Applied Geotechnical Engineering & Geologic Consulting

September 2, 2015

Travois, Inc.
Attention: Lauren DuCharme, RA
310 W. 19th Terrace
Kansas City, MO 64108

SUBJECT: **Geotechnical Investigation**
Karuk 30 Home Sites Development
Yreka, California

At your request, Applied Geotechnical Engineering and Geologic Consulting LLC (AGEGC) has conducted a geotechnical evaluation for the proposed new Karuk 30 single-family residences to be located in Yreka, California. The purpose of our investigation was to evaluate site conditions with respect to the proposed new homes and develop guidelines and criteria for foundation design for the proposed residences. Our investigation consisted of a ground-level site reconnaissance, subsurface explorations, and engineering analyses. This report summarizes our findings and presents our geotechnical recommendations for the thirty proposed new homes.

The project consists of development of 30 single-family residential lots and two park lots in an existing residential development on the southeastern side of Weed, California. The residential homes will include 15 three bedroom homes, 13 four bedroom homes, and 2 five bedroom homes. The two park lots will include playground areas and garden areas. We have assumed the new homes will be wood-frame construction with an attached garage. The homes will be supported on standard spread footing foundations. Due to existing grades on the lots, retaining walls and/or cuts and fills will be required to build a level building pad for the new homes. Significant grading will be required for driveways to some of the home sites due to the relatively steep slopes on some of the lots.

A licensed geotechnical engineer/geologist from AGEGC completed a site visit on August 11, 2015, for a ground-level reconnaissance of the lots and to observe the test pit explorations. The lots have variable grades and are covered with sparse brush and scattered trees. The geology across the development is highly variable and includes sedimentary rock, low-grade metamorphic rock, and schist with local zones of quartzite. Areas of significant ground desiccation cracks were observed on portions of the lots, indicating areas of highly expansive clayey silt soils. Outcrops of relatively hard rock were observed on several of the lots. Indications of shallow groundwater seepage were not observed. Indications of deep-seated slope instability were not observed.

Evaluation of subsurface conditions in the development included completion of seventeen test pits and mapping of existing roadcuts across the site. The test pits were completed using a Case 590 rubber-tired extend-a-hoe. The logs of the test pit explorations are contained in Appendix A at the end of this report.

The test pit explorations were backfilled with the excavation spoils after mapping of each excavation as completed by our geotechnical engineer. The approximate locations of the test pits are shown on Figure 1 North and South. Descriptions of the materials encountered in the test pits are provided in Tables 1A and 2A.

CONCLUSIONS AND RECOMMENDATIONS

Based on the results of this investigation and our experience with similar residential projects, it is our opinion that the lots, from a geotechnical standpoint, can be developed with the proposed single-family residences. Indications of slope instability or other geologic hazards that could preclude development of the lots were not observed during our fieldwork. The northern lots are mantled with expansive clayey silt soils which must be taken into account during design and construction for these lots.

Rock Excavation. Local outcrops of hard, intact rock were observed locally on some of the lots. We anticipate that the majority of the building pads can be completed using a large trackhoe equipped with a rock bucket; however, depending on final grades (the amount of cut required), there is some risk that hard rock requiring rock excavation methods (hoe-ram) may be required. The risk of encountering hard rock in the excavation for the home can be minimized by orienting the homes parallel to the existing topography and decreasing the depth of cut required to build a flat building pad.

Site Preparation and Grading. The ground surface within areas of grading for driveways and building pads should be stripped of vegetation, surface organics, and loose surface soils. We estimate that stripping will generally be necessary to a depth of about 6 in. Deeper grubbing will be necessary to remove stumps and roots larger than about 1 in. in diameter. The strippings can be used in landscaped areas or should be removed from the site. Following stripping and prior to filling, the resulting subgrade should be evaluated for the presence of soft areas. If present, soft areas should be overexcavated and replaced with compacted structural fill as described below. During and following stripping and excavation, the contractor must use care to protect the subgrade from disturbance by construction traffic.

In areas of surficial expansive soils, the clayey silt soils should be removed 3 ft beyond the limits of all fill areas, building footprints, concrete flatwork, and areas to be paved with asphaltic concrete.

