In accordance with Washington City Zoning Ordinance 29-2-103(7), the Preliminary Geology and Soils Report for Milepost 13 is attached. Upon request, color photos will be made available by the State of Utah School and Institutional Trust Lands Administration.

Applied Geotechnical Engineering Consultants, Inc.

GEOLOGICAL HAZARD EVALUATION

SITLA PROPERTY
INTERSTATE 15, MILEPOST 13

WASHINGTON, UTAH

PREPARED FOR:

SITLA C/O ALLIANCE CONSULTING
2303 NORTH CORAL CANYON BOULEVARD
WASHINGTON, UTAH 84780

ATTENTION: DELOSS HAMMOND

PROJECT NO. 2031291

SEPTEMBER 15, 2003

158 West 1600 South • St. George, Utah 84770 • (435) 673-6850 • FAX (435) 673-1044

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SUMMARY

1. The geology of the site consists of a combination of bedrock of the Chinle, Moenave, and Kayenta Formations and Quaternary landslide, talus, eolian, and colluvial deposits.

2. Geologic hazards which could impact the proposed development consist of landslide, rock-fall, flash flooding and debris flows, and collapsible and expansive soil and rock in particular areas of the site. These areas are discussed in detail within the text of the report. Through proper engineering practices these hazards can be mitigated or avoided for the proposed development.

3. Slope stability should be evaluated if development will extend into or near areas of landslide features and areas mapped as landslide deposits.

4. Rock-fall is a potential hazard in areas where there is evidence of past rockfall. Areas which may present a rock-fall hazard are generally localized along the western slope of the Washington Black Ridge, located on the eastern edge of the property. Rock-fall hazard can be mitigated through avoidance of rockfall paths, removal of source rock or construction of barriers to stop or deflect rock-fall.

5. The near surface soils at the site are likely slightly to highly collapsible. The collapse potential can likely significantly reduces with over excavation and compaction of these soils. In general the native soils will be suitable for use as fill.

6. The mudstone of the Chinle Formation, which was observed on the southeast corner of the site and along a portion of the eastern edge of the site is known to exhibit expansive characteristics when wetted. The mudstone of the Chinle Formation is also susceptible to sliding and slope failures. Landslide hazard within this formation is typically related to changing slope configurations or introduction of water into the subgrade significantly reducing the strength of the mudstone.

   Based on a review of the geologic map of the site and a site reconnaissance, the mudstone may be limited to a small portion of the property. Construction in areas of expansive soil and rock generally require the use of special foundation systems and drainage precautions and typically result in an increased risk of road and building damage when compared to constructing in areas of non-expansive soil and rock.

PURPOSE AND SCOPE OF STUDY

This study was conducted to evaluate on a preliminary basis the geologic hazards of the SITLA Property located in the vicinity of Interstate 15, Milepost 13 in Washington, Utah (Figure 1). The evaluation of the site for potential geologic hazards was performed by review of geologic literature which covers the site and vicinity. Site reconnaissance was also performed. The data gathered from our study were analyzed to develop conclusions and recommendations in relation to potential geologic hazards at the site. No sampling of soil or bedrock, subsurface investigation, or engineering analysis was performed as a part of this study. A preliminary geotechnical investigation, prepared for the site by Bingham Engineering (Project No. 3397-007), dated March 2002 (updated November 2002), was also reviewed as part of this study.

PROPOSED CONSTRUCTION

We understand that it is proposed to construct an interchange at milepost 13 and to develop the site for residential and commercial construction.

GEOLOGIC AND SEISMOTECTONIC SETTING

A. Regional Geology

The site is located in the St. George Basin. This basin is bounded by the Pine Valley mountains to the north, the Hurricane cliffs to the east, the Beaver Dam mountains to the west and the Mt. Trumball area to the south. Within the basin are numerous mesas, buttes and pediment surfaces which formed as fluvial systems incised the strata along the western margin of the Colorado Plateau.

The stratigraphy of the area is comprised of Triassic to Quaternary age deposits. Bedrock units include various sedimentary rocks including sandstone, siltstone and mudstone. Quaternary units include basalt flows, talus, landslide, and colluvial deposits.

