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March 9, 2023 BSK Project No. G00000499

Mr. Larry Theis, PE
City Engineer
City of Clayton
6000 Heritage Trail
Clayton, California 94517

SUBJECT: Geological and Geotechnical Site Review
Oakhurst Geologic Hazards Abatement District (GHAD)
Clayton, CA

Dear Mr. Theis:

At your request, BSK Associates (BSK) has performed an annual geological and geotechnical site review of the Oakhurst Geohazards Abatement District (GHAD) located in the City of Clayton (City), California (see Figure 1, Vicinity Map), as required by the First Amended Plan of Control (June 29, 1990). BSK visited properties located within the GHAD boundaries (see Figure 2, Oakhurst GHAD Boundaries) on December 8th and December 13th, 2022 and on March 1st, 2023. We have also reviewed available GHAD files. The purpose of our review was to evaluate the existing condition of previous landslide repairs and erosion control/drainage facilities throughout residential areas and paved roadways within the GHAD. This letter presents a summary of our observations, conclusions, and our recommendations.

GEOLOGICAL AND GEOTECHNICAL SITE REVIEW

On December 8th, 2022, a Certified Engineering Geologist (CEG), a project geologist, and a registered geotechnical engineer (GE) from BSK visited the residential portions of the GHAD to review the existing condition of slopes, drainage and erosion mitigation and control measures, and landslide repairs that have previously been constructed at trouble areas within the GHAD. BSK's project geologist returned to the GHAD on December 13th, 2022 to finish review of a slope near Peacock Creek Drive and on March 1, 2023 to view damage from mudflows that occurred during severe storms in early 2023 near the northeast corner of the GHAD boundary within a canyon located northeast of Windmill Canyon Drive. Our site review was coupled with a review of available GHAD data and information made available to us via reports, plans and newsletters. Note that our site review was limited to only those open space areas immediately adjacent to the residential areas and paved roadways within the GHAD. In general terms, we were favorably impressed by the current state of maintenance and repairs that we encountered, but also have some recommendations for various conditions within the GHAD.

Following is a summary of our observations and recommendations from the site review and reviews of previous monitoring reports, dewatering and drainage plans and reports, and other investigations and repairs or construction that has occurred throughout the history of the Oakhurst GHAD.

For ease in discussion, we have separated the GHAD into three areas as follows (see Figure 2 for subdivided area locations):

1. **North Area:** The first area consists of the developed portions of the GHAD including open space/slopes that is located immediately adjacent to homes in the northeastern portion of the GHAD (see Site Plan – North Area, Figure 3A).
2. **Kelok Way Area:** The second area is the area associated within Kelok Way and adjacent open space/slopes (see Site Plan – Kelok Way Area, Figure 3B).
3. **South Area:** The third area is associated with the Pebble Beach Drive, Peacock Creek Drive, and Peacock Creek, including slopes and known areas of instability and mitigation measures previously installed between Pebble Beach Drive and Peacock Creek (see Site Plan – South Area, Figure 3C).

North Area

BSK walked V-ditches and boundaries between open space slopes, homes, and other improvements along the northeastern boundary of the GHAD (see Figure 3A). We made cursory observations of homes and roadways and did not visually observe obvious evidence of geohazards impacts to homes or roadways in the general area. Our site review was primarily focused on the open space and slopes bordering the limits of the GHAD, where slopes either ascend from, or descend to yards and residences, primarily on the north and east side of Windmill Canyon Drive. Figure 3A presents a legend key to the locations of our observations and photos of conditions we encountered that should be considered for future repairs or should be watched and monitored annually before the onset of the annual storm season.

In general, we observed surface creep[1] above most V-ditches, particularly in areas where slopes are mowed (presumably for fire control). Periodic maintenance should be sufficient to prevent soil from entering into and disrupting flow in the ditches. We also observed shallow slope sloughing and raveling in various areas, which are also identified on Figure 3A.

The following photos depict the conditions documented during our site review. The approximate photo locations are presented on Figure 3A.

[1] The slow, gradual downward displacement of soil, rock, and organic material on slopes.

Photo A – V-ditch offset uphill from Crow Place.

Photo B – Shallow raveling above a drop inlet uphill from Windmill Canyon Drive. Based on our communication with the City, we understand that movement of the uphill from this drop inlet blocked the drop inlet of an uphill V-ditch during the early 2023 rain storms.

