G3SoilWorks

GEOLOGY • GEOTECH • GROUNDWATER

BONTERRA PSOMAS
225 South Lake Avenue, Suite 1000
Pasadena, CA, 91101

July 14, 2021
Project No. 1-1048-C

Attention: Joan P. Kelly, AICP, Principal-in-Charge
Jennifer Marks, Senior Project Manager

CC: Mr. Thomas DiPrima
Northlake Associates, LLC

Subject: Geotechnical / Hydrogeologic Review of
Creek Avoidance Alternative Design
Northlake, Vesting Tentative Tract Map No. 73336
Castaic, Los Angeles County, California

Dear Mr. DiPrima,

Pursuant to your request and authorization, G3SoilWorks, Inc. (G3) has reviewed the referenced project alternative to the Approved Northlake Specific Plan which would avoid Grasshopper Canyon (a.k.a. "Grasshopper Creek") – herein termed the Creek Avoidance Alternative (CAA). The original approved plan designated Grasshopper Creek – an ephemeral drainage / canyon bottom that runs southeasterly through the site – as a fill zone and a structurally important component that both controlled the ultimate elevations of the original project and provided key support / buttressing to mitigate existing slope instability. Sikand Engineering Associates (Sikand) has designed the CAA (Reference 1, Exhibit A) to avoid grading impacts to Grasshopper Creek. G3 has prepared this review of Sikand's CAA design report and has presented opinion of project feasibility herein based on that review from a geotechnical / hydrogeologic perspective. Other available information for this geotechnical / hydrogeologic review and evaluation included the referenced geotechnical studies, aerial photo review, ongoing desktop research of published and proprietary information, and substantial knowledge of this project site and underlying geologic conditions. Our review found that the CAA configuration results in significant increased geotechnical, engineering hydrogeologic, and safety / critical access risks to the development. The CAA was also found to seriously impact Grasshopper Creek as well. It is our opinion that the CAA approach, in an attempt to "save" the creek, would likely result in the ultimate degradation and destruction of the creek and canyon habitat. We also conclude that the engineering geologic / geotechnical adversities that would develop as a result of implementing the CAA approach would result in unacceptable increases in risk and, as a result, would not be feasible.

CREEK AVOIDANCE ALTERNATIVE PROJECT DESCRIPTION

The proposed Northlake project is a large-scale residential development in the Castaic area of unincorporated Los Angeles County, California, located easterly of Interstate 5 (Golden State Freeway) and westerly of the Castaic Lake State Recreation Area. Implementation of the original Approved Project is separated into two phases, with the first phase incorporating the southern 720± acres and the second phase incorporating the northern 610± acres. The extent of the original project layout encompassed the lower portion of Grasshopper Creek and the adjoining ridges to the east and west. In order to avoid grading impacts to Grasshopper Creek, the layout of the subject CAA moves the development easterly of Grasshopper Creek with a setback of approximately 300 feet, reduces the development acreage to 368 acres, and leaves in place basal landslides at the creek bottom (see Exhibit B). To accommodate travel into and out of this development, at least two bridges on the order of 90 to 120 feet high will need to be installed in Phase 1 with an additional bridge installed in Phase 2 for a total of three bridges (see Exhibit A).

SETTING

The project site is in a westerly facing flank complex that trends from Castaic Lake to the Golden State Freeway. In ancestral time, when rainfall was more plentiful, associated undercutting / downcutting caused the formation of Grasshopper Canyon. This erosional activity also undermined / exposed the underlying geologic structure and resulted in numerous landslide complexes (see Glossary, Figure 1). The current canyon is generally steep-sided on the west and gentler on the east - a geometry that is reflective of the existing geologic conditions. In the present day, the climate has become much drier, and the creek has only developed limited alluvial structure within its bottom (See Glossary, Figure 2). Surface flows have become ephemeral with extended dry periods and only occasional flows ranging from a trickle following typical rain events to a torrent following extreme rain events. Sources of water to the creek include surface water directed by tributaries and transient groundwater / moisture stored largely within landslide debris and, to a lesser extent, along bedding planes and other structure that is hydraulically favorable (see Glossary). Groundwater storage as free water within the alluvial structure of the canyon is very limited due to the limited alluvial development, and is, rather, present in the form of near-surface moisture. Surface water is generally only present during and immediately following rainfall of sufficient intensity / duration to create flow, which occurs infrequently. The majority of water comes from the easterly tributaries and northerly headwaters, as illustrated in Exhibit C. The only semi-permanent surface water is limited to the man-made pond which is located on a terrace above the creek on the easterly flank tributary system (see Exhibit C). This pond is understood to have been created in the early- to mid-20th century for support of livestock activities. Based on our review, this pond is to be removed under both the CAA and the original Approved Project.

Habitat quality along Grasshopper Creek from a hydrogeologic / geomorphic perspective is predominantly poor to mediocre, as described in Table 1 below, Glossary Figure 2, the project environmental studies (Reference 7), and from aerial photo studies. In “better alluviated” portions of the creek that can store water / moisture, the flow corridor has scrubby semi-riparian vegetation development as exemplified in Glossary Figure 2b. These “better alluviated” portions of the creek are not considered to be sufficiently developed / contiguous to be considered "good" or "well-developed" habitat, as exemplified in Glossary Figure 2a. In other areas, alluvial development is marginal to absent, with some areas exposing relatively barren bedrock. The areas of limited to absent alluvial development generally have only poorly developed vegetation and are considered mediocre to poor quality habitat as exemplified in Glossary Figure 2c-2d. Locations of poor, mediocre, and fair habitat along Grasshopper Creek from a geomorphic perspective are shown in Exhibit C. For habitat conditions from a biologic perspective, refer to Glenn Lukos Associates technical memorandum dated June 25, 2021.

Table 1: Description of habitat quality based on hydrogeologic / geomorphic conditions present.

Habitat Quality	Alluviation	Vegetation
Poor	Marginal to absent	Sparse to absent phreatophyte development / low and scrubby growth
Mediocre	Limited	Low density of low growing vegetation
Fair	Moderate	Medium dense cover with moderately defined corridor

CONSIDERATIONS

Hydrogeologic Considerations

The new CAA configuration sets the development back approximately 300 feet from Grasshopper Creek and removes / replaces the upper landslides with engineered compacted fills and associated underground back drains while leaving the lower landslides in place within the 300± feet set back zone. As Exhibit C shows, a majority of the tributaries to the east which contribute both water and sediment to Grasshopper Creek will be eliminated and/or redirected toward storm drain systems where the earthwork assemblies are constructed. Even though development, grading, and placement of fill within Grasshopper Creek proper has been eliminated under the CAA, Grasshopper Creek's habitat will still be significantly impacted by the neighboring development. The modification of the easterly tributaries with geotechnically-required buttressing systems required to stabilize the slopes will result in the loss of up to 2/3 of Grasshopper Creek's current tributary water. Not only will the surface flows be affected, but any subsurface water (a major contributor during drought conditions) that once fed the creek through landslide deposits and, to a lesser extent, through bedding planes on the easterly flank will be reduced or cutoff entirely. As the bedding planes dip away from the creek on the westerly flank, subsurface water from the westerly flank is not expected to contribute nearly to the same degree as from the easterly flank, which dips toward the creek. This significant reduction in subsurface and surface water will negatively impact / reduce habitat productivity. Even with Grasshopper Creek preserved in place, the surface and subsurface water / moisture sources that once fed it will no longer be available to sustain it under the proposed CAA development plan.

