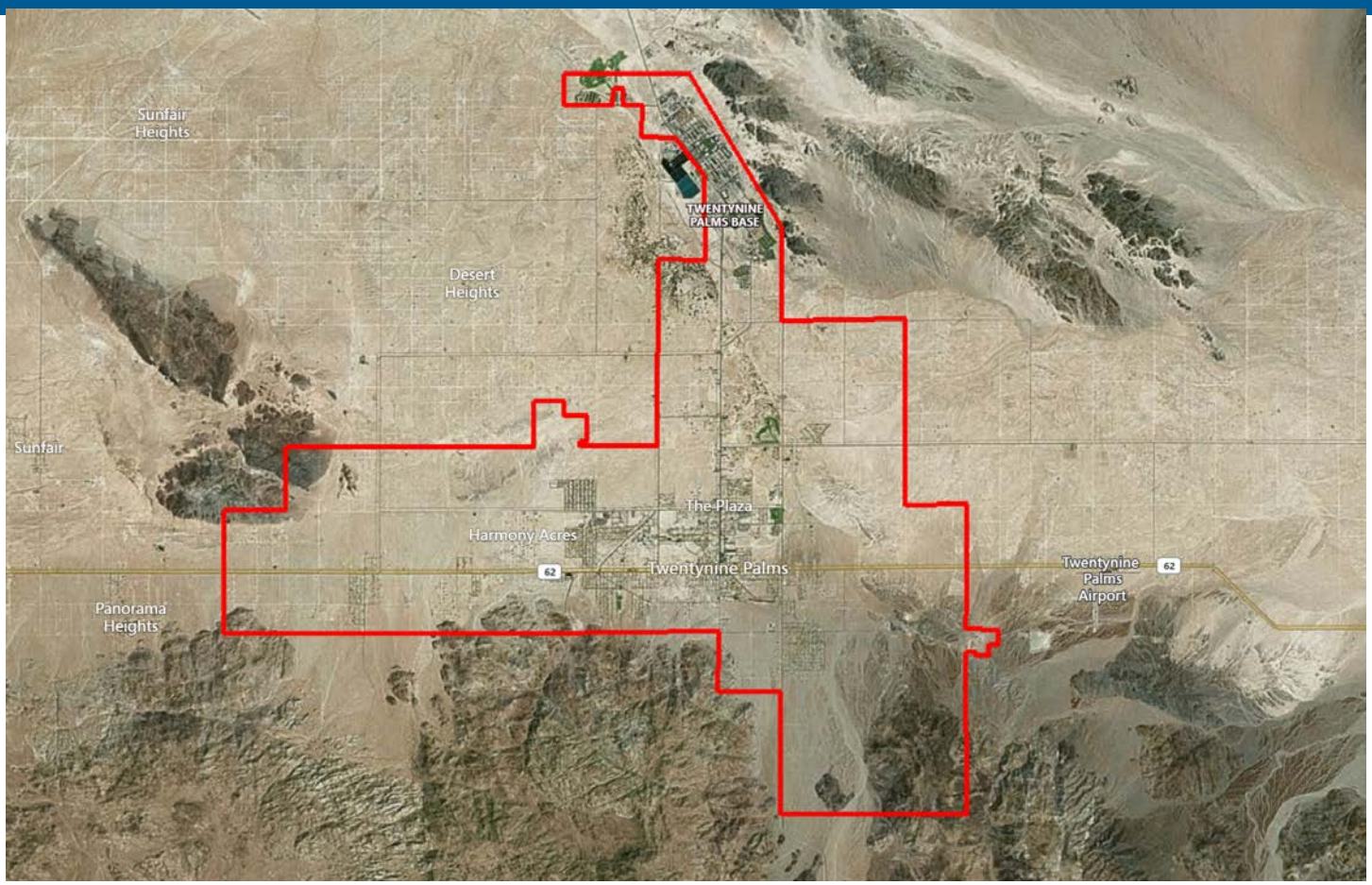
GEOTECHNICAL DESKTOP STUDY

June 2, 2021

Prepared For:

City of Twentynine Palms
6136 Adobe Road
Twentynine Palms, California 92277



Proposed Wastewater Management System
Twentynine Palms, CA 92277

Project No.: 227521-0000132.00

NV5 West, Inc.
15092 Avenue of Science, Suite 200
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Mr. Farnk Luckino, MPA
City Manager
City of Twentynine Palms
6136 Adobe Road
Twentynine Palms, CA 92277

June 2, 2021
Project No.: 227521-0000132.00

Subject: Geotechnical Desktop Study

Project: Proposed Wastewater Management System Feasibility Study
City of Twentynine Palms
Twentynine Palms, California

Dear Mr. Luckino:

This report presents the results of NV5 West, Inc.'s (NV5) limited desktop geologic reconnaissance for the proposed City of Twentynine Palms wastewater management system feasibility study project, located in the City of Twentynine Palms, County of San Bernardino, California. Based on the information obtained during this desktop study, it is NV5's opinion that the site is suitable for the proposed development, provided that the pertinent, preliminary recommendations and design parameters contained in this report are incorporated into the design and construction of the project.

NV5 appreciates the opportunity to provide this geotechnical engineering service for this project and looks forward to continuing its role as your geotechnical engineering consultant.

Respectfully submitted,

NV5 West, Inc.

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1.0 INTRODUCTION

This report presents the results of the limited desktop geologic reconnaissance for the proposed City of Twentynine Palms wastewater management system project, located in the City of Twentynine Palms, County of San Bernardino, California. The approximate boundary of the City of Twentynine Palms is shown in *Figure 1, Site Location Map*.

The purpose of this limited desktop study was to gather readily available published geologic and subsurface soil information at the site in order to recognize and address the presence of geologic hazards, and to provide preliminary recommendations for the anticipated project earthwork. This report summarizes the information collected and presents NV5's preliminary findings, conclusions and recommendations.

This report has been prepared for the exclusive use of the client and their consultants in the preliminary design of the proposed project. In particular, it should be noted that this report has not been prepared from the perspective of a construction bid preparation instrument and should be considered by prospective construction bidders only as a source of general information subject to interpretation and refinement by their own expertise and experience, particularly with regard to construction feasibility. Contract requirements as set forth by the project plans and specifications will supersede any general observations and specific recommendations presented in this report. Additionally, the preliminary findings, conclusions, and recommendations presented in this report may be revised in the subsequent report after subsurface investigation is completed.