B. Tectonic Setting

The site is located west of the Washington Black Ridge. The nearest fault is the north-south trending Washington Fault which is located approximately 1 mile west of the subject site. The sense of displacement on this 42 mile long, high angle normal fault is down to the west (Higgins, 1998). The fault is thought to bifurcate into several smaller faults creating a wide fault zone north of the city of Washington (Christenson and Deen, 1983; Willis and Higgins, 1995). The Washington Fault is considered to be active due to evidence for late Quaternary offset of both the Washington basalt flow and late Pleistocene sediments (Willis and Higgins, 1995).

The Virgin Anticline is located approximately 1½ to 2 miles east of the subject property. The anticline is a 30 mile long, northeast-trending, generally symmetrical fold (Biek, 2003). Three structural domes are located along the length of the Virgin Anticline; the Bloomington Dome, the Washington Dome, and the Harrisburg Dome (Biek, 2003). The Harrisburg Dome is located approximately 1½ to 2 miles east of the subject site. The flanks of the Harrisburg Dome dip at approximately 30 to 50 degrees (Biek, 2003).

C. Stratigraphy

The geology of the site consists of a combination of bedrock of the Triassic-aged Chinle Formation, bedrock of the Jurassic-aged Moenave and Kayenta Formations, and Quaternary-aged landslide, talus, eolian, and colluvial deposits (Figure 2). Descriptions (from Biek) of these units follow.

1. Quaternary artificial deposits (Qf) - Man made fills used to create roads, dams, and retaining ponds.

2. Quaternary eolian deposits (Qes & Qed) - Well to very well-sorted very fine- to medium-grained, well rounded sand.

3. Quaternary landslide deposits (Qmsy) - Very poorly sorted, clay- to boulder-size, locally derived material deposited principally by rotational slump processes; commonly characterized by hummocky topography, numerous subdued internal scarps, and chaotic bedding attitudes. Slip surfaces are in the Petrified Forest Member of the Chinle Formation.

4. Quaternary talus deposits (Qmt) - Very poorly sorted, angular boulders and lesser fine-grained interstitial sediments; locally derived material deposited by rock-fall processes on and at the base of steep slopes; locally includes, and is gradational with, colluvial deposits.

5. Quaternary alluvial and eolian deposits (Qae & Qaeo) - Poorly to moderately sorted, clay- to boulder-size sediments with well-sorted eolian sand and reworked eolian sand.

6. Quaternary residual deposits (Qr/Jk) - angular cobble- to boulder-size basalt clasts apparently let down by erosion of underlying beds.

7. Kayenta Formation (Jk) - Interbedded, thin- to medium-bedded, moderate reddish-brown to moderate reddish-orange siltstone, fine-grained sandstone, and mudstone with planar, low-angle, and ripple cross-stratification.

8. Moenave Formation, Springdale Sandstone Member (Jms) - Medium- to very thick-bedded, fine-grained, or rarely medium grained sandstone, with planar and low-angle cross-stratification.

9. Moenave Formation, Whitmore Point Member (Jmw) - Interbedded, pale-red-purple, greenish-gray, and blackish-red mudstone and claystone, lesser moderate-reddish-brown very fine- to fine-grained sandstone and siltstone.

10. Moenave Formation, Dinosaur Canyon Member (Jmd) - Interbedded, generally thin-bedded, moderate reddish-brown to moderate reddish-orange, very fine- to fine-grained sandstone, and lesser siltstone and mudstone with planar, low-angle, and ripple cross-stratification.

11. Chinle Formation, Petrified Forest Member (TRcp) - Varicolored mudstone, claystone, siltstone, lesser sandstone and pebbly sandstone, and minor chert and nodular limestone; swelling mudstones and claystones are common throughout and although typically poorly exposed, their bright colors of various shades of purple, grayish red, dark reddish brown, light greenish gray, brownish gray, olive gray, and similar hues locally show through the surface; mudstones weather to a "popcorn" surface and are responsible for numerous foundation problems in the area; commonly forms slumps, especially along steep hillsides; deposited in a variety of fluvial, floodplain, and lacustrine environments. Slumps are typically formed when exposed to significant water. Poor grading practices, such as removing to much of these slopes, also contributes to slump failures.

The geology of the site and vicinity is shown on Figure 3.

