CHAPTER 5. GEOLOGICAL AND SOIL RESOURCES

5.1 INTRODUCTION

This chapter discusses the potential environmental consequences associated with implementation of the ROD associated alternatives within the region of influence (ROI) for this resource. For a description of the affected environment for all resources, refer to the respective chapter of Volume 2 (Marine Corps Relocation – Guam). The locations described in that volume include the ROI for the utilities and roadway projects. The chapters are presented in the same order as the resource areas discussed in this volume. Analysis on long-term alternatives was not done because those alternatives are not yet ripe for project specific analysis.

5.2 ENVIRONMENTAL CONSEQUENCES

5.2.1 Approach to Analysis

5.2.1.1 Methodology

Utilities

The methodology for identifying, evaluating, and mitigating impacts to geology and soil resources was established through geologic and soil studies and reports, along with federal laws and regulations, including state and local building codes and grading ordinances. The assessment of geological and soils impacts was conducted, in part, by reviewing available literature such as previously published National Environmental Policy Act (NEPA) documents for actions in the Mariana Islands Range Complex and surrounding area. A site-specific geotechnical investigation was not undertaken for this Environmental Impact Statement/Overseas Environmental Impact Statement EIS/OEIS. The impact analyses presented in this section discuss each alternative with geologic and soil impacts by geographic area as described in the previous affected environment section. Geology and soils also affect the placement or location of a land use; where such constraints occur, they are discussed. The geology and soils region of influence includes all the geologic resources on Guam that are subject to construction and operation activities.

LIDAR Contour Data was used to identify potential sinkholes on proposed sites. Development of road alignments were adjusted to avoid these potential sinkhole location and buffer areas of 100 feet (ft) (30 meters [m]) or more were implemented around the potential sinkhole sites. These buffer areas would be maintained in their current natural state and would not be used for any facility development. Analysis of topography, soil, and vegetation was completed during site characterization using LIDAR Contour Data, geotechnical reports, and site visits to ensure minimal impacts to geological and soil resources.

Project effects and constraints that can take place during construction and during operations or may limit activities may include:

Construction

- Cut and fill activities leading to soil erosion
- Removal of vegetation and landscaping leading to soil erosion
- Use of heavy equipment resulting in soil compaction
- Identification and avoidance of karst geological features, such as caves and sinkholes
- Increased risk of damage from liquefaction, landslides, and tsunamis

Operation

- Impervious surface increase resulting in increased runoff and soil erosion
- Vehicle movements resulting in increased soil erosion and compaction
- Troop movements resulting in increased soil erosion
- Munitions impacts resulting in soil and subsurface contamination
- Explosive detonations resulting in soil and subsurface contamination
- Fires resulting in reduced vegetation and increased soil erosion

The potential effects of these activities and their significance within the areas of occurrence under the alternative actions are described below. The analysis of potential impacts to geology and soils considers both direct and indirect impacts. Such disturbance may cause increased erosion and loss of productive soil.

- Potential direct impacts of construction include stormwater discharges that contain elevated sediment concentrations, that may increase pollutant loading into the surface water.
    - Indirect impacts are those that result from the completed project, such as the leaching of contaminants into soils. For non-training operation activities, indirect impacts include stormwater discharges that contain elevated sediment concentrations, as described under direct impacts of construction above.

Many effects are associated with the training operations activities. Increases in runoff due to the removal of ground cover may increase sedimentation. Siltation and formation of sediment plumes and heavy metals and hazardous materials may be leached from munitions and explosives of concern.

Indirect groundwater impacts associated with the construction and operational activities include direct contamination of groundwater resources through percolation for surface runoff. Stormwater runoff can contribute to groundwater contamination. Water impacts are addressed in Chapter 6.

Applicable Regulatory Standards

The U.S. Environmental Protection Agency Region 9 gives the Guam Environmental Protection Agency (GEPA) the authority to enforce portions of federal statutes via a Memorandum of Agreement. Under this agreement, the Safe Drinking Water Program, Water Resources Management Program, and the Water Pollution Control Program are administered by GEPA. GEPA Water Pollution Control Program is responsible for protecting Guam's resources from point and non-point source pollution, including administration of the National Pollutant Discharge Elimination System program. National Pollutant Discharge Elimination System permits are required for large and small construction activities. Requirements include a Notice of Intent, a Notice of Termination and a construction site Storm Water Pollution Prevention Plan. Permits are required for projects that disturb greater than one acre of soil, including lay-down, ingress and egress area. Phase I regulates construction activity disturbing 5 acres (ac) (2 hectares [ha]) or more of total land area and Phase II regulates "small" construction activity disturbing between 1 and 5 ac (0.4 and 2 ha) of total land area.

Government of Guam (GovGuam) has established a Soils and Water Conservation Program as defined in Chapter 26 of Title 17 of the Guam Code Annotated, as authorized by Public Law 28-179. The program is administered by the University of Guam. This regulation promotes the Territory of Guam's soil and water conservation policy in an effort to prevent erosion and water management problems; conserves and improves the use of the Territory's land and water resources; establishes Soil and Water Conservation Districts; and affirms the University of Guam's role as the Territory's lead soil conservation agency.

Conservation programs are also administered by the Public Utility Agency of Guam and GEPA (COMNAV Marianas 2008).

Seismic, Liquefaction and ground shaking would be reduced by following Unified Facility Criteria (UFC) 3-310-04 Seismic Design for Buildings (USACE 2007).

GovGuam regulations regarding solid waste landfills adhere to *Rules and Regulations for the Guam Environmental Protection Agency (GEPA) Solid Waste Disposal* (Guam Code Annotated Title 22, Div. 4, Chapter 23). These regulations are no less stringent than the U.S. Environmental Protection Agency (USEPA) standards. These requirements are common to all sites:

- Access Control
- Office and Maintenance Facilities
- Base Liner System
- Leachate Collection
- Stormwater Control
- Landfill Operation
- Landfill Closure/Post-Closure
- Landfill Gas Collection and Monitoring

In addition, soil at all municipal landfills must cover disposed solid waste with six inches (15 centimeters) of earthen material at the end of the work day (Guam DPW 2005).

Off Base Roadways

The affected environment for geological resources and soils for the proposed roadway improvement projects on Guam is described in the Geology and Soils chapter in Volume 2 of this Environmental Impact Statement/ Overseas Environmental Impact Statement.

Each of the action alternatives would result in construction and operation of a set of individual roadway improvement projects on the island of Guam, as defined in Chapter 2 of this volume. Implementation of each alternative would result in construction activities in each of the four geographic regions shown in that chapter.

Construction activities would consist of intersection improvements, bridge replacements, pavement strengthening, road relocation, road widening, and construction of a new road. Typical activities associated with each of these types of projects are described in Table 5.2-2. While many projects would involve construction work in developed and paved areas, some roadway projects could result in alteration of topography and disturbance to soils. A preliminary screening of project types and potential effects on geological resources is provided in Table 5.2-1.

