CHAPTER 2. PROPOSED ACTION AND ALTERNATIVES

The proposed military relocation on Guam associated with the relocation of the U.S. Marine Corps (Marine Corps), the Navy aircraft carrier berthing, and the Army Air and Missile Defense Task Force (AMDTF) would increase the demand for power, potable water, and wastewater utilities. It would also affect the remaining life of existing solid waste facilities and the demand for the new Government of Guam (GovGuam) Layon Landfill in Dandan. The proposed actions would also require roadway improvements. To support the proposed military relocation, utility and roadway alternatives were developed.

It is anticipated that some solutions would be implemented by Special Purpose Entities (SPEs), which would likely be SPEs formed to finance, operate, manage, upgrade, or develop utility plants and associated infrastructure such as collection or distribution systems. It is anticipated that the SPEs would utilize GoJ financing provided in accordance with the Realignment Roadmap. Alternatively, GoJ financing could be provided to Guam utilities to conduct the upgrades. The precise manner in which these SPEs would operate is not known. The Department of Defense (DoD) will not exercise any authority or control over the SPEs but is committed to facilitate discussions between the Government of Japan, the SPEs, and Guam to focus efforts on addressing utility impacts associated with the realignment, including short-term construction workforce and long-term population growth. The U.S. Government would then likely purchase utilities from the SPE or utility under a Utilities Service Contract. Fees generated through utilities service contracts could be used to repay financing costs. The DoD rate structure would reflect current rates adjusted for inflation. Given that these SPEs have yet to be formed, these business arrangements are not currently defined in detail. Therefore, they are presented as "conceptual" business arrangements.

For utilities, basic and long-term alternatives have been developed.

- ***Basic alternatives*** would meet the demand for utilities to support the military relocation on Guam for both the near-term and long-term and are evaluated in this Final Environmental Impact Statement (EIS) in a project-specific manner. For basic alternatives, no additional National Environmental Policy Act (NEPA) analysis, other than what is included in this EIS, would be conducted.
- ***Long-term alternatives*** would meet the demand for utilities over the long term in the event that the basic alternatives are found to be insufficient in the future. Long-term alternatives are presented conceptually, as much of the detail related to them is unknown and would require substantial study, planning coordination, and budgeting. In the future, if the long-term alternatives are pursued, additional NEPA analysis would be required because the long-term alternatives are currently not ripe for detailed project-specific environmental impact evaluation.

Basic Alternatives

The following basic alternatives for utilities are analyzed in a project-specific manner. They are described in more detail later in this Volume and are graphically presented in Figure 2.0-1.

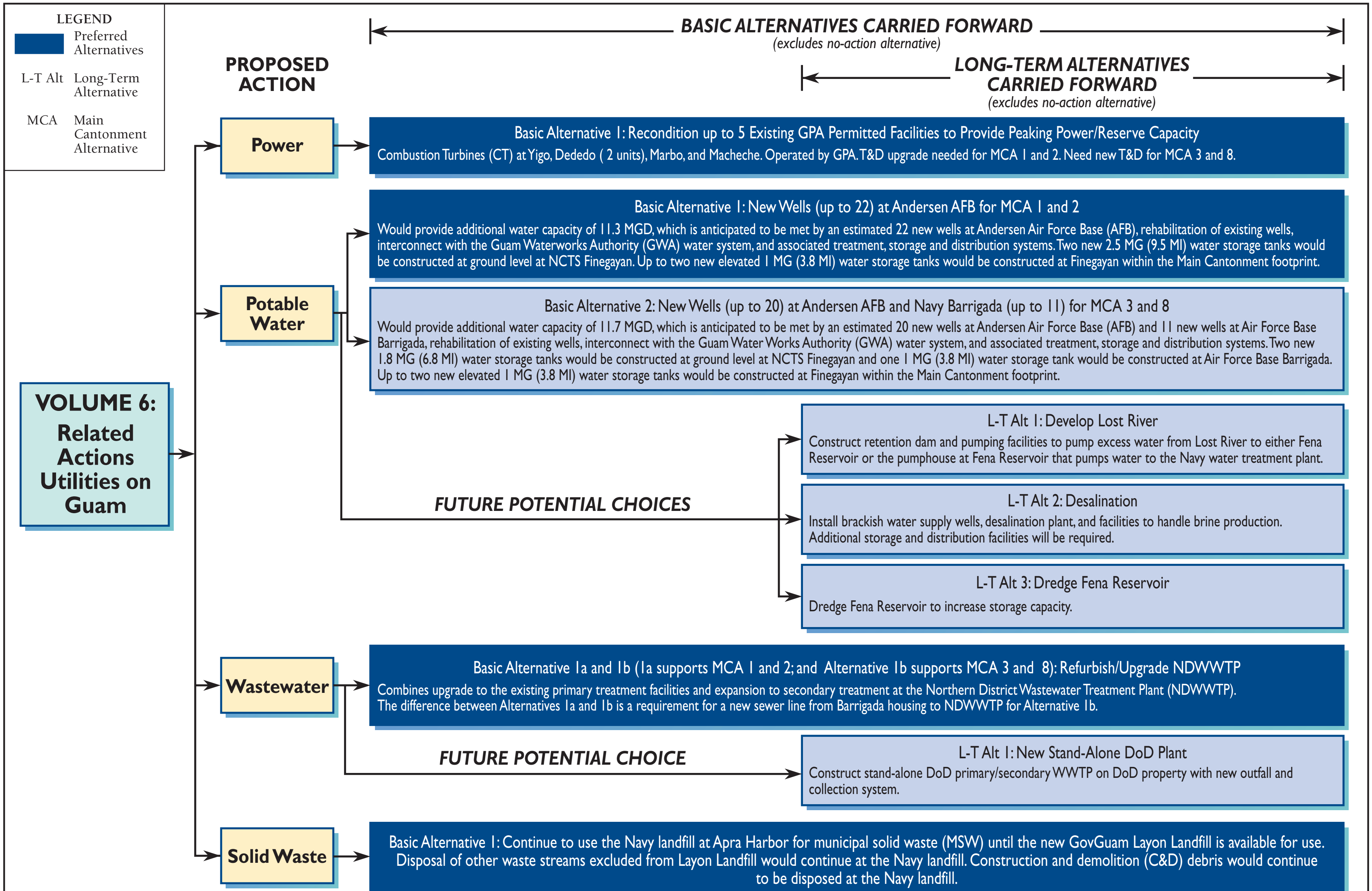

Figure 2.0-1
Summary of Proposed Action and Alternatives Carried Forward for Utilities, Guam

Power

- Basic Alternative 1 — supports all alternatives by reconditioning up to five existing Guam Power Authority (GPA) generating facilities and continue to operate within existing permitted capacity and upgrade Transmission and Distribution (T&D) systems.

The other power alternatives presented in the Draft EIS were deemed unnecessary after the reevaluation of current power demand on the GPA system and estimated increases in power demand from the proposed military relocation. This showed that adequate power would be fairly easily provided in time to accommodate the proposed military relocation.

Potable Water

- Basic Alternative 1 — supports Main Cantonment Alternatives 1 and 2 by providing additional water capacity of 11.3 MGd (42.8 MLd), which is anticipated to be met by an estimated 22 new wells at Andersen Air Force Base (AFB), rehabilitate existing wells, interconnect with the Guam Waterworks Authority (GWA) water system, and associated treatment, storage and distribution systems. Two new 2.5 MG (9.5 ML) water storage tanks would be constructed at ground level at NCTS Finegayan. Up to two new elevated 1 MG (3.8 ML) water storage tanks would be constructed at Finegayan within the Main Cantonment footprint.
- Basic Alternative 2 — supports Main Cantonment Alternatives 3 and 8 by providing additional water capacity of 11.7 MGd (44.3 MLd), which is anticipated to be met by an estimated 20 new wells at Andersen Air Force Base (AFB) and 11 new wells at Air Force Base Barrigada, rehabilitate existing wells, interconnect with the Guam Waterworks Authority (GWA) water system, and associated treatment, storage and distribution systems. Two new 1.8 MG (6.8 ML) water storage tanks would be constructed at ground level at NCTS Finegayan and one 1 MG (3.8 ML) water storage tank would be construction at Air Force Base Barrigada. Up to two new elevated 1 MG (3.8 ML) water storage tanks would be constructed at Finegayan within the Main Cantonment footprint.

Wastewater

- 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 Basic Alternatives 1a & 1b is an additional requirement for a new sewer line from new proposed DoD housing at Barrigada to NDWWTP for Basic Alternative 1b.

Solid Waste

- Basic Alternative 1 — supports all alternatives with the continued use of the Navy landfill at Apra Harbor for municipal solid waste (MSW) until the new GovGuam Layon Landfill at Dandan is available for use. Disposal of other waste streams excluded from Layon Landfill would continue at the Navy landfill. Construction and demolition (C&D) debris would continue to be disposed at the Navy hardfill.

Long-Term Alternatives

As mentioned previously, a programmatic approach is taken in this Final EIS for long-term alternatives. Based on available information, the potential environmental effects associated with the long-term utility projects are analyzed for impacts to the utilities themselves but impacts of the long-term utilities alternatives to other resource areas are not analyzed in this EIS. Additional studies further defining these long-term alternatives are required to properly assess the impacts on the other resource areas. Those studies are beyond the time frame required for this EIS. If such projects were to be pursued, additional NEPA documentation and resource surveys would be completed in the future when project-specific information and funding becomes available for these long-term projects.

The following long-term utilities alternatives are analyzed in a programmatic manner. They are described in more detail later in this Volume.

Potable Water (to augment basic alternative chosen if required):

- Long-Term Alternative 1 — Development of Lost River
- Long-Term Alternative 2 — Desalination of Brackish Water
- Long-Term Alternative 3 — Dredge Sediment from the Navy Reservoir to Increase Storage Capacity

Wastewater (if required):

- Long-Term Alternative 1 — New DoD Only Stand Alone Primary/Secondary Treatment Facility on DoD land at Finegayan including a New Outfall in Support of all Main Cantonment Alternatives.

The utility studies assumed that the construction workforce would reside off base and would be served by Guam public utilities at their places of residence. The dates when utility demand would exceed capacity were estimated to assess the potential effect on Guam public utilities of the combined DoD population increases, construction workforce increases, and civilian population increases with specific discussion of impacts on the NDWWTP, the GWA water system, and the GPA Island-Wide Power System (IWPS).

A socioeconomic analysis performed in support of this EIS projected that in addition to direct increases in DoD-related personnel, the on-base civilian workforce, and the temporary construction workforce, the proposed military relocation would likely affect civilian population growth. The population loadings developed by the socioeconomics team and assumed for analysis in this Final EIS are summarized in Volume 1, Table 2.1-2.

Non-project population increases for the Air Force, Navy, and Coast Guard are considered in the utilities analyses to ensure adequate services and capture the entire impact for the foreseeable future. These "non-project" populations are shown in Table 2.0-1.

All the DoD bases on Guam are now considered one joint region with the Navy as the administrator of base operations and maintenance. However, for the sake of clarity in this EIS, the various utilities systems are still referred to by their original military administrator (e.g., AF Water System, Navy Water System, AF Recycling Center, Navy Landfill).

For roadways, the alternatives listed below were developed in conjunction with each cantonment alternative configuration and are analyzed in a project-specific manner. Each alternative consists of a set of Guam Road Network (GRN) projects, the majority of which are common to all four alternatives. Each project may consist of one or more of six types of roadway improvements (intersection improvements [including Military Access Points (MAP)], bridge replacements, pavement strengthening, roadway widening, roadway relocation, and new road). They are described in more detail later in this Volume and presented in Table 2.5-3. Alternative 2, the preferred Off Base Roadways alternative, supports the preferred Main Cantonment Alternative (also referred to as Alternative 2).

- Alternative 1 — There are 49 GRN projects that would be required for Alternative 1. These are listed in Table 2.5-3, with the exception of GRN #s 38, 39, 41, 47, 48, 49, 49A, 63, and 74. These projects consist of 24 pavement strengthening, 7 roadway widening, 14 intersection improvements (includes 8 MAPs), 2 bridge projects covering a total of eight bridge or culvert replacements, 1 road relocation, and 1 new road.
- Alternative 2 — There are 49 GRN projects that would be required for Alternative 2. These are similar to the GRN projects for Alternative 1 but reflect different locations and configurations for some of the MAP projects.
- Alternative 3 — There are 51 GRN projects that would be required for Alternative 3. These are listed in Table 2.5-3, with the exception of GRN #s 20, 31, 38A, 39A, 41, 41A, and 124. These projects consist of 22 pavement strengthening, 9 roadway widening, 17 intersection improvements (includes 11 MAPs), 2 bridge projects covering a total of eight bridges or culvert replacements, and 1 road relocation.
- Alternative 8 — There are 50 GRN projects that would be required for Alternative 8. They are listed in Table 2.5-3, with the exception of GRN #s 38, 39, 41, 47, 48, 49, 63, and 74. These projects consist of 24 pavement strengthening, 7 roadway widening, 15 intersection improvements (includes 9 MAPs), 2 bridge replacements projects covering a total of eight bridges or culvert replacements, 1 road relocation, and 1 new road.

Table 2.0-1. Projected "Non-Project" Population Considered in the Analysis of Utilities

	Baseline[1] (Non-Project)	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*Total at 2019 (incl. baseline)*
Non-Project*: Air Force[2]												
Active	2,145	80	80	80	80	120	120	120	120	120	120	2,265
Dependents (44% Spouse, 56% Children)	2,950	118	118	118	118	210	210	210	210	210	210	3,160
Transient	0	900	900	1,256	1,256	1,256	1,256	1,256	1,256	1,256	1,780	1,780
Civilian Work Force (on-base)[2]	805	17	17	17	17	25	25	25	25	25	25	830
Subtotal	5,900	1,115	1,115	1,471	1,471	1,611	1,611	1,611	1,611	1,611	2,135	8,035
Navy[3]												
Non-Project: Active	4,350	0	0	0	0	0	80	80	80	80	280	4,630
Non-Project: Dependents (44% Spouse, 56% Children)	5,230	0	0	0	0	0	50	50	50	50	50	5,280
Non-Project: Civilian Work Force (on-base)[3]	1,631	0	0	0	0	0	3	3	3	3	10	1,641
Subtotal	11,211	0	0	0	0	0	133	133	133	133	340	11,551
Non-Project*: United States Coast Guard[4]												
Active	140	0	0	0	50	50	50	50	50	50	50	190
Dependents (44% Spouse, 56% Children)	180	0	0	0	30	30	30	30	30	30	30	210
Transient	0	0	0	0	0	0	0	0	0	0	0	0
Civilian Work Force (on-base)[5]	53	0	0	0	10	10	10	10	10	10	10	63
Subtotal	373	0	0	0	90	90	90	90	90	90	90	463
Grand Total Non-Project:	17,484	1,115	1,115	1,471	1,561	1,701	1,834	1,834	1,834	1,834	2,565	20,049

Notes:
[1]Baseline loadings (from the Guam Integrated Military Development Plan, July 2006) are not included in projected loadings (years 2010-2019). Projected loading numbers for each year are additive for each year from 2010 through 2019. "Total at 2019" column is baseline plus projected loadings.
[2]15 Sep. 08 Congressional Memo (using specific Air Force #s in the 22 Aug 08 Gregory Perkinson email for civilian workforce, factoring out 25% who are assumed to be dependents, and 25% who are assumed current Guam residents).
[3]15 Sep. 08 Congressional Memo is basis for Aircraft Carrier (CVN) transient load; 22 Dec 08 email from Thomas McLemore (Numbers) is the basis for other numbers. 25% of the civilian workforce was assumed to be part of the dependent population, and 25% were assumed current Guam residents.
[4]Guam Integrated Military Development Plan, 2006.
[5]Civilian Work Force is 40% of Active Duty and of that 40%, 25% live on base (are assumed part of the dependent population). An additional 25% are assumed current Guam residents.

2.1 POWER

2.1.1 Overview

The proposed actions on Guam would create an increased power demand. Table 2.1-1 lists the anticipated demand for each component of the proposed military relocation, including the AMDTF. The estimated total Marine Corps demand is 21.36 megawatts (MW) and total estimated future DoD demand is 126.29 MW (existing, transient, and future). The total demand is anticipated to occur as early as 2015, when all planned facilities would be in service and operational. Each of the demand values in Table 2.1-1 is based on the Unified Facilities Criteria (UFC) planning criteria, but does not include additional capacity for future growth, which would be used for long-term power generation planning.

Power requirements presented are based on planned facilities to meet the needs of the projected population. Different Main Cantonments would require different T&D upgrades, but the basic facility demands would be the same as presented in Table 2.1-1. Proposed generation facilities are expected to remain the same in both capacity and location.

The DoD estimates a future peak demand of 126.29 MW. This includes 56 MW of current DoD demand at existing DoD facilities on Guam, a total of 9.11 MW from other planned non-project DoD actions, a total of 21.36 MW from the proposed Marine Corps relocation, and a net total of 39.82 MW of transient demand.

Transient power demand would occur when either the proposed berthing of a transient aircraft carrier and escorts or the ships that make up an Expeditionary Strike Group (ESG) would be in port. The demand from the transient aircraft carrier and associated escort ships is estimated at 39.82 MW. The ESG demand is estimated at 16.78 MW. The transient aircraft carrier and its associated escort ships would not be in port at the same time as an ESG; therefore, the power demand for the transient aircraft carrier and an ESG is not combined. The higher demand number related to the transient aircraft carrier was considered in demand projections and is part of the total estimated future demand of 126.29 MW.

Table 2.1-1. Estimated Department of Defense Power Demand for Guam

Demand Description	*Demand (MW)*			
	Existing DoD Demand	*Other Planned DoD Demand Increases*	*Marine Corps Demand Increases*	*Total DoD Future Planned Demand*
Andersen AFB	In Total	7.76	1.12	8.88 + exist
Northwest Field	In Total	0.00	0.00	0.00 + exist
Andersen South	In Total	0.00	0.00	0.00 + exist
NCTS Finegayan (plus utilities)	In Total	0.88	20.00	20.88 + exist
Barrigada	In Total	0.00	0.00	0.00 + exist
Naval Hospital	In Total	0.47	0.00	0.47 + exist
Naval Base Guam	In Total	0.00	0.24	0.24 + exist
Total Demand (excludes transient)	56	9.11	**21.36**	86.47
Naval Base Guam (max. transient demand) [1]				39.82
Total Electrical Demand (MW) [2]				**126.29**

Notes:
[1] Represents maximum demand on any given day for aircraft carrier and associated escort ships (Navy), or Expeditionary Strike Group (ESG) (Marine Corps) (not in port on the same days).
[2] For 19 service locations.
Legend: AFB = Air Force Base; DoD = Department of Defense; MW = megawatts; NCTS = Naval Computer and Telecommunications Station.
Source: NAVFAC Pacific *2010f*.

Current planning for the transient demand includes a dedicated transmission line between the planned transient aircraft carrier berthing at Polaris Point and Piti Substation, located near Cabras Power Plant. Under the proposed action for a transient aircraft carrier wharf, there would be a cumulative total of up to 63 visit days per year, with an anticipated length of 21 days or less per visit. Because of the short length of the transient visits, such visits are categorized as a peaking type load, and planned power for transient ships would be provided by peaking-power facilities instead of a base load power generation facility.

A peaking-power facility is operated for relatively short periods of time and often has a lower installed cost per MW of capacity because of the type of facility and operating requirements. Base load power generation must operate continuously except for periods of maintenance or equipment failure, thus typically has a higher cost per MW of installed capacity to achieve this operational ruggedness. Thus, using peaking power units for short time periods is more economical when factoring in capital costs.

The non-transient DoD demand increase is estimated to be 30.47 MW (126.29 MW – 39.82 MW – 56 MW). Power usage at existing DoD facilities was evaluated to determine their ratio of minimum power demand to maximum power demand so the power demand could be segregated into base and peaking type power demands. Thirty-one days of data from 17 DoD utility meters were reviewed and resulted in an approximate ratio of 90/10. That is, 90% of the peak load is the minimum load in a day and generally represents the base load percentage typically needed to serve DoD demand.

The minimum continuous demand from the existing DoD system is approximately 90% of the peak demand. The 90/10 ratio of base demand to peak demand is applied to the anticipated future DoD demand, which results in a required increased base demand of 27.42 MW, with 3.05 MW plus the transient load of 39.82 MW, which results in an additional peaking demand of 42.87 MW.

Although the above analysis of power requirements does include power required for the transient ships, the basic alternative presented does not include this power demand. It is anticipated that a transient aircraft carrier and its escort ships would rely on shoreside utility infrastructure for water, wastewater, and solid waste after 2015. Electric power would be provided in accordance with customer service agreements between Guam Power Authority (GPA) and the U.S. Navy. Any GPA commitments for additional power to support the aircraft carrier and its escort ships will be determined by future CSA modifications. Any required changes in the shoreside power infrastructure or their operations to meet the requirements for the aircraft carrier and its escort ships may require additional NEPA review.

Two other types of demand would increase power demand on Guam. One is induced civilian growth and the other is construction workers. Power demand from induced civilian growth was considered to be similar to but less than existing per capita power demand because less additional infrastructure per person is expected to be required. In other words, the basic infrastructure is currently present on Guam and any additional power consuming infrastructure required to support the induced civilian growth would be less than existing per capita power demand. Given that consideration, the power demand for induced civilian growth was estimated at two-thirds of the current per capita demand for Guam, which is 1.1 kilowatt (kW). The construction worker load was assessed at a smaller demand because of the expectation that construction workers would be in a high-density living arrangement and have somewhat limited amenities in their housing (e.g., minimal yard lighting, minimal/shared kitchen and entertainment appliances). Thus, the power demand from this population was considered at one-third of current per capita civilian demand.

Power demand from induced civilian population growth caused by the planned military relocation on Guam would then be estimated at 0.74 kW average demand per person. Power demand from construction workers would be estimated at 0.36 kW per person. Table 2.1-2 shows the anticipated demand requirements for DoD, construction workers, general population growth projections, and population growth induced by the proposed military relocation on Guam. This table uses an 80/20 split for baseload and peaking load as that is the approximate split GPA uses in managing their generating facilities.

The majority of the construction activities associated with the proposed Marine Corps relocation is expected to be completed between 2012 and 2015, with other non-project actions completing in 2019. The proposed military relocation on Guam coincides with GPA exceeding its “1 day in 4.5 years” reserve capacity to meet reliability goals. This capacity represents a statistical system capacity that would result in an outage of less than 1 day in 4.5 years. The IWPS reserve analysis is based on the Reliability Manual (GPA 1998). In general, the capacity used by GPA to meet its reserve capacity of “1 day outage in 4.5

years" requires a generation capacity in the installed system of approximately 1.52 times the peak demand level. That is, 1.52 MW of supply capacity is required for every 1.0 MW of demand (a simplification of the actual reliability requirements for the power system). GPA's current system supply capacity is indicated in Table 2.1-2 as 324.21 MW and 363.68 MW after the proposed reconditioning of Combustion Turbines (CTs). This is based on a system generation capacity of 492.8 MW and 552.8 MW, respectively, for the years from 2010 to 2014.

GPA's supply forecast is based on an installed generation capacity of 552.8 MW. A review of 1 year of GPA's actual generation capacity indicates an average daily generation capacity of 492.8 MW, or nearly 15% less than its stated capacity. This appears to be largely related to units that are under repair and/or not needed and, therefore, not included in the generation capacity for the daily report. The daily-capacity report is a document produced by GPA that was evaluated over a 1-year period to determine what GPA's typical unavailable capacity is on a regular basis. In this report, the existing CTs had been under repair and/or not needed. A CT refers to a facility that includes a direct-fired turbine (i.e., one in which fuel is fed directly to the turbine) that is connected to and drives a generator for power production. The CT system includes fuel storage and handling, the turbine generator unit, exhaust handling system, cooling system, and related components.

Table 2.1-2. Power Supply and Demand on Guam (MW)

	Megawatts (MW)									
GPA Power System	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Islandwide, including DoD and GPA baseline projected growth										
Existing Guam	272	278	285	290	294	297	300	303	306	309
Guam Induced Civilian Increase (induced growth caused by military increase)	4.93	12.25	19.99	23.44	29.24	22.08	11.23	7.75	7.75	7.88
Construction Worker Increase	1.18	2.99	5.19	6.51	6.7	4.43	1.38	0	0	0
DoD Increase	1.83	2.18	5.04	11.35	17.99	27.55	29.53	29.53	29.53	30.5
Total Demand	279.94	295.42	315.22	331.3	347.93	351.06	342.14	340.28	343.28	347.38
Total Baseload Demand (80%)	223.95	236.34	252.18	265.04	278.34	280.85	273.71	272.22	274.62	277.90
Total Peaking Demand (20%)	55.99	59.08	63.04	66.26	69.59	70.21	68.43	68.06	68.66	69.48
Base Load Supply	352	352	352	352	352	352	352	372	372	372
Other Load Supply (medium load, peaking and reliability reserve)	140.8	140.8	200.8	200.8	200.8	200.8	200.8	200.8	200.8	200.8
Total Supply	492.8	492.8	552.8	552.8	552.8	552.8	552.8	572.8	572.8	572.8
Baseload Supply – Baseload Demand	128.05	115.66	99.82	86.96	73.66	71.15	78.29	99.78	97.38	94.10
Total Supply/1.52 reliability factor	324.21	324.21	363.68	363.68	363.68	363.68	363.68	376.84	376.84	376.84
Total Supply/1.52 – Total Demand	44.27	28.79	48.46	32.38	15.75	12.62	21.54	36.56	33.56	29.46

Legend: DoD = Department of Defense; GPA = Guam Power Authority; MW = megawatts.
Source: NAVFAC Pacific 2010f. GPA 2008 for existing Guam growth projections.

Planning indicates that new power generation capacity would not be required to meet the planned demand increase. However, additional renewable generation is planned by GPA and would be available by approximately 2017. This new power capacity would be approximately 20 MW based on the Integrated Resource Plan (GPA 2008). It is planned to have the reconditioned CTs used as peaking/standby capacity as future generation capacity is added.

2.1.2 Screening Process

The following power generation alternatives were evaluated in the Guam Power Generation Study Report for Proposed USMC [United States Marine Corps] Relocation (Naval Facilities Engineering Command [NAVFAC] Pacific 2010f). These alternatives were evaluated for their ability to provide a long-term solution to meet anticipated increased energy demands.

The following alternative energy sources for producing base load power were considered:

- Ocean Thermal Energy Conversion (OTEC)
- Wind power
- Solar energy conversion
- Biofuel power
- Waste-to-Energy (WTE)
- Fuel cells
- Wave energy conversion
- Geothermal

In addition, the following conventional generation fuel options were considered:

- Heavy (No. 6) fuel oil
- Liquefied Natural Gas
- Diesel No. 2
- Coal

These alternatives were evaluated based on a qualitative approach to identify the most viable alternatives, using the following criteria for base load and peak power generation:

- *Quality:* Stable frequency and voltage (affected by the balance of the IWPS)
- *Quantity:* Sufficiency to handle peak demand and unscheduled surge, coordinated with GPA generation
- *Fuel Source Availability:* Availability of fuel resources to supply generation plants with sufficient reserve storage for extended delivery schedule
- *Cost Effectiveness:* Analysis of cost-versus-benefit analysis
- *Reliability:* Infrequent outages and reliability in excess of 85% (includes planned outages for operation and maintenance)
- *Ability to Support Base Load:* Ability of the source or system to reliably generate power to meet base load demand
- *Suitability of Site:* Reasonable availability of suitable site to construct plant

A summary of these alternatives and evaluation to the criteria is included in Table 2.1-3.

2.1.3 Alternatives Dismissed

The long-term alternatives that were evaluated but dismissed and the rationale for their dismissal are summarized below.

Table 2.1-3. Summary of Alternatives Evaluated for Power Systems

Power System Alternative	*Evaluation Considerations*	*Recommendation*
Ocean Thermal Energy Conversion	• Suitable for base load power • Not a reliable mature technology at utility scale installations • Very high cost of generation capacity (potentially 20 times) when compared to steam or combustion turbine technologies	Eliminated (possible future consideration with technology improvement)
Wind Power Generation	• Marginal wind quality on Guam • Limited data (a study done at Andersen AFB concluded that wind quality was rated as a 2, or approximately 12 mph, on a scale of 1 of 5 with 5 being the best) • Few installed applications with similar typhoon exposure; therefore, not a mature application for the technology in a typhoon area • Not suitable for base load power (wind is not consistent)	Eliminated (possible future consideration with technology improvement)
Solar Energy Conversion	• Not suitable for base load power (energy available only during daylight) • Relatively high cost for energy when compared to conventional technology • Large land area required (possibly not available) to meet demand requirements; therefore, not viable	Eliminated
Biofuel Power Generation	• No source of bioenergy (crops, vegetable oil source) on Guam • Fuel cost is higher than diesel fuel or heavy fuel oil currently used and conversion technology is similar to current generation (no technology advantage)	Eliminated
Waste-to-Energy Generation	• No available site on Guam • Possibly suitable for base load generation • Insufficient quantity of waste to supply generation large enough to support planned loads	Eliminated
Fuel Cell Power Generation	• No current facility larger than 200-500 kW (would not support planned loads) • No site available suitable to support a fuel cell based facility	Eliminated
Wave-Energy Generation	• Insufficient wave energy/intensity to provide viable facility • Occurrence of typhoons limits ability to provide a suitable installation; therefore, not viable • Not commercially available in sufficient size to support planned demand	Eliminated
Geothermal	• Insufficient geothermal activity on Guam based on available data • Generally reliable with consistent energy source • No suitable site on Guam identified	Eliminated (possible future consideration with additional study

Power System Alternative	*Evaluation Considerations*	*Recommendation*
Conventional Generation (Fuel Options)		
Heavy (No. 6) Fuel Oil	• High sulfur content results in excessive air emissions • Most used fuel for existing base load generation • Substantial fuel storage capacity on Guam to support generation needs	Retained
Liquefied Natural Gas	• Fuel not currently available on Guam in quantities to support generation • Supplier identified that would provide turnkey natural gas supply on Guam; therefore, could be a viable option because the desire is to go for cleaner fuels • Fuel can be transported in liquid form (smaller volume) and gasified at the generation site • Lower emissions than diesel or heavy fuel oil	Retained
Coal	• Fuel not currently available on Guam • Stable fuel cost and historically lower than oil to produce energy • High carbon dioxide emissions • Mercury emissions	Eliminated
Diesel No. 2	• Higher fuel cost than heavy fuel oil or coal • Lower sulfur emissions than heavy fuel oil • Available sources on Guam	Retained
Interconnection Options		
Construct a New PE-Owned/Operated Base load Power Plant on DoD-Provided Land with the Ability to Sell Excess Power to GPA	• Unlikely that GPA would purchase power during low DoD use periods (GPA does not currently have a shortage of power) • Additional cost of backup capacity from GPA could increase energy costs another 10% to 20% • The PE would not be able to increase the size of the facility to serve loads outside of Finegayan (and thus reduce the per-MW capital cost)	Eliminated
Construct a New PE-Owned/Operated Base Load Power Plant for Load on North Finegayan with No Connection to the GPA	• A separate system would require the power producer to provide the necessary system backup and spinning reserve capacity to meet system demands and reliability requirements • The system would require privately owned transmission lines to deliver power to remote load locations for loads associated with the Marine Corps relocation, and would require the associated rights-of-way for these transmission line routes • The facility design requirements would include additional standby generation units to address reliability criteria required by the DoD facilities	Eliminated

Power System Alternative	*Evaluation Considerations*	*Recommendation*
Construct a New Power Plant at Cabras/Piti—Combination of Repowering Existing Generation Units and New Power Plant and Distribution System, with Base Load Generation Fueled by Coal and Peaking Generation Fueled by Diesel No. 2	• Coal was dismissed as a viable fuel alternative because of the investment in infrastructure, air quality concerns, and inability of coal to benefit the current generating units on Guam • Land is available near the existing generation facilities in Cabras/Piti that is suitable for development of additional generation capacity • The current nonattainment area near Cabras/Piti would require an agreement with GEPA before any progress could be made to site a facility or increase generation capacity in the Cabras area • Fuel storage/availability is convenient because of proximity to the harbor and existing storage (in the case of diesel and No. 6 fuel oil)	Eliminated
Construct a New Power Plant at Cabras/Piti and Related Distribution System Improvements, and Repower Existing Generation Units, with Base Load Generation Fueled by No. 6 Oil or LNG, and Peaking Generation Fueled by Diesel No. 2 or LNG.	• Use of low-sulfur fuel oil or LNG offers the potential to operate within air quality limits for the area • Land is available near existing generation facilities and T&D systems for interconnection with the IWPS • Close proximity to the harbor allows limited overland transportation of fuel or minimal new pipelines to deliver fuel	Eliminated
Construct a New Power Plant at Potts Junction and Associated Distribution System Improvements to Deliver the Power, and Repower Existing Generation Units, with Base Load Generation Fueled by No. 6 Oil or LNG, and Peaking Generation Fueled by Diesel No. 2 or LNG	• The site area would be less impacted by existing air pollution concerns than the Piti/Cabras location • The area is owned by DoD • Either fuel would need to be trucked in or a new fuel line would need to be built for delivery • A new electrical substation adjacent to the new power plant would be required instead of potential upgrades to an existing substation	Eliminated
Place All Generation Planning, Sizing, and Implementation Responsibility with GPA, Possibly by Using Current Generation Capacity (Including Long-Term Higher Use of Combustion Turbine Site Fueled with Diesel) to Meet Power Needs beyond 2015 and Delay New Generation	• GPA would have final decision regarding use of new generation or longer term operation of existing assets. Existing diesel combustion turbines would have higher energy costs because of higher fuel costs. • Current system performance managed by consolidated commission on utilities would be maintained. • Higher energy costs of combustion turbine operation would be passed on to DoD based on input from GPA. • Current projected demand and generation improvements by GPA would meet electrical needs as discussed in the April 2010 Study.	Retained

Legend: AFB = Air Force Base; DoD = Department of Defense; GEPA = Guam Environmental Protection Agency; GPA = Guam Power Authority; IWPS = Island-Wide Power System; kW = kilowatt; LNG = Liquefied Natural Gas; mph = miles per hour; MW = megawatt; SPE = Special Purpose Entity; T&D = Transmission and Distribution.
Source: NAVFAC Pacific 2010f.

2.1.3.1 Construct a New SPE-Owned/Operated Base Load Power Plant on DoD-Provided Land with the Ability to Sell Excess Power to GPA

This alternative anticipates that a PE would construct a new power-generating facility (on DoD-provided land) to meet the anticipated load requirements for the Marine Corps relocation to Guam. The facility would be configured primarily to provide energy to support DoD loads and would include the ability to sell excess power to GPA. The facility would rely on GPA for backup power requirements.

This alternative was dismissed because of the following primary issues:

- It is unlikely that GPA would purchase power during low DoD use periods. (GPA does not currently have a shortage of power generation that would require such a purchase and needs to maximize use of current assets to cover the cost of the facilities.)
- The additional cost of backup capacity from the GPA could increase energy costs by another 10% to 20%.
- The PE would not be able to increase the size of the facility to serve loads outside of Finegayan (and thus reduce the per-MW capital cost). The customer base would be limited to Finegayan and the amount of power that the GPA would agree to purchase. (Although the system would be sized to meet peak requirements, it would operate at that level for only a small percentage of the time and thus would not maximize output and minimize cost.)

2.1.3.2 Construct a New SPE-Owned/Operated Base Load Power Plant for Load on North Finegayan with No Connection to the GPA

This alternative would establish a separate grid system for planned loads. One of the main issues associated with this approach is backup power and system reliability. In general, a power facility with a firm capacity of 60 MW (e.g., three 20-MW units) would require installation of two additional 20-MW units so that one unit could be removed from service, a second unit could fail, and the 60-MW firm capacity rating could still be met. This would enable the system to provide sufficient capacity for stand-alone power with standby capacity, allowing for maintenance of duty units and continued operation should a duty unit fail unexpectedly. The system's reliability would also be affected by the distribution system design. Most distribution systems provide multiple paths to provide power to a location. The number of paths would depend on the voltage level and type of equipment located at the point in question.

Either of these two issues (generation and distribution) would have a tremendous effect on the installed cost for this alternative. The installed generation capacity could be up to double the estimated demand to meet reliability requirements. Moreover, to maintain an equivalent level of redundancy with the existing GPA transmission system, the distribution system would need to be designed with alternate feeders to be used should the primary feeder fail.

Several other major considerations make this alternative undesirable:

- A separate system would require the power producer to provide the necessary system backup and spinning reserve capacity to meet system demands and reliability requirements.
- The system would require privately owned lines to deliver power to the Finegayan load locations associated with the Marine Corps relocation, and would require the associated rights-of-way for these routes if not on DoD land.
- The facility design requirements would include additional standby generation units to address reliability criteria required by the DoD facilities.

These issues would result in a cost basis that cannot provide a competitive power cost to the new customers associated with the Marine Corps relocation. This option was therefore eliminated from further consideration.

2.1.3.3 Construct a New Power Plant at Cabras/Piti—Combination of Reconditioning Existing Generation Units (20-40 MW) and New Power Plant and Distribution System, with Base Load Generation Fueled by Coal and Peaking Generation Fueled by Diesel No. 2

Coal is a cheaper fuel option than oil, but carries with it some other burdens. Coal use would require a large investment in material handling infrastructure to transport, unload, transfer, and store coal near the new power plant. These activities would require a substantial amount of space. Because this location is currently considered a nonattainment area with regard to air pollution, implementation of this alternative would likely require state-of-the-art combustion such as a fluidized bed that refers to the combustion chamber/process for a boiler system, in combination with exhaust cleanup technologies such as electrostatic precipitators and wet scrubbers. Even with these features, exhaust from the existing oil-fired generators would likely need to be cleaned up to prevent degradation in the region's air quality.

In considering potential new fuel sources, coal offers a viable new and more economical source for only the new power plant. Diesel generators cannot be converted to coal use except through coal liquefaction or gasification, which are both more expensive than oil.

Coal was dismissed as a viable fuel alternative because of the cost of the infrastructure, air quality concerns, and the inability of coal to benefit the current generating units on Guam.

2.1.3.4 Wind Power

Wind turbines for electrical generation are commercially available in sizes from 25 kW to 3,000 kW. Based on review of the available wind studies for Guam, the best areas for wind development for the military are Andersen Air Force Base (AFB) in northern Guam, the ridgeline at the Naval Munitions Site, and the Orote Peninsula at Naval Base Guam in central Guam. Long-term historical wind data are not available for Andersen AFB. Data are available for the Guam Airport: however, winds there average 11 miles per hour (mph) (18 kilometers per hour [kph]) at 164 feet [ft] [50 meters (m) above ground]). Based on a wind-speed scale of Class 1 to Class 5 (with 5 being the best), these speeds achieve only a Class 2 rating. A minimum wind-speed rating of Class 3 (average wind speed of approximately 15 mph [24 kph.]) is generally considered necessary to prove cost effective based on current capital costs.

Because a unit of power varies proportionally with the cube of the wind speed, a 12-mph (19-kph) wind-speed site would have only one-half the potential wind power output of a 15-mph (24-kph) wind-speed site. However, because electrical costs on Guam are much higher than those in the U.S., 12-mph (19-kph) wind speeds may be adequate to make this wind development viable. This fact was also weighed against the much higher construction costs for Guam, compared with average costs in the U.S.

Consideration was also given to typhoon wind requirements. Facility design for Guam requires the ability to withstand 180-mph (290-kph) winds. Although some wind-power towers have been developed in Japan for typhoon conditions, few have withstood typhoon winds to provide a basis for a proven tower design.

Wind energy provides the benefit of being a renewable and sustainable energy source that is nonpolluting. However, visual aesthetics and the large land area required for siting the wind turbines are major considerations. In addition, this energy source is intermittent depending on the actual wind speeds present at the site, and cannot be used as a reliable means of power generation to serve as a continuous-duty or even backup source of power. For these reasons, wind power generation was eliminated from further consideration for base load power generation. However, wind energy could be used to supplement the base load power generation.

2.1.3.5 Photovoltaic Energy (Solar)

The majority of photovoltaic panels for electrical generation are commercially available in crystalline, polycrystalline, and amorphous silicon panels. A residential system is typically 2 kW and commercial applications are typically 50 kW or larger. Inverters are used to convert the direct-current power output from the panels into alternating-current power. Most of these systems are installed on houses or buildings, and supply the power at 120 or 220 volts.

Based on the available solar insulation data for Guam made available by National Renewable Energy Laboratory, a majority of the U.S. military lands on Guam are in areas with an average of 5.08 kilowatt hours per square meter (m^2) per day (or the amount of solar energy that strikes a square meter of the earth's surface in a single day). However, large land or large rooftop areas are required for panel installation. As a rule of thumb, 1 kW of power output requires 100 square feet (ft^2) (9 m^2) of roof area. A 5-MW system would thus require 500,000 ft^2 (152,400 m^2) of area; a 50-MW system, 5,000,000 ft^2 (465,000 m^2). In addition, this energy source is available only during sunlight hours, and is intermittent depending on the weather.

Consideration was given to the wind design requirements associated with typhoon regions. Facility design for Guam requires the ability to withstand 180-mph (290-kph) winds. Photovoltaic systems can be installed with mechanisms that rotate panels and minimize exposure to wind but damage from wind driven objects would be likely during a typhoon.

Consequently, photovoltaic energy cannot be used as a reliable means of continuous-duty or even backup power generation; therefore, solar energy generation was eliminated from further consideration for base load power generation. However, photovoltaic energy could be used to supplement the base load power generation.

Although photovoltaic power generation would not be used for baseline power needs, it may be used for incremental usage. Solar hot water heaters and photovoltaics are being considered for individual buildings including housing and office buildings.

2.1.3.6 Biofuel (Biodiesel) Power

Biofuels, ethanol, and hydrogen can be burned in power-generating turbines or engines principally designed to use fossil fuels. CTs can operate on ethanol or biodiesel, gas engines can operate on ethanol, and diesel engines can operate on biodiesel fuels. Examples include a simple or combined Brayton cycle CT (originally developed for aircraft jet engine technology); reciprocating gas or diesel engine technology can also be employed.

Air emissions from biofuel power plants would be lower than from power plants burning conventional fossil fuels. Improvements in air emission control technology such as low-nitrogen-oxide control burners would further reduce emissions of nitrogen oxides. Further reduction in air emissions is possible with the use of water or steam injection, or with the use of selective catalytic reduction technology. However, these additional emission controls add substantial capital and operational maintenance costs.

Currently, no agricultural business on Guam is developing crops for the biofuel market, and no producers of biofuel are present on Guam. At present, 20% of the land on Guam is used for agriculture, and another 15% is used for pastureland. Although some potential exists for further development, the implementation of biofuel power on a sustainable basis is not realistic at this time. In addition, there are no current biofuel importers on Guam. Thus, biofuels would need to be imported to Guam if they are to be used in the immediate future; therefore, biofuel power generation was eliminated from further consideration.

2.1.3.7 Fuel Cell Power

Fuel cells operate on the chemical reaction between hydrogen and oxygen that produces electricity, and water as a byproduct. Although a few DoD lands using fuel cell power are in operation, the technology is still in commercial development. Although they are also nonpolluting, fuel cells rely on hydrogen as their fuel source. The potential of fuel cell technology to provide reliable power is limited because of the high cost and lack of applications for systems other than small (less than 500-kW) system capacity.

Hydrogen is not commercially available as a fuel source, and extracting hydrogen from water and/or the reducing gas or other fuels into hydrogen requires additional equipment and is energy intensive. Natural gas is often used as a fuel stock for the fuel cells. However, because Guam lacks natural gas resources, the natural gas would need to be imported if it is to be used.

Because this technology is not yet commercially available, and because sustainable sources for the production of hydrogen fuel have not yet been developed and the quantity that could be produced would be limited, the use of fuel cell generators is not recommended at this time; therefore, fuel cell power generation was eliminated from further consideration.

2.1.3.8 Wave-Energy Generation

Wave-energy generators extract the energy carried in ocean waves that flow across the coastline, principally through mechanical action. Wave-energy generators are not commercially available; however, a wave-energy demonstration project sponsored by DoD is being constructed offshore from Marine Corps Base Hawaii. Although wave-energy generators are nonpolluting and renewable, the amount of power extracted from these units would be intermittent and dependent on the strength of the ocean waves. These units cannot be used to provide a reliable means of power for continuous-duty, peak shaving, or emergency power generation; therefore, wave-energy generation was eliminated from further consideration.

2.1.3.9 Waste-to-Energy Conversion

Conventional WTE power plants are steam power plants that sort and burn solid wastes. Because the wastes are normally burned to generate steam (which drives a turbine generator), air emissions are a primary issue. The typical needs for combustion air-emission controls and scrubbing of the waste-exhaust air stream add to the complexity and operating costs for this type of system.

Alternative technologies to conventional WTE steam power plants include gasification, smelting, and plasma-arc technologies. However, none of these competing technologies are yet available in the commercial market.

This alternative was dismissed because under Guam Public Law 25-175, it is unlawful for any person to construct or operate a municipal solid waste incinerator or WTE facility on Guam, as defined by the rules and regulations of the U.S. Environmental Protection Agency (USEPA) or U.S. laws. However, this alternative would still be considered as a supplemental energy source if the law prohibiting operation of a WTE facility were to change to support this technology.

2.1.3.10 Long-Term Renewable-Energy Concepts

Implementation of the renewable-energy concepts discussed below would require additional studies. However, these sources of renewable energy have the potential to provide supplemental power for long-term solutions, given Guam's available resources and available technology. Because these energy concepts may be considered viable as the technology matures, they are being carried as notional options for renewable alternative-energy sources for long-term power solutions.

Ocean Thermal Energy Conversion

OTEC is a method for generating electricity that uses the temperature difference between deep and shallow waters to run a heat engine. As with any heat engine, the greatest efficiency and power is produced with the largest temperature difference. This temperature difference generally increases with decreasing latitude (i.e., near the equator, in the tropics). OTEC systems utilize this temperature gradient between warm surface-ocean waters and cold deep-ocean waters to drive an ammonia-closed cycle, an open cycle, or a combined-cycle power plant. Although none of these systems are in commercial production, the technology has been proven several times. In 1979, a 50-kW demonstration plant was operated at the National Energy Laboratory of Hawaii Authority. This plant generated 50 kW of gross power and a net power of 10 kW, with about 40 kW required for pumping. Although this plant is not currently operating, the Navy is examining a barge-mounted OTEC facility for its Diego Garcia base. A 1-MW net power output production plant is being built at the National Energy Laboratory of Hawaii Authority.

Guam is an ideal location for OTEC because its western coastline fringes on cold deep-ocean water from the Mariana Trench. In fact, a difference of 40 degrees Fahrenheit (22.2 degrees Celsius) can be found between sea level and 3,281 ft (1,000 m) below sea level at a location less than 0.6 mile (1 kilometer) from Guam's shore. This cold ocean water, in conjunction with Guam's warm coastal surface waters, can provide a renewable and sustainable energy source that is nonpolluting. Cold water pumped from the deep ocean can also be used for aquaculture, as a direct cooling source for central chilled-water air conditioning systems, and as a source of freshwater that is generated as a byproduct in open OTEC cycles. Because the supply of deep cold water and warm surface water is available daily throughout the year, OTEC systems could provide a reliable source of power for either continuous-duty or even backup or supplemental power generation.

Geothermal Power Generation

Geothermal power is energy generated from heat stored in the earth, or the collection of absorbed heat derived from underground. Guam is situated several miles east of the southern projection of a historically active line of volcanoes that compose the Mariana volcanic arc. The area is still subject to volcanic activity, with the nearest known active volcanism being an underwater eruption that occurred 100 mi (161 kilometers) north, just south of Saipan. Because the Mariana island chain is at the edge of the subduction zone between the Philippine and Pacific Plates, Guam is subject to frequent earthquakes and tectonic plate movements that make Guam a likely candidate for subterranean volcanic activity and possible geothermal development.