When considering the influence of the altered hydrology on the canyon system – with most of the alluvial and habitat-sustaining, low-flow water and moisture crimped or eliminated under the proposed plan – the canyon would still be exposed to high-flow water rain events (10- to 50-year storms) in wet years. As ordinary transport mechanisms that move eroded soils downstream continue to occur, the lost sediments would not be replaced from the sediment-loading easterly tributaries (which will be lost as a result of development) as they once were, and the creek will begin to suffer from sediment starvation and deflation. This change in flow regime will reduce the vegetation density which act as an erosion control, making the canyon more susceptible to greater erosion. Continued downcutting of the canyon will eventually lead to exposure of the underlying bedrock and unfavorable bedding planes (Glossary Figure 1). This downcut condition presents several negative consequences as they pertain to both the creek habitat and to the proposed development alternative which include: 1) degradation of habitat / loss of phreatophytes due to removal of alluvial sediment platform, nutrients, and moisture / groundwater storage carried with it; 2) increased risk for uncontrolled deflation / downcutting during periods of heavy rain; 3) scour of sediments and bedrock compromising the integrity of the proposed bridge additions (as in Glossary Figure 3); and 4) daylighting and undermining of bedding planes and related geologic structure leading to slope instabilities and endangerment to the development above (as in Glossary Figure 1).

Geotechnical / Engineering Geologic Considerations

From a structural geology perspective, the geologic formations underlying the project area which includes Grasshopper Creek generally dip to the west, as in Glossary Figure 1. These rocks are relatively low strength materials that became highly unstable due to the downcutting action of the ancestral Grasshopper Canyon during high-flow climate conditions, which daylighted out-of-slope bedding and resulted in the original failures (i.e., landslides, see Exhibit B).

The success and safety of any project design at this location is predicated on the stabilization of these slopes to protect the development above. In order to preserve Grasshopper Creek in place, the CAA shifts development to the east of Grasshopper Creek and leaves lower portions of landslides in place within the setback area. This leaves no option but to place earthen keys and retaining wall systems upslope of these landslides (see Exhibit D). However, along some portions of the lower canyon, complete landslide removal will very likely still be required within the setback zone to even achieve an acceptable factor of safety for the proposed development. With the creek now being starved of sediment load, the creek bottom will begin to erode and deflate further, and the canyon will start scouring its banks and bottom (see Glossary). This will result in a reoccurrence of the conditions which produced the original landslides – the escalation of downcutting and mass wasting – likely developing new instabilities that can / will undermine the proposed buttress and/or retaining wall systems.

An option to increase the setback distance from the Grasshopper Creek flow line may possibly be considered. However, potential drawbacks must be considered, including: 1) a larger setback increases the amount of landslide material immediately below the proposed fill – this will greatly increase existing slope instability and will require even wider and deeper remedial keyways; 2) the larger setback will considerably reduce the developable area and further decreases the lot count; and 3) remedial grading associated with the larger keyway excavation will likely require back cut slopes to approach or go beyond the current eastern ridgeline. The development of undercutting / erosion / deflation will still be expected to occur and cause problems unacceptably increasing risk of instability.

In addition, the integrity of the proposed bridges is expressly dependent upon the strength of the soil / rock into which its foundations are embedded. Foundation elements will likely need to bear into the canyon sidewalls and creek bottom to support the bridges. However, the canyon sidewalls – particularly the easterly side – have unfavorable geology, including landslide debris and shallow / unsupported bedding structure. If foundation elements are founded in the creek, they will become increasingly exposed to extreme scour (Glossary, Figure 3) because of the unbalanced sediment-starvation condition, resulting in deflation and undermining of the supports. The unfavorable geologic conditions will be at significantly increased risk of becoming unstable and damaged, undermining the foundation elements. Neither the sidewalls nor the creek bottom present suitable conditions for bridge foundation embedment and expose the bridges to high risks of instability. Moreover, since most of the utilities required to support the development will need to be suspended under these bridges, instability to the bridge abutments from scour would introduce risk of both utility separation and/or spillage into the creek, as well as the loss of functionality of the utilities. Not only is the bridge itself exposed to significant increased risk of instability, but the introduced undermining / mass wasting condition further destabilizes the banks and side slopes, presenting great risk to the development above.

CONCLUSIONS

Our review considered the detailed studies and information database developed by the Northlake design team for the subject area from engineering geologic, geotechnical, and hydrogeologic perspectives. Based on our technical and expert opinion, feasibility of the CAA is heavily influenced by the following key considerations:

1. The site area is underlain by bedrock that dips westerly over the majority of the area to be developed. In ancestral time when climate was wetter, the downcutting action of Grasshopper Canyon daylighted bedding in the canyon by action of erosion. These unsupported / daylighted beds became unstable and formed the complexes of landslides present on the site, as shown on Exhibit B.

2. Hydrogeologically, the predominant tributaries for Grasshopper Creek are located to the east of the creek, and to a lesser extent, the headwater areas to the north. Note that the easterly tributaries will be eliminated and filled in under both the CAA and the Approved Project. The new storm drain controls and mandated BMPs will introduce a new hydrologic regime, re-directing water away from the creek and removing not only surface flows provided by the tributaries, but their sediment loads as well. This new regime increases susceptibility to creek deflation, accelerated erosion of the canyon, and associated slope destabilization.