The site strippings and expansive soils are not suitable for use as structural fill and should be removed from the site or limited to use in landscaping areas.

Past experience has indicated that the fine-grained soils that mantle the site are sensitive to moisture content. Typically, when these soils are in excess of 4 to 5% of their optimum moisture content, construction traffic will remold, rut, and soften the soil and limit its use as a subgrade material for roads, parking areas, slabs, or foundations. For this reason, we recommend that, if practical, all site preparation and earthwork be accomplished during the dry summer months, typically extending from May to mid-October of any given year.

The test pit excavations were backfilled with relatively loose spoils from the excavations. If the test pit excavation locations occur within building pad or driveway areas, the spoils should be removed and replaced with structural fill.

We understand the driveways for the proposed homes will be graded with cut and full. Cut and fill slopes should be no steeper than 2H:1V. Fills may be constructed of on-site, non-expansive native soils free of deleterious materials. Fills constructed of on-site, native soils should be placed in lifts of less than 9-in.-thick (loose) and compacted with several passes of a large segmented pad compactor. Structural fills should be compacted to at least 95% of the maximum dry density as determined by ASTM D 698. The fills should be built at least 2 ft beyond final grades, then trimmed back to design elevations using a trackhoe equipped with a smooth-lip bucket.

On slopes steeper than 5H:1V, the toe of the fill slope area should be benched to provide a level area to start the fill. The bench should be at least 12 ft wide.

Fills should be compacted within 3% of the optimum moisture content. This will require moisture conditioning (adding and blending water) to fills during dry summer and fall months. During wet weather conditions (typically winter and spring months), silt soils cannot be adequately dried to optimum moisture and are not suitable for use as structural fills. Fill should not be placed on frozen ground.

For gravel drives, we recommend a maximum grade of 15%. Where practical, the grades should be kept less than 12% to minimize long-term maintenance of the driveways. If paved, driveway grades may be increased up to 18%. We recommend a minimum rock section of 12 in. of aggregate base.

Structural Fills. Structural fill for the building pads should consist of imported hard, angular rock (such as 4-in.-minus crushed rock). The crushed rock should have less than 12% passing the no. 200 sieve (washed analyses), and be hard and durable. Crushed rock fill must be compacted using several passes with a moderate-sized smooth-drum vibratory roller. Fill lifts should be less than 6 in. thick (loose).

Foundation Support. Foundation support for the proposed homes can be provided by conventional wall-type (continuous) spread footing foundations founded on undisturbed silt soils, undisturbed rock, and/or structural fill. Pad foundations should not be used for house support. Expansive soils are not suitable for support of spread footing foundations and must be removed within 3 ft of all building pads and concrete flatwork. The width of footings should not be less than 12 in. for continuous spread footing foundations. For foundations founded on undisturbed silt soils, we estimate that the total, long-term settlement of spread footings designed in accordance with the above recommendations and imposing a real bearing pressure of up to 1,500 psf will be less than ½ in. For design purposes, the real bearing value refers to the total of dead load plus frequently and/or permanently applied live loads, and can be increased by one-third for the total of all loads; dead, live, and wind or seismic.

On steeper lots, it may be more cost-effective to build the house pad with steps to reduce the amount of site grading and imported fill required. Where steps are constructed for the home pad, we recommend that foundations be constructed perpendicular to the slope are much as possible to reduce the risk of differential movement of the foundations.

Retaining Walls. Given existing slopes on the lots, cut slopes adjacent to homes may need to be supported by retaining walls. Design lateral earth pressures for embedded walls depend on the type of construction, i.e., the ability of the wall to yield and whether the wall is drained. For design purposes, cantilevered retaining walls and rockery walls are typically assumed to be yielding. Assuming drained and yielding retaining wall conditions, the retaining walls can be designed based on an equivalent fluid pressure of 35 pcf. These design criteria assume the wall will be backfilled within 2 ft of the back of the wall with relatively clean (less than 10% passing the No. 200 sieve – washed analysis) granular fill and that the ground surface slopes slightly down away from the top of the wall. A non-woven geotextile (minimum 6 oz weight) should be placed between any drain material and any soil to prevent of erosion of the soils into the drainage material.