2.0 SCOPE OF SERVICES

NV5's scope of services for this project included the following tasks:

- Review of preliminary project information, geologic maps, geologic hazard maps, general planning maps, and geotechnical literature pertaining to the site vicinity.
- Performing an assessment of general seismic conditions and geologic hazards affecting the site area and their possible impact on the proposed project.
- Geotechnical/Geologic analysis of the accumulated information.
- Development of conclusions with respect to the recognized geologic hazards, and their potential impact on the proposed project.
- Preparation of this report, including reference maps and graphics, summarizing the information collected and presenting NV5's preliminary findings, conclusions, and geotechnical recommendations for the design and construction of the proposed development.

3.0 PROJECT AND SITE DESCRIPTION

Based on preliminary project information provided, NV5 understands that the City of Twentynine Palms (City) is working closely with the Marine Corps Air Ground Combat Center (MCAGCC) exploring the possibility of developing a joint use wastewater treatment plant that will benefit both the MCAGCC and the City. It is understood that budget has been allocated (though not yet part of an approved budget)

for the construction of a 2.1 million-gallon (MG) treatment plant to be located on the base to replace the current aging treatment plant which only provides Secondary treatment. It is understood that over 170 MG/year of water is lost to evaporation since the effluent from the existing plant is not suitable for use in irrigation. The new treatment plant will be able to provide Tertiary treatment which will be suitable for irrigation purposes and groundwater recharge. NV5 understands that the treatment plant will be constructed using a Design/Build approach and is anticipated to be completed in late 2023. Early coordination will be required to determine how the City's collection system could be directed to the wastewater treatment plant which is to be located on the base and how treated effluent can be transported back to the areas and groundwater basins if a joint use treatment plant is an option. It is understood that construction will include significant open trench conduit construction, inspection vaults, accessory structures, and a treatment facility consisting of moderate sized pumping, storage and treatment structures.

The site consists of developed and undeveloped areas of high desert terrain, incised with both minor and major tributary drainages that receive sparse flash flood precipitation events. Other than the incised natural drainages, the site is topographically gentle, and generally slopes and drains to the east and localized playas.

4.0 GEOLOGIC AND SOIL INFORMATION

4.1 REGIONAL GEOLOGIC SETTING

The project site is located in southern San Bernardino County traversing the Mojave Desert Geomorphic Province at the northern end of the site and the Transverse Ranges Geomorphic Province at the southern end of the site. The Mojave Desert province is characterized by isolated mountain ranges separated by expanses of desert plains. The province is known for its interior drainage systems and many playas. There are two important fault trends that control topography, a prominent NW-SE trend and a secondary east-west trend (apparent alignment with Transverse Ranges is significant). The province is topographically controlled by the two major active fault zones known as the Garlock (to the north) and the Southern San Andreas (to the south). As such, many major secondary faults and fault zones traverse the interior of the province, and at a transverse manner to the previously mentioned fault zones.

The Transverse Ranges province are characterized by east-west trending mountain ranges bordered by relatively straight-sided, sediment-floored valleys. The western limit of the province is the offshore island group of San Miguel, Santa Rosa and Santa Cruz. The eastern limit extends into the Mojave Desert and includes the San Bernardino Mountains on the east side of the San Andreas Fault.

4.2 SITE-SPECIFIC GEOLOGIC AND SOIL INFORMATION

Typical geologic stratigraphy in the site vicinity include erratic outcrops of Precambrian-age igneous and metamorphic rocks and Mesozoic-age granitic and metamorphic rocks that make up the underlying "basement" bedrock, with vast and massive bedded Cenozoic-age and Quaternary-age sedimentary deposits covering the desert valley floors. The general geologic conditions in the project vicinity are displayed in *Figure 2, Regional Geologic Map*.

Reference to the regional geologic map *Geologic Map of the Twentynine Palms Quadrangle, San Bernardino and Riverside Counties, California, by T.W. Dibblee, Jr., 1968*, indicates that the site vicinity is predominantly underlain by Quaternary-age relatively younger surficial sediments and older surficial sediments.

These relatively younger surficial sediments derived from the adjacent highlands are described as unconsolidated and undissected fill found in the valley areas and flood plains of stream channels, and are mapped as windblown sand (Qs), younger alluvium (Qa), and micaceous clay and silt (Qc). The older alluvial surficial sediments (Qoa) are described as older valley fill materials derived from mountains to the west and south. These materials are found at slightly elevated positions and are much more dissected and lie unconformably on pre-Tertiary aged rocks. Anticipated soil conditions in the site vicinity are discussed in detail below.

- Windblown Sand (Qs): These materials are described as loose, fine sands that are deposited by the prevailing westerly winds as dunes or thin cover over alluvial materials.

- Micaceous Clay and Silt (Qc): These materials are generally alkaline clay and some micaceous silt of playa lakes.

- Younger Alluvium (Qa): These younger alluvial deposits are described as ranging from sub-angular boulders and cobbles in small alluvial fans adjacent to mountains, through pebbly sands down slope, to sand and silt in valleys; includes sand and gravel of stream washes.

- Older Alluvium (Qoa): These older alluvial deposits are described as poorly bedded to non-bedded, fine-to-coarse sand with some pebble-cobble gravel and little micaceous silt or clay.

4.3 GROUNDWATER

Groundwater in the region is located within the Morongo Basin. The Morongo Basin consists of about 1,000-square miles of alluvium filled valleys surrounded by mountains. In the vicinity of the site, the Morongo Basin is divided into multiple subbasins separated from each other by hydrologic barriers, including bedrock ridges, faults, and folds. The degree of separation and depth to groundwater between the subbasins is dependent upon the character of the aquifer materials and types of barriers separating them. In general, groundwater elevations reportedly range from a high of approximately 2,400 feet above mean sea level (MSL) in the southwest portion of the City limits (Indian Cove Subbasin) to a low of approximately 1,600 feet above MSL near the Mesquite Fault in the Mesquite Lake Subbasin on the eastern portion of the City limits (reference: *Groundwater Management Plan – 2014 Update, Prepared for Twentynine Palms Water District* by Kennedy/Jenks Consultants, dated May 28, 2014).

Groundwater is generally not anticipated to be a constraint during construction along majority of the project alignment, however, field explorations would be needed to preclude any such groundwater conditions that may or may not exist.

In general, experience indicates that near-surface groundwater conditions or localized seepage zones can develop in areas where no such groundwater conditions previously existed, especially in areas where a substantial increase in surface water infiltration results from landscape irrigation, agricultural activity, artificial recharge, storage facility leaks, or unusually heavy precipitation. Seasonal variations

in the groundwater levels should be anticipated. In addition, it should be understood that groundwater movement near the active fault traces that traverse the site can be complex and difficult to predict and shallow groundwater may be encountered at these locations.