SITE DESCRIPTION AND CONDITIONS

An engineer from AGEC visited the site on August 25, 2003 to observe site conditions and to observe potential geologic hazards. The site (Photo Exhibits 1-4) is located west of the Washington Black Ridge (Photo Exhibits 1-3), south of Interstate 15 (Photo Exhibit 1), and north of Telegraph Street (Photo Exhibit 4). The topography of the site is uneven and

generally slopes down to the south. Multiple dry washes which drain to the south intersect the property. Vegetation at the site generally consists of sagebrush, creosote, cacti, and yuccas. A significant number of trees are located on the northeast corner of the site and generally follow the washes.

A small concrete masonry unit (CMU) building was observed near the northeast corner of the site (Photo Exhibit 1). The building does not have a roof and is not currently occupied. Several small earthen dams were observed on the northeast corner of the site. A small amount of water was observed behind one of the dams. The others were dry at the time of the site visit.

Several residential subdivisions are located to the south and southwest of the subject site (Photo Exhibit 4). A small commercial development is located adjacent to the southwest corner of the site.

GEOLOGIC HAZARDS

Geologic conditions at the site were evaluated by a review of published geologic literature. Site reconnaissance was also performed to evaluate the geologic conditions at the site. Based on these evaluations, it is our professional opinion that geologic hazards related to landslide, rock-fall, flooding and debris flows, and collapsible and expansive soil and rock are present at the site. Evidence for other hazards such as surface fault rupture was not observed.

A. Landslide Hazard

The southeastern portion of the site is underlain by the Petrified Forest member of the Chinle Formation. This member of the Chinle Formation is known to be unstable, particularly on steep slopes but also in areas of low relief (e.g., Biek, 2003). A review of geologic literature (Biek, 2003) indicates that much of the west slope of the Washington Black Ridge (eastern edge of the subject site) consists of landslide

deposits (Figure 3). Terrain with hummocky surfaces and various scarps and terraces usually associated with landslides were observed in this area during our site reconnaissance. According to Biek, most of the movement in these slides took place in the Pleistocene era. Changing slope configurations (grading to remove the toe of the slope or loading the slope with fill) and the introduction of water into the subgrade could result in increased landslide potential.

B. Rock-fall Hazard

Rock-fall deposits are mapped on the northeast edge of the site along the western slope of the Washington Black Ridge (Figure 3). Site reconnaissance and field mapping found that these deposits are not particularly thick. The rock-fall deposits consist of basalt cobbles and boulders. Rock-fall hazard at the site appears to be the result of weathering of the less resistant Kayenta Formation which underlies the basalt flow near the northeast corner of the site.

C. Flooding and Debris Flows

The site is not located within a flood plain but is susceptible to flash flooding and debris flows associated with flash floods. The washes and drainages located at the site carry water only intermittently. However, they have large catchment basins on the flanks of the Pine Valley Mountains (Biek, 2003). Flash floods commonly contain high sediment or debris loads and commonly begin or end as debris floods or flows (e.g. Lund, 1992; Biek, 2003).

The Kayenta and Moenave Formations, which are mapped on the northern portion of the site are known to contain confined springs and seepages. No springs or seepages were observed during the site visit. However, excavations which extend into these formations have the potential to expose springs and/or seepages.

D. Collapsible and Expansive Soil and Rock

According to the preliminary geotechnical investigation prepared for the site by Bingham Engineering, the near surface soils at the site are slightly to highly collapsible when wetted. The report indicates that the depth of collapsible soils is limited to approximately 6 feet. These findings are consistent with our experience in the area.

The Petrified Forest Member of the Chinle Formation consists of expansive mudstone. Based on the geologic map of the site and observations made during our site reconnaisance, it appears that the extent of expansive soil/rock are located at the southeast corner of the site and along a portion of the eastern edge of the property.

CONCLUSIONS AND RECOMMENDATIONS

Based on the review of the referenced literature and a site reconnaissance the following conclusions and recommendations are provided.

- Much of the west slope of the Washington Black Ridge, which lies along the eastern edge of the subject site, is mapped as an ancient landslide area. Slump features were observed within this area. Stability analysis should be performed for development of these areas. Recommendations including drainage and slope configuration (grading) can be provided to reduce risk of landslide.

