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Reference: 017052

March 24, 2017

City of Trinidad
Attn: Dan Berman, City Manager
409 Trinity Street
P.O. Box 390
Trinidad, CA 95570

Subject: Preliminary Assessment of Current Slope Stability Conditions, Trinidad Memorial Lighthouse, Edwards Street, Trinidad

Introduction

This report presents the results of a visual assessment of slope conditions conducted by a Certified Engineering Geologist from SHN Consulting Engineers & Geologists, Inc. (SHN) on March 13, 2017 at the Trinidad Memorial Lighthouse. SHN's site assessment was performed at the request of the Trinidad City Manager, Mr. Dan Berman. Our work scope for this assessment has been limited to site reconnaissance, preliminary mapping of scarps, and review of existing published and unpublished geologic and geotechnical data. The results of the 2012 Trinidad stormwater study were especially useful, as it includes subsurface data and geophysical information in the near vicinity of the Memorial Lighthouse.

Included with this report are recommendations for immediate action the City of Trinidad should undertake to remove the hazardous, broken concrete walkways and fencing, and to control surface runoff near the parking lot. We have also included recommendations to perform subsurface monitoring of earth movements to address the potential instability hazard posed to the lighthouse and to the southern edge of Edwards Street and underground utilities.

Site Conditions

During our recent site visit we observed fresh vertical head and lateral scarps, and open fissures adjacent to the lighthouse, and extending approximately 100 feet westward through the paved parking area along Edwards Street (Figure 1). The fresh escarpment forms an arcuate feature that defines the head of an active earthflow-type landslide; the highest extent of which occurs in the parking area west of the lighthouse. The earthflow is occurring in low strength bedrock and overlying unconsolidated terrace materials on the bluff face (discussed below). Available geomorphic indicators suggest the slide is large and deep-seated, likely encompassing all or most of the bluff face below the recently active head scarp (that is, it likely extends to the beach). Landslides of this type are generally moisture-sensitive (they move under elevated pore water pressure conditions); therefore, the accelerated movement and expansion during the current rainy season can at least partially be attributed to the high levels of rainfall this year.

The recent episode of slide activity in this area initiated over two years ago, and appears to have substantially accelerated throughout the current winter season, especially over the past month. The height of the scarps and the amount of deformation recorded by the concrete walkways and ground surface displacement has significantly increased when compared to observations over a year ago and as recently as a few weeks ago. Tension cracks currently extend beneath the southwest corner of the concrete apron (sidewalk) located immediately adjacent to the lighthouse. Settlement of the grass-covered ground surface adjacent to the concrete apron is evident, and exceeds 6 inches. The main, active slide scarp has propagated to within about a foot of the southwest corner of the lighthouse's perimeter sidewalk.

The site and vicinity is underlain by Franciscan Complex mélange. This regional bedrock unit is composed of a chaotic mixture of highly erodible, low strength matrix of pervasively sheared and highly decomposed clay-rich argillite surrounding rock blocks of a variety of sizes and lithologies. The rock blocks are "rootless" in that they are suspended in the matrix material, and do not necessarily extend to significant depth. Slope stability conditions on slopes underlain by Franciscan mélange are strongly influenced by the distribution of the competent rock blocks. The rock blocks form resistant areas that frequently result in headlands (Trinidad Head is a particularly large block), while the low strength matrix is frequently subject to earthflows (it is locally referred to as "blue goo" due to its tendency to move when saturated) and is typically associated with receding portions of the coastline.

Nearby borings indicate that about 70 feet of marine terrace deposits composed of medium dense to dense and weakly to moderately cemented poorly-graded sand overlie the Franciscan bedrock. This material forms the relatively level plateau that most of the City of Trinidad is built on. The terrace is interpreted as a late Pleistocene age landform.

The distribution of rock blocks in the bluff along Edwards Street can, in part, be estimated by the geomorphic expression of the bluff face. The Axel Lindgren trail that descends the bluff below the lighthouse follows a topographic ridgeline likely controlled by competent shallow bedrock. An obvious topographic bench midway down this ridge appears associated with a rock block that underlies this portion of the slope (Figure 2). In addition, an east-west oriented geophysical transect conducted along the southern edge of Edwards Street as part of the ASBS Stormwater Improvement Project Geotechnical Analysis (GHD, 2012) is useful in interpreting subsurface conditions near the site. The profile is particularly useful in interpreting the distribution of underlying bedrock. The profile indicates a relatively large bedrock block to be present in the subsurface to the east and north of the lighthouse. From the geophysical imaging it appears that the western edge of the block may underlie the lighthouse at a depth of 35 feet or less. In the area directly west of the lighthouse along Edwards Street, however, the geophysical profile appears to image the steep west-facing edge of the rock block. The location of the recently active earthflow appears to coincide with the western edge of the buried rock block at depth (that is, the slide is occurring in the materials just west of the stable rock block).