For a more detailed discussion on hydrogeological conditions in the site vicinity see NV5's *Preliminary Hydrogeological Conditions Study* that will be presented under a separate cover as part of this Project.

4.4 PERCOLATION

In an effort to evaluate percolation rates for the site vicinity NV5 reviewed available USDA Soil Maps https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. USDA defines four distinct hydrologic soil groups: A, B, C and D. These groups correspond to distinct infiltration rates [i.e. A = high infiltration rate (low runoff potential) when thoroughly wet, B = moderate infiltration rate when thoroughly wet, C = slow infiltration rate when thoroughly wet, and D = very slow infiltration rate (high runoff potential) when thoroughly wet]. The vast majority of the site vicinity has no mapped soil group data available. Based on NV5's review of the geologic map for the project area the majority of the site vicinity is underline by alluvial soils, with portions along the perimeter composed of near-surface bedrock units. The granular alluvial materials are interpreted as having High to Moderate infiltration rates, with hydrologic soil groups of A and B, with the exception of the playa lake deposits that are higher in silt and clay content with a hydrologic soil group of D. The bedrock materials are described as having a Very Slow infiltration rate with a hydrologic group of D. In general, the site vicinity should be considered to have favorable infiltration conditions with the exception of the playa lake deposits. Site conditions may vary from data obtained from the USDA soil maps. Prior to final design or construction activities, NV5 should be retained to evaluate the percolation and infiltration characteristics of the site's soils.

For a more detailed discussion on percolation and infiltration in the site vicinity see NV5's *Preliminary Hydrogeological Conditions Study* that will be presented under a separate cover as part of this Project.

4.5 FAULTS

The numerous faults in southern California include active, potentially active, and inactive faults. As used in this report, the definitions of fault terms are based on those developed for the Alquist-Priolo Special Studies Zones Act of 1972 and published by the California Division of Mines and Geology (Hart and Bryant, 1997).

Active faults are defined as those that have experienced surface displacement within Holocene time (approximately the last 11,000 years) and/or have been included within any of the state-designated *Earthquake Fault Zones* (previously known as Alquist-Priolo Special Studies Zones). Faults are considered potentially active if they exhibit evidence of surface displacement since the beginning of Quaternary time (approximately two million years ago) but not since the beginning of Holocene time. Inactive faults are those that have not had surface movement since the beginning of Quaternary time.

Reference to the State of California Earthquake Hazards Zone searchable map web application indicates that the site is traversed by two separate State-designated Earthquake Fault Zones. They are the Pinto Mountain Fault zone and the Mesquite Lake Fault zone. The Pinto Mountain Fault zone is located at the southern end of the site and trends in an east-west manner, and the Mesquite Lake Fault zone is located at the northeastern end of the site and trends in a southeast-northwest manner. The approximate locations of these fault zones are displayed in *Figure 3, Site Fault Map*. These faults are considered active, and as such, special consideration should be taken with respect to any

proposed structures and/or facilities within close proximity to these zones, and/or any proposed conduit alignments that may cross these active fault zones.

Other important active faults that could affect the project area and their distance to the site are included in the following Table 1. In addition, *Figure 4, Regional Fault Map* depicts the site location in relation to known active faults in the region.

Table 1 - Distance From the Site to Major Active Faults

Fault	Distance From the Site
Pinto Mountain	0.0 miles
Mesquite Lake	0.0 miles
Calico-Hidalgo	5.7 miles
So Emerson-Copper Mountain	7.0 miles
Eureka Peak	19 miles
Burnt Mountain	21 miles
Landers	21 miles
Johnson Valley	26 miles
South San Andreas	27 miles
North Frontal	29 miles
Lenwood-Lockhart-Old Woman Springs	36 miles
Helendale-So Lockhart	45 miles
San Jacinto	52 miles
Cleghorn	66 miles
Elmore Ranch	67 miles
Gravel Hills-Harper Lake	70 miles
Earthquake Valley	74 miles
Elsinore	75 miles
Superstition Hills	78 miles

5.0 SEISMIC AND GEOTECHNICAL HAZARDS

NV5 performed a review of state and municipal geologic hazard maps. The findings of NV5's seismic and geotechnical hazards evaluation for the proposed project are summarized in the following sections.

5.1 FAULT RUPTURE

As previously mentioned in Section 4.4, the site is traversed by two Earthquake Fault Zones (EFZ) that are deemed active by the State of California. As such, the potential for ground-surface rupture and/or shallow ground deformation occurring at the site due to a seismic event are a significant concern for the site development. Special consideration should be taken with respect to any proposed structures and/or facilities within close proximity to these zones, and/or any proposed conduit alignments that may cross these active fault zones.

The planned development of any structures and/or facilities within and/or in close proximity to the two EFZ's should be avoided. However, should a structure and/or facility be planned within and/or in close proximity to either of the noted EFZ's, NV5 should be retained to perform a fault hazard study in order to preclude the possibility of an active fault trace underlying the proposed development area.

5.2 SEISMIC SHAKING

The project site is located in an area of California considered a seismically active area, and as such, the seismic hazard most likely to impact the site is ground shaking resulting from an earthquake along one of the known active faults in the region.

For preliminary seismic design criteria, the site may be considered as a Site Class D. Once locations for proposed structures are developed, NV5 can provide seismic design parameters for specific sites.

5.3 LIQUEFACTION AND SEISMICALLY-INDUCED SETTLEMENT

Liquefaction of soils can be caused by ground shaking during earthquakes. Research and historical data indicate that loose, relatively clean granular soils are susceptible to liquefaction and dynamic settlement, whereas the stability of the majority of clayey silts, silty clays and clays is not adversely affected by ground shaking. Liquefaction is generally known to occur in saturated cohesionless soils at depths shallower than approximately 50 feet. Dynamic settlement due to earthquake shaking can occur in both dry and saturated sands.

Reference to published geologic and geotechnical maps and documents indicates that the site is generally underlain at depth (greater than 10 feet bgs) by medium dense to dense alluvium. Within these areas, the potential for liquefaction and associated ground deformation occurring beneath the structural site areas during a seismic event is considered low. However, within and/or along the fault zones and playas to the south and southeast of the site, the potential for liquefaction may exist. If structures and/or facilities are planned in these areas, field explorations and soil testing are warranted in order to preclude the possibility of liquefiable subsurface materials in these areas.