Table 5.2-1. Typical Effects of Guam Road Network Roadway Project Construction Activities on Geological Resources

Item	*Project Type*	*Description*	*Potential Effect on Geological Resources and Soils*
1	Intersection Improvement (including military access points)	Installation of new traffic loop sensors, extending lanes through the intersection, striping and paving to include new approach or turn lanes, reconfiguring intersection shapes (i.e., from Y-intersection to T-intersections), combining lanes, creating shared lanes, restriping, signalization modifications or upgrades, and grade separations.	Generally, intersection improvement work would not result in contact with subsurface soils or any changes in topography. Geologic resources would be affected only when reconfiguration or grade separations include excavation, trenching, or grading into the subsoil.
2	Bridge Replacement	Bridge replacement would be conducted in phases. The new bridge structure would be lengthened to adequately accommodate the hydraulic flow of the river. The width of the new structure would accommodate more or wider lanes and a median, with sidewalks and barriers on each side.	Bridge replacement can include excavation, trenching, or grading into the subsoil. Geologic resources would be affected when foundation work requires excavation beneath the existing bridge structure, utility work requires new trenching, or when new structures require expansion of the footprint of the existing bridge.
3	Pavement Strengthening	Existing asphalt pavement sections would be strengthened by rehabilitating the existing pavement materials in place and placing an asphalt overlay or by reconstructing with new materials. The widened pavement section would be constructed of residual material from the existing pavement rehabilitation, new material, or a combination thereof, and an asphalt overlay. Pavement strengthening would also include matching existing access connections, pavement striping, signing, intelligent traffic systems, and safety lighting. The project would match existing horizontal and vertical alignment as required. Minor realignment of the road may be necessary to accommodate design elements.	Physical disturbance to soils from pavement strengthening would only occur when pavements are widened, new traffic systems or devices are installed, or minor road realignment occurs in previously undisturbed ground. Most activities associated with pavement strengthening would not require soil intrusion.

Item	*Project Type*	*Description*	*Potential Effect on Geological Resources and Soils*
4	Road Relocation (Route 15 only)	Route 15 would be realigned to accommodate the location of military firing ranges. New asphalt pavement would be constructed on the new alignment. The roadway cross section would consist of one lane in each direction, outside shoulders and inside shoulders, with an unpaved median that would accommodate future widening. Bicycles would be accommodated in the outside shoulders of the shared roadway. Alternatively, future widening would be accommodated to the outside, and the roadway cross section would consist of two lanes and outside shoulders with a paved median. Realignment would also include construction of new bridge(s) to grade separate Route 15 and the frontage road(s), obliterating existing Route 15 pavement, building removal, connecting to existing roadways or other access roads, utility relocation, pavement striping, signing, property fence, and guardrail installation.	Realignment into previously undisturbed soils may be required to accommodate design of the roadway. This activity would require building removal and relocation of existing utilities.
5	Road Widening	New lanes would be added to an existing roadway to accommodate predicted increased traffic volumes and to relieve congestion caused by increase in traffic volumes due to buildup activities. Widening would result in rebuilding the entire roadway, including removing the existing roadway segment. A new sub-base, base course, asphalt, and friction course layers would be constructed.	Road widening activities would affect previously undisturbed soil and topography of affected areas.
6	Construction of New Road	The Finegayan Connection would be constructed on a new alignment with new asphalt pavement on a compacted base or engineered fill.	New road construction would affect previously undisturbed soil and topography of affected areas.
7	Other	Temporary placement of equipment laydown areas may be required.	Equipment laydown areas associated with any of the above project types may require clearing and other disturbance of soils.

Potential impacts to geological resources and soils can occur during cut and fill operations, removal of vegetation, use of heavy equipment, and as a result of leaks and spills onto soils. Direct impacts that result in physical soil loss would occur during construction, while indirect impacts can result from the completed project (e.g., geologic hazards, increased erosion, or contaminants leach into soils). To evaluate the geological resource impacts of each project, physical activities associated with each project type were identified, as shown in Table 5.2-2.

Table 5.2-2. Activities Associated with Guam Road Network Roadway Project Types

Item	*Project Type*	*Minor Grading*	*Vegetation Removal*	*Excavation and/or Cut and Fill*	*Heavy Equipment Use*	*Leaks and Spills of Contaminants*
1	Intersection Improvement (including military access points)	•			•	•
2	Bridge Replacement		•	•	•	•
3	Pavement Strengthening	•			•	•
4	Road Relocation (Route 15 only)		•	•	•	•
5	Road Widening	•	•	•	•	•
6	Construction of New Road		•	•	•	•
7	Temporary placement of equipment laydown areas or storage areas for road demolition material	•	•		•	•

Based on the anticipated activities associated with each project type, it was determined that:

- Intersection improvements and pavement strengthening projects represented the project types with the lowest potential for impacts to geological resources and soils. These projects would involve the least amount of physical soil disturbance because most work would occur upon existing pavements or developed areas.
- The placement of temporary equipment laydown areas at any of the Guam Road Network (GRN) project work sites would represent a moderate potential for impacts to geologic resources and soils only when the use of previously undisturbed areas are selected. To avoid this impact, previously disturbed (e.g., paved) areas adjacent to the work site would be selected for use as temporary construction staging areas or storage for roadway demolition materials whenever possible. The use of heavy equipment would occur, and leaks or spills of contaminants could occur at equipment staging areas.
- Bridge replacement, road relocation, road widening, and construction of the new road would represent the greatest potential for impacts to geologic resources and soils because vegetation removal, excavation, and/or cut and fill operations would be required at various locations. These projects would result in changes in topographic features, exhibit the greatest degree of soil disturbance, and have the most potential for erosion.

For roadway projects that would not require road widening, all proposed improvements would occur within the existing impervious cover footprint. These projects would not directly or indirectly affect geological resources. Intersection improvement projects associated with military access points would require removal of vegetation and soil intrusion; therefore, they were not eliminated from evaluation.

Indirect impacts from the roadway projects could also occur. Indirect impacts would be associated with; geologic hazards, increased erosion, or contaminants leaching into soils. Projects with the most potential for increased vulnerability to geologic hazards would be those located in areas of high liquefaction potential and those in or near karst geological formations (nearest to known sinkholes or caves). In general, the potential vulnerability to effects from seismic activity is consistent throughout the island because of the presence of known and inferred earthquake faults that transect Guam. Increased erosion from the operation of new roadways and bridges would not be expected due to improved design features and proper maintenance. The potential for contaminants leaching into the soil would be prevented or managed through implementation of spill prevention and emergency spill response procedures.

5.2.1.2 Determination of Significance

For geology and soils, the significance of impacts is determined by subjective criteria and by regulatory standards. To be considered a significant impact, the following factors would be considered for each project area:

- Increased rate of erosion and soil loss from physical disturbance
- Reduced amounts of productive soils
- Loss of vegetation
- Alteration of surrounding landscape and affect on important geologic features (including soil or rock removal and filling of sinkholes)
- Diminished slope stability

Increased vulnerability to a geologic hazard (e.g., seismic activity, tsunami, liquefaction), and the probability that such an event could result in injury.