The backfill for the retaining walls should be placed in horizontal lifts not to exceed 12 in. (loose) and compacted to about 93% of the maximum dry density as determined by ASTM D 698. Overcompaction of the backfill should be avoided, and compaction of the wall backfill should be accomplished using a hand-operated compactor.

Horizontal shear forces on spread footing foundations (building and retaining wall foundations) can be resisted by frictional forces developed between the base of spread footings and the underlying soil. The total frictional resistance between the footing and the soil is the normal force times the coefficient of friction between the soil and the base of the footing. We recommend an ultimate value of 0.4 for the coefficient of friction; the normal force is the sum of the vertical forces (dead load plus real live load). If additional lateral resistance is required, passive earth resistance against embedded footings or walls can be computed using a pressure based on an equivalent fluid with a unit weight of 300 pcf. This design passive earth pressure is appropriate only if granular structural fill is to be used for the backfill around footings.

Slab-on-Grade Floors. To provide uniform floor support, concrete slab-on-grade floors should be underlain by a minimum 8-in.-thick granular base course placed as structural fill. We recommend installation of a vapor-retarding membrane beneath the slab-on-grade floors. Vapor-retarding membranes should be installed in accordance with the manufacturer's recommendations but is typically installed under the slab, over the crushed rock section.

Foundation drains should be installed around the perimeter of the home. The foundation drain should consist of a 4-in.-diameter perforated drain pipe bedded in at least 6 in. of angular drain rock that is wrapped inside a non-woven geotextile (6 oz minimum weight).

Exterior water-proofing for the retaining walls should extend from 6 in. above final grades down to the base of the foundations.

Seismic Considerations. Rock typically occurs at a depth of less than 10 ft at these lots. In our opinion, the subsurface conditions at this site may be classified as a Site Class B for seismic design purposes. Geologic mapping of the area indicates that the area is underlain by several faults; however, based on the mapping, the faults do not appear to be active and the risk of fault rupture at the site is low.

Construction Considerations. Lots 58, 59, 60, 61, 62, and 65, and portions of Lots 31, 32, and 33 are mantled with moderately expansive clayey silt soils. Given the relatively gently sloping topography on Lot 65, we recommend Lot 65 be used to fill for the park lot instead of Lot 61. We anticipate that site spoils that do not contain significant organics may be used to grade Lot 65 for the park and garden areas. The fill should be compacted to at least 90% of the dry density as determined by ASTM D 698.

Lot 42 contains significant fill likely placed during grading for the site roadways. The fill appears to be loose (non-structural). Structures built on this lot will have significant risk of post-construction settlement. We recommend that this lot be used as the park and garden lot instead of Lot 45.

Lots 38, 43 and 44 are located downslope of the access road to the city's water reservoir. Based on site grades, it may be prudent to access these three lots from the access road rather than off of Apsuun Road. In our opinion, this will minimize construction costs by reducing the amount of site grading needed for driveways to these lots.

LIMITATIONS

This report has been prepared to aid in the evaluation of the 30 residential lots in Yreka, California. The scope is limited to the specific improvements and locations described herein, and our description of the project represents our understanding of the significant aspects of the project relevant to the design and construction of the proposed homes. In the event that any changes in the design and location of the home, as outlined in this report, are planned, we should be given the opportunity to review the changes and to modify or reaffirm the conclusions and recommendations of this report in writing.

Please contact AGEGC if you have any questions or require additional information.

Sincerely,
Applied Geotechnical Engineering and Geologic Consulting LLC

Robin L. Warren, P.E., G.E., R.G.
Principal

Appendix A
Subsurface Explorations

Test Pit TP-1

00 to 12 in	Medium stiff, light brown SILT; trace clay.
12 to 42 in	Soft to medium hard (RH-1 to RH-2) light brown Meta-SANDSTONE; close fractures, low-grade metamorphic, slightly weathered.

Rock outcrop near test pit location.
Practical refusal of extend-a-hoe on RH-3 rock at a depth of 42 in.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed September 19, 2014.

Test Pit TP-2

00 to 24 in	Medium stiff, reddish-brown SILT; trace clay (no desiccation cracks observed).
24 to 54 in	Soft to medium hard (RH-1 to RH-2) light brown Meta-SANDSTONE; close fractures, low-grade metamorphic, slightly weathered.