Seismic settlement is often caused when loose to medium-dense granular soils are densified during ground shaking.

Near-surface (shallower than 10 feet bgs) alluvium in the site area is typically considered to be in a relatively compressible state. Mitigative efforts such as removal and recompaction of the near-surface soils would reduce potential damage to future structures due to seismic settlement. However, within and/or along the fault zones and playas to the south and southeast of the site, the presence of "deep" compressible soils may or may not exist. Once specific sites for proposed structures and/or facilities have been selected, NV5 should be retained to explore the depths and lateral extent of any potentially compressible soils at each site.

5.4 LANDSLIDES AND SLOPE INSTABILITY

The site is predominantly underlain at depth by medium dense to dense granular alluvium. In addition, the sites mapped topography generally displays a gently sloping valley floor with some moderate to shallow drainage channel incisions. Therefore, the potential for deep-seated landsliding and slope instability within these geologic materials is considered low. There are two types of slope instabilities

that are more likely to affect the alluvial hills and crystalline mountains surrounding the desert floor, being shallow soil slip and rock falls.

Shallow soil slips may occur in steeper alluvial hills should near-surface poorly consolidated cohesionless materials become saturated for longstanding periods of time. Engineered fill slopes and adequate hillside drainage design would greatly reduce the potential for shallow soil slips.

Rock falls may occur along the "walls" of the crystalline basement rocks that surround the valley floors. Gravity, heavy precipitation, and seismic events are the major catalysts for rock fall events in these desert regions. Other factors affecting potential for rock falls are steepness of slopes and degree of weathering/fracturing of crystalline rock. Engineered structures such as debris barrier walls and rock fall catch fencing/netting would greatly reduce the chance of a rock fall event damaging any proposed structures.

5.5 SUBSIDENCE

The site is not located in an area of known ground subsidence due to the withdrawal of subsurface fluids. Based on NV5's review of the *Groundwater Management Plan – 2014 Update, Prepared for Twentynine Palms Water District* by Kennedy/Jenks Consultants, dated May 28, 2014, land subsidence has not been identified as an issue within the Twentynine Palms area. However, playa lake deposits like those mapped at Mesquite Lake have been known to be a source of land subsidence in Antelope Valley and in other similar areas. Accordingly, the potential for subsidence occurring at the site outside of the playa lake deposits due to the withdrawal of oil, gas, or water is considered to be low.

5.6 TSUNAMIS, INUNDATION SEICHE, AND FLOODING

The site is located within the southern region of the Mojave Desert, and at or above an elevation of approximately 1750 feet above MSL. Also, the site is not located downslope of any large body of water that could affect the site in the event of an earthquake-induced failure or seiche (oscillation in a body of water due to earthquake shaking). Therefore, the potential for damaging tsunamis (seismic sea waves) or seiche is considered remote.

Based on a review of Federal Emergency Management Agency (FEMA) flood insurance rate map (FIRM) and the County of San Bernardino General Planning Map, portions of the site are known to be susceptible to flooding during infrequent but substantial precipitation events. The potential for flooding should be considered during project planning and design. The approximate locations of areas deemed susceptible to flooding are displayed in *Figure 5, Flood Hazard Map*.

5.7 EXPANSIVE SOILS

NV5's research and review of geologic and geotechnical documents in the site vicinity, indicate that the site is predominantly underlain by granular alluvium that is generally considered to have a low expansion potential. However, the lower elevation playa lake deposits may or may not contain significant clay content. Should proposed structures and/or facilities be planned in these playa areas, NV5 should be retained to evaluate the expansion potential characteristics of the site's soils.

5.8 EROSION

In an effort to evaluate erosion potential for the site vicinity NV5 reviewed available USDA Soil Maps https://websoilsurvey.sc.egov.usda.gov/App/HomePage.htm. Soils are described as having several erosion factors (i.e. Kw, Kf, T) which estimate the soil potential for sheet and rill erosion. The project area generally has erosion factors which indicate a low to moderate potential for surface erosion. Certain soil deposits in the project area such as young surficial sediments (i.e., alluvium, clay and windblown sand deposits) may be more susceptible to erosion than other soils.

6.0 CONCLUSIONS AND DESIGN RECOMMENDATIONS

6.1 GENERAL

Based on the results of our background review, the proposed project is considered geotechnically feasible. The most significant geotechnical concerns for the project are the presence the two mapped active fault zones, and the presence of potentially compressible near-surface soils.

When preliminary or conceptual plans are completed, NV5 should be retained for review. Planning of any proposed structures and/or facilities will warrant the need for field explorations and appropriate soil testing.

Paleontological resources will be evaluated by the City separately as part of the California Environmental Quality Act (CEQA) process for the project.

6.2 TRENCH EXCAVATIONS

All trench excavations and access pits should be shored in accordance with Cal-OSHA regulations. For planning purposes, the native soil materials may be considered as Type C, as defined in the current Cal-OSHA soil classification.

Stockpiled (excavated) materials should be placed no closer to the edge of a trench excavation than a distance defined by a line drawn upward from the bottom of the trench at an inclination of 1(H):1(V), but no closer than 4 feet. All trench excavations should be made in accordance with Cal-OSHA requirements.

6.3 DEWATERING

As previously mentioned, reported groundwater elevations vary across and within the various subbasins in the site vicinity. Although, groundwater is generally not anticipated to be a constraint along majority of the project alignment, any cases of seepage, perched water, or heavy precipitation should be monitored during construction. The actual means and methods of any dewatering scheme should be established by a contractor with local experience. It is important to note that temporary dewatering, if necessary, will require a permit and plan that complies with RWQCB regulations. If excessive water is encountered, NV5 should be contacted to provide additional recommendations for temporary construction dewatering. Based on the NV5's review of USDA Soil Maps, the onsite near-surface soils may be considered to be relatively permeable.

7.0 DESIGN REVIEW AND CONSTRUCTION MONITORING

Geotechnical review of plans and specifications is of paramount importance in engineering practice. The poor performance of many structures has been attributed to inadequate geotechnical review of construction documents. Additionally, observation and testing of the subgrade will be important to the performance of the proposed improvements. The following sections present recommendations relative to the review of construction documents and the monitoring of construction activities.

7.1 PLANS AND SPECIFICATIONS

The design plans and specifications should be reviewed by NV5 prior to bidding and construction, as the geotechnical recommendations may need to be reevaluated in consideration of the actual design configuration. This review is necessary to evaluate whether the recommendations contained in this report and future reports have been properly incorporated into the project plans and specifications.