However, there are no known detailed studies or assessment of the geothermal potential for Guam other than a report from the Colorado School of Mines, published in 1975, that provided an overview of the potential for geothermal energy in the Pacific region (Colorado School of Mines 1975). Additional geological studies and drilling are needed to quantify and determine the potential for geothermal development on Guam.

2.1.4 Power Basic Alternative 1 (Preferred)

Power basic alternative 1 was chosen as it utilizes existing GPA generating resources, can be implemented in a timely fashion, and provides adequate power for the proposed relocation and preferred cantonment alternative. Upgrades to T&D facilities would use existing corridors. Not requiring new generating facilities or new T&D corridors renders this a desirable approach, which has been agreed to by GPA. See below for additional details.

It is projected that new power requirements would be the same for all four Main Cantonment alternatives, and only the cantonment locations and thus T&D requirements of the planned DoD facilities would be different. Main Cantonment Alternatives 1, 2, 3, and 8 would require different T&D upgrades to support substantially different load locations. The locations of the currently proposed power sources are shown in Figure 2.1-2.

This alternative would recondition up to five existing permitted GPA CTs to restore the IWPS system to its original design capacity and support required reserve capacity for reliability. These CTs are designated as reserve/peaking units for the power system. Units to be reconditioned would include the CTs at Yigo, Dededo Units No. 1 and No. 2, Marbo, and Macheche. Projected generation requirements to meet demand indicate the ability to serve DoD facilities while maintaining CT operation as dominantly reserve capacity. GPA evaluated an operating scenario that results in CT operation at a maximum of 500 hours per unit per year on average, or 2500 hours per year total for 5 CTs. The 500 hours per unit per year maximum on average was established as a conservative value based on projected generator unit operational data prepared by GPA. This document evaluates generator unit operation by year for years 2010 to 2021 and accounts for all projected demand growth on Guam using 2009 actual data as the baseline (for more details, see Volume 9, Appendix K). A summary of operating hours for the five CTs is presented in Figure 2.1-1.

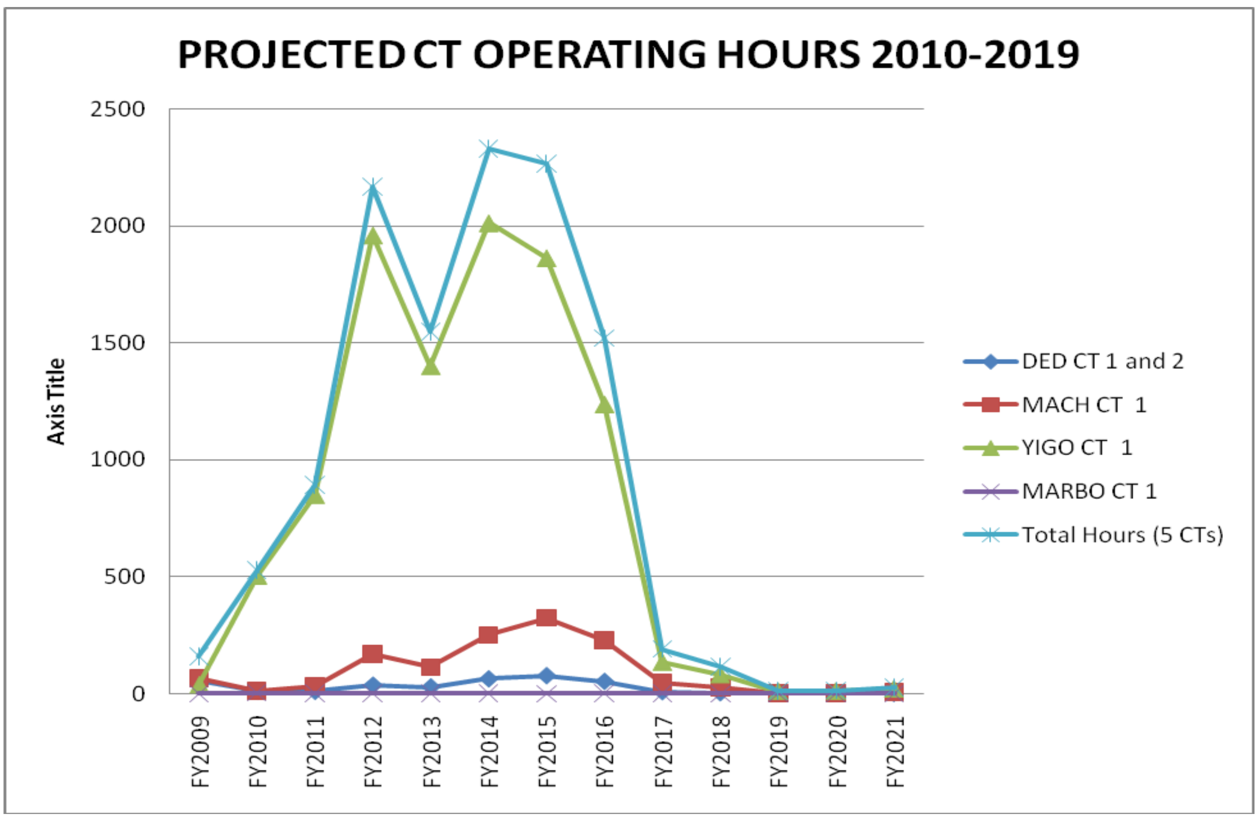

Figure 2.1-1. Projected CT Operating Hours 2010-2019

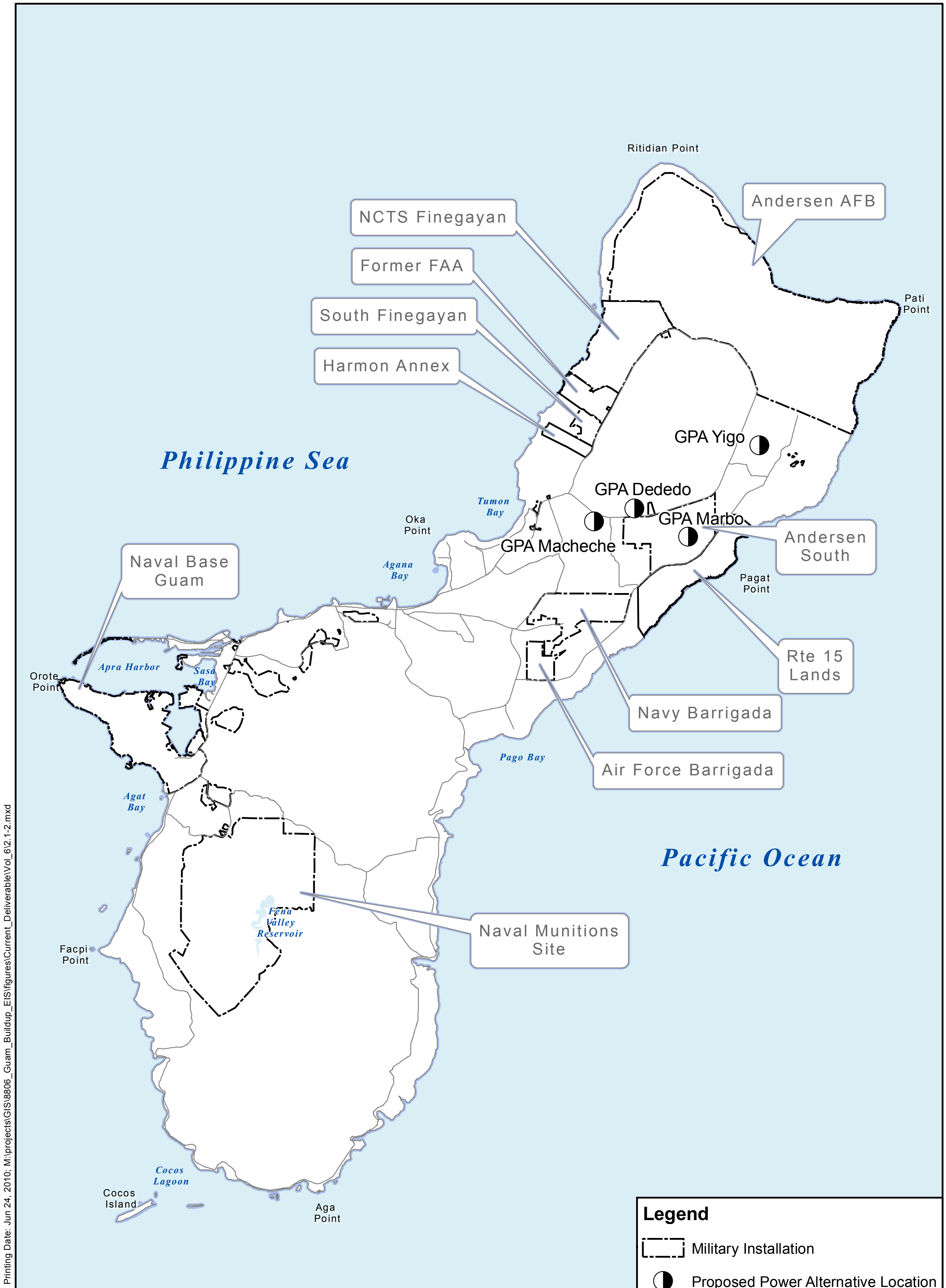

Figure 2.1-2
Proposed Power Alternative Locations

This alternative supports Main Cantonment Alternatives 1 and 2. For Main Cantonment Alternatives 3 and 8, the reconditioned CTs selected would remain the same but require additional upgrades to the T&D system to support these Main Cantonment locations as described in Table 2.1-4.

The evaluation of power generation considered islandwide power capacity and requirements. The DoD load calculations include DoD facilities only, but the effects of construction workers and induced civilian growth were considered when evaluating overall IWPS demands as shown in Table 2.1-2 and also in Chapter 3 of this Volume. This increased demand on the IWPS has been estimated by year in order to evaluate the yearly ability of the IWPS to meet the increased demand. The location of workforce housing is currently in flux, with about 9 applications for housing locations and facilities currently submitted to Guam authorities and one facility already starting construction. Necessary localized power T&D upgrades to support workforce housing would be coordinated between the contractor and GPA.

Present requirements for T&D upgrades associated with the military relocation on Guam for the Main Cantonment Alternatives 1 and 2, in addition to elements required for the Main Cantonment Alternatives 3 and 8, are listed in Table 2.1-4. The anticipated transmission facilities are expected to support the Marine Corps relocation and other proposed DoD actions, including non-project actions. The proposed T&D modifications include the following major components identified as part of Cantonment Alternatives 1 and 2:

- North Finegayan Marine Corps facilities
- South Finegayan Marine Corps facilities
- ESG facilities at Naval Base Guam
- Aircraft carrier located at Polaris Point

The Marine Corps relocation results in impacts to the IWPS. The demand increases require a series of T&D upgrades to support T&D of the increased power. Those T&D upgrades are summarized in Table 2.1-4 and include capacity for all anticipated demands.

Each of the listed upgrades was identified while coordinating with GPA during preparation of the Power Generation Study Report (NAVFAC Pacific 2010f) as well as additional meetings. These upgrades were identified as necessary to meet system requirements for voltage and capacity while maintaining two sources of power to each area. The transmission line projects described would upgrade T&D for Guam circuits that impact Yigo, Andersen, Finegayan, Pott's Junction, Orote, Piti, and Naval Computer and Telecommunications Station (NCTS). These upgrades would be sized to support all Marine Corps projected loads for Finegayan, Andersen AFB, and Main Navy Base to avoid upgrading the same lines twice within a short period of time. The lines follow existing utility distribution rights of way and the new 34.5 kilovolts Harmon/Finegayan/Andersen line would require underground trenching.

The capacitor banks would be installed at existing facility locations (substations, switchgear, or similar locations) and connected to the circuits to improve system voltage regulation. The existing and proposed upgrades to the GPA T&D system for Guam are shown in Figure 2.1-3.

Reconditioning existing CT generation facilities would not require new generating units. This reconditioning would ensure reliability for service as peaking and reserve capacity.

Table 2.1-4. Proposed T&D Upgrades

Item	*Project Description*	*System Overhead/Underground*	*Voltage*
1	Upgrade Piti X20 to Orote X35 line	Overhead	34.5kV
2	Upgrade Harmon X87 to Andersen X73 line	Overhead	34.5kV
3	Upgrade Yigo X160 line to Andersen X70	Overhead	34.5kv
4 and 4A	New Harmon-Finegayan-Andersen Line (via Routes 3 and 9; or Item 4A via Alternate Route 1)	Overhead	115kV
5	New Harmon-Finegayan-Andersen line	Underground	34.5kV
6	New Piti to Orote line	Overhead	115kV
7	New Harmon-Andersen via Route 1 (alternative to item 4 above)	Overhead	115kV
8	New 2-6 MVAR Capacitor Bank at Orote 13.8kV	NA	13.8kv
9	New 2-6 MVAR Capacitor Bank at Andersen 13.8kV	NA	13.8kV
10	New 2-6 MVAR Capacitor Bank at NCTS	NA	13.8kV
11	New Andersen Substation (Anticipated 112 MVA) Power Transformer	NA	115kV
12	New Orote Substation With 112 MVA Power Transformer	NA	115kV
13	New 2-3 MVAR Capacitor Bank at North Ramp 13.8kV	NA	13.8kv
14	Harmon Substation Reconstruction	NA	115kV/34.5kV
15	Piti Substation Reconstruction	NA	115kV/34.5kV
16	New 2-3 MVAR Polaris Point Capacitor Bank	NA	13.8kV
1	AF Barrigada (Eagle Field) Substation located at Air Force Barrigada	NA	34.5kV
2	Line from Barrigada to Air Force Barrigada (Eagle Field)	Overhead	34.5kV
3	Line from Air Force Barrigada (Eagle Field) to Pulantat (essentially re-routing Barrigada to Pulantat 34.5 kV line to go through Eagle Field Substation first)	Overhead	34.5kV
4	Apra to Talofofo Line	Overhead	34.5kV
5	12 MVAR capacitor bank at Air Force Barrigada (Eagle Field) for voltage support.	NA	13.8kV
6	6 MVAR capacitor bank at Navy Barrigada for voltage support	NA	13.8kV

Legend: kV = kilovolt; MVA = mega volt ampere; MVAR = mega volt ampere reactive; NA = not applicable; NCTS = Naval Computer and Telecommunications Station.

2.1.5 Energy Efficiency and Renewable Energy Initiatives

Energy efficiency and renewable energy power generation are both aspects that would allow the DoD to meet the goals set by Executive Orders and Energy Policy Act of 2005 (EPA Act 2005) to reduce energy consumption and increase use of alternative energy sources. Part of the design basis for planned facilities in Guam would be to meet Leadership in Energy and Environmental Design (LEED) silver design goals. This approach would reduce energy consumption in planned facilities. Additional energy goals require sourcing power from renewable resources. The reduction in energy consumption is expected to be more than 10% based on the information presented below.

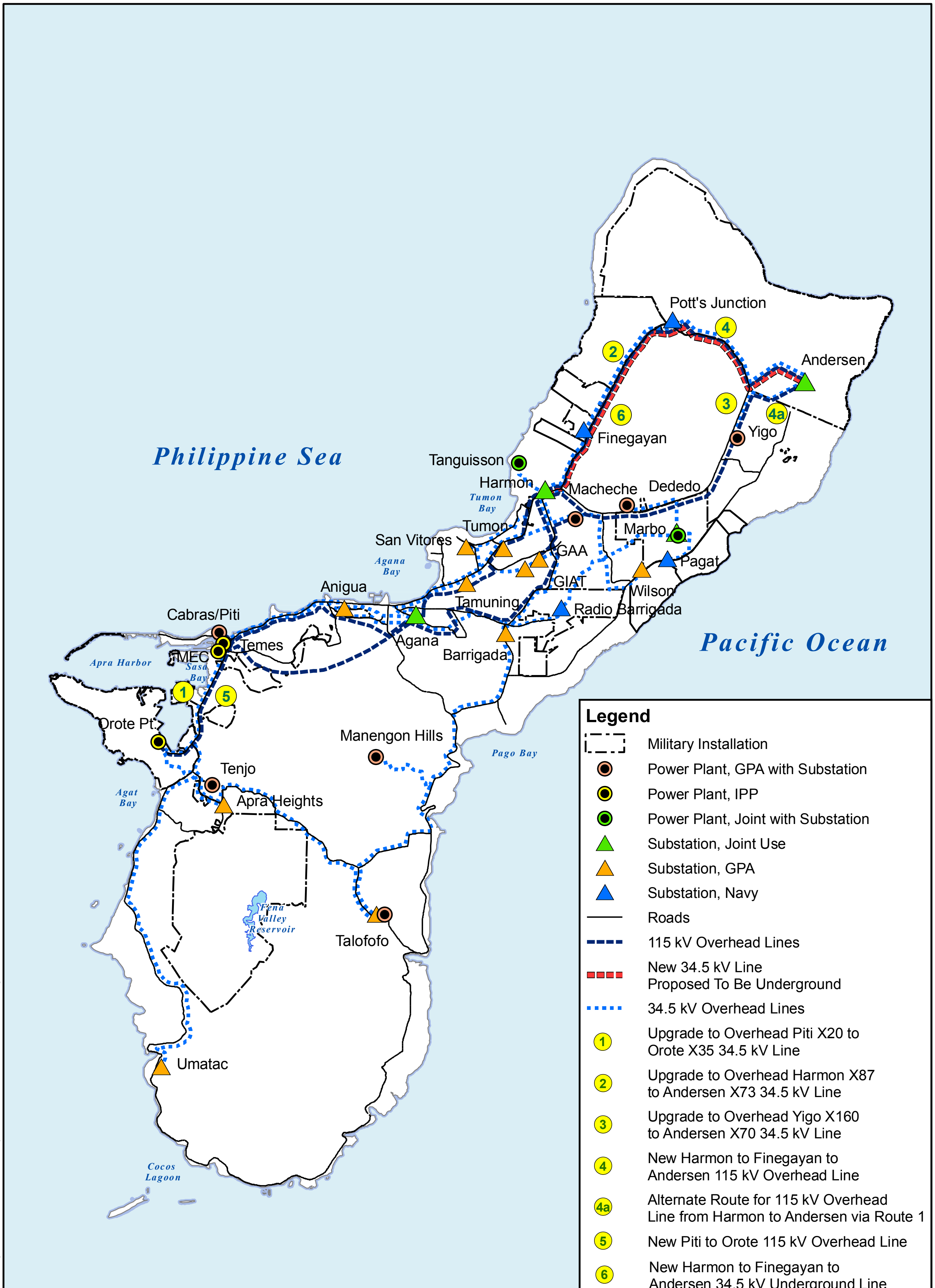

Figure 2.1-3
Proposed Upgrades to Existing GPA T&D System

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A comprehensive energy management plan is being developed for Guam to support the on base development related to the military relocation. The plan has interest from several federal executive departments and would focus on the following: reducing the energy consumption of DoD infrastructure, a "Nega Watt" approach, and the development of renewable energy sources for Guam. Nega Watt and renewable energy efforts would be coordinated closely with GPA. The strategy is comprised of the following basic elements with a listing of some of the measures being taken with respect to existing and proposed facilities:

a. Conservation and demand reduction:

Existing Infrastructure	Relocation Infrastructure
Facility Energy Audits	Smart Metering on all buildings
Energy Conservation Programs	Demand reduced through sustainability
Energy Conservation Investment Program	User training and education
	Smart base technology

b. Sustainable Design/Development Strategies

Existing Infrastructure	Relocation Infrastructure
LEED projects being implemented	All Facilities LEED Silver
Sustainable Program Officer	
Sustainable Systems Integration Modeling	

c. Sustainable Infrastructure

Existing Infrastructure	Relocation Infrastructure
Foot Print Reduction	Low Impact Development
Adaptive Reuse of Facilities	Integrated Site Design
Brown Field Development	Passive Solar Orientation
	Carbon Sequestration
	Reuse of Construction and Demolition Debris
	Transportation Demand Management

d. Renewable Energy

Existing Infrastructure	Relocation Infrastructure
Solar Hot Water System Conversions	Solar Hot Water Systems
Integrated Solar Photovoltaic Systems	Photovoltaic Compatible Facilities
	Renewable Energy Studies

UFC incorporate energy conservation standards and policy from various Executive Orders and public laws to provide guidance and goals for new and renovated DoD facilities. These conservation measures would result in a reduction in the increased demand for utilities. Many of these conservation standards and policy were initiated in compliance with the EPA Act 2005. The following provisions would be incorporated into the planning, design and construction of DoD facilities:

- New Bachelor Enlisted Quarters (BEQ) and Bachelor Officer Quarters would be designed and constructed in accordance with the EPA Act 2005.
- New buildings (excluding residential areas) would be designed to comply with American Society of Heating, Refrigerating and Air Conditioning Engineers Standard 90.1. Based on UFC guidance, the building design would also strive to achieve an energy consumption level that is 30% below American Society of Heating, Refrigerating and Air Conditioning Engineers Standard 90.1.
- New residential buildings would be designed to comply with the International Code Council International Energy Conservation Code. Based on UFC guidance, the building design would

also try to achieve an energy consumption level that is 30% below International Energy Conservation Code standards.

- All new purchases of energy consuming products would be either Energy Star-qualified or Federal Energy Management Program-recommended.
- Relevant energy conservation measures to be considered include:
- Optimizing building orientation to reduce cooling loads or energy loads to cool the buildings
- Building insulation optimization
- Sealing building envelope for air tightness
- “cool roof”
- Using motion detectors to reduce lighting and to setback cooling in unoccupied buildings
- Natural Lighting
- Energy compliance analysis and life cycle cost analysis:
- Systems modeling is being used to analyze usage of energy conservation measures and provide comparative life cycle costs. This process comprehensively examines energy, water, transportation, ecological resources, green building, social/cultural and economic factors. Within the parameters of energy, this modeling evaluates: building insulation; windows; infiltration; lighting; heating, ventilation, and air conditioning systems; delivery efficiency; water use; conventional water heating; solar thermal water heating; and building integrated Photovoltaics. This modeling approach follows a three step process:
- First it considers measures to make the building work more efficiently. This includes orientation, solar shading/high performance facades, and building envelope/air tightness considerations.
- Secondly, use of various levels of system efficiencies is considered, analyzing energy usage, capital, and life cycle costs.
- Thirdly, it considers what potential renewable systems could be utilized for the specific location and facilities.
- To date, this analysis has been performed on two types of buildings: BEQ and duplex housing. The modeling analysis has thus far resulted in the following estimates of energy savings:
- BEQ – 31% savings for $1.88/ft^2
- Duplex House – 32% savings for $4.93/ft^2

The DoD is committed to meet the required 30% energy savings and has identified approaches to reach this goal. The areas that would allow meeting that goal for the BEQ are listed in Table 2.1-5.

The modeling has validated that it is possible to meet the 30% energy reduction at a minimal cost resulting in a lower energy footprint for the new facilities. The DoD is committed to meeting the 30% reduction and would be looking to leverage additional savings where deemed appropriate and affordable on a facility by facility basis. Since the energy compliance behavior of the occupants, proper maintenance of systems, and other life cycle aspects would play a major role in the ability to sustain the full savings, the power demand requirements used for planning purposes provided to GPA were conservatively reduced by 10% instead of the 30% energy savings goal. This conservative approach would cover unknown contingencies and provide GPA with reasonable planning data to address the new demand requirements in a cost effective manner.

Table 2.1-5. Approaches Associated With Achieving 30% Reduction in Facilities Demand

Package Summary	*Baseline*	*Efficiency Approach*
BEQ Energy Modeling Summary		
Windows	Code Minimum	High Efficiency
Infiltration	0.5 ACH	0.25 ACH
Lighting	100% Incandescent Fixtures	50% Incandescent/ 50% Compact Fluorescent
HVAC	Standard Efficiency Packaged Terminal AC	High Efficiency Packaged Terminal AC
DHW Use Reduction	USEPA 1992 Baseline	40% DHW Reduction
Environmental Benefit and Cost Indicators		
% Energy Use Improvement	NA	31.20%
% CO_2 Emissions Improvement	NA	31.20%
Additional Capital Cost ($/ft^2)	NA	$1.88/ft^2
Simple Payback Years	NA	~2

Note: Baseline Defined as ASHRAE 90.1.
Legend: AC= air conditioning; ACH = air flow change rate; BEQ = Bachelor Enlisted Quarters; CO2 = carbon dioxide; DHW = domestic hot water; ft2 = square feet; HVAC= heating, ventilation, and air conditioning; NA = not applicable; USEPA = United States Environmental Protection Agency.

NAVFAC Marianas with the DoD is working to implement alternative energy projects in Guam to lower the use of conventional generation. A contract was awarded with Johnson Controls to replace HVAC equipment, install a grid connected solar photovoltaic system to produce as much as 3% of the energy consumed on base (Naval Base) and similar energy efficiency improvement measures with the anticipated reduction of energy consumption by 6.4MWh per year. Additional work has been done to lay the foundation of a wind energy project planned for the Navy Ordinance Annex area to produce up to 4MW of wind energy. Preliminary data gathering has been done for the area and work is proceeding to implement a wind energy project. While these initiatives are not part of the proposed action, they provide examples of energy reduction projects and alternative energy sources that are being implemented on Guam and reduce power demands on the IWPS.

2.2 POTABLE WATER

2.2.1 Overview

The proposed actions on Guam would be located at Andersen AFB, NCTS Finegayan, South Finegayan, Andersen South, Barrigada, and Naval Base Guam. These areas are currently served by the DoD potable water systems of Andersen AFB and Navy.

2.2.2 Anticipated Demand

Population loadings used to calculate the projected future demand included active duty Marine Corps, Army, and Navy personnel and their dependents, transient personnel associated with the aircraft carrier group and the ESG (non-concurrent transient demand), and demands associated with on-base civilian support workers. These are considered direct actions associated with the proposed military relocation. Table 2.2-1 lists the DoD populations for the military relocation. The EIS considered four main cantonment alternatives. Assessment of the water utilities grouped the main cantonment alternatives by military housing locations for the Marine Corps Base. Main Cantonment Alternatives 1 and 2 have military housing at Finegayan only. Main Cantonment Alternatives 3 and 8 have military housing at Finegayan, Navy Barrigada, and Air Force Barrigada. More information on the main cantonment alternatives is provided in Volume 2.

Table 2.2-1. Department of Defense Population Increases

Population Type	*Baseline*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Project-Related Cantonment Alternatives 1 and 2											
Active duty	33	535	1,220	1,220	1,220	8,602	9,182	9,182	9,182	9,182	9,182
Dependents	52	537	1,231	1,231	1,231	9,000	9,950	9,950	9,950	9,950	9,950
Transient	0	0	400	400	400	2,000	2,000	2,000	2,000	2,000	2,000
Civilian Work Force	12	102	244	244	244	1,720	1,836	1,836	1,836	1,836	1,836
Finegayan Total	**97**	**1,174**	**3,095**	**3,095**	**3,095**	**21,323**	**22,968**	**22,968**	**22,968**	**22,968**	**22,968**
Project-Related Cantonment Alternatives 3 and 8											
Active duty	33	395	884	884	884	6,239	6,659	6,659	6,659	6,659	6,659
Dependents	52	179	410	410	410	3,000	3,317	3,317	3,317	3,317	3,317
Commuters from Barrigada	0	140	335	335	335	2,364	2,523	2,523	2,523	2,523	2,523
Transient	0	0	400	400	400	400	2,000	2,000	2,000	2,000	2,000
Civilian Work Force	12	92	220	220	220	1,548	1,653	1,653	1,653	1,653	1,653
Finegayan Total	**97**	**806**	**1,850**	**2,250**	**2,250**	**13,551**	**16,152**	**16,152**	**16,152**	**16,152**	**16,152**
Active duty	0	140	335	335	335	2,364	2,523	2,523	2,523	2,523	2,523
Dependents	0	358	821	821	821	6,000	6,633	6,633	6,633	6,633	6,633
Transient	0	0	0	0	0	0	0	0	0	0	0
Civilian Work Force	0	10	24	24	24	172	184	184	184	184	184
Barrigada Total	**0**	**508**	**1,180**	**1,180**	**1,180**	**8,535**	**9,340**	**9,340**	**9,340**	**9,340**	**9,340**
Nonproject-Related Cantonment Alternatives 1, 2, and 3 and 8											
Active duty	2,145	80	80	80	80	120	120	120	120	120	120
Dependents	2,950	118	118	118	118	210	210	210	210	210	210
Transient	0	900	900	1,256	1,256	1,256	1,256	1,256	1,256	1,256	1,780
Civilian Work Force	805	17	17	17	17	25	25	25	25	25	25
Andersen AFB Total	**5,900**	**1,115**	**1,115**	**1,471**	**1,471**	**1,611**	**1,611**	**1,611**	**1,611**	**1,611**	**2,135**
Active duty	4,490	0	0	0	50	50	130	130	130	130	330
Dependents	5,410	0	0	0	30	30	80	80	80	80	80
Transient	0	0	0	0	0	0	7,222	7,222	7,222	7,222	7,222
Civilian Work Force	1,684	0	0	0	10	10	13	13	13	13	20
Navy Bases Total	**11,584**	**0**	**0**	**0**	**90**	**90**	**7,445**	**7,445**	**7,445**	**7,445**	**7,652**

Notes: 1. 7,222 transients at Apra Harbor are housed on ships. Water utilities are provided dockside for the ships. 2. Civilian workforce does not include construction workers. The civilian workforce lives off base.
Legend: AFB = Air Force Base.

The future induced civilian population and construction workers are not included in the DoD populations. The induced population, construction workers, civilian workers, and their dependents are expected to be housed off base and are considered indirect or induced actions associated with the proposed military relocation. The demand calculation for GWA is provided in Section 2.2.2.2 and includes the induced population and construction workers and dependent water demands anticipated off base. The estimated indirect future water demand on the GWA system from the off-base induced population and the construction workers is presented in Section 2.2.2.2. The estimated indirect impacts to the GWA water system from the civilian population growth is examined and discussed in Volume 6, Chapter 3.

2.2.2.1 On-Base Water Demand

On-Base Water Demand with Current DoD Criteria Demand Calculation

The demand calculations presented in Water, Wastewater, and Solid Waste Management Impact Assessment for GJMMP, Guam (Helber Hastert & Fee, Planners, Inc. 2006) are the basis for the calculation of anticipated on-base water demand below, with modifications as necessary.

The water capacity for the water system to support the new Marine Corp Base was calculated using the UFC 3-230-19N guidance, UFC Design: Water Supply Systems (DoD 2005). System capacity calculations include total requirements for domestic, industrial, fire protection, and unaccounted for water (UFW) demands for the military relocation population in year 2019. The UFC guidance provides a means of estimating water demands considering primarily water uses, peak demands, and climatic effects. The quantity estimate is the basis for sizing components of the facility using factors prescribed in the UFC guidance. The guidance document was developed from an evaluation of facilities, and best design practices and standards of the military, national professional societies, associations, and institutes. Because the design would incorporate sustainability and water conservation practices, water consumption is expected to be less than estimated by UFC guidance. An estimate of water usage incorporating sustainability and water conservation practices is provided later in this section.

Estimates for potable water demand for the direct DoD on-base population were made based on DoD UFC guidance (DoD 2005). Per capita (person) requirements for domestic potable water uses including drinking water, household uses, and household lawn irrigation for permanent and temporary installations (DoD 2005) are as follows, with the per capita requirements for the tropics selected for Guam:

- Unaccompanied Personnel Housing, 155 gallons per capita per day (gpcd)
- Family Housing, 180 gpcd
- Transients and On-Base Workers Living Off Base (per shift), 45 gpcd

The average domestic demand in gallons per day (gpd) is calculated by Equation 1:

Equation 1

Average daily domestic demand in gpd = gpcd x design population x growth factor

The following growth factors are used in Equation 1:

- Large systems (5,000 population or greater), 1.25.
- Small systems (populations less than 5,000), 1.50.

Total average demand is the sum of average demands for unaccompanied personnel housing, family housing, and workers. Other controlling demands are calculated by Equation 2:

Equation 2

Maximum Daily Domestic Demand = average daily domestic demand in gpd x K

Where

K is 2.25 for populations < 5,000 and 2 for populations > 5,000.

Visiting ships docked at Apra Harbor would be connected to the Navy islandwide water system for potable water. Potable water requirements for visiting ships are included in the domestic demand based on transient populations as described in Volume l4 of the EIS for aircraft carriers and UFC 4-150-02 (DoD 2003) for other visiting ships. Visiting ship-related water demand of 0.44 MGd (1.66 MLd) is included in the Navy demands.

It is assumed that the water demands for the services would be addressed by the DoD water systems as follows:

- Marine Corps—Finegayan Base Complex water system and Navy islandwide system
- Air Force—Andersen AFB water system
- Navy—Navy islandwide water system
- Army—Finegayan Base Complex water system
- U.S. Coast Guard—Navy islandwide water system
- Special Operations Force—Finegayan Base Complex water system, Navy islandwide water system, and Andersen AFB water system

Two basic scenarios for housing the Marine Corps are examined: (1) entirely within the Finegayan Base Complex (Main Cantonment Alternatives 1 and 2), or (2) split between the Finegayan Base Complex, Navy Barrigada, and/or Air Force Barrigada (Main Cantonment Alternatives 3 and 8). Main Cantonment Alternative 2 was taken as representative for both Alternatives 1 and 2, and Alternative 3 was taken as representative for both Alternatives 3 and 8.

Industrial water uses include air conditioning, irrigation, swimming pools, shops, laundries, dining, processing, flushing, and boiler makeup water. Demands for air conditioning were assigned according to the values in UFC 3-230-19N (DoD 2005). Additionally, UFC 3-230-19N (DoD 2005) requires the use of water demand data from other activities with uses similar to those anticipated. The industrial demands for the facilities not covered by UFC 3-230-19N (DoD 2005) were assigned a demand based on the measured demands for similar facilities within the existing Navy bases. The future estimated average daily industrial use is 1.2 MGd (4.5 MLd) at the Finegayan Base Complex. This demand includes 225 gallons per minute (851 liters per minute) for use in on-base power generation. The industrial demands for Main Cantonment Alternatives 3 and 8 are similar to the industrial demands estimated for Main Cantonment Alternatives 1 and 2. There is a water demand on the Navy bases of 0.05 MGd (0.19 MLd) for ship washdowns. The water demand related to construction is not included in the DoD water demand estimates. The construction-related demand is relatively low (0.05 MGd [0.19 MLd]) and for this analysis is assumed to be supplied by the contractor through the GWA water system. The DoD could provide the construction-related demand through the DoD water system depending upon location of available sources and water availability from GWA. Industrial demands are summarized in Table 2.2-2.

Table 2.2-2. Future DoD Industrial Demands

Industrial Demands (MGd)	*Marine Corps Finegayan Base*	*Andersen AFB*	*Navy Bases*
Existing	0.1	0.76	3.8
Marine Corps Relocation	0.8	0.07	0.02
Additional from Projects In Progress	0	0.17	0.73
Washdown 25,000 gallons over 5 days	0	0	0.05
225 gpm for Power Generation	0.32	0	0
Total Industrial	1.2	1	4.6

Legend: AFB = Air Force Base; gpm = gallons per minute; MGd = million gallons per day.

UFW is water that is not metered, and includes water loss due to leakage in the distribution system, tank overflows, water connections that are not documented or billed, theft, and inaccurate metering. UFW is derived by subtracting the amount of water measured by meters, from the water that is produced from the treatment plants and wells and net changes in water storage tank inventories. Most water utilities, policymakers, and associations such as the American Water Works Association consider a 10% to 15% UFW loss to be acceptable. However, the utility reports for the DoD facilities indicate Navy and Air Force systems currently have higher loss rates. Estimates of the existing UFW rates from base personnel were used in the demand calculations. The DoD UFW rates are shown in Table 2.2-3. The existing UFW rate for the Navy is 25%. The existing UFW rate at Andersen AFB is 50%.

Table 2.2-3. DoD Unaccounted for Water

Facility	*Existing UFW*
Existing Navy [a]	25%
Existing Andersen AFB [b]	50%
Future Additional Navy	15%
Future Additional Andersen AFB	50%
Future Marine Corp Base	5%

Legend: AFB = Air Force Base; [a] Personal Communication (Barker 2010), [b] Personal Communication (McKnight 2010).

A UFW of 15% is assumed for additional demands at the Navy islandwide system because the growth is confined to Apra Harbor and water would not be transmitted across island putting this estimate at the high end of the acceptable UFW range. The UFW of 50% is kept for additional demands at Andersen AFB because the proposed action does not include replacement of existing T&D water lines. However, the actual UFW for Andersen AFB in the future is likely to be lower because plans are in discussion to replace portions of the aging water mains including the line from Andersen South Annex to the main base. A UFW of 5% is assumed for Marine Corps relocation areas at the proposed new Marine Corps Finegayan base and Barrigada because the water systems would be brand new, there would be more meters installed to monitor water use, and conservation and sustainability concepts would be integrated into the design of facilities which include measures to prevent water loss. The future UFW demands for the Marine Corps relocation are shown in Table 2.2-4.

The anticipated DoD water demands are summarized in Table 2.2-5.

Table 2.2-4. Future DoD UFW

	Marine Corps Finegayan Base (MGd)	*Andersen AFB (MGd)*	*Navy Bases (MGd)*
Average UFW Demand	0.3	1.1	3.2
Maximum UFW Demand	0.5	1.6	3.7

Legend: AFB = Air Force Base; MGd = million gallons per day; UFW = Unaccounted for Water; Marine Corps = United States Marine Corps.

Table 2.2-5. Projected Future DoD Water Demands

	Baseline	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Average Daily Demand (MGd)											
Cantonment Alternatives 1 and 2											
Finegayan	0.13	0.32	1.00	1.40	1.79	4.73	5.02	5.02	5.02	5.02	5.95
Andersen AFB	2.14	2.29	2.41	2.56	2.68	2.71	2.71	2.71	2.71	2.71	3.19
Navy	8.10	8.10	8.41	8.71	9.03	9.03	9.57	9.57	9.57	9.57	10.14
Total	10.37	10.71	11.81	12.67	13.50	16.48	17.30	17.30	17.30	17.30	19.28
Cantonment Alternatives 3 and 8											
Finegayan and Barrigada	0.13	0.33	1.03	1.42	1.82	4.90	5.20	5.20	5.20	5.20	6.18
Andersen AFB	2.14	2.29	2.41	2.56	2.68	2.71	2.71	2.71	2.71	2.71	3.19
Navy	8.10	8.10	8.41	8.71	9.03	9.03	9.57	9.57	9.57	9.57	10.14
Total	10.37	10.72	11.84	12.69	13.53	16.65	17.48	17.48	17.48	17.48	19.51
Maximum Daily Demand (MGd)											
Cantonment Alternatives 1 and 2											
Finegayan	0.16	0.59	1.63	2.02	2.42	8.17	8.75	8.75	8.75	8.75	10.61
Andersen AFB	3.14	3.44	3.55	3.75	3.86	3.94	3.94	3.94	3.94	3.94	4.88
Navy	9.82	9.82	10.13	10.43	10.77	10.77	11.84	11.84	11.84	11.84	12.98
Total	13.12	13.85	15.31	16.20	17.05	22.87	24.52	24.52	24.52	24.52	28.48
Cantonment Alternatives 3 and 8											
Finegayan and Barrigada	0.16	0.61	1.68	2.08	2.47	8.52	9.11	9.11	9.11	9.11	11.07
Andersen AFB	3.14	3.44	3.55	3.75	3.86	3.94	3.94	3.94	3.94	3.94	4.88
Navy	9.82	9.82	10.13	10.43	10.77	10.77	11.84	11.84	11.84	11.84	12.98
Total	13.12	13.87	15.36	16.26	17.11	23.22	24.89	24.89	24.89	24.89	28.94

Legend: AFB = Air Force Base; MGd = million gallons per day.

<u>Demand Adjusted to Reflect Federal Mandates to Reduce Consumption</u>

The on-base potable water demand assumptions presented in Section 2.2.2.1 are based on UFC (UFC-3-230-19N DoD, 2005) and provides a conservative estimate to plan the potable water source demand for a standalone system to serve the long-term needs of a generic military base located anywhere in the world. Construction on military bases is standardized and dictated by UFC documents that provide planning, design, construction, sustainment, restoration, and modernization criteria. They are applicable to Military Departments, Defense Agencies, and DoD Field Activities. They were relied upon in the development of project designs and would be incorporated into construction documents and permits, and operations and maintenance activities. The documents address issues such as design standards for water systems based primarily on installation population. There is little flexibility in minimal design standards, but there is flexibility in site planning. Congressional appropriations require the incorporation of all relevant UFCs in design.

Unfortunately, UFC-3-230-19N addresses the criteria to be used to define the source of water, but does not account for the fact that several federal mandates (Executive Order [EO] 13423, Energy Policy Act of

2005, Energy Independence and Security Act of 2007, EO 13514) have been issued since the last release of UFC-3-230-19N. These federal mandates require the use of water conservation technology to achieve significant reductions in water usage. EO l3514 (5 October 2009) requires federal agencies to reduce their water consumption 26% by 2020 as compared to the federal agency's water consumption in 2007. As a result of mandated reductions in usage, the capacity of a UFC-compliant water source would exceed projected demand. To address this situation in advance of an update of UFC-3-230-19N and to factor in a more realistic scenario based on Guam, the analysis presented herein incorporates sustainability and water conservation into the water demand calculation. This approach has been endorsed by the Navy Criteria team that is responsible for updating the UFCs and is considered consistent with the spirit and intent of the UFCs. It is essential to start with UFC-3-230-19N and apply sound engineering judgment to adjust requirements to preclude the construction of a more costly system that would constrain a limited water resource and ultimately be underutilized, potentially resulting in long term operating issues for the Marines if other water demands are not addressed with the system.

The reduction in on-base water demand for the proposed new Marine Corps base is expected to be in the order of 22% or more for the average daily demand and 40% or more for the maximum daily demand if conservation measures, sustainability principles, and Guam site-specific conditions are applied. The reduced demand presented below provides a realistic estimate of the expected demand for planning purposes.

Sustainability Principles

The following directives and guidance documents address water conservation:

- EO 12902, Energy Efficiency and Water Conservation at Federal Facilities
- EO 13423, Strengthening Federal Environmental, Energy, and Transportation Management
- Energy Policy Act of 2005
- Energy Independence and Security Act of 2007
- 10 U.S. Code 2866, Water Conservation at Military Installations
- 10 U.S. Code 2915, New Construction: Use of Renewable Forms of Energy and Energy Efficient Products
- Military Handbook 1165, Water Conservation, Mil-HDBK-1165 (1996)
- Navy Water Conservation Guide For Shore Activities
- EO 13514, Federal Leadership in Environmental, Energy, and Economic Performance (5 October 2009)
- Greenhouse Gas Targets Announcement for DoD (29 January 2010)
- Energy Awareness Message from Secretary of the Navy Ray Mabus (30 October 2009)
- LEED for New Construction and Major Renovation 2009

The existing Navy and Air Force bases are subject to water conservation goals, such as those in EO 13423. Implementation of this order requires a reduction in water usage of 16% by 2015 on existing bases. This percent reduction is included in the modified potable water demand estimates presented herein. The water conserved at the existing bases would then be available for future uses as "excess" water supply. For more information on sustainability policies and guidance, refer to Volume 8, Chapter 6.

The DoD is in the process of developing and approving water conservation measures for the Marine Corps base through equipment selection and management practices. Water consumption at the Marine Corps base would differ from consumption at the existing bases because, as part of the proposed action, the design and construction of the new base at Finegayan would implement low-flow equipment and other improvements to the extent practical. Reduction strategies being considered are indoor reduction, indoor reuse, and outdoor capture. Examples include the following potential water conserving measures:

- Low-flow faucets
- Ultra-low-consumption toilets/urinals with electric flush sensors
- Low-flow showerheads
- Lower flow commercial-type “Energy Star” washing machines in housing units
- Energy- and water-saving dishwashers (Energy Star)
- Use of washwater recycling in industrial washing and rinsing of aircrafts and vehicles
- Water efficient cooling systems
- Rainwater collection and reuse
- Air conditioning condensate recycling
- Water conservation education

For more information on the sustainability measures, see Volume 8. A summary of the Sustainability Program Summary Report is provided in Section 2.2.5.8. The text of the Sustainability Program Summary Report is provided in Volume 9, Appendix F.

Water management practices would be implemented at the Marine Corps base to better control water consumption and prevent water loss. The amount of water used to water lawns and landscapes would be minimized or eliminated through sustainable landscape design and use of native vegetation. Meters would be installed at all facilities and at key locations within the water distribution system significantly improving the ability to quickly identify leaks and take corrective action. Water management operation procedures would be reviewed periodically and revised as needed. Base residents would be educated with regard to living responsibly on a sustainable base in order to create a sustainable culture through responsible actions by residents. Education programs on proper use of water would include: watering lawns sparingly or not at all, installing low-flow fixtures, water reuse, full load clothes washing, etc. Metering would provide water users with full awareness of their water usage. For housing residents, meters would support billing of water usage directly to the residents. Water conservation would be a key program and receive command level attention and monitoring.

Site-Specific Water Conservation Measures

Because the proposed Marine Corps base would be located on Guam, some of the assumptions behind the development of the UFC guidance are not relevant. Notably, the water needed for lawn irrigation would be minimal because of Guam’s climate, particularly during the rainy season. As described above, the facility design would be expected to utilize water conserving equipment and design elements that would likely produce at least a 22% water savings compared to UFC requirements. This water savings is mandated by EO 13514. No irrigation would be utilized for housing and minimally used elsewhere on the base. Landscaping throughout the base would use local plants that can survive with little watering. A common components manual to guide the development of the new Marine Corps base at Finegayan would address which local plants could be utilized in landscaping. Improved leak detection, extensive metering, and management systems would be expected to reduce the amount of UFW to a rate of 5% based on engineering judgment. It is noted that the UFC-3-230-19N does not address the issue of UFW. The controlling demand factor used to estimate the maximum daily demand and to size water system components would be lower for Guam because there are limited climatic changes on Guam as compared to the mainland and other locations. Actual water demand at the base is expected to differ from the UFC-based water demand estimate due to the incorporation of water conservation measures.

The potential savings from water conservation measures for Main Cantonment Alternatives 1 and 2 at Andersen AFB and Navy bases are shown below in Table 2.2-6. The potential water conservation reductions are similar for Main Cantonment Alternatives 3 and 8.

Incorporating these assumptions, the average daily water demand for the proposed Marine Corps base is estimated at 22% less and maximum daily water demand at 40% less than that based on the UFC. Impacts of these estimated water demand reductions is discussed in Volume 6, Chapter 3.

Table 2.2-6.Water Demand Comparisons Using Conservation/Sustainability Measures for Main Cantonment Alternatives 1 and 2

	Water Demand (in MGd)			
Water Demand Criteria(Existing and Proposed)	*Marine Corps Finegayan*	*Andersen AFB*	*Navy*	*Total*
Average Daily Demand using UFC Guidance	6.0	3.2	10.1	19.3
Average Daily Demand using Sustainability Principles	4.7	2.5	8.7	15.8
Potential Percent Reductions for Average Daily Demand	22%	22%	14%	18%
Maximum Daily Demand using UFC Guidance	10.6	4.9	13.0	28.5
Maximum Daily Demand using Sustainability Principles	6.3	3.0	9.8	19.1
Potential Percent Reductions for Maximum Daily Demand	40%	39%	25%	33%

Legend: AFB = Air Force Base; MGd = million gallons per day; UFC = Unified Facilities Criteria.

2.2.2.2 Off-Base Water Demand (Including Indirect Off-Base Induced Population and Construction Workforce)

Off base water demand including indirect impacts of the military relocation would be placed on the GWA water system. The indirect population growth consists of the baseline growth (the expected growth in the Guam population without military relocation) in the existing population plus indirect impacts of the proposed military relocation (the induced civilian population growth and construction workers). Most construction workers are expected to reside in work camps. The islandwide off-base population is estimated to peak in the year 2014 at 249,642 as shown in Table 2.2-7.

