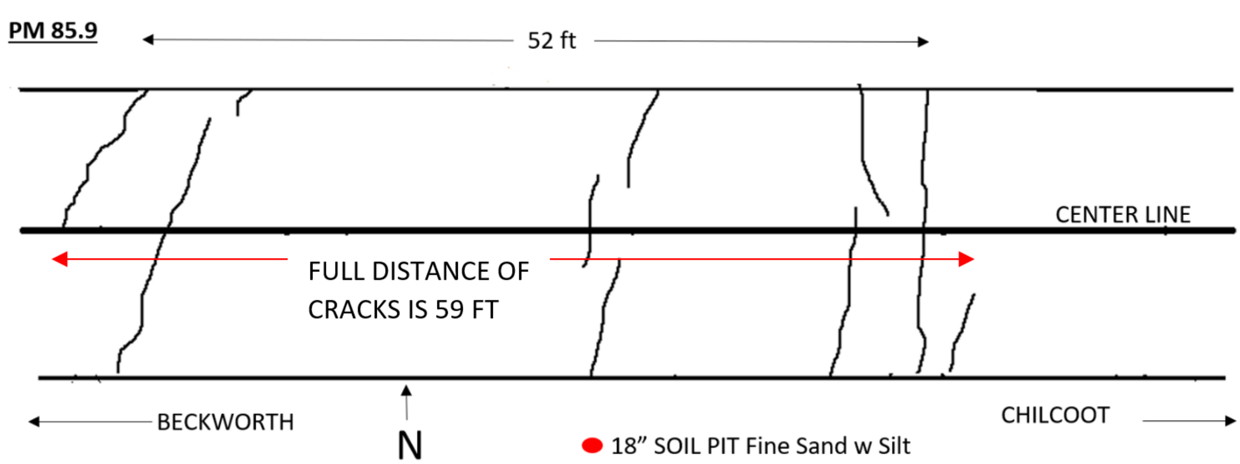

Figure 2. Crack Layout at Site 1 (PM 85.9)