Slope movements now occurring near the top of the bluff are most likely occurring in response to deep-seated earthflow activity (previous or recent) within the underlying mélange matrix within the bluff. A review of time-series aerial photographs indicates the presence of an outwardly convex

bulge of mélange matrix at the back edge of the beach directly downslope of the observed landsliding that appears to have been mobilizing seaward for some time (Figure 2). The rate and magnitude of slope movements occurring at the top of the bluff has been observed to be greatest during the recent and previous wet seasons when pore water pressures within the clay-rich mélange matrix and overlying terrace sediments are highest and the water table is elevated. The large areal extent of the active earthflow underlying the zone of accelerated slope movement leads us to conclude that the recent wetter-than-average rainy seasons have exacerbated stability conditions within this previously dormant landslide. The addition of storm runoff into the subsurface, which has the effect of artificially elevating the ground water table, may also be contributing to the destabilization of the bluff edge. It should therefore be expected that episodic (or even chronic) slope movements will continue into the future at rates similar to, or even greater than, those of the recent winters (particularly if similar above-normal rainfall occurs). However, the timing and magnitude of future slope movements cannot be predicted at this time.

Discussion

The margin of the active landslide at the site is currently encroaching on the southwest corner of the lighthouse apron. Therefore, any significant additional lateral expansion of the landslide will undermine the lighthouse. Available information (geomorphology, geophysics) suggests that the slide is occurring adjacent to a buried rock block. As the precise location of the edge of this block is not known, we cannot predict with any certainty the potential for future lateral expansion of the slide. Additional subsurface data would be required.

In addition to potential adverse impacts to the lighthouse, headward expansion of the landslide would ultimately affect the outboard edge of Edwards Street and potentially a buried water line.

Fortunately, the end of the wet of season is nearing, which will likely result in a reduced rate of ground movement through the coming dry season (although the timing and magnitude of this reduction in rate of movement cannot currently be estimated). It is likely that given the increase in slide activity observed this past winter that reactivation of the slide complex is in its early stages; therefore, significant natural reduction of the rate of movement or the potential for headward expansion are unlikely over an extended period of time.

Recommendations

Interim measures should be undertaken to discourage the public from using the affected areas in order to reduce the risk of personal injury, particularly in light of the coming tourist season. These include the following recommendations that can be achieved with the use of hand labor and light construction equipment:

- Completely remove all concrete sidewalks that are currently in a state of disrepair;
- Remove all wooden fencing at the bluff edge;
- Remove the wooden benches at the top of the bluff within the affected areas;

- Construct or place a temporary barrier at the sidewalk around the west side of the lighthouse while directing access to the Axel Lindgren Memorial Trail around the east side of the lighthouse.
- Remove most of the paved parking area and curb while maintaining enough width for vehicles to park parallel to Edwards Street;
- Construct a new continuous asphalt or concrete curb on the seaward edge of the remaining parking area. The curb should be constructed in such a manner so as to direct surface runoff to flow back onto Edwards Street and be directed to the nearest downslope storm drain inlet. Grade the new parking area such that no ponding or overtopping of the curb can occur.

Additional Work

As described above, it is difficult to predict the areas or rate of potential future landsliding with the existing level of information. Additional subsurface information, specifically targeting the location of the edge of the rock block, would greatly enhance our ability to evaluate future impacts. As such, we recommend drilling a series of boreholes around the lighthouse to evaluate the distribution of buried bedrock. Additional borings along Edwards Street would also be useful, depending on the City's interests and resources.

With additional knowledge regarding the subsurface conditions, we would be better able to discuss potential mitigation options. At this time, we can envision opportunities to underpin the lighthouse through a variety of methods including development of a pile-supported cut-off wall to isolate the head of the landslide from the remainder of the slide body lower on the slope. However, we currently do not have adequate information to successfully evaluate, design, or implement potential repairs; we specifically need to know where bedrock is located in the subsurface near the lighthouse.

Due to the limited access to the site, a portable drill rig would likely be required to develop the necessary subsurface information. Hand augered borings are unlikely to penetrate deeply enough, and large machine rigs will be unable to access the site. A portable rig would be favorable at this site, as the support vehicle can be parked adjacent to the lighthouse on Edwards Street and the tooling carried manually to the study area. As appropriate, inclinometers can be placed in some of the boreholes to facilitate future slope monitoring (particularly the depth, magnitude, and rate of movement in the subsurface).