- The majority of the rock-fall hazard at the site appears to be limited to the northeast corner of the site. Additional rock-fall hazard was observed along the eastern edge of the site (west slope of the Washington Black Ridge). The majority of the rock-fall hazard south of the northeast corner of the property appears to be minor due to the distance of the crest of the ridge from the property limits and the more gradual slope in these areas. Additional study could be performed to evaluate the rock-fall hazard if development is planned in these areas. This would allow the recommendation of options such as avoidance of the hazard, removal of the hazard, or construction of a

barrier to mitigate the hazard.

- The site is not located within a flood plain. However, a review of geologic literature and observations made during our site reconnaissance indicates that flash flooding and debris flows associated with flash flooding are a concern at the site. These potential hazards can be lessened by proper drainage control during preparation of the drainage study for the subject site.

- It is likely that springs and/or seepages may be encountered in the bedrock of the Kayenta and Moenave Formations, which are mapped on the northern portion of the site. Fluctuations in rainfall and groundwater levels may affect the flow from springs and seepages. Potential difficulties or concerns associated with springs and seepages can typically be controlled by the use of subdrains.

- The preliminary geotechnical investigation prepared for the site indicates that the near surface soils are slightly to highly collapsible when wetted. Mitigation of collapse potential can likely be accomplished with overexcavation and recompaction of the collapsible soil. The native soils will likely be suitable for reuse as fill.

  Mudstone of the Petrified Forest Member of the Chinle Formation was observed on the southeast corner of the site and along a portion of the east edge of the property (See Figure 2). Subsurface investigation and laboratory testing will be required to further define the extent of expansive soil and rock and to develop recommendations for development of these areas. Recommendations for development in areas where expansive soil and rock are of concern may include deep foundations, strict drainage control, and/or overexcavation and replacement of the expansive soil/rock.

LIMITATIONS

The analysis and report findings are preliminary and based on published geologic maps and reports, and site reconnaissance. Our geologic interpretation and conclusions are based on currently accepted geologic practices in the area. No attempt has been made to predict earthquake ground motions or to determine potential magnitude for earthquakes associated with faults in the project area, or to estimate recurrence intervals. Variations in the geologic conditions may not become evident until subsurface investigation or additional exploration is conducted.

APPLIED GEOTECHNICAL ENGINEERING CONSULTANTS, INC.

Shawn Turpin, P.E.

Reviewed by Arnold DeCastro, P.E.

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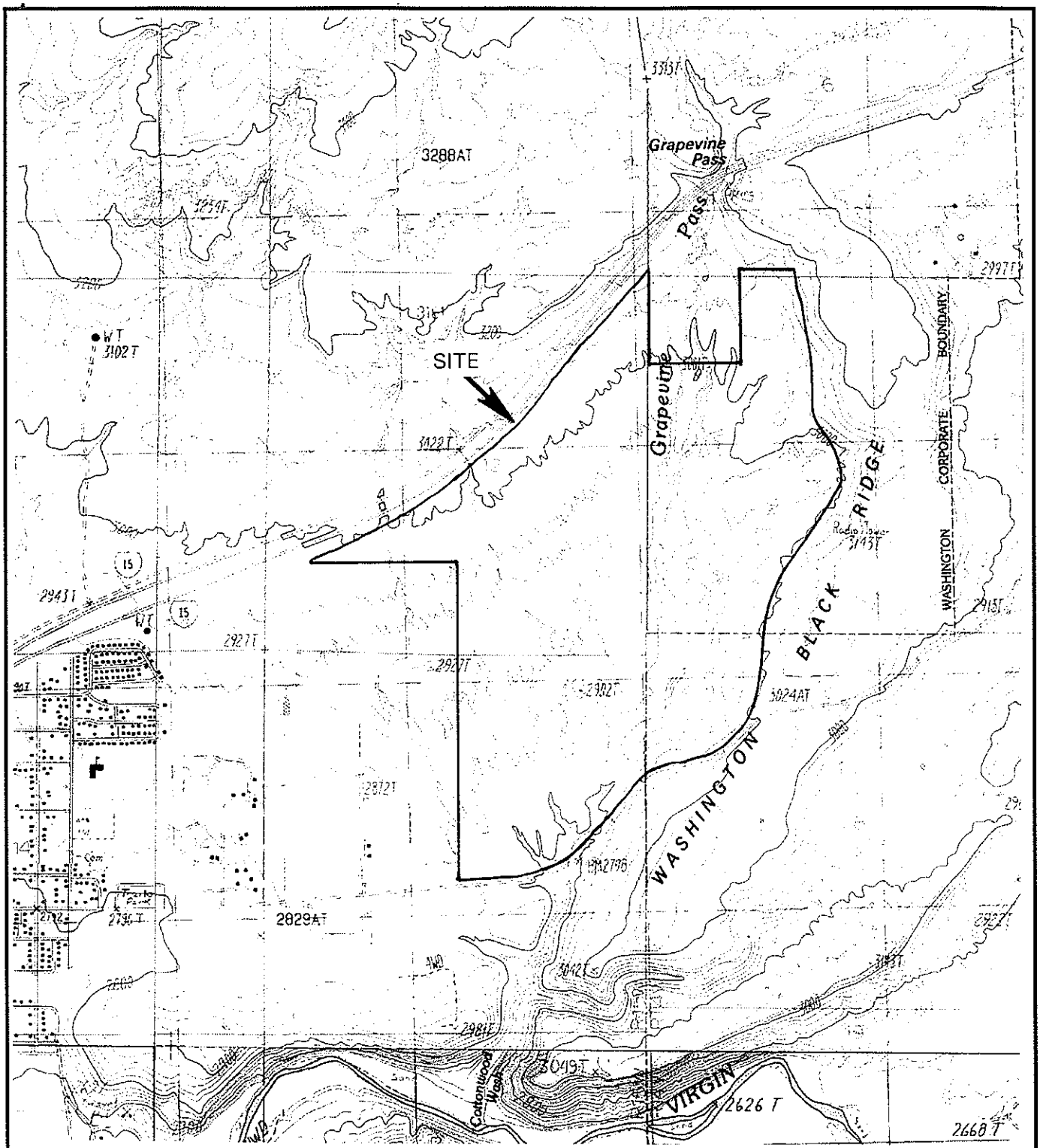
REFERENCES