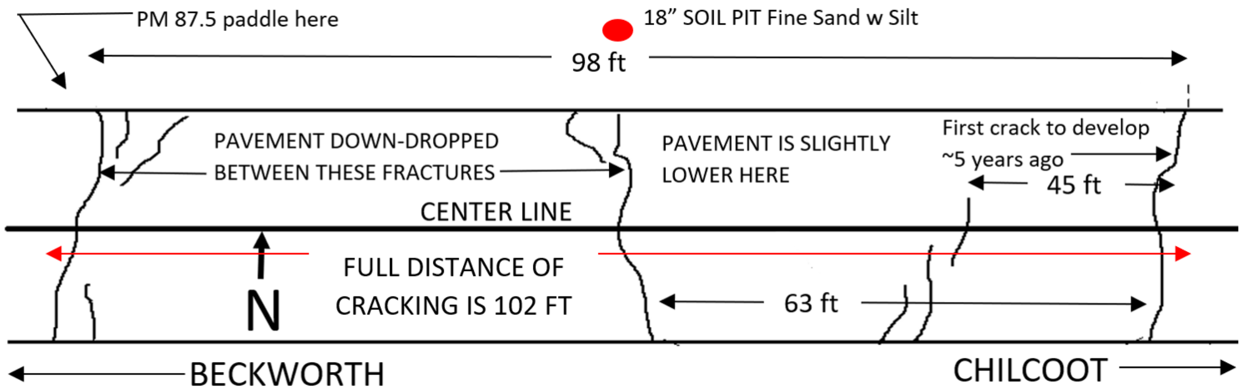

Figure 3. Crack Layout at Site 2 PM 87.5

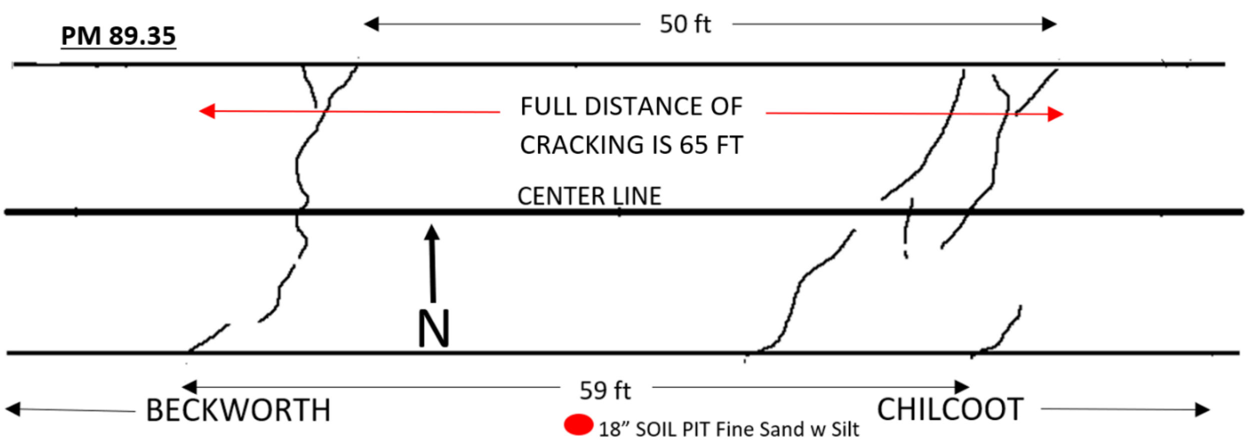

Figure 4. Site 3 PM 89.35

The cracking at all three sites displays some degree of extension, with the cumulative extension at any one site estimated (based on measurements) to be close to 4 inches. Some cracks show vertical offset and little extension, some show no vertical offset and little to some extension, and still others show vertical offset AND some extension. Some individual cracks demonstrated up to about 1.5 inches of extension and 1 inch of vertical subsidence. These quantities are an indication of how much extension or down-dropping has occurred since the most recent patching effort by maintenance. Pavement areas between cracks show various types of movement, primarily tilting and down-dropping. This varied movement creates a "roller coaster" effect on vehicles driving through the site.

Site features that might potentially be connected to the same forces that are creating these cracks were sought in an effort to deduce the cause of the cracking, but none were observed. No faulting or cracks were observed on the unpaved surfaces of the roadway prism or the native ground in the fields neighboring the sites. While cracks at Sites 1 and 2 are generally oriented in a north-south direction, those at Site 3 are oriented roughly N30˚E. Besides not being consistent with one another, these orientations demonstrate no significant alignment with the regional tectonic stress field and faults associated with it, which greatly reduces the possibility that these crack systems are tectonic in origin. No evidence was observed of surface water and/or shallow groundwater flowing through and beneath the crack zone. Such flow might cause stripping and removal of some of the fine silty sand of which the roadway prism and the surrounding fields are composed of, a stripping that might potentially cause subsidence. The only field evidence observed aside from the pavement cracks was a slight depression in the drainage ditch paralleling the roadway at the location of these sites, a depression indicative of subsurface subsidence.

Subsidence

Figure 5 below presents a graphic from the online SMGA data viewer showing cumulative measured subsidence values for the Sierra Valley area from June 2015 to September 2019. The stretch of highway where sites 1, 2, and 3 are located is in an area that underwent 0.25 to 0.5 ft of subsidence during this period, according to the data in the SMGA data viewer.

Subsidence occurring in the Sierra Valley is considered to be a result of extensive groundwater pumping. When ground water is pumped and subsurface water levels drop, certain aquifers and aquitards become unable to support the existing void space within their sediments due to overburden pressure and they undergo permanent compaction, thereby reducing available void space for aquifer recharge. This is a phenomenon that has been well documented in many parts of the world, including the United States and California. Such over-pumping of groundwater has caused over 28 ft of subsidence in parts of the San Joaquin Valley of California (USGS, NASA). Besides reducing the storage capacity of aquifers, this subsidence can negatively impact buildings and infrastructure.