Table 2.2-7. Off-Base Indirect Population Estimates

			Off-Island Construction Workers			*Off-Island Civilian DoD Workers*			
Year	*Current*	*Baseline Growth*	*On-Campus Worker*	*Off-Campus Worker*	*Off-Campus Dependent*	*Workers*	*Depen-dents*	*Off-Island Induced*	*Total*
2010	180,692	0	2,300	940	1,160	119	97	5,393	190,700
2011	NA	2,389	5,840	2,360	2,585	261	232	13,723	208,082
2012	NA	4,743	10,320	3,900	3,797	261	232	22,957	226,902
2013	NA	7,062	12,970	4,860	3,968	261	232	27,450	237,495
2014	NA	9,350	13,280	5,090	4,725	1,745	1,634	33,126	249,642
2015	NA	11,610	8,660	3,480	2,832	1,861	1,745	25,233	236,113
2016	NA	13,849	2,690	1,090	1,052	1,861	1,745	12,374	215,353
2017	NA	16,065	0	0	0	1,861	1,745	8,718	209,081
2018	NA	18,250	0	0	0	1,861	1,745	8,718	211,266
2019	NA	20,403	0	0	0	1,861	1,745	8,895	213,596

Legend: NA = not applicable.

The off-base water demand is estimated using existing water supply information from GWA. The current GWA water production rate of 42 MGd (159 MLd) was used as the current baseline. The current production rate covers all water demands from the general public including domestic, industrial, tourist related and UFW loss.

Of the 42 MGd (159 MLd), 18 MGd (68 MLd), is billed. The remaining 24 MGd (91 MLd), is UFW. According to GWA, the loss from leaks is 10% and the remainder is from unmetered or undermetered connections. USEPA has commented that the 10% UFW from leaks is unreasonably low. They are concerned that UFW fraction attributed to leaks is unacceptably low because the leak detection study focused on water lines greater than 6-inches (in) in diameter. Not all water lines greater than 6-in in diameter were surveyed. Most water lines with a diameter less than 6-in in diameter were not surveyed. Leakage from the smaller water lines could be significant. Many of the smaller water lines are made of heavily corroded galvanized iron with a history of leaks. Additionally, the leak detection study documentation did not describe the quality control measured instituted for the study. USEPA recommends using a range of 25% to 40% as the best estimate for UFW due to, recognizing that the true number could be higher or lower.

The midpoint of the UFW range between GWA's reported UFW due to leakage (10%) and the high end of USEPA's recommended range (40%) is used in this estimate of GWA's water demand. The selected UFW due to leakage for the GWA water system is 25%. Most water utilities, policymakers, and associations, such as the American Water Works Association deem a 10% to 15% UFW loss as acceptable. A UFW of 25% is outside of the acceptable range of UFW loss and is the same as the UFW for the current Navy Island Wide water system. In Chapter 3, the GWA supply is compared to the estimated water demands assuming 10%, 25%, and 40%.

The estimated increases to the population served by GWA is consistent with Table ES-2 of the Final EIS. The table is provided below with the civilian populations identified within red boxes. The civilian military workers are additional civilian staff supporting Finegayan base who work on base, but are housed off base with their dependents. Off-Island Construction Workers would work temporarily on Guam to construct the base and related facilities. Most construction workers would be housed within a hotel like work camp. A portion of the construction workers, probably having management or supervisor roles, are assumed to live outside of the work camp with their dependents. Off-Island Workers for Indirect/Induced Jobs are assumed to live within the general Guam population, supporting the additional military, civilian military workers and construction workers in employment such as teaching and commercial businesses. Information on how the population estimates were developed is presented in Volume 9, Appendix F of the Final EIS. The population estimates used in the water demand calculations are from the unconstrained scenario which assumes no constraints would be imposed by Guam to lessen the indirect economic growth potential resulting from the action.

Future water demand for GWA is estimated as the current production rate (42 MGd [159 MLd]) plus water demand resulting from the population increases. Table 2.2-8 provides the domestic water demand calculation for the population increase in 2014. The populations were multiplied by the gpcd rates shown in Table 2.2-8. The consumption rate for Construction Workers On-Campus is 70 gpcd, which is the hotel domestic water allowance from Table 2-1 of UFC 3-230-03A 16 January 2004 for Water Supply (DoD 2004). For all other off-base populations the consumption rate is 125 gpcd from the 2007 Water Resources Management Plan. The domestic water demand in 2014 for the additional populations is 7.89 MGd (29.9 MLd).

Table 2.2-8. Increases in Off-Base Domestic Daily Water Demand for 2014

	Off-Base Population Increase Year 2014	*Rate (gpcd)*	*2014 Increase in Daily Domestic Water Demand (MGd) [A x B]*
Column	**A**	**B**	**C**
Baseline Growth	9,350	125	**1.17**
Construction Workers On-Campus	13,280	70	0.93
Construction Worker + Dependents Off-Campus	9,815	125	1.23
Construction Workers & Dependents			**2.16**
Civilian Workers Project	1,720	125	0.22
Non-Project Civilians	25	125	0.003
Civilian Workers Dependents Project	1,634	125	0.20
DoD Civilian Workforce & Dependents			**0.42**
Induced	33,126	125	**4.14**
Total			**7.89**

Legend: DoD = Department of Defense; gpcd = gallons per capita per day; MGd = million gallons per day.

Table 2.2-9 presents the calculation of the overall water demand for GWA in 2014. UFW from leaks is assumed at a rate of 25% (1.97 MGd [7.5 MLd]). Water required for construction of 0.05 MGd (0.19 MLd) is added. The estimated total demand for GWA in 2014 of 51.92 MGd (196.5 MLd) is the sum of the current production, domestic demand, additional UFW from leaks and water from construction.

Table 2.2-9. 2014 Estimated Off-Base Water Demands

	2014 Increase in Daily Domestic Water Demand (MGd)	*2014 Increase in UFW (MGd) [A x 25%]*	*2014 Total Increase in Water Demands (MGd) [A+B]*	*Demand in 2014 (MGd)*
Column	**A**	**B**	**C**	
Baseline	-	-	-	42
Baseline Growth	1.17	0.29	1.46	1.5
Construction Workers & Dependents	2.16	0.54	2.70	2.7
DoD Civilian Workforce & Dependents	0.42	0.11	0.53	0.5
Induced	4.14	1.04	5.18	5.2
Water for Construction	0.05	0.0125	0.06	0.06
Total	**7.94**	**1.99**	**9.93**	**51.96**

Legend: DoD = Department of Defense; MGd = million gallons per day; UFW = unaccounted for water.

The off-base water demand estimate is provided in Table 2.2-10 for the 2010 through 2019. Off-base water demand peaks in 2014 at 51.9 MGd (196 MLd). A separate estimate is provided for the population located in northern and central Guam, where the water demand is met primarily through GWA groundwater resources.

Table 2.2-10. Estimated Off-base Water Demands by Year

Units: MGd Year	*Current*	*Baseline Growth*	*Off-Island Construction Workers: On-Campus Worker*	*Off-Island Construction Workers: Off-Campus Worker*	*Off-Island Construction Workers: Off-Campus Dependents*	*Off-Island Civilian DoD Workers: Workers*	*Off-Island Civilian DoD Workers: Dependents*	*Off-Island Civilian DoD Workers: Off-Island Induced*	*Total*	*North and Central*	*South*
2010	42.0	0.0	0.2	0.1	0.2	0.0	0.0	0.8	43.4	35.3	8.1
2011	NA	0.4	0.5	0.4	0.4	0.0	0.0	2.1	45.9	37.4	8.5
2012	NA	0.7	0.9	0.6	0.6	0.0	0.0	3.6	48.5	39.7	8.8
2013	NA	1.1	1.1	0.8	0.6	0.0	0.0	4.3	50.0	41.0	9.0
2014	NA	1.5	1.2	0.8	0.7	0.3	0.3	5.2	51.9	42.6	9.2
2015	NA	1.8	0.8	0.5	0.4	0.3	0.3	3.9	50.1	41.0	9.1
2016	NA	2.2	0.2	0.2	0.2	0.3	0.3	1.9	47.2	38.5	8.8
2017	NA	2.5	0.0	0.0	0.0	0.3	0.3	1.4	46.4	37.7	8.7
2018	NA	2.9	0.0	0.0	0.0	0.3	0.3	1.4	46.8	38.0	8.8
2019	NA	3.2	0.0	0.0	0.0	0.3	0.3	1.4	47.1	38.3	8.8

Legend: MGd = million gallons per day.

The baseline average water demand per person is estimated in Table 2.2-11 for the GWA water system. The baseline population is increased to account for the tourist population which was estimated at 23,000 in a comment from Guam Environmental Protection Agency (GEPA) on the Draft EIS. The industrial demand estimate provided in the 2007 WRMP was subtracted from the total water demand to estimate the average daily domestic water demand including the UFW. The gallons per person per day is 126 gpcd after accounting for 25% UFW.

Table 2.2-11. GWA Baseline Gallons per Person per Day Estimate

	Population
GWA Baseline Population	180,692
Tourists	23000
Population + Tourists	**203,692**
	Demand
Total Demand (MGd)	42
Industrial Demand (MGd)	-10
Domestic Demand (MGd)	32
Gallons per Capita per Day (gpcd)	157
Adjusted for UFW (gpcd)	**126**

Legend: gpcd = gallons per capita per day; GWA = Guam Waterworks Authority; MGd = million gallons per day; UFW = Unaccounted for Water.

A similar comparison is provided below. Water demand was estimated using 70 gpcd for construction workers housed on the work camp; and 125 gpcd was used for the remaining population. The average gallons per person is lower during 2010 through 2016 when the construction workers housed on campus are present. After 2016, the average gallons per person is 125 gpcd. The water demand per person used in this analysis is consistent with the baseline average demand per person of 126 gpcd. As shown in Table 2.2-12, the percent increase in population is not the same as the percent increase in water demand, but these differences are due to the use of to the lower water demand for the construction workers housed on campus; the presence of a tourist population that is not included in the baseline population estimate and the use of water for industrial purposes.

Table 2.2-12. Comparison between GWA Population and Water Demand Increases

	2010	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
GWA Population	190,700	208,082	226,902	237,495	249,642	236,113	215,353	209,081	211,266	213,596
Population Increases Over Baseline	10,008	27,390	46,210	56,803	68,950	55,421	34,661	28,389	30,574	32,904
Population Percent Increase	6%	15%	26%	31%	38%	31%	19%	16%	17%	18%
Total Projected Demand (UFW: 25%)	43	46	49	50	52	50	47	46	47	47
Demand Increases Over Baseline	1.4	3.9	6.5	8.0	9.9	8.1	5.2	4.4	4.8	5.1
Water Demand Percent Increase	3%	9%	16%	19%	23%	19%	12%	11%	11%	12%
Gallons per Capita per Day (gpcd)	140	142	141	141	143	146	151	156	156	156
Adjusted for UFW (gpcd)	**112**	**113**	**113**	**112**	**114**	**116**	**121**	**125**	**125**	**125**

Legend: gpcd = gallons per capita per day; GWA = Guam Waterworks Authority; UFW = Unaccounted-for Water.

2.2.3 Water Supply Sources

Water supply sources considered to meet on-base and off-base water demands are described below. These include groundwater as the primary supply source, and surface water. Development of groundwater resources would require coordination between DoD, GWA, and the GEPA. This coordination is a necessary part of the well permitting and the construction process, and for proper management of the Northern Guam Lens Aquifer (NGLA), a designated sole source aquifer. The NGLA, located directly underneath northern Guam, is a sole-source aquifer and is the primary source of available drinking water on Guam. A sole-source aquifer is an underground water supply designated by USEPA as the "sole or principal" source of drinking water for an area because it supplies at least 50% of the drinking water consumed in the area overlying the aquifer. The DoD recognizes that the best future sources of water within the NGLA are under DoD land; therefore, coordination between DoD, GWA, and GEPA regarding the use and management of the NGLA is paramount to sustain this critical resource.

2.2.3.1 DoD Water Supply Sources

The current DoD water resources are summarized in Table 2.2-13. The existing DoD water supply is sufficient to meet current on-base DoD demands at Naval Station Guam and Andersen AFB. Additional supply to meet future Marine Corps, Army, and Navy demands would be required for the military relocation.

Table 2.2-13. Current On-Base DoD Potable Water Supply

Resource		*Capacity (gpm)*	*Capacity (MGd)*
Navy Surface Water Resources		**7,614**	**10.97**
Navy Southern Guam	Almagosa Spring	928	
Navy Southern Guam	Bona Spring	426	
Navy Southern Guam	Fena Reservoir	6,260	
Navy Groundwater Resources		**1,534**	**2.21**
Navy Hospital	NRMC #1	234	
Finegayan	NCTS #6	125	
Finegayan	NCTS #7	235	
Finegayan	NCTS #9	200	
Finegayan	NCTS #10	180	
Finegayan	NCTS #11	180	
Finegayan	NCTS #12	180	
Finegayan	NCTS B1	200	
Air Force Groundwater Resources		**3,285**	**4.73**
Andersen South Annex	Marbo Well No. 1	170	
Andersen South Annex	Marbo Well No. 3	210	
Andersen South Annex	Marbo Well No. 5	180	
Andersen South Annex	Marbo Well No. 6	480	
Andersen South Annex	Marbo Well No. 7	255	
Andersen South Annex	Marbo Well No. 8	490	
Andersen South Annex	Marbo Well No. 9	400	
Main Base	Well 3A	300	
Main Base	Well 5	200	
Main Base	Well 6	200	
Main Base	Well 7	200	
Main Base	Well 8	200	

Legend: gpm = gallons per minute; MGd = million gallons per day; NCTS = Naval Computer Telecommunications Station; NRMC = Navy Regional Medical Center.

2.2.3.2 Non-DoD Water Supply Sources

Non-DoD water supply sources consist of groundwater and surface water supplies throughout Guam. The GWA water supply sources are presented in Table 2.2-14. Potable water is mainly supplied to the northern system by 119 deep wells. Collectively, these wells have a current daily average production rate of approximately 38 MGd (144 MLd). Due to high chlorides, GEPA is proposing that GWA reduce production of wells in the Agana subbasin. It is expected that a reduction of 2 MGd (7.6 MLd) would be undertaken. GWA has advised DoD that it intends to drill additional wells with a capacity of up to 7 MGd (26.5 MLd). Additional water supply capacity is not included in the future water supply estimate for GWA because it is not certain that funding will be available for the improvements. It is assumed that GWA would reduce leakage from their distribution system in northern Guam to support baseline growth by 3.2 MGd (12.1 MLd) by 2019. This assumption is made because the baseline growth would occur with or without the proposed DoD relocation and water supply for this population would be the responsibility of GWA, not the DoD. Water supply from GWA surface water resources currently totals 2.4 MGd (9.1 MLd). Modification to the Ugum Water Treatment Plant (WTP) has the potential to increase water supply in southern Guam by 1.8 MGd (6.8 MLd).

In addition to the deep wells, the northern system also receives up to 4.0 MGd (15 MLd) from the Navy WTP in southern Guam, which is supplied by surface water from Fena Reservoir, according to the current agreement between DoD and GWA.

The total future GWA water supply of 45.6 MGd (173 MGd) including the water transferred from Fena Reservoir is adequate to meet normal expected civilian growth without the proposed indirect impacts of the military relocation. Between the existing non-DoD water supply sources and GWA's rehabilitation and expansion plans, there would be sufficient water supply to meet the anticipated normal civilian growth without the proposed military relocation.

Table 2.2-14. Guam Waterworks Authority Water Supplies

	Current Production (MGd)	*Current Capacity (MGd)*	*Future Expansions (MGd)*	*Future Capacity (MGd)*
North and Central				
Deep Wells	38	39.4	0	39.4
Planned Lower Production of Agana Wells with Elevated Chloride	0	0	-2	-2.0
Well Expansion to Meet Baseline Growth in 2019	0	0	0	0
South				
Ugum Water Treatment Plant	2.2	2.2	1.8	4.0
Santa Rita Spring	0.2	0.2	0	0.2
Total GWA Supplies	**40.4**	**41.8**	**-0.2**	**41.6**
Navy to GWA Transfer to Central	4	4	0.0	4.0
Total with Existing Navy Transfer	**44.4**	**45.8**	**-0.2**	**45.6**

Legend: GWA = Guam Waterworks Authority; MGd = million gallons per day.

2.2.3.3 Development of Alternatives to Increase DoD Water Supply Sources

The future DoD water supply requirements are shown in Table 2.2-15. Using UFC guidance, the supply is based on the maximum daily demand. For water systems based on groundwater supply wells, UFC guidance requires that the supply equivalent to the capacity of the largest well in the system be added. For DoD an additional 11.3 MGd (42.8 MLd) of additional water supply would be required to meet future on-base DoD demands projected for the military relocation for Main Cantonment Alternatives 1 and 2 utilizing UFC requirements (Marines). The water transferred to GWA from the Navy water system is not included in the maximum daily demand shown in Table 2.2-15.

Table 2.2-15. Projected Future DoD Water Supply Requirements

	Maximum Daily Demand	*Largest Well*	*Required Supply*	*Current Supply*	*Additional Supply Needed*
Marines	10.61	0.65	11.26	0.00	**11.26**
Andersen AFB	4.88	0.71	5.59	4.73	**0.86**
Navy	12.98	NR	12.98	13.18	**-0.20**
Total	28.48		29.83	17.91	**11.92**

Notes: Units: MGd
Legend: AFB = Air Force Base; MGd = million gallons per day; NR = not required.

Several alternatives for increasing DoD water supply sources are carried forward for analysis in this EIS, which are discussed in detail in Section 2.2.4 below. These alternatives were developed based on an assessment of nine primary water system improvement options. These water system improvement options were evaluated in the Guam Water Utility Study Report for Proposed U.S. Marine Corps Relocation (NAVFAC Pacific 2010h) and are listed below.

- *Option 1:* Optimize groundwater resource development within DoD land and add additional supply wells
- *Option 2:* Rehabilitate, replace, or treat well water from existing wells that are not currently in production due to contamination, structural, and/or mechanical problems
- *Option 3:* Coordinate with GWA to establish the quantity of potable water that GWA would be agreeable to selling to DoD, and purchase water from GWA
- *Option 4:* Dredge sediment from the Navy Reservoir to increase storage capacity
- *Option 5:* Expand storage capacity of the Navy Reservoir by raising the dam crest
- *Option 6:* Reclaim potable water through effluent reuse
- *Option 7:* Indirectly reclaim potable water through groundwater recharge
- *Option 8:* Perform desalination
- *Option 9:* Develop a new surface water source (e.g., the "Lost River").

Each of the nine options identified above was evaluated with regard to several factors: feasibility, technical complexity, reliability, regulatory acceptance, environmental impacts, overall cost, time to implement, and the quantity of water that would potentially be obtained. This screening process is included in the Guam Water Utility Study Report for Proposed USMC Relocation (NAVFAC Pacific 2010h). Options 5, 6, and 7 were dismissed from further consideration. Combinations of the remaining options were used to build the alternatives that are carried forward for analysis in this Final EIS, as discussed in Section 2.2.4.

For potable water, no distinction is made between interim and long-term alternatives for the first two basic alternatives. These alternatives would be pursued in a phased implementation approach, which reduces costs and the time needed to implement. Should there be a need for additional water supply sources, three long-term alternatives have been identified and carried forward on a programmatic basis.

2.2.3.4 Water Supply Options Considered to Build Alternatives

The following is a brief discussion of the water supply options that were retained for further consideration and are used to build the alternatives carried forward for analysis in this EIS.

<u>Option 1: Optimize Groundwater Resource Development within DoD Land and Add Additional Supply Wells</u>

This option includes the development of groundwater wells drawing water from the NGLA in the Navy water system and the Andersen AFB water system. Because they and the GWA water system in northern Guam draw water from the same sole source aquifer with a limited sustainable yield, the development of this option to include new production wells must consider the effects of wells pumping in adjacent areas and proposed additional well production from GWA. The effects include potential saltwater intrusion problems, excessive drawdown in the aquifer, and other related water quality problems. This option includes continued use of the existing Navy wells at Finegayan that produce up to 2.2 MGd (8.3 MLd) for the Navy islandwide water system. The Marine Corps water system would be connected with both the Air Force and Navy islandwide systems to allow the flexibility needed to meet water demands on the DoD bases in northern Guam if housing were to be shifted away from the Finegayan Base and in emergencies.

The development and implementation of this option would be managed by DoD, avoiding uncertainties in timely implementation through direct management. Coordination with GWA is important in the development of new production wells in the DoD areas to avoid negative effects caused by overpumping of the aquifer.

The freshwater lens aquifer is segregated into six distinct and hydrologically separate subbasins on the northern portion of the island. The primary subbasin used for groundwater extraction by the Navy, Finegayan Subbasin, is near its maximum sustainable yield. The subbasin being utilized by Andersen AFB still appears to have sustainable yield available before reaching capacity. Based on review of the sustainable yield and current pumping capacity for existing wells, the water supply obtained from within DoD lands can meet the projected Marine Corps demand.

Option 2: Rehabilitate, Replace, or Treat Well Water from Existing Wells that Are Not Currently in Production Due to Contamination, Structural, and/or Mechanical Problems

This option includes the development of nonoperational and under-performing existing groundwater wells drawing water from the NGLA in the Navy water system and the Andersen AFB water system. Because DoD and the GWA water systems in northern Guam draw water from the same aquifer with a limited sustainable yield, the development of this option to include rehabilitation or replacement of existing production wells also considers the effects of wells pumping in adjacent areas. These impacts would include potential saltwater intrusion problems, excessive drawdown in the aquifer, and other related water quality problems. Successful rehabilitation or replacement of the inactive wells would not provide sufficient water supply to meet the projected future DoD water demand for the Marine Corps Base. The DoD would support efforts to rehabilitate these wells to support off-base water demands related to the Marine Corps relocation depending on need and regulatory approval.

This option has the potential to add to the reliability of a DoD water supply. Coordination with GWA is important in rehabilitation of production wells in the DoD areas to avoid negative effects caused by over pumping.

Option 3: Coordinate with GWA to Establish the Quantity of Potable Water that GWA Would Be Agreeable to Sell to DoD, and Purchase Water from GWA

This option includes obtaining water from GWA by either purchasing water or exchanging water through metered interconnections between the GWA and DoD water systems. There are several existing connections between the GWA and Navy water systems, although given the information currently available, none of these connections would be sufficient to meet a substantial portion of the demand in the northern region without well development, water facilities improvements, and other construction. The implementation of this option would include establishing or upgrading metered connections between the GWA and DoD water systems.

Because the Northern Public Water System operated by GWA is an elaborate water supply system in northern Guam with 119 wells that draw water from the NGLA, this option could supplement DoD's groundwater supply. This option could potentially result in energy cost savings by reducing the cross-island pumping of large quantities of water through the existing parallel water mains running from the north to the south. However, little or no water is available for purchase from GWA in the north that is not already required for GWA customers in that region. The Navy currently transfers up to 4 MGd (15 MLd) of water to GWA for use in central Guam. In the future, the water purchase option may become available if the GWA system is improved to reduce the loss rate, and if expansion of the GWA northern well systems is implemented (GWA 2007).

Option 4: Dredge Sediment from the Navy Reservoir to Increase Storage Capacity

The Navy Reservoir (also known as Fena Reservoir), located in southern Guam, is a primary source of potable water for the island and was created through the impoundment of the Fena River Valley by a dam

(Navy Reservoir Dam). The Navy Reservoir Dam, constructed by the Navy and completed in 1951, is a zoned earth and rockfill embankment with a maximum height of 85 ft (26 m) above original grade. The entire watershed impounded by the dam covers an area of 5.88 square miles (15.23 square kilometers) of moderately to steeply sloped lands, and soil within the watershed is predominantly clay of volcanic origin. The slopes and soil type both contribute to rapid runoff rates and substantial erosion, particularly in areas where the native vegetation has been removed. Eroded soil is ultimately transported to the reservoir itself by the runoff, and resulting sedimentation contributes to ongoing reduction of reservoir capacity.

The increased water supply from implementation of this option would serve DoD demands in southern Guam. It is assumed that the water supply would increase by approximately 2.5 MGd (9.5 MLd) if the reservoir were dredged to the original design elevations. If water were supplied from the NGLA near the Finegayan Base Complex, water supply from implementation of this option would not support the Marines relocation, but would provide additional supply in the south that could be transported to northern Guam if necessary.

Potential benefits of the proposed dredging are several. First, the proposed work is relatively simple and would not present a great demand for skilled labor that may be difficult to procure from the limited labor pool on Guam. Secondly, the dredging would not result in the creation of new capital structures that must be operated and maintained indefinitely. Dredging would maintain the existing hydrology of the reservoir system and would not require inundation of additional land. Finally, this option would not require changes to the existing water distribution network, in that the existing discharge and bypass points would be maintained in place.

Potential obstacles and drawbacks exist as well. In particular, the potential difficulty in mobilizing a dredge to the project site because of its remote location and the large mobilization distances for dredges would cause actual project costs to be uncertain. In addition, there are substantial logistical difficulties in managing dredged material on Guam. The lack of sufficient land area may complicate implementation.

Although dredging is a viable option, it cannot be sustained as a stand-alone alternative for Marine Corps relocation. Water supplied by this option to the Marine Corps Base would require transportation to northern Guam. The option is retained as part of ongoing maintenance for the Navy Reservoir as a long term alternative, which supplies water to DoD facilities in southern Guam.

Option 8: Desalination

Desalination is a process that removes dissolved minerals from seawater, brackish water, or treated wastewater. The water supply provided by implementation of desalination would support the Marine Corps relocation.

Several technologies have been developed for desalination, including reverse osmosis, electrodialysis reversal, and distillation. In reverse osmosis, feedwater is pumped at high pressure through permeable membranes, separating salts from the water. In electrodialysis reversal, ions are transferred through the membranes by means of direct current voltage and are removed from the feedwater as the current drives the ions through the membranes. In the distillation process, feedwater is heated and then evaporated to separate out dissolved minerals.

It is assumed that the brackish water would have a total dissolved solids (TDS) level ranging from about 3,000 mg/L to 4,000 mg/L. Within this TDS range, reverse osmosis is the preferred technology. Brackish water generally requires less energy to desalinate than seawater because of its lower concentration of dissolved solids. Therefore, the desalination of brackish water is generally less expensive than desalination of seawater. Energy costs represent about one-third to one-half of the cost of desalination, and as a result, desalination costs are relatively sensitive to the cost of energy.

For this option, the lowest salinity water available outside of the NGLA would be considered. Brackish-water wells would be located within 1,000 ft (305 m) of the shoreline to avoid effects on the NGLA and existing wells. Sufficient brackish water would be collected from a series of wells to generate 12 MGd (45 MLd) of potable water. The desalination plant would be located near the Finegayan Base Complex on Andersen AFB to be close to the location of the source and the demand. The plant would include units for pretreatment (filtration and disinfection), desalination, and post-treatment (corrosion control and remineralization), resulting in a product of drinking water quality with TDS less than 500 mg/L. If desalination of brackish water were to be implemented, untreated brackish water may be used to meet fire demands, requiring a separate set of nonpotable waterlines and storage.

Desalination plants produce liquid wastes that may contain some or all of the following constituents: high salt concentrations, chemicals used during defouling of plant equipment, and pretreatment residues. Liquid wastes may be discharged directly into the ocean, combined with other discharges (e.g., power plant cooling water or sewage treatment plant effluent) before ocean discharge, discharged into a sewer for treatment in a sewage treatment plant, or dried and disposed in a landfill.

Desalination is a viable option that results in very pure water, excellent pathogen removal, and flexible operations. The costs for this option are likely to be high relative to the water supplied by freshwater wells. The high power demand for desalination would need to be considered in the utility planning for electricity. The cost for desalination would also be sensitive to the TDS level in the brackish water supply. The quantity of brine requiring disposal would be substantial if used as the primary water supply. If water demands eventually exceed the capacity of the freshwater aquifer in the north, desalination could potentially provide a source of potable water for DoD. Therefore, this option is retained as a long-term alternative.

Option 9: Develop a New Surface Water Source (e.g., the "Lost River")

Development of a new surface water source on Guam would require identifying a new water source; conceptualizing and designing the water source area, the treatment process, and T&D infrastructure; and constructing the complete system to supplement the existing water systems. Such a system preferably would have to be sited within DoD lands, and finding an alternate surface water source with substantial capacity would likely be a major and costly initiative.

A possible new surface water source is the Lost River. The increased water supply from implementation of the Lost River would serve DoD demands in southern Guam. If water were supplied from the NGLA near the Finegayan Base Complex, water supply from implementation of this option would not support the Marine Corps relocation. This option is carried forward as a long-term alternative to supplement water supply to DoD in southern Guam. However, based on comments received from GWA during the public comment period of the Draft EIS, this option could potentially result in loss of a potential surface water source to GWA, so DoD coordination and resolution with GWA would be required if it is considered in the future.

2.2.3.5 Options Eliminated from Further Analysis

Following is a brief discussion of the options that were eliminated from further consideration, and are not used to build the alternatives carried forward in this EIS taken from NAVFAC (NAVFAC Pacific 2010h).

Option 5: Expand Naval Reservoir Storage Capacity by Raising Dam Crest

This option would involve raising the dam crest of the Navy Reservoir to increase capacity. Based on a review of topographic maps depicting the immediate vicinity of the Navy Reservoir, the topography is such that raising the elevation of the dam crest by 20 ft (6 m) would increase total reservoir capacity by 3,940 acre-feet (4.86 million cubic meters), or 1.28 billion gallons. Assuming that the watershed would generate sufficient runoff to ensure the reliability of this supply, the safe yield of the reservoir would increase by 35%, from 11.4 MGd to 15.4 MGd (43.1 MLd to 58.3 MLd).

This option would have the advantage of improving DoD's water supply by increasing its storage capacity in the Navy Reservoir. However, the disadvantages and uncertainties are substantial and include the following:

- Technical complexity of design and implementation
- Potential adverse environmental impacts (wetlands, endangered species)
- Uncertainties with respect to relative advantages compared to other viable options
- Studies (hydraulic, geotechnical, seismic) required
- Potential difficulties during construction limiting use of the reservoir
- Uncertainties regarding construction and operations and maintenance costs

Because of uncertainties regarding its viability, this option was eliminated from further evaluation.

Option 6: Reclaim Potable Water through Effluent Reuse

This option would include construction of a new tertiary WWTP near the Marine Corps base on DoD land at Finegayan. The plant would provide primary treatment, secondary biological treatment, and advanced tertiary treatment. It would treat the DoD wastewater from existing sources and proposed future expansions in the northern Guam region to drinking water standards.

This treatment application is categorized as direct potable reuse of reclaimed water. Normal treatment practice consists of primary settlement, submersible membrane bioreactor, disinfection, reverse osmosis, and advanced oxidation. The treated, potable water would be returned to the main water supply for reuse.

Although much research has been conducted on the direct potable reuse of reclaimed water, this is not a practice that is in widespread use. Only a few direct potable-reuse applications have been reported worldwide. Even without factoring in its extremely high capital investment cost and sophisticated process operation, it might be difficult to gain regulatory acceptance of this approach. Because of the negative connotations and public perceptions surrounding the use of reclaimed water as a potable water source, it is expected that community acceptance of this approach would also be difficult to achieve. Currently, there are no direct potable-reuse applications in the U.S. All reclaimed water that is treated by WWTPs has been used as potable water in an indirect way, with a natural buffer (e.g., either a stretch of river or a groundwater aquifer) between the reclaimed water introduction and its distribution to the potable-water treatment plant.

This option would require permission from either USEPA or GWA. Because no regulations exist for the reclaimed-water potable-reuse application, treatment requirements and performance monitoring standards for this option would need to be established, adding time and cost to its implementation. Therefore, this option was dismissed.

Option 7: Indirectly Reclaim Potable Water through Groundwater Recharge

This option would include construction of a new tertiary treatment plant on DoD land. The plant would treat the DoD wastewater from existing sources and future proposed military relocation to northern Guam. Treated effluent would be injected into the underground aquifer (i.e., the freshwater lens) for groundwater recharge or to limit salt water intrusion.

Due to the NGLA being a sole source aquifer as discussed above, additional precautions must be taken in managing recharge with reclaimed water. At the selected effluent injection point, the recommended 9- to 12-month detention time in the aquifer before removal could not be met because of the high hydraulic conductivity in the aquifer. Under these conditions, a very high degree of treatment (normally beyond USEPA primary drinking water standards) would have to be achieved.

In practice, even if tertiary treatment of effluent were applied for this kind of indirect potable reuse of reclaimed water, it is expected that this option would not be readily accepted by regulatory agencies. Underground injection control regulations established by GEPA categorize recharge wells discharging effluent from sewage treatment plants as Class V wells. GEPA does not specify the treatment standards and criteria for underground injection of this type of effluent to recharge the aquifer. The process of establishing treatment requirements and performance monitoring standards for this option would increase the cost and time to implement the project. Also public acceptance of recharging the NGLA with WWTP effluent would likely be controversial. Therefore, this option was dismissed.

2.2.4 Alternatives Developed Forward for Potable Water

Using the options carried forward that are outlined in Section 2.2.3, two basic alternatives were developed to meet the water demand resulting from the Marine Corps relocation. If the supply provided by the chosen alternative needs future augmentation, three additional long-term alternatives have also been carried forward. Basic Alternative 1 supports Main Cantonment Alternatives 1 and 2 (use of Finegayan) and basic Alternative 2 supports Main Cantonment Alternatives 3 and 8 (use of Finegayan and Barrigada). These alternatives are summarized below. A summary of the components for the alternatives is provided in Table 2.2-16.

Either basic alternative would fully meet the DoD water demand for the Marine Corps relocation.

Table 2.2-16. Summary of Potable Water Alternatives

Alternative	*Components*				*Comments*
	Water Supply	*Water Treatment*	*Water Storage*	*Distribution System*	
Basic Alternative 1	• The capacity of 11.3 MGd anticipated to be met by an estimated 22 new wells on Andersen AFB • Use of five recently installed wells at Andersen AFB • Continued use of existing Navy wells on Finegayan • Rehabilitation of Navy wells	• Disinfection and fluorination prior to transmission to the base	• Construction of new storage tanks on Finegayan • Abandonment of existing Navy storage tanks on Finegayan	• Waterlines: transport of water to storage tanks, and distribution of water throughout Finegayan • Improvements and interconnect with Andersen AFB water system and Navy islandwide system • Connection to GWA water system	• Supports Main Cantonment alternatives 1 and 2 • Preferred alternative • Revised UFC reduces demand
Basic Alternative 2	• The capacity of 11.7 MGd anticipated to be met by an estimated 31 wells. • 20 water supply wells located on Andersen AFB • 11 water supply wells located on Navy Barrigada	• Disinfection and fluorination prior to transmission to the base	• Construction of new storage tanks on Finegayan • Construction of new storage tank at Air Force Barrigada • Use of existing Barrigada tank • Abandonment of existing Navy storage tanks on Finegayan	• Waterlines: transport of water to storage tanks • Improvements and interconnect with Andersen AFB water system and Navy islandwide system	• Supports Main Cantonment alternatives 3 and 8 • Revised UFC reduces demand
Long-Term Alternative 1	• Rehabilitation of the Lost River cofferdam • Potential to provide additional water supply to DoD in southern Guam during the dry season				• Supplemental supply if basic alternative inadequate
Long-Term Alternative 2	• Applicable to both potable water alternatives • Production of up to 12 MGd of potable water by desalination, which would require 18 MGd of brackish water • This alternative provides supplemental water in the event freshwater resources are inadequate to meet DoD demand.				• Supplemental supply if basic alternative inadequate
Long-Term Alternative 3	• Dredging of the Navy Reservoir to original design elevation to increase storage capacity • Part of long-term water system maintenance				• Supplemental supply if basic alternative inadequate

Legend: AFB = Air Force Base; DoD = Department of Defense; GWA = Guam Waterworks Authority; MGd = million gallons per day; UFC = Unified Facilities Criteria.

If either basic alternative is selected and water conservation measures and sustainability principles are not implemented (i.e., what is assumed by the current DoD UFC demand calculations), then on-base water demand at Finegayan would exceed the available water supply in 2013. The year when the anticipated water demand would exceed the current on-base DoD water supply is called the “breakpoint year.” Development of new wells and transmission lines would need to begin in 2011 to ensure their additional supply of water in 2012 to avoid the breakpoint in 2013. This coincides with the expected completion of the initial wells being developed to support Marine Corps needs. Installation of the proposed water system would begin prior to the breakpoint year. Although the maximum daily demand would not be met by the existing supply on Finegayan in 2013, with the installation of a subset of the DoD-planned wells there would be sufficient capacity to meet the estimated average daily demand, though not the required maximum daily demand of the water system (assuming water conservation and sustainability measures are applied). It is assumed that up to 10 wells at Andersen AFB would be required by 2014 to meet the DoD maximum daily demand. Construction workers’ water demand would be met by the contractor, through the GWA water systems. Impacts to the GWA water system from this demand are addressed in Chapter 3 of this Volume. If a water shortfall would be predicted, then DoD could implement force flow reductions and/or adaptive program management of construction principals would be implemented such as reducing the pace of construction activity. More information on adaptive program management is provided in Volume 7.

Permits would be required from Guam agencies for either alternative. A full list of permit requirements is provided in Chapter 3 of Volume 8.

Three long-term alternatives were developed to supplement Basic Alternatives 1 and 2. These include rehabilitation of the Lost River, desalination, and dredging the Navy Reservoir. Additional information is needed to fully define the long-term alternatives.

2.2.4.1 Basic Alternative 1 (Preferred)

Basic Alternative 1 supports cantonment alternative 1 and preferred cantonment alternative 2 and provides adequate water supplies with minimal new facilities and costs. Basic Alternative 2 supports cantonment alternatives 3 and 8, which are not preferred. Thus, Basic alternative 1 was selected as the preferred water alternative. See below for additional details.

Basic Alternative 1 would provide additional water capacity of 11.3 MGd (42.8 MLd), which is anticipated to be met by an estimated 22 new wells at Andersen Air Force Base (AFB), rehabilitate existing wells, interconnect with the Guam Waterworks Authority (GWA) water system, and associated treatment, storage and distribution systems. Two new 2.5 MG (9.5 ML) water storage tanks would be constructed at ground level at NCTS Finegayan. Up to two new elevated 1 MG (3.8 ML) water storage tanks would be constructed at Finegayan within the Main Cantonment footprint.

Basic Alternative 1 would require water supply, water treatment, water storage, and water distribution components to meet the demand of the military relocation as summarized in Table 2.2-17 and presented in Figure 2.2-1. Development of these water system components would result in a future water supply as summarized in Figure 2.2-1 and Table 2.2-18.

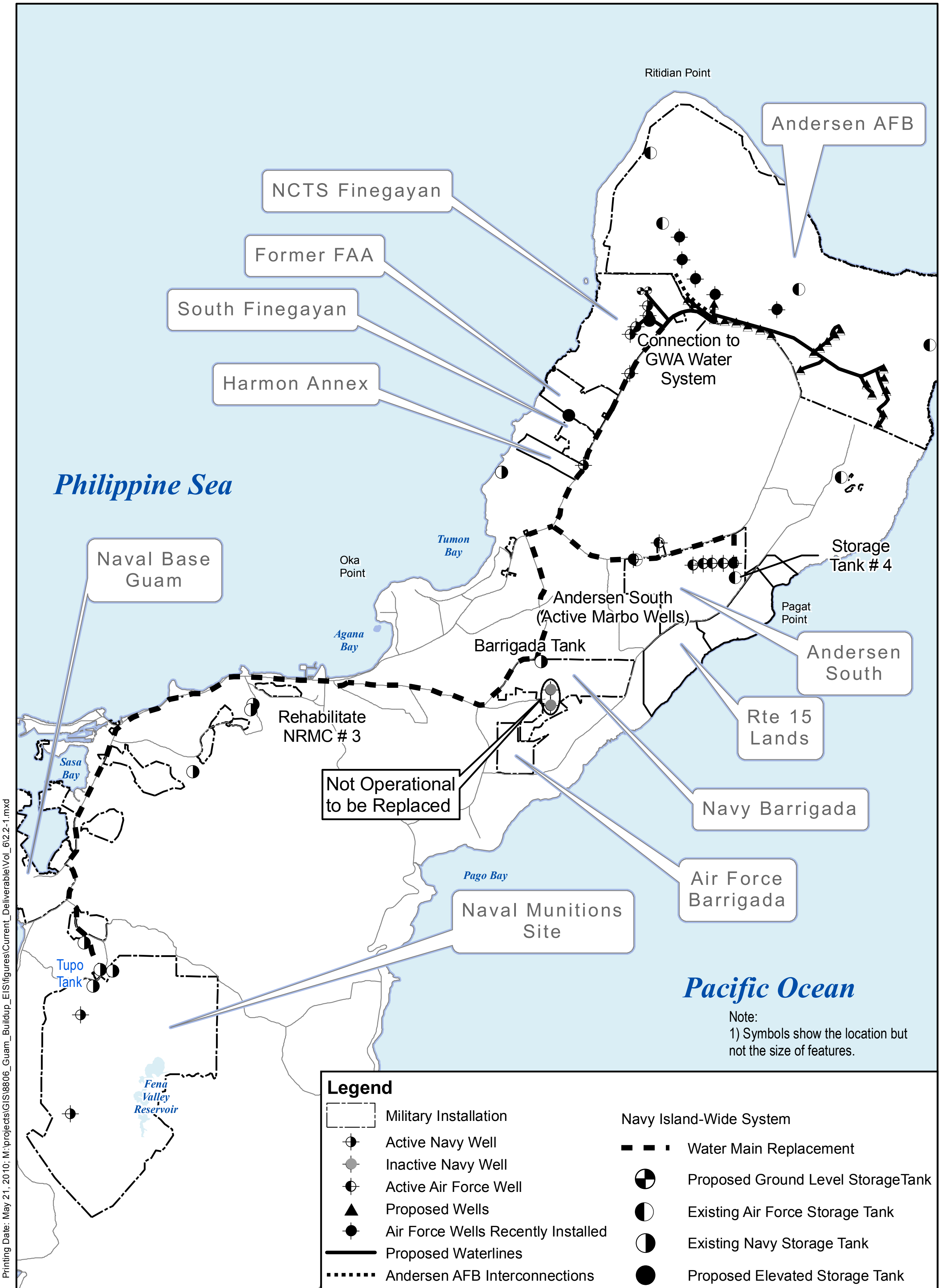

Figure 2.2-1
Basic Alternative 1 - Proposed Water System Components

Table 2.2-17. Basic Alternative 1—Proposed Water System Components

Component	*Description*
Water Supply	• Development of well capacity of 11.3 MGd anticipated to be met by an estimated 22 new wells (including one contingency well) on Andersen AFB • Use of five recently installed wells at Andersen AFB • Continued use of existing Navy wells on Finegayan • Rehabilitation of Navy wells
Water Treatment	• Disinfection and fluorination at the well heads prior to transmission to the base
Water Storage	• Construction of new storage tanks on Finegayan • Abandonment of existing Navy storage tanks on Finegayan
Distribution System	• Waterlines to transport the water from supply wells to storage tanks • Waterlines to distribute water throughout Finegayan • An interconnect with the Navy's islandwide water system • For purposes of the EIS, provide improvements to the Navy's islandwide water system (i.e., size pipes appropriately, replace corroded pipes, transport water to the south as well as north) • Replace water mains connecting existing Navy wells to the water system • Connection to the AF water system • Connection to the GWA water system

Legend: AFB = Air Force Base; EIS = Environmental Impact Statement; GWA = Guam Waterworks Authority.
Source: NAVFAC Pacific 2010h.

Table 2.2-18. Basic Alternative 1—Proposed DoD Water Supply and Demand

	Water Supply (in MGd)			
Water Supply Sources(Existing and Proposed)	*Marine Corps Finegayan*	*Andersen AFB*	*Navy*	*Total*
Main Cantonment Alternative 1 & 2				
Current Surface Water Supply			10.97	10.97
Current Groundwater Supply		4.73	2.21	6.94
Development of new water supply wells	11.28			11.28
Rehabilitation of existing Navy wells			1.23	1.23
Planned Supply Cantonment Alternative 1 & 2	11.28	4.73	14.41	30.42
GWA Transfer From Fena Reservoir	0.00	0.00	4.00	4.00
Maximum Daily Demand using UFC Guidance	10.61	4.88	12.98	28.48
Maximum Daily Demand using UFC Guidance+ GWA Transfer	10.61	4.88	16.98	32.48
Maximum Daily Demand using Sustainability Principles	6.33	2.99	9.75	19.08
Maximum Daily Demand using Sustainability Principles +GWA Transfer	6.33	2.99	13.75	23.08

Legend: AFB = Air Force Base; GWA = Guam Waterworks Authority; MGd = million gallons per day; UFC = Unified Facilities Criteria.
Source: NAVFAC Pacific 2010h.

This alternative would result in excess water of 0.7 MGd (2.5 MLd) at Marine Corps Finegayan, a deficit of 2.6 MGd (9.8 MLd) for the Navy's islandwide system and a deficit of 0.2 MGd (0.8 MLd) at Andersen AFB for Main Cantonment Alternatives 1 and 2. The water demand estimates are based on the conservative assumptions presented in the UFC water supply guidance (DoD 2001, 2005, 2006). There is adequate water supply on all DoD bases to meet average daily demand. Assuming the modified demand shown in Table 2.2-14, the capacity of the Navy and Andersen AFB water supply would be sufficient.

DoD Water Supply

Basic Alternative 1 would develop water supplies in northern Guam (water supply wells) and rehabilitation of a Navy well on Finegayan, and central Guam (rehabilitation of the Navy wells at the Navy Regional Medical Center and Navy Barrigada), would include the capability to distribute water from north to south, and interconnections with the Andersen AFB and GWA water systems. The proposed locations for new water supply wells to be constructed under Basic Alternative 1 are based on information regarding the sustainable and available yield of aquifer subbasins and other siting constraints as discussed below.

Potential Locations for New Proposed DoD Wells

There are numerous constraints imposed through DoD and GEPA guidance relating to well siting. This guidance is intended to minimize contamination of the water supply and interference between adjacent wells. All proposed DoD wells would be located on DoD land. DoD would consult with GEPA on applicability of this guidance and where wells would be located.

Potential water supply well locations were initially sited with consideration of the following land ownership and constraints:

- Limiting well production within subbasins so that the sustainable yield would not be exceeded
- Preferentially locating wells in parabasal zones (as opposed to basal zones) to achieve higher yield with lower chloride levels, thereby reducing the number of wells and associated costs
- Maintaining a 1,000-ft (305-m) distance from the shoreline to avoid saltwater intrusion
- Maintaining an approximately 800- to 1,000-ft (244- to 305-m) distance from other supply wells

The parabasal zones—areas where the freshwater lens bottom is in contact with basement rock, where the basement surface rises above the freshwater-saltwater interface—are roughly drawn in Figure 2.2-2. It is assumed that the parabasal zone extends seaward to a point where the top of the impermeable volcanic basement underlies the limestone aquifer at depth of approximately 131 ft (40 m) below mean sea level (msl). A transitional parabasal/basal zone is assumed to exist in the area where the top of the impermeable volcanic basement underlies the limestone aquifer at depths between 131 and 196 ft (40 and 60 m) below msl. These assumptions are based on existing GWA well locations described as parabasal or transitional that appear to meet these characteristics, according to available volcanic basement contour maps.

The proposed well locations are clustered in the region of the parabasal zones because the wells are expected to have a higher capacity than wells in the basal zone and are less likely to have saltwater intrusion. Some considerations for the proposed locations include:

- According to volcanic-bedrock contour mapping, a substantial portion of the available potential high-yield parabasal zone exists on or near the military reservation boundary.
- If the parabasal zone were to yield less than the proposed well production, some of the wells may need to be relocated to the basal zone on DoD land, farther from the DoD boundary, and additional wells may need to be installed. This alternative layout is not presented in this document because of the uncertainty about land use by Andersen AFB closer to the active facilities. Approximately twice the number of wells would be required if wells were to be located in the basal zone rather than the parabasal zone.
- One of the proposed well locations falls within the inhabited building distance explosive safety quantity-distance arc on Andersen AFB. Because of the spatial limitations, some proposed well locations are near or within residential zones. The Air Force would review and approve facility locations at Andersen AFB. Facility design would incorporate Andersen

AFB requirements. For instance, wells located near the runways would be frangible or flush mounted.
- Wells are located more than 300 ft from the nearest unsewered areas outside of DoD land.
- Wells are located more than 300 ft from the nearest GWA wastewater pumping station.