Closure

We recognize that the Trinidad Memorial Lighthouse is a treasured landmark in the Trinidad community (and beyond). Preservation of this landmark is a high priority, and we are committed to assisting the City in developing a strategy for assessing the risk to the lighthouse, and defining potential mitigation options. We anticipate this strategy will be developed in a phased approach that will involve stakeholder meetings and extensive discussion with City staff. We are happy to engage in these discussions as soon as feasible, at the City's discretion.

This preliminary assessment was prepared in a short time frame with a limited scope, and is based on currently available information. Our intent is to educate the City and stakeholders regarding what is currently known about the geologic condition of the site, as well as what is not known. It is our desire that the information will allow the City to move forward in a knowledgeable manner, such that they can make informed decisions based on the best available data.

Please feel free to call me at 707-441-8855 if you have any questions.

Sincerely,

SHN Consulting Engineers & Geologists, Inc.

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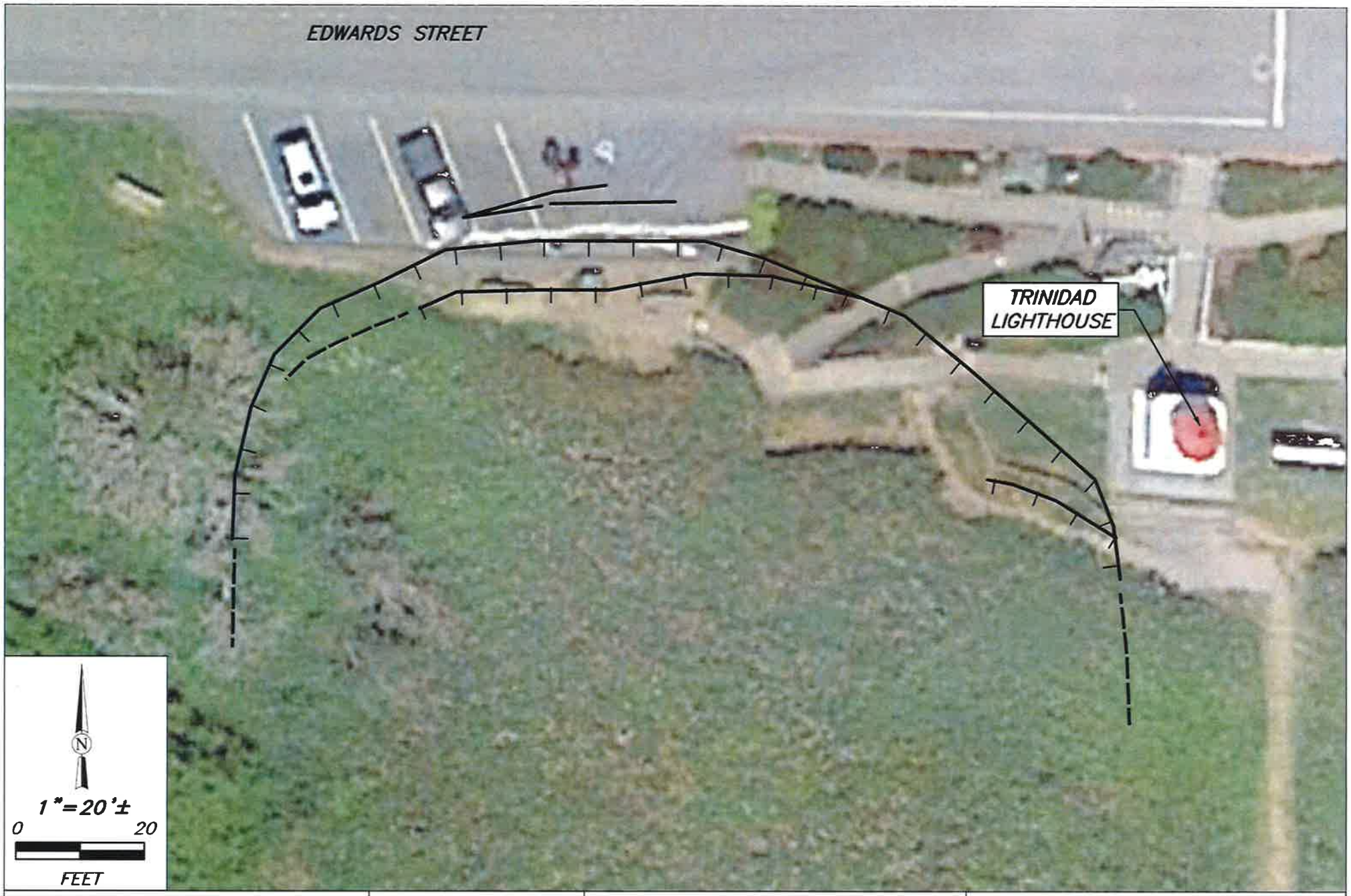