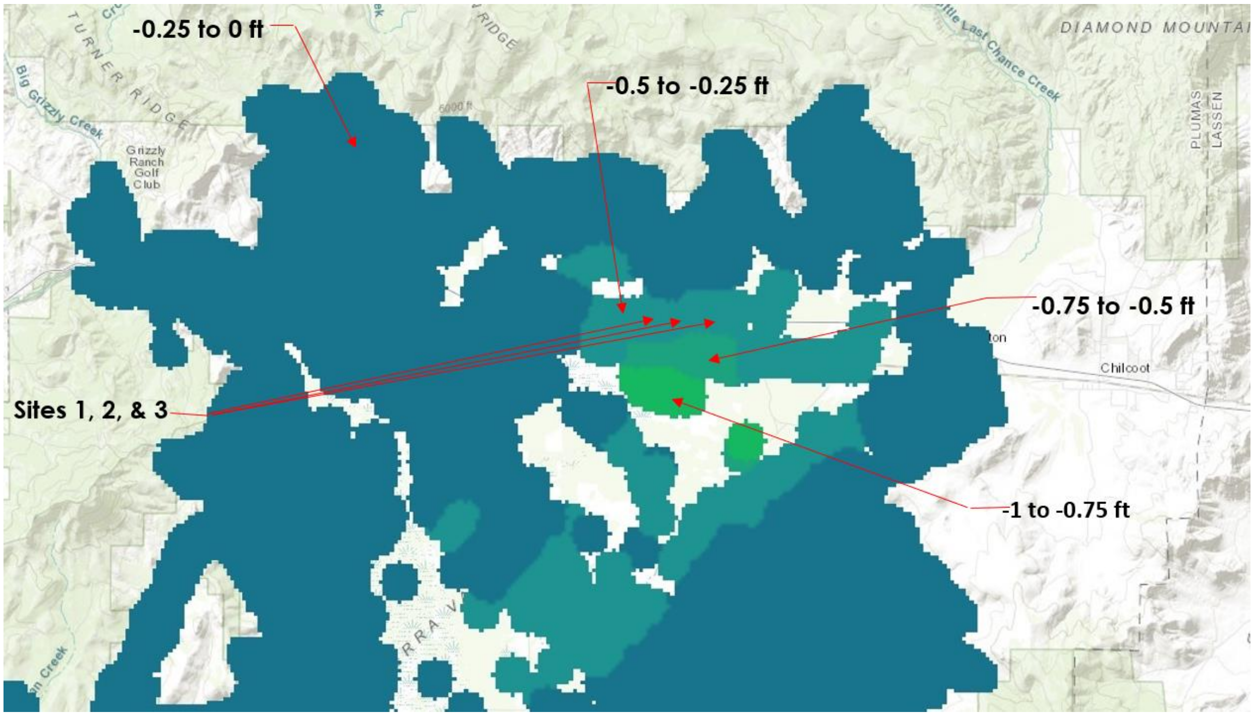

Figure 5. Map from SGMA data viewer showing total measured subsidence from 6/2015 to 9/2019. The three subsidence sites on SR70 are located within the region of -0.5 to -0.25 ft subsidence. Subsidence amounts (negative numbers) for the three different color-coded areas are indicated.

Due to a lack of any evidence linking the roadway pavement fractures to tectonic or surficial water processes, coupled with the documented evidence of ongoing subsidence occurring in the Sierra Valley, OGDN believes that it is highly probable that the fractures developed in SR70 east of Beckwourth are the result of this subsidence.

Because aquifers and aquitards vary considerably in thickness, spatial coverage, depth, and compaction characteristics, local variations in subsidence can typically occur at the surface. Rather than smooth equally distributed subsidence across the entire Sierra Valley, subsidence has occurred differentially at these three sites on SR70 due to some variations in these aquifer/aquitard parameters. Considering that groundwater extraction is likely to continue at present, or even increased, rates, such subsidence is likely to continue. It is likely that it will continue to impact SR70 in the same three locations, and it is possible that differential subsidence may expand in the future to other stretches of SR70 in the Sierra Valley, though predicting exactly where and to what degree is not possible given available information and data.

Mitigation Design

Short term mitigation involves AC patching by maintenance. The determination whether or not this should be performed prior to the upcoming Cap M project lies entirely within the judgement of Maintenance Engineering. OGDN believes it is likely, though by no means a certainty, that the three sites will continue to experience subsidence forces and commensurate deformation in the future. It is also likely, though not a certainty, that the rate of potential future deformation will continue at somewhere near its current rate.