Biek, R.F., 2003; Geologic map of the Harrisburg Junction quadrangle, Washington County, Utah; Utah Geological Survey Map 191.

Christenson, G.E., and Deen, R.D., 1983; Engineering geology of the St. George area, Washington County, Utah, Utah Geological and Mineral Survey, Special Study 58.

Willis, G.C., and Higgins, J.M., 1995; Interim map of the Washington Quadrangle, Washington County, Utah, Utah Geological Survey open file report 324.



Washington Quadrangle, 1986
Harrisburg Junction Quadrangle, 1986
St. George Quadrangle, 1986
Washington Dome Quadrangle, 1986

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Scale 1:24,000

SITLA PROPERTY
INTERSTATE 15, MILEPOST 13
WASHINGTON, UTAH

2031291	AGEC	Vicinity Map	Figure 1

SITLA PROPERTY
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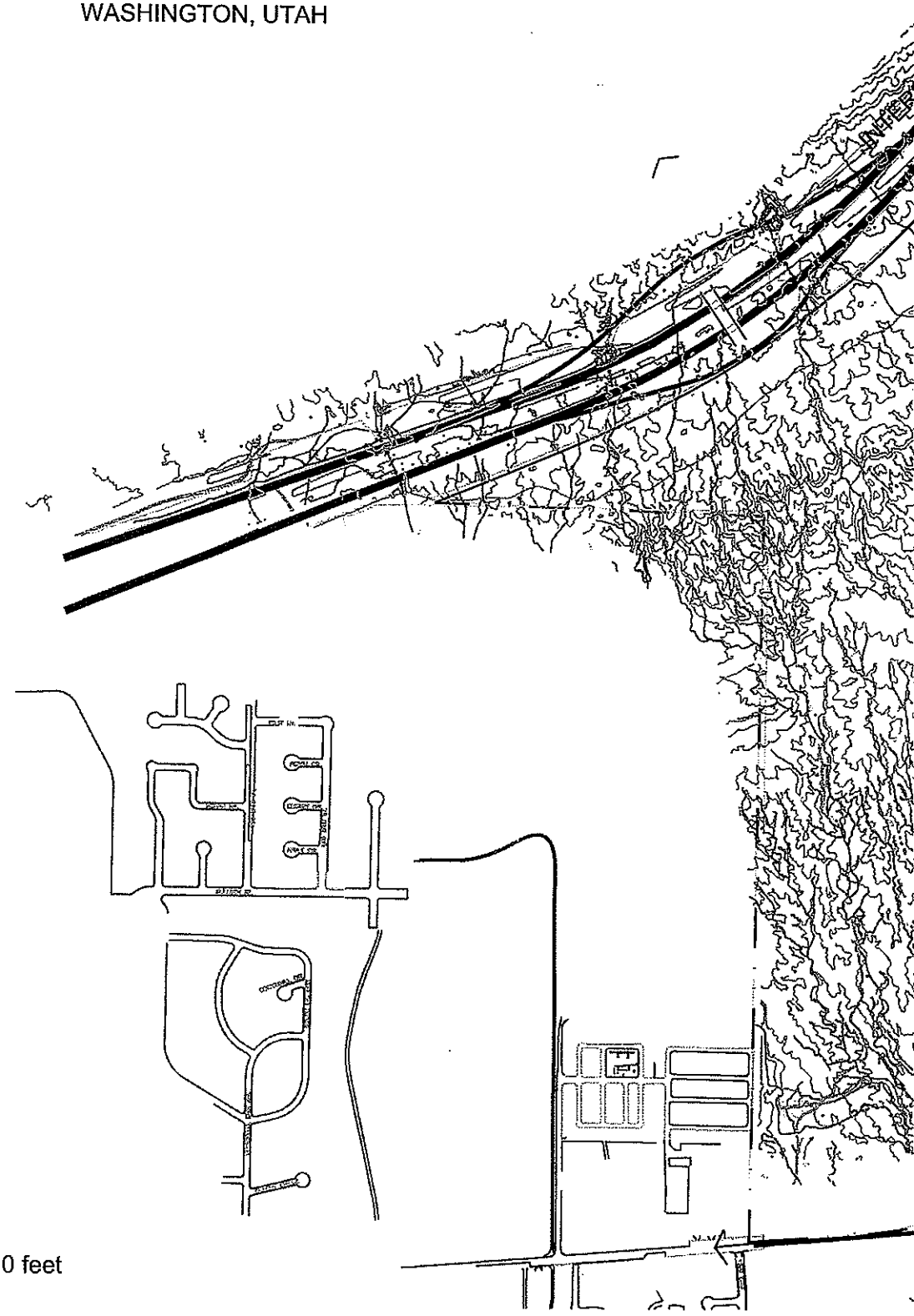
WASHINGTON, UTAH