Figure 2.2-2 presents the l well location or placement constraints. Figure 2.2-5 shows the locations of sinkholes and caves. This figure is from the technical report prepared by WERI, Karst Features of Guam, Mariana Islands (WERI 2004). DoD would continue to seek additional information sources for sinkholes and caves as current sources may not be complete and any new information would be used in future design work. Additional constraints are listed in Table 2.2-19.

Potential Contaminant Impacts on Sources of Drinking Water

- Potential sources of contamination exist on or near Andersen AFB. These include, but are not limited to, the installation restoration sites, a utility corridor including a sewer line, and storm water injection wells.
- DoD would comply with all necessary stormwater requirements. Because the primary military relocation area would not be at Andersen AFB, impacts on stormwater resulting from the military relocation on the proposed wells would be minimal. The Main Cantonment area is within the Finegayan subbasin. Design of the Marine Corps Base would implement Low Impact Development (LID) to manage stormwater in a manner which is similar to the predevelopment hydrology at the site. Design techniques are selected which infiltrate, filter, store, evaporate, and detain runoff close to its source. Small landscape features, known as Integrated Management Practices, are located at the lot level to manage stormwater. Areas selected for Integrated Management Practices include open space, rooftops, streetscapes, parking lots, sidewalks, and medians. The benefits of implementing LID include groundwater recharge and less environmental impact. More information on the LIDs study is provided in Section 2.4.1. This scope of this study does not cover all areas where water system structures are planned.
- Dry wells would not be installed on the Marine Corps Base. Dry wells can provide a direct conduit to the NGLA.
- Sinkholes would be avoided in design and construction; a licensed geologist would conduct a pre-construction survey to identify sinkholes; impacts of sinkholes found during this survey would be determined and projects would be designed in consideration of these sinkholes.
- The proposed wells would be located away from Installation Restoration sites where warranted, based on the nature of the IR site. All well locations would be tested for water quality before installation. If elevated contaminant levels were detected, the wells would be relocated or the design would be revised to include the appropriate treatment processes. A chlorinated-solvent plume containing trichloroethylene (TCE) and perchloroethylene (PCE) concentrations greater than the USEPA drinking water maximum contaminant levels (MCLs) is identified in groundwater on Andersen AFB. Monitoring wells with elevated levels of chlorinated solvents are shown in Figure 2.2-2. This plume is downgradient from the wells and is not expected to affect the proposed well locations.

Table 2.2-19. Well Location Constraints

Location Constraint	*Comments/Approach to Well Placement*
DoD Land	Wells are located on DoD land.
Sustainable Yield	The combined capacity of the existing and planned wells is less than the 1992 sustainable yield estimate.
Parabasal/Basal Zones	Wells are clustered in the parabasal zone to maximize production of the aquifer. Lower chloride levels and higher production are anticipated for parabasal zone wells. Wells are located more than 1,000 ft from the shoreline to avoid saltwater intrusion.
Proximity to Existing and Proposed Air Force and GWA wells	Maintain an approximately 800- to 1,000-ft distance from other supply wells. Monitor for saltwater intrusion. Coordinate with GWA.
Current and Future Land Usage: • Impact on Air Force Mission and Quality of Life • Future Construction in Residential Area • Future Paving of the Utility Corridor	All facility locations would be reviewed by and require the approval of the Air Force.
Explosive Safety Quantity Distance (ESQD)	Wells are located outside all ESQD arcs, except one well that falls inside the inhabited building distance (IBD) arc near the boundary.
Potential Contaminant Sources: • Fuel Pipeline in the Utility Corridor • Fuel Storage • Dry Cleaners • 79 Installation Restoration Program Sites including Active and Inactive Landfills • Areas of past hazardous substance activities • Landfills and target ranges on the Marine Corps Finegayan Base • Underground Injection Control Wells in the Andersen AFB Main Base Area • Unsewered properties • Wastewater pumping stations	Maintain an approximately 800- to 1,000-ft distance from contaminant sources where possible. Water quality would be evaluated during the pilot hole testing and periodically during well use.
Chlorinated VOC Plumes in the Andersen AFB Main Base Area	Monitoring wells with elevated levels of chlorinated VOCs are downgradient from the proposed well locations. Water quality would be evaluated during the pilot hole testing.
UXO/MEC	Precautions would be taken during construction for UXO/MEC.
Sewer Main along Route 9	If wells are proposed along Route 9, DoD would conduct a study to evaluate the integrity of the sewer main.
Runway Approach	DoD/Air Force requirements for design would be observed. Well heads would be flush with the ground or frangible.
Sinkholes and caves	Wells would be located away from known sinkholes and caves.
• Cultural Resources • Sensitive Habitat	Location specific studies are being conducted by DoD. Facility locations would be adjusted as required.

Legend: DoD = Department of Defense; ESQD = explosive safety quantity-distance; ft =feet; GWA = Guam Waterworks Authority; UXO/MEC = unexploded ordnance/ munitions and explosives of concern; VOC = volatile organic compound.

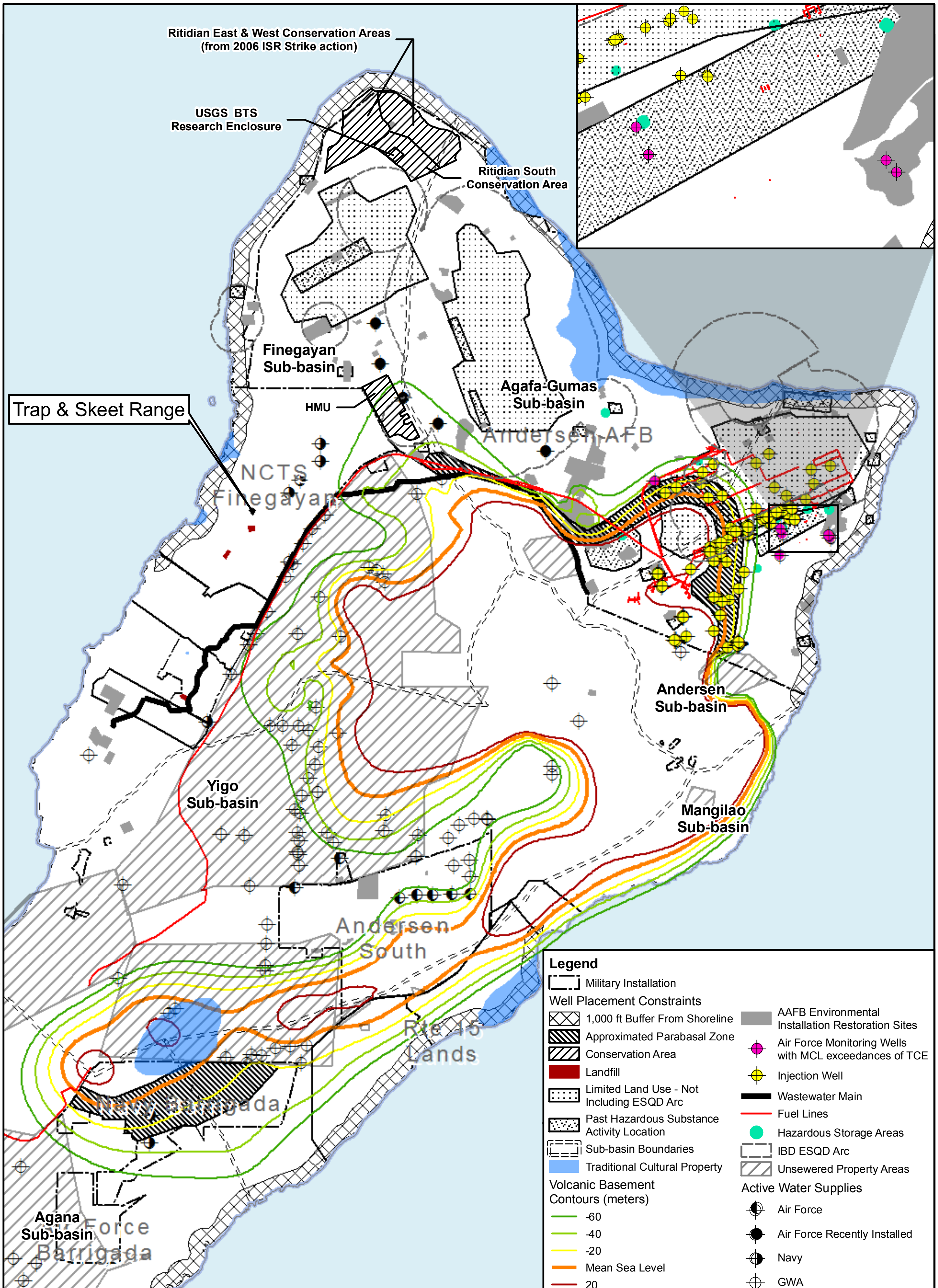

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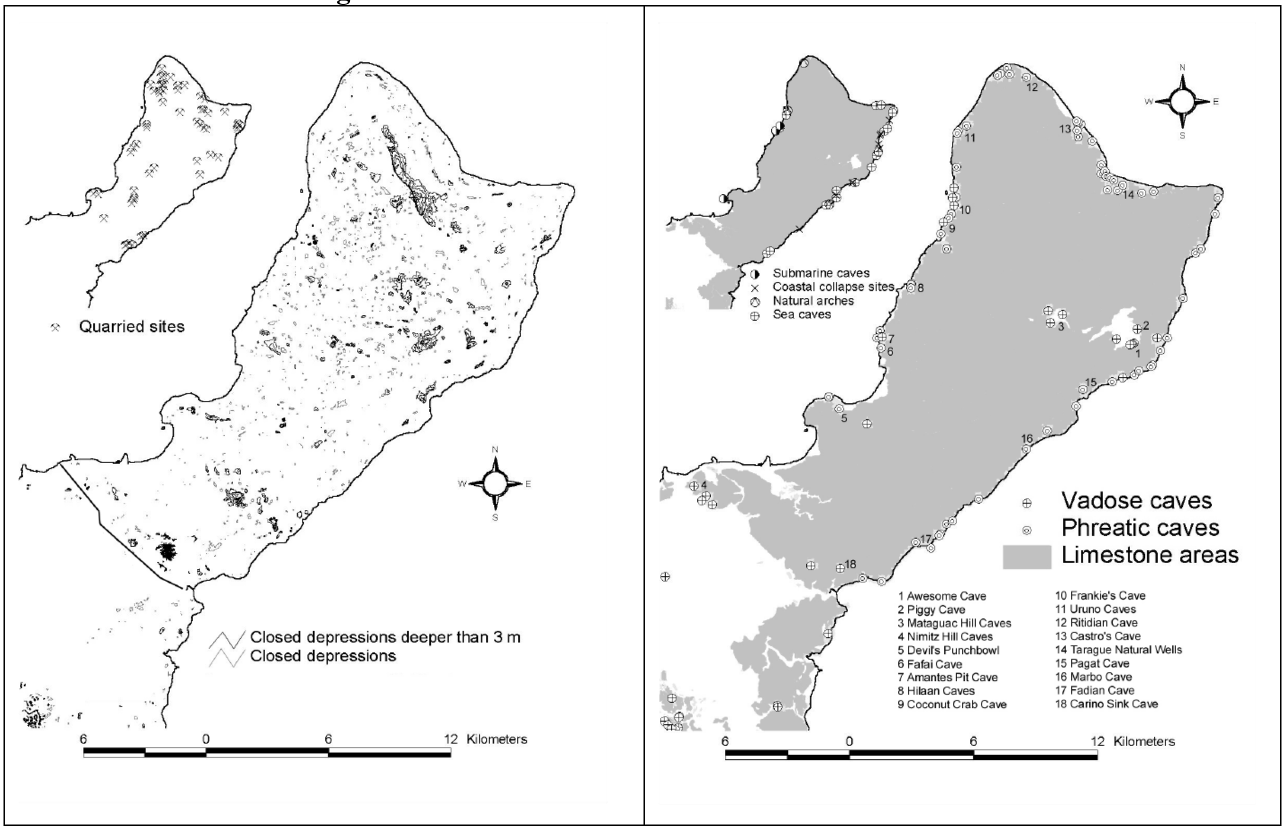
Figure 2.2-2
Constraints on Well Placement

Miles 0 1 2
Kilometers 0 1 2
N E S W

Figure 2.2-3. Sinkholes and Caves in Northern Guam



- Unexploded ordnance (UXO) and munitions and explosives of concern may be found at Andersen AFB. In accordance with Naval Ordnance Safety and Security Activity Instruction 8020.15B, Explosives Safety Submission (ESS) documentation must be prepared that details how explosive safety standards are applied to munitions responses. The ESS also addresses how a project would comply with applicable environmental requirements related to the management of munitions and explosives of concern and material potentially presenting an explosive hazard. At munitions response sites, no site operations may begin unless Naval Ordnance Safety and Security Activity and the DoD Explosive Safety Board have reviewed and approved the ESS. An ESS is prepared for on-site construction support where the likelihood of encountering UXO is determined to be moderate or high and where ground-disturbing or other intrusive activities, including dredging may occur in areas known or suspected to contain UXO. The ESS outlines specific measures to be taken to ensure the safety of workers and the public.
- Studies of cultural resources and sensitive habitat are ongoing. Well locations may be modified as a result of these studies.
- As part of the well permitting process, GEPA would conduct a review of each well location and review site-specific data. Additionally, all federal projects proposed over the NGLA are subject to an aquifer protection review. Projects are reviewed for potential direct or indirect impacts on groundwater. Submittal of detailed site plans, plumbing plans, engineering studies, and calculations may be required. Most recent cultural and natural resources studies being conducted by DoD would also be reviewed.

Groundwater Quality

Historical water quality data from GWA wells are in Table 2.2-20. The Air Force regularly monitors the water quality at South Andersen Annex in the Yigo subbasin. A summary of data collected from the Tumon Maui and Marbo wells is provided in Table 2.2-20 through Table 2.2-24. No data is available for the Agafa-Gumas subbasin. Monitoring well data related to site investigations is available for the Andersen subbasin. Data characterizing biological contamination in the groundwater is not available for this study. Some issues with the water quality from the DoD wells are:

- Groundwater from the Northern Guam Lens is typically hard, containing calcium and magnesium carbonate.
- Tumon Maui and Marbo #2 are not in service due to volatile organic contamination.
- Routine bacteriological testing at wells in the Finegayan area and Naval Hospital area has identified the presence of total coliform and E. coli.
- Chloride levels rose to unacceptable levels (i.e., greater than 250 mg/L) in some wells.
- TCE was detected in monitoring wells above MCLs located on the eastern side of Andersen AFB.

Table 2.2-20. Historical Water Quality

Constituent	*MCL*	*Wells*				*H-1*	*M1-1*
		A Series	*A-9*	*D Series*	*Y Series*		
pH	6.5-8.5	7.0	7.0	7.2	7.3	7.3	7.1
Residue on evap.	n/a	360	600	370	275	450	350
Total Hardness	n/a	292	360	226	242	265	380
Calcium (Ca)	n/a	113	130	78	85	88	98
Ca as $CaCO_3$	n/a	283	325	195	213	220	245
Magnesium (Mg)	n/a	2	10	6	7	10	8
Mg as $CaCO_3$	n/a	8	41	25	29	41	33
Chloride	250	16	140	50	17	95	30
NO_3	n/a	9	9	9.5	9.3	9	4
SO_4	250	2.5	13	8.0	2.0	20	4.5
Iron	0.3	0.01	0.01	0.02	0.02	0.02	0.03

Note: Units are mg/L, except pH
Legend: Ca = Calcium; $CaCO_3$ = Calcium Carbonate; MCL = maximum contaminant level; Mg = Magnesium; n/a = not available; NO_3 = Nitrate; pH= hydrogen ion concentration; SO_4 = Sulfate.
Source: Mink 1976

Table 2.2-21. Harmon and Tumon Sampling Points Downgradient of Andersen South Annex Operating Unit

Analyte	*Units*	*MCL*	*Samples Taken 1978-2007*		
			Min.	*Max.*	*Meeting or Exceeding USEPA Threshold, Result (month/year)*
VOCs					
PCE	µg/L	5	0.2 (est.)	22.4	5 (9/89), 9 (8/90), 8.3 (4/91), 6.1 (6/91), 7.6 (3/94), 14.6 (12/94), 11.6 (3/95), 11.6 (4/95), 12.9 (5/95), 13.1 (5/95), 13.4 (9/95), 9.4 (9/95), 11 (12/96), 11.2 (2/97), 18.2 (2/97), 19.9 (2/97), 19.5 (2/97), 22.4 (2/97), 5.2 (6/01), 5.4 (8/01), 5.0 (8/01)
TCE	µg/L	5	0.2	5.2	5.4 (6/01)
Water Quality Parameters					
Alkalinity, Bicarbonate	mg/L	n/a	154	160	
Chloride	mg/L	250	0.19	9200	

Legend: µg/L= microgram per liter; n/a = not available; PCE = Tetrachloroethene; VOC = volatile organic compounds.

Table 2.2-22. Tumon Maui Well Groundwater Field Quality Parameters 2003-2007

Parameter	*Units*	*MCL*	*Min.*	*Max.*
Ph	pH	6.5-8.5	6.7	7.46
Specific Conductivity	µmhos/cm	1600	0.756	980
Temperature	ºC	n/a	27.01	28.96
Turbidity	NTU	TT	0	9.5
Dissolved Oxygen	mg/L	n/a	3.46	16.23
Redox	mV	n/a	86	508
Chloride	mg/L	250	75.3	119

Legend: mV = millivolt; n/a = not available; NTU = nephelometric turbidity unit; ºC = degree Celsius; TT = 95% of samples measured every 4 hours < 0.3 NTU; µmhos/cmmicromhos per centimeter.

Table 2.2-23. Production Well MW-2 Groundwater Analytical Results, Andersen South Annex

Analyte	Units	MCL	Samples Taken 1996-2006		
			Min.	Max.	Meeting or Exceeding USEPA Threshold, Result (month/year)
VOCs					
PCE	µg/L	5	>0.1	0.2	—
TCE	µg/L	5	0.4	5.8	5 (10/96), 5.4 (10/00), 5.8 (10/01), 5.7 (5/02), 6 (10/02)
Water Quality Parameters					
Alkalinity, Bicarbonate	mg/L	n/a	210	216	—
Chloride	mg/L	250	13.8	67.2	—

Legend: n/a = not available

Table 2.2-24. MW-2 Groundwater Field Quality Parameters, 1996-2006

Parameter	Units	MCL	Min.	Max.
pH	pH	6.5-8.5	6.44	8.31
Specific Conductivity	µmhos/cm	1600	398	686
Temperature	ºC	n/a	26.61	30.11
Turbidity	NTU	TT	0	271
Dissolved Oxygen	mg/L	n/a	0.32	9.41
Redox	mV	n/a	-175	3932
Chloride	mg/L	250	6.28	74.7

Legend: NA = not available; NTU = nephelometric turbidity unit.

Installation Restoration Program

There are 79 sites for Andersen AFB and annexes (Figure 2.2-4) with Installation Restoration preprogram (IRP) activities that are currently implemented or proposed to be implemented. There are two sites where groundwater impacts are currently a concern. Site 20, Waste Pile 7, in Andersen South Annex has impacts to groundwater exceeding MCLs for TCE and PCE. A 2000 Interim Remedial Measure covered contaminated soil, long-term management of soil and groundwater contamination. No new wells are proposed in Andersen South Annex. Site 1, Landfill 1, is an active sanitary landfill on the main base that is operated under a Resource Conservation and Recovery Act Subtitle D permit. The inactive portion of the landfill was capped in 1998 with a geotextile membrane and soil cap cover. The inactive portion of the landfill was closed in 2001 with a Resource Conservation and Recovery Act Subtitle D cap in 2001. Groundwater samples from 16 monitoring wells are collected semi-annually to monitor potential impacts of contaminants in the landfill to groundwater. No further actions are planned for the inactive portion of the landfill. Groundwater monitoring would continue as part of the long-term management plan for a period of 30 years. At Site 26, Firefighter Training Area 2, the Air Force opted to install and operate a vapor extraction/bioventing system to address contamination released from an abandoned underground storage tank used to store waste fuel, although the contamination did not represent an unacceptable risk to human health and the environment due to concern that the chemicals could potentially impact groundwater.

There are 24 sites where no further actions are required according to a signed Record of Decision (ROD) or are proposed pending signature of a ROD. Three sites were transferred to Military Munitions Response Program because only ordnance and explosives (OE) was identified. Land use controls are recommended for six sites to prevent exposure to contaminated soil. Contaminated soil removal is recommended at 19 sites. Remedial actions or Interim Remedial Measures have been conducted at 23 sites.

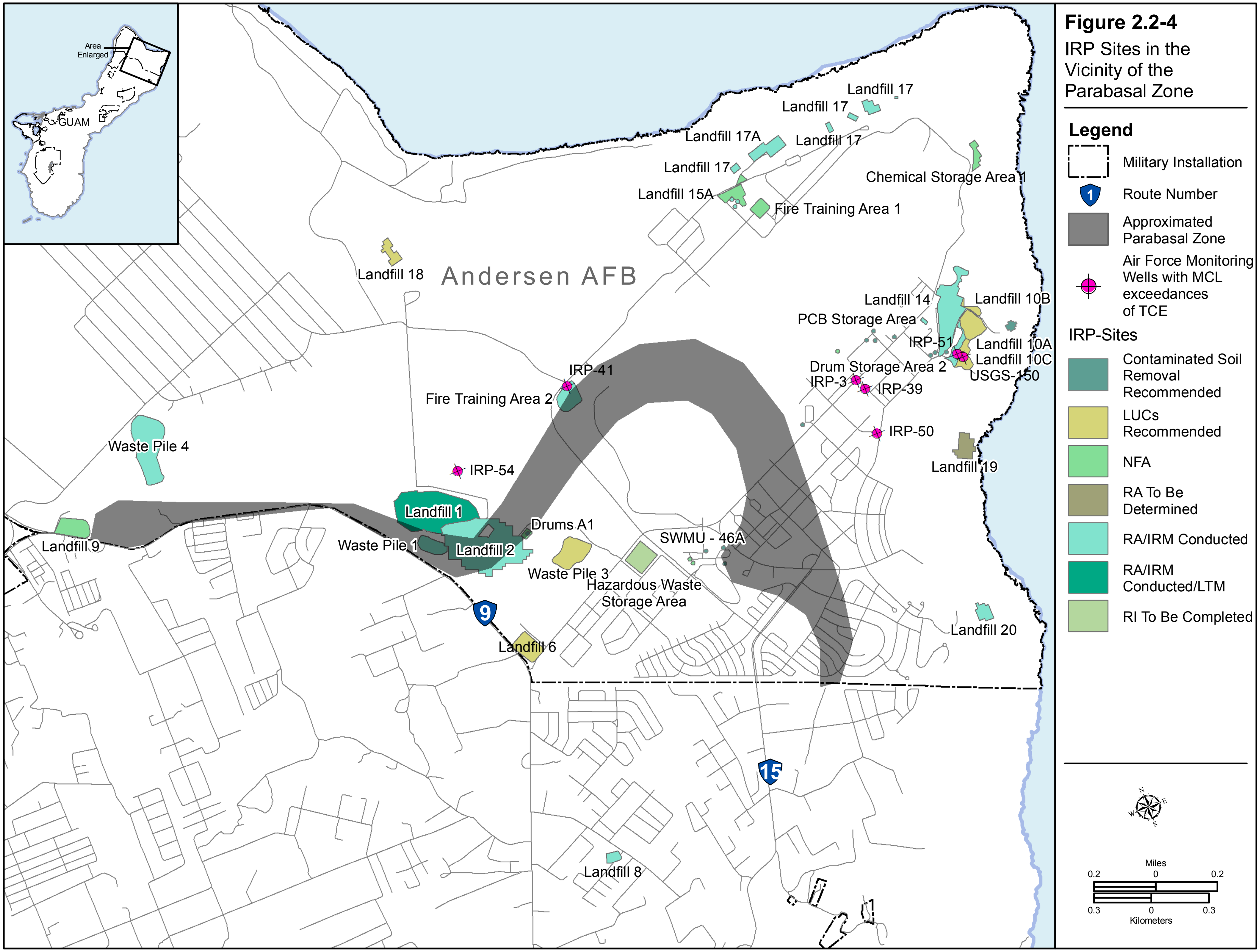


Figure 2.2-4
IRP Sites in the Vicinity of the Parabasal Zone

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Remedial Investigations are being conducted at three sites on the main base. Site 27, Hazardous Waste Storage Area 1, reportedly used as an outside storage of petroleum, oils, lubricants and solvents from the 1950s to the 1970s. No compounds of concern were identified during an investigation in 1998. Site 54, Building 18006, is an area where wastes from aircraft operations were disposed according to historical documents. Previous investigations detected TCE in subsurface soils. Site 79, Air to Ground Gunnery Range, was reportedly used as a gunnery range and a sanitary dump. Dichlorodiphenyltrichloroethane, copper and lead were detected above residential preliminary remediation goals at this site. At Site 14, Landfill 19, investigation identified surface soils containing polychlorinated biphenyls, arsenic, and lead identified. The ROD documenting the recommended remedial action is expected in 2010.

A groundwater monitoring program is conducted for all operable units. Groundwater sampling at the Main Base Operable Unit has identified volatile organic compounds, semivolatile organic compounds, polynuclear aromatic hydrocarbons, pesticides, and metals. Benzo(a)pyrene, PCE, TCE, and chromium have been detected above the MCL. Benzo(a)pyrene, PCE, TCE, and chromium are the only compounds in the long-term groundwater monitoring program for the Main Base Operable Unit. Chromium contamination has been attributed to non-contaminant sources such as well screen corrosion. During the Spring 2006, of the 19 wells sampled all TAL metals were below action level except one well, IRP-54, which was detected above the federal MCL of 100 µg/L at 104 µg/l. Table 2.2-17 lists the wells with TCE or PCE exceedances above MCLs between 1996 and 2006. IRP-3, IRP-39, IRP-51, U.S. Geological Service (USGS)-150 and IRP-50 are located downgradient from the parabasal zone in the Andersen subbasin. Well IRP-41 with TCE concentrations ranging from nondetect to 8 µg/L is located near the parabasal zone. Groundwater sampling would be conducted as part of production well installation to determine if treatment is required. Three of the wells with concentrations exceeding MCLs are located within an IRP sites (Site 8, Site 26, and Site 33). Information on the sites is provided in Table 2.2-25. Given the distance below ground surface, the TCE or PCE contamination may originate from a different location.

Table 2.2-25. TCE and PCE Concentration Ranges in Wells with Detections above MCLs

Well ID	*TCE Concentrations (µg/L)*	*PCE Concentrations (µg/L)*	*IRP Site Where Well is Located*
IRP-3	49 to 169	3 to 7.3	None
IRP-39	15 to 28	14 to 35	None
IRP-51	12 to 30	<MCL	Site 33 Drum Storage Area 2 Oil stained soil and drums of debris Soil removal completed in 2007
USGS-150	0.3 to 15	<MCL	Site 8 Landfill 10 Lead, pesticides and benzo(a)pyrene in soil ROD recommending LUCs awaiting signature
IRP-50	1.3 to 5	<MCL	None
IRP-41	ND to 8	<MCL	Site 26 Firefighter Training Area 2 Fuels, MOGAS, Petroleum, Oils, Lubricants and Solvents Vapor Extraction/Biovent System Operated until 2007

Notes: PCE MCL = 5 µg/L; TCE MCL = 5 µg/L.
Legend: ID = identification; IRP = Installation Restoration Program; LUC = Land Use Control; MCL = Maximum Contaminant Level; ND = non detect; PCE = tetrachloroethylene; ROD = Record of Decision; TCE = trichloroethylene; µg/L = micrograms per liter; USGS = United States Geological Service.

Groundwater sampling was discontinued at the Northwest Field Operable Unit and the Harmon Annex Operable Unit in 2003. Groundwater sampling is conducted at the Marbo Operable Unit for volatile organic compounds as a component of the monitored natural attenuation remedy for groundwater impacted by TCE and/or PCE. Several monitoring wells are sampled for all compounds of concern near Waste Pile 7 to monitor for potential contamination of groundwater by leachate from the capped waste pile. No production wells are proposed in the Northwest Field, Harmon Annex, or Andersen South Annex.

Estimates of Sustainable and Available Yield

Sustainable yield is defined as the rate at which groundwater can be continuously withdrawn from an aquifer without impairing the quality or the quantity of the pumped water. To sustainably approach the hypothetically available sustainable yield, the means of water withdrawal has to be optimized.

The NGLA is divided into six subbasins based on hydrological divides in the subsurface: Agafa-Gumas; Agana; Andersen; Finegayan; Mangilao; and Yigo. Figure 2.2-2 shows the location of the subbasins. Two estimates of the NGLA have been published, one by the Northern Guam Lens Study (NGLS) (CDM 1982) and one by Barrett Consulting with John Mink (Barrett 1992).

The NGLS estimates were based on a steady-state condition and relied on conservative assumptions such that future development and groundwater management programs could be easily implemented. The NGLS was the first to divide the aquifer into a series of six subbasins and 47 management zones. The subbasin division is based primarily on topographic expression of basement topography forming effective hydrological divides in the subsurface. Based on the position of the freshwater lens, the subbasins can be either basal (freshwater lens floating on top of saltwater) or parabasal (freshwater lens bottom in contact with basement rock, where the basement surface rises above the freshwater-saltwater interface). Management zones were established to optimally manage well fields within the basin.

The second estimate of sustainable yield was prepared by Barrett (1992), who revised the simulation to a transient system rather than steady-state. Barrett argued that the NGLA is best described as a transient system because the majority of the recharge comes during the wet season and transient conditions best represent seasonal variations in recharge. The revised estimate of sustainable yield using transient conditions increased sustainable yield to approximately 80.5 MGd (305 MLd).

Table 2.2-18 compares sustainable yield estimates of the NGLS (CDM 1982) and Barrett (1992) reports for each subbasin, and presents current estimates of well production and available yield. The majority of the Andersen and Agafa-Gumas subbasins lie beneath existing DoD land (Andersen AFB and Northwest Field). Additionally, a substantial portion of the Finegayan subbasin lies below the Naval Communication Station property abutting the Northwest Field to the south. The yield estimates presented here use the yield estimates presented by Barrett (1992) as the basis for determining available yield (Jensen 2006).

The management zones identified in the 1982 NGLS do not match the subbasin boundaries, which are based on the 1991 volcanic-basement contours. As a result of this discrepancy, the analysis presented here does not rely on the 1982 NGLS management zones. Additionally, the NGLS management zones were established as a means of managing well fields. With the changes to the number and location of wells since the early 1980s, the zones described by the NGLS in 1982 appear to be outdated.

University of Guam WERI provided an expert technical review of the assumptions used in the Barrett 1992 sustainable yield estimate for the NGLA in 2009. The study concluded that the approach and methodology used in Barrett 1992 to estimate the sustainable yield are still valid and are appropriate for initial planning; and the Barrett 1992 sustainable-yield estimates should be used instead of the earlier 1982 sustainable-yield estimates (CDM 1982) because the later values are based on an additional decade of field data. The 1982 sustainable-yield estimates are excessively conservative according to WERI.

The DoD is supporting a USGS study of the NGLA that would include a state-of-the-art groundwater model and verification of the sustainable yield on all relevant and available site-specific data collected to date. The study is expected to take three years to complete. Installation of the water system for the relocation would commence in 2011. By this time, the modeling effort would be advanced and preliminary results of this study would be reviewed by DoD and incorporated into the construction specifications as appropriate. The model would also be used in the long-term maintenance of the NGLA groundwater resource. This is consistent with the 2009 WERI review of the earlier studies. Specifically, the study concluded that while a revised state-of-the-art model would be a useful tool for long-term management of the aquifer, it is not likely to provide a significantly different outcome for sustainable yield. More information on the WERI 2009 study and the USGS modeling effort is provided in Section 2.2.5.

Based on these estimates of available yield presented in Table 2.2-26, it is clear that groundwater resources are underdeveloped within the Andersen and Agafa-Gumas subbasins. Assuming average daily demand for the base, use of the Andersen and Agafa-Gumas subbasins would be much less than even the more conservative 1982 estimates of sustainable yield. Well production from the Andersen and Agafa-Gumas subbasin would not significantly impact the GWA water system, even if the 1982 sustainable yield estimates are incorrect, because only a few percent of the combined well capacity of the GWA water supply falls within these subbasins.

Table 2.2-26. Estimates of Sustainable and Available Yield for Subbasins in the NGLS

Subbasin	*Well Production*	*NGLS (CDM 1982)*		*Barrett (1992)*	
		Sustainable Yield	*Available Yield*	*Sustainable Yield*	*Available Yield*
Agana	10.4	11.7	1.3	20.5	10.1
Mangilao	2.5	3.9	1.4	6.6	4.1
Andersen	0.7	6.2	5.5	9.8	9.1
Agafa-Gumas	0.3	10.1	9.8	12.0	11.7
Finegayan	8.9	6.4	-2.5	11.6	2.7
Yigo-Tumon	19.4	19.1	-0.3	20.0	0.6
Totals	42.4	57.4	15.0	80.5	38.1

Legend: NGLS = Northern Guam Lens Study.
Sources: CDM 1982, Barrett 1992, NAVFAC Pacific 2005, HHMI Corporation, Helber Hastert & Fee, Planners, Inc. 2006, GWA 2007.

Climate change is likely to negatively impact Pacific islands including Guam. The degree to which climate change and variability would affect Guam depends upon a variety of factors including geology, area, height above sea level, extent of reef formation, and the size of the freshwater aquifer (USEPA 2009c). *Because* Guam *i*s *a* small islands, *it* is considered vulnerable to c*limate change because extreme ev*ents can have a major impact on small islands. The climate studies conducted are global in focus or centered on particular regions or the earth. *However, studies s*pecific to Guam are not currently available. WERI plans to complete studies specific to Guam. *S*tudies *specific to Guam* would presumably be more relevant to predictions of future impacts on the NGLA because the characteristics and hydrogeology of the aquifer can be considered.

A parabasal zone exists in both the Andersen and Agafa-Gumas subbasins, meaning that these subbasins have the potential for increased production rates. The majority of these subbasins lie under DoD land (see Figure 2.2-2). They are also close to the proposed location for the Main Cantonment at Finegayan. Therefore, Basic Alternative 1 proposes to develop 19 new water supply wells within the Agafa-Gumas and Andersen subbasins. Three wells are proposed for the Finegayan subbasins. Additionally, five wells were recently installed at Andersen AFB.

Components of the Water Systems Figure 2.2-1 and Table 2.2-27 present the well capacity and subbasin location for each of the proposed wells needed to meet new demands for potable water at the Finegayan Base resulting from the military relocation on Guam. DoD would work with GWA during design and implementation of the DoD wells and during well operation to maximize use of the aquifer. DoD would attempt to locate water system components including wells and transmission mains within existing utility corridors to the extent possible.

Table 2.2-27. Basic Alternative 1—Proposed Well Details

Well Number	*Proposed Capacity (gpm)*	*Subbasin*
1	450	Agafa-Gumas
2	450	Andersen
3	250	Finegayan
4	450	Agafa-Gumas
5	450	Agafa-Gumas
6	450	Agafa-Gumas
7	450	Agafa-Gumas
8	400	Finegayan
9	450	Agafa-Gumas
10	250	Andersen
11	450	Andersen
12	250	Agafa-Gumas
13	250	Andersen
14	250	Agafa-Gumas
15	250	Agafa-Gumas
16	250	Finegayan
17	450	Andersen
18	250	Andersen
19	250	Agafa-Gumas
20	375	Agafa-Gumas
21	450	Andersen
22	300	Agafa-Gumas

Legend: gpm = gallons per minute.
Source: NAVFAC Pacific 2010h.

DoD is conducting a study to determine optimal well and well field configurations needed to meet the future Marine Corps base water demands. This study will develop groundwater source well-design criteria used in developing the Marine Corps base water supply system. Test wells would be installed to characterize the production capacity of well fields in the areas of interest. Step-drawdown, pumping tests, collection of salinity and basic water quality parameters data, and groundwater sample collection for primary and secondary drinking water standard contaminants will be conducted. The test wells may eventually be converted to production wells. Completion of the study with report documentation is anticipated at the end of 2010. Preliminary results will not be available in time for the Final EIS. The results of this study could change the location and number of wells or the water treatment requirements. DoD is complying with permit requirements. GEPA reviews well siting proposals. DoD has worked with GEPA to select the test boring locations, avoiding potential sources of hazardous materials. The LIDs study includes an assessment of existing and future contamination within the watershed drainage basin. A source water assessment is not required by regulatory agencies and is not planned. However, the planning and permitting efforts for base and water system design and construction meet the substantive requirements of a source water assessment.

Well Construction

Wells would be constructed in limestone. For wells in the parabasal zone, it is assumed that wells would be terminated approximately 50 ft (15 m) below msl, and for wells in the basal/transitional zones, well termination is assumed to be 30 ft (9 m) below msl. Estimates of total well depth range between 512 and 577 ft (156 and 176 m) below grade. Drilling of investigatory wells would be undertaken before installation of each production well to establish correct well placement based on accurate volcanic basement contours.

Rehabilitation of Navy Wells

Water from two of the three wells at the Navy Regional Medical Center are biologically contaminated. The existing disinfection process would be evaluated and improved. Two Navy wells on Navy Barrigada are currently being replaced. One Navy well on Finegayan could be rehabilitated or replaced. Additional Navy wells may be replaced in another location to permit construction of the base and associated road-widening.

Water Treatment

Groundwater would be extracted and disinfected and fluorinated prior to transmission to the new base.

Water Distribution and Storage

Pumps at each well station would pump water from the wells to a storage tank after disinfection and fluorination.

Well Pumping Stations

Wellhouses would be constructed to meet typhoon and local building code requirements. Sufficient standby power would be provided to ensure that the average daily demand at the new base could be met during power outages. Each well station would include a submersible well pump with an aboveground discharge pipe that would need to be protected. Wells would be installed with pitless adapters for security. The discharge pipe would have an air/vacuum relief valve, check valve, surge relief valve, and flow meter. The land area requirement for each well station is estimated to be a minimum of 1,000 ft^2 (93 m^2).

Transmission Mains

Transmission mains would convey water from the wells to the storage tanks. The mains are expected to range from 8 to 30 in (20-76 centimeters [cm]) in diameter and would be sized to provide velocities less than 6 ft (2 m) per second to minimize head losses from friction.

Water transmission mains would convey water from the wells to the water storage and distribution system. Interconnections with Andersen AFB and the Navy islandwide water system would permit the transfer of water between the DoD water systems. A connection to the GWA system shown in Figure 2.2-1 is also proposed.

Water Distribution Pipes

Water would be distributed throughout the Main Cantonment through both 8-in (20-cm) and 12-in (30-cm) water mains with valves and hydrants spaced at intervals no greater than 500 ft (152 m). It is assumed that the pipes would follow the preliminary street layout. The size and locations of distribution piping would need to be coordinated with expected land uses, estimated domestic demands, and fire flow requirements for the structures that would be constructed on the base.

Water Storage

Two new 2.5 million gallon (MG) (9.5 million liter [ML]) ground level and up to two 1 MG (3.8 ML) elevated water storage tanks would be constructed at Finegayan.

2.2.4.2 Basic Alternative 2

Basic Alternative 2 would support Main Cantonment Alternatives 3 and 8, which would locate housing areas at Finegayan and Navy and Air Force Barrigada. For Basic Alternative 2, new water supply wells would be installed at Andersen AFB and Navy Barrigada, existing wells would be rehabilitated, and the T&D systems would be upgraded. Basic Alternative 2 would require water supply, water treatment (disinfection and fluorination), water storage, and water distribution components, as summarized in Figure 2.2-5 and Table 2.2-28.

Table 2.2-28. Basic Alternative 2—Proposed Water System Components

Component	*Description*
Water Supply	• Development of well capacity of 11.7 MGd anticipated to be met by an estimated 31 new water supply wells (20 new water supply wells (including one contingency well) at Andersen AFB and 11 new water supply wells (including one contingency well) at Navy Barrigada.
Water Treatment	• Disinfection and fluoridation prior to transmission to storage, if deemed appropriate.
Water Storage	• Continued use of existing Navy Barrigada storage tank • Construction of new storage tanks at Finegayan • Construction of a new storage tank at Air Force Barrigada • Abandonment of existing Navy storage tanks at Finegayan
Distribution System	• Waterlines to transport the water from supply wells to storage tanks • An interconnect with the Navy's islandwide water system • Improvements to the Navy's islandwide water system between Air Force Barrigada and Finegayan (i.e., extend system to Air Force Barrigada, size pipes appropriately, replace corroded pipes, transport water to the south as well as north)

Legend: *AFB = Air Force Base.*
Source: NAVFAC Pacific *2010h.*

Alternative 2 addresses the water demands in northern Guam. Water requirements at Andersen AFB and the Navy bases are projected to be currently adequate under average daily demand conditions and are not discussed in this alternative. It is estimated that water from wells installed on Navy Barrigada would be sufficient to meet the demand at Air Force Barrigada. Additional Marine Corps relocation–related demand at Barrigada would be met by the Finegayan water supply via the Navy's islandwide water system. As presented in Table 2.2-29, this alternative would result in excess water of 0.6 MGd (2.3 MLd) at Marine Corps Finegayan. The maximum daily demand on Navy bases plus the GWA transfer from Fena Reservoir exceeds the planned supply for the Navy by 2.6 MGd (9.8 MLd). The maximum daily demand on Andersen AFB exceeds the planned supply for the AF by 0.2 MGd (0.8 MLd). Assuming average daily demand from the Navy bases and the GWA transfer, there is an excess water supply of 1.7 MGd (6.4 MLd) in the Navy's islandwide water system. Assuming average daily demand from the Andersen AFB bases, there is an excess water supply of 1.7 MGd (6.4 MLd) in the Andersen AFB water system.

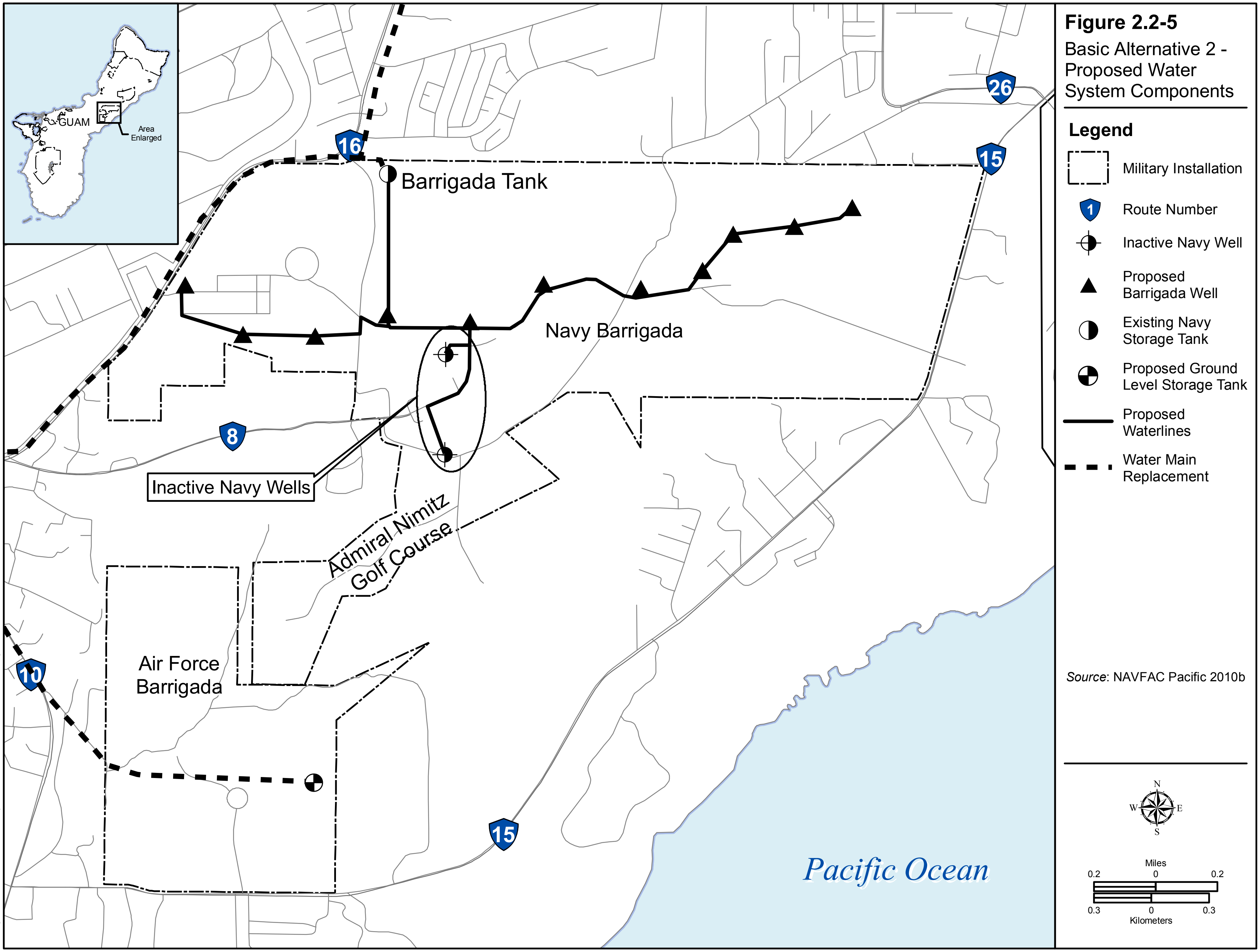

Figure 2.2-5
Basic Alternative 2 - Proposed Water System Components

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Table 2.2-29. Basic Alternative 2—Proposed DoD Water Supply and Demand

Water Supply Sources(Existing and Proposed)	Water Supply (in MGd)			
	Marine Corps Finegayan	Andersen AFB	Navy	Total
Main Cantonment Alternative 3 & 8				
Current Surface Water Supply			10.97	10.97
Current Groundwater Supply		4.73	2.21	6.94
Development of new water supply wells	11.68			11.68
Rehabilitation of existing Navy well			1.23	1.23
Planned Supply Cantonment Alternative 3 & 8	11.68	4.73	14.41	30.82
GWA Transfer From Fena Reservoir	0.00	0.00	4.00	4.00
Maximum Daily Demand using UFC Guidance	11.07	4.88	12.98	28.94
Maximum Daily Demand using UFC Guidance+ GWA Transfer	11.07	4.88	16.98	32.94
Maximum Daily Demand using Sustainability Principles	6.61	2.99	9.75	19.36
Maximum Daily Demand using Sustainability Principles+ GWA Transfer	6.61	2.99	13.75	23.36

Legend: AFB = Air Force Base; GWA = Guam Waterworks Authority; MGd = million gallons per day; UFC = Unified Facilities Criteria.
Source: NAVFAC Pacific 2010h.

Water Supply

Basic Alternative 2 would develop water supplies (water supply wells) in northern Guam and would include the capability to distribute water from Finegayan to Navy and Air Force Barrigada. The proposed locations for new water supply wells to be constructed under Basic Alternative 2 are based on information regarding the sustainable and available yield of aquifer subbasins and other siting constraints as discussed for Basic Alternative 1 in Section 2.2.4.1. Wells would be placed on Navy Barrigada within the parabasal region (Figure 2.2-5).

Estimates of Sustainable and Available Yield

For Basic Alternative 2, wells are proposed at Andersen AFB in the Andersen and the Agafa-Gumas subbasins, which are underdeveloped compared to the southern subbasins. A parabasal zone exists in both the Andersen and Agafa-Gumas subbasins, meaning that they have the potential for increased production rates. The majority of these subbasins lie under DoD land (see Figure 2.2-2). They are also close to the proposed location for the Main Cantonment at Finegayan. Therefore, Basic Alternative 2 proposes to develop 20 new water supply wells within the Agafa-Gumas and Andersen subbasins.