7.2 CONSTRUCTION MONITORING

Site preparation, removal of unsuitable soils, assessment of imported fill materials, fill placement, and other earthwork operations should be observed and tested. The substrata exposed during the construction may differ from that encountered in the test borings. Continuous observation by a representative of NV5 during construction allows for evaluation of the soil/bedrock conditions as they are encountered, and allows the opportunity to recommend appropriate revisions where necessary.

8.0 LIMITATIONS

The recommendations and opinions expressed in this report are based on NV5's review of background documents. It should be noted that this study did not evaluate the possible presence of hazardous materials on any portion of the site.

Due to the limited nature of this desktop study, conditions not described in this report may be present on the site. Uncertainties relative to subsurface conditions can be reduced through additional subsurface exploration. Additional subsurface evaluation and laboratory testing can be performed upon request. It should be understood that conditions different from those anticipated in this report may be encountered during grading operations, e.g., the extent of removal of unsuitable soil, and that additional effort may be required to mitigate them.

Site conditions, including ground-water level, can change with time as a result of natural processes or the activities of man at the subject site or at nearby sites. Changes to the applicable laws, regulations, codes, and standards of practice may occur as a result of government action or the broadening of knowledge. The findings of this report may, therefore, be invalidated over time, in part or in whole, by changes over which NV5 has no control.

NV5's recommendations for this site are, to a high degree, dependent upon appropriate quality control of subgrade preparation, fill placement, and foundation construction. Accordingly, the recommendations are made contingent upon the opportunity for NV5 to observe grading operations and foundation excavations for the proposed construction. If parties other than NV5 are engaged to provide such services, such parties must be notified that they will be required to assume complete

responsibility as the geotechnical engineer of record for the geotechnical phase of the project by concurring with the recommendations in this report and/or by providing alternative recommendations.

This document is intended to be used only in its entirety. No portion of the document, by itself, is designed to completely represent any aspect of the project described herein. NV5 should be contacted if the reader requires additional information or has questions regarding the content, interpretations presented, or completeness of this document.

NV5 has endeavored to perform its evaluation using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar soil conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this report.

9.0 SELECTED REFERENCES

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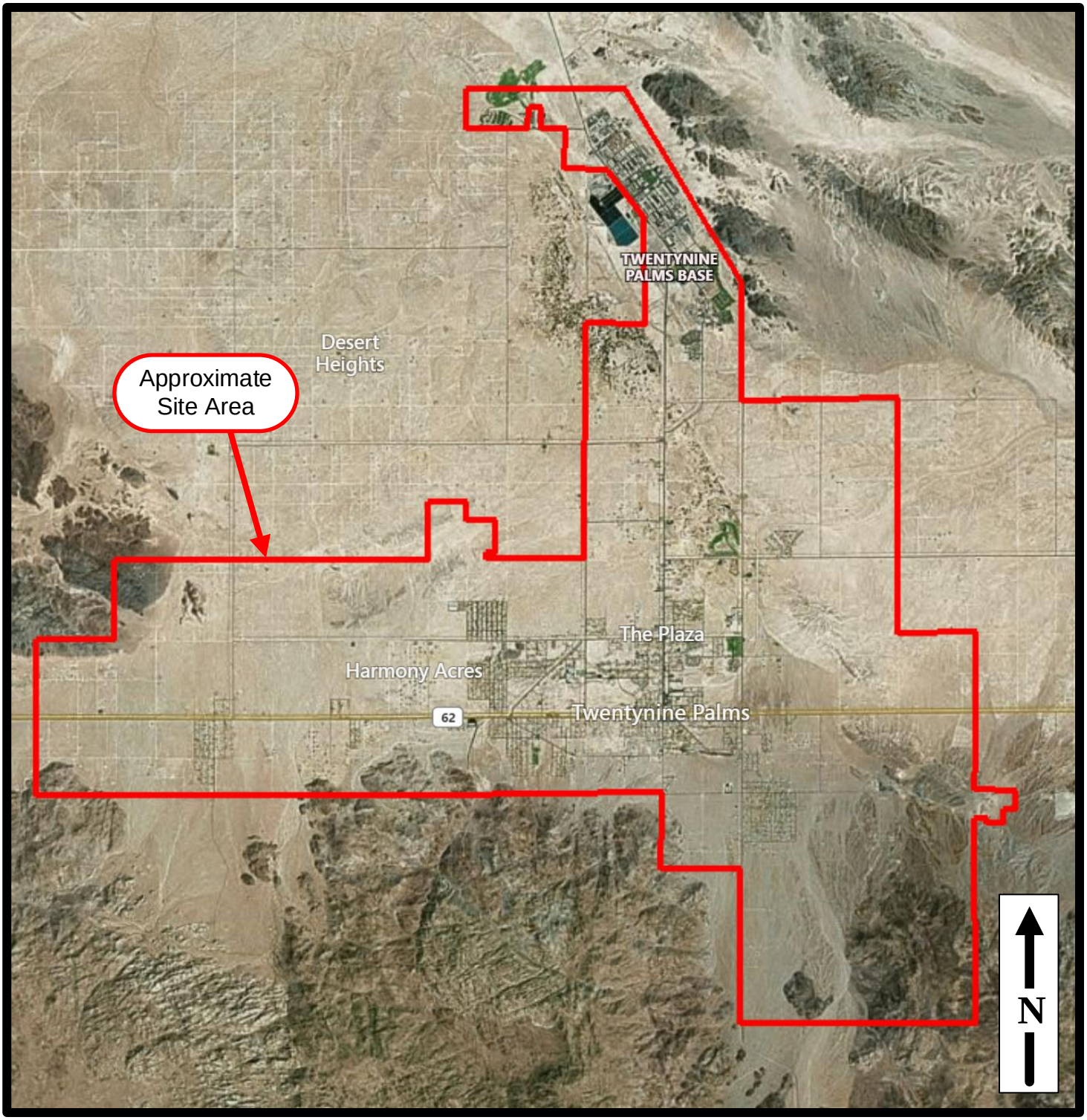
USGS Probabilistic Seismic Hazards Deaggregation Tool, http://geohazards.usgs.gov/deaggint/2008/.



NOTE: Map Not to Scale.