Practical refusal of extend-a-hoe on RH-3 rock at a depth of 54 in.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed September 19, 2014.

Test Pit TP-3

00 to 6 in	Medium stiff, brown SILT; trace clay.
6 to 48 in	Soft to medium hard (RH-1 to RH-2) light brown Meta-SANDSTONE; close fractures, low-grade metamorphic, slightly weathered.

Practical refusal of extend-a-hoe on RH-3 rock at a depth of 48 in.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed September 19, 2014.

Test Pit TP-4

00 to 30 in	Soft to medium hard (RH-1 to RH-2) light brown Meta-SANDSTONE; close fractures, low-grade metamorphic, slightly weathered, thin soil veneer at the ground surface.

Practical refusal of extend-a-hoe on RH-3 rock at a depth of 30 in.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed September 19, 2014.

Test Pit TP-5

00 to 6 in	Medium stiff, brown SILT; trace clay.
6 to 32 in	Soft to medium hard (RH-1 to RH-2) light brown Meta-SANDSTONE; close fractures, low-grade metamorphic, slightly weathered.

Practical refusal of extend-a-hoe on RH-3 rock at a depth of 32 in.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed September 19, 2014.

Test Pit TP-6

00 to 24 in	Medium stiff, reddish-brown clayey SILT; desiccation cracks at ground surface, moderately to highly expansive.
24 to 32 in	Medium stiff, brown/reddish-brown SILT; some clay, slight to moderate expansive, some scattered gravel and cobble.
32 to 72 in.	Stiff, brown SILT; trace clay, scattered gravel and cobble.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015.

Test Pit TP-7

00 to 36 in	Medium stiff, reddish-brown clayey SILT; desiccation cracks at ground surface, moderately to highly expansive, scattered gravel and cobble.
36 to 72 in	Medium stiff, brown/reddish-brown SILT; some clay, slightly expansive.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-8

00 to 18 in	Medium stiff, brown clayey SILT; moderately expansive.
18 to 54 in	Stiff, brown SILT; scattered gravel and cobble.
54 to 60 in.	Hard, brown SILT; relict rock structure.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-9

00 to 18 in	Medium stiff, brown clayey SILT; desiccation cracks at ground surface, moderately to highly expansive.
18 to 60 in	Medium stiff, brown SILT; trace clay, scattered gravel and cobble.

Groundwater seepage not observed.
Slight caving to 1.5 ft.
Completed August 11, 2015

Test Pit TP-10

00 to 24 in	Medium stiff, brown SILT; scattered gravel.
24 to 48 in	Medium soft (RH-1) brown Meta-Sedimentary; close fractures, moderate weathering.
48 to 54 in.	Medium hard (RH-2) gray Meta-Sedimentary; close fractures, slight weathering, local zones of RH-3.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-11

00 to 06 in	Medium stiff, brown SILT; relict rock structure.
06 to 36 in	Medium hard (RH-2) gray Meta-Sedimentary; close fractures, slight weathering, local zones of RH-3.

Practical refusal of the backhoe on RH-3 rock at a depth of 3 ft.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-12 (roadcut)

00 to 120 in	Medium hard (RH-2) gray Meta-Sedimentary; close fractures, slight weathering, local zones of RH-3.

Groundwater seepage not observed.
Completed August 11, 2015

Test Pit TP-13

00 to 24 in	Medium stiff, brown SILT.
24 to 72 in	Medium soft to medium hard (RH-1 to RH-2) brown to reddish-brown Meta-Sedimentary; low grade metamorphic, close fractures, moderate weathering.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-14

00 to 48 in Medium hard (RH-2) gray Meta-Sedimentary; close fractures, slight to moderate weathering.

Practical refusal of the backhoe on RH-3 rock at a depth of 2 to 4 ft. (irregular bottom of test pit excavation). Hard rock outcrop southwest of the site.
Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-15

00 to 120 in FILL: soft to medium stiff, brown SILT; local zones of scattered gravel.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-16 (roadcut)

00 to 72 in Medium hard (RH-2) gray Meta-Sedimentary; close fractures, slight weathering.