Navy Barrigada is located within the Agana and Mangilao subbasins. Based on either the 1982 or 1992 estimate of sustainable yield (Table 2.2-16), sufficient yield remains available to meet the 2.5 MGd (9.5 MLd) required supply for Air Force Barrigada. Therefore, Alternative 2 proposes to develop up to 11 new water supply wells within the Agana and Mangilao subbasins.

The number of wells for Basic Alternative 2 is greater than the number of wells for Alternative 1 to meet the higher UFC system requirement. The causes of the higher water demand are as follows: lower expected yield from the new supply wells at Barrigada versus the wells at Andersen AFB, and additional water supply to accommodate the active duty population that lives on Navy Barrigada or Air Force Barrigada, but works on the Marine Corps base.

Components of the Water Systems

Figure 2.2-5 and Table 2.2-30 present the well capacity and subbasin locations for proposed wells needed to meet new demands for potable water at the Finegayan Base Complex and Barrigada housing areas resulting from the military relocation on Guam.

Well Construction

Wells would be constructed in limestone as discussed for Basic Alternative 1 (see Section 2.2.4.1).

Table 2.2-30. Alternative 2—Proposed Well Details

Well Number	*Proposed Capacity (gpm)*	*Subbasin*
Located on Andersen AFB		
1	**450**	**Agafa-Gumas**
2	350	Andersen
3	150	Finegayan
4	200	Agafa-Gumas
5	400	Agafa-Gumas
6	400	Agafa-Gumas
7	400	Agafa-Gumas
8	100	Finegayan
9	350	Agafa-Gumas
10	350	Andersen
11	350	Andersen
12	350	Agafa-Gumas
13	355	Andersen
14	400	Agafa-Gumas
15	350	Agafa-Gumas
16	350	Finegayan
17	350	Andersen
18	350	Andersen
19	350	Agafa-Gumas
20	250	Agafa-Gumas
Located on Navy Barrigada		
1	200	Mangilao
2	200	Mangilao
3	150	Mangilao
4	150	Mangilao
5	150	Mangilao
6	100	Agana
7	100	Agana
8	100	Agana
9	150	Agana
10	100	Agana
11	100	Agana
NCTS #3 *(rehab.)*	50	Agana
NCTS #8 *(rehab.)*	200	Agana

Legend: AFB = Air Force Base; gpm = gallons per minute; NCTS = Naval Computer and Telecommunications Station.
Source: NAVFAC Pacific 2010a.

Water Treatment

Water treatment would be the same as discussed for Alternative 1 (see Section 2.2.4.1).

Water Distribution and Storage

Water distribution and storage would be constructed as discussed for Alternative 1 in Section 2.2.4.1, except as described below.

Water Transmission Mains

The water from these wells on Navy Barrigada would be transported from the storage tank on Navy Barrigada to Air Force Barrigada through the Navy islandwide system (30-in [76-cm] main) and a planned connection from the Navy islandwide system to a planned reservoir on Air Force Barrigada (24-in [61-cm] main). Water from the wells on Finegayan would be conveyed to Barrigada housing areas through the Navy islandwide system main. The cost includes replacement of the Navy islandwide system water main in sections, which are planned for use in Alternative 2 because the water mains are more than 50 years old and substantial water loss is expected in these water lines from leakage. Distribution of treated water to users within the bases is not included in this plan.

Water Storage

Water storage at Finegayan would be the same as Basic Alternative 1.

For Navy Barrigada, it is assumed that the existing 3-MG (11 ML) Barrigada reservoir can be used to meet the 1.6-MG (6.1 ML) minimum required storage for Alternative 2.

For Air Force Barrigada, a new 1-MG (3.8 ML) ground level tank is planned to meet the 0.95-MG (3.6 ML) minimum required storage. There is no existing storage in this area.

2.2.4.3 Long-Term Alternatives

The long-term alternatives would require follow-on analysis and tiered NEPA documentation. This may substantially change which long-term alternatives are pursued. Therefore, while a preliminary description of the long-term alternatives is presented in the following subsections, impacts related to these long-term alternatives are not assessed in this EIS because they are not ripe for analysis.

Long-Term Alternative 1

Development of the Lost River (Tolaeyuus River) is considered a long-term alternative to provide additional supply to the Navy water system during the dry season. It is estimated that the Lost River supply would yield 1.7 to 5.6 MGd (6.4 to 21 MLd) during the dry season, based on the USGS data collected between 1998 and 2001. Supply from the Lost River would be limited by downstream habitat considerations. The U.S. Fish and Wildlife Service has identified a minimum conservation flow of 1 cubic foot per second (0.03 cubic meters per second). The existing cofferdam would be rehabilitated, the reservoir area dredged, and a pump station and discharge pipeline would be installed for distributing the supply to the existing Fena Reservoir pump station. The water would be delivered either to the Navy reservoir or the Fena WTP. The capacity of the WTP and Navy distribution system would not be expanded, because the added supply is needed to compensate for the drawdown on the Navy reservoir during the dry season. Additional study is required to define the conceptual design of this alternative.

Long-Term Alternative 2

Desalination (removal of salt) of brackish water by reverse osmosis is a long-term alternative to meet projected DoD water demands in the event that the supply from freshwater wells is insufficient to meet DoD demand. Desalination of brackish water would replace the development of new freshwater potable water supply wells at Andersen AFB and Barrigada.

Under the desalination option, a WTP would produce up to a total of 12 MGd (45 MLd) of potable water. To supply the remaining approximately 12 MGd (45 MLd) of potable water, it is assumed that 18 MGd (68 MLd) of brackish water would be required. Brackish water wells would be placed at Andersen AFB, toward the coastline.

Brackish water would be supplied by up to 28 new brackish water wells and one contingency well, each with a capacity of 450 gallons per minute (1,700 liters per minute). Wells would be separated by a distance of at least 1,000 ft (305 m) to avoid interference and upconing, and would be located within 1,000 ft (305 m) of the shoreline to avoid influencing existing freshwater wells. Well water extracted from the new wells would be collected, desalinated, and treated for water supply to the end user.

Desalination would include options for new brackish-water supply wells (up to 28 wells at Andersen AFB) and upgrades to T&D systems. Desalination would require water supply, water treatment, water storage, and water distribution components as summarized in Table 2.2-31 and presented in Figure 2.2-6.

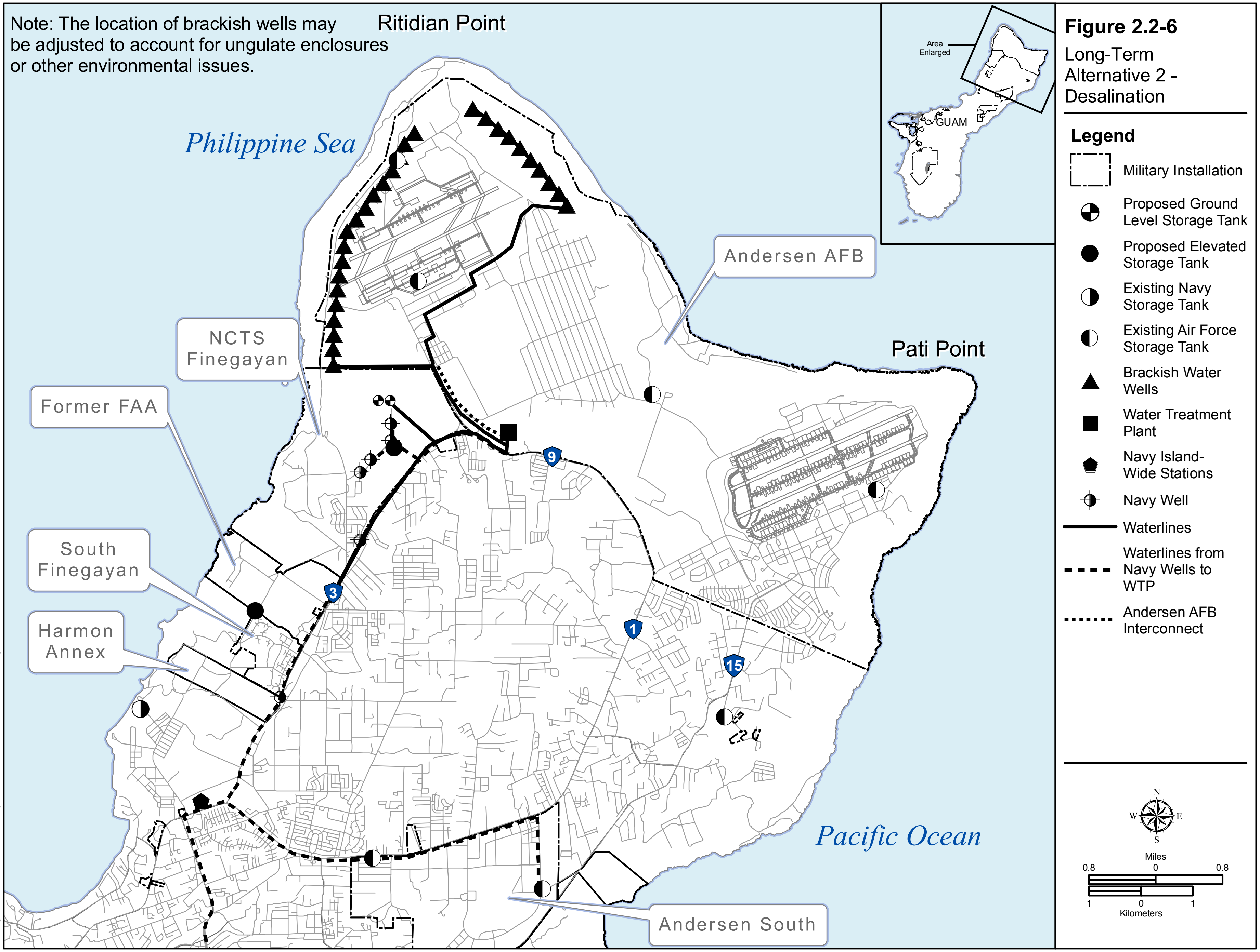
Table 2.2-31. Desalination—Proposed Water System Components

Component	*Description*
Water Supply	• Development of up to 28 new brackish-water supply wells plus one contingency well at Andersen AFB
Water Treatment	• One 12-MGd WTP at Andersen AFB
Water Storage	• Construction of new storage tanks at Finegayan
Distribution System	• Waterlines to transport the water from supply wells to treatment plants • Waterlines to transport treated water to storage tanks • Waterlines to distribute water throughout Finegayan • Replace water mains connecting existing Navy wells to the water system

Legend: AFB = Air Force Base; MGd = million gallons per day; WTP = Water Treatment Plant.
Source: NAVFAC Pacific 2010h.

Water Supply

Brackish-water wells would be planned to supply the treatment plant with enough water to produce a total of 12 MGd (45 MLd) of potable water. It is assumed that 18 MGd (68 MLd) of brackish water (3,000-4,000 mg/L TDS) would be required. The brackish-water supply wells would be designed with a higher capacity, 450 gallons per minute (1,703 liters per minute), because these wells would be drawing saline water. This limit is consistent with the recommendations for supply wells presented in the 1982 NGLS. To meet the supply, 28 supply wells would be required. Consistent with the constraints for the freshwater wells, the brackish-water supply wells would be separated by a distance of at least 1,000 ft (305 m) to avoid interference and upconing. To avoid influencing existing freshwater wells, the supply wells would be placed within 1,000 ft (305 m) of the shoreline. The brackish-water wells would be screened within the brackish-water zone.



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Proposed brackish-water supply well locations are shown in Figure 2.2-6. Most of the wells located near the northwest shoreline would be within the fenced area of the military reservation. The wells located outside of the fenced area might be relocated for security. The wells along the northern shoreline would be located in a limestone forest. These wells may need to be relocated because of habitat considerations. Most of the area around the Northwest Field is considered important habitat by the regulatory agencies. This area is home to the island's last known nesting area of the endangered Mariana fruit bat. Well locations may need to be adjusted be outside of the ungulate enclosure. The area to the northeast is prime limestone forest, which is important habitat for many species. It may be necessary to identify alternate well locations in areas of Andersen AFB that are outside of the Andersen AFB constraints shown in Figure 2.2-6 or other limitations to be specified by the base.

Components of the Water Systems

Water system requirements would be the same as described for Alternative 1 in Section 2.2.4.1 except as noted below.

Well Construction

It is assumed that the well construction for the brackish-water wells would be similar to construction for the freshwater wells described in Section 2.2.4.1, but the wells in the brackish-water zone would be screened.

Water Treatment

Well water extracted from the proposed 28 new wells would be collected, desalinated, and treated for use as water supply by end users. This section presents a design basis for desalination, water treatment, treatment technologies and processes, and costs. The plant is designed for a peak treatment capacity of 12 MGd (45 MLd). Before design, the water quality of the brackish water would be tested to determine the optimal treatment processes. The area required for installation of the proposed process units and support systems is estimated to be approximately 225,000 ft^2 (21,000 m^2).

Desalination plants produce liquid wastes (brine) that may contain high salt concentrations, chemicals used during defouling of plant equipment, and pretreatment residues. Brine may be discharged directly into the ocean, combined with other discharges (e.g., power plant cooling water or sewage treatment plant effluent) before ocean discharge, discharged into a sewer for treatment in a sewage treatment plant, or dried and disposed of in a landfill.

Long-Term Alternative 3

Dredging of sediment from the Navy Reservoir is included as a long-term option. This option is retained as part of the ongoing maintenance of the reservoir and to provide additional supply to DoD in southern Guam by increasing the storage capacity of the reservoir up to the original design capacity. Additional assessment is required to address potential obstacles related to mobilizing a dredge over long distances to the project site, which is in a remote location, as well as logistical difficulties in managing dredged material on Guam.

2.2.5 Supplemental Water Source Supply Studies

Additional studies have been completed or are planned to better define the elements of the Marine Corps base water supply sources. These studies evaluate the available information on NGLA sustainable yield, gather design-level information on well locations, and update the demand and supply requirements based on the latest population estimate (February 2009). The studies are as follows:

- Guam Water Utility Study (NAVFAC Pacific 2010h)
- Barrigada Utility Study to Support Marine Corps Off-Base Housing Facilities Requirements (NAVFAC Pacific 2010a)
- University of Guam – Water and Environmental Research Institute of the Western Pacific Review of Northern Guam Lens Aquifer Sustainable Yield – Guam Water Utility Study for Proposed Marine Corps Relocation (NAVFAC Pacific 2009b)
- Guam Water Well Testing Study (NAVFAC Pacific 2010i)
- NGLA groundwater under the direct influence of surface water (GWUDI) Evaluation
- Ground-Water Availability in Guam
- Sustainability Program Summary Report
- Guam Low Impact Design (LID) Study

These studies are described in the sections below. Also discussed are the time frames when information is expected to be available and the ways in which the resulting information would be incorporated into the design of the water system for the Marine Corps base, including location of the wells and protection of groundwater resources.

2.2.5.1 Guam Water Utility Study (NAVFAC Pacific 2010h)

This report identified all reasonable alternatives for potable water supply to support the proposed Marine Corps relocation to Guam and provide sufficient and detailed information to support the EIS process. In 2007, AECOM Technical Services, Inc. staff visited NAVFAC Pacific facilities on Guam and met with decision makers within NAVFAC and several other agencies on Guam to discuss the regulatory requirements and design features for this project. The water utility report presents the findings of the evaluations conducted based on the information gathered during the field study, and subsequent detailed analysis of the recommended water supply options. The demand calculations are based on population data in the Navy memorandum of February 9, 2009, which are consistent with the DoD population estimates presented in Table ES-2 of the Final EIS. Water supply for Main Cantonment Alternatives 1 and 2 and DoD water requirements throughout Guam are addressed in the water utility report. The recommended alternative consisted of developing groundwater resources, rehabilitating selected DoD wells, providing an interconnection with GWA, and dredging sediment from the Navy Reservoir. Proposed well placement incorporated the sustainable yield estimates from Barrett 1992. Alternative 1, presented above, is based on the *Water Utility Study* report.

2.2.5.2 Barrigada Utility Study to Support USMC Off-Base Housing Facilities Requirements (NAVFAC Pacific 2010a)

The *Barrigada Utility Study* developed a detailed alternative to address water demand for Main Cantonment Alternatives 3 and 8. The water demand estimates were based on the February 9, 2009 population projections, which are consistent with the DoD population estimates presented in Table ES-2 of the Final EIS. The recommended alternative consists of groundwater resource development and well rehabilitation. Proposed well placement incorporated the sustainable yield estimates from Barrett 1992. Alternative 2 is based on this report.

2.2.5.3 University of Guam—Water and Environmental Research Institute of the Western Pacific Review of Northern Guam Lens Aquifer Sustainable Yield—Guam Water Utility Study for Proposed USMC Relocation (NAVFAC Pacific 2009b)

This WERI report provides an expert technical review of the sustainable yield estimates for the NGLA contained in Groundwater in northern Guam: Sustainable Yield and Groundwater Development (Barrett 1992) to assess the validity of the estimates in sufficient detail and objectivity to assist in obtaining public and professional acceptance of the conclusions of the study. The sustainable yield estimates are a basis for determining the proposed well locations presented in the Guam Water Utility Study (NAVFAC Pacific 2010h) and the Barrigada Water Utility Study (NAVFAC Pacific 2010a) described above. Additionally, the study addresses other related questions from DoD and USEPA on the proposed well locations. The main conclusions of the study related to the Guam water utility studies are as follows:

- The approach and methodology used in Barrett 1992 to estimate the sustainable yield are still valid. The recommendations in Barrett 1992 are appropriate for initial planning.
- The Barrett 1992 sustainable-yield estimates should be used instead of the earlier 1982 sustainable-yield estimates (CDM 1982) because the later values are based on an additional decade of field data. The 1982 sustainable-yield estimates are excessively conservative.
- A revised analysis would be more accurate because there is currently a larger data set available on well performance, recharge, and water table response.
- A state-of-the-art model would be a useful tool for long-term management of the aquifer, but is not likely to provide a significantly different outcome for sustainable yield.
- Use of the updated basement contour maps to locate the parabasal zone for well placement provides a higher degree of confidence in the productivity of the proposed wells.
- The wells would be located or “clustered” in the parabasal zone to maximize groundwater yield and water quality:
- In this zone the freshwater lens is most likely to be thickest, have the lowest chloride content, and be least vulnerable to saltwater intrusion.
- The subbasins are hydrologically separate entities. Therefore, withdrawal from one subbasin does not affect the adjacent subbasins.
- Additional field studies and incremental assessment of well performance as the wells are installed would increase the likelihood of optimal yield, water quality, and sustainability of the resource.
- Sustainable-yield confirmation studies should be performed.

No revisions to the proposed well placement for Basic Alternative 1 or Basic Alternative 2 (Section 2.2.4) are required based on the conclusions of the WERI review.

2.2.5.4 Guam Water Well Testing Study (NAVFAC Pacific 2010i)

The purpose of the Guam Water Well Testing Study is to locate and design wells for potable water supply in support of the proposed United States Marine Corps relocation. The goal of the water well testing study is to support the evaluation of improvements to the potable water system. Optimal well and well field configurations needed to meet the future Marine Corps base water demands will be determined. The project has produced a point paper which outlines the process for evaluating test well sites.

The results of this study could change the location and number of wells on Andersen AFB and Navy Barrigada or the water treatment requirements. If required, follow on NEPA documentation would be prepared for the wells.

The Point Paper is a planning document which includes an evaluation of historical and current water system; geologic, hydrogeologic, water quality, and water quantity data; and recommends locations for test well sites. The final Point Paper is provided in Volume 9, Appendix K. At the completion of the field study, a separate report will be prepared that includes discussions of the boring testing methodologies employed, results of logging and pump testing activities, results of water quality tests, and recommendations for well design criteria, construction details, well development procedures, and the estimated number of wells required to meet future demands. This report will also support the recommended water supply options that were discussed in the Water Utility Study (NAVFAC Pacific 2010h).

The scope of work for the study is provided below.

- Visit the University of Guam Water and Environmental Research Institute of the Western Pacific (WERI) to review readily available wells/boring logs from the Navy, Air Force, GWA, and Guam Environmental Protection Agency (GEPA) and update the volcanic basement contour map (Vann 2000).
- Review unexploded ordnance (UXO)/munitions and explosives of concern (MEC) records at University of Guam, the War in the Pacific National Historical Park, and NSA Andersen and Navy explosive ordinance disposal offices.
- Prepare this point paper to evaluate historical and current water system; geologic, hydrogeologic, water quality, and water quantity data; and recommend locations for further study.
- Acquire permits necessary for test boring drilling and testing.
- Drill 11 pilot test borings to characterize the production capacity of well fields in the areas of interest. The objective is to have some test borings eventually converted to production wells.
- Mobilize equipment to perform drilling and testing operations including: utility and UXO/MEC avoidance, surveying, and clearing the site, if necessary.
- Perform the following actions for each proposed pilot test boring:
  - Drill test boring.
  - Determine borehole plumbness.
  - Perform geophysical logging of borehole.
  - Perform step-drawdown and 72-hour constant-rate pumping tests at appropriate pumping rates to determine well capacity.
  - Log salinity and basic water quality parameters of the saturated zone at appropriate intervals.
  - Collect groundwater samples at the conclusion of each constant-rate pump test and have the samples analyzed by a USEPA–certified laboratory for primary and secondary drinking water standard contaminants.
  - Supply and install a test boring cover and 20 feet (ft) of steel casing at each of the 11 boreholes at the conclusion of testing.
  - Survey each test boring site to determine the groundwater elevations.
- Deepen one of the 11 test borings (AECOM 3) (before installing the cover) to a depth of 250 ft below mean sea level (msl) to allow future monitoring (outside this contract) of depth and thickness of the transition zone between fresh and salt water.
- Prepare a report documenting the water well study and include details on the testing methodologies employed, logging and pump testing activities results, water quality test

results, and suggestions for production well design criteria, construction details, and well development procedures. The report will recommend final production well locations and give anticipated production rates.

Well drilling permit applications were received from GEPA. Test well drilling activities commenced in May 2010. Completion of the study with report documentation is anticipated at the end of 2010. Preliminary results will not be available in time for the Final EIS.

2.2.5.5 Northern Guam Lens Aquifer (NGLA) GWUDI Evaluation

GWUDI is groundwater with inadequate natural filtration when surface water filters through soils into the groundwater table (called "recharge"). This inadequate filtration through soils may lead to contamination of the groundwater from microorganisms or contaminants in the soils. The concern for wells considered GWUDI is that protozoa (*Cryptosporidium, Giardia*) could contaminate the well water. Treatment in addition to chlorine disinfection could be required to comply with Surface Water Treatment Rule requirements such as filtration or disinfection using ozone, ultraviolet light, or chlorine dioxide.

GEPA is currently conducting a study to determine if wells extracting water from the NGLA are GWUDI. Soils in northern Guam are highly porous, and past sampling has indicated that contaminants may enter the aquifer during sewer pump station spills and rain events. If portions of the aquifer subbasins are identified as GWUDI, then treatment requirements may be imposed on individual wells, including filtration and/or disinfection.

The results of the GEPA study are expected in late 2010. GEPA has tentatively determined that the aquifer should be considered groundwater (not GWUDI). This determination stands until the results of the study are completed. This EIS was developed assuming that the proposed and existing DoD wells are not subject to GWUDI based on the preliminary results provided in a March 2010 data workshop and June 2010 follow up workshop conducted by the Guam GWUDI Study group. DoD is a participant in the Guam GWUDI Study group. It is acknowledged that the information provided in the data workshop is not conclusive and the final decision may differ. More information from the March 2010 data workshop is provided below. The DoD decision to consider the new wells to be not subject to GWUDI requirements is speculative until GEPA makes a final determination. If the GWUDI determination is made in the future for the DoD wells, a separate NEPA document would be developed to address the additional water treatment requirements.

A data workshop was conducted by the Guam GWUDI Study group to review the progress to date and present the status for field activities in March 2010. Data have been collected during one year for rainfall, turbidity, *Escherichia coli* (bacterium), and microscopic particulate analyses (MPA) data. The study group has developed preliminary analyses of the data.

The MPA data from the wells indicate a low probability of being GWUDI. The microorganisms *Cryptosporidium* or *Giardia* were not present in any sample and MPA levels are very low for the other indicators. However, the MPA monitoring frequency may be insufficient to confirm absence of *Giardia* or *Cryptosporidium* on Guam.

The available turbidity data indicate little or no surface influence with levels that are generally very low (<0.1 nephelometric turbidity unit). Spikes and elevated periods of turbidity may indicate equipment malfunctions. Turbidity is likely to result from particulates in the aquifer stirred up by water movement or seismic activity. Turbidity spikes did not correlate with rainfall events.

Fecal contamination was observed in most study wells. Detections of fecal contamination did not correlate with rain events. The type of fecal contamination detected does not by itself indicate surface influence. A few wells have been rapidly contaminated in the past following failures of adjacent sewage lift stations and resulting spills indicating GWUDI. However, this type of event was not monitored during the study.

Most of the study wells have evidence of occasional fecal contamination. Chlorination to achieve 4-log virus reduction and continuous chlorine residual monitoring are necessary to meet groundwater rule requirements. Wells considered to be GWUDI with low turbidities(<5 nephelometric turbidity unit) would need to have continuous treatment with two disinfectants (e.g., chlorine and ultraviolet [UV]), be monitored continuously for turbidity and disinfection, and Long Term 2 Enhanced Surface Water Treatment Rule monitoring would be conducted. A watershed control program to minimize *Giardia* and *Cryptosporidium* contamination would be required for wells designated GWUDI or occasional GWUDI.

The study group presented recommendations for new well siting and existing wells. New wells should be sited outside of the influence of lift stations, injection wells, and other potential sources of contamination. Wells located within the potential influence of contaminant sources should be monitored weekly for bacterial indicators, continuously for turbidity and conductivity, and as indicated for MPA. Control options should be considered for wells sited in proximity to potential contaminant sources which could result in massive fecal contamination events. Options for prevention include backup pumps, auxiliary power, and containment to prevent lift station failure; removal of injection wells or mitigation strategies in ponding basins to prevent sewage from rapidly entering the aquifer; and installation of a second disinfection system to provide additional treatment at the well head. Groundwater treatment at the well head should provide chlorination to achieve 4-log virus inactivation to the first customer and continuous monitoring for chlorine residual.

The Guam GWUDI Study group plans several next steps. Turbidity and MPA data will be collected to supplemental data lost through apparent instrument problems. Quality assurance and quality control procedures will be revised for adequate calibration of tubidimeters. GEPA wellhead assessments will be reviewed and mapping conducted to determine the proximity of potential contaminant sources, including wastewater lift stations, injection wells, septic systems, and cesspools, to production wells. The study group will develop mitigation strategies for wells potentially influenced by contaminant sources. Other research ideas may be pursued such as determining whether the fine particulate matter is the same material as the aquifer; and determine whether some turbidity spikes occur from a common event such as rainfall or a seismic event.

2.2.5.6 Ground-Water Availability in Guam

DoD is supporting a study of the groundwater availability on Guam to be conducted by USGS that will include a state-of-the-art groundwater model and verification of the sustainable yield on all relevant and available site-specific data collected to date. The study is planned for completion by the end of 2013. However, well installation is not expected to be complete until 2014. Preliminary findings from the study will be incorporated into the construction of the wells. The model is expected to be used in the long-term management of the NGLA groundwater resource.

2.2.5.7 Guam LID Study

The Guam LID Study (NAVFAC Pacific 2010c) was developed to determine the pre- and post-development hydrology of the site, which will be used to determine the stormwater runoff quantities and qualities that would need to be accommodated. This characterization of stormwater runoff will allow LID planning to proceed, using variety of natural and built features that reduce the rate of runoff, filter out pollutants, and facilitate the infiltration of water to the ground. LID planning will ultimately provide the foundation for the Basis of Design for permanent stormwater infrastructure at the site. The final Guam LID Study is provided in Volume 9, Appendix K.

The boundaries of the study are limited to the Marine Corps Base. Areas of development on Andersen AFB are not covered by this study. The scope of work for the study is listed below:

- For the predevelopment state, characterize stormwater runoff generation (rates, volumes, durations, overland flow patterns) and infiltration patterns using available topographic and soil/geologic information, for the following storm events:
  - 1-year and 2-year 24-hour storms;
  - 10-, 25-, 50-, 100-, and 500-year 24-hour recurrence event storms; and
  - 80 percent (%) (0.8-inch), 90% (1.5-inch), and 95% (2.2-inch) annual exceedances.
- Evaluate the contribution of offsite runoff into the area of interest for each storm event. Determine if there are discharges to the ocean from the area of interest during the storm events of interest. Characterize the relationships on site between stormwater and groundwater in terms of ranges of infiltration rates and percolation time to groundwater.
- Based on available references, provide preliminary grading schemes to accommodate the facilities depicted in the current version of the Guam Joint Military Master Plan (GJMMP) dated September 18, 2009 (NEPA Alternative 2) (Joint Guam Program Office 2009), including minimum and maximum site slopes; objectives to minimize cut and fill quantities; and preliminary grading schemes for the undetermined future uses of Smart Growth Areas.
- Based on the grading schemes developed, provide notional stormwater routing scenarios. Provide preliminary siting and sizing of stormwater detention basins based on the development plan and associated imperviousness. Address Smart Growth Areas in their interim undeveloped state and at buildout using a range of post development imperviousness. Address the need for dry wells and placement constraints, and stormwater routing near sinkholes.
- Assess drainage impacts resulting from the proposed site development and grading schemes. Provide the limits for site disturbance, including setbacks from the shoreline and steep slopes, and address wellhead protection setbacks.
- Address site contamination (runoff and/or leaching from installation restoration [IR] sites) and water quality issues. Based on the most current land use plan, estimate loading of total suspended solids (TSS), nutrients, and contaminants of concern from various areas. Address groundwater contamination issues related to sinkholes in terms of preferential pathways for percolation to groundwater.
- Address maintaining predevelopment hydrology to protect water quality (based on most current land use map). Based on available references, assess efficacy of bioretention, filtration, and other strategies for removal of pollutants. Address the potential impacts to groundwater from stormwater infiltration.
- Based on current available references, recommend best management practices (BMPs) and Integrated Management Practices (IMPs) best suited for the Northern Guam environment. Provide notional layouts of IMPs throughout the development. These should include potential layouts of site-specific IMPs at various sites and land uses within the development plan, and a conceptual configuration of “neighborhood level” IMPs at various areas within the base (with associated stormwater runoff routing requirements).

- Estimate the required sizing and placement of onsite stormwater detention basins and the interaction of the basins with stormwater routing and water quality improvement IMPs. Address the potential use of Anti-Terrorism/Force Protection setbacks, roadway shoulders, open space, and Smart Growth Areas for IMPs.
- Address strategies for avoiding/minimizing traditional underground storm drainage infrastructure.
- Provide Guam budgetary construction cost estimates for recommended IMPs identified.
- Prepare a sustainability study documenting stormwater resource issues associated with green building practices such as, preserving/enhancing site permeability; rainwater harvesting; stormwater adopting quantity and quality strategies; and using green roofs. The study should also provide recommendations for architectural and aesthetic stormwater elements.

Recommended IMPs as identified in this study include:

- Oil/sediment separators
- Dry swales
- Filter strips
- Bioretention basins
- Subsurface infiltration devices
- Subsurface TSS filter chambers
- Detention basins

The following IMPs and IMP accessory were identified as having limited or specific application:

- Green roofs
- Rain barrels and cisterns
- Porous pavement
- Inlet protectors (in the event a curb inlet is needed under special circumstances)

IMPs determined to have limited applicability for a variety of reasons include: organic filters, sand/gravel filters, infiltration trenches, and infiltration basins. These limited IMPs could be employed for use in treatment trains; however, based on the assessment described above, the recommended IMPs are more suitable for application in this study.

IMPs not recommended for use include: wet swales, micropool extended detention ponds, wet ponds, wet extended detention ponds, extended detention wetlands, pocket wetlands/pocket ponds, and shallow marshes.

2.2.5.8 Sustainability Study Program Summary Report

The purpose of the GJMMP Sustainability Program is to develop and define a program that delivers the highest level of environmental improvements to meet all applicable federal mandates at the lowest possible cost. The following goals were established:

- Reduce the total ownership cost of facilities
- Improve the energy efficiency and water conservation
- Provide safe, healthy and productive built environments
- Promote sustainable environmental stewardship

The Sustainability Program builds on the master planning effort underway and includes five primary tasks:

- Identify Unified Facilities Criteria that adversely impact sustainable efforts and propose alternative criteria;
- Develop a GJMMP Sustainable Systems Integration Model (SSIM);
- Integrate LEED New Construction;
- Integrate sustainability into the master plan; and
- Provide initial direction with regard to implementation and monitoring.

The Sustainability Program is founded on federal mandates and targets related to energy, water, transportation, green building/LEED and greenhouse gas (GHG) emissions. For water, the performance level to be achieved is established by the EPACT/EISA 2007 at a 26% reduction. This level is the minimum requirement to meet facility related mandates.

The water planning result provided by the SSIM water model are intended to provide guidance on possible strategies toward water conservation and are not intended to be a building specific design guide. Individual buildings may use the selected strategies as part of the design and construction process. The projected water savings would vary for individual buildings with some buildings achieving lower or higher levels of water savings compared to the predicted values.

Water conservation and reuse strategies were developed and applied to facility types (single family residences, bachelor enlisted quarters/bachelor officer quarters, high density commercial and low density commercial) to determine the most efficient and cost effective way to achieve the required water savings. The strategies applied consist of low flow fixtures and interior reuse of harvested rainwater and air conditioning condensate. Irrigation use is not anticipated or included in water consumption savings calculations based on Guam's annual rainfall and direction from NAVFAC MAR. Reuse of harvested graywater and treated sewage effluent were not included in the analysis.

Performance and cost based analysis was optimized for the following packages:

- Standard Package: Minimum potable water use through water fixture flow rates for FY 2007 defined in EPACT 1992.
- Baseline Package: Minimum requirements that meet the water consumption reduction of 26%.
- Package A: Exceeds the Baseline package. Optimizes performance and minimizes the capital cost.
- Package B: Exceeds the Baseline package for sustainability and provides the quickest payback term for infrastructure.
- Package C: Exceeds the Baseline package and provides the highest life cycle cost savings over 42 years.

Package A is recommended. The detailed analysis of all packages is provided in the sustainability study.

Ongoing efforts would be required to maintain system efficiencies. All new infrastructure would be equipped with meters accommodating an advanced metering system according to Navy and Marine specifications.

2.3 WASTEWATER

2.3.1 Overview

The proposed military relocation on Guam would be potentially located at Andersen AFB, NCTS Finegayan, South Finegayan, Andersen South, Barrigada, and Naval Base Guam at Apra Harbor. These areas are currently serviced by three WWTPs owned by the GWA and the Navy. Of these plants, two are considered as alterative locations for wastewater treatment for the discharges directly associated with the military relocation, which inlcudes wastewater from the DoD population and new facilities on DoD land. These two plants are GWA's NDWWTP and Navy's Apra Harbor WWTP. Figure 2.3-1 shows the locations of these WWTPs that could receive wastewater from the direct DoD populations that would result from the military relocation. The NDWWTP could also potentially receive a portion of wastewater from the indirect construction workforce population and the induced civilian population resulting from the military relocation.

Table 2.3-1. Wastewater Treatment Facilities Servicing Areas of the Proposed Military Relocation

Area of Proposed Military Relocation	*Wastewater Treatment Facility*	*Region/Subregion*
Andersen AFB	NDWWTP	North/Andersen AFB
NCTS Finegayan	NDWWTP	North/Finegayan
South Finegayan	NDWWTP	North/Finegayan
Andersen South	NDWWTP	Central/Andersen South
Barrigada	Hagatna WWTP	Central/Barrigada
Naval Base Guam	Apra Harbor WWTP	Apra Harbor/Naval Base Guam

Legend: AFB = Air Force Base; NCTS = Naval Computer and Telecommunications Station; NDWWTP = Northern District Wastewater Treatment Plant; WWTP = Wastewater Treatment Plant.
Source: GWA 2007.

Table 2.3-2 and Table 2.3-3 show information for each of the WWTPs considered under the wastewater alternatives analysis, including design capacity, estimate of the current wastewater flow (demand), and the current maximum treated-wastewater disposal flow under each plant's National Pollutant Discharge Elimination System (NPDES) permit. NPDES permits are issued to WWTPs and include provisions for the following:

- The plant must meet minimum standards for removal of pollutants
- The plant cannot discharge pollutants into a water body above limits that are set in the permit
- The owner of the plant must properly operate and maintain the plant
- The plant must be operated by trained and certified workers
- Wastewater throughout the plant and at the discharge must be routinely sampled and tested
- Test results must be reported to USEPA Region 9 and GEPA in reports called Discharge Monitoring Reports

Table 2.3-2. Existing Wastewater Treatment Capacities and Demand for Plants Direct Populations

Treatment Plant	*Owner/ Operator*	*Treatment Level*	*Design Average Capacity (MGd)*	*Current Average Demand (MGd)*	*Design Peak Capacity (MGd)*	*NPDES Permit Maximum Daily Flow (MGd)*
NDWWTP	GWA	Primary	12.0	5.7	27	6.0
Apra Harbor WWTP	Navy	Secondary	4.3	2.9	9.0	4.3 (Average daily flow)

Legend: GWA = Guam Waterworks Authority; MGd = million gallons per day; NDWWTP = Northern District Wastewater Treatment Plant; NPDES = National Pollutant Discharge Elimination System; WWTP = Wastewater Treatment Plant.

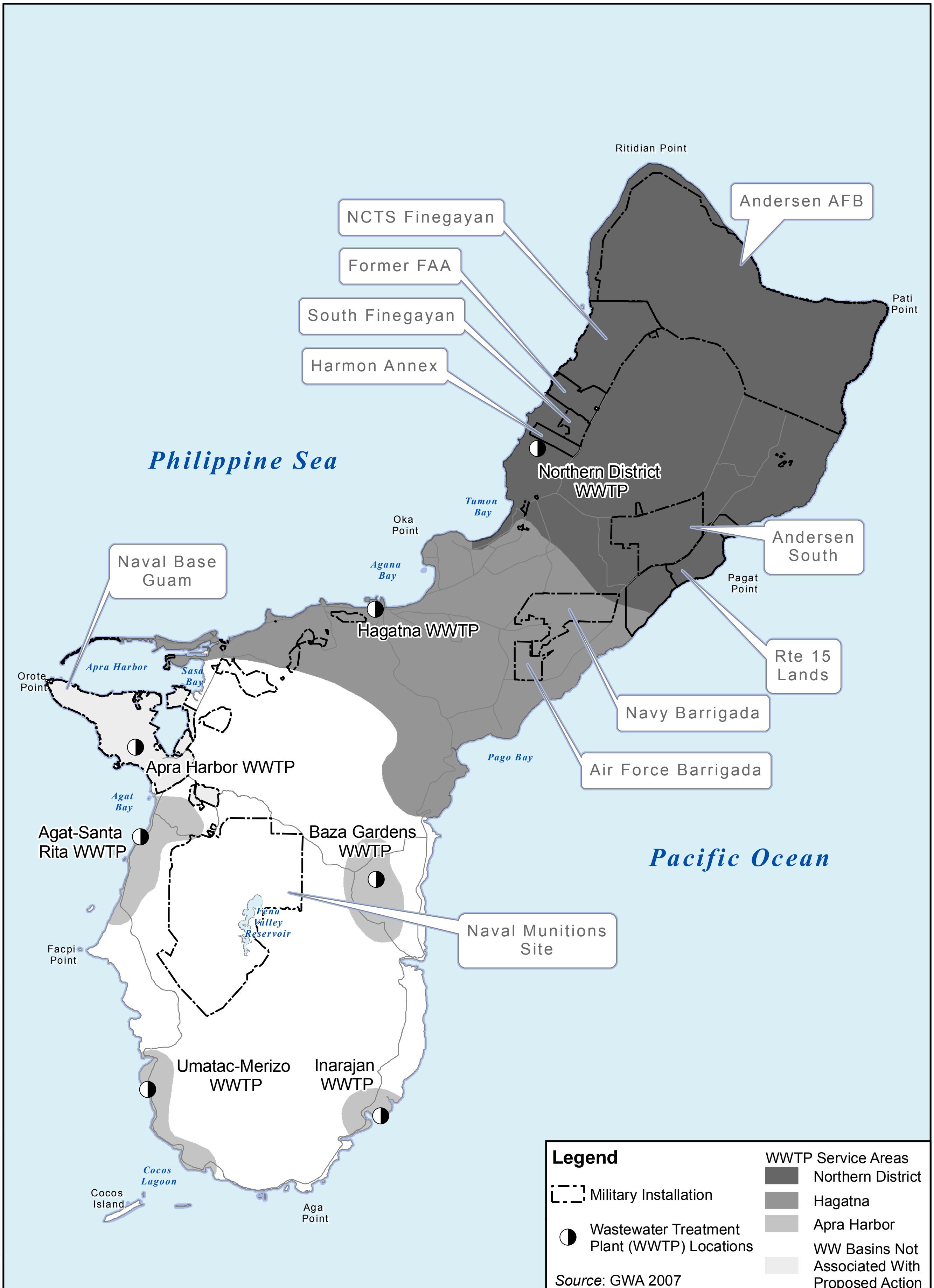

Figure 2.3-1
Wastewater Treatment Plant Locations and Service Areas, Guam

GWA owns five other WWTPs on Guam, which along with the NDWWTP treat the majority of domestic sewage generated on Guam. These are are the Hagatna WWTP in central Guam, and the Agat-Santa Rita WWTP, the Baza Gardens WWTP, the Umatac-Merizo WWTP, and the Inarajan WWTP in southern Guam. Figure 2.3-1 shows the locations of these WWTPs. These plants are not considered as alterative locations for wastewater treatment for the discharges directly associated with the military relocation (i.e.: wastewater from the DoD population and new facilities on DoD land). However, these plants could potentially receive wastewater from the indirect construction workforce population and the induced civilian population resulting from the military relocation.

Table 2.3-3 shows plant design capacities, estimate of the current wastewater flows (demands), and the current maximum treated-wastewater disposal flows under each plant's NPDES permit for these plants.

Table 2.3-3. Existing Wastewater Treatment Capacities and Demand for Plants, Indirect Populations

Treatment Plant	*Owner/ Operator*	*Treatment Level*	*Design Average Capacity (MGd)*	*Current Average Flow (MGd)*	*Design Peak Capacity (MGd)*	*NPDES Permit Maximum Daily Flow (MGd)*
Hagatna WWTP	GWA	Primary	12.0	4.7	21	12.0
Agat–Santa Rita WWTP	GWA	Secondary	0.75	1.81	2.2	0.75
Baza Gardens WWTP	GWA	Secondary	0.60	0.50	NA	0.60
Umatac Merizo WWTP	GWA	Secondary	0.39	0.41	NA	0.39
Inarajan WWTP	GWA	Secondary	0.19	0.07	NA	NA

Legend: GWA = Guam Waterworks Authority; MGd = million gallons per day; NA = not applicable; NPDES = National Pollutant Discharge Elimination System; WWTP = Wastewater Treatment Plant.

2.3.2 Available Wastewater Facilities

2.3.2.1 DoD Wastewater Facilities

Apra Harbor WWTP

The Apra Harbor WWTP could potentially receive wastewater flows from a portion of the direct DoD population that would result from the military relocation. The current average wastewater flow to the Navy's Apra Harbor WWTP is 2.9 MGd (11.0 MLd). Proposed increases in the Navy and U.S. Coast Guard population in the Apra Harbor area would increase the wastewater flow to the Apra Harbor WWTP by about 0.79 MGd (2.99 MLd), for a total projected flow of 3.69 MGd (13.96 MLd). With a design capacity of 4.3 MGd (16.3 MLd), the Apra Harbor WWTP would have enough capacity to treat the projected total wastewater flow (3.69 MGd [13.69 MLd]) to be generated as a result of proposed military relocation activities in the Apra Harbor area. Therefore, no additional wastewater treatment capacity would be needed at the Apra Harbor WWTP, and no changes to the NPDES permit would be necessary.

The Apra Harbor WWTP experiences violations of its permit effluent limits for aluminum, copper, nickel, total residual chlorine, biological oxygen demand, and total suspended solids. Compliance problems have been attributed capacity limitations, and to infiltration/inflow of stormwater into the sewer lines, which result in reduced pollutant removal efficiencies at the plant. Metals sources originating from the introduction of Fena WTP sludge supernatant to the Apra Harbor WWTP, and from metals in shipboard wastewater also contribute to violations of metals limits. The Navy conducted a study to investigate compliance strategies to address these violations at the Apra Harbor WWTP (NAVFAC Pacific 2010g). This study is under review by the Navy, GEPA, and USEPA Region 9 to determine the best course of action to address these violations. This study is discussed in further detail in Chapter 3, Section 3.1.3.2 of this Volume.

2.3.2.2 GWA Wastewater Facilities

Northern District WWTP

The NDWWTP could potentially receive the majority of wastewater flows from the direct DoD population that would results from the military relocation. It could also potentially receive a portion of the wastewater flows from the indirect construction workforce population and the induced civilian population. The NDWWTP is a GWA plant that services the areas where much of the direct military relocation would occur. GWA holds an NPDES permit for the NDWWTP which was issued by USEPA Region 9 in June 1986. The NDWWTP discharges to the Philippine Sea through an ocean outfall.

The NPDES permit for the NDWWTP expired in 1991. Since that time USEPA Region 9 administratively extended the permits. The permits contained a variance that allows plant to utilize only primary treatment processes instead of more advanced treatment processes that are typically required for sewage treatment plants. Primary treatment refers to sewage treatment that uses physical separation of solid material from the waste stream prior to discharge to a water body. More advanced treatment, called secondary treatment, provides for removal of organic matter and pollutants in sewage beyond what can be removed in primary treatment plants, typically by using bacteria as a means to digest and remove wastes. Secondary treatment variances are allowed under Section 301(h) of the Clean Water Act. Sewage treatment facilities that are granted a 301(h) secondary treatment variance must demonstrate that their discharge does not have an adverse impact on the environment or on water quality. They must also demonstrate that they adequately control industrial wastes that could enter the plant, and they must meet minimum standards for pollutants removal efficiencies in their treatment processes.

On September 30, 2009, USEPA Region 9 made a decision to deny the secondary treatment variance for the NDWWTP, which effectively requires GWA to install full secondary treatment at the plant. GWA has formally challenged USEPA's decision to deny the secondary variance, so it is unclear at this time if secondary treatment would be required at the NDWWTP. However, the alternatives presented in this EIS were adjusted to recognize this secondary variance denial, and reflect the potential future need for secondary treatment plant upgrades for all alternatives evaluated by providing a phased approach to upgrading the plant. This is discussed in detail in Section 2.3.4 and Section 2.3.6 of this Volume.

Hagatna WWTP

The Hagatna WWTP could potentially receive wastewater flows from the indirect construction workforce population and the induced civilian population that would result from the military relocation. The Hagatna WWTP is a primary treatment plant with a similar permit as the NDWWTP. GWA holds an NPDES permits for the Hagatna WWTP which was issued by USEPA Region 9 in June 1986. The Hagatna WWTP discharges to the Philippine Sea through an ocean outfall.

Like the NDWWTP, the NPDES permit for the Hagatna WWTP expired in 1991, and USEPA administratively extended it. The Hagatna WWTP had a 301(h) secondary treatment variance like the NDWWTP, which was denied by USEPA at the same time as the NDWWTP. This variance denial effectively requires GWA to install full secondary treatment at the plant. Like the NDWWTP, GWA has formally challenged USEPA's decision to deny the secondary variance, so it is unclear at this time if secondary treatment would be required at the Hagatna WWTP. Although changes to Hagatna WWTP are not part of DoD's proposed action, DoD is seeking funding from GoJ to make repairs and upgrades to this plant and its collection system (for more detail, see Volume 6, Chapter 1).