Reference: Google Earth 2021

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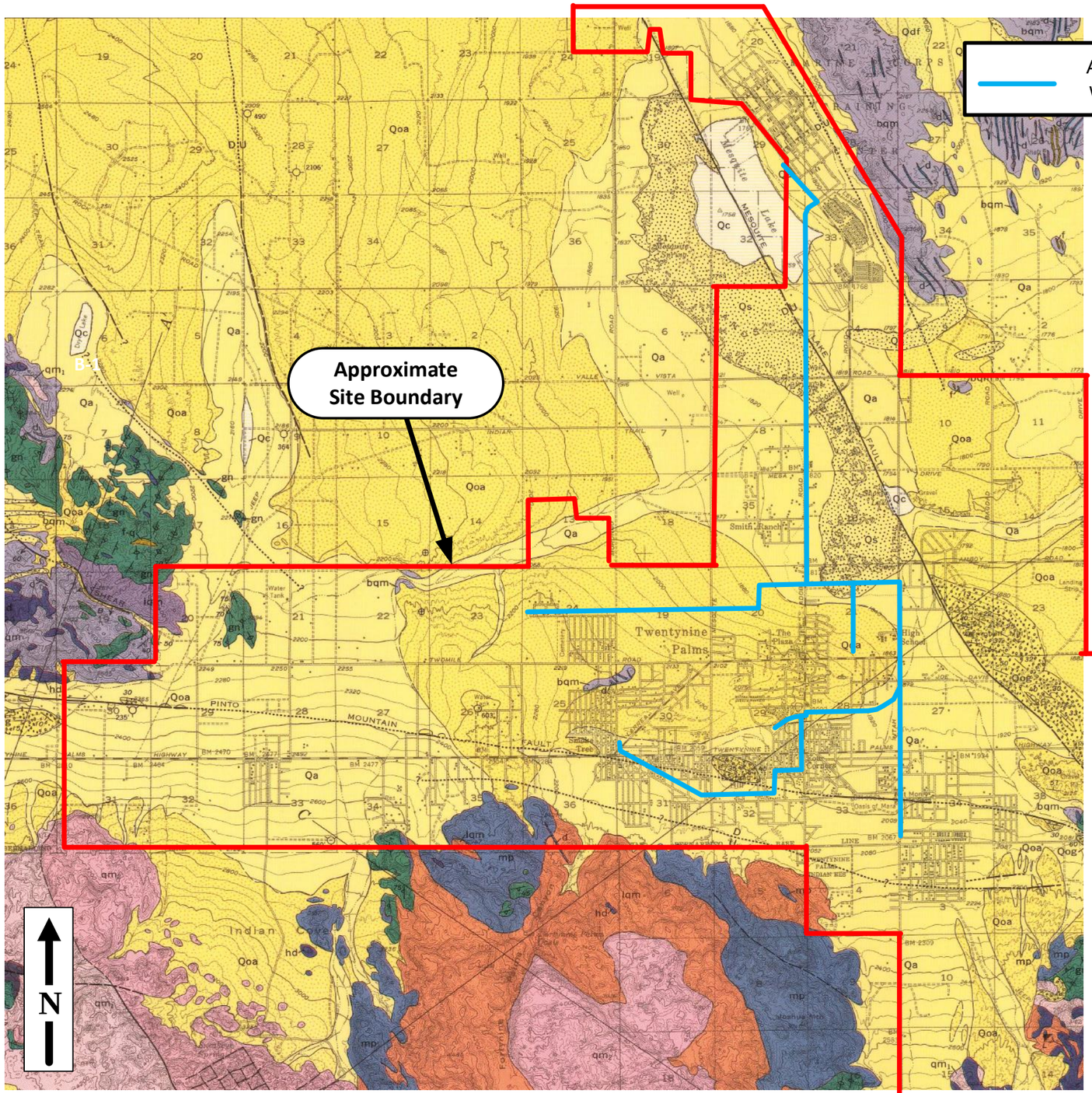
Project No: **227521-0000132.00**
Drafted By: **A. Hespeler**
Date: **May 2021**

SITE LOCATION MAP
Proposed Feasibility Study for Future Waste Water Management System
Twentynine Palms, CA

FIGURE 1



Description of Map Units

SEDIMENTARY DEPOSITS

Qs / Qa / Qc

Surficial sediments
Qs, *windblown sand*
Qa, *alluvium*
Qc, *clay*

Qdf

Dissected alluvial fan gravel

Qoa / Qog

Older surficial sediments
Qoa, *older alluvium*
Qog, *older gravel and sand*

QUATERNARY — CENOZOIC

UNCONFORMITY

VEIN ROCK

q

Quartz

PLUTONIC AND HYPABYSSAL IGNEOUS ROCKS

qm_1 / qm_2

Quartz monzonite
qm_1, *medium-grained*
qm_2, *coarse-grained*

d / f

Dike rocks
d, *mafic (dioritic to andesitic) dikes*
f, *felsite dikes*

grd / lqm / bqm / iqm / mp

Older granitic rocks
lqm, *leucocratic quartz monzonite*
grd, *granodiorite to quartz monzonite*
bqm, *biotite-rich quartz monzonite*
iqm, *iron-stained quartz monzonite*
mp, *monzonite porphyry*

bd / hd

Dioritic rocks
bd, *biotite diorite*
hd, *hornblende diorite-gabbro*

MESOZOIC

METAMORPHIC ROCKS

gn

Gneissic rocks

PRECAMBRIAN(?)

EXCERPT FROM THE "GEOLOGIC MAP OF THE TWENTYNINE PALMS QUADRANGLE, SAN BERNARDINO AND RIVERSIDE COUNTIES, CALIFORNIA"
By: T. W. Dibblee, Jr., 1968