Photo C – Overtopped and eroded debris-flow containment basin above drainage easement northeast of Windmill Canyon Drive. Based on our communication with the City, we understand the erosion and overtopping occurred during the early 2023 rain storms.

Note: At the time of our initial site reconnaissance conducted on December 8th, 2022, the debris-flow containment structure appeared clear and in good repair. Damage and overtopping/erosion occurred during the intense rain events in early 2023. Muddy water from the failed containment structure flowed into the backyard of 3081 Windmill Canyon Drive, which is located immediately downhill from the structure.

Photo D – V-ditch cracking and displacement East of Windmill Canyon Drive, adjacent to high voltage power line easement.

Photo E – Incised gully flow above the V-ditch located East of Windmill Canyon Drive. Erosion and flow occurred during early 2023 storm events.

Note: This photo was taken during our March 1st, 2023 site reconnaissance. At the time of our initial site reconnaissance conducted on December 8th, 2022, we did not observe the eroded, incised channel above the V-ditch. Erosion and gullying occurred with intense rainfall events in early 2023.

Photo F – Upper reaches of the gully erosion East of Windmill Canyon Drive.

This photo was taken during our March 1st, 2023 site reconnaissance. At the time of our initial site reconnaissance conducted on December 8th, 2022, we did not observe this gully erosion. Erosion and gullying occurred with intense rainfall events in early 2023.

Kelok Way Area

BSK walked V-ditches and boundaries along open space slopes north of Kelok Way, in the open space area south of Keller Ridge Road, and both west and east of those areas (see Figure 3B). We made cursory observations of homes and roadways throughout the area, and aside from those documented below, we did not observe obvious evidence of geohazards impacts to homes or roadways in the general area except for the home at 8053 Kelok Way.

Our site review focused on the open space and slopes bordering the limits of the homes along Kelok Way, Keller Ridge Drive, and east of Acorn Drive. The areas of known instability at the west end of Kelok Way and between the eastern end of Kelok Way and Golden Eagle Way will be addressed in greater detail later in this letter.

Figure 3B presents a legend key to the locations of our observations and photos of conditions we encountered that should be considered for future repairs or should be watched and monitored annually before the onset of the annual storm season.

In general, we observed surface creep above most V-ditches. Periodic maintenance should be sufficient to prevent soil from entering into and disrupting flow in the ditches. We also observed shallow slope sloughing and raveling in various areas, which are also identified on Figure 3B.

The following photos depict the conditions documented during our site review. The approximate photo locations are presented on Figure 3B.

Photo G – Slope creep depositing debris in V-ditch and resulting in minor cracking of V-ditch.

Photo H – Slope creep overtopping edge of V-ditch. V-ditch offsets and shallow raveling uphill visible. Note that the homeowner has secured trees beyond property line (see red arrow), including a V-ditch panel (not depicted in this photo).

Photo I – V-ditch offsets and ponded water. Slope creep is overtopping and possibly offsetting V-ditches.

Photo J – Catch basin blocked by soil and debris.

Photo K – Slope creep towards Kelok Way as evidenced by separation of soil from the downhill side of the V-ditch.

Photo 1 – Settlement/incipient crown scarp impacting the residence (8053 Kelok Way) at the end of the cul-de-sac on Kelok Way.

Note: See additional discussion regarding instability downhill from the cul-de-sac area on Kelok Way later in this letter.

Photo M – Offset and debris in V-ditch northwest of the cul-de-sac at Kelok Way.

Photo N – Wellhead north (downhill) of the cul-de-sac at Kelok Way. Note that the slope has settled several inches relative to the wellhead.

Kelok Way Cul-de-sac

Ongoing slope movement north of, and impinging on the cul-de-sac at the west end of Kelok Way has resulted in damage to the roadway (see Photo L, above) and to the residence at 8053 Kelok Way. Damage has been documented for both the residence and the roadway according to Steven, Ferrone & Bailey (2016)[2]. The inclinometer that was used to monitor rate and depth of movement has been distorted, via horizontal shearing, to the extent that the inclinometer is no longer useable. We understand that the home at 8053 Kelok Way was "red-tagged" and is no longer eligible for inhabitance.

Monitoring of inclinometer casing CSA SI-4, roughly 50 feet downhill (north) of the edge of the cul-de-sac, has not been completed since May of 2014 due to offset in the casing blocking the bottom portion of the casing. Measurements of the inclinometer between November 2007 and July 2014 indicates that the movement is occurring at a depth of 52 feet, at a rate of ¼ inch per year. Total offset during the useable life of the inclinometer was 1½ inches. It is not known how much additional offset, if any, has occurred since the last monitoring event (nearly nine years ago). Note that the 1½ inch offset occurred over a 6½-year interval.