5.2.1.3 Issues Identified during Public Scoping Process

The following analysis focuses on possible effects to the geologic and soil resources that could be impacted by the proposed alternatives. As part of the analysis, concerns relating to geologic and soil resources mentioned by the public, including regulatory stakeholders, during scoping meetings were addressed. These include:

- Implementing erosion control measures for construction and post construction phases
- Ensuring that proper permitting and local government clearances are sought, where applicable

5.2.2 Power

5.2.2.1 Interim Alternative 1 (Preferred Alternative)

Interim Alternative 1 would recondition existing combustion turbines and upgrade transmission and distribution (T&D) systems. This work would be undertaken by the Guam Power Authority (GPA) on its existing permitted facilities. Reconditioning would be made to existing permitted facilities at the Marbo, Yigo, Dededo No. 1, and Macheche combustion turbines. These combustion turbines are not currently being used up to permit limits. T&D system upgrades would include above ground and underground transmission lines. This alternative supports Main Cantonment Alternatives 1 and 2 and Main Cantonment Alternatives 3 and 8 would require additional upgrades to the T&D system.

Development under Interim Alternative 1 would disturb soil during construction associated with T&D upgrades, but would not require new construction or enlargement of the footprint of the power facilities. There is a risk of increased rate of erosion, compaction, and soil loss from physical disturbance caused by construction activity, but standard operating procedures (SOPs) and best management practices (BMPs) would be implemented to control and minimize impacts. The following measures are current SOPs for activities that could impact geology and soils in the project area:

- Locate ground-disturbing roadwork on previously disturbed sites whenever possible.
- Restrict vehicular activities to designated/previously identified areas.
- Prohibit off-road vehicle use except in designated off-road areas or on established trails.
- Monitor erosion and drainage at select locations.
- Comply with existing policies and management activities to conserve soils.
- Standard erosion control measures (i.e., temporary and permanent soil stabilization; location of temporary soil piles; placement of sediment barriers around storm sewer inlets; sediment controls

such as filter fabric fences, straw bales, or vegetative barriers; timely disposal of construction material wastes) would be implemented during any ground-disturbing activities (e.g., excavation and grading).

- Any topsoil removed from the site would be placed in the immediate area and reused for re-compaction purposes (if appropriate, in accordance with geotechnical recommendations).
- Any contaminated topsoil removed from the site would be properly disposed of in an approved landfill in accordance with applicable regulatory requirements.
- Earthwork would be planned and conducted in such a manner as to minimize the duration of exposure of unprotected soils.
- For soil disturbance activities that occur during the rainy season, installation of berms and plastic sheeting would be utilized.
- Locate temporary equipment laydown areas on previously disturbed or developed (i.e., paved) areas whenever possible to avoid the need for vegetation removal or grading.
- Proper storage and containment of contaminants would be required at all temporary equipment staging areas.
- Erosion control plans for roadway work shall be prepared and implemented in construction plans and practices to the maximum extent practicable, including but not limited to:
- the area of land to be graded shall be kept to a minimum, stabilized, or receive temporary covering if delays exceeding 2 months of exposure occur;
- critical areas shall be protected during construction with the use of temporary ditches, dikes, vegetation, and/or mulching;
- all disturbed areas, slopes, channels, ditches, and banks shall be stabilized as soon as possible after final grading has been completed;
- stormwater runoff from disturbed areas would be collected and diverted for removal of sediment before discharge to any surface or marine waters; and,
- all erosion and sedimentation control facilities would be maintained until stabilization of the site is complete.
- Ensure that all construction work areas are clearly identified or marked on contractor drawings. Restrict vehicular activities to designated/previously identified areas within the construction work zone only.
- Prohibit off-road vehicle use except in designated off-road areas or on established trails.
- Ensure that contaminants (i.e., oils, greases, lubrication fluids for heavy equipment) are properly stored at the work site to avoid spills and leaks.

Erosion potential of soils found at facilities proposed for reconditioning and in the areas underlying T&D upgrades under Interim Alternative 1 is shown in Table 5.2-3.

Table 5.2-3. Erosion Potential at Power Alternative Sites

Soil Type	*Location*	*Erosion Potential*
Guam Yigo Complex at 0-7% slope	Marbo, Yigo, and Dededo	slight
Guam Cobbly Clay Loam at 3-7% slope	Marbo, Yigo, Macheche, and Dededo, Andersen AFB, Potts Junction	slight
Guam Cobbly Clay Loam at 3-7% slope	Harmon/Yigo and Dededo/Andersen, Andersen AFB	slight
Guam Urban Land Complex at 0-3% slope	Orote Point, Potts Junction	slight
Urban Land-Ustorthents complex at 0% slope	Cabras/Piti	slight

Source: Young 1988.

Construction activities under Interim Alternative 1 would include clearing, grading and grubbing, trenching, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Installation of underground T&D lines would permanently displace soil; however the volume of soil moved would result in less than significant impacts to soil resources. Therefore, Interim Alternative 1 would result in minimal impacts to unique geologic resources by changing the landscape of the affected area.

There are no known sinkholes in the vicinity of Interim Alternative 1 construction. Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Therefore, Interim Alternative 1 would result in less than significant impacts to a unique geologic resource.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Interim Alternative 1 would result in less than significant impacts associated with geologic hazards.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs and BMPs would be followed to control and minimize soil erosion. The construction SOPs would include requirements for stormwater compliance, and with BMPs implementation would ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. Implementations of measures such as revegetation as soon as possible after any ground disturbance or grading, and minimizing construction and grading during times of inclement weather would control and minimize erosion, thus there would be minimal impacts from soil erosion. A more detailed explanation of regulatory permitting requirements is also available in Volume 8.

Potential Mitigation Measures

There would be less than significant impacts to geological and soil resources as a result of implementing Alternative 1; therefore, no potential mitigation measures are proposed. Implementation of SOPs and BMPs including erosion and sedimentation controls and stormwater management would minimize impacts to geological and soil resources.

5.2.2.2 Interim Alternative 2

Interim Alternative 2 is a combination of reconditioning of existing permitted GPA facilities, an increase in operational hours for existing combustion turbines, and upgrades to existing T&D systems. Interim Alternative 2 would not require new construction or enlargement of the existing footprint of facilities. Reconditioning would be performed on the existing permitted GPA facilities at the Marbo, Yigo, and Dededo combustion turbines. This alternative supports Main Cantonment Alternatives 1 and 2 and Main Cantonment Alternatives 3 and 8 would require additional upgrades to the T&D system.

Construction activities under Interim Alternative 2 would include clearing, grading and grubbing, trenching, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Therefore, Interim Alternative 2 would result in minimal impacts to unique geologic resources by changing the landscape of the affected area. Soil types disturbed would not be agriculturally productive soils. Soil erosion is primarily a concern for discharge into surface or nearshore waters from the proposed construction. Construction SOPs and BMPs would be followed to control and minimize soil erosion. The construction SOPs would include requirements for stormwater compliance, with BMPs to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. Implementations of measures noted in the geology and soils column would prevent erosion, thus there would be minimal impacts from soil erosion. A more detailed explanation of regulatory permitting requirements is also available in Volume 8.

There are no known sinkholes in the vicinity of Interim Alternative 2 construction. Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Therefore, Interim Alternative 2 would result in less than significant impacts to a unique geologic resource.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Interim Alternative 2 would result in less than significant impacts associated with geologic hazards.

Development under Interim Alternative 2 would disturb soil during construction associated with T&D upgrades. Installation of underground T&D lines would permanently displace soil, however the volume of soil moved would result in less than significant impacts to soil resources.