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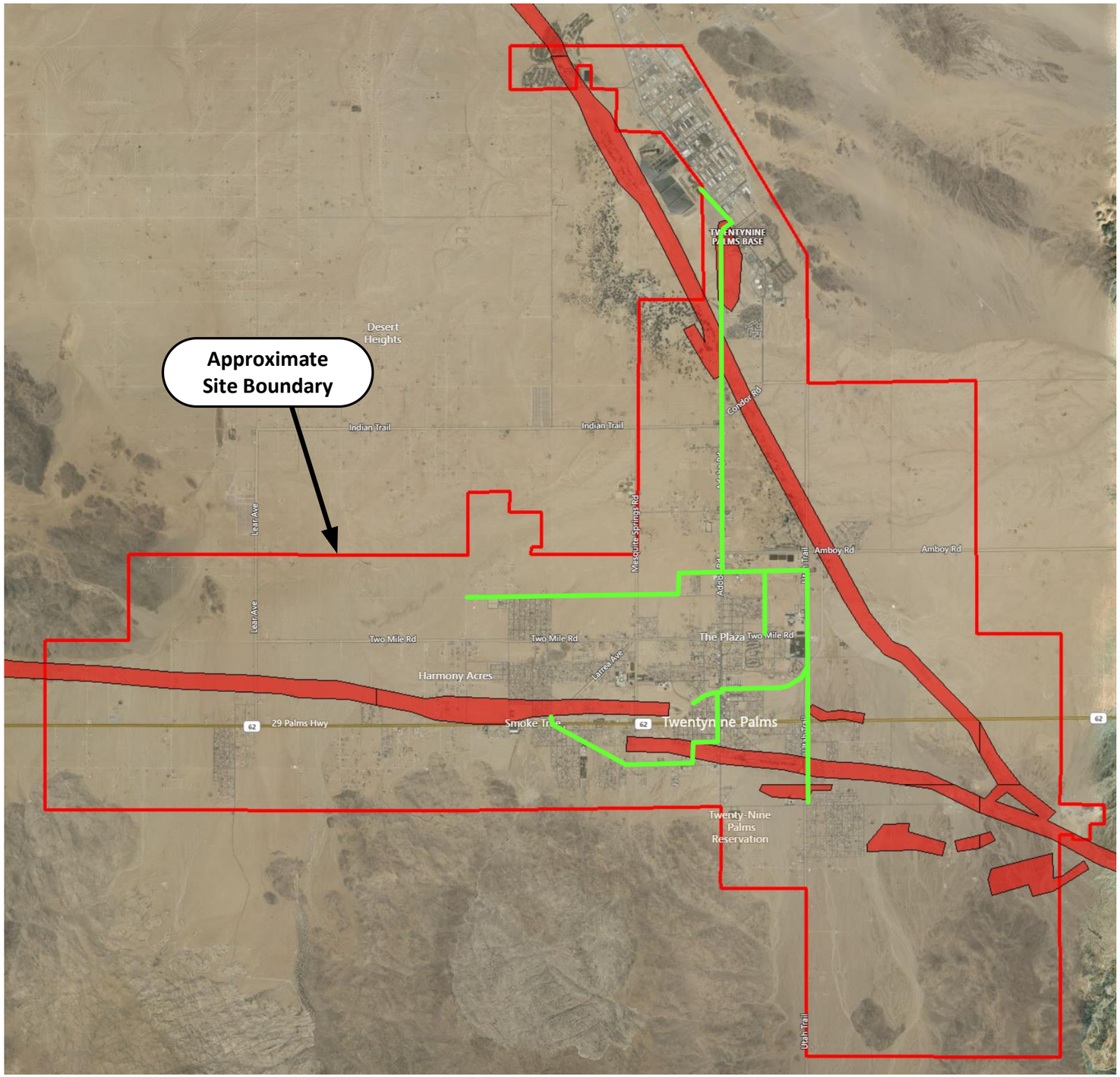
Project No: **227521-0000132.00**
Drafted By: **A. Hespeler**
Date: **May 2021**

REGIONAL GEOLOGIC MAP
Proposed Feasibility Study for Future Waste Water Management System
Twentynine Palms, CA

FIGURE 2



LEGEND

Approximate locations of California State designated Earthquake Fault Zones (EFZ).

Approximate location of proposed waste water alignment.

N

Reference:
City of Twentynine Palms
Community View: Web Accessible Maps & Planning
http://maps.digitalmapcentral.com/production/vecommunityview/cities/twentyninepalms/index.aspx

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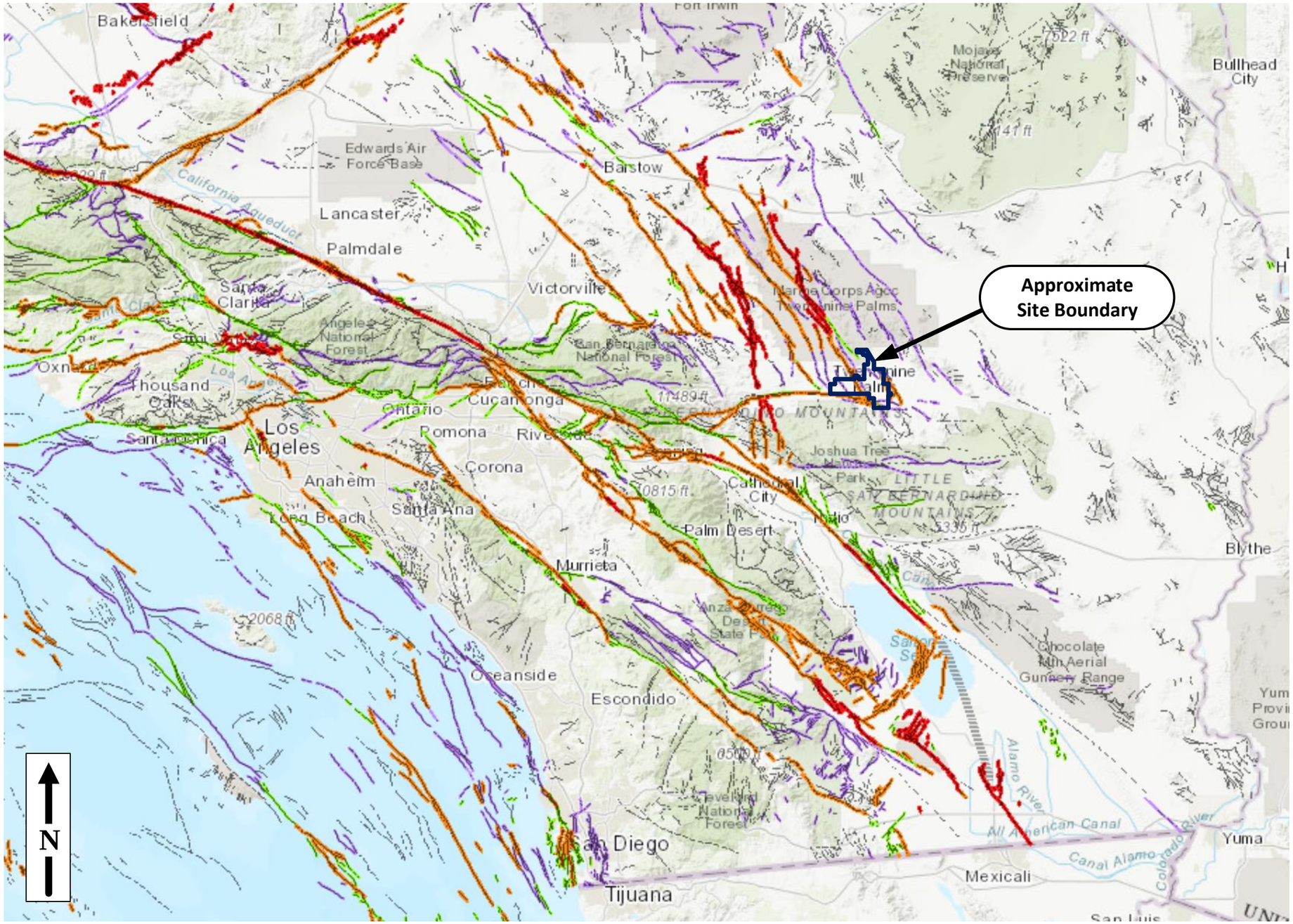
SITE FAULT MAP
Proposed Feasibility Study for Future Waste Water Management System
Twentynine Palms, CA

FIGURE 3



LEGEND

Fault along which historic (last 200 years) displacement has occurred.