3. Although low-flow, low-threshold contributions to the Grasshopper Creek drainage will likely be strongly reduced by removal of the easterly tributaries, high-flow events will still occur in response to upper bound storms, creating susceptibility to an increased rate of erosion and resulting in derogatory effects on embankment and foundational stability.
4. The keyway / buttress assemblies along the western revised earthwork limits will be less effective than the original plan that used essentially the entire canyon as a buttress fill and removed all landslide remnants, replacing them with engineered, compacted fill. Since the keyway / buttress assemblies for the CAA have been moved up-dip / upslope to the east to accommodate preservation of the creek, their effective depth relative to the rock exposed along the canyon bottom is reduced, providing a lesser degree of protection against future instabilities when compared to the original plan remedial concepts.
5. The existing habitat quality along the creek is predominantly poor to mediocre from a geomorphic perspective, and generally has only limited alluvial development that may be locally absent. Surface water flows are highly ephemeral (uncommon / infrequent), and storage of water / moisture in the alluvial materials is limited, even within the better-developed portions. This alluvium has been shown in site specific studies to be sensitive to erosion and mobilization (References 6-7).
6. Site specific studies and our expert experience with similar canyon and creek bottom terrain indicate that during the majority of time, when surface water contributions are lacking to absent, an important contributor of essential moisture is local groundwater. The landslide bodies, unlike the surrounding bedrock, are failed masses of rock that are broken up and disarticulated. These landslide complexes have the ability to store considerable groundwater / moisture (relative to intact bedrock) that is proximal to the drainage and can contribute water through seepage mechanisms into the creek – particularly its alluvial complexes – to be available to habitat during recurring dry and drought periods. With remedial grading of the vast majority of landslides on the east slope, this potential subsurface water for the creek will be removed, eliminating a significant portion of – if not all – groundwater sources for Grasshopper Creek.
7. The subject CAA plan will result in the need to install multiple high bridges to cross the canyon to provide access to the east side development from the west side. These bridges and their supports will likely include foundation elements that will bear into either the canyon sidewall or creek bottom. The canyon sidewall areas, particularly the easterly side, have been identified as being comprised of materials that are poor stability candidates – namely landslide debris and geologically unfavorable bedding structure. The canyon bottom is subject to erosion and scour. These geologic / hydrogeologic conditions present risks of instability to the proposed bridges and risk of spillage / interruption to associated utilities.

Integrating the above, we conclude the following:

A. The Creek Avoidance Alternative still significantly impacts the hydrogeology of Grasshopper Creek, namely by elimination of 1) surface water / sediment load recharge from the easterly tributaries; and 2) elimination of subsurface water from remedial removal of landslide debris that are both considered primary. This loss will starve the creek of a large proportion of low-flow water along with sediment that are critical components to habitat productivity. Habitat of the canyon bottom will be strongly degraded as the alluvial materials deflate and erode away, ultimately leaving an actively downcutting rock-bottomed gully.

B. The loss of the easterly tributary will produce a substantial reduction in sediment recharge, which will have profound engineering repercussions. When the creek is starved of sediment recharge, it will begin to scour its bottom and banks to make up for the lost sediment recharge loads. This will result in deflation of the already scant alluvial materials present. As already described, detailed project studies have shown the alluvial materials to be easily mobilized and eroded. With a strongly reduced sediment recharge, this deflation will likely continue such that the canyon resumes downcutting. This will have a destabilizing effect to the development by 1) undermining the keyways / buttresses by exposing / removing support from underlying adverse bedding planes and/or introducing new failures; and 2) accelerated ongoing scour and downcutting of bridge supports.

C. To provide suitable slope stability for the development, complete remedial removal of landslides, significantly enhanced and deepened cut-off keyway / buttress systems, and/or other heavy engineering mitigation within the setback and creek flow line area will likely be required. Even still, the creek-ward portions will be subject to undercutting and mass wasting failures that can damage / destroy creek habitat and create dangerous undermining / destabilizations.

We have found, based on our direct study and experience, that any attempt at saving Grasshopper Creek and isolating it from the development results in either a degradation of the habitat character of the creek and/or presents an increased risk of instability to the Project elements. Climate change studies we have reviewed show that current climate trends of drought interrupted by heavy atmospheric river type events are likely to remain in place for the foreseeable future. The influence of these climate effects on the subject canyon and creek is important to consider from both engineering and habitat perspectives. Storms that produce periodic heavy flows in times of drought interruption will tend to be favored as has been in recent past events – favoring alluvial deflation and canyon downcutting. Stress to the habitat from prolonged drought will increase and available water sources and quantities will be reduced strongly, effectively destroying the creek.

We conclude from our review that the subject CAA approach would likely result in the ultimate degradation and destruction of the creek and canyon habitat. We also conclude that the engineering geologic / geotechnical adversities that would develop as a result of implementing the CAA approach would result in unacceptable increases in risk. As such, it is our expert opinion that the CAA proposed development is infeasible from engineering geologic, geotechnical, and hydrogeologic perspectives.

This memorandum is subject to the review and approval by the controlling jurisdiction. If you have any questions, or require additional information, please contact the undersigned.

Respectfully submitted,
G3SoilWorks, Inc.

CERTIFIED ENGINEERING GEOLOGIST
RICHARD H. SPINDLER
No. 1802
EXP. 4-30-22
STATE OF CALIFORNIA

By: ______________________
Richard H. Spindler, P.G., C.E.G.
Senior Engineering Geologist

REGISTERED GEOLOGIST
LARRY E. FANNING
No. 1907
CERTIFIED ENGINEERING GEOLOGIST
STATE OF CALIFORNIA

By: ______________________
Larry E. Fanning, P.G., C.E.G., R.E.P.A., Q.S.D
President

By: ______________________
Dana L. Mariscal
Staff Engineer

Attachments: List of Selected References
Glossary
Exhibit A – Developmental Study
Exhibit B – Landslide and Inferred Landslide Map
Exhibit C – Tributary and Habitat Map
Exhibit D – Cross-Section A-A'

Distribution: Addressee

LIST OF SELECTED REFERENCES

1. Sikand Engineering Associates, Creek Avoidance Alternative Assessment, Northlake, Castaic, Los Angeles County, California, dated April 2021.
2. LACDPW, Geotechnical and Materials Engineering Review sheet, Tentative Tract 73336, Castaic, Tentative Map Feasibility Approval, dated May 25, 2016, PCA: GMPH / A867.
3. G3SoilWorks, Inc., Response to Geologic and Soils Engineering Review Sheet, Tentative Tract 73336, Northlake, Castaic, Los Angeles County, California, dated May 19, 2016, Project No. 1-1048.
4. G3SoilWorks, Inc., Response to Geologic and Soils Engineering Review Sheet, Tentative Tract 73336, Northlake, Castaic, Los Angeles County, California, dated April 18, 2016, Project No. 1-1048.
5. G3SoilWorks, Inc., Updated Geologic / Geotechnical Report and Response to County Review Comments, Northlake Vesting Tentative Tract Map No. 73336, Los Angeles County, California, dated February 10, 2016, Project No. 1-1048.
6. Geosyntec Consultants, Low Impact Development Plan, Vesting TTM No. 073336, Northlake Phase 1, dated April 2017, Project Number: WW1993.
7. BonTerra Psomas, Biological Resources Downstream Impacts Assessment, NorthLake Specific Plan Project, Revision dated March 2017.