Potential Mitigation Measures

Potential mitigation measures are the same as those for Interim Alternative 1.

5.2.2.3 Interim Alternative 3

Interim Alternative 3 is a combination of reconditioning existing GPA permitted facilities at Marbo, Yigo, and Dededo and upgrades to the Department of Defense power plant at Orote. Upgrades would be made to existing T&D. The proposed reconditioning to the existing power generation facilities at Marbo, Yigo, and Dededo would not require new construction or enlargement of the existing footprint of the facility. For the Orote power plant, upgrades would include a new fuel storage facility to facilitate longer run times between refueling. This would disturb approximately 1 acre (4,047 square m). This alternative supports Main Cantonment Alternatives 1 and 2 and Main Cantonment Alternatives 3 and 8 would require additional upgrades to the T&D system.

The proposed reconditioning to the facilities at Marbo, Yigo, and Dededo include overhauls of the

existing systems that do not include new construction or enlargement of the existing footprint of the facility. For the Orote power plant, upgrades would include a new fuel storage facility to facilitate longer run times between refueling. This would disturb approximately 1 acre (4,047 square m).

Development under Interim Alternative 3 would disturb soil during construction associated with facilities upgrades. Installation of underground T&D lines would permanently displace soil, however the volume of soil moved would result in less than significant impacts to soil resources. There is a risk of increased rate of erosion, compaction, and soil loss from physical disturbance caused by construction activity, but SOPs would be implemented to prevent impacts. Soil types disturbed would not be agriculturally productive soils. Construction SOPs and BMPs would be followed to minimize soil erosion. The construction SOPs would include requirements for stormwater compliance, with BMPs to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. Implementations of measures noted in the geology and soils column would prevent erosion, thus there would be minimal impacts from soil erosion. A more detailed explanation of regulatory permitting requirements is also available in Volume 8.

In accordance with site-specific geotechnical reports produced for project planning and construction, specific SOPs and BMPs that would be utilized in this area include:

- Revegetation should occur as soon as possible after any ground disturbance or grading.
- Construction and grading should be minimized during times of inclement weather.

Construction activities under Interim Alternative 3 would include clearing, grading, and grubbing, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Therefore, Interim Alternative 3 would result in minimal impacts to unique geologic resources by changing the landscape of the affected area.

There are no known sinkholes in the vicinity of Interim Alternative 3 construction. Any sinkhole discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Therefore, Interim Alternative 3 would result in less than significant impacts to a unique geologic resource.

Orote Point is located in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, and slope instability would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). The Interim Alternative 3 proposed developments are to be located on a relatively flat area that would not be subject to slope instability. Interim Alternative 3 would result in less than significant impacts associated with geologic hazards.

Seismic, liquefaction and ground shaking would be reduced by following UFC 3-310-04 Seismic Design for Buildings (USACE 2007).

Potential Mitigation Measures

Potential mitigation measures are the same as those for Interim Alternative 1.

5.2.2.4 Summary of Impacts

Table 5.2-4 summarizes the potential impacts of each interim power alternative. A text summary is provided below.

Table 5.2-4. Summary of Potential Power Impacts

Interim Alternative 1	*Interim Alternative 2*	*Interim Alternative 3*
Topography		
LSI • Interim Alternative 1 would result in minimal impacts to topography by changing the landscape at proposed development sites.	LSI • Interim Alternative 2 would result in minimal impacts to topography by changing the landscape at proposed development sites.	LSI • Interim Alternative 3 would result in minimal impacts to topography by changing the landscape at proposed development sites.
Geology		
LSI • Sinkholes would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Minimal impacts to sinkholes would occur.	LSI • Sinkholes would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Minimal impacts to sinkholes would occur.	LSI • Sinkholes would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Minimal impacts to sinkholes would occur.
Soil		
LSI • Interim Alternative 1 operations would not result in significant soil erosion or loss of agriculturally productive soil. • Soil disturbances and loss of vegetation would cause increased rate of erosion and soil loss form physical disturbance at all proposed construction areas. Minimal impacts would occur with the use of BMPs. • Slope stability would not be altered, thus minimal impacts to soil resources would occur.	LSI • Interim Alternative 2 operations would not result in significant soil erosion or loss of agriculturally productive soil. • Soil disturbances and loss of vegetation would cause increased rate of erosion and soil loss form physical disturbance at all proposed construction areas. Minimal impacts would occur with the use of BMPs. • Slope stability would not be altered, thus minimal impacts to soil resources would occur.	LSI • Interim Alternative 3 operations would not result in significant soil erosion or loss of agriculturally productive soil. • Soil disturbances and loss of vegetation would cause increased rate of erosion and soil loss form physical disturbance at all proposed construction areas. Minimal impacts would occur with the use of BMPs. • Slope stability would not be altered, thus minimal impacts to soil resources would occur.
Geologic Hazards		
LSI • Adherence to UFC 3-310-04 Seismic Design for Buildings would reduce risk of damage to structures from seismic, liquefaction and ground shaking hazards.	LSI • Adherence to UFC 3-310-04 Seismic Design for Buildings would reduce risk of damage to structures from seismic, liquefaction and ground shaking hazards.	LSI • Adherence to UFC 3-310-04 Seismic Design for Buildings would reduce risk of damage to structures from seismic, liquefaction and ground shaking hazards.

Legend: LSI = Less Than Significant Impact. * Preferred Alternative

Relocation of Marines to Guam would require construction and reconditioning that would potentially disturb soil, increase erosion, and change the landscape of Guam in multiple areas. Reconditioning of existing generation facilities, upgrading and construction of a new fuel storage tank, and trenching for underground transmission line upgrades are required to support the increase in population.

Rates of erosion and soil loss from physical disturbance due to construction would temporarily increase during construction and renovation associated with all of the alternatives for power infrastructure improvements. With implementation of BMPs, less than significant impacts from soil erosion would occur. The soil types that would be lost are not agriculturally productive soils. The topographic and landscape features would not be substantially changed by proposed construction activities. Some areas contain karst geologic features that would be of concern during the construction and operation of the facilities. Careful planning would minimize changes to geological features such as Guam's caves and sinkholes.

5.2.3 Potable Water

5.2.3.1 Basic Alternative 1 (Preferred Alternative)

Basic Alternative 1 would consist of installation of up to 22 new potable water supply wells at Andersen Air Force Base (AFB), rehabilitation of existing wells, interconnection with the GWA water system, and associated T&D systems. A new 5 MG (19 ML) water storage tank would be constructed at ground level at Finegayan. Basic Alternative 1 would affect the following areas of Guam:

- North (water supply wells)
- Central (rehabilitation of Navy Regional Medical Center well)

A total of up to 22 new water wells (including one contingency well) at AFB would be drilled through the limestone plateau into the Northern Guam Lens Aquifer (NGLA). Total well depths would be from 512 to 577 feet (ft) (156 to 175 meters [m]). A new 5 MGD water storage tank would be placed on the ground on site at Finegayan and would be connected to the existing system.