Based on damage to the roadway and to the home at 8053 Kelok Way, it is clear that there is slope movement on the north facing slope adjacent to the home and the cul-de-sac. We do not know the rate of movement at this time, but based on the amount of movement in the roadway and damage to the home, we anticipate that underground utilities may become damaged and, if water bearing, could accelerate the movement considerably. Further, the potential danger in accelerated movement from a seismic event is also considerable. Based on the current data and our understanding of minimal investigation efforts on this area of instability, we cannot predict the impact of seismicity, increased pore water pressure, and decreases in shear strength with continued movement on the timing or extent of movement in the future.

Kelok/Golden Eagle Way Slope

At the time of our site review, we did not observe cracking in pavements, V-ditches, or improvements that we were able to view at this location. While it is known that many homes in this area have been built over a partially removed/repaired, deep seated landslide that underlies the area, there have been significant efforts taken to de-water the known landslide between Kelok Way and the park located north (downhill) from the homes on Kelok Way according to Steven, Ferrone & Bailey (2012)[3].

Inclinometers located in the roadway on Kelok Way, as well as those installed on the slope beneath Kelok Way show creep and very slow movement on suspected slip surfaces located between 88 and 111 feet below the surface. Stevens, Farrone & Bailey Engineering (2016) reported that offset on the landslide plane is limited to 0.1 to 0.2 inch since monitoring began in 2014. It should be noted that there was up to 1.6 inches of movement, at a depth of 54 feet, prior to installation of the dewatering wells gallery in 2012. There is no record of monitoring of those inclinometers since the dewatering wells were constructed.

[2] Stevens, Ferrone & Bailey (2016), *Summary of Geotechnical Monitoring and Inspection Services on June 30, 2016 Inclinometers/Piezometers/Wells at Kelok Way, Clayton, California*, dated June 30, 2016, SFB Project No: 555-2.
[3] Stevens, Ferrone & Bailey (2012), *Geotechnical Observation and Testing – Final Report Kelok Way Dewatering Wells, Clayton, CA*, dated December 17, 2012 - SFB Project No.: 555-1.

South Area

BSK walked V-ditches and boundaries along open space slopes north of Pebble Beach Drive (down to Peacock Creek), South of Peacock Creek Drive, and along the eastern boundary of the GHAD (see Figure 3C). We made cursory observations of improvements and roadways throughout the area, and aside from those documented below, we did not visually observe obvious evidence of geohazards impacts to homes or roadways in the general area. The roadway immediately adjacent to the north-facing slopes at Pebble Beach Drive appeared to have recently been resurfaced at the time of our visit.

Our site review focused on the open space and slopes bordering the homes along the north side of Pebble Beach Drive, and the slopes immediately south of the homes on Peacock Creek Drive. The areas of known instability north of Pebble Beach Drive and Peacock Creek will be addressed in greater detail later in this letter.

Figure 3C presents a legend key to the locations of our observations and photos of conditions we encountered that should be considered for future repairs or should be watched and monitored annually before the onset of the annual storm season.

In general, we observed surface creep above most V-ditches. Periodic maintenance should be sufficient to prevent soil from entering into and disrupting flow in the ditches. We also observed shallow slope sloughing and raveling in various areas, which are also identified in Figure 3C.

The following photos depict the conditions documented during our site review. The approximate photo locations are presented on Figure 3C.

Photo O – Slope creep and minor sloughing adjacent to V-ditch

Photo P – Slope creep or expansion cracking adjacent to the edge of the V-ditch.

Photo Q – Moist ground and seepage from the slope. Note the marsh grasses and standing water in the ditch.

Photo R – Moist slope with shallow sloughing. Note the scarp at the upper end of the movement.

Photo S – Resident has planted trees and built a short keystone-type retaining wall uphill from the V-ditch. Note soil erosion from the disturbed slope sloughing into the ditch.

Based on our communication with the City, we understand that during the early 2023 rain storms, a debris-flow occurred within a swale/V-ditch located upslope of Clayton Road and south of Peacock Creek Drive (circled in red), which clogged a drop inlet and caused water to overflow onto Clayton Road.