Long term mitigation can be attempted during the Beckwourth Cap M project by excavating down to 1 foot below the bottom of the existing roadway prism embankment, installing geogrid together with a separating fabric at this base level, and then installing an additional subgrade enhancement geotextile at the bottom of the structural section. Figure 6 below provides both a plan view and profile view of this mitigation design.

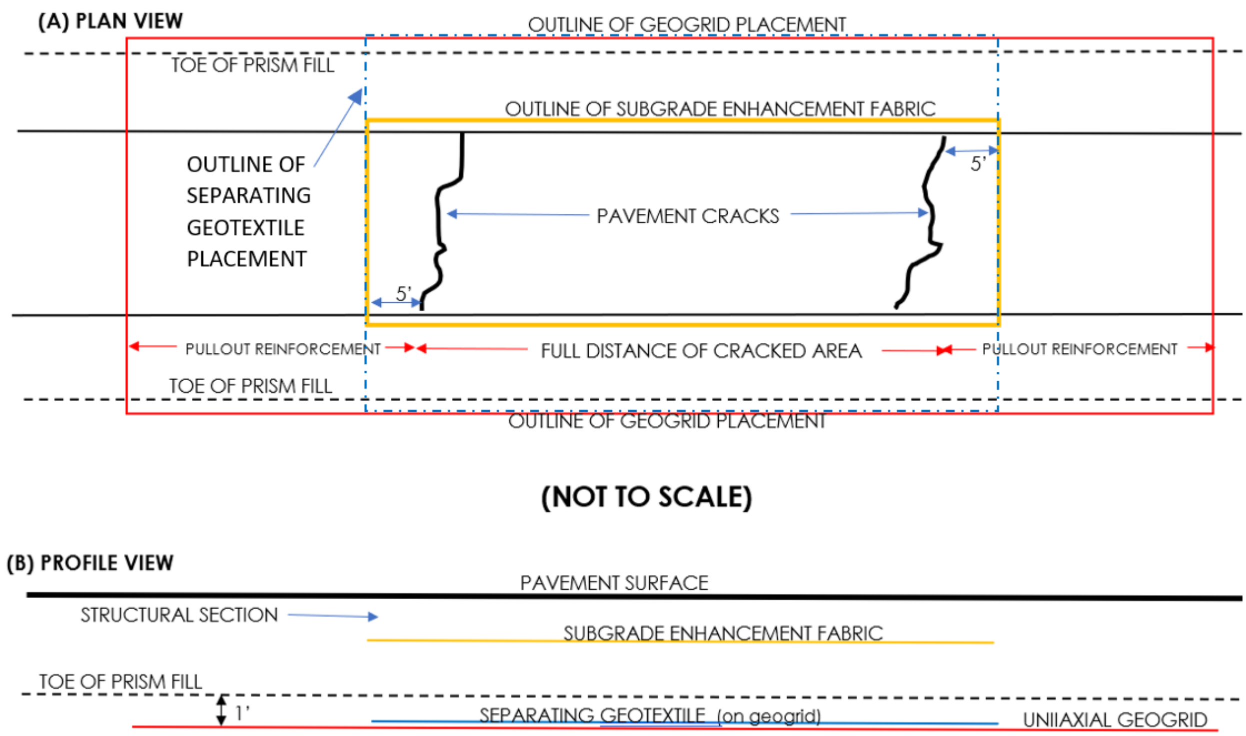

Figure 6. (A) Plan View (top) and (B) Profile View (bottom) of subsidence/ cracking long-term mitigation design. The plan view outline of the geogrid placement is shown in red. The plan view outline of the separating fabric is shown with a blue dashed line. The plan view outline of the subgrade enhancement fabric is shown in orange. See text for more details.

The base uniaxial geogrid should be placed as a series of intact, spliced strips with the strength direction (machine direction) running parallel to the roadway direction. The minimum lengths of these strips should be uniform within each site and should equal the full distance of the cracked area as shown above plus an additional pullout reinforcement distance of 30 ft on both the east and west ends. This means, for example, that the minimum uniaxial geogrid strip lengths for Site 1 will be equal to 59 ft plus 2 times 30 ft, which equals 119 ft. Adjacent geogrid strips should not be overlapped but should be butted against each other. Geogrid coverage to the north and south shall extend at least 2 feet beyond the toe of the roadway prism embankment.