IMAGE SOURCE:
GOOGLE EARTH (5/26/2016)

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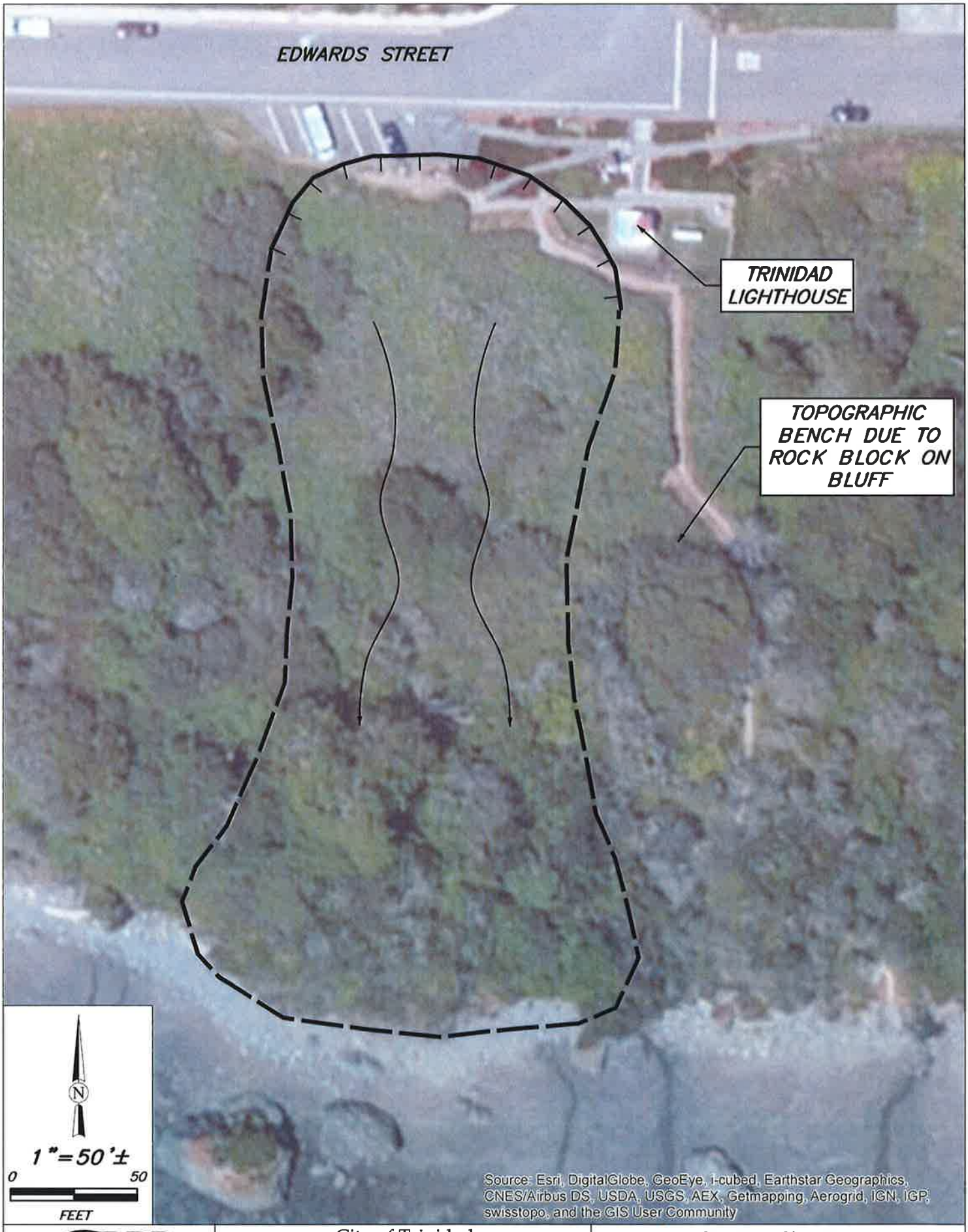
City of Trinidad
Lighthouse Landslide Assessment
Trinidad, California

Site Map Showing
Landslide Scarps
SHN 017052

March 2017	Figure1_SiteMap	Figure 1



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City of Trinidad
Lighthouse Landslide Assessment
Trinidad, California

Site Map Showing
Earth Flow
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