Pebble Beach Drive/Peacock Creek Landslide

Instability on the north-facing slope between Pebble Beach Drive and Peacock Creek, in the vicinity of homes on Lots 59 through 61 (1033, 1031, and 1029 Pebble Beach Drive, respectively) of the Peacock Ridge Subdivision was originally evidenced by separations in concrete flatwork at the residences on those lots. Two slope inclinometers were installed in January and February of 2007 by Berlogar Geotechnical Consultants (see Figure 4, Landslide Repair Cross Section – Pebble Beach Drive/Peacock Creek)[4]. The inclinometers were subsequently monitored over the course of two years and inclinometer SI-2, located approximately 200 feet downslope of the roadway has shown rapid deformation at a depth of about 72 feet below the surface. Berlogar Geotechnical Consultants noted in their 2009 report[5] that "The shape and character of the plot of Slope Indicator SI-2 is clearly the result of landslide movement". Per the report, the casing had deflected 1½ inches since installation, and rate of deformation had increased over the previous 5 months to a rate of between 1 and 1 ¼ inches per year. Surface observations confirmed the movement. In an attempt to arrest or slow the movement, a series of horizontal drains were installed, but none of the drains encountered groundwater.

The area underlying the subject slope was, in part, a landslide prior to mass grading for the subdivision. Figure 4 presents a cross section showing the repair efforts made prior to placing fill to accommodate the home sites. Of note is, the landslide was only partially removed, but the current depth of movement is significantly below the mapped slide plane as presented on the cross section.

Our observations of the slope and pavements near the top of the slope suggest that movement has slowed. Since inclinometer data has not been available (due to the sheared casing) since 2014, it is difficult to know whether movement has slowed or is still ongoing.

During our site review, BSK was not able to locate any of the horizontal drain outfalls, but did locate at least one subdrain outfall associated with the landslide repair that occurred during initial site grading.

CONCLUSIONS AND RECOMMENDATIONS

Based on our site review and our review of the available GHAD data, it is our opinion that several areas within the GHAD pose potential risk to several homes and roadways within the GHAD. Areas of concern are as follows:

General

- Storm damage debris retention basin above Windmill Canyon Drive is no longer able to stop and retain debris flow materials. The basin will require reconstruction of the earthen berm that was in-place to stop and retain flow.
- The Swale/V-ditch located upslope of Clayton Road and south of Peacock Creek Drive should be repaired and the drop inlet should be unclogged.

[4] Berlogar Geotechnical Consultants (2007), *Interim Report, Slope Inclinometer Installation and Monitoring Program, Open Space Between Lots 59 Through 61, Pebble Beach Drive, Clayton, California*, dated August 10, 2007,BGC Job No. 2947.100.

[5] Berlogar Geotechical Consultants (2009), *Slope Inclinometer Plots and Observations of Progressive Offset to V-Ditches, Open Space Slope Below Lots 59 through 61, Pebble Beach Drive, Clayton, CA*, dated January 19, 2009, BGC Job No. 2947.100.

- Moist and hummocky slopes above Peacock Creek Drive and east of Brandywine place indicate large areas of shallow slope instability that could result in shallow flows during heavy rain events.
- Cracked and/or offset V-ditch panels, while not numerous, can result in drainage obstructions, overflow, and erosion to slopes. Patches and/or replacement of V-ditch panels should be prioritized and undertaken on a regular basis.
- V-ditch and drop inlet maintenance should be continued and inspections of the drainage system, slopes and pavements should be continued. We recommend that drainage system maintenance occur prior to the onset of the rainy season each year. Inspections should take place prior to maintenance.

Cul-de-sac at Kelok Way

- Significant settling and downslope movement on the north side of the Cul-de-sac at Kelok Way is likely to result in failure of the pavement, failure of utilities traversing the area of instability, and continue to cause damage to the residence at 8053 Kelok Way. It is unclear how much the incipient landslide mass may have moved, and at what rate it is moving, since the inclinometer that was used to gauge movement has been compromised. We strongly recommend that a replacement inclinometer be installed and, together with available piezometers that have been installed during previous investigations, monitoring of both the inclinometer and piezometers should be resumed. If possible, additional inclinometers should be considered to better isolate stable ground versus landslide mass.