A separating geotextile is placed directly atop the geogrid. Geotextile strips should also run parallel to the roadway direction, with adjacent strips overlapped by at least 2 ft. Geotextile overlaps should be placed so that they are at least three feet away from the butted geogrid strip edges below. The lengths of the geotextile strips are to extend a minimum of 5 ft beyond the limit of cracking as shown in Figure 6 above. Th extent of the separating geotextile coverage to the north and south shall be similar to the underlying geogrid, extending at least 2 feet beyond the toe of the roadway prism embankment.

The uniaxial geogrid should be pulled taught from both ends with a force of 2,000 pounds per 10-foot width of geogrid before being loaded with the first lift of soil. Nothing beyond manual tension is required for installing the overlying geotextile. Geogrid tension should not be released until at least 8 inches of compacted soil is in place atop the geogrid and geotextile.

Soil lifts should be compacted to a minimum of 95% relative compaction up to the bottom of the structural section. At that elevation strips of biaxial subgrade reinforcement fabric should be placed under manual tension atop the compacted soil. These strips should run parallel to roadway direction and be similar in length to the separating geotextile below- i.e., with at least 5 ft extending beyond the limits of cracking. The edges of neighboring subgrade reinforcement fabric strips shall butt against each other. Subgrade reinforcement fabric coverage to the north and south shall extend at least 1 foot beyond the edge of pavement. The completion of reinforcement fabric installation is then followed by construction of the structural section and paved surface.

This design offers the most tenable solution to stop and/or retard the future cracking and deformation at these three sites. The viable longevity of this mitigation cannot be determined with certainty due to the uncertainties surrounding future subsidence rates and locations within Sierra Valley. Though not considered likely, it is possible that this repair may simply concentrate future cracking somewhere just beyond the periphery of the existing crack limits, i.e., the periphery of the proposed repair.

Lengths and coverage of the three different geosynthetics at each site is summarized in Table 1 below.

SITE	FULL DISTANCE OF CRACKING (ft)	UNIAXIAL GEOGRID STRIP LENGTHS (ft)	SEPARATION FABRIC STRIP LENGTHS (ft)	SUBGRADE ENHANCEMENT FABRIC STRIP LENGTHS (ft)
1 (PM 85.7)	59	119	69	69
2 (PM 87.9)	102	162	112	112
3 (PM 89.35)	65	125	75	75

Table 1. Strip lengths of geosynthetics at each site.

Material Specifications

OGDN recommends that subgrade enhancement fabric consist of subgrade enhancement geotextile Class B2.

OGDN recommends utilizing RSP fabric Class 10 for the separating fabric.

OGDN recommends that the uniaxial geogrid be constructed of either polyester, polypropylene, combined polyester and polypropylene, or High-Density Polyethylene (HDPE), and that it meet or exceed the following specifications:

QUALITY CHARACTERISTIC	TEST METHOD	REQUIREMENT
Tensile Strength at Ultimate (Tult)(min, lb/ft)	ASTM D6637	26,000
Tensile Strength, 5% strain (min, lbs/ft)	ASTM D6637	6900
Creep Limited Strength (min, lbs/ft)	ASTM D5262	18,000

If you have any questions related to this report or require further assistance, please call Scott Lewis at (530) 225-3516 or Yusuf Zaka at (916) 227-1065.

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California Department of Transportation, 2016, GPS Project Control Report, Plumas 70 PM 89.0/95.9 and Lassen 70 PM 0.0/3.91.

California Institute of Technology (Jet Propulsion Laboratory), December 2016, Progress Report: Subsidence in California, March 2015 – September 2016

Department of Water Resources, Sustainable Groundwater Management Data Viewer. https://sgma.water.ca.gov/webgis/?appid=SGMADataViewer#landsub

Land Subsidence in the San Joaquin Valley https://www.usgs.gov/centers/ca-water-ls/science/land-subsidence-san-joaquin-valley

San Joaquin Valley is Still Sinking, https://earthobservatory.nasa.gov /images/89761/san-joaquin-valley-is-still-sinking