Glossary

1. Ephemeral creek – A dry creek bed with flowing water only during / after precipitation for a short period.
2. Key – Excavation of predetermined depth and width starting at the toe of a proposed slope. When compacted engineered fill is placed at designed grade, the created fill prism counters the downslope driving force of uphill daylighted bedding. (also, Buttress).
3. Keyways – An excavated trench into competent earth material beneath the toe of a proposed fill slope for increased slope stability (see Key).
4. Undercutting – erosion of materials at base of slope (in this case, by action of stream flow)
5. Downcutting – downward erosion that cuts, erodes, and deepens the channel by removing material.
6. Alluviation – Deposition / accumulation of sediment created by running water (also, Alluvial; Alluvium).
7. Bedding Planes – The surface that separates each successive layer of a stratified rock from its preceding layer. Depending on its engineering geologic character, bedding planes represent a discontinuity / plane of weakness.
8. Tributaries – A smaller body of water that feeds into a larger body of water.
9. Headwaters – The upstream source / where a stream begins.
10. Sediment Starvation – When sediment export exceeds sediment import of an alluvial / fluvial system.
11. Deflation – Geomorphic process of removal of soil resulting in bedrock exposure.
12. Mass Wasting – Downward slope movement, failure, and ground loss triggered by a variety of derogatory processes often acting in combination to create an unzippering / run-away instability that may occur rapidly over a large area.
13. Daylighted bedding – when rock layers dip at angles less than the angle of the slope.
14. Scour – removal of sediment by fast flowing water causing scour holes around objects in the path of flowing water, particularly bridge abutments (see Figure 3 below).

Glossary Figures

Figure 1: Illustration of interaction mechanism between stream flow and weak zones in a rock mass with resulting slope instability and slope deformation. The slope can be stressed by downcutting and weak zones / daylighted bedding planes.

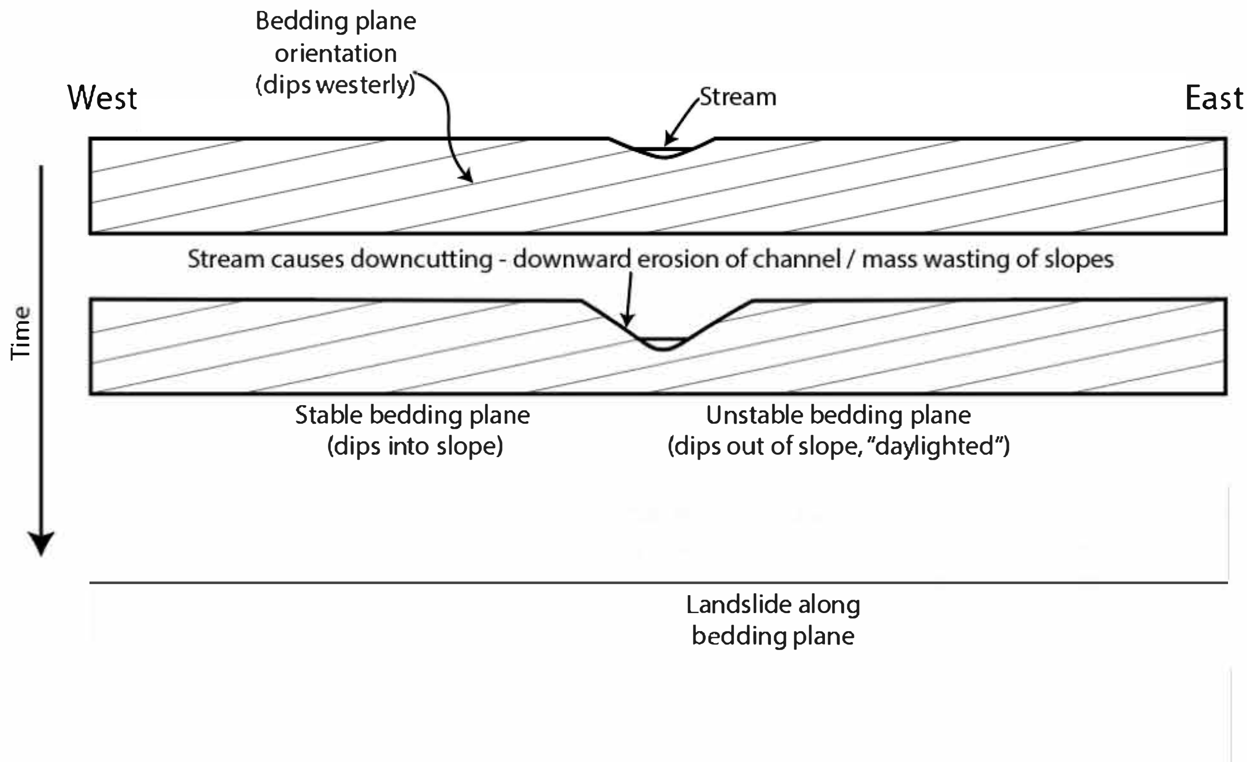
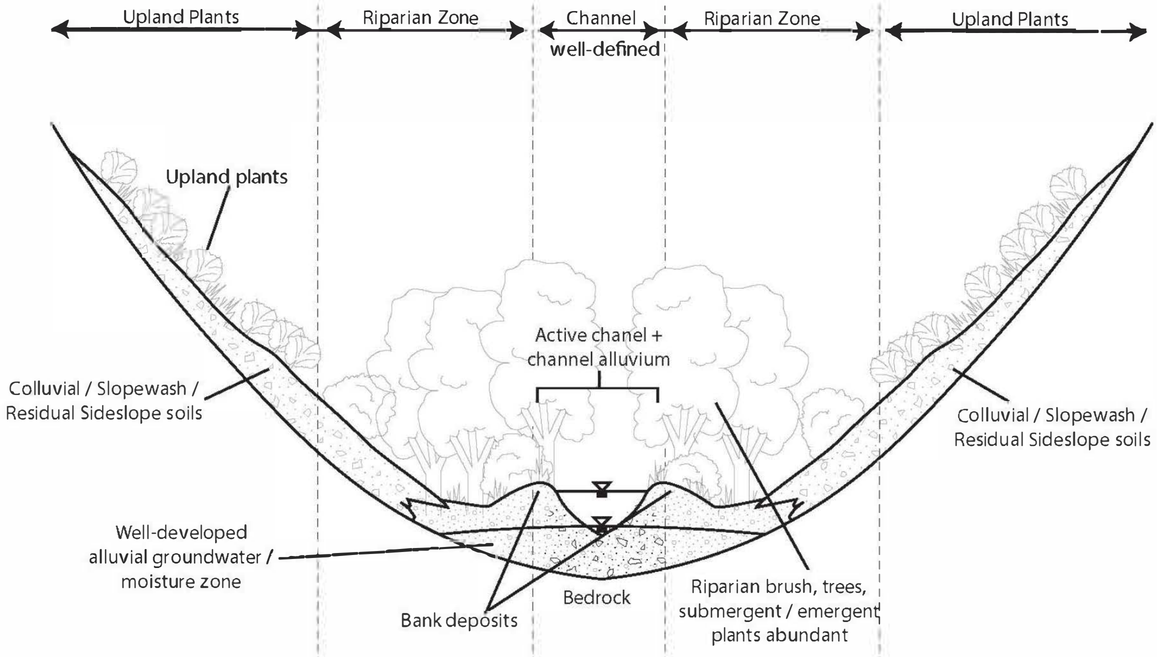


Figure 2a-d: Examples of habitat quality from a geomorphic perspective.