Other GWA WWTPs

Although the proposed military relocation would not occur off base in central and south Guam, the military relocation would result in induced civilian population growth that could generate wastewater flows to the following GWA wastewater treatment facilities: the Agat-Santa Rita WWTP, Baza Gardens WWTP, Umatac-Merizo WWTP, and Inarajan WWTP. All of these facilities are currently not in compliance with their effluent NPDES permits limits due to inadequate treatment capacity, deterioration of equipment, and lack of maintenance. More detailed information on these plants is provided in Volume 6, Chapter 3, Section 3.1.3.6 to Section 3.1.3.9.

2.3.3 Projected Wastewater Flows

The total projected wastewater flow from the direct DoD population related to the proposed military relocation consists of both domestic and industrial flows. The projected domestic wastewater flow was calculated using per capita wastewater generation criteria from UFC 3-240-02N, Wastewater Treatment System Augmenting Handbook (DoD 2004), and the industrial flows were calculated using criteria from the Water Pollution Control Federation's Manual of Practice No. FD-5, Gravity Sanitary Sewer Design and Construction (Water Pollution Control Federation 1982). The criteria are as follows:

- Resident Personnel, 120 gpcd
- Transient Personnel, 35 gpcd
- Civilian Workers living off base but working on base, 35 gpcd
- Construction Workers living in Camp, 70 gpcd
- Industrial Users, 15,500 gpd/acre
- Consistent with Navy and Marine Corps policies and existing laws related to sustainability and reductions in energy and water use at military bases, the Marine Corps would incorporate technology to improve wastewater efficiency to the degree feasible and economical. Attempts would be made to reduce wastewater quantities and improve treatment and conveyance efficiencies.

Per capita wastewater generation as shown above was applied to estimate wastewater flow generated by the indirect off base nonmilitary population, which includes the local Guam population, the construction workforce, and their dependents not living in construction workforce camps, and induced civilian population increases. Based on the socioeconomic analysis discussed in Volume 2, Chapter 16, two-thirds of the construction workforce was estimated to reside in northern Guam and one-third in central Guam. The induced civilian population growth was estimated to be distributed as follows: 38% in northern, 43% in central, and 19% in south Guam. This socioeconomic analysis took into account where construction workforce housing camp applications were being proposed, current housing availability, historic housing and development trends, and future housing and development trends projected by the Guam Land Use Commission. For more details on population distribution, see Volume 1, Chapter 4. Domestic wastewater flow is determined by multiplying per capita wastewater generation by respective population. Industrial wastewater flow is calculated by multiplying the above industrial wastewater generation per unit area by industrial used land acreage.

2.3.3.1 Wastewater Flows Associated with Proposed Main Cantonment Alternatives 1 and 2

Locating the Marine Corps Main Cantonment and the Army AMDTF at Finegayan would increase wastewater flows from the direct DoD population at NCTS Finegayan, South Finegayan, and Andersen AFB. Table 2.3-4 shows the current DoD population in these areas of northern Guam and the projected population at the end of the military relocation in 2019 for Main Cantonment Alternatives 1 and 2.

Table 2.3-4. Current and Projected DoD Population at Completion of Military Relocation in Northern Guam for Main Cantonment Alternatives 1 and 2

Service	*Active Duty (Direct)*	*Dependents (Direct)*	*Transient (Direct)*	*Civilian Workforce[a] (off-island) (Direct)*	*Civilian Workforce[b] (Guam) (Indirect)*
Current					
Marine Corps	3	2	0	1	0
Air Force	2,145	2,950	0	805	402
Navy	39	66	0	351	1,130
Army	30	50	0	11	5
Projected Increase					
Marine Corps	8,552	9,000	2,000	1,710	855
Air Force	120	210	1,780	25	12
Navy	0	0	0	0	0
Army	630	950	0	126	63
Total Future Population in 2019					
Marine Corps	8,555	9,002	2,000	1,711	855
Air Force	2,265	3,160	1,780	830	414
Navy	39	66	0	351	1,130
Army	660	1,000	0	137	68

Notes:
[a] Civilian Workforce (off-island) – Military civilian workers (coming off-island) living on the island and work on the base.
[b] Civilian Workforce (Guam) – On-Island residents who work on the base.
Source: Socioeconomic analysis in support of this EIS.

Wastewater from these locations is currently conveyed to the NDWWTP in northern Guam for treatment and disposal. Projected year 2019 increases in average daily wastewater flows to the NDWWTP for Main Cantonment Alternatives 1 and 2 are summarized in Table 2.3-5.

Table 2.3-5. Current and Projected Civilian and DoD Flows at Completion of Military Relocation for Main Cantonment Alternatives 1 and 2

Source	*Current Wastewater Flow (MGd)*	*Projected Increase in Wastewater Flow (MGd)*	*Total Projected 2019 Average Daily Flow (MGd)*
Northern District Wastewater Treatment Plant			
Civilian	5.20	1.88	7.08
Military	0.50	2.97	3.47
Marine Corps	0.00	2.56	2.56
Navy	0.13	0.00	0.13
Air Force	0.36	0.20	0.56
Army	0.01	0.20	0.21
Total	**5.70**	**4.85**	**10.55**

Legend: MGd = million gallons per day.
Sources: NAVFAC Pacific 2010g.

As a result of the proposed military relocation, the total year 2019 average daily flow to the NDWWTP from direct DoD sources and from indirect workforce housing is projected to increase to 3.47 MGd

(13.1 MLd). The total average flow to the NDWWTP in year 2019 from both direct DoD and indirect civilian sources would be 10.55 MGd (39.9 MLd). The year 2019 peak daily flow to the plant would be calculated at 23.74 MGd (89.9 MLd) (based on a ratio of 2.25 to 1 of peak flow to average flow from the original design calculations of the NDWWTP). Based on the current conditions of the existing structures and equipment at the NDWWTP, the plant would need to be refurbished and upgraded to restore its original design capacity of 12 MGd (45.4 MLd) average flow in order to meet the 10.55 MGd (39.9 MLd) total projected flow shown in Table 2.3-5. Also, a compliance agreement would need to be issued by USEPA Region 9 to GWA to allow the original design treatment capacity of 12 MGd (45.4 MLd) average daily flow and 27 MGd (102.2 MLd) maximum daily flow in order to accommodate the projected ultimate flow from the planned military relocation for Main Cantonment Alternatives 1 and 2. Currently, the NPDES permit allows only a 6 MGd (22.7 MLd) flow at the plant discharge, even though the plant design flow is 12 MGd (45.4 mild).

A socioeconomic analysis of the proposed military relocation has estimated that induced civilian growth could increase the islandwide population on Guam by up to approximately 80,000 in the peak year of 2014. This includes populations from DoD, construction workforce and induced civilian population growth associated with the proposed action, along with ordinary civilian population increases and other DoD population increases that are not associated with the military relocation (for more information, see Volume 6, Chapter 2, Table 2.0-1). This corresponds to a total wastewater peak average daily flow of up to 12.13 MGd (45.9 MLd) at the NDWWTP in year 2014.

Table 2.3-6 summarizes existing civilian and peak DoD flows for northern Guam for Main Cantonment Alternatives 1 and 2. Included in this table are projected increases in northern Guam's civilian flows as a result of natural population growth, projected DoD increases associated with the military relocation, increases associated with the imported construction workforce, and civilian increases that could result from induced population growth in northern Guam.

Table 2.3-6. Projected Peak Wastewater Flows for Main Cantonment Alternatives 1 and 2

Source of Wastewater Flow (MGd)	*Year*					
	2010	*2011*	*2012*	*2013*	*2014*	*2015*
Northern District Wastewater Treatment Plant						
Existing Guam Civilian	5.20	5.20	5.20	5.20	5.20	5.20
Existing DoD	0.50	0.50	0.50	0.50	0.50	0.50
Guam Civilian Increase	0.23	0.37	0.48	0.58	0.95	1.08
DoD Increase	0.23	0.46	0.51	0.55	2.56	2.79
Construction Workforce	0.28	0.67	1.10	1.31	1.40	0.91
Subtotal Direct DoD and Guam Civilian	**6.44**	**7.19**	**7.78**	**8.14**	**10.62**	**10.47**
Induced Civilian Increase	0.25	0.63	1.05	1.25	1.51	1.15
Total Average Daily Flow—all sources	**6.68**	**7.82**	**8.83**	**9.39**	**12.13**	**11.63**
Total Peak Daily Flow—all sources	**15.03**	**17.59**	**19.87**	**21.14**	**27.29**	**26.16**

Legend: DoD = Department of Defense; MGd = million gallons per day.

Peak daily flows in Table 2.3-6 are calculated from the plant-designed peak-to-average flow ratios for the NDWWTP (2.25 to 1). Under Main Cantonment Alternatives 1 and 2, both the projected peak increased average flow and maximum daily flow to the NDWWTP would be slightly over the NDWWTP originally designed treatment capacity of 12 MGd (45.4 MLd) average daily flow and 27 MGd (102.2 MLd) peak daily flow, but would far exceed the NPDES permitted flow of 6 MGd (22.7 MLd). Based on the current conditions of the existing structures and equipment, the plant would need to be refurbished and upgraded to restore its original design capacity to accommodate peak increased flow during the peak period not only to address flow and capacity limitations, but also to restore treatment processes that are currently bypassed or degraded, and improve overall pollutant removal. In addition to these upgrades, additional treatment in the form of chemical addition to enhance solids removal would be needed to ensure discharge permit limits would be met during the peak flow period. Lastly, the permit would need to be modified to allow the originally designed treatment capacity flows of 12 MGd (45.4 MLd) average daily flow and 27 MGd (102.2 MLd) maximum daily.

The projected peak wastewater flow generated from the proposed military relocation associated construction workforce and induced population, and on-island Guam population growth at 2014 in Central Guam would be about 7.86 MGd (29.8 MLd) average daily flow and 13.8 (52.2 MLd) maximum daily flow to the Hagatna WWTP, which are less than the plant designed treatment capacity.

2.3.3.2 Wastewater Flows Associated with Proposed Main Cantonment Alternatives 3 and 8

Locating the Marine Corps' Main Cantonment and the Army AMDTF at Finegayan and their housing at DoD Barrigada properties would increase wastewater flows generated from the direct DoD population not only at Finegayan in northern Guam, but also at Navy Barrigada and Air Force Barrigada in central Guam. Table 2.3-7 shows the current military population in the Barrigada area of central Guam and the projected population at the end of the military relocation in 2019 if Main Cantonment Alternatives 3 and 8 were to be selected.

Table 2.3-7. Current and Projected DoD Population at Completion of Military Relocation in the Barrigada Area of Central Guam under Main Cantonment Alternatives 3 and 8

Service	*Active Duty*	*Dependents*	*Civilian Workforce*
Current			
Marine Corps	0	0	0
Air Force	0	0	0
Navy	—	—	—
Army	0	0	0
Proposed Increase			
Marine Corps	2,181	5,683	1,058
Air Force	0	0	0
Navy	0	0	0
Army	342	950	166
Total Future Loading in 2019			
Marine Corps	2,181	5,683	1,058
Air Force	0	0	0
Navy	—	—	—
Army	342	950	166

Source: Socioeconomic analysis in support of this EIS.

Wastewater from DoD Barrigada properties is currently conveyed to the Hagatna WWTP in central Guam for treatment and disposal. However, the projected DoD wastewater increases associated with the military relocation at Barrigada would instead be conveyed to the NDWWTP for treatment under this alternative. Projected year 2019 increases in average daily wastewater flow increases to the NDWWTP under Main Cantonment Alternatives 3 and 8 are summarized in Table 2.3-8.

Under the proposed Main Cantonment Alternatives 3 and 8, the projected DoD wastewater increases from the proposed Barrigada housing would be conveyed to the NDWWTP for treatment. If the wastewater flows generated from military relocation, both at Finegayan area and Barrigada area, are still treated at the NDWWTP, the total year 2019 average flow to the NDWWTP would increase to 10.55 MGd (39.9 MLd). This is the same flow that is projected for the NDWWTP for Main Cantonment Alternative 1 and 2, and the flow to the Hagatna WWTP is also the same as projected for Main Cantonment Alternative 1 and 2 Therefore, recommendations for Main Cantonment Alternatives 3 and 8 would be the same as for Main Cantonment 1 and 2. These include refurbishing and upgrading the existing NDWWTP treatment processes to restore them to their original design capacity to address capacity limitations and improve overall pollutant removal, adding chemical treatment to enhance solids removal during peak flow years, and modifying the NPDES permit to allow for the increased flows.

Table 2.3-8. Current and Projected Civilian and DoD Flows at Completion of Military Relocation for Main Cantonment Alternatives 3 and 8

Source	*Current Wastewater Flow (MGd)*	*Projected Increase in Wastewater Flow (MGd)*	*Total Projected 2019 Average Daily Flow (MGd)*
Northern District Wastewater Treatment Plant			
Civilian	5.20	1.88	7.08
Military	0.50	2.97	3.47
Marine Corps (Finegayan)	0.00	1.65	1.65
Marine Corps (Barrigada)	0.00	0.91	0.91
Navy	0.13	0.00	0.13
Air Force	0.36	0.20	0.56
Army (Finegayan)	0.01	0.06	0.06
Army (Barrigada)	0.00	0.14	0.14
Total	**5.70**	**5.81**	**10.55**

Legend: MGd = million gallons per day.
Sources: GWA 2008, NAVFAC Pacific 2008*g*.

2.3.3.3 Projected Long-Range Wastewater Flows on Guam

Absent the military relocation on Guam, wastewater flows across Guam are expected to increase over time as part of normal civilian population growth. The wastewater flows presented in the previous section include expected wastewater flows that are part of normal civilian population growth during the period of time of the military relocation - years 2010 to 2019. After 2019, normal civilian population growth on Guam would continue, thereby generating additional wastewater flows from the population in the out years.

As part of DoD's ongoing consultation with GWA, GEPA, and USEPA Region 9, GWA has indicated that if DoD selects an alternative that involves using the NDWWTP, long-range wastewater flows at the NDWWTP beyond the military relocation (e.g., beyond the year 2019) would quickly exceed the 12 MGd design capacity of the plant. GWA projects a future capacity need at the NDWWTP between 12 and 18 MGd. As mentioned previously in Section 2.3.2, USEPA Region 9 recently issued a decision to deny GWA's secondary treatment 301(h) variance, effectively requiring GWA to upgrade its NDWWTP and Hagatna WWTP to secondary treatment. The treatment plant upgrades needed to meet this new requirement should be planned to ultimately provide plant capacity at the NDWWTP of between 12 and 18 MGd.

2.3.4 Screening Process

DoD developed numerous options for wastewater treatment to support the military relocation that addressed how wastewater could be managed and treated for each of the alternatives. Once developed, these options were screened to determine which ones were the most viable for implementation. These viable options were then carried forward in the analysis in the Volume to determine potential impacts from each.

In support of Main Cantonment Alternatives 1 and 2, eight alternatives for increasing the treatment capacity in northern Guam were evaluated to address treatment needs of wastewater resulting from the direct DoD population. These wastewater solutions were developed to support a Marine Corps Main Cantonment at Finegayan. All of the wastewater solutions involving an upgrade or tie-in to the GWA NDWWTP would necessarily be undertaken as joint ventures, and would require close coordination between DoD and GWA to ensure that planned facilities would provide capacity for total projected wastewater flows from both military and civilian sources. The eight wastewater alternatives evaluated are as follows:

- Restore and upgrade the existing primary treatment system at the GWA NDWWTP to accept the projected future flow and load from northern Guam (GWA facility and operation).
- Restore, expand, and upgrade the GWA NDWWTP to secondary treatment.
- Build a new DoD secondary treatment plant near the proposed development on DoD land and construct a new outfall (DoD facility and operation).
- Build a new separate DoD secondary treatment plant at the GWA NDWWTP site to treat the DoD load only (construction and operation of wastewater treatment facility not determined).
- Build a new DoD tertiary treatment plant near the selected Main Cantonment on DoD land and send effluent to a new or existing WTP (DoD facility and operation).
- Build a new DoD secondary treatment plant, and construct a new DoD outfall on the eastern coastline (DoD facility and operation).
- Build a new DoD tertiary treatment plant near the selected Main Cantonment and reuse the effluent; send the residual to the GWA NDWWTP outfall (DoD facility and operation; GWA outfall).
- Build a new DoD tertiary treatment plant near the selected Main Cantonment on DoD land and install injection wells (DoD facility and operation).

The eight wastewater alternatives to support Main Cantonment Alternatives 1 and 2 were initially evaluated through the screening process; three of them were retained as viable wastewater solutions for addressing projected increased wastewater flow. A summary of the eight wastewater alternatives for Main Cantonment Alternatives 1 and 2 and a fundamental evaluation of these alternatives are provided in Table 2.3-9.

Table 2.3-9. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 1 and 2

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Restore and upgrade the existing primary-treatment system at the GovGuam NDWWTP to accept the additional load	• Offshore construction would not be required, and a GWA outfall exists. • The discharge permit for the 301(h) waiver needs to be modified for additional flow. • The long-term impact of the primary effluent on the aquatic habitat is a concern. • No construction would occur on undeveloped land. • Public traffic disruption could occur during construction of relief interceptor. • GWA operates the NDWWTP. • Construction and operation costs would need to be shared with GWA. • Coordination with GWA on ongoing CIP projects would be required.	Retained
Restore, expand and upgrade the GovGuam NDWWTP to secondary treatment	• Offshore construction is not required and a GWA outfall exists. • The existing permit needs updating for secondary treatment limits. • The long-term impact of the secondary effluent on the aquatic habitat is a concern. • No construction would occur on undeveloped land. • Public traffic disruption could occur during construction of relief interceptor. • GWA operates the NDWWTP. • Upgrading to secondary treatment would increase GWA sewer rates for non-DoD users. • Construction and operation costs would need to be shared with GWA. • Coordination with GWA on ongoing CIP projects would be required.	Retained
Build a new secondary-treatment plant near the proposed development on DoD land and construct a new outfall	• Offshore outfall construction would be required. • A new NPDES permit from USEPA would be required. • Construction on undeveloped land may be required, causing habitat disruption. • The long-term impact of the treated effluent on the coral reef habitat is a concern. • The construction site may contain historical artifacts. • New sewer line construction would be required for diverting DoD wastewater. • DoD owns the outfall. • GWA treatment revenue would be reduced.	Retained

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Build a new separate DoD secondary-treatment plant at the GovGuam NDWWTP site to treat the DoD load only	• Offshore construction would not be required, and a GWA outfall exists. • The existing permit would require updating for revised limits. • Construction on undeveloped land may be required, causing habitat disruption. • The long-term impact of the blended primary and secondary effluent on the aquatic habitat is a concern. • The construction site may contain historical artifacts. • New sewer line construction is required for diverting DoD loads. • GWA owns the outfall. • GWA treatment revenue would be reduced.	Eliminated
Build a new tertiary-treatment plant near the proposed development on DoD land and send effluent to a new water treatment plant (or existing plant)	• Offshore construction would not be required. • GEPA regulates potable water supplies. • USEPA sets safe drinking water limits for local agencies. • Construction on undeveloped land may be required, causing habitat disruption. • The construction site may contain historical artifacts. • New sewer line construction is required for diverting DoD wastewater. • Construction of a new water line connection is required. • GWA purchases water from the DoD system, and monitoring requirements would be more stringent than current condition. • Construction and operation and maintenance costs would be high. • A longer planning effort and construction schedule would be required. • Public acceptance may be needed.	Eliminated
Build a new secondary-treatment plant and construct a new outfall on the eastern coastline	• Offshore construction would be required. • A new NPDES permit from USEPA would be required. • Construction on undeveloped land may be required, causing habitat disruption. • The new discharge would cause concern about the long-term impact of secondary effluent on aquatic habitat. • The construction site may contain historical artifacts. • New sewer line construction would be required for diverting DoD wastewater. • GWA treatment revenue would be reduced. • A longer planning effort and construction schedule would be required.	Eliminated

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Build a new tertiary-treatment plant near the proposed development and reuse the effluent; send the residual to the GWA outfall	• Offshore construction would not be required, and a GWA outfall exists. • GEPA would regulate reclaimed water. • The existing permit would require updating for revised limits. • Construction on undeveloped land may be required, causing habitat disruption. • The long-term impact of the blended primary and tertiary effluent on the aquatic habitat is a concern. • The construction site may contain historical artifacts. • New sewer line construction is required for diverting DoD wastewater. • Construction of a new reused-water line is required. • GWA owns the outfall. • GWA treatment revenue would be reduced. • Construction and operation and maintenance costs would be high. • A longer planning effort and construction schedule would be required.	Eliminated
Build a new tertiary-treatment plant near the proposed development and install injection wells	• Offshore construction would not be required. • High energy demands would result. • A new groundwater recharge permit would be required from GEPA. • Construction on undeveloped land may be required, causing habitat disruption. • The construction site may contain historical artifacts. • New sewer line construction would be required for diverting DoD wastewater. • New pipeline construction would be required for diverting effluent to injection wells. • GWA's potable water supply is from the same aquifer. • GWA treatment revenue would be reduced. • Construction and operation and maintenance costs would be high. • A longer planning effort and construction schedule would be required. • Public acceptance may be needed.	Eliminated

Legend: CIP = Capital Improvements Program; DoD = Department of Defense; GEPA = Guam Environmental Protection Agency; GovGuam = Government of Guam; GWA = Guam Waterworks Authority; NDWWTP = Northern District Wastewater Treatment Plant; NPDES = National Pollutant Discharge Elimination System; USEPA = United States Environmental Protection Agency.

In support of Main Cantonment Alternatives 3 and 8, six wastewater treatment solutions for increasing the treatment capacity were evaluated to address treatment needs of wastewater resulting from the direct DoD population. These wastewater solutions were developed to support the Marine Corps housing option at Barrigada. All of the wastewater solutions involving an upgrade or tie-in to the GWA NDWWTP and/or the GWA Hagatna WWTP would necessarily be undertaken as joint ventures, and would require close coordination between DoD and GWA to ensure that planned facilities would provide capacity for total projected wastewater flows from both military and civilian sources. The six wastewater alternatives evaluated are as follows:

- Restore and upgrade the existing primary treatment system at the GWA NDWWTP to accept the additional flow and load from both central and northern Guam (GWA facility and operation).
- Restore, expand, and upgrade the GWA NDWWTP to secondary treatment.
- Expand and upgrade the existing primary treatment system at the GWA Hagatna WWTP to accept the additional flow and load from central Guam.
- Expand and upgrade the GWA Hagatna WWTP to secondary treatment.
- Build a new secondary treatment plant near the proposed development on DoD land and construct a new outfall.
- Build a new separate DoD secondary-treatment plant at the GovGuam Hagatna WWTP site to treat the DoD load only.

Three wastewater alternatives supporting Main Cantonment Alternatives 3 and 8 are retained as viable wastewater solutions.

A summary of the five wastewater alternatives for Main Cantonment Alternatives 3 and 8 and a fundamental evaluation of these alternatives are provided in Table 2.3-10.

2.3.5 Alternatives Dismissed

The alternatives for wastewater solutions in support of Main Cantonment Alternatives 1 and 2 that were dismissed are summarized below. The rationale for dismissal is provided for each alternative.

2.3.5.1 Build a New DoD Tertiary-Treatment Plant near the Selected Main Cantonment on DoD Land and Send Effluent to a New or Existing Water Treatment Plant

Under this alternative, a new tertiary-treatment plant would be built near the proposed development on DoD land. Tertiary treatment falls into a category of direct potable reuse of reclaimed water; it normally consists of primary settlement, use of a submersible membrane bioreactor, disinfection, reverse osmosis, and advanced oxidation. The new tertiary-treatment plant would treat the DoD wastewater from existing sources and proposed future expansions in northern Guam, including the proposed Marine Corps relocation, and would inject treated effluent directly into the raw-water supply immediately upstream of a new WTP that would be constructed in northern Guam.

Although the discharge from the proposed tertiary-treatment plant would eliminate the need to construct an ocean outfall, the approach of discharging treated wastewater directly to a potable-water treatment plant does not have a proven track record. Only a few direct potable-water-reuse applications have been reported worldwide. Even without factoring in the extremely large capital investment required for this approach and its sophisticated process, gaining regulatory acceptance of direct potable-water-reuse application might be difficult. No direct potable-water-reuse programs currently operate in the U.S. All reclaimed treated wastewater has been used as potable water in an indirect way, with a natural buffer (e.g., either a stretch of river or a groundwater aquifer) between introduction of the reclaimed water and its distribution to the potable-water treatment plant.

Table 2.3-10. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 3 and 8

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Restore and upgrade the existing primary treatment system at the GWA NDWWTP to accept the additional flow and load from both central and northern Guam (GWA facility and operation).	• Offshore construction would not be required, and a GWA outfall exists. • The discharge permit for the 301(h) waiver needs to be modified for additional flow. • The long-term impact of the primary effluent on the aquatic habitat is a concern. • No construction would occur on undeveloped land. • Public traffic disruption could occur during construction of sewers. • GWA operates the NDWWTP. • Coordination with GWA on ongoing CIP projects would be required. • Requires force main from Barrigada housing to the NDWWTP.	Retained
Restore, expand, and upgrade the GWA NDWWTP to secondary treatment.	• Offshore construction is not required and a GWA outfall exists. • The existing permit needs updating for secondary treatment limits. • The long-term impact of the secondary effluent on the aquatic habitat is a concern. • No construction would occur on undeveloped land. • Public traffic disruption could occur during construction of relief interceptor. • GWA operates the NDWWTP. • Upgrading to secondary treatment would increase GWA sewer rates for non-DoD users. • Construction and operation costs would need to be shared with GWA. • Coordination with GWA on ongoing CIP projects would be required. • Requires force main from Barrigada housing to the NDWWTP.	Retained
Recondition and upgrade the existing primary treatment system at the GWA Hagatna WWTP to accept the additional flow and load from central Guam.	• Offshore construction would not be required, and a GWA outfall exists. • The discharge permit for the 301(h) waiver needs to be modified for additional flow. • The long-term impact of the primary effluent on the aquatic habitat is a concern. • No construction would occur on undeveloped land. • Public traffic disruption could occur during construction of sewers. • GWA operates the Hagatna WWTP. • Coordination with GWA on ongoing CIP projects would be required. • Require relief gravity sewer from the Barrigada housing to the Hagatna WWTP.	Eliminated

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Expand and upgrade the GWA Hagatna WWTP to secondary treatment	• Offshore construction is not required and a GWA outfall exists. • The existing permit needs updating for secondary treatment limits. • No construction would occur on undeveloped land. • Public traffic disruption could occur during construction of sewer. • GWA operates the Hagatna WWTP. • Upgrading to secondary treatment would increase GWA sewer rates for non-DoD users. • Construction and operation costs would need to be shared with GWA. • Coordination with GWA on ongoing CIP projects would be required. • Require relief gravity sewer from the Barrigada housing to the Hagatna WWTP.	Eliminated
Build a new secondary-treatment plant near the proposed development on DoD land and construct a new outfall	• Offshore outfall construction would be required. • A new NPDES permit from USEPA would be required. • No construction would occur on undeveloped land. • The long-term impact of the treated effluent on the coral reef habitat is a concern. • New sewer line construction would be required for diverting DoD wastewater. • DoD owns the outfall. • GWA treatment revenue would be reduced. • Requires force main from Barrigada housing to the DoD stand along WWTP.	Retained

Legend: CIP = Capital Improvements Program; DoD = Department of Defense; GWA = Guam Waterworks Authority; NDWWTP = Northern District Wastewater Treatment Plant; NPDES = National Pollutant Discharge Elimination System; USEPA = United States Environmental Protection Agency; WWTP = Wastewater Treatment Plant.

Brine generated through reverse osmosis requires some kind of discharge. Typical brine disposal routes include evaporation, crystallization to solidify the salts, deep underground injection, and ocean or sewer discharge. From an economic standpoint, only the last two options may be feasible, and they require permission from either USEPA or GWA. Because no regulations have been promulgated on the potable reuse of reclaimed water, the process of establishing treatment requirements and performance monitoring standards for this option would add time and cost resulting in the determination that this alternative should be eliminated.

2.3.5.2 Build a New DoD Secondary-Treatment Plant and Construct a New Ocean Outfall on the Eastern Coastline

Under this alternative, a new secondary-treatment plant would be built on the eastern side of Guam to treat DoD wastewater from existing sources and future sources (wastewater from the proposed military relocation in northern Guam, including the proposed Marine Corps relocation), and a new outfall would be constructed along the eastern coastline. This option would be feasible only if the majority of Marine Corps relocation were to occur on the east side of northern Guam. This alternative would require all existing wastewater flow and future flow associated with the Marine Corps relocation to be routed and diverted to the new treatment plant.

The construction of a new outfall would likely require implementation of mitigation measures to satisfy both the Guam Bureau of Statistics and Planning Office and the Guam Division of Aquatic and Wildlife Resources. The entire northeast coastline around Andersen AFB is designated as the Pati Point Marine Preserve. The Pati Point Marine Preserve contains 8 square miles (21 square kilometers)—approximately 4,900 acres (ac) (2,000 hectares [ha])—of reef environment, which would be restricted as a potential site for an ocean outfall. Also, construction of the plant on a site located in forested or preservation areas that are populated by native species of animals and vegetation may require implementation of mitigation measures to satisfy the Guam Division of Aquatic and Wildlife Resources. With little chance to get a new ocean outfall discharge permit along northeast coast of Guam and all other above presented detrimental impacts, this alternative should be eliminated.

2.3.5.3 Build a New DoD Tertiary-Treatment Plant near the Selected Main Cantonment and Reuse the Effluent; Send the Residual to the GovGuam NDWWTP Outfall

Under this alternative, a new tertiary-treatment plant would be built near the proposed development on DoD land. This new plant would treat DoD wastewater from both existing sources and the future proposed military relocation in northern Guam, including the proposed Marine Corps relocation. The treated effluent from the tertiary-treatment system would be reused for toilet flushing, wash water for vehicles and aircraft, landscape irrigation, and cooling water for building climate control; it could also be provided to other non-DoD end users. Excess effluent that is produced would be discharged to the existing NDWWTP outfall. To achieve the level of treatment required for these reuse practices, a wastewater treatment process would be needed, consisting of primary treatment, a membrane bioreactor, disinfection, and color removal. DoD would be responsible for the treatment, effluent reuse, and biosolids disposal associated with this alternative.

The total reclaimed water produced under this alternative could be an estimated 3.77 MGd (14.27 MLd); however, the Finegayan area lacks sustainable and reliable demand for reuse of reclaimed water. A study assessing the demand for reclaimed-water usage and identifying a sustainable water-reuse rate structure would be required. In addition, a separate water distribution and dual plumbing system would be required, and the cross-connection risk would need to be addressed. These steps would add time and cost to the project. The installation of a dual plumbing system for existing buildings may not be economically feasible. All these result in the determination that this alternative should be eliminated.

2.3.5.4 Build a New DoD Tertiary-Treatment Plant near the Selected Main Cantonment on DoD Land and Install Injection Wells

Under this alternative, a new tertiary-treatment plant would be built near the proposed development on DoD land. The new plant would treat DoD wastewater from existing sources and future proposed military relocation in northern Guam, including the Marine Corps relocation. Treated effluent would be injected into the underground aquifer for groundwater replenishment, increasing the sustainability of the groundwater in the NGLA. DoD would be responsible for treatment, groundwater monitoring, and biosolids disposal.

The NGLA is a sole-source aquifer that is located directly underneath northern Guam. Northern Guam is underlain by a karst limestone plateau with high water conductivity that results in low retention times between injection wells and withdraw wells, and a minimum of soil aquifer treatment. Under these conditions, a very high degree of treatment (normally beyond USEPA primary drinking water standards) has to be achieved. In practice, even if tertiary treatment of effluent were applied for this kind of indirect potable reuse of reclaimed water, it is expected that this alternative would not be readily accepted by regulatory agencies. Because no regulations are promulgated on Guam regarding the indirect potable reuse of reclaimed water, the process of establishing treatment requirements and performance monitoring standards for this option would consume time and increase project costs. Therefore, this alternative should be eliminated.

2.3.5.5 Build a New Separate Secondary Treatment Plant at the GWA NDWWTP Site to Treat DoD Load Only

This option would build a new secondary treatment plant at the NDWWTP site, and treat the DoD wastewater from the DoD land at Finegayan including proposed Marine Corps housings. The existing NDWWTP would be upgraded to have two separate and independent treatment process trains. The existing primary treatment would continue to treat flow from civilian population in northern Guam. The new process train consists of primary and secondary treatment, as well as UV disinfection, and solids treatment. The new treatment plant would have separate headworks, primary treatment, secondary treatment, UV disinfection, and sludge handling facilities to treat the load from the DoD land at Finegayan. The new process train, including both liquid treatment and solids treatment, is a self-contained and complete secondary treatment system from the start to the end, and it would require jointly utilizing the existing NDWWTP ocean outfall for its secondary treated effluent disposal. This alternative requires constructing a new independent sewer main to convey all military generated wastewater from the DoD land at Finegayan to the NDWWTP site. GWA does not agree on a separate DoD treatment facility to use its outfall and NPDES permit to discharge DoD treated flow, as a result this alternative should be eliminated.

The alternatives for wastewater solutions in support of Main Cantonment Alternatives 3 and 8 that were dismissed are summarized below. The rationale for dismissal is provided for each alternative.

2.3.5.6 Recondition and Upgrade the Existing Primary Treatment System at the GWA Hagatna WWTP to Accept the Additional Flow and Load from Central Guam

In this Interim Alternative, the primary-treatment facilities of the NDWWTP would be refurbished and upgraded to accept the additional DoD flows and military relocation–related flows from Finegayan area.

The effluent pump station of the Hagatna WWTP would be refurbished to accept the additional DoD flows and military relocation–related flows from proposed Barrigada housing area. A new UV disinfection system would also be added for effluent disinfection. This interim alternative would require modification of the Hagatna WWTP’s existing NPDES permit by USEPA Region 9 to increase the effluent-discharge limit from a maximum daily flow of 12.0 MGd (45.4 MLd) to 21.0 MGd (79.5 MLd). The proposed modifications to the Hagatna WWTP should be completed by 2011.

In addition, new sewer lines would need to be installed from the Barrigada to the Hagatna WWTP.

2.3.5.7 Expand and Upgrade the GWA Hagatna WWTP to Secondary Treatment

Under this alternative, the existing Hagatna WWTP would be upgraded to secondary-treatment plant. By expanding and upgrading the existing primary system, the Hagatna WWTP can be converted to a new secondary treatment process. A trickling filter system was selected as the secondary treatment process not only because of its lower power requirement and less sludge production compared with a suspended growth system (such as Activated Sludge System) but also because of its simple and reliable operational nature. It is desirable to have a simple process to minimize future operation and maintenance requirements on the island of Guam.

This plant would treat DoD wastewater from existing sources and future sources (wastewater from the proposed military relocation in Barrigada, including the proposed Marine Corps relocation). This option would be feasible only if the majority of Marine Corps relocation were to occur in Barrigada area. This alternative would require all existing wastewater flow and future flow associated with the Marine Corps relocation to be routed and diverted to the Hagatna treatment plant.

2.3.5.8 Build a New Separate Secondary Treatment Plant at the GWA Hagatna WWTP Site to Treat DoD Load Only

This option would build a new secondary treatment plant at the Hagatna WWTP site, and treat the DoD wastewater from the DoD land at Barrigada including proposed Marine Corps housings. The existing Hagatna WWTP would be upgraded to have two separate and independent treatment process trains. The existing primary treatment would continue to treat flow from civilian population in Central Guam. The new process train consists of primary and secondary treatment, as well as UV disinfection, and solids treatment. The new treatment plant would have separate headworks, primary treatment, secondary treatment, UV disinfection, and sludge handling facilities to treat the load from the DoD land at Barrigada. The new process train, including both liquid treatment and solids treatment, is a self-contained and complete secondary treatment system from the start to the end, and it would require jointly utilizing the existing Hagatna WWTP ocean outfall for its secondary treated effluent disposal. This alternative requires constructing a new independent sewer main to convey all military generated wastewater from the DoD land at Barrigada to the Hagatna WWTP site.

Alternatives discharging wastewater from Barrigada Housing to Hagatna WWTP were eliminated because of the following reasons:

- The majority of the improvements due to Marine relocation to Guam would be located in northern Guam, where wastewater is routed to the NDWWTP. Collection of all DoD flows at one WWTP allows for efficient management of the wastewater treatment.
- Concentrating WWTP improvements associated with DoD wastewater at one plant owned by GWA would help with efficient utilization of GWA's limited Capital Improvement Program budget resources. This approach also relieves the logistical burden of upgrading two WWTPs in the same time period.
- The ocean outfall for the Hagatna WWTP does not have a diffuser installed, and is in a heavily populated area of Guam. The NDWWTP has a newly installed ocean outfall with a diffuser system that is currently undergoing design evaluation based on future flow forecasts and the effluent discharges in a relatively remote area of the island. It is preferable to route the wastewater flows to the NDWWTP to minimize the environmental impacts from the effluent discharge.

2.3.6 Alternatives Developed Forward for Wastewater

As discussed in Section 2.3.2, the alternatives presented in this EIS were adjusted to recognize the secondary treatment variance denial, and reflect the need for secondary treatment plant upgrades for all alternatives evaluated. Based on the evaluation, the Preferred Alternative (Basic Alternative 1) was selected to meet the interim wastewater needs and to meet the year 2019 projected DoD demand at the completion of the military relocation. Under Basic Alternative 1, in addition to providing restoration and upgrades to NDWWTP's primary treatment system to meet the short-term wastewater demand, this alternative provides upgrading the NDWWTP to secondary treatment. Two options for Basic Alternative 1 are provided to support the Main Cantonment Alternatives 1 and 2 (Basic Alternative 1a), and Main Cantonment Alternatives 3 and 8 (Basic Alternative 1b).

Basic Alternative 1a focuses improvements for DoD wastewater services at one plant, the NDWWTP, and is fully supportive of the preferred cantonment alternative 2. Existing treatment plant facilities would be expanded at the current location, not requiring new stand alone treatment facilities. Basic Alternative 1b supports cantonment alternatives 3 and 8, which are not preferred. This alternative would require a long new force main from the Barrigada housing area to the NDWWTP. Since Basic Alternative 1a supports the preferred cantonment alternative, it was chosen as the preferred alternative. See below for additional details.

Basic Alternative 1a (Preferred Alternative) supports Main Cantonment Alternatives 1 and 2; Basic Alternative 1b supports Main Cantonment Alternatives 3 and 8. The difference between Alternatives 1a and 1b is a requirement for a new sewer line and associated pumping stations from Barrigada housing to NDWWTP for Alternative 1b.

Induced civilian growth as a result of the military relocation could increase the islandwide civilian population on Guam by up to approximately 33,000 in the peak year of 2014. Therefore, to provide the capacity to treat the near-term wastewater flow generated by a portion of the indirect construction workforce and induced population growth that would be expected in northern Guam, this wastewater alternative would address near-term wastewater flow as well as wastewater flow at the NDWWTP. It does not address the wastewater generated by the indirect construction workforce and induced population growth that could be sent to other GWA WWTPs on Guam.

Under Basic Alternative 1a, the NDWWTP would be refurbished and the plant's primary treatment capacity would be upgraded to accept the additional DoD flows and military relocation–related flows and loads. Additionally, expansion of the plant to secondary treatment would be completed. Refurbishment of the primary system, upgrade of the primary system, and installation of a secondary system would be constructed in separate phases. This refurbishment would result in improved pollutant removal at the plant and overall improved water quality of the discharge effluent.

Near-term wastewater flows to the NDWWTP from military and civilian sources are projected to increase to a peak of 12.13 MGd (45.91 MLd) in 2014, which would slightly exceed the design capacity of 12 MGd (45.4 MLd). DoD and GWA are assessing options to enhance treatment until primary treatment upgrades can be implemented. One option being investigation is to add chemical coagulants (enhanced primary treatment) or increase the surface overflow rate (within the normal design range) of the clarifier, which would improve plant operations so that the primary clarifier would be able to treat the additional flow without adverse effect on the NDWWTP. Normally, a chemically enhanced primary treatment system can significantly increase overflow rate of a conventional primary clarifier as recommended by the Manual of Practice 8 (Water Environment Federation 2010). However, the permit limit of 6 MGd (22.7 MLd) would still be exceeded and the plant would still need some refurbishment and upgrades to restore it to the original design capacity and pollutant removal efficiencies.

The existing NPDES permit for the NDWWTP is based on a maximum daily flow of 6 MGd (22.7 MLd). Under this alternative, the liquid treatment system of the NDWWTP would be refurbished to restore the plant's originally designed treatment capacity of 12 MGd (45.4 MLd) so that the plant would comply with regulations associated with treating the increased wastewater flow from the military relocation. At the same time, the plant's solids treatment system would be refurbished and upgraded to process sludge produced by treatment of 12 MGd (45.4 MLd) of influent wastewater. The solids treatment system has two anaerobic digesters and a dewatering complex that are currently nonfunctional and in disrepair; the system would need to be rehabilitated and upgraded with sufficient capacity to treat solids generated at the plant. The dewatered stabilized solids would then be hauled away, most likey to a landfill. Potential future beneficial use of the dewatered stabilized solids somewhere on Guam could be explored in the future.

The Navy has completed an evaluation of capacity and required improvements needed at NDWWTP entitled Evaluation of Northern District Wastewater Treatment Plant Capacity (NAVFAC Pacific 2009a). Based on the plant's current capacity, to accommodate anticipated near-term flow and loadings while still achieving the existing primary-treatment requirement, the following necessary improvements would have to be implemented at the NDWWTP to restore its primary treatment capacity and pollutant removal efficiencies:

- Septage (liquid and solid material pumped from a primary treatment source) and fat/oil/grease receiving station
- Headworks improvement
- Primary clarifier rehabilitation
- Sludge digester rehabilitation
- Centrifuge building and one centrifuge replacement
- Sludge-drying bed rehabilitation
- Standby power
- Hydraulic improvements to the chlorine contact tank
- Third digester
- Second centrifuge
- Odor control
- Digester gas utilization
- Administration/laboratory, office, and workshop/storage areas rehabilitation

The new ocean outfall that was put into service in December 2008 at the NDWWTP enables the plant to discharge a peak-hour treated flow of 27 MGd (102.2 MLd) to the Philippine Sea. This would be enough capacity to handle the increased flow during the peak period.

Under Basic Alternative 1a, all DoD-generated wastewater, either from Andersen AFB or from the proposed Marine Corps relocation, would be conveyed to the NDWWTP for treatment. All flows from the current and proposed future military relocation at Andersen AFB would be conveyed through the existing GWA sewer to the NDWWTP, while wastewater flow generated from the proposed Marine Corps relocation at Finegayan would be conveyed via a new relief sewer line to the NDWWTP (Figure 2.3-2). A new 24-in (61-cm), 7,500-ft (2,300-m) gravity relief sewer would be connected from the collection system of the Marine Corps Finegayan area on the west side of the planned Marine Corps Finegayan development to the headworks of the NDWWTP. The proposed modifications to the NDWWTP and collection system should be completed by 2013.

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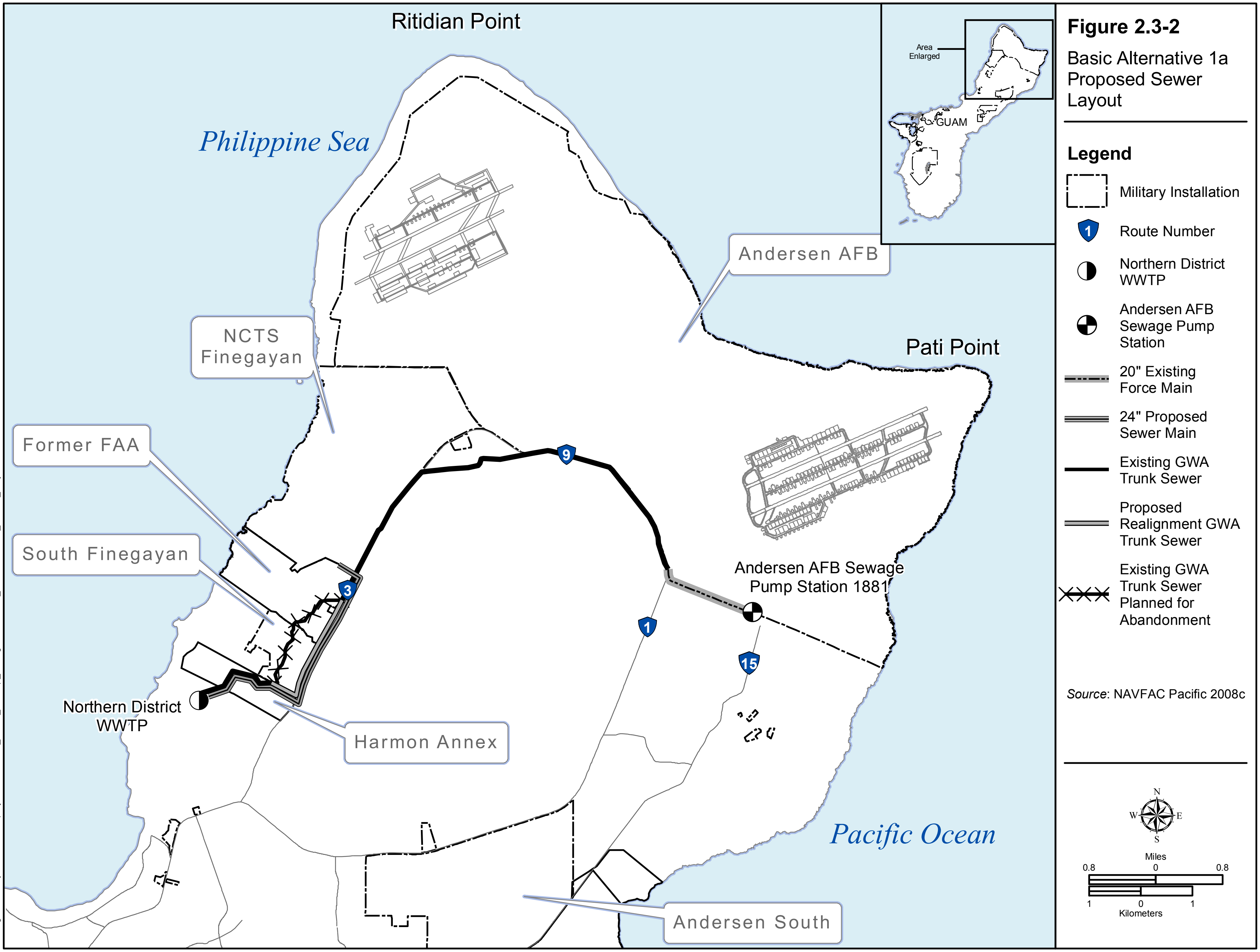

Figure 2.3-2
Basic Alternative 1a Proposed Sewer Layout

The Navy would coordinate with GWA to expedite the required plant improvements so that the NDWWTP would have enough capacity to bridge the gap between existing conditions and the final long-term wastewater solution. The proposed necessary improvements to restore the primary treatment capacity of the NDWWTP should be completed by December 2012. The Navy would also need to coordinate with GWA and USEPA Region 9 to facilitate a compliance agreement that allows an increase in the effluent discharge limitation from 6.0 MGd (22.7 MLd) to 12 MGd (45.4 MLd) average daily flow and the maximum daily discharge to 27 MGd (102.2 MLd).

The DoD's strategy to deliver reliable utility support for the military relocation was shaped based on the potential use of SPEs, which would likely be SPEs formed to finance, operate, manage, upgrade, or develop utility plants and associated infrastructure. It is anticipated that the SPEs would utilize GoJ financing. DoD is seeking funding from GoJ for the needed improvements to the NDWWTP.

Basic Alternative 1a would also upgrade the refurbished primary treatment system at the NDWWTP to secondary treatment with a capacity between 12 and 18 MGd (46.4 and 61.8 MLd) as determined by GWA and DoD, to treat both current wastewater flow and projected future flows from both civilian and military sources. It is expected that a trickling filter system is the best option as the secondary treatment process. In addition to the above presented primary treatment improvements, the following new process components and upgrades would be required at the NDWWTP for this alternative:

- One primary clarifier (the same size as existing ones)
- Three trickling filters
- Four secondary clarifiers
- One chlorine contact tank
- Two additional anaerobic digesters (the same size as existing ones)
- One additional centrifuge solids-dewatering system and odor control
- Effluent monitoring and measurement expansion
- Outfall diffuser capacity expansion

The proposed secondary treatment upgrades to the NDWWTP should be completed by July 2013. This alternative would require modifications to the NPDES permit from USEPA Region 9 to set new discharge limits and permit conditions. It is anticipated that the PEs would utilize GoJ financing. DoD is seeking funding from GoJ for the needed improvements to the NDWWTP.