Kelok Way Landslide

- Monitoring of inclinometers between Kelok Way and the park by Golden Eagle Way should also be resumed. We recommend that the seven inclinometers (BGC SI-1, CEG SI-1, CSA SI-1, CSA SI-2, CSA SI-3, W SI-1 and W SI-5) be monitored at least twice per year, preferably quarterly. Depth to groundwater in each inclinometer should also be measured and logged.
- All subdrain clean-outs and discharge pipes for the slope should be located and flow should be measured (or approximated). Depth to water and discharge should also be measured and recorded for the dewatering wells in the roadway at Kelok Way.

Pebble Beach Landslide

- It is crucial that the inclinometer on the north slope between Pebble Beach Drive and Peacock Creek be replaced. Monitoring of movement on this slide, as well as monitoring of piezometric surface is necessary to judge the status of the slope.
- All horizontal drain discharge points, and all subdrain clean-outs and discharge points should be located and it should be determined if they are providing any subdrainage from beneath the fill and landslide repair.

Prioritization of our recommendations regarding Kelok Way (both sites) and Pebble Beach Drive is desirable. These sites have the potential to result in significant property damage and also have the potential to endanger residents should movement accelerate or a seismic event occur.

LIMITATIONS

Our services were performed in a manner consistent with that level of care and skill ordinarily exercised by other members of BSK's profession practicing in the same locality, under similar conditions and at the date the services are provided. Our findings and conclusions are based on our review of available GHAD files and limited site reconnaissance of the GHAD area completed on December 8th and 13th, 2022 and on March 1st, 2023. It is possible that conditions could vary between or beyond the data evaluated or have changed since we visited the GHAD area or that previous GHAD files not available to us could influence the findings and conclusions presented herein. BSK makes no other representation, guarantee or warranty, express or implied, regarding the services, communication (oral or written), report, opinion, or instrument of service provided.

This report may be used only by the Client and only for the purposes stated within a reasonable time from its issuance, but in no event later than two (2) years from the date of the report, or if conditions at the site have changed. If this report is used beyond this period, BSK should be contacted to evaluate whether site conditions have changed since the report was issued.

CLOSURE

BSK appreciates the opportunity to provide our services to you and trusts this letter report meets your needs at this time. If you have any questions concerning the information presented, please contact us at 925-315-3151.

Respectfully submitted,
BSK Associates

Omar K. Khan, GIT
Project Geologist

Cristiano Melo, PE, GE #2756
Livermore Branch Manager

Richard E. Johnson, CEG #1452
Principal Engineering Geologist

ATTACHMENTS: Figure 1 – Vicinity Map
Figure 2 – Oakhurst GHAD Boundaries
Figure 3A– Site Plan – North Area
Figure 3B – Site Plan – Kelok Way Area
Figure 3C – Site Plan – South Area
Figure 4 – Landslide Repair Cross Section – Pebble Beach Drive/Peacock Creek

References: 1. https://www.arcgis.com/apps/mapviewer/index.html, 2023

Note: Locations are approximate

BSK ASSOCIATES

PROJECT NO.	G00000499
DRAWN:	03/08/23
DRAWN BY:	D. Tower
CHECKED BY:	O. Khan
FILE NAME:	Figures.indd