Groundwater seepage not observed.
Completed August 11, 2015

Test Pit TP-17

00 to 24 in Medium stiff, brown SILT; some clay, slightly expansive.
24 to 78 in Medium soft to medium hard (RH-1 to RH-2) gray mica SCHIST; close fractures, moderate weathering, local zones of hard quartz.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-18

00 to 24 in Medium stiff, brown SILT; some clay, slightly expansive.
24 to 78 in Medium soft to medium hard (RH-1 to RH-2) brown SCHIST; close fractures, moderate weathering, local zones of gray mica schist.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

Test Pit TP-19

00 to 24 in	Stiff, brown SILT; some clay, slight to moderate expansive.
24 to 28 in.	Soft, light gray SILT.
28 to 48 in	Medium soft to medium hard (RH-1 to RH-2) gray SCHIST; close fractures, moderate weathering, local zones of mica schist.

Groundwater seepage not observed.
No significant caving of test pit sidewalls.
Completed August 11, 2015

TABLE 1A: SOIL DESCRIPTION TERMINOLOGY

Coarse-Grained Soils (Sand Size and Larger)

Relative Density	Standard Penetration Resistance (N-Values)
Very Loose	0-4
Loose	4-10
Medium Dense	10-30
Dense	30-50
Very Dense	Over 50

Fine-Grained (Cohesive) Soils

Consistency	Standard Penetration Resistance (N-Value)	Torvane Undrained Shear Strength, tsf	Field Identification
Very Soft	2	Less than 0.125	• Easily penetrated by fist.
Soft	2-4	0.125-0.25	• Easily penetrated by thumb.
Medium Stiff	5-8	0.25-0.50	• Penetrated by thumb with moderate effort.
Stiff	9-15	0.50-1.0	• Readily indented by thumb but penetrated only with great effort.
Very Stiff	16-30	1.0-2.0	• Readily indented by thumbnail.
Hard	Over 30	Over 2.0	• Indented with difficulty by thumbnail.

Grain Shape

Term	Description
Angular	Corners and edges sharp.
Subangular	Corners worn off, angles not worn off
Subrounded	Corners and angles worn off, flat surfaces remain.
Rounded	Worn to almost spherical shape.

Grain Size Classification

Boulders	6 to 36 inches
Cobbles	3 to 6 inches
Gravel	¼-¾ inch (fine)
	¾-3 inches (coarse)
Sand	No. 200-No. 40 sieve (fine)
	No. 40-No. 10 sieve (medium)
	No. 10-No. 4 sieve (coarse)
Silt/Clay	Pass No. 200 sieve

Modifier for Subclassification

Adjective	Percentage of Other Material in Total Sample
Clean	0 – 1.5
Trace	1.5 - 10
Some	10 - 30
Sandy, Silty, or Clayey	30 - 50

TABLE 2A: ROCK DESCRIPTION TERMINOLOGY

Scale of Rock Hardness (After Panama Canal Company, 1959)

RH-1	Soft	Slightly harder than very hard over-burden, rock-like character, but crumbles or breaks easily by hand.
RH-1	Medium Soft	Cannot be crumbled between fingers but can be easily picked with light blows of the geology hammer.
RH-2	Medium Hard	Can be picked with moderate blows of geology hammer. Can be cut with knife.
RH-3	Hard	Cannot be picked with geology hammer but can be chipped with moderate blows of the hammer.
RH-4	Very Hard	Chips can be broken off only with heavy blows of the geology hammer.

Terms Used to Describe the Degree of Weathering

Descriptive Term	Defining Characteristics
Fresh	Rock is unstained. May be fractured but discontinuities are not stained.
Slight	Rock is unstained. Discontinuities show some staining on their surface but discoloration does not penetrate rock mass.
Moderate	Discontinuity surfaces are stained. Discoloration may extend into rock along discontinuity surfaces.
High	Individual rock fragments are thoroughly stained and can be crushed with pressure hammer. Discontinuous surfaces are thoroughly stained and may be crumbly.
Severe	Rock appears to consist of gravel-sized fragments in a "soil" matrix. Individual fragments are thoroughly discolored and can be broken with fingers.