2a) Well-Developed Habitat



2b) Fair Habitat

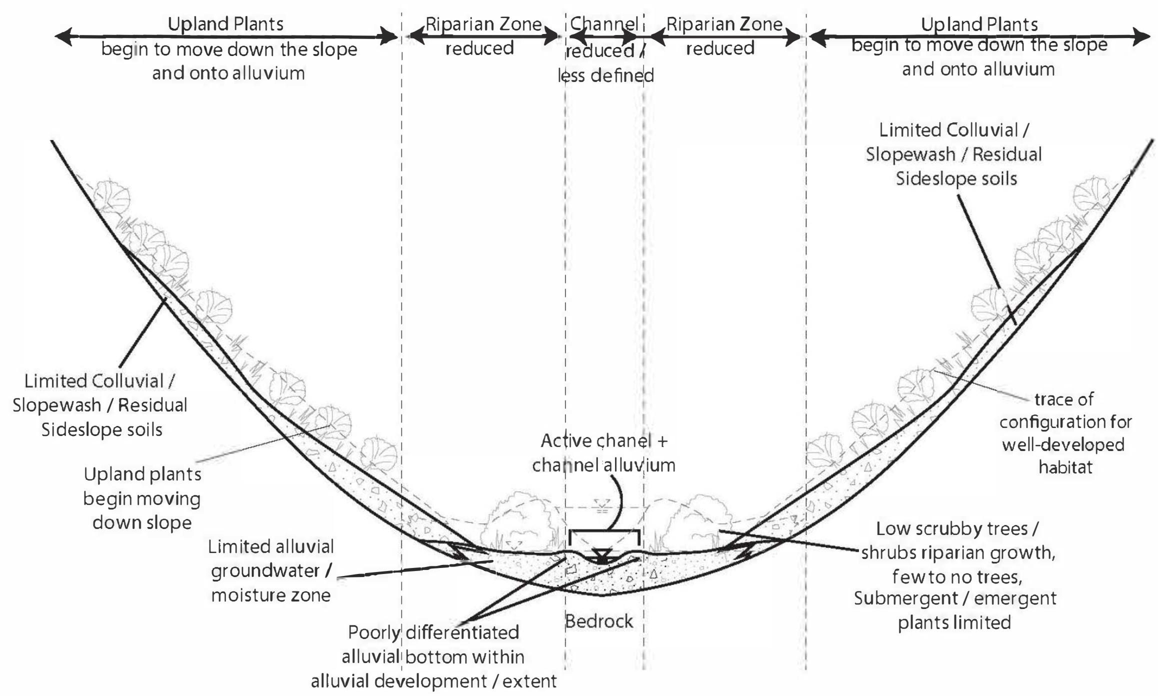
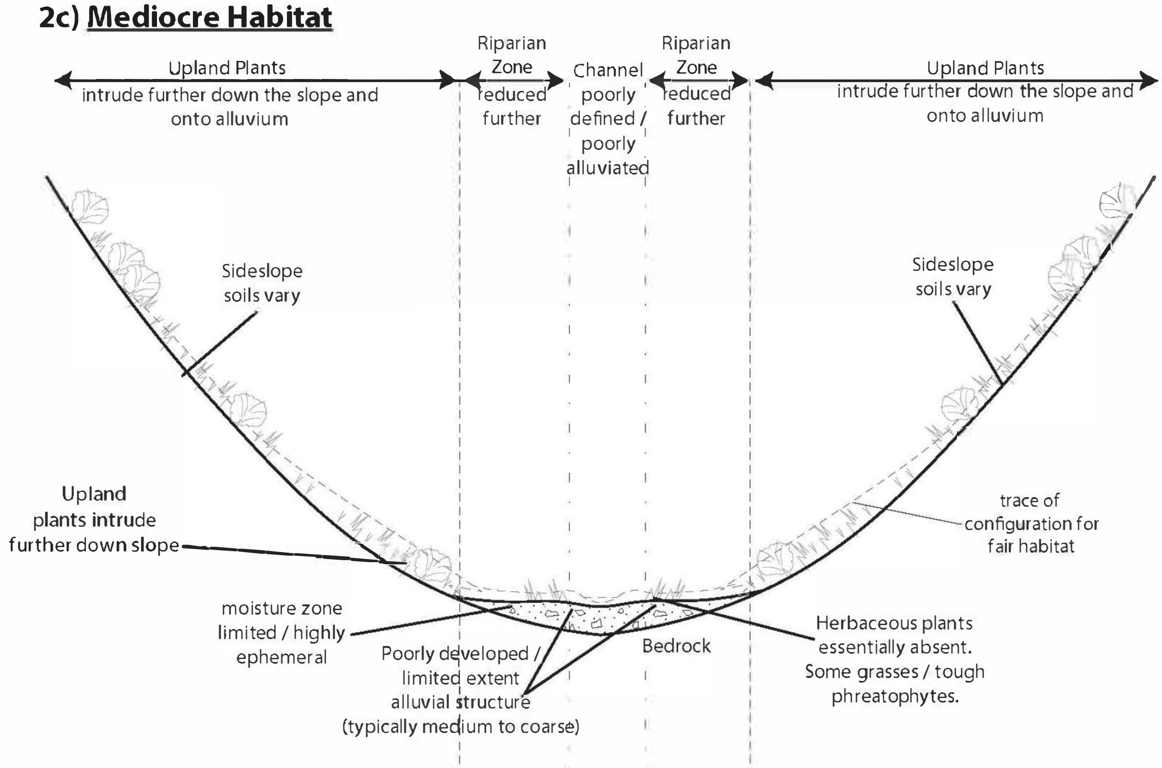


Figure 2a-d: Examples of habitat quality from a geomorphic perspective.