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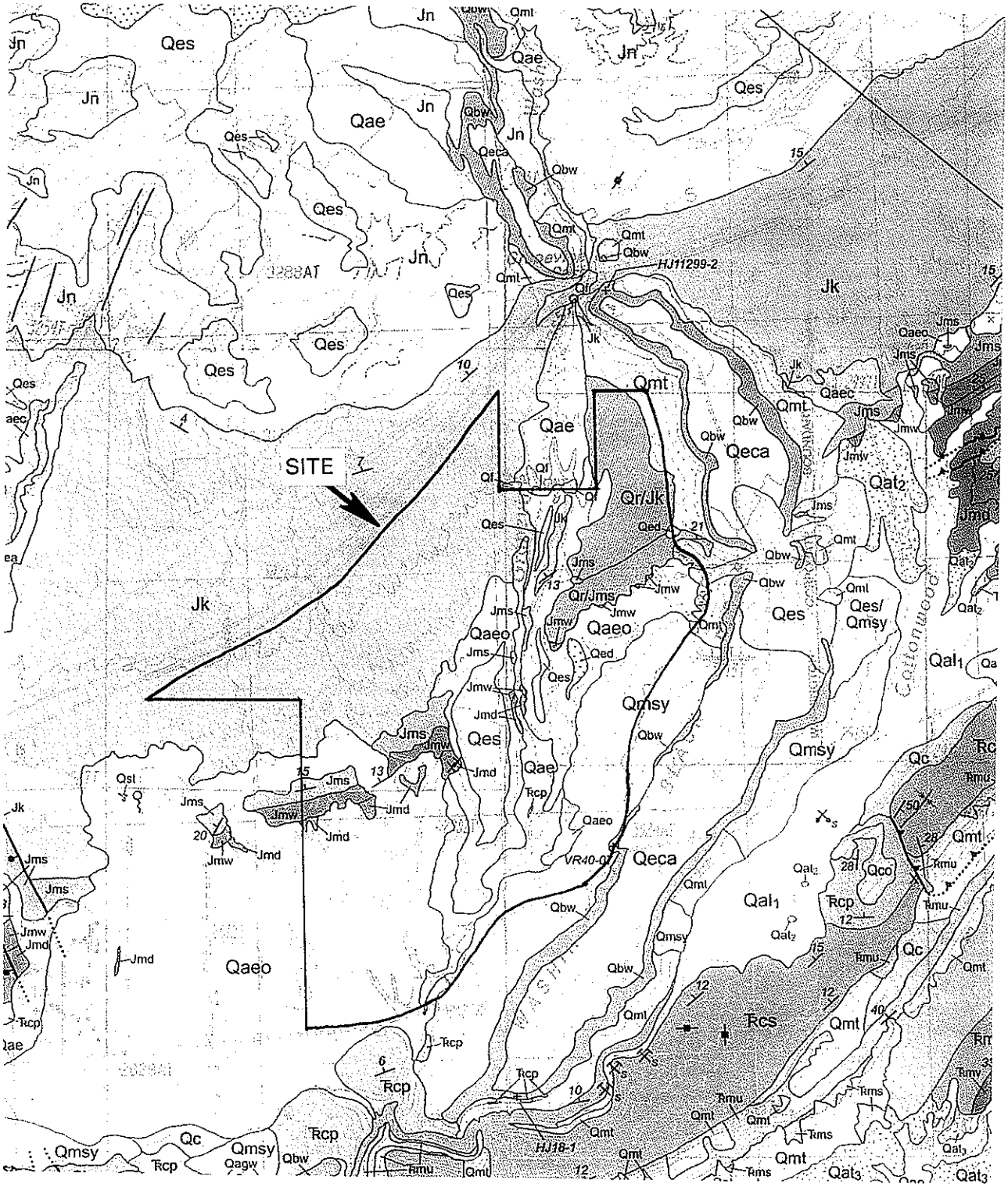
Approximate Scale

2031291	AGEC	Site Plan



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SITLA PROPERTY
INTERSTATE 15, MILEPOST 13
WASHINGTON, UTAH

2031291	AGEC	Geologic Map	Figure 3

Geologic Units

Quaternary
Qf - artificial fill
Qes - eolian sand deposits
Qed - eolian sand deposits
Qmsy - landslide deposits
Qmt - talus deposits
Qae and Qaeo - alluvial and eolian deposits
Qr/Jk - residual deposits

Jurrasic
Jk - Kayenta Formation
Jms - Springdale Sandstone Memeber of the Moenave Formation
Jmw - Whitmore Point Member of the Moenave Formation
Jmd - Dinosaur Canyon Member of the Moenave Formation

Triassic
TRcp - Petrified Forest Member of the Chinle Formation

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2031291	AGEC	Key to Geologic Map	Figure 3a

Photo Exhibit 1: View of subject site looking to the southwest. The Washington Black Ridge is visible to the left. Interstate 15 is to the right. A concrete masonry unit structure can be seen on the bottom right.

Photo Exhibit 2: View of the north end of the eastern edge of the site and the Washington Black Ridge. View is looking to the east.