Generally, soil erosion is a concern primarily for discharge into surface or nearshore waters, that are not located near the proposed wells. However, potential sediment contamination of groundwater may result from drilling new wells. Erosion potential for soils found at proposed upgrade sites is shown in Table 5.2-5. A new ground-level 5 MGD storage tank is proposed on Naval Computer and Telecommunications Station (NCTS) Finegayan. Development under Alternative 1 would disturb soil, but SOPs and BMPs would be implemented to control and minimize impacts. Therefore, Alternative 1 well-drilling would not result in significant soil erosion, compaction, or loss of agriculturally productive soil.

Table 5.2-5. Erosion Potential at Potable Water Sites

Soil Type	*Location*	*Erosion Potential*
Guam Cobbly Clay Loam at 3-7% slope	Andersen AFB	slight
Guam Cobbly Clay Loam at 7-15% slope	Andersen AFB	slight
Guam Urban Land Complex at 0-3% slope	Andersen AFB	slight
Guam Urban Land Complex at 0-3% slope	NCTS Finegayan	slight
Guam Cobbly Clay Loam at 7-15% slope	Andersen South	slight
Guam Cobbly Clay Loam at 7-15% slope	Andersen South	slight
Guam Urban Land Complex at 0-3% slope	Andersen South	slight
Guam Cobbly Clay Loam at 3-7% slope	Air Force Barrigada	slight
Chacha Clay at 0-5% slope	Air Force Barrigada	slight
Pulantat-Kagman Clays at 0-7% slope	Air Force Barrigada	slight
Inaranjan Clay at 0-4% slope	NMS	slight
Akina Silty Clay at 7-15% slope	NMS	severe
Akina-Urban Land Complex at 0-7% slope	NMS	slight

Source: Young 1988.

Construction of wells under Basic Alternative 1 would include minor clearing, grading, and grubbing, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Therefore, Alternative 1 would result in minimal impacts to unique geologic resources by changing the landscape of the affected area.

Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Therefore, Alternative 1 would result in less than significant impacts to a unique geologic resource.

Water distribution mains would be replaced and upgraded in central and northern Guam. Construction activities would include clearing, grading and grubbing, trenching, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Therefore, Alternative 1 would result in minimal impacts to unique geologic resources by changing the landscape of the affected area.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Alternative 1 would result in less than significant impacts associated with geologic hazards.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs would be followed to minimize soil erosion. The construction SOPs would include requirements for stormwater compliance, with BMPs to ensure that all aspects of the project construction would be performed in a manner to minimize impacts during construction activity. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. Implementations of measures noted in the geology and soils column would control and minimize erosion, thus there would be minimal impacts from soil erosion. A more detailed explanation of regulatory permitting requirements may also be available in Volume 8.

To reduce significant impacts during construction under Alternative 1, the following measures are suggested for implementation in accordance with site-specific geotechnical reports produced for project planning and construction:

- Revegetation would occur as soon as possible after any ground disturbance or grading.
- Construction and grading would be minimized during times of inclement weather.

Seismic, liquefaction and ground shaking would be reduced by following UFC 3-310-04 Seismic Design for Buildings (USACE 2007).

Potential Mitigation Measures

There would be less than significant impacts to geological and soil resources as a result of implementing Potable Water Basic Alternative 1; therefore, no potential mitigation measures are proposed. Implementation of SOPs and BMPs including erosion and sedimentation controls and stormwater management would minimize impacts to geological and soil resources. Basic Alternative 2

Basic Alternative 2 includes water resource development options such as new water supply wells, rehabilitation of existing wells, interconnection with GWA, upgrades and construction of new transmission and distribution systems that would be staged over 5 years, from 2010 to 2015, much like Alternative 1. However, the number of wells would be up to 20 at Andersen AFB and up to 11 at Navy Barrigada.

Impacts to soil and geological resources at Andersen AFB are identical to those of Basic Alternative 1.

At Navy Barrigada, installation of up to 11 new wells, as well as replacement and upgrades to water distribution mains, would include minor clearing, grading, and grubbing, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Basic Alternative 2 would result in less than significant impacts associated with geologic hazards.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs would be followed to minimize soil erosion as stated in Alternative 1 impacts.

Seismic, liquefaction and ground shaking would be reduced by following UFC 3-310-04 Seismic Design for Buildings (USACE 2007).

5.2.3.2 Basic Alternative 2

Basic Alternative 2 includes water resource development options such as new water supply wells, rehabilitation of existing wells, interconnection with GWA, upgrades and construction of new transmission and distribution systems that would be staged over 5 years, from 2010 to 2015, much like Alternative 1. However, the number of wells would be up to 20 at Andersen AFB and up to 11 at Navy Barrigada.

Impacts to soil and geological resources at Andersen AFB are identical to those of Basic Alternative 1.

At Navy Barrigada, installation of up to 11 new wells, as well as replacement and upgrades to water distribution mains, would include minor clearing, grading, and grubbing, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Basic Alternative 2 would result in less than significant impacts associated with geologic hazards.

Soil types disturbed would not be agriculturally productive soils. Construction SOPs would be followed to minimize soil erosion as stated in Alternative 1 impacts.

Seismic, liquefaction and ground shaking would be reduced by following UFC 3-310-04 Seismic Design for Buildings (USACE 2007).

Potential Mitigation Measures

Potential mitigation measures are the same as those for Basic Alternative 1.

5.2.3.3 Summary of Impacts

Table 5.2-6 summarizes the potential impacts of each action alternative. A text summary is provided below.

Table 5.2-6. Summary of Potential Potable Water Impacts

*Basic Alternative 1**	*Basic Alternative 2*
Topography	
LSI • Alternative 1 would result in minimal impacts to topography by changing the landscape at proposed sites.	LSI • Alternative 2 would result in minimal impacts to topography by changing the landscape at proposed sites.
Geology	
LSI • Sinkholes would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Minimal impacts to sinkholes would occur.	LSI • Sinkholes would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Minimal impacts to sinkholes would occur.
Soil	
LSI • Soil disturbances and loss of vegetation would cause increased rate of erosion and soil loss form physical disturbance at all proposed construction areas under Alternative 1. Minimal impacts would occur with the use of BMPs. • Soil types impacted would not be agriculturally productive soils, thus minimal impacts to soil resources would occur.	LSI • Soil disturbances and loss of vegetation would cause increased rate of erosion and soil loss form physical disturbance at all proposed construction areas under Alternative 2. Minimal impacts would occur with the use of BMPs. • Soil types impacted would not be agriculturally productive soils, thus minimal impacts to soil resources would occur.
Geological Hazards	
LSI • Adherence to UFC 3-310-04 Seismic Design for Buildings during construction would reduce risk of damage to structures from seismic hazards that could potentially impact operations. Minimal impacts would occur due to geologic hazards.	LSI • Adherence to UFC 3-310-04 Seismic Design for Buildings during construction would reduce risk of damage to structures from seismic hazards that could potentially impact operations. Minimal impacts would occur due to geologic hazards.

Legend: LSI = Less Than Significant Impact. * Preferred Alternative

Relocation of Marines to Guam would require construction and renovation that would potentially disturb soil, increase erosion, and change the landscape of Guam in multiple areas. Buildup of the potable water infrastructure is required to support the increase in population.