2c) Mediocre Habitat



2d) Poor Habitat

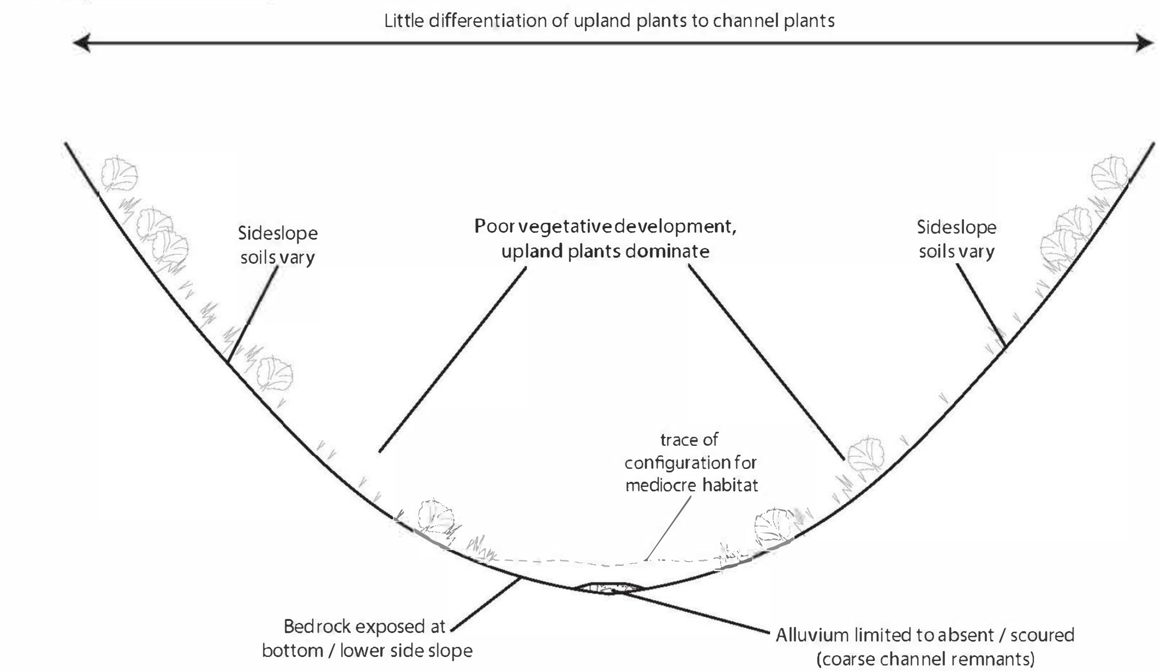
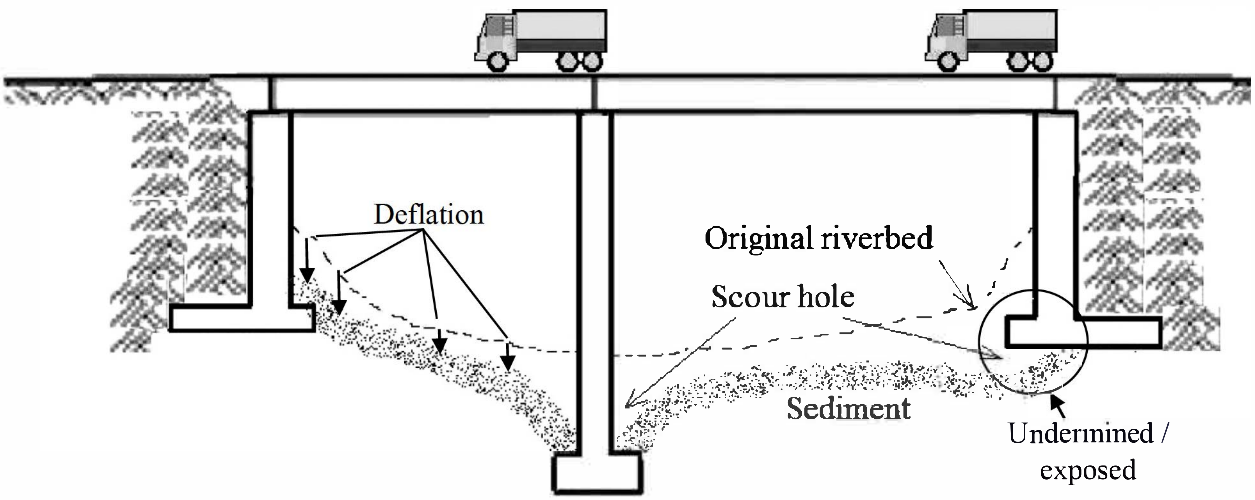
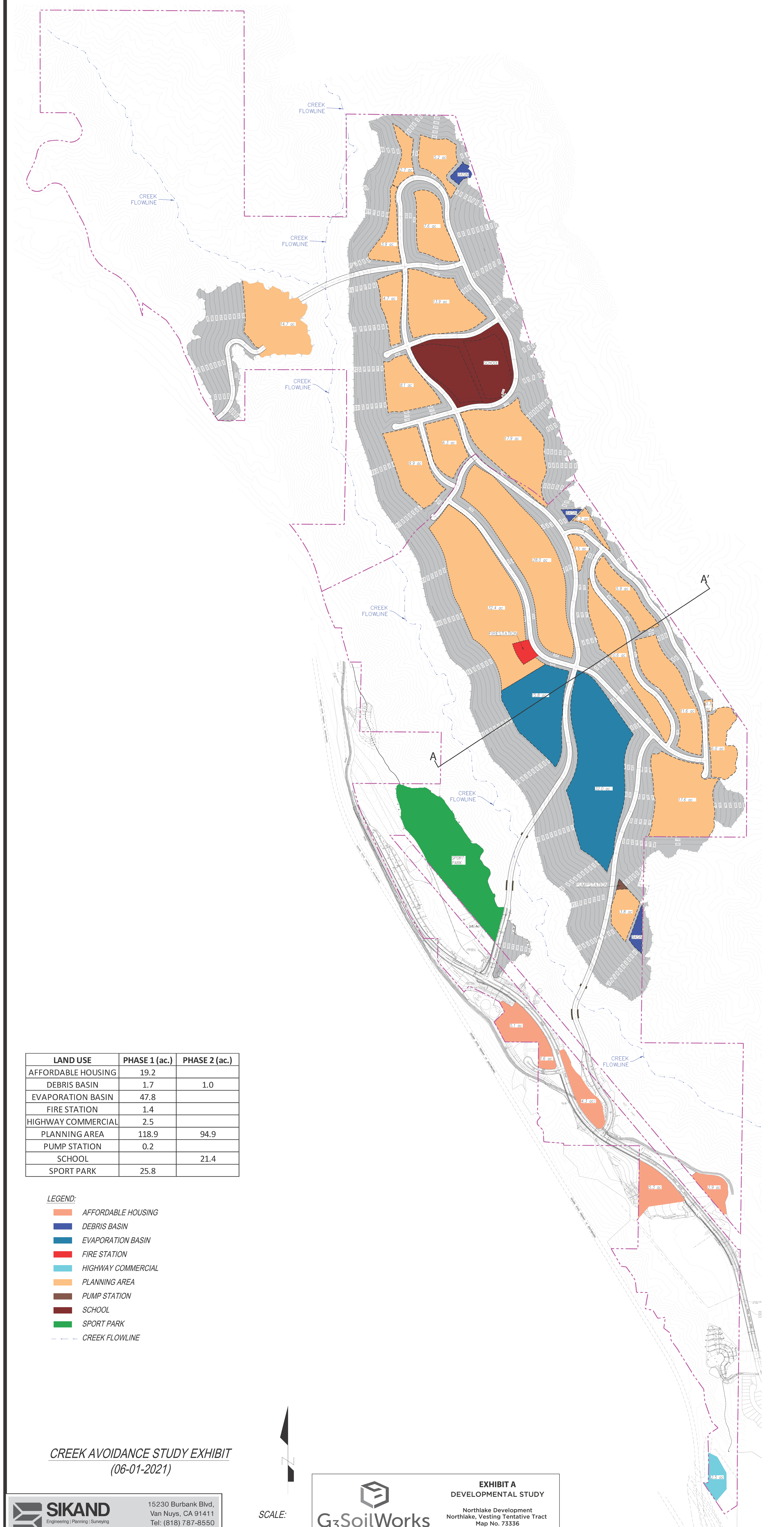