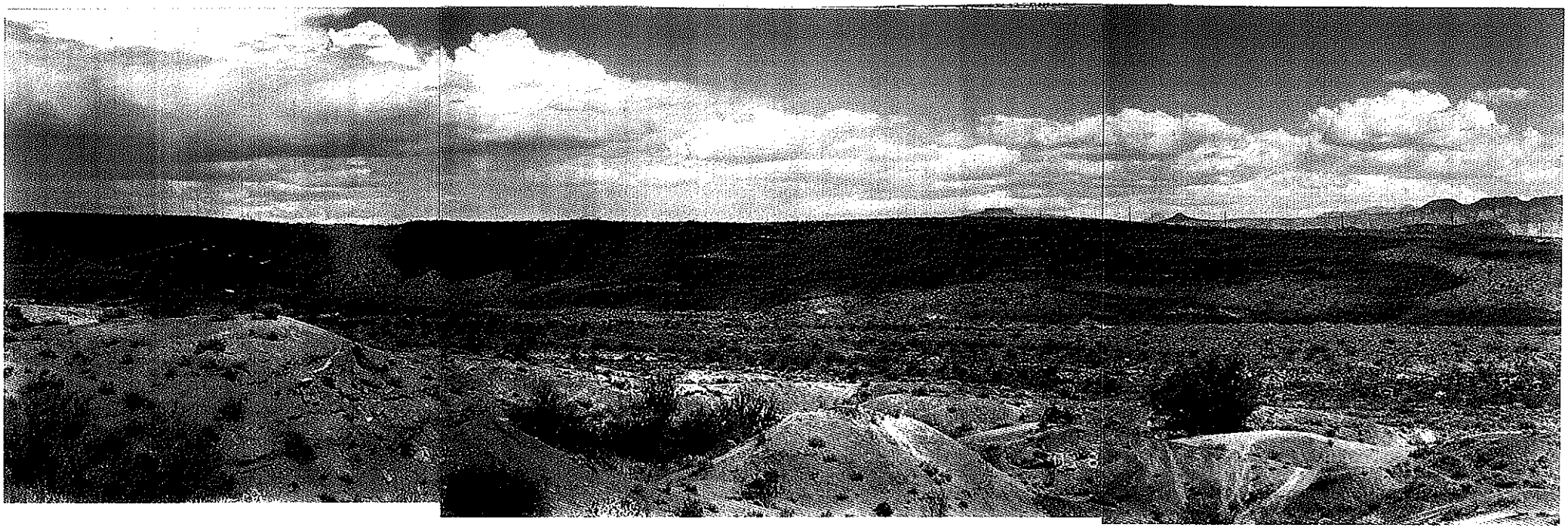

Photo Exhibit 3: View of the south end of the eastern edge of the site. View is looking to the east.

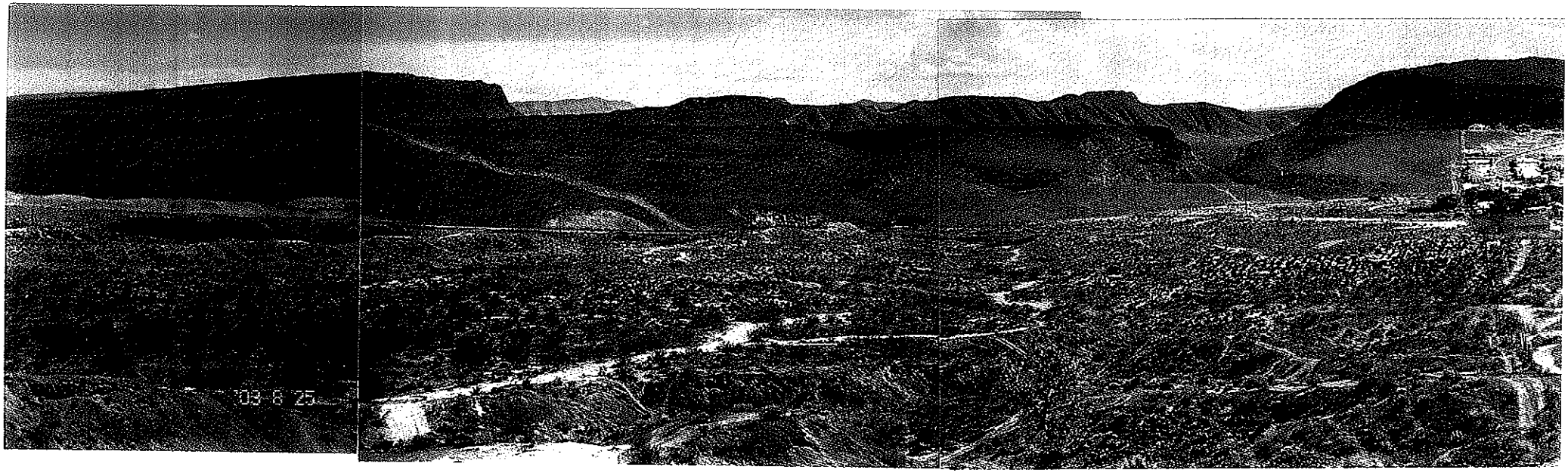

Photo Exhibit 4: View of the southern end of the subject site. Telegraph Street is visible in the center. English Oaks and Ridge Point residential subdivisions are on the right. The fence to the right appears to be the west property line. View is looking to the south.