Temporarily increased rates of erosion, compaction, and soil loss due to physical disturbance from construction would occur during construction and renovation associated with all of the alternatives for the potable water infrastructure improvements. With implementation of BMPs, less than significant impacts from soil erosion would occur. The soil types that would be lost are not agriculturally productive soils. The topographic and landscape features would not be substantially changed by construction activities. Some areas contain karst geologic features that are of concern during construction and operation of the facilities. Careful planning would be used to minimize changes to geological features like Guam's caves and sinkholes.

5.2.4 Wastewater

5.2.4.1 Basic Alternative 1a (Preferred Alternative) and 1b

Basic Alternative 1 (1a supports Main Cantonment Alternatives 1 and 2; and 1b supports Main Cantonment Alternatives 3 and 8) combines upgrade to the existing primary treatment facilities and expansion to secondary treatment at the Northern District Wastewater Treatment Plant (NDWWTP).The difference between Alternatives 1a and 1b is a requirement for a new sewer line from Barrigada housing to NDWWTP for Alternative 1b.

The action areas are located in northern Guam, an area with karst geologic features that would require consideration when planning new construction. The proposed upgrade to the facilities does not include enlargement of the plant footprint. Expansion of the NDWWTP outfall would require a laydown area.

Generally, soil erosion is a concern primarily for discharge into surface or nearshore waters, none of which are found near Alternative 1 construction. Erosion potential for soils found at proposed upgrade sites is shown in Table 5.2-7. Soil types disturbed would not be agriculturally productive soils.

Table 5.2-7. Erosion Potential at Wastewater Alternative Sites

Soil Type	*Location*	*Erosion Potential*
Guam Cobbly Clay Loam at 3-7% slope	NDWWTP	Slight
Guam Yigo Complex at 0-7% slope	Proposed Sewer Line	Slight
Guam Cobbly Clay Loam at 3-7% slope	Proposed Sewer Line	Slight

Source: Young 1988.

Construction under Basic Alternatives 1a and 1b would include minor clearing, grading, and grubbing, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Therefore, Alternative 1 would result in minimal impacts to topography by changing the landscape of the affected area.

Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Therefore, Basic Alternative 1 would result in less than significant impacts to a unique geologic resource.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Basic Alternative 1 would result in less than significant impacts associated with geologic hazards.

Standard construction BMPs would be included in the Regional Stormwater Pollution Prevention Plan as part of the Construction Stormwater Management Program for the Guam Military Buildup. As part of an integrated approach to stormwater management, construction managers and contractors would be required to follow this Regional SWPPP for development of their site specific SWPPP. To prevent soil erosion, erosion and sediment control measures would be included as part of the Regional SWPPP, and required for inclusion in the Contractor's Site Specific SWPPP under NPDES Construction Permit Compliance Program for the Guam Buildup. A description of the standard BMPs and resource protection measures required by regulatory mandates can be found in Volume 7. Implementations of measures noted in the geology and soils column would prevent erosion, thus there would be minimal impacts from soil erosion. A more detailed explanation of regulatory permitting requirements is also available in Volume 8.

To reduce significant impacts during construction under Basic Alternative 1, the following measures are

suggested for implementation in accordance with site-specific geotechnical reports produced for project planning and construction:

- Revegetation would occur as soon as possible after any ground disturbance or grading.
- Construction and grading would be minimized during times of inclement weather.

Seismic, liquefaction and ground shaking would be reduced by following UFC 3-310-04 Seismic Design for Buildings (USACE 2007).

Potential Mitigation Measures

There would be less than significant impacts to geological and soil resources as a result of implementing Basic Alternative 1; therefore, no potential mitigation measures are proposed. Implementation of SOPs and BMPs including erosion and sedimentation controls and stormwater management would minimize impacts to geological and soil resources.

5.2.4.2 Basic Alternative 1b

Basic Alternative 1b supports Main Cantonment Alternatives 3 and 8 and consists of the same actions as Basic Alternative 1a with the addition of a new force main sewer from Barrigada to the existing sewer that feeds wastewater to the NDWWTP.

The action areas in addition to those in Basic Alternative 1a are located in central Guam, an area with karst geologic features that would require consideration when planning new construction. Erosion potential for soils found at proposed new force main sewer is shown in Table 5.2-7. Soil types disturbed would not be agriculturally productive soils.

Construction under Basic Alternative 1b would include minor clearing, grading, trenching, grubbing, and demolition of existing earthwork and grass. Temporary loss of vegetation would occur. Therefore, Basic Alternative 1b would result in minimal impacts to topography by changing the landscape of the affected area.

Any sinkholes discovered would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Therefore, Basic Alternative 1b would result in less than significant impacts to a unique geologic resource.

Construction areas are in a potentially active seismic zone. Hazards associated with earthquakes, fault rupture, slope instability and liquefaction would be minimized by adherence to UFC 3-310-04 Seismic Design for Buildings (USACE 2007). Therefore, Basic Alternative 1b would result in less than significant impacts associated with geologic hazards. Standard construction BMPs would be included as discussed under Alternative 1.

Seismic, liquefaction and ground shaking would be reduced by following UFC 3-310-04 Seismic Design for Buildings (USACE 2007).

5.2.4.3 Potential Mitigation Measures

Potential mitigation measures are identical to those of Basic Alternative 1a.

Table 5.2-8. Summary of Wastewater Impacts

Interim Alternative 1a and 1b*
LSI • Interim Alternative 1 would result in minimal impacts to topography by changing the landscape at proposed development sites
LSI

• Sinkholes would be avoided and a buffer zone of vegetation would be left around it to prevent further erosion or expansion. Minimal impacts to sinkholes would occur.
LSI • Soil disturbances and loss of vegetation would cause increased rate of erosion and soil loss from physical disturbance at all proposed construction areas. Minimal impacts would occur with the use of BMPs. • Slope stability would not be altered, thus minimal impacts to soil resources would occur.
LSI • Adherence to UFC 3-310-04 Seismic Design for Buildings would reduce risk of damage to structures from seismic, liquefaction and ground shaking hazards.

Legend: LSI = Less Than Significant Impact. * Preferred Alternative

Relocation of Marines to Guam would require construction and renovation that would potentially disturb soil, increase erosion, and change the landscape of Guam in multiple areas. Buildup of wastewater treatment infrastructure is required to support the increase in population.

Rates of erosion and soil loss from physical disturbance due to construction would temporarily increase during construction and renovation associated with all of the alternatives for wastewater treatment infrastructure improvements. With implementation of BMPs, less than significant impacts from soil erosion would occur. The soil types that would be lost are not agriculturally productive soils. The topographic and landscape features would not be substantially changed by proposed construction activities. Some areas contain karst geologic features that would be of concern during the construction and operation of the facilities. Careful planning would minimize changes to geological features such as Guam's caves and sinkholes.

5.2.5 Solid Waste

5.2.5.1 Basic Alternative 1 (Preferred Alternative)

The Preferred Alternative for solid waste would be the continued use of Navy Landfill at Apra Harbor until Layon Landfill is opened, which is scheduled for July 2011. Though no construction or upgrades to utilities occur, geological and soil resources need to be analyzed for impact from increased amounts of solid waste at current facilities. An increase in the volume of solid waste would potentially impact the daily soil-covering routines at the existing plant. More soil would potentially be required to cover greater amounts of solid waste. Impact to soils and geological resources would be minimal, because soil is used at the landfill for the purpose of covering solid waste and more soil is available to use as pressure on the existing facility increases.