To support Main Cantonment Alternatives 3 and 8, Basic Alternative 1b includes upgrades to the existing primary treatment facility and expansion to secondary treatment at the NDWWTP would be needed to accept additional wastewater flow and load from both central and northern Guam.

Under Basic Alternative 1b, in addition to all the proposed improvements presented in Alternative 1a, a new sewer line and lift pump stations would need to be installed to convey wastewater generated at Barrigada housing to the GWA NDWWTP for treatment. Figure 2.3-3 indicates the most likely routing of the proposed sewer lines. The proposed sewer lines and pump station should be completed in 2013.

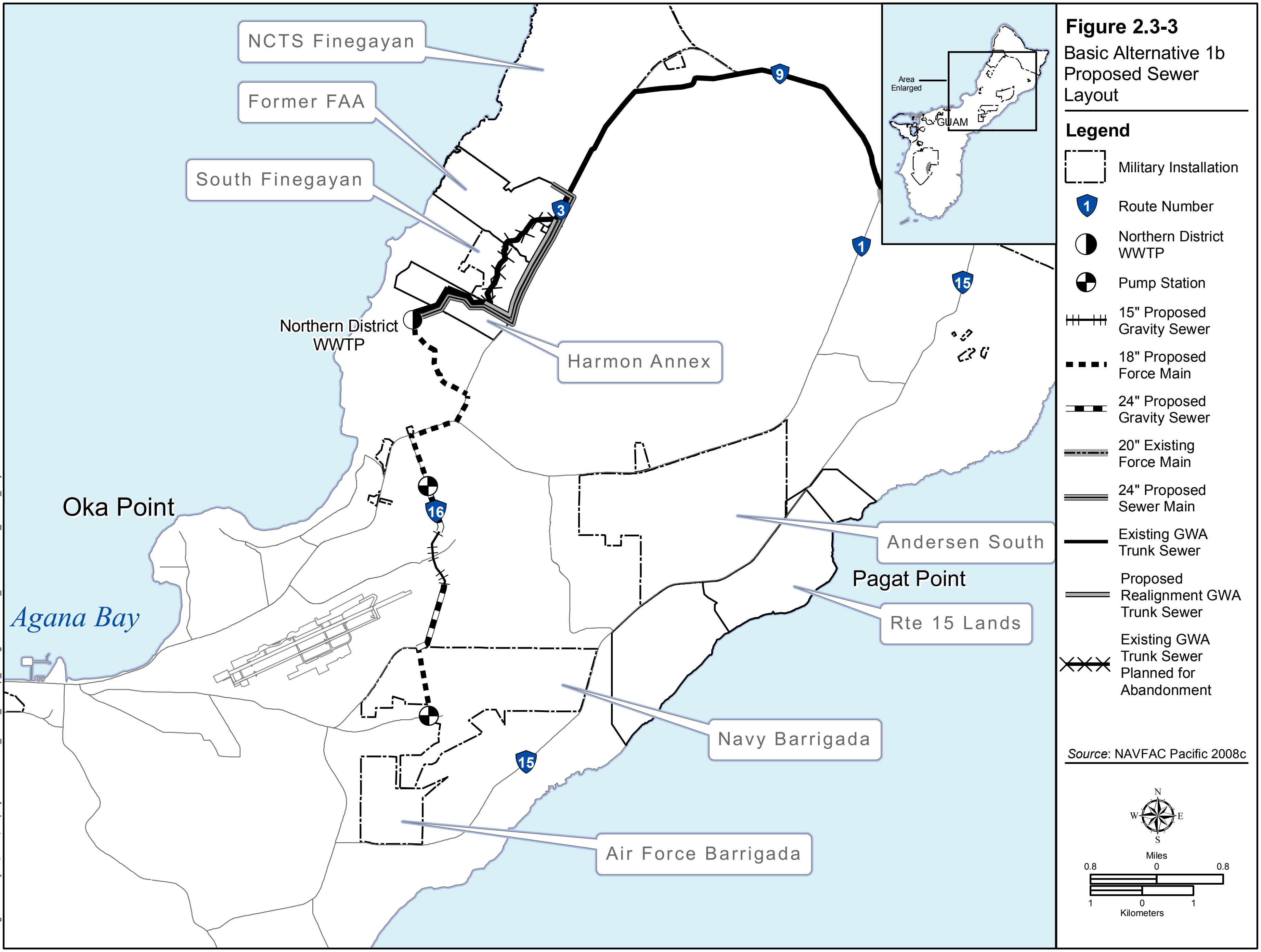

Figure 2.3-3
Basic Alternative 1b Proposed Sewer Layout

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2.3.7 Long-Term Alternatives

The wastewater alternative outlined below is considered to meet the year 2019 projected DoD demand at the completion of the military relocation, assuming that the Main Cantonment would be located at Finegayan (Main Cantonment Alternatives 1 and 2) or split between Finegayan and Barrigada (Main Cantonment Alternatives 3 and 8). The wastewater alternative supporting Main Cantonment Alternatives 3 and 8 would still require implementation of the alternative in support of Main Cantonment Alternatives 1 and 2 because Main Cantonment Alternatives 3 and 8 would still use the Finegayan area for military facilities. This long-term alternative would only be considered if the ultimate upgrade of NDWWTP to secondary treatment did not get implemented and the USEPA requirements to provide secondary treatment prevailed.

Long-Term Alternative 1: New DoD Only Stand Alone Secondary Treatment Facility on DoD Land at Finegayan Including a New Outfall in Support of all Main Cantonment Alternatives

Under Long-Term Alternative 1, to address interim wastewater needs, existing primary treatment facilities at the NDWWTP would have been refurbished to meet primary treatment standards as described in Basic Alternative 1 (Section 2.3.4). The NDWWTP would have been refurbished and the plant's primary treatment capacity would have been upgraded to accept the additional DoD flows and military relocation–related flows and loads in the short term. Construction of a new stand alone DoD secondary wastewater treatment facility on DoD land at Finegayan would be considered a long-term alternative and is discussed herein programmatically.

Interim wastewater flows to the NDWWTP would be handled in the same way as Alternative 1a.

Under Long Term Alternative 1a, all military-generated wastewater, either from Andersen AFB or from the proposed Marine Corps relocation, would be conveyed to the NDWWTP for treatment. All flows from the current and proposed future military relocation at Andersen AFB would be conveyed through the existing GWA sewer to the NDWWTP, while wastewater flow generated from the proposed Marine Corps relocation at Finegayan is planned to be conveyed via a new relief sewer line to the NDWWTP (as shown in Figure 2.3-2). A new 24-in (61-cm), 7,500-ft (2,300-m) gravity relief sewer would be connected from the collection system of the Marine Corps Finegayan area to the headworks of the NDWWTP. The proposed short-term modifications to the NDWWTP and collection system should be completed by December 2012.

The Navy would coordinate with GWA to expedite the required plant improvements so that the NDWWTP would have enough capacity to bridge the gap between existing conditions and the final long-term wastewater solution. The proposed necessary improvements to restore the primary treatment capacity of the NDWWTP should be completed by December 2012. The Navy would also need to coordinate with GWA and USEPA Region 9 to facilitate a compliance agreement that allows an increase in the effluent discharge limitation from 6.0 MGd (22.7 MLd) to 12 MGd (45.4 MLd) average daily flow and the maximum daily discharge to 27 MGd (102.2 MLd).

Long-Term Alternative 1 would require DoD to construct its own independent sewage interceptor to collect wastewater generated from military activities both at Andersen AFB and in the Finegayan area in support of Main Cantonment Alternatives 1 and 2. The interceptor sewer would connect to the Andersen AFB collection system at its main gate lift station, run west along Route 3, and then combine the flow generated by the Marine Corps and Army into the proposed DoD secondary treatment plant located at the southwest corner of the DoD proposed Finegayan development. Approximately 33,300 ft (10,000 m) of

21-in (53-cm) sewer and 8,700 ft (2,700 m) of 24-in (61-cm) sewer would be required to convey flow from the Andersen AFB and Finegayan areas to the new DoD plant (Figure 2.3-4).

Long-Term Alternative 1 also proposes to construct a new secondary-treatment plant on DoD land and construction of a new DoD ocean outfall. Under this alternative, a newly constructed independent sewer main would convey all military-generated wastewater in northern Guam to a DoD secondary-treatment plant near the proposed Marine Corps Finegayan development on DoD land in support of Main Cantonment Alternatives 1 and 2. The new sewer main would carry a total average daily wastewater flow of 3.77 MGd (14.27 MLd). The treated effluent from this secondary-treatment plant would be discharged via a new DoD ocean outfall into the Philippine Sea.

The new secondary-treatment plant would likely consist of the following components:

- Headworks (two screens and two aerated grit chambers with odor control)
- Three primary clarifiers
- Three trickling filters
- Three secondary clarifiers
- Two chlorine contact tanks
- Three anaerobic digesters
- Two centrifuge solids-dewatering systems with odor control
- Effluent monitoring and measurement
- New ocean outfall

Should Main Cantonment Alternatives 3 or 8 be selected, an additional sewer modification from wastewater Basic Alternative 1 would be required to convey wastewater generated at Barrigada from the connection at GWA’s NDWWTP sewer collection system to this new stand alone DoD secondary treatment facility. The new proposed forcemain sewer extension is shown on Figure 2.3-3. The proposed modified sewer lines and new pump station should be completed by 2015.

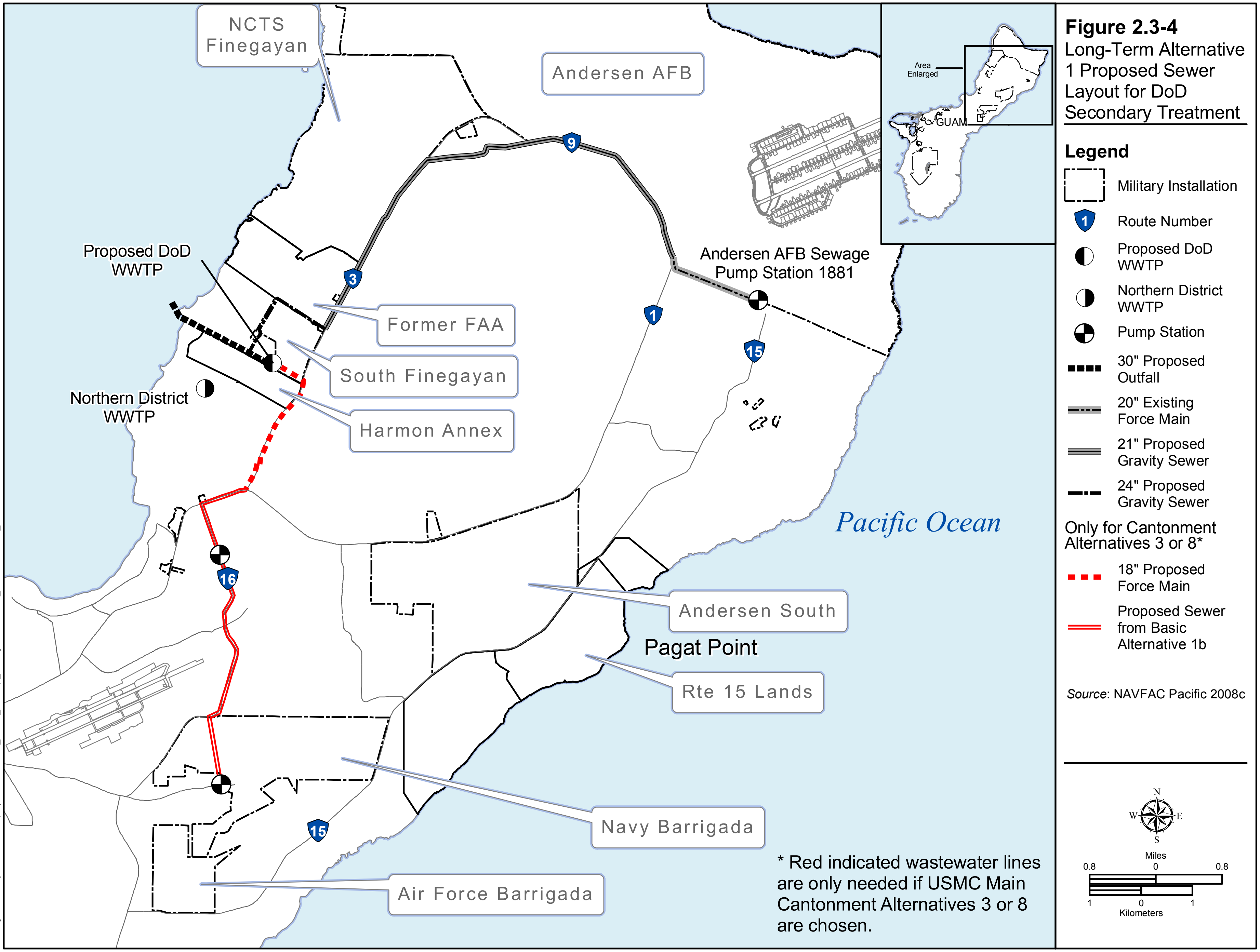

Figure 2.3-4 Long-Term Alternative 1 Proposed Sewer Layout for DoD Secondary Treatment

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2.4 SOLID WASTE

2.4.1 Anticipated Demand

Projections for solid waste generation rates from the proposed military relocation on Guam are presented in Table 2.4-1. The table lists projected populations due to direct and indirect actions through year 2019 and the resulting annual tonnages of solid waste generated. The solid waste estimates are based on an assumed generation rate of 7.4 pounds (lb) (3.4 kilograms [kg]) per capita per day for on base personnel and 5.28 lb (2.39 kg) per capita per day for off base populations. The assumed generation rate for on base personnel includes residential; commercial; industrial; and construction waste streams not related to the military relocation (NAVFAC Pacific 2008). Table 2.4-1

also reflects the DoD's diversion requirement of 50% of solid waste by weight by 2015. Construction and demolition (C&D) debris that would be generated by base improvements to accommodate the military relocation are not included in these per capita estimates. The Navy recently completed a study that evaluates the C&D debris waste stream (NAVFAC Pacific 2010d) that provides recommendations for processing and disposing of this waste. The study estimates that approximately 469,000 tons (425,000 metric tons) of C&D debris would be generated as a result of new C&D of existing structures and a diversion goal of 50% can be achieved. Recycling and diversion initiatives for municipal solid waste and C&D debris as well as waste characterization are discussed further in Section 2.4.5.

2.4.2 Available Solid Waste Facilities

The current solid waste disposal sites on Guam are as follows:

- Navy Sanitary Landfill (accepts Navy-generated solid waste)
- Andersen AFB Landfill and Recycling Center (accepts Air Force–generated solid waste)
- GovGuam Ordot Dump (accepts all civilian solid waste)

The locations of the existing facilities are shown in Table 2.4-1.

The Navy Sanitary Landfill at Apra Harbor currently accepts solid waste from all of the Navy's military personnel, residents, DoD employees, and contractors located on base. This landfill also accepts commercial waste streams from base activities, including C&D waste. The unlined landfill has been in use since 1965 and is currently operated by the Base Operations Support contractor, under the terms of the administratively extended Solid Waste Management Permit, No. 95-1009, dated December 26, 1995. The Navy has applied for a permit renewal from GEPA. The Navy currently plans to continue to fill the landfill to an elevation of 54 ft (16 m) above msl. The current landfill ranges in height from 20 ft (6 m) up to 52 ft (16 m) above msl.

The Air Force owns and operates a landfill on Guam, located at Andersen AFB near Route 1 and the entrance road to Andersen AFB. The landfill provides service to military personnel and residents of the bases as well as commercial waste streams from base activities. Base operations personnel operate and maintain the facility under a current Resource Conservation and Recovery Act Subtitle D Permit. The landfill reached its original design capacity in September 2007; therefore, the Air Force recently constructed a 2-ac (0.81-ha) expansion to meet its disposal needs through 2009. Because the GovGuam landfill would not become available until July 2011, the Air Force has awarded a project to design and construct an expansion to the Air Force landfill to accommodate receiving of solid waste for an additional 18 months. This expansion would handle Air Force municipal and industrial waste streams.

Table 2.4-1. Projected Solid Waste Estimates

	2010		2011		2012		2013		2014		2015	
	Population	Solid Waste (tons/yr) [1]	Population	Solid Waste (tons/yr) [a]	Population	Solid Waste (tons/yr) [a]	Population	Solid Waste (tons/yr) [a]	Population	Solid Waste (tons/yr) [a]	Population	Solid Waste (tons/yr) [a]
DoD Project Related (with Transient Personnel from CSG and ESG)												
Active (USMC + Army)	510	689	1,220	1,648	1,220	1,648	1,220	1,648	8,602	11,617	9,182	12,400
Dependents (USMC + Army)	537	725	1,231	1,663	1,231	1,663	1,231	1,663	9,000	12,155	9,950	13,437
Transient (USMC + Army)	0	0	400	540	400	540	400	540	2,000	2,701	2,000	2,701
Transient (Navy) (up to 3 times/yr, 21 days/visit)	0	0	0	0	0	0	0	0	0	0	7,222	1,683
Civilian Work Force (on-base) (USMC + Army)[b]	102	0	244	0	244	0	244	0	1,720	0	1,836	0
DoD Project-Related Subtotal	**1,149**	**1,414**	**3,095**	**3,851**	**3,095**	**3,851**	**3,095**	**3,851**	**21,322**	**26,473**	**30,190**	**30,222**
DoD Non-Project Related												
Navy/USCG/Air Force												
Active	80	108	80	108	80	108	130	176	170	230	250	338
Dependents	118	159	118	159	118	159	148	200	240	324	290	392
Transient	900	1,215	900	1,215	1256	1,696	1,256	1,696	1,256	1,696	1,256	1,696
Civilian Work Force (on-base)[b]	17	0	17	0	17	0	27	0	35	0	38	0
DoD Non-Project Related Subtotal	**1,115**	**1,483**	**1,115**	**1,483**	**1,471**	**1,964**	**1,561**	**2,072**	**1,701**	**2,250**	**1,834**	**2,425**
DoD Baseline Population (USMC/Army/Navy/Air Force/USCG)	**17,581**	**20,366**	**17,581**	**20,366**	**17,581**	**20,366**	**17,581**	**20,366**	**17,581**	**20,366**	**17,581**	**20,366**
DOD SOLID WASTE STREAM TOTAL	**19,845**	**23,262**	**21,791**	**25,699**	**22,147**	**26,180**	**22,237**	**26,288**	**40,604**	**49,088**	**49,605**	**53,013**
Implement Recycling and Diversion (Percentage)		**10%**		**10%**		**20%**		**30%**		**40%**		**50%**
Quantity Reduced by Recycling and Diversion		**2,326**		**2,570**		**5,236**		**7,886**		**19,635**		**26,507**
NET DOD SOLID WASTE STREAM TOTAL	**19,845**	**20,936**	**21,791**	**23,129**	**22,147**	**20,944**	**22,237**	**18,402**	**40,604**	**29,453**	**49,605**	**26,507**
Non-Military (Operation-Related Non-DoD population) [c]												
Full-Time Equivalent Jobs (direct, from purchases)	122	118	278	268	278	268	278	268	1,620	1,561	2,254	2,172
Full-Time Equivalent Jobs (indirect and induced)	108	104	254	245	254	245	254	245	1,532	1,476	2,092	2,016
Dependents (includes dependents of civilian work force)	353	340	849	818	860	829	850	819	5,520	5,319	6,116	5,893
Non-Military (Operation-Related Non-DoD population) Subtotal	**583**	**562**	**1,381**	**1,331**	**1,392**	**1,341**	**1,382**	**1,332**	**8,672**	**8,356**	**10,462**	**10,081**
Non-Military (Construction Related Non-DoD Population) [c]												
Construction Jobs (direct, onsite)	3,239	3,121	8,202	7,903	14,217	13,699	17,834	17,184	18,374	17,705	12,140	11,698
Full-Time Equivalent Jobs (direct, from purchases)	1,518	1,463	3,749	3,613	6,380	6,148	7,795	7,511	8,037	7,744	5,284	5,092
Full-Time Equivalent Jobs (indirect and induced)	1,017	980	2,755	2,655	4,860	4,683	5,749	5,540	5,797	5,586	3,310	3,190
Dependents	3,534	3,405	8,651	8,336	14,355	13,832	16,719	16,110	16,974	16,356	10,753	10,362
Non-Military (Construction Related Non-DoD Population) Subtotal	**9,308**	**8,969**	**23,357**	**22,507**	**39,812**	**38,363**	**48,097**	**46,346**	**49,182**	**47,392**	**31,487**	**30,341**
NON-MILITARY OPERATIONS AND CONSTRUCTION RELATED TOTAL	**9,891**	**9,531**	**24,738**	**23,837**	**41,204**	**39,704**	**49,479**	**47,678**	**57,854**	**55,748**	**41,949**	**40,422**
TOTAL SOLID WASTE	**29,736**	**30,467**	**46,529**	**46,967**	**63,351**	**60,648**	**71,716**	**66,079**	**98,458**	**85,201**	**91,555**	**66,929**

Legend: CSG = Carrier Strike Group; ESG = Expeditionary Strike Group; USMC = U.S. Marine Corps; USCG = U.S. Coast Guard

1. SW generation estimates are based on population loading of 02-09-09.
2. DoD solid waste quantities are based on a generation rate of 7.4 lbs/capita/day (HDR/Hawaii Pacific Engineers 2008). This rate includes solid waste generated by on-base civilian work force.
3. Non-military (operation and construction related non-DoD population) solid waste quantities are based on a generation rate of 5.28 lb/capita/day (GEPA 2006).

	2016		2017		2018		2019	
	Population	Solid Waste (tons/yr) [a]	Population	Solid Waste (tons/yr) [1]	Population	Solid Waste (tons/yr) [a]	Population	Solid Waste (tons/yr) [a]
DoD Project Related (with Transient Personnel from CSG and ESG)								
Active (USMC + Army)	9,182	12,400	9,182	12,400	9,182	12,400	9,182	12,400
Dependents (USMC + Army)	9,950	13,437	9,950	13,437	9,950	13,437	9,950	13,437
Transient (USMC + Army)	2,000	2,701	2,000	2,701	2,000	2,701	2,000	2,701
Transient (Navy) (up to 3 times/yr, 21 days/visit)	7,222	1,683	7,222	1,683	7,222	1,683	7,222	1,683
Civilian Work Force (on-base) (USMC + Army)[b]	1,836	0	1,836	0	1,836	0	1,836	0
DoD Project-Related Subtotal	**30,190**	**30,222**	**30,190**	**30,222**	**30,190**	**30,222**	**30,190**	**30,222**
DoD Non-Project Related								
Navy/USCG/Air Force								
Active	250	338	250	338	250	338	450	608
Dependents	290	392	290	392	290	392	290	392
Transient	1,256	1,696	1,256	1,696	1,256	1,696	1,780	2,404
Civilian Work Force (on-base)[b]	38	0	38	0	38	0	45	0
DoD Non-Project Related Subtotal	**1,834**	**2,425**	**1,834**	**2,425**	**1,834**	**2,425**	**2,565**	**3,403**
DoD Baseline Population (USMC/Army/Navy/Air Force/USCG)	**17,581**	**20,366**	**17,581**	**20,366**	**17,581**	**20,366**	**17,581**	**20,366**
DOD SOLID WASTE STREAM TOTAL	**49,605**	**53,013**	**49,605**	**53,013**	**49,605**	**53,013**	**50,336**	**53,991**
Implement Recycling and Diversion (Percentage)		**50%**		**50%**		**50%**		**50%**
Quantity Reduced by Recycling and Diversion		**26,507**		**26,507**		**26,507**		**26,996**
NET DOD SOLID WASTE STREAM TOTAL	**49,605**	**26,507**	**49,605**	**26,507**	**49,605**	**26,507**	**50,336**	**26,996**
Non-Military (Operation-Related Non-DoD population) [c]								
Full-Time Equivalent Jobs (direct, from purchases)	2,254	2,172	2,254	2,172	2,254	2,172	2,356	2,270
Full-Time Equivalent Jobs (indirect and induced)	2,092	2,016	2,092	2,016	2,092	2,016	2,125	2,048
Dependents (includes dependents of civilian work force)	6,116	5,893	6,116	5,893	6,116	5,893	6,156	5,932
Non-Military (Operation-Related Non-DoD population) Subtotal	**10,462**	**10,081**	**10,462**	**10,081**	**10,462**	**10,081**	**10,637**	**10,250**
Non-Military (Construction Related Non-DoD Population) [c]								
Construction Jobs (direct, onsite)	3,785	3,647	0	0	0	0	0	0
Full-Time Equivalent Jobs (direct, from purchases)	1,634	1,575	0	0	0	0	0	0
Full-Time Equivalent Jobs (indirect and induced)	365	352	0	0	0	0	0	0
Dependents	2,704	2,606	0	0	0	0	0	0
Non-Military (Construction Related Non-DoD Population) Subtotal	**8,488**	**8,179**	**0**	**0**	**0**	**0**	**0**	**0**
NON-MILITARY OPERATIONS AND CONSTRUCTION RELATED TOTAL	**18,950**	**18,260**	**10,462**	**10,081**	**10,462**	**10,081**	**10,637**	**10,250**
TOTAL SOLID WASTE	**68,555**	**44,767**	**60,067**	**36,588**	**60,067**	**36,588**	**60,973**	**37,245**

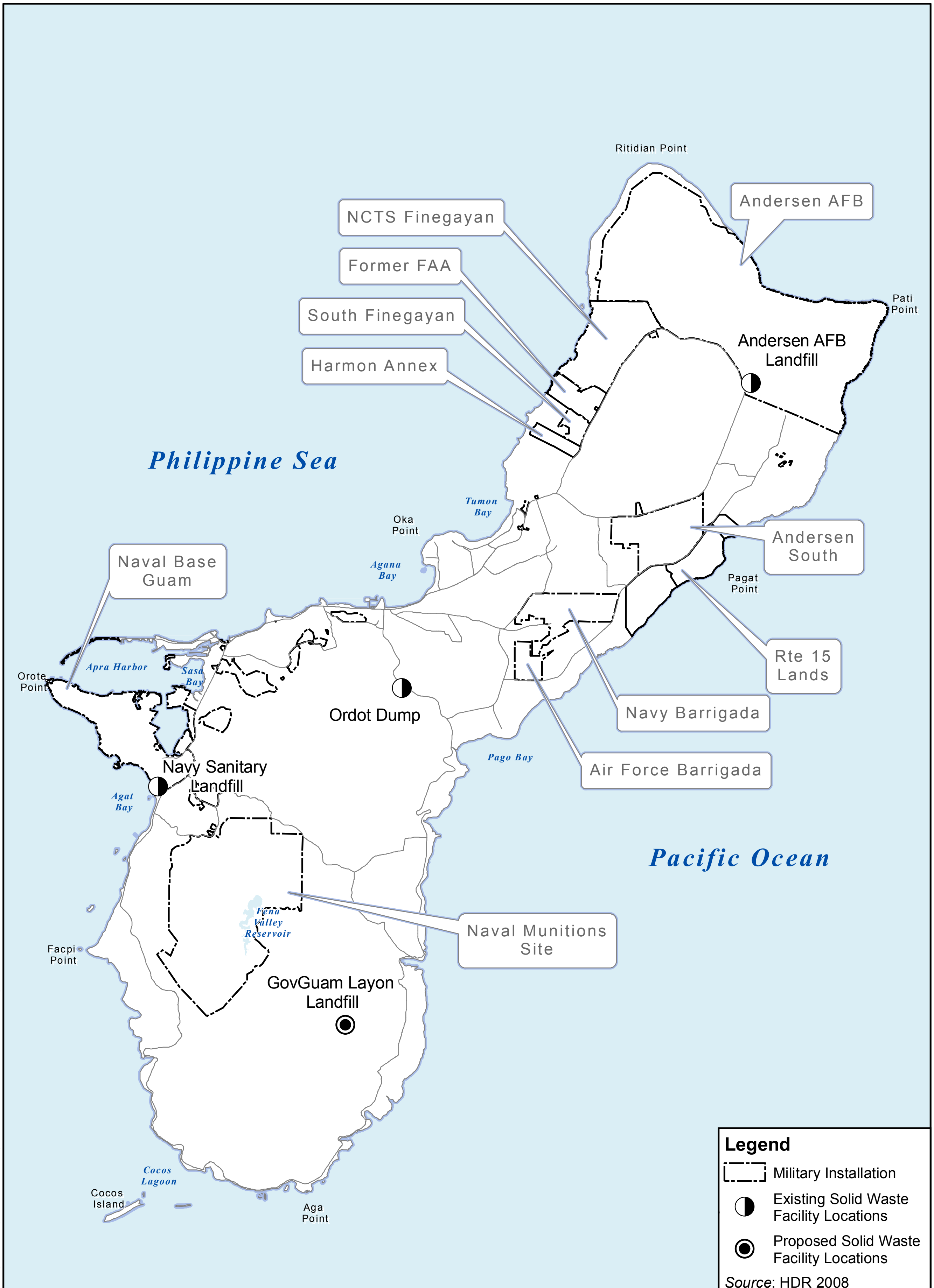

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Figure 2.4-1
Solid Waste Facility Locations, Guam

The remaining non-DoD waste stream on Guam is disposed of directly at the GovGuam Ordot Dump facility located in central Guam or via citizen drop-off transfer stations. The Ordot Dump does not accept construction or demolition debris; two on-island hardfills (i.e., for C&D debris) are currently permitted and available to accept this type of waste. The Northern Hardfill is a privately owned landfill that accepts C&D debris and is located on Route 15 (back road to Andersen AFB). Another privately owned facility allowed to accept C&D debris is the Eddie Cruz Hardfill Facility located in Yigo.

The planned replacement for the GovGuam Ordot Dump is the new GovGuam Layon Landfill. The proposed site is located in Layon near the village of Inarajan, in the higher badland (highly eroded rocky) areas on the west side of the Dandan parcel, southwest of the former National Aeronautics and Space Administration tracking station. Construction of the new facility began on February 25, 2009, and the landfill is expected to be ready for acceptance of solid waste by July 2011 (Gershman, Brickner, & Bratton, Inc. [GBB] 2009). The Layon Landfill was designed to accommodate solid waste from all current and future DoD sources as well as civilian and commercial sources. The Layon Landfill would have a capacity of 15.8 million cubic yards (CY) (12.1 million cubic meters [m^3]) of solid waste as presented in the GEPA Draft Municipal Solid Waste Landfill Facility Permit (GEPA 2009).

Table 2.4-2 presents a comparison of the expected solid waste that would be generated during the military relocation versus the potential design capacity of the existing DoD facilities. Because the Andersen AFB Landfill is essentially at full capacity, only the Navy Sanitary Landfill is presented. It is assumed that the Navy Sanitary Landfill can be filled to a height of 54 ft (16 m) above msl (NAVFAC Pacific 2008). The projection indicates that the Navy Sanitary Landfill would have the capacity to accommodate the on-base generated solid waste during the military relocation, assuming that the landfill was filled to a maximum height of 54 ft (16 m) above msl.

Table 2.4-2. Solid Waste Projections versus Available Capacity (tons)

Solid Waste Projections			*Available Capacity at Navy Sanitary Landfill, Fill Elevation = 54 ft msl*	*Difference between Solid Waste Projections and Available Capacity*
From On Base Baseline Population, 2010 to 2019	*From On Base Population Increase, 2010 to 2019*	*Total — On Base Baseline and Population Increase*		
130,340[a]	115,550 [a]	245,890	540,000 [b]	294,110

Notes:
[a] From

Table 2.4-1 assuming diversion requirement of 50% by 2015 is achieved;
[b] Based on computed volume from Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation (NAVFAC Pacific 2008), and converting to weight using an in-place density = 1,200 pounds/cubic yards and solid waste to cover material ratio of 3:1.
Legend: ft = feet; msl = mean sea level.

2.4.3 Screening Process

Although the solid waste disposal demand as a result of the proposed military relocation (on base) would not exceed DoD's current capacity for solid waste in the next 10 years, it would be exceeded shortly thereafter. In July 2009, a letter of intent between the Navy, GovGuam, and GBB was signed that establishes the Navy's intent to pursue a contractual arrangement for the use of GovGuam's new Layon Landfill (see Appendix C). With this additional alternative, the DoD community would have long-term capacity for solid waste disposal. Based on a comprehensive review of the available solid waste disposal alternatives for DoD on Guam in the Guam Solid Waste Utility Study for Proposed U.S. Marine Corps

Relocation (NAVFAC Pacific 2008) and the letter of intent mentioned above, the following alternatives were identified for evaluation:

- Install Liner and Other Improvements at Existing Navy Sanitary Landfill at Apra Harbor.
- Continue to use the Navy landfill at Apra Harbor for municipal solid waste until the new GovGuam Layon Landfill at Dandan is available for use. Disposal of other waste streams excluded from Layon Landfill would continue at the Navy landfill. C&D debris would continue to be disposed at the Navy hardfill.
- Construct New DoD Landfill in Central Guam.
- Construct a WTE Facility.
- Barge Waste off Guam to a Permitted Facility.
- Construct New DoD Landfill in northern Guam.
- Utilize Existing Landfill at Andersen AFB.
- Expand Existing Landfill at Andersen AFB.
- Use Potential New Private WTE Facility with Landfill at Atantano.

A preliminary screening analysis was conducted and the technical aspects of the alternatives were developed to a conceptual level to allow evaluation of the relative viability of the nine identified alternatives. The alternatives were screened on the basis of environmental and regulatory issues, implementation and policy issues, and potential scheduling issues. Based on the screening analysis, eight of the nine identified alternatives were judged as nonviable and were eliminated from further consideration, as discussed below in Section 2.4.4.

A summary of these alternatives and fundamental evaluation is included in Table 2.4-3.

2.4.4 Alternatives Dismissed

A description of the alternatives for solid waste solutions that were dismissed, and the rationale for their dismissal, is provided below.

2.4.4.1 Install Liner and Other Improvements at Existing Navy Sanitary Landfill at Apra Harbor

This alternative would consist of installing a liner system over the present Navy Sanitary Landfill at Apra Harbor. This landfill is operated by a Base Operations Support contractor for the Navy. The Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation (NAVFAC Pacific 2008) looked at three filling scenarios and concluded that the landfill could be filled vertically an additional 50 ft (15 m), to a height of 100 ft (30 m) above msl, after a new liner is installed. This alternative would provide capacity for 1,305,000 tons (1,183,900 metric tons) based on a volume increase of 2,900,000 CY (2,217,000 m^3), assuming that minor operational changes were made.

The utility study concluded that this alternative would provide 27 years of landfill life and was chosen as the Preferred Alternative; however, a new liner system would require approximately 3 years for design, permitting, and construction (assuming that the Navy would hire contractors to do this work) and therefore would not be ready by 2010 when the Marine Corps would begin to relocate. This alternative also assumes that the liner system could be installed at the Navy Sanitary Landfill at Apra Harbor simultaneously with active solid waste disposal operations that would need to continue until completion of the lined area. Conducting both operations very close to each other would be logistically challenging.

Table 2.4-3. Summary of Alternatives Evaluated for Solid Waste Disposal

Solid Waste Disposal System Alternative	*Evaluation Considerations*	*Recommendation*
Install Liner and Other Improvements at Existing Navy Sanitary Landfill at Apra Harbor	• *Environmental/Regulatory:* A solid waste permit application to GEPA would be required to expand the landfill. • *Environmental/Regulatory:* The current landfill is unlined and therefore the potential for leachate to affect groundwater exists. • *Implementation/Policy:* Installing a new liner system over an existing landfill would have high construction costs and construction of a new liner system while maintaining active solid waste disposal operations would be logistically difficult. • *Schedule:* Construction of the new liner system could not be completed before relocation of the Marine Corps.	Dismissed
Continue to Use Unlined Existing Navy Sanitary Landfill at Apra Harbor Until New Layon Landfill is Completed by GovGuam in 2011, then Use Layon Landfill for Disposal of All DoD Municipal Solid Waste	• *Environmental/Regulatory:* The Layon Landfill would be lined with a double liner meeting federal and GEPA requirements. • *Implementation/Policy:* GovGuam and GEPA favor use of a regional landfill for civilian and DoD solid waste disposal. • *Implementation/Policy:* The Navy, GovGuam, and GBB have reached an agreement documented in a letter of intent that DoD would be able to dispose of waste at the new GovGuam landfill facility. • *Implementation/Policy:* Layon Landfill has sufficient design capacity to handle increased solid waste generation by DoD and the civilian population. • *Implementation/Policy:* Using the existing Navy Sanitary Landfill at Apra Harbor provides a short-term, low-cost solution until a lined landfill (i.e., Layon Landfill) becomes available. • *Schedule:* Layon Landfill completion is expected sooner than improvements to the Navy Sanitary Landfill at Apra Harbor could be completed.	Retained
Construct New DoD Landfill in Central Guam	• *Environmental/Regulatory:* Development of a landfill in this area could significantly affect groundwater and surface water resources. • *Environmental/Regulatory:* Remnants of World War II structures exist at the site and would require a Section 106 consultation. Additionally, there is an active spring (Santa Rita) near the site that could require mitigation. • *Implementation/Policy:* A lengthy NEPA review process would be required and it is likely that public support for a new landfill in Guam would be low. • *Schedule:* A lengthy siting, planning, public review, and permitting process would be required.	Dismissed
Construct a WTE Facility	• *Environmental/Regulatory:* Per Guam Public Law 25-175, it is unlawful to operate a municipal solid waste incinerator or WTE facility on Guam. • *Schedule:* A lengthy schedule would be required (5 years) to bring a WTE facility online.	Dismissed

Solid Waste Disposal System Alternative	*Evaluation Considerations*	*Recommendation*
Barge Waste off Guam to a Permitted Facility	• *Environmental/Regulatory:* There are no nearby locations to dispose of waste that are able to handle the waste in an environmentally sound manner. • *Implementation/Policy:* There is a high probability for cargo handling and trucking inefficiencies, which could result in shipping delays, resulting in high costs and potential public health issues.	Dismissed
Construct New DoD Landfill in Northern Guam	• *Environmental/Regulatory:* The potential site is located over the NGLA, an environmentally sensitive potable groundwater source.	Dismissed
Use Existing Landfill at Andersen AFB	• *Environmental/Regulatory:* The site is located over the NGLA, an environmentally sensitive potable groundwater source. • *Implementation/Policy:* Very limited site capacity exists. • *Implementation/Policy:* This option would not provide sufficient capacity for the military relocation.	Dismissed
Expand Existing Landfill at Andersen AFB	• *Environmental/Regulatory:* The site is located over the NGLA, an environmentally sensitive potable groundwater source.	Dismissed
Use Potential New Private WTE Facility with Landfill at Atantano	• *Environmental/Regulatory:* The Final Site Selection Report, EIS for the Siting of a Municipal Solid Waste Landfill Facility for the island of Guam concluded that this site location was deficient based on the siting criteria (GDPW 2005). • *Implementation/Policy:* Permits have not yet been obtained, and the process could be long. • *Implementation/Policy:* Funding for the project is uncertain.	Dismissed

Legend: AFB = Air Force Base; DoD = Department of Defense; EIS = Environmental Impact Statement; GBB = Gershman, Brickner, & Bratton, Inc.; GDPW = Guam Department of Public Works; GEPA = Guam Environmental Protection Agency; GovGuam = Government of Guam; NEPA = National Environmental Policy Act; NGLA = Northern Guam Lens Aquifer; WTE = Waste-to-Energy.

Because the landfill is unlined, there is a potential for leachate to affect the underlying groundwater. Studies are currently under way to assess the nature and extent of contamination and would provide recommendations for additional sampling and installation of additional monitoring wells if necessary. Should additional investigation indicate substantial contamination, corrective action would be required. One of the corrective action alternatives could be closure of the landfill and installation of a final cover. Because of these challenges and the fact that DoD and GovGuam have reached an agreement to use the new GovGuam Landfill in Layon, this alternative was dismissed.

2.4.4.2 Construct New DoD Landfill in Central Guam

This alternative would consist of constructing a new DoD landfill in central Guam in the northwest portion of the Naval Munitions Site. This site has not been investigated in detail by the Navy, but was identified as a potentially suitable site. The utility study estimated that the site would provide a service life of 50 years. The conceptual design assumes a landfill footprint of approximately 50 ac (20 ha) that provides a design capacity of 6,350,000 CY (4,855,000 m^3) or 2,860,000 tons (2,595,000 metric tons) (assuming an in-place density of 1,200 lb/CY and a solid waste-to-cover material ratio of 3:1).

The utility study also concluded that a time period of approximately 4-5 years would be needed to design, permit, and construct this type of facility, assuming that no substantial challenges were encountered, which is unlikely. Remnants of World War II structures exist at the site and would require a Section 106 consultation. Additionally, there is an active spring (Santa Rita) near the site that could require permitting and mitigation. Because a new DoD landfill could not be designed, permitted, and built in time for the relocation of the Marine Corps, and because of the expected high capital cost of developing a new landfill site, this alternative was dismissed.

2.4.4.3 Construct a Waste-to-Energy Facility

This alternative would consist of constructing a WTE facility to dispose of the combustible portion of the DoD solid waste stream and reduce the volume of landfilled material. For the same reasons stated in Section 2.1.3.9, WTE power plants have conventionally been steam power plants that sort and burn solid wastes. Because the wastes are normally burned to generate steam, emissions of air pollutants are a primary issue. Combustion air emission controls and scrubbing of the waste exhaust air stream are normally required, and these add to the complexity and operating costs for the system.

For this alternative, the Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation (NAVFAC Pacific 2008) assumed that the WTE facility would be constructed by DoD on federal land, but with no specific location identified. The facility would need to be located near a landfill because the byproduct ash material would need to be landfilled. The utility study assumed that the facility would have a capacity of 150 tons per day to handle the anticipated increase in waste from the military relocation. An extended time period is required for permitting and construction of a WTE facility. Generally, 3-5 years are required before startup of a new facility can occur.

Per Guam Public Law 25-175, it is unlawful for any person to construct or operate a municipal solid waste incinerator or WTE facility on Guam, as defined by the rules and regulations of USEPA or the laws of the U.S. Because of the lengthy schedule required to bring a WTE facility online and because of Guam Public Law 25-175, this alternative was dismissed.

2.4.4.4 Barge Waste Off Guam to a Permitted Facility

This alternative considers disposal of solid waste generated on Guam by shipping it to a location outside Guam that is environmentally sound and is permitted for solid waste disposal by a governmental agency. A majority of the materials that result in waste generation on the island are brought to Guam in cargo containers, resulting in an excess capacity of shipping containers that are sent back empty. These excess containers could be used to ship the waste outside Guam. However, shipment of DoD’s solid waste would be subject to the availability of excess containers. Therefore, this alternative included scheduled barge service dedicated to the movement of DoD solid waste to a location outside Guam. This alternative would require that DoD construct a facility to shred and bail the solid waste somewhere in Apra Harbor. The facility would be sized to accommodate the anticipated flow of solid waste from the military relocation. The utility study assumed a facility size of 210 tons (191 metric tons) per working day.

Landfill sites in Southeast Asia were considered to help reduce shipping costs; however, there is a lack of appropriate sanitary landfills equipped with U.S.-equivalent protection standards. Because of the lack of viable disposal alternatives near Guam that meet these criteria, disposal of barged waste was assumed to be at a landfill in the state of Washington. Preliminary assessment indicates that the life-cycle costs associated with this alternative are very high. In addition, there is a high probability for cargo handling and trucking inefficiencies, which could result in shipping delays, resulting in high costs and potential public health issues. For these reasons and because of potential sociopolitical concerns, this alternative was eliminated from further consideration.

2.4.4.5 Construct New DoD Landfill in Northern Guam

This alternative assumes that the Navy would construct a new lined landfill somewhere in northern Guam; however, a specific site was not identified. The utility study determined that DoD construction of a new landfill in northern Guam was nonviable because it would be located over the NGLA, an environmentally sensitive groundwater protection zone providing the only important source of potable groundwater and almost 80% of the potable water for the island. The NGLA area had been ruled out as a suitable area for siting a new landfill during an environmental impact study process conducted by GovGuam (Guam Department of Public Works [GDPW] 2005). GEPA may be unlikely to approve a new landfill over the NGLA given the availability of less-sensitive available locations on the island; this alternative was therefore eliminated from further consideration.

2.4.4.6 Use Existing Landfill at Andersen AFB

This alternative consists of continued use of the existing landfill at Andersen AFB. The landfill reached its original design capacity in September 2007, with the anticipation that the new GovGuam Layon Landfill would be available. Because development of the GovGuam Layon Landfill was not complete, the Air Force constructed a 2-ac (0.81-ha) expansion to meet its disposal needs through 2009. Because the GovGuam landfill would now not become available until July 2011, the Air Force is further expanding their landfill to provide 18 months of interim capacity until the Layon Landfill is opened.

Therefore, using the existing landfill at Andersen AFB as a long-term disposal alternative was judged as nonviable because its remaining site life is very limited. Similar to the previous alternative in northern Guam, the landfill is located above the NGLA, an environmentally sensitive groundwater protection zone providing the only important source of potable groundwater and almost 80% of the potable water for the island. For these reasons, this alternative was eliminated from further consideration.

2.4.4.7 Expand Existing Landfill at Andersen AFB

This alternative involves expanding the existing Andersen AFB landfill. As described above, Andersen AFB is expanding their landfill to provide 18 months of interim capacity until the GovGuam Landfill is opened. The existing landfill is located over the NGLA, a sensitive environmental area that provides almost 80% of the drinking water for Guam. A major expansion of the landfill at Andersen AFB was judged as nonviable because it would be located over the NGLA, an area that has been ruled out by GovGuam and GEPA in a previous landfill siting study. Similar to Section 2.4.4.5, it may not be advisable or possible to pursue permitting a large landfill expansion located above the NGLA; this alternative was therefore eliminated from further consideration.

2.4.4.8 Use Potential New Private WTE Facility with Landfill at Atantano

This alternative would involve using a planned WTE facility and landfill owned and operated by Guam Resource Recovery Partners located at Atantano. As described in the Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation (NAVFAC Pacific 2008), the landfill would have a projected life of 19-21 years, assuming that the WTE facility was utilized and based on current Guam non-DoD municipal solid waste generation rates. Permits have not yet been obtained for construction of either the landfill at Atantano or the private WTE facility. In a recent letter from GEPA to Guam Resource Recovery Partners dated December 2, 2009, GEPA indicated that Guam Resource Recovery Partners' 2008 solid waste permit application is incomplete, and that further information is required before it can be approved (GEPA 2009). Given these factors, this alternative is considered nonviable and was therefore eliminated from further consideration.

2.4.5 Alternative Retained

2.4.5.1 Preferred Alternative

Basic Alternative 1 would utilize planned and currently in construction new Gov Guam landfill at Layon for municipal waste. This addresses the DoD requirements for all cantonment alternatives including the preferred alternative as well as provides GovGuam additional customer base for its new landfill, enhancing the economic viability of this new landfill. Thus other alternatives were not considered and this is the preferred alternative. See below for additional details.

The Preferred Alternative would be to continue to use the Navy landfill at Apra Harbor for municipal solid waste (MSW) until the new GovGuam Layon Landfill at Dandan is available for use. Disposal of other waste streams excluded from Layon Landfill would continue at the Navy landfill. Construction and demolition (C&D) debris would continue to be disposed at the Navy hardfill.

As described in Section 2.4.2, the Navy Sanitary Landfill has the potential to provide more than 10 years of capacity based on the computed demand in Figure 2.4-2 and a capacity of 1,200,000 CY (917,500 m^3) or 540,000 tons (490,000 metric tons), assuming a landfill height of 54 ft (16 m) above msl and completion of minor operational improvements. The Navy Sanitary Landfill is shown in Figure 2.4-2. Such operational improvements include reducing the daily cover (which is required) and using larger compaction equipment to achieve greater densities. Because the landfill is unlined, there is a potential for leachate to adversely affect the underlying groundwater. Studies are currently under way to assess whether or not the underlying groundwater has been affected by leachate. Based on the conclusions of these studies, further action may be required.