Figure 3: Example depiction of bridge scour





LAND USE	PHASE 1 (ac.)	PHASE 2 (ac.)
AFFORDABLE HOUSING	19.2	
DEBRIS BASIN	1.7	1.0
EVAPORATION BASIN	47.8	
FIRE STATION	1.4	
HIGHWAY COMMERCIAL	2.5	
PLANNING AREA	118.9	94.9
PUMP STATION	0.2	
SCHOOL		21.4
SPORT PARK	25.8	

LEGEND:

- AFFORDABLE HOUSING
- DEBRIS BASIN
- EVAPORATION BASIN
- FIRE STATION
- HIGHWAY COMMERCIAL
- PLANNING AREA
- PUMP STATION
- SCHOOL
- SPORT PARK
- CREEK FLOWLINE

CREEK AVOIDANCE STUDY EXHIBIT
(06-01-2021)

SIKAND
Engineering | Planning | Surveying
15230 Burbank Blvd,
Van Nuys, CA 91411
Tel: (818) 787-8550
Fax: (818) 901-7451
info@sikand.com

SCALE:

G3SoilWorks
350 Fischer Ave. Front
Costa Mesa, CA 92626
Phone: 714 668 5600
G3SoilWorks.com

EXHIBIT A
DEVELOPMENTAL STUDY

Northlake Development
Northlake, Vesting Tentative Tract
Map No. 73336
Los Angeles County, CALIFORNIA

JULY 2021 PN 1-1048-C

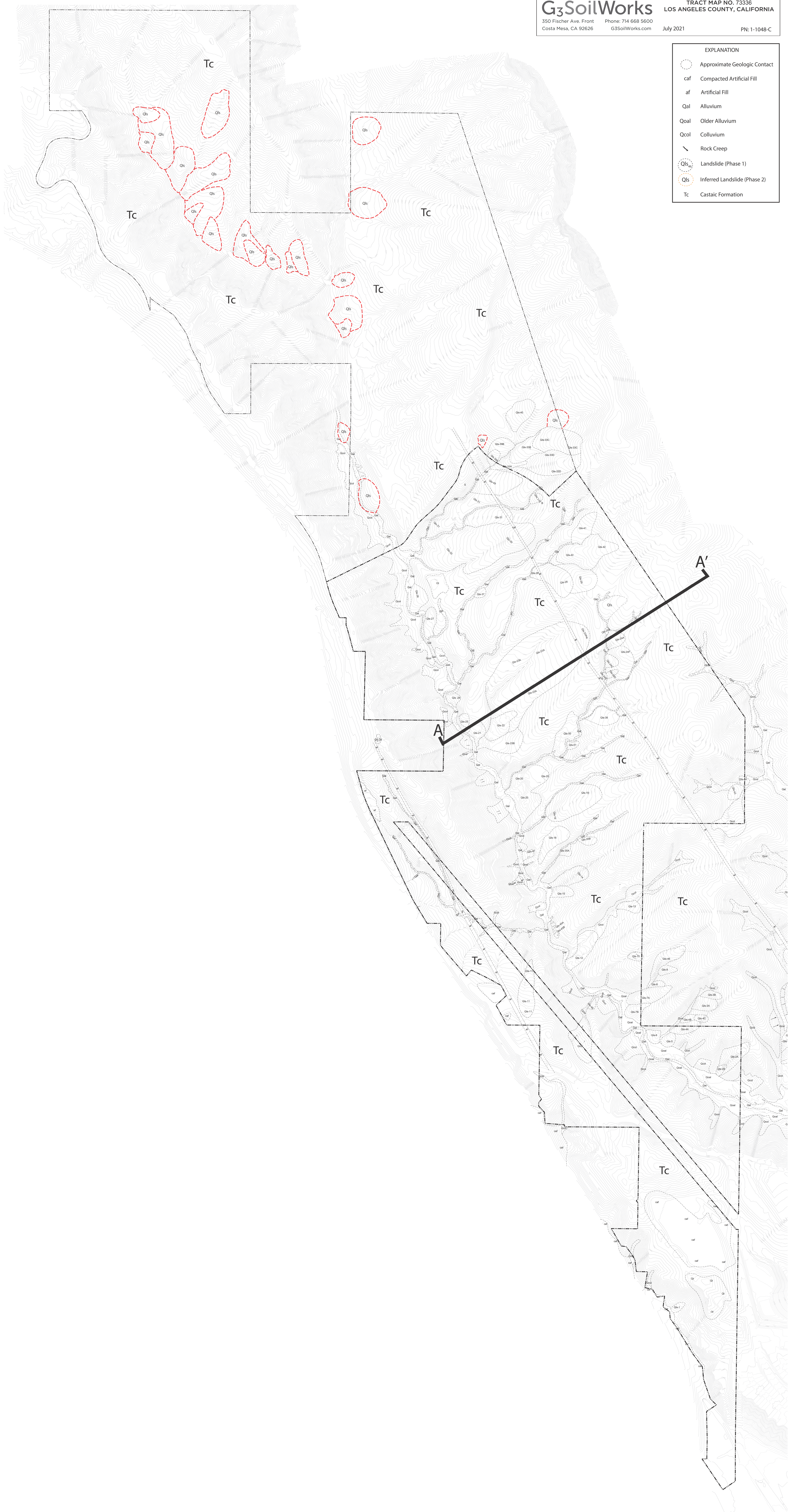
Exhibit B
Landslide and Inferred Landslide Map