Potential Mitigation Measures

No mitigation measures are required.

5.2.5.2 Summary of Impacts

Table 5.2-9 summarizes the potential impact of the Preferred Alternative. A text summary is provided below.

Table 5.2-9. Summary of Potential Solid Waste Impacts

*Basic Alternative 1**
LSI • Alternative 1 would result in minimal impacts to topography by changing the landscape at proposed sites.
LSI • Sinkholes and other geological resources would not be affected by the increase in the

*Basic Alternative 1**
volume of solid waste taken to existing facility. Minimal impacts to sinkholes would occur.
LSI • Soil disturbances would not be greatly increased by the increase in the volume of solid waste taken to existing facility. Minimal impacts would occur with the use of BMPs.
LSI • Minimal impacts would occur due to geologic hazards.

Legend: LSI = Less Than Significant Impact.* Preferred Alternative

Solid waste basic alternative 1 would not involve new or expanded facilities. It would involve higher generation of solid waste. Therefore, the impacts of solid waste to geological and soil resources would be less than significant.

5.2.6 Off Base Roadways

5.2.6.1 Alternative 1

Alternative 1 would result in direct impacts to geologic resources as a result of construction. Impacts on geological resources could include soil disturbance and the suspension of soil, soil loss, and localized erosion. Ground disturbance for roadway improvements would be conducted in accordance with construction SOPs listed in Section 5.2.2.1 and below and BMPs listed in Volume 7

- Individual roadway projects would be designed and constructed in accordance with recommendations of the project- and site-specific geotechnical investigation and applicable geotechnical code requirements. Each project would be designed and constructed in accordance with recommendations from a registered professional geologist for the following aspects, as applicable, and included in the project-specific geotechnical investigation: liquefaction, erosion, site grading, excavation and utility trenches, foundations, mitigation of soil corrosivity on concrete, and seismic design criteria. Approval by a licensed Geotechnical Engineer would be required for placement and compaction of fill, backfilling of trenches, and testing of soils.
- Earthwork would be conducted using BMPs to minimize erosion during demolition and road or bridge construction including, but not limited to, watering for dust control during earthwork to minimize soil loss; and establishing grass or other landscaping in disturbed areas immediately after construction is completed.
- Material from demolition of existing road pavements shall be stored in previously disturbed areas whenever possible.
- For projects involving military access, control erosion through the Site Approval Process, whereby each proposed project is reviewed for its erosion potential. Obtain concurrence of the designated installation Natural Resource Specialist in the process.
- Manage erosion in accordance with the applicable Storm Water Pollution Prevention Plans at each roadway project location.

<u>North</u>

Thirteen GRN projects would occur in the North Region as a result of Alternative 1:

- One intersection improvement project (GRN #117) and two pavement strengthening projects (GRN #8 and 23) would not require road widening or road realignment in previously undisturbed ground. No impacts to geological resources and soils would occur.

- Four intersection improvement projects involving modifications to MAPs (GRN #38A, 39A, 41A, and 42) would be required. To construct new access gates, removal of vegetation and disturbance to Limestone Upland soils would be required.
- Five road widening projects (GRN #9, 10, 22, 22A, and 57) would require removal of vegetation and disturbance to Limestone Upland soils.
- Construction of the Finegayan Connection, a new road (GRN #124), would require removal of vegetation and disturbance to Limestone Upland soils.

Soil disturbances from the latter three project groups described above could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of construction SOPs and BMPs, impacts from soil erosion would be prevented or minimized. Alternative 1 would result in less than significant impacts to unique geologic resources and would not result in significant soil erosion. Impacts to soils would be considered less than significant.

Central

Twenty-seven GRN projects would occur in the Central Region as a result of Alternative 1:

- Three intersection improvement projects (GRN #1, 2, and 113) and 16 pavement strengthening projects (GRN #6, 7, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 30, 31, 32, and 33) would not require road widening or road realignment in previously undisturbed ground. No impacts to geological resources and soils would occur.
- Two intersection improvement projects involving modifications to MAPs (GRN #44 and 46) would be required. Both projects would occur in previously developed areas, and minimal soil disturbance would be required.
- Two bridge replacement projects (GRN #3 and 35) would require clearing and excavation of soil, as well as construction activities adjacent to, and over water.
- Three road widening projects (GRN #16, 28, and 29) would require removal of vegetation and disturbance to Limestone Upland soils.
- The relocation of Route 15 (GRN #36) would require removal of vegetation and disturbance to Limestone Upland soils.

Soil disturbances from the latter three project groups described above could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of appropriate SOPs and BMPs, impacts from soil erosion would be prevented or minimized. Impacts to soils would be considered less than significant.

Apra Harbor

Five GRN projects would occur in the Apra Harbor Region as a result of Alternative 1:

- One intersection improvement project (GRN #5) and three pavement strengthening projects (GRN #4, 24, and 26) would be required. While GRN #4, 24 and 26 would not require road widening or realignment, GRN #5 would require removal of vegetation for road widening and would result in limited soil disturbance.
- One intersection improvement project involving modification to a MAP (GRN #50) would be required. This access point would be constructed on previously cleared ground, and soil disturbance would be minimal.

Soil disturbances from projects GRN #5 and GRN #50 could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation

of appropriate SOPs and BMPs, impacts from soil erosion would be prevented or minimized. Impacts to soils would be considered less than significant.

South

Four GRN projects would occur in the South Region as a result of Alternative 1:

- One intersection improvement project (GRN #110) and two pavement strengthening projects (GRN #25 and 27) would not require road widening. No impacts to geological resources and soils would occur.
- One intersection improvement project involving modification to a MAP (GRN #52) would be required. This access point would be constructed on previously cleared ground, and soil disturbance would be minimal.

Soil disturbances from the GRN #52 project could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of appropriate SOPs and BMPs, impacts from soil erosion would be prevented or minimized. Impacts to soils would be considered less than significant.

Potential Mitigation Measures

No mitigation measures would be required. Alternative 2 (Preferred Alternative)

5.2.6.2 Alternative 2

North

Thirteen GRN projects would occur in the North Region as a result of Alternative 2:

- One intersection improvement project (GRN #117) and two pavement strengthening projects (GRN #8 and 23) would not require road widening or road realignment in previously undisturbed ground. No impacts to geological resources and soils would occur.
- Four intersection improvement projects involving modifications to MAPs (GRN #38, 39, 41, and 42) would be required. To construct new access gates, removal of vegetation and disturbance to Limestone Upland soils would be required.
- Five road widening projects (GRN #9, 10, 22, 22A and 57) would require removal of vegetation and disturbance to Limestone Upland soils.
- Construction of the Finegayan Connection, a new road (GRN #124), would require removal of vegetation and disturbance to Limestone Upland soils.

Soil disturbances from the MAP intersection improvements and road widening project groups described above could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of construction SOPs as listed in Section 5.2.2.1 and Alternative 1 and BMPs listed in Volume 7, impacts from soil erosion would be prevented or minimized. Alternative 2 would result in less than significant impacts to unique geologic resources or result in significant soil erosion. Impacts to soils would be considered less than significant.