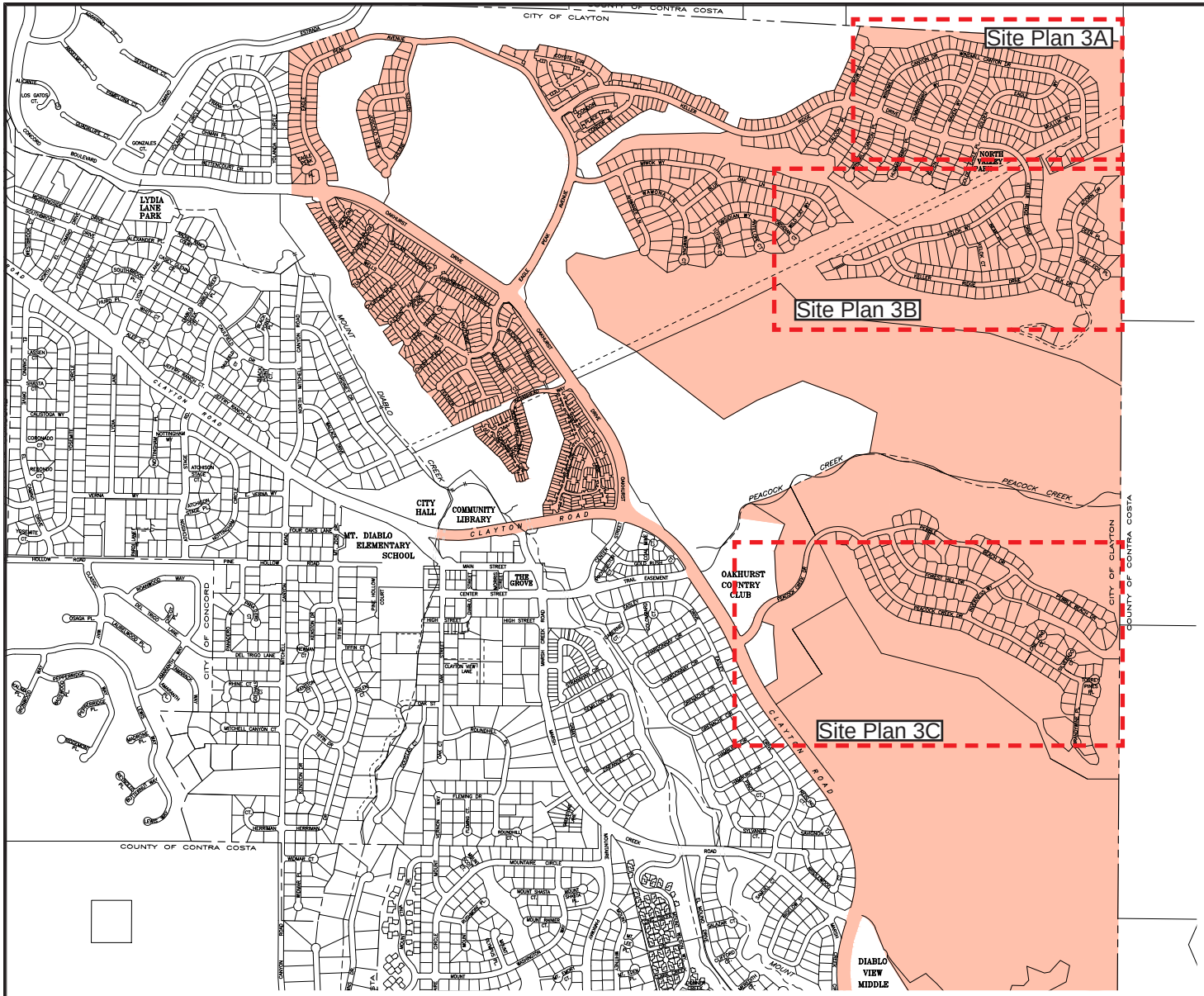
VICINITY MAP

Geological and Geotechnical Site Review
Oakhurst GHAD
Clayton, California

FIGURE 1

ATTACHMENT 2

OAKHURST GEOLOGIC HAZARD ABATEMENT DISTRICT



GRAPHIC SCALE

600 0 300 600 1200 2400

(IN FEET)
1 inch = 600 ft.

Approximate Site Plan Limits (see Figures 3A through 3C)

GHAD PROPERTIES

BSK ASSOCIATES

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FILE NAME:	SitePlan.indd

OAKHURST GHAD BOUNDARIES

Geological and Geotechnical Site Review
Oakhurst GHAD
Clayton, California

FIGURE 2

ATTACHMENT 2

LEGEND:

- (A) Approximate location of photo
- Drop Inlet - blocked or partially blocked
- Incipient Failure/ Debris Flow
- V-Ditch Cracked or Offset
- Slough/Ravelling

References: 1. http://earth.google.com, 20223
2. Locations are approximate

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SITE PLAN
North Area

Geological and Geotechnical Site Review
Oakhurst GHAD
Clayton, California

FIGURE
3A

ATTACHMENT 2

References: 1. http://earth.google.com, 2023
2. Locations are approximate

LEGEND:

- (G) Approximate location of photo
- Drop Inlet - blocked or partially blocked
- Incipient Failure/ Debris Flow
- V-Ditch Cracked or Offset
- Slough/Ravelling
- △ Well

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SITE PLAN
Kelok Way Area

Geological and Geotechnical Site Review
Oakhurst GHAD
Clayton, California

FIGURE
3B

ATTACHMENT 2

LEGEND:

- (O) Approximate location of photo
- Slough/Ravelling
- V-Ditch Cracked or Offset
- Swampy/Wet Area