Thickness of Bedding

Massive	Beds are 3 feet thick or greater.
Thick Bedding	Beds from 1 to 3 feet thick.
Medium Bedded	Beds from 4 inch to 1 feet thick.
Thin Bedded	Beds less than 4 inch thick.

Test Pits Completed by AGEGC, September 19, 2014 and August 11, 2015

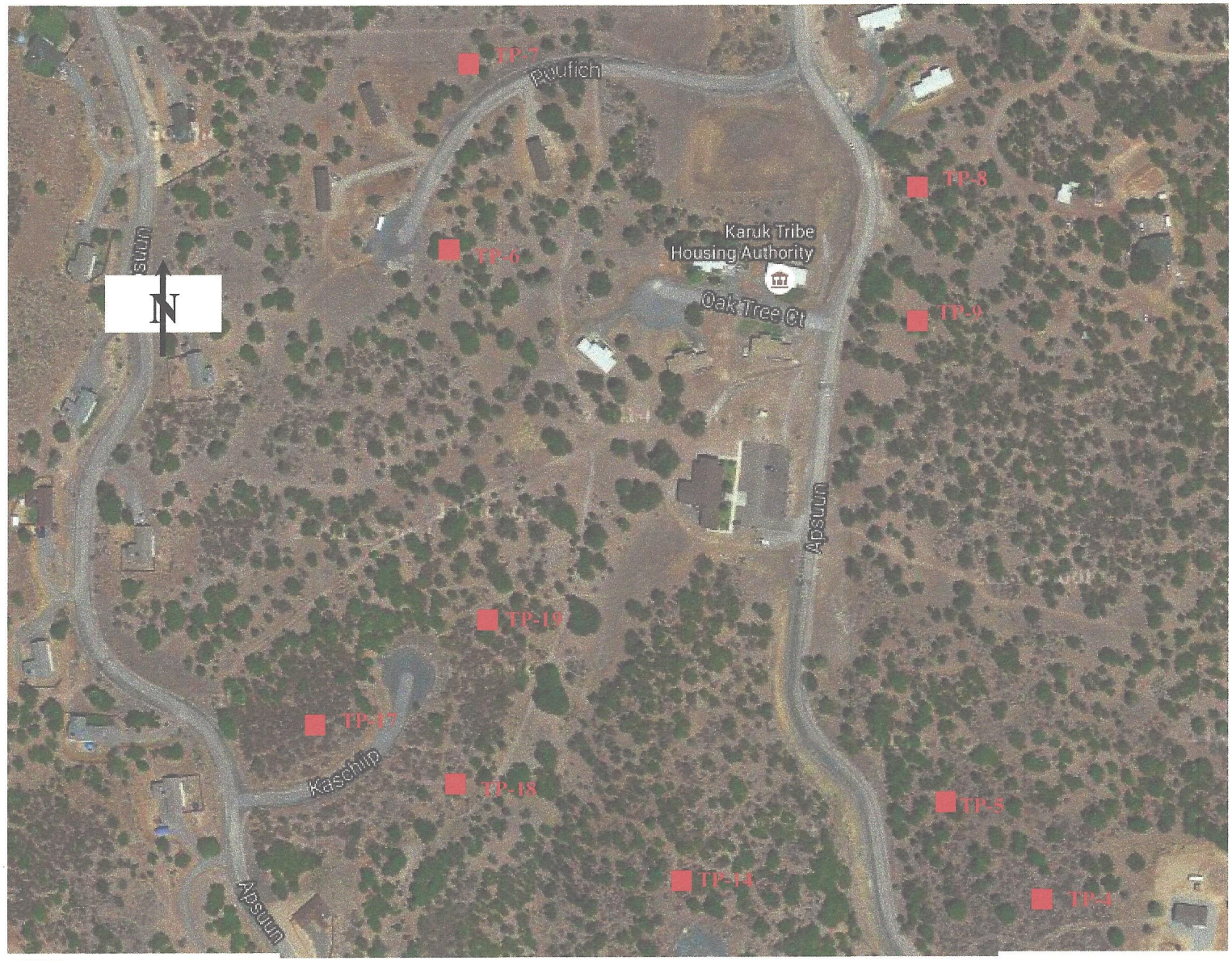

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Figure 1