Central

Twenty-seven GRN projects would occur in the Central Region as a result of Alternative 2:

- Three intersection improvement projects (GRN #1, 2, and 113) and 16 pavement strengthening projects (GRN #6, 7, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 30, 31, 32, and 33) would not require road

widening or road realignment in previously undisturbed ground. No impacts to geological resources and soils would occur.

- Two intersection improvement projects involving modifications to MAPs (GRN #44 and 46) would be required. These projects would occur in previously developed areas, and minimal soil disturbance would be required.
- Two bridge replacement projects (GRN #3 and 35) would require clearing and excavation of soil, as well as construction activities adjacent to, and over water.
- Three road widening projects (GRN #16, 28, and 29) would require removal of vegetation and disturbance to Limestone Upland soils.
- The relocation of Route 15 (GRN #36) would require removal of vegetation and disturbance to Limestone Upland soils.

Soil disturbances from the latter three project groups described above could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of appropriate SOPs listed in Section 5.2.2.1 and Alternative 1 and BMPs listed in Volume 7, impacts from soil erosion would be prevented or minimized. Impacts to soils would be considered less than significant.

Apra Harbor

Impacts would be nearly identical to Alternative 1.

South

Impacts would be nearly identical to Alternative 1.

Potential Mitigation Measures

No mitigation measures would be required. Standard construction SOPs and BMPs would be to the same as Alternative 1.

5.2.6.3 Alternative 3

North

Twelve GRN projects would occur in the North Region as a result of Alternative 3. Roadway projects would be the same as those described for Alternative 1, with the exclusion of GRN #124 (Finegayan Connection) that would not be constructed and different locations of the Main Gate and commercial gate to NCTS Finegayan. Soil disturbances from Alternative 3 projects could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of appropriate SOPs as listed in Section 5.2.2.1 and Alternative 1 and BMPs listed in Volume 7, impacts from soil erosion would be prevented or minimized.

Central

Twenty-nine GRN projects would occur in the Central Region as a result of Alternative 3:

- Three intersection improvement projects (GRN #1, 2, and 113) and 13 pavement strengthening projects (GRN #6, 7, 11, 12, 13, 14, 15, 17, 18, 21, 30, 32, and 33) would not require road widening or road realignment in previously undisturbed ground. No impacts to geological resources and soils would occur.

- Five intersection improvement projects involving modifications to MAPs (GRN #44, 46, 47, 48 and 49) would be required. These projects would occur in previously developed areas, and minimal soil disturbance would be required.
- Two bridge replacement projects (GRN #3 and 35) would require clearing and excavation of soil, as well as construction activities adjacent to, and over water.
- Five road widening projects (GRN #16, 28, 29, 63, and 74) would require removal of vegetation and disturbance to Limestone Upland soils.
- The relocation of Route 15 (GRN #36) would require removal of vegetation and disturbance to Limestone Upland soils.

Soil disturbances from the latter three project groups described above could result in an increased rate of erosion and soil loss. Soil erosion would be a concern for discharge into any nearby surface waters. With implementation of appropriate SOPs and BMPs, impacts from soil erosion would be prevented or minimized.

Apra Harbor

Impacts would be nearly identical to Alternative 1.

South

Impacts would be nearly identical to Alternative 1.

Potential Mitigation Measures

No mitigation measures would be required.

5.2.6.4 Alternative 8

North

Impacts would be nearly identical to Alternative 1.

Central

Impacts would be nearly identical to Alternative 1.

Apra Harbor

Impacts would be nearly identical to Alternative 1.

South

Impacts would be nearly identical to Alternative 1.

Potential Mitigation Measures

No mitigation measures would be required.

5.2.6.5 No-Action Alternative

Under the no-action alternative, Marine Corps units would remain in Japan and would not relocate to Guam, the visiting aircraft carrier would berth at Kilo Wharf, and an Army Air and Missile Defense Task Force would not be positioned on Guam; therefore, the no-action alternative would obviate the need to improve roads necessary for the military relocation. While none of the GRN projects identified herein would be constructed, road improvements associated with the organic growth of Guam's population would continue. The road segment and intersection improvement projects planned by the GovGuam are

identified in Table 2.5-4. Road improvements supporting organic growth would most likely require vegetation removal, grading, excavation and/or cut and fill, use of heavy equipment, and possible leaching of contaminants into soils; therefore, direct and indirect effects associated with localized soil disturbance would also occur as a result of the no-action alternative. Future organic growth projects would be conducted in previously disturbed areas in accordance with established procedures and site-specific constraints, including BMPs to prevent effects such as erosion or loss of topsoil. With incorporation of SOPs and BMPs identified for Alternative 1, the roadway projects to be conducted for the no-action alternative would have minimal effects on geological resources and soils.

The geologic hazards associated with earthquakes, active volcanoes, and collapse of subterranean cavities in limestone formation have not resulted in any impact on existing roadways. Localized disruption of soils may result from GovGuam road widening projects that extend beyond the existing road footprints. With adherence to SOPs and BMPs for control of erosion, impacts to geologic resources would be less than significant.

2013/2014

The years 2013/2014 represent the roadway network without any future plans for improvements for the military buildup. While no construction associated with the planned military buildup would occur, GovGuam would have initiated construction of road segment and intersection improvement projects along segments of Routes 1, 7, 10A, and 27 (extension), and Tiyan Parkway, as identified in Table 2.5-4. With incorporation of SOPs and BMPs for roadway construction, the no-action alternative would have less than significant impacts on geological resources or soils.

2030

The year 2030 represents the roadway network without any future plans for improvements for the military buildup. While no construction associated with the planned military buildup would occur, GovGuam would have completed construction of road segment and intersection improvement projects along segments of Routes 1, 2, 4, 7A, 16, 25, and 26, as identified in Table 2.5-4. With incorporation of SOPs and BMPs for roadway construction, the no-action alternative would have less than significant impacts on geological resources or soils.

5.2.6.6 Summary of Impacts

Table 5.2-10 summarizes the potential impacts of each alternative.

Table 5.2-10. Sumary of Potential Roadway Project Impact

Potentially Impacted Resource	*Alternative 1*	*Alternative 2**	*Alternative 3*	*Alternative 8*
Increased rate of erosion and soil loss from physical disturbance	LSI	LSI	LSI	LSI
Soil contamination levels that are potentially harmful to human health or the environment	LSI	LSI	LSI	LSI
Increased vulnerability to geologic hazards	LSI	LSI	LSI	LSI

*Legend: LSI = Less Than Significant Impact. * Preferred Alternative*

Construction activities would consist of intersection improvements, bridge replacements, pavement strengthening, road relocation, road widening, and construction of a new road. While the typical activities associated with each of these types of roadway construction projects would involve work in developed and paved areas, some roadway projects could result in alteration of topography and disturbance to soils.

These disturbances could lead to an increased rate of erosion and soil loss. Loss of vegetation would contribute to soil loss and erosion. Improper storage of construction materials could result in spills or leaks that could result in contaminants leaching into the soil. Construction SOPs and BMPs would be implemented to avoid or minimize potential effects on geologic resources and soils. Roadways and bridges would be designed in accordance with specific geotechnical considerations to prevent impacts from geologic hazards. With implementation of SOPs and BMPs, these impacts would be less than significant.