References: 1. http://earth.google.com, 2023
2. Locations are approximate

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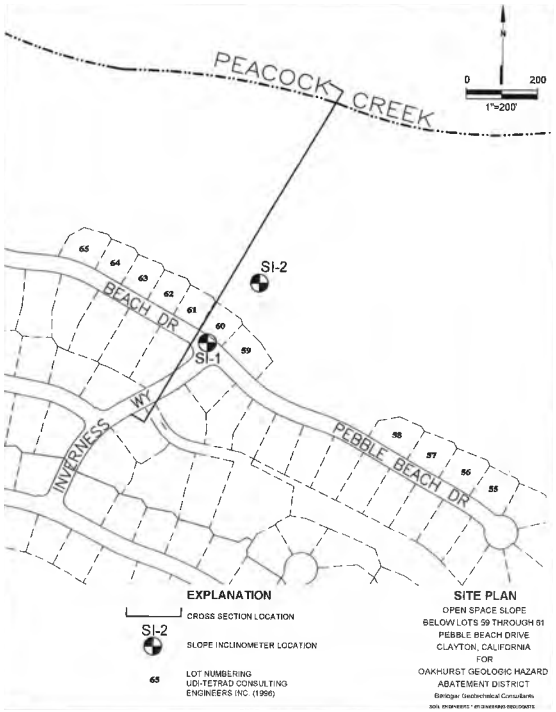
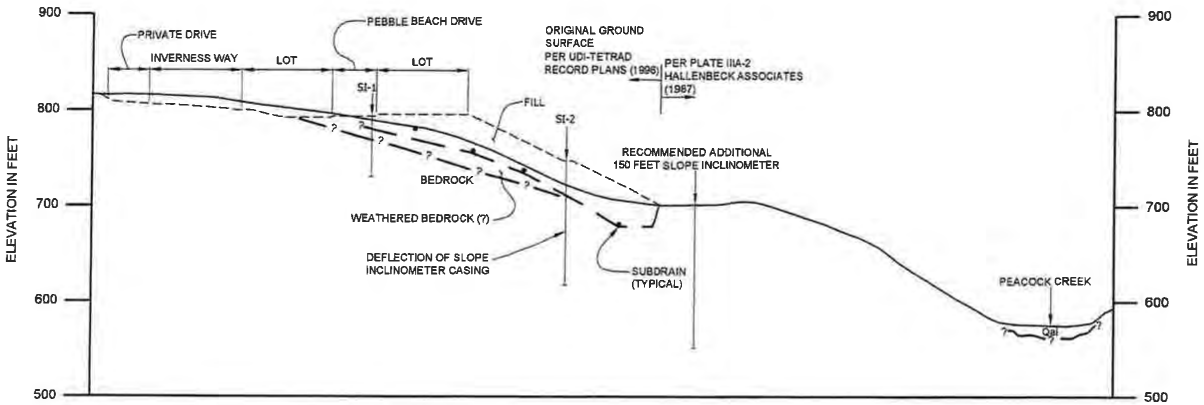
SITE PLAN
South Area

Geological and Geotechnical Site Review
Oakhurst GHAD
Clayton, California

FIGURE
3C

ATTACHMENT 2





EXPLANATION

- ORIGINAL GROUND SURFACE
- DESIGN (EXISTING) GRADE PER UDI-TETRAD RECORD PLANS
- GEOLOGIC CONTACT, DASHED WHERE APPROXIMATE, QUIERED WHERE UNCERTAIN
- SI-2 — SLOPE INCLINOMETER LOCATION
- SUBDRAIN LOCATION PER UDI-TETRAD RECORD DRAWINGS (1996)

CROSS SECTION

OPEN SPACE SLOPE
BELOW LOTS 59 THROUGH 61
PEBBLE BEACH DRIVE
CLAYTON, CALIFORNIA
FOR
OAKHURST GEOLOGIC HAZARD
ABATEMENT DISTRICT

Berlogar Geotechnical Consultants
SOIL ENGINEERS * ENGINEERING GEOLOGISTS

References:
1. Berlogar Geotechnical Consultants (August 10, 2007) – Interim Report, Slope Inclinometer Installation and Monitoring Program, Open Space Between Lots 59 Through 61, Pebble Beach Drive, Clayton, California. Job No. 2947.100

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LANDSLIDE REPAIR CROSS SECTION
Pebble Beach Drive/Peacock Creek

Geological and Geotechnical Site Review
Oakhurst GHAD
Clayton, California

FIGURE
4

ATTACHMENT 2