Site Plan - North

Project No. 4078
Karuk Homes
Yreka, California
September 2015

Test Pit Completed by AGEGC, May 21, 2015 and August 11, 2015

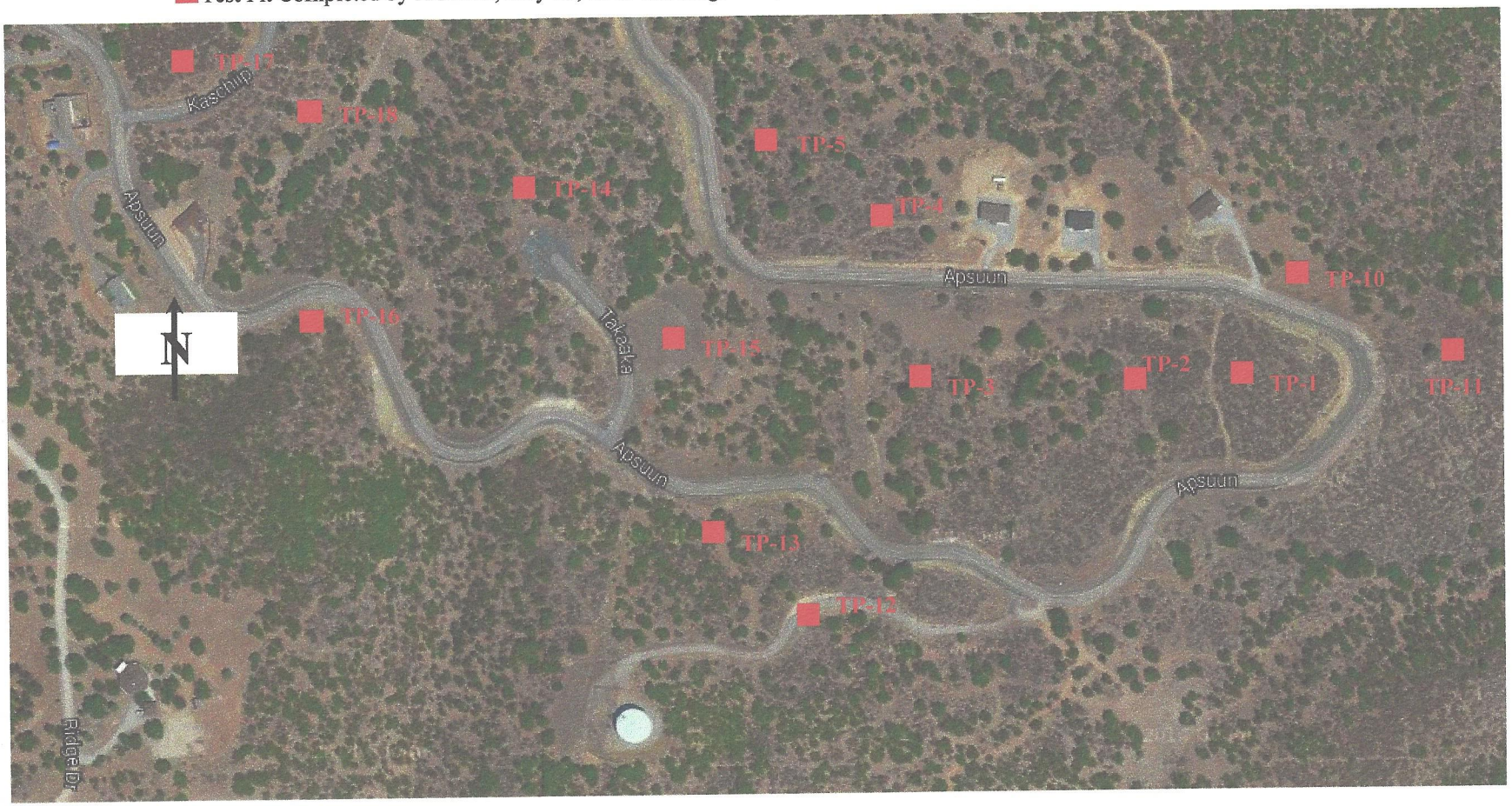

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Figure 1
Site Plan - South

Project No. 4078
Karuk Homes
Yreka, California
September 2015