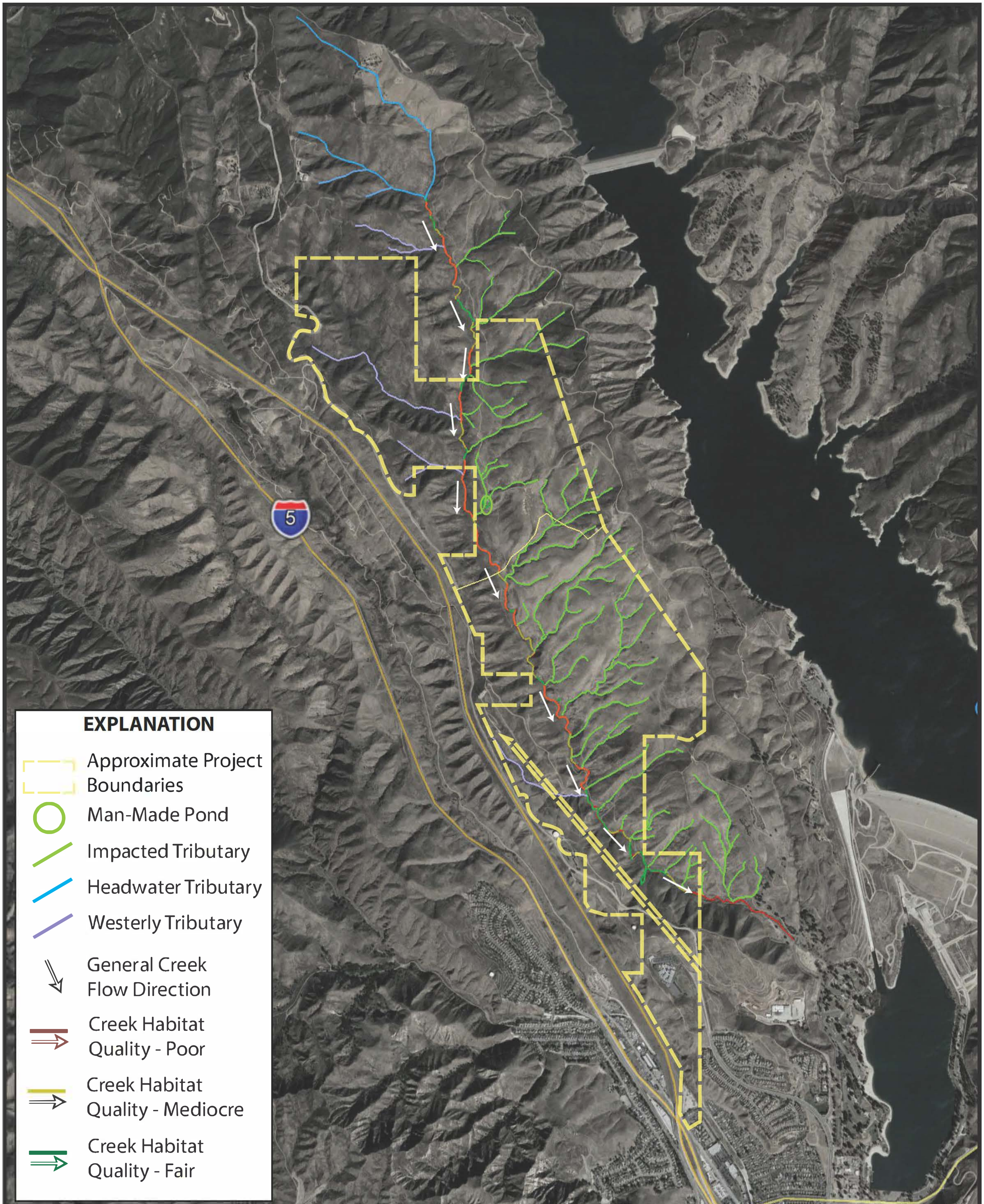
NORTHLAKE, VESTING TENTATIVE TRACT MAP NO. 73336
LOS ANGELES COUNTY, CALIFORNIA

G3SoilWorks
350 Fischer Ave. Front
Costa Mesa, CA 92626
Phone: 714 668 5600
G3SoilWorks.com

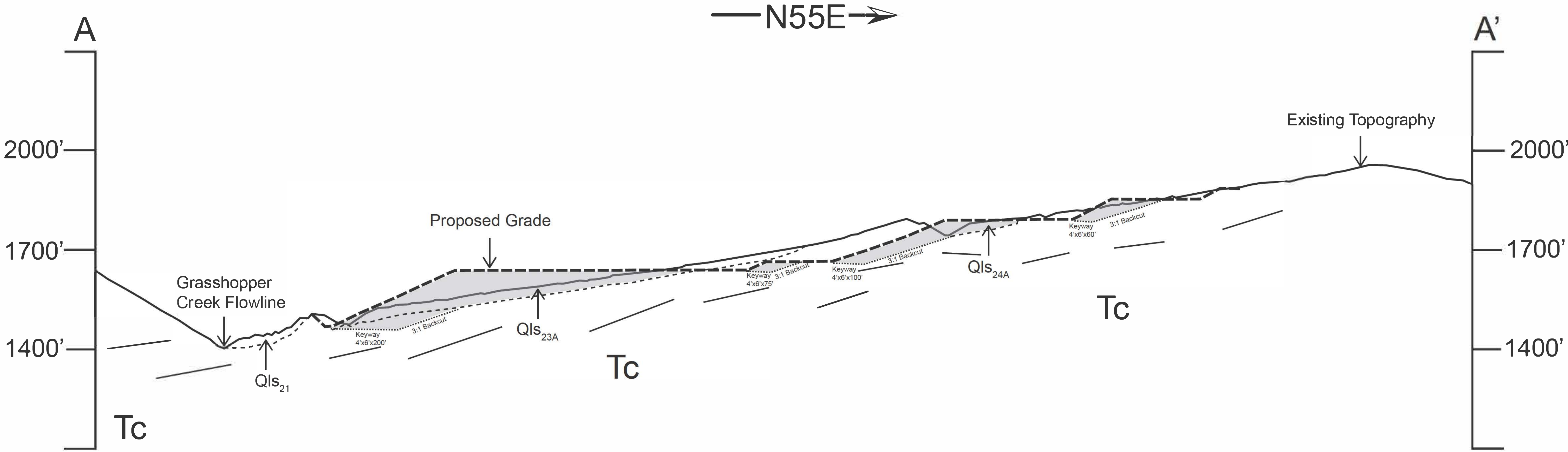
July 2021

PN: 1-1048-C





Tributary and Habitat Map	Proj. No. 1-1048-C	July 2021	G3SoilWorks 350 Fischer Ave. Front Costa Mesa, CA 92626 Phone: (714) 668 5600 www.G3SoilWorks.com
Northlake Development	Los Angeles County, CA	Exhibit C	



EXPLANATION

Tc	Castaic Formatation
Qls	Landslide with Number Designation
/	Schematic Bedding

Schematic Geologic Cross-Section A-A'
Based on Creek Avoidance Study Exhibit (Exhibit A)
Dated 06-01-2021

Scale: 1" = 300' H&V

Geotechnical Cross-Section A-A'	Project No. 1-1048-C	July 2021	G3SoilWorks
Northlake Development	Los Angeles County, CA	Exhibit D	

350 Fischer Ave. Front
Costa Mesa, CA 92626
Phone: (714) 668 5600
www.G3SoilWorks.com