A triangle to the right or left of the date indicates termination point of observed surface displacement. Solid red triangle indicates known location of rupture termination point. Open black triangle indicates uncertain or estimated location of rupture termination point.

Date bracketed by triangles indicates local fault break.

No triangle by date indicates an intermediate point along faultbreak.

CREEP

Fault that exhibits fault creep slippage. Hachures indicate linear extent of fault creep. Annotation (creep with leader) indicates representative locations where fault creep has been observed and recorded.

Square on fault indicates where fault creep slippage has occured that has been triggered by an earthquake on some other fault. Date of causative earthquake indicated. Squares to right and left of date indicate terminal points between which triggered creep slippage has occurred (creep either continuous or intermittent between these end points).

Holocene fault displacement (during past 11,700 years) without historic record.

Late Quaternary fault displacement (during past 700,000 years).

Quaternary fault (age undifferentiated).

Pre-Quaternary fault (older that 1.6 million years) or fault without recognized Quaternary displacement.

Approximate site boundary.

Reference:
California Department of Conservation / California Geological Survey
Fault Activity Map of California (interactive)
https://maps.conservation.ca.gov/cgs/fam/

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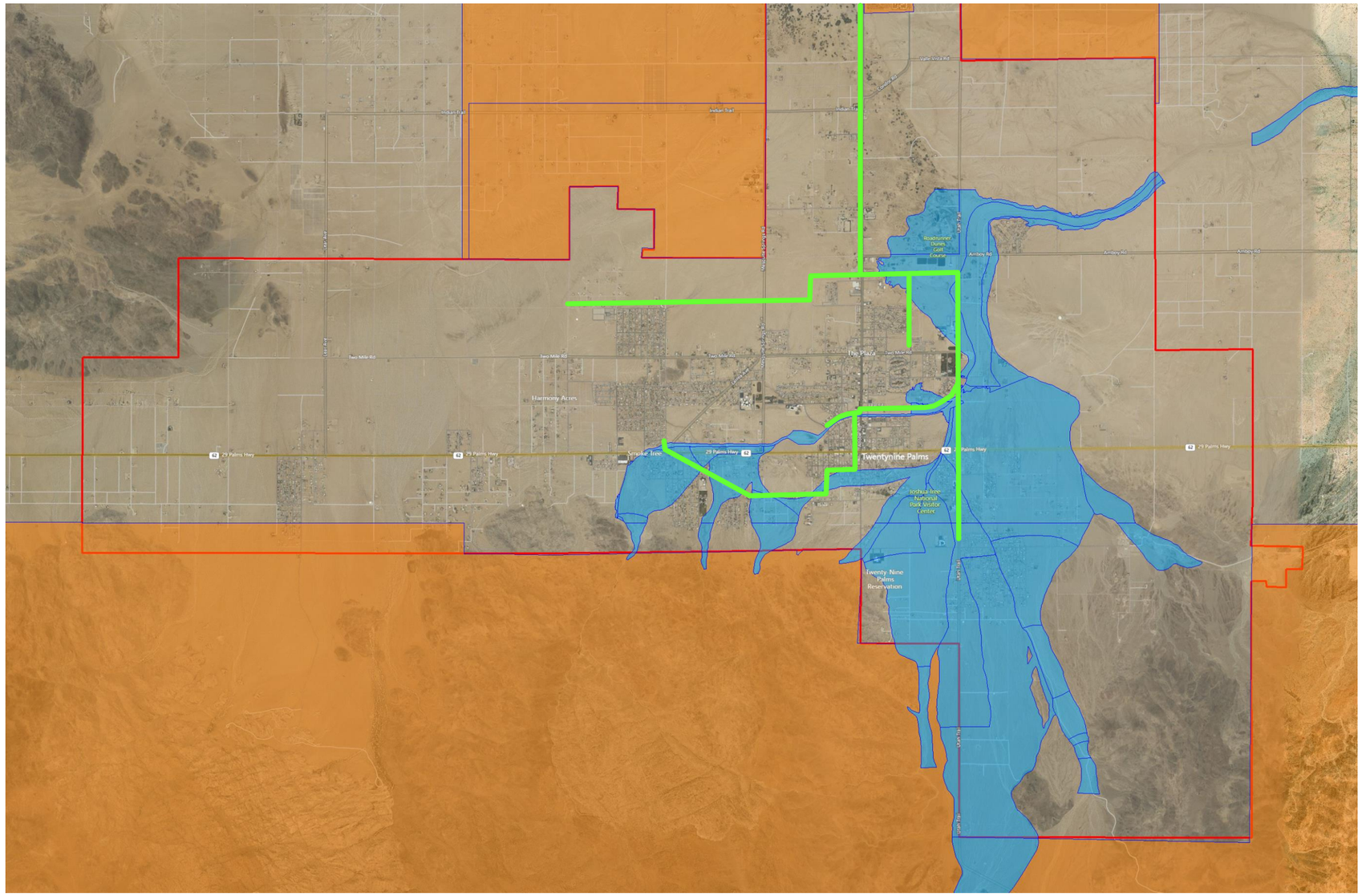
REGIONAL FAULT MAP
Proposed Feasibility Study for Future Waste Water Management System
Twentynine Palms, CA

FIGURE 4



LEGEND

Approximate location of FEMA/FIRM delineated special flood hazard areas.

Approximate location of proposed waste water alignment.

N

Reference:
City of Twentynine Palms
Community View: Web Accessible Maps & Planning
http://maps.digitalmapcentral.com/production/vecommunityview/cities/twentyninepalms/index.aspx

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FLOOD HAZARD MAP
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FIGURE 5

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