Once the new Layon Landfill is opened, DoD would send its municipal solid waste to the GovGuam Layon Landfill. A site plan of the Layon Landfill is presented in Figure 2.4-3. The site selected for the Layon Landfill is approximately 317 ac (128 ha) in size, with a landfill footprint of 127.4 ac (51.6 ha) and a capacity of 15,808,794 CY (12,086,690 m^3) or 9,485,276 tons (8,604,898 metric tons), assuming an in-place density of 1,200 lb/CY (712 kg/m^3) (GEPA 2009). The construction of the Layon Landfill is proposed to occur in two phases. Phase 1 would include the reconstruction of approximately 1.3 miles (2.1 kilometers) of existing Dandan Road to provide safe and suitable access for heavy trucks, construction of approximately 2 miles (3 kilometers) of new road, and bulk excavation. Phase 2 would include the construction of the actual landfill facility.

The landfill site would be accessed from Route 4 by approximately 3.3 miles (5.4 kilometers) of reconstructed road and new road. The landfill would be designed, built, and operated in compliance with Guam Solid Waste Disposal Rules and Regulations and would incorporate the following:

- Access road
- Berms
- Liner system
- Leachate collection system
- Landfill gas collection system
- Stormwater collection and disposal system
- Seismic design appropriate to site conditions
- Monitoring wells
- Security system
- On site soil cover source
- Buffer zone

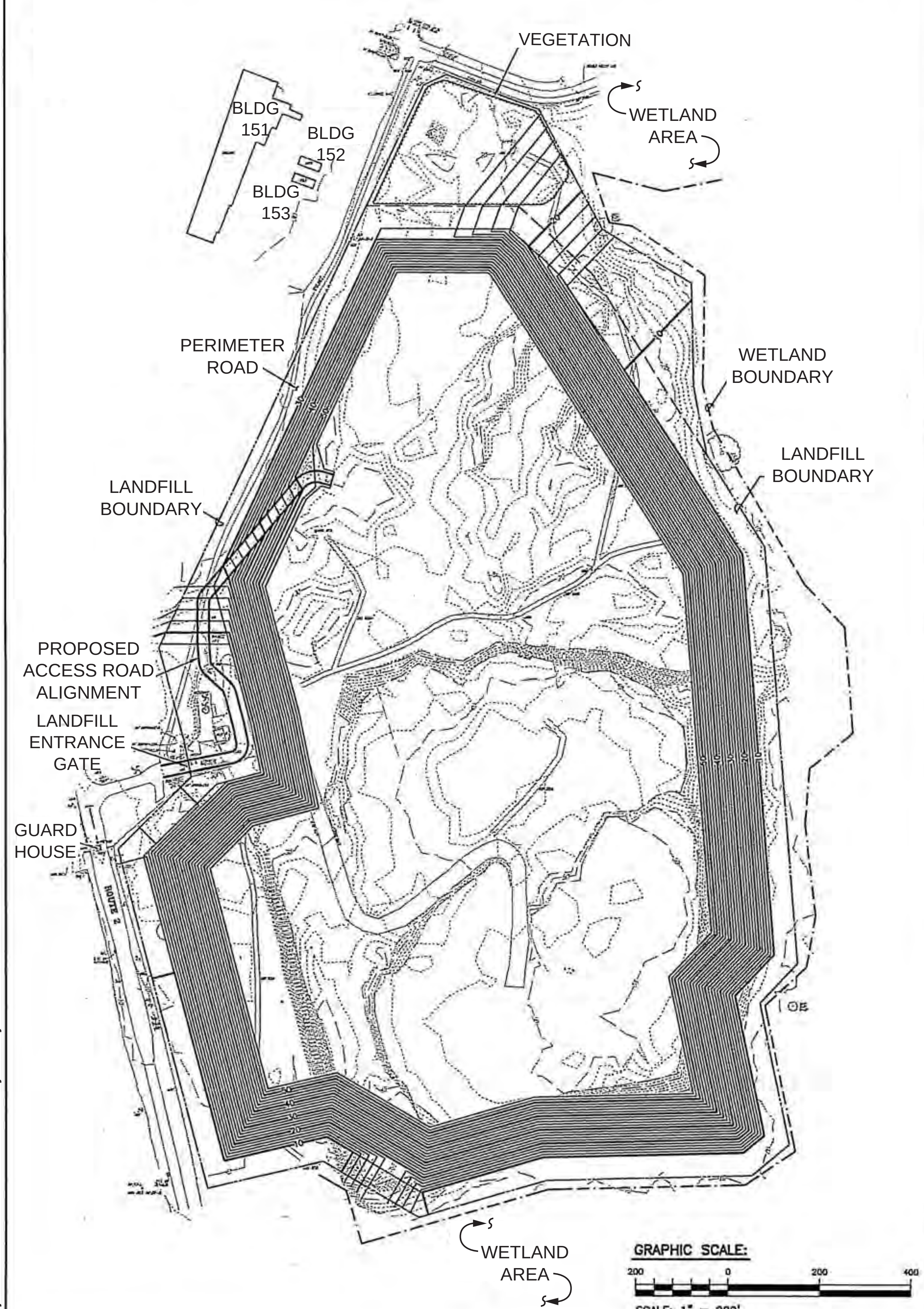

Figure 2.4-2
Navy Sanitary Landfill with Maximum Elevation = 54 ft MSL, Guam

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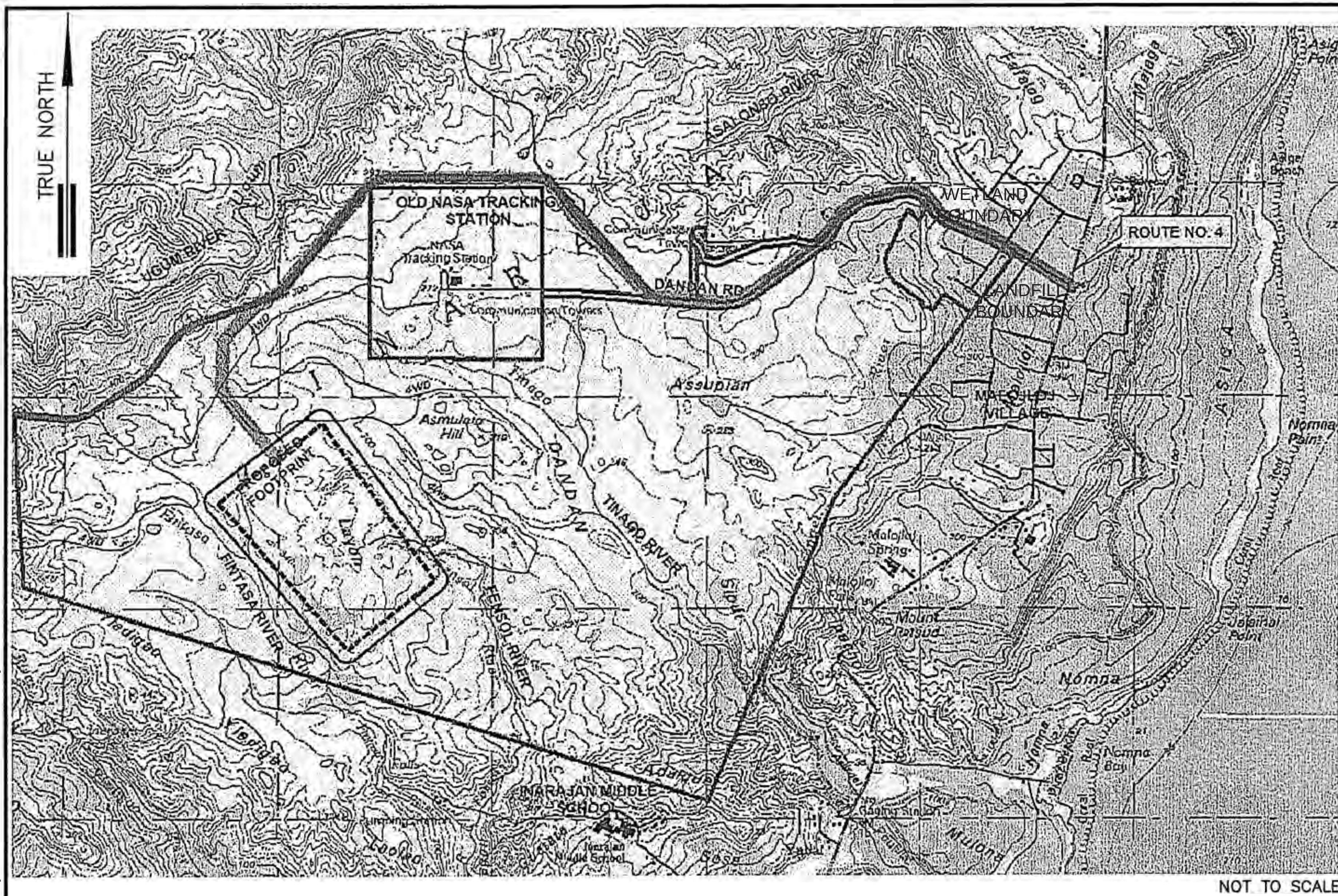

Figure 2.4-3
Layon Landfill Location, Guam

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The Layon Landfill would be constructed as a mounded landfill. The final top elevation of the landfill would be approximately 460 ft (140 m) above msl. The landfill would be excavated approximately 15.0 ft (4.6 m) below existing grade to provide cover soils. Support facilities, an entrance control structure, scale and scale house, administration facility, leachate storage and treatment facility, and equipment and maintenance storage facilities, would be located adjacent to the access road in the buffer area in the northeast corner of the site. An area of 5 ac (2 ha) would be reserved for these facilities within the buffer area of the landfill.

The proposed Layon Landfill and its impacts were evaluated in the Final Supplemental Environmental Impact Statement for the Siting of a Municipal Solid Waste Facility, Guam (GDPW 2005). The design, permitting, and construction of the new landfill is being managed by GBB, the firm assigned receivership of GovGuam's solid waste program by the U.S. District Court of Guam as a result of a consent decree issued by USEPA. GBB recently awarded a construction contract for the initial phase of the landfill, and construction began on February 25, 2009. The current phase consists of constructing the landfill operations road and performing mass grading for landfill Cells 1 and 2. Invitations to bid on the construction of the Layon Municipal Sanitary Landfill Entrance Area Facilities and Cells 1 and 2 liner system were released on August 17, 2009.

Landfills are typically constructed in phases in accordance with an approved sequencing plan. The phases or "cells" are constructed to be large enough to handle waste for approximately 3-5 years. Once the active landfill phase is near capacity, a new landfill cell is constructed. The draft operations plan for the Layon Landfill (TG Engineers 2009) indicates that subsequent disposal cells would be constructed at intervals of 2-5 years. The initial phase at Layon Landfill would consist of Cells 1 and 2 that are 11.07 ac (4.48 ha) and 11.33 ac (4.58 ha) in size, respectively, with a combined waste capacity of 1,407,173 CY (1,075,861 m^3) (GEPA 2009). Table 2.4-4 presents the projected solid waste generation rates from both the military relocation and the civilian Guam population by year. These two categories were added together to determine total estimated solid waste in tons, which were then converted to cubic yards. As shown in the table, in year 2014, Cells 1 and 2 would have reached their capacity and would have provided about 4 years of useful life, which is consistent with the phasing presented in the Layon Landfill Operations Plan.

Table 2.4-4 also provides an estimate of when the Layon Landfill would reach its ultimate capacity from solid waste generated by DoD and the Guam general population. Using a landfill airspace capacity of 15,808,794 CY (12,086,690 m^3), the table indicates that the landfill would reach capacity in 2044, 33 years after opening.

The Layon Landfill is currently projected to be ready for acceptance of solid waste by July 2011 (GBB 2009). The Layon Landfill has been designed to accommodate solid waste from all current and future DoD sources, as well as civilian and commercial sources. The Layon Landfill is expected to enforce a ban similar to the current ban at Ordot Landfill for disposal of old corrugated cardboard, green waste, construction waste, wooden pallets, and inert waste. Layon Landfill is also expected to exclude junk vehicles, white goods, C&D debris, polychlorinated biphenyl wastes, petroleum contaminated soil, E-wastes, used motor oil, batteries, radioactive waste, solvents, paints, oily wastes, acids, corrosives, industrial wastes, explosives, asbestos, sludge, and asbestos containing materials.

Additionally, an important milestone was reached on April 3, 2009, when GEPA approved the Final Integrated Hydrogeologic Assessment for the Layon Municipal Sanitary Landfill Site (AMEC Geomatrix

Consultants, Inc. 2008). This document has established that the proposed landfill is not located over an important source of groundwater because of potential low yield and marginal back groundwater quality.

2.4.5.2 Construction and Demolition Debris

C&D debris would be generated as a result of proposed construction and proposed demolition of old structures to facilitate the proposed military relocation. The DoD recently completed a C&D Debris Reuse and Diversion Study for DoD Bases Guam (NAVFAC Pacific 2010d). The purpose of the study was to characterize the C&D waste stream and develop recommendations for diversion and reuse. DoD agencies must comply with EO 13514 which establishes a goal of diverting at least 50% of C&D materials and debris by the end of fiscal year 2015.

The study utilized available master plans, record drawings, and base maps to determine the types and quantity of C&D debris that would be generated. The study estimated that approximately 469,000 tons (425,000 metric tons) of C&D debris would be generated and that approximately 80% is potentially divertable. Table 2.4-5 provides a breakdown of C&D by category.

The C&D characterization determined that the largest category of C&D waste that could be diverted would be concrete (without lead-based paint) at 46% by weight. The next largest category of potentially divertable C&D was untreated wood at 15% by weight, followed by asphalt concrete at 13% by weight. Other significant categories included scrap metal (2%), and cardboard (4%).

Green waste would be generated by clearing of land and was evaluated separately from C&D debris. The study estimated that approximately 535,000 tons (485,000 metric tons) of green waste material would be generated from the military relocation and 100% is potentially divertable. The study divided the green waste material into a "woody material" category and a "leafy material" category. The woody material could be chipped to create mulch for onsite use at construction sites and the leafy material could be composted. Untreated and unpainted wood generated during construction activities could also be mulched; however, procedures would need to be developed to assure that treated wood generated during demolition activities be diverted and disposed separately at the hardfill portion of the Navy Sanitary Landfill. The Navy is currently preparing a C&D Waste Management Plan that will define procedures for keeping these and waste streams separate.

The major findings of the study were:

- Based on the characteristics of the projected C&D debris generated by the military relocation construction projects, diverting concrete without lead-based paint, untreated wood, asphalt concrete, cardboard, and scrap metal would achieve the DoD goal of a minimum of 50% diversion of C&D debris by the end of fiscal year 2015.
- Diversion goals could be achieved by having DoD contractors continue to process all C&D debris and DoD establishing a composting facility to process the leafy material portion of the green waste.
- GEPA would require contractors to obtain an Air Pollution Control Permit and Solid Waste Facility Permit for processing to crush concrete at construction sites or at processing facilities.
- DoD intends to construct a central processing facility to process and temporarily store C&D debris until it can be reused, recycled, or otherwise disposed. A permit from GEPA would be required to operate this type of facility.

- C&D debris that could not be diverted would be disposed of in the hardfill located at the Navy Sanitary Landfill at Apra Harbor. This debris would include any C&D debris containing asbestos since the Navy Sanitary Landfill is approved to accept this type of waste.

Table 2.4-4. Projected Solid Waste Generation Rates for the Military Relocation and Civilian Guam Population (by year)

Year	*DoD Related Solid Waste (tons/year)* [a,b]	*Guam General Population Solid Waste (ton/year)* [c,d]	*Total Solid Waste (tons/year)* [e]	*Total Solid Waste (CY/year)*	*Cumulative Total Solid Waste (CY)*
2011	46,967	176,417	223,383	372,306	372,306
2012	60,648	178,685	239,333	398,888	771,194
2013	66,079	180,920	246,999	411,665	1,182,859
2014 [f]	85,201	183,124	268,325	447,209	1,630,068
2015	66,929	185,302	252,231	420,385	2,050,453
2016	44,767	187,460	232,226	387,044	2,437,497
2017	36,588	189,595	226,183	376,971	2,814,468
2018	36,588	191,701	228,288	380,481	3,194,949
2019	37,245	193,775	231,020	385,034	3,579,983
2020	82,347	195,713	278,060	463,434	4,043,417
2021	82,347	197,670	280,017	466,696	4,510,113
2022	82,347	199,647	281,994	469,990	4,980,103
2023	82,347	201,643	283,991	473,318	5,453,421
2024	82,347	203,660	286,007	476,678	5,930,099
2025	82,347	205,696	288,044	480,073	6,410,172
2026	82,347	207,753	290,101	483,501	6,893,673
2027	82,347	209,831	292,178	486,964	7,380,637
2028	82,347	211,929	294,276	490,461	7,871,098
2029	82,347	214,048	296,396	493,993	8,365,091
2030	82,347	216,189	298,536	497,560	8,862,651
2031	82,347	218,351	300,698	501,164	9,363,815
2032	82,347	220,534	302,882	504,803	9,868,617
2033	82,347	222,740	305,087	508,478	10,377,096
2034	82,347	224,967	307,314	512,191	10,889,286
2035	82,347	227,217	309,564	515,940	11,405,227
2036	82,347	229,489	311,836	519,727	11,924,954
2037	82,347	231,784	314,131	523,552	12,448,505
2038	82,347	234,101	316,449	527,415	12,975,920
2039	82,347	236,442	318,790	531,317	13,507,237
2040	82,347	238,807	321,154	535,257	14,042,494
2041	82,347	241,195	323,542	539,237	14,581,732
2042	82,347	243,607	325,954	543,257	15,124,989
2043	82,347	246,043	328,390	547,317	15,672,307
2044 [7]	82,347	248,503	330,851	551,418	16,223,725

Notes:
[a] Assumes DoD waste generation of 7.4 lbs/per person/per day.
[b] Assumes DoD population after 2019 is constant.
[c] Assumes general population generation of 5.28 lbs/per person/per day.
[d] Assumes general population growth after 2019 increases at 1% per year.
[e] Assumes solid waste density of 1,200 lbs per cubic yard.
[f] 2014 indicates the year which Layon Landfill Cells 1 and 2 would reach capacity.
[7] 2044 indicates the year which the Layon Landfill would reach total capacity.
Legend: CY = cubic yards; DoD = Department of Defense.

Table 2.4-5. Projected Diversion of C&D Debris and Green Waste Generation, All DoD Bases

Material	*Estimated Volume (CY)*	*Estimated Weight (Tons)*	*Recyclable*	*Maximum Estimated Potentially Divertable Weight (Tons)*	*Maximum Estimated % Potentially Divertable (by Weight)*
Construction Debris					
Wood (untreated)	146,445	69,195	Yes	69,195	15%
Gypsum Board	57,998	39,540	No	0	0%
Scrap Metal	14,278	4,284	Yes	4,284	1%
Plastics	3,630	4,284	No	0	0%
Cardboard	659,003	16,475	Yes	16,475	4%
Miscellaneous	192,758	38,552	No	0	0%
Total Construction Debris	**1,074,112**	**172,330**		**89,954**	
Demolition Debris					
Concrete w/LBP	3,200	6,479	No	0	0%
Concrete w/o LBP	107,077	216,831	Yes	216,831	46%
Asphalt concrete	49,837	59,804	Yes	59,804	13%
Glass	132	280	Yes	280	0%
Wood (treated)	2,248	1,062	No	0	0%
Scrap Metal	7,804	8,427	Yes	8,427	2%
PVC	750	879	No	0	0%
VCP	17,008	597	Yes	597	0%
Gypsum Board	911	621	No	0	0%
Porcelain Plumbing Fixtures	185	94	No	0	0%
Miscellaneous	9,543	1,909	No	0	0%
Total Demolition Debris	**198,695**	**296,983**		**285,939**	
TOTAL C&D DEBRIS		**469,313**		**375,893**	**80%**
Green Waste					
Woody Material	453,069	113,267	Yes	113,267	21%
Leafy Material	3,322,505	415,313	Yes	415,313	78%
Grass	31,700	6,404	Yes	6,404	1%
Total Green Waste	**3,807,274**	**534,984**		**534,984**	**100%**

Note: Concrete w/LBP contains a concentration of lead above the USEPA LBP criterion of 0.5% lead by weight, concrete w/o LBP may contain lead in concentrations below 0.5%.
Legend: C&D = Construction and Demolition; CY = cubic yards; LBP = lead-based paint; PVC = polyvinyl chloride; USEPA = United States Environmental Protection Agency; VCP = vitrified clay pipe.

2.4.5.3 Integrated Solid Waste Management Plan

The DoD is in the process of preparing an Integrated Solid Waste Management Plan (ISWMP) for Joint Region Marianas, which incorporates all DoD services on Guam (including the New Marine Corps Base Guam and its facilities and activities). The ISWMP will reflect how solid wastes will be managed now and in the future. The ISWMP will include any new information from studies and reports that have been conducted as part of the military relocation and will combine the existing solid waste plans for Naval Complex Guam and Andersen AFB.

The new DoD ISWMP would potentially include discussion and analysis of existing facilities; applicable regulations and policies; source reduction; diversion; recycling and recycling facilities; solid waste and recycling diversion goals; service and construction contract requirements for solid waste; roles and responsibilities; detailed description and waste characterization of waste streams from all DoD facilities (including municipal waste, recyclables, green waste, wood, C&D debris, biological waste, asbestos containing materials, shipboard solid waste, asphalt, and special wastes); solid waste disposal facilities;

solid waste collection methods (including transfer stations); education, awareness and outreach; solid waste opportunities; and an implementation plan.

The ISWMP will comply with EO 13514 that expands upon the energy reduction and environmental requirements of EO 13423. EO 13514 states that the federal government must lead by example in safeguarding the health of the environment. To comply with EO 13514, DoD agencies shall promote pollution prevention and eliminate waste by:

- Minimizing the generation of waste and pollutants through source reduction;
- Diverting at least 50% of non-hazardous solid waste, excluding C&D materials and debris by the end of fiscal year 2015;
- Diverting at least 50% of C&D materials and debris by the end of fiscal year 2015; and
- Increasing diversion of compostable and organic material from the waste stream.

To support the ISWMP, the Navy recently completed the Final Report, Recycling and Solid Waste Diversion Study for DoD Bases, Guam (NAVFAC Pacific 2010e) that has established a diversion goal of 50%, not including C&D debris. The study recommends the following alternatives:

- DoD would construct two refuse transfer facilities, one in northern Guam and one in Southern Guam;
- DoD would implement a source separation recycling program at all facilities;
- DoD would construct recycling center(s); and
- DoD would construct a materials resource recovery facility.

In order to complete the recycling study, waste characterization data from Marine Corps Base (MCB) Hawaii were utilized. Due to the lack of solid waste characterization data for military installations on Guam, it was assumed that the solid waste characterization for MCB Hawaii would best represent the solid waste characteristics for military installations on Guam. Solid waste generation activities for a military installation on Guam and MCB Hawaii are similar. Both military installations have similar facilities including maintenance shops, administrative officers, commissary and exchange facilities, fast-food establishments, club operations, family housing, and unaccompanied personnel housing.

The results of the solid waste characterization were originally presented in the Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation (NAVFAC Pacific 2008). The waste characterization provides a breakdown of solid waste into major categories (aluminum cans, glass, ferrous and non-ferrous metals, newspaper, mixed paper, office paper, cardboard, plastics, compostable material, wood pallets, and miscellaneous waste) as well as residential and commercial/industrial categories.

The percentages observed at MCB Hawaii were then applied to the anticipated waste stream for Guam DoD facilities. Table 2.4-6 provides a breakdown of the anticipated waste stream from the military relocation. Regularly occurring construction waste for small projects not related to the military relocation are also included in Table 2.4-6 as a separate category. Given this waste characterization, if 100% of the recyclables from the residential/commercial/industrial waste streams are recovered, only 46.7% diversion would be achieved. While the estimated 46.7% does not meet the EO 13514 diversion goal of 50%, MCB Hawaii's waste characterization study indicated miscellaneous waste accounted for 53.3% of the solid waste stream. It is believed that miscellaneous waste contains additional recyclable materials. The MCB Hawaii's waste characterization study indicated that miscellaneous waste included material that was not segregated from solid waste during sorting. The miscellaneous waste category included discarded items such as clothing, shoes, small appliances, small furniture, and carpet. If an additional 3.3% of the 53.3% miscellaneous waste contains recyclable materials, the diversion goal can be met.

Table 2.4-6. Projected Average Daily Solid Waste Quantities and Composition, Total

	Residential		*Commercial/ Industrial*		*Composite*	
Per Capita Waste Generation (lbs/day)						7.4
2009 Military Population						15,080
Total Weight (lbs/day)						111,592
Projected Military Population						45,954
Total Projected Weight (lbs/day)						295,852
Residential/Commercial/Industrial Waste						
Percent of Total		19.7		42.6		
Total 2009 Computed Weight (lbs/day)		21,984		47,538		69,522
Total Projected Weight (lbs/day)		58,283		126,033		184,316
Composition	percent	lbs/day	percent	lbs/day	percent	lbs/day
Aluminum Cans	3.4	1,981.6	1.2	1,512.4	1.9	3,494.0
Glass (Brown)	4.0	2,331.3	0.5	630.2	1.6	2,961.5
Glass (Clear)	3.0	1,748.5	1.8	2,268.6	2.2	4,017.1
Glass (Green)	0.8	466.3	0.2	252.1	0.4	718.3
Ferrous Metals	0.8	466.3	5.0	6,301.6	3.7	6,767.9
Non-Ferrous Metals	1.4	816.0	1.4	1,764.5	1.4	2,580.4
Newspaper	1.3	757.7	0.9	1,134.3	1.0	1,892.0
Mixed Paper	1.9	1,107.4	4.0	5,041.3	3.3	6,148.7
Office Paper	0.3	174.8	3.0	3,781.0	2.1	3,955.8
Cardboard	6.6	3,846.7	2.3	2,898.8	3.7	6,745.4
Plastics	1.7	990.8	1.2	1,512.4	1.4	2,503.2
Compostable Material	6.2	3,613.5	15.7	19,787.2	12.7	23,400.7
Wood Pallets	11.3	6,586.0	11.3	14,241.7	11.3	20,827.7
Miscellaneous Waste	57.3	33,396.1	51.5	64,907.0	53.3	98,303.1
Total Collected Waste	100.0	58,282.9	100.0	126,033.0	100.0	184,315.8
Construction Waste						
Percent of Total						37.7
2009 Total Weight (lbs/day)						42,070
Total Projected Weight (lbs/day)						111,536

Legend: lbs/day = pounds per day.

Solid waste such as corrugated cardboard, green waste, construction waste, wooden pallets, junk vehicles, white goods, C&D debris, polychlorinated biphenyl wastes, petroleum contaminated soil, electronic wastes, used motor oil, and batteries would either be recycled or handled in accordance with Navy's existing Standard Operating Procedures for these types of waste. Management of hazardous wastes is discussed in Chapter 18 of this Volume.

DoD may construct and/or utilize non-DoD transfer stations to allow consolidation of solid waste before it is hauled to Layon Landfill. In general, transfer facilities consolidate waste from multiple collection vehicles into larger, high-volume transfer vehicles for more economical delivery to distant disposal sites. Typically, local waste collection vehicles deposit solid waste in a designated receiving area within the transfer facility. Waste is often compacted while being loaded into larger transfer vehicles. The transfer vehicles are used to transport the waste to the landfill for disposal. No long-term storage of waste occurs at a transfer station; waste is consolidated quickly and removed from the site. Transfer stations would require approval and permitting through GEPA prior to startup. Transfer stations also provide convenience to self-haulers who can dispose of solid waste at the transfer station rather than having to haul waste to Layon Landfill.

2.5 Off Base Roadways

2.5.1 Introduction

This section provides a detailed description of the proposed action and alternatives comprising the off base roadway improvements that would support the relocation of the Marine Corps to Guam, transient berthing of nuclear carriers at Apra Harbor, and placement of an Army AMDTF on the island. This section had been prepared by Federal Highway Administration (FHWA). On base roadway improvements are described in the individual volumes for each proposed action.

The proposed off base roadway improvements are collectively referred to as the GRN, a related action to the relocation activity. The GRN also includes road projects that address organic growth on Guam without the military relocation (for analysis under the no-action alternative). The road projects for Tinian are discussed in Volume 3 and the access road impacts at Polaris Point for the proposed aircraft carrier action is covered in Volume 2.

2.5.1.1 Project Background

In response to the island's ongoing roadway problems, the 2030 Guam Transportation Plan (GDPW 2008) has programmed projects to address many of the immediate needs of Guam that have not been addressed in many years. The planned military relocation would include relocation of approximately 8,600 military personnel and 9,000 dependents from Okinawa, Japan; improvements to pier/waterfront infrastructure to support transient nuclear aircraft carriers on the island; and placement of an AMDTF on Guam, as well as related construction activities required to support these relocations. Troops would begin relocating to Guam in 2011; relocation would be complete by 2014. Military relocation activities related to military facility construction would occur from 2011 through 2017, with peak construction and population in 2014. Road construction to support the military relocation would also need to commence in 2011 and extend beyond 2017.

The existing traffic volumes, physical conditions, and designs of Guam's roads vary widely. As a result of the military relocation on the island, traffic volumes and congestion levels are anticipated to reach unacceptable levels. Military-related traffic would add to the congestion levels, worsening already poor conditions. In addition, the structural integrity of the roads and bridges would be compromised as a result of the increased number and weight of trucks.

The following subsections explain the need for the proposed action.

2.5.1.2 Roadway and Bridge Strength

The island of Guam has roadways and bridges with inadequate load capacity. An evaluation of background traffic loading and pavement condition of the existing roadways on Guam was conducted to identify the improvements that would be required to support the increased loading that is projected in the future (Parsons Brinkerhoff 2008). The increased traffic and specifically the volume of truck traffic, especially during the construction period, have been assessed relative to the impact on the integrity of the existing roadway infrastructure (pavement and bridges). A summary of the heavy military vehicle use that would occur is provided in Table 2.5-1.

Table 2.5-1. Travel Projections for Heavy Military Vehicles

Typical Military Heavy Vehicles	*Max. Weight (lb)*	*Designated Route*	*Frequency (movements)* [a]
MK48/16/870 With a D-7	122,775	Apra Harbor to Andersen AFB (Routes 1, 3, and 9 or Routes 1, 8, 16, and 1 or Routes 1, 8, 10, and 15)	4 – 6 times per year
		Apra Harbor to Andersen South (Route 1 or Routes 1, 8, 10, and 15)	
		Apra Harbor to NCTS Finegayan (Routes 1 and 3 or Routes 1, 8, 16, 1, and 3)	
		Apra Harbor to Naval Munitions Site (Routes 1, 2A, 5, and 12 or Routes 1, 2A, and 12)	
		NCTS Finegayan to Naval Munitions Site AFB South (Routes 3, 1, 2A, 5, and 12)	
MK48/15 Wrecker towing another MK48/15 Wrecker	121,752	Apra Harbor to Andersen AFB (Routes 1, 3, and 9 or Routes 1, 8, 16, and 1 or Routes 1, 8, 10, and 15)	8 – 10 times per year
		Apra Harbor to Andersen South (Route 1 or Routes 1, 8, 10, and 15)	
		Apra Harbor to NCTS Finegayan (Routes 1 and 3 or Routes 1, 8, 16, 1, and 3)	
		Apra Harbor to Naval Munitions Site (Routes 1, 2A, 5, and 12 or Routes 1, 2A, and 12)	
		NCTS Finegayan to Naval Munitions Site AFB South (Routes 3, 1, 2A, 5, and 12)	
MK48/18A1 With an ISO container	87,082	Apra Harbor to Andersen AFB (Routes 1, 3, and 9 or Routes 1, 8, 16, and 1 or Routes 1, 8, 10, and 15)	2 – 3 times per month
		Apra Harbor to Andersen South (Route 1 or Routes 1, 8, 10, and 15)	
		Apra Harbor to NCTS Finegayan (Routes 1 and 3 or Routes 1, 8, 16, 1, and 3)	
		Apra Harbor to Naval Munitions Site (Routes 1, 2A, 5, and 12 or Routes 1, 2A, and 12)	
		NCTS Finegayan to Naval Munitions Site AFB South (Routes 3, 1, 2A, 5, and 12)	
MK31/970 MTVR/Semi-Refueler	94,302	Apra Harbor to Andersen AFB (Routes 1, 3, and 9 or Routes 1, 8, 16, and 1 or Routes 1, 8, 10, and 15)	TBD
		Apra Harbor to Andersen South (Route 1 or Routes 1, 8, 10, and 15)	
		Apra Harbor to NCTS Finegayan (Routes 1 and 3 or Routes 1, 8, 16, 1, and 3)	
		Apra Harbor to Naval Munitions Site (Routes 1, 2A, 5, and 12 or Routes 1, 2A, and 12)	
		NCTS Finegayan to Naval Munitions Site AFB South (Routes 3, 1, 2A, 5, and 12)	
MTVR/EET trailer with a Back-hoe	87,441	Apra Harbor to Andersen AFB (Routes 1, 3, and 9 or Routes 1, 8, 16, and 1 or Routes 1, 8, 10, and 15)	TBD
		Apra Harbor to Andersen South (Route 1 or Routes 1, 8, 10, and 15)	
		Apra Harbor to NCTS Finegayan (Routes 1 and 3 or Routes 1, 8, 16, 1, and 3)	
		Apra Harbor to Naval Munitions Site (Routes 1, 2A, 5, and 12 or Routes 1, 2A, and 12)	
		NCTS Finegayan to Naval Munitions Site AFB South (Routes 3, 1, 2A, 5, and 12)	

Typical Military Heavy Vehicles	*Max. Weight (lb)*	*Designated Route*	*Frequency (move-ments)* [a]
MK36 Wrecker towing another MK36 Wrecker	98,758	Apra Harbor to Andersen AFB (Routes 1, 3, and 9 or Routes 1, 8, 16, and 1 or Routes 1, 8, 10, and 15)	TBD
		Apra Harbor to Andersen South (Route 1 or Routes 1, 8, 10, and 15)	
		Apra Harbor to NCTS Finegayan (Routes 1 and 3 or Routes 1, 8, 16, 1, and 3)	
		Apra Harbor to Naval Munitions Site (Routes 1, 2A, 5, and 12 or Routes 1, 2A, and 12)	
		NCTS Finegayan to Naval Munitions Site AFB South (Routes 3, 1, 2A, 5, and 12)	

Note:
[a] Frequency is based on normal situations and peace time in Garrison. Due to JCS, PACOM, MARFORPAC, III MEF Directed and Other Contingency Operations (OCO) movements may increase.
Legend: AFB = Air Force Base; EET = Energy Efficient Transport; ISO = International Organization for Standardization; lb = pound; MTVR = Medium Tactical Vehicle Replacement; NCTS = Naval Computer and Telecommunications Station; TBD = To Be Determined.
Source: Marine Corps 2009.

A pavement analysis was conducted to systematically identify and quantify the structural effects on Guam's roadways that would result from military relocation, primarily those activities associated with constructing the infrastructure to support the relocation of Marines to Guam. The pavement analysis focused on the roadways that would be used during the construction and military relocation period. The pavement analysis included the following elements:

- An evaluation of the existing pavement (i.e., measuring pavement depth to determine structural properties)
- Calculations of truck loading on roadways connecting the Port of Guam to the Finegayan area, Andersen AFB, and rock quarries on the east side of the island
- A determination of the design thickness of the pavement
- Prioritization of projects based on planned construction-loading activities
- Determinations of constructability and the availability of materials for road and military construction

A functional evaluation of the pavement found that the overall condition of the pavement is very good, requiring only preventive maintenance (e.g., surface seal) under current traffic conditions; however, the structural pavement analysis found that the existing pavement is sound but not structurally adequate, the depth of the pavement base and subbase is inconsistent throughout the study area, and existing drainage is inadequate, with substantial areas where water flows over the roadway rather than through drainage structures. Flooding of roadways on Guam occurs primarily along Route 1. Inadequate drainage systems and structures can cause weakening of the base and subbase and premature failure of the pavement, and can be hazardous to the traveling public. As part of the pavement analysis, equivalent single-axle loading for trucks was calculated to determine projected future truck traffic.

The condition of 10 bridges within Guam's transportation network was also evaluated. The locations of bridges on Guam are shown in Figure 2.5-1. These bridges would be essential to the construction and operational activities associated with the military relocation. The bridges were evaluated to determine structural adequacy for military and construction traffic before, during, and after redeployment (Table 2.5-2).

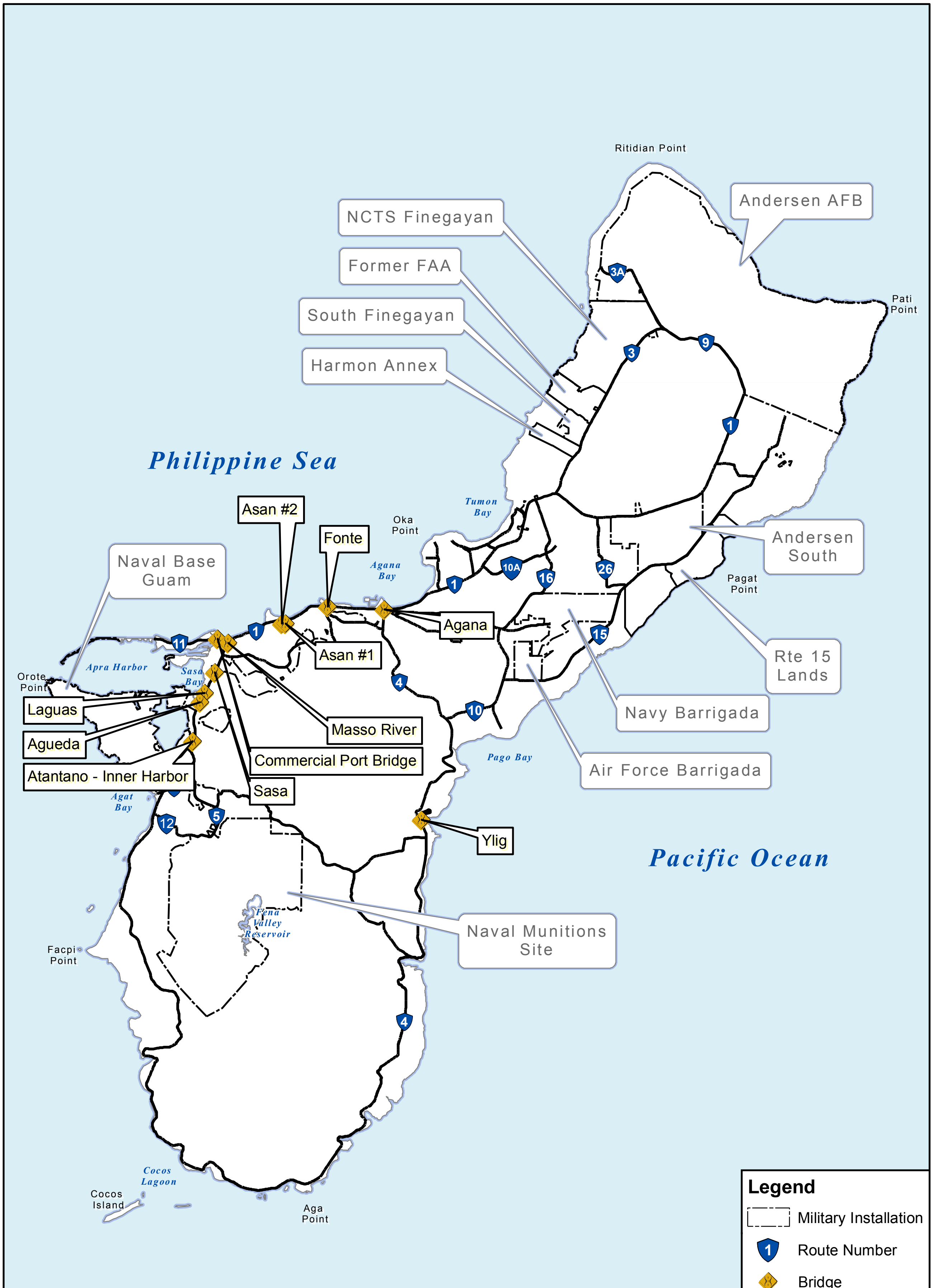

Figure 2.5-1
Bridges on Guam

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Table 2.5-2. Structural Data for Bridges on Guam

Route	*Structure*	*Year Built*	*Rating Factors**
1	Atantano Bridge	1970	0.68
1	Agueda Bridge	1987	0.48
1	Laguas Bridge	1985	0.81
1	Sasa Bridge	1985	0.62
1	Masso Bridge	1980	1.00
1	Asan Bridge #2	1985	0.67
1	Asan Bridge #1	1983	0.32
1	Fonte Bridge	1982	0.69
1	Agana Bridge #1	1945	0.32

Notes: * Rating Factors based on 2009 Guam Department of Public Works/Federal Highway Administration bridge inspection reports. Rating Factors shown are lowest from all the military vehicles.

The analysis found that Agana Bridge #1 has an insufficient rating factor and would not be able to support the proposed loadings associated with the hauling of construction materials and equipment. (The rating factor represents the live load capacity to demand ratio) For this reason, replacement of this bridge would be required. Six other bridges (Fonte, Asan #1, Asan #2, Sasa, Agueda, and Atantano) have rating factors below the appropriate load-bearing capacities for many of the military vehicles and require replacement. Laguas Bridge can support the military vehicles with certain restrictions and may require replacement. The structural integrity of the Commercial Port Bridge was not evaluated because it is a culvert. Unlike a culvert that also acts as a bridge, this culvert has fill on top of it and has a retaining wall that confines the roadway structure. Ylig Bridge is currently being replaced by GovGuam.

2.5.1.3 Roadway Capacity

The effect on the population of Guam during the period of peak construction and population (2014) and complete relocation of the Marines (2014) was determined. The analysis included a projection of the number of construction-related trucks and other traffic that would use roads connecting the Port of Guam to the Finegayan area, Barrigada area, Andersen AFB, and rock quarries on the island.

A traffic model was created to evaluate the need for additional traffic lanes (roadway widening) that would be required for the project. The traffic study found that traffic would double along segments of three primary routes: Route 3 (Route 28 to NCTS Finegayan), Route 3 (NCTS Finegayan to Route 9), and Route 9 (Route 3 to Andersen AFB North Gate). Certain roadways on Guam would lack sufficient capacity to handle the increased traffic load.

2.5.1.4 Roadway Access

To support the movement of cargo across the island and avoid normally congested corridors, new options for truck routes and access points are needed. A preferred truck route was identified (Routes 1, 3, 8, 9, 11, 16, and 27) for cargo being hauled from the Port of Guam to the northern part of the island. The route from the quarry was identified to include Route 15 and Chalan Lujuna. These preferred routes are shown in Figure 2.5-2. Preliminary transportation studies have identified individual projects to provide new intersections that would serve as MAPs along existing roadways. The MAPs were identified by the military and are for commercial and/or residential access.

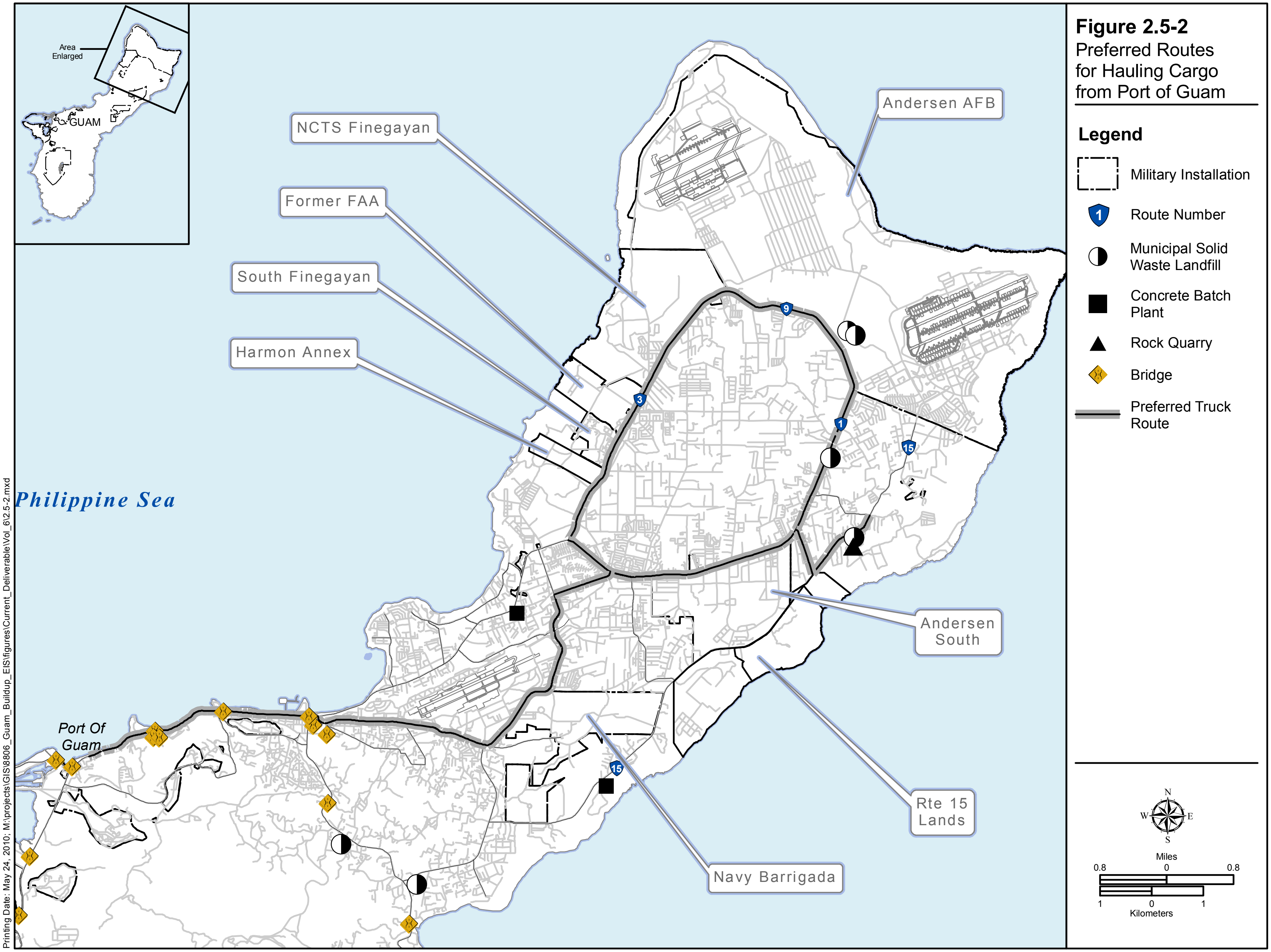


Figure 2.5-2
Preferred Routes for Hauling Cargo from Port of Guam

2.5.1.5 Mass Transit

The traffic projections developed by the GDPW show that congestion levels in both the short term and the long term would result in substantial delays, as measured by the ratio of traffic volume to roadway capacity. Analysis indicated that it is unlikely that sufficient additional roadways or traffic lanes could be built to completely eliminate traffic congestion. Mass transit would help address this need. Existing mass transit routes and service areas are depicted in Figure 2.5-3.

As part of the 2030 Guam Transportation Plan (GDPW 2008), a new Core Bus System has been proposed to help support islandwide mobility during the 2010-2014 time period. Although most construction worker housing areas would be expected to include vans or buses to and from the work sites, the Core Bus System is expected to be operational by 2012. The new system is designed to connect major employment and population centers. The system consists of five new fixed routes. All major military facilities that house workers or are major employment destination points would be connected by this new system. The Dededo area (near NCTS Finegayan) would be especially well served because it is one of the major population centers; by 2030 it would experience a 50% increase in population. Projections show that ridership has the potential to reach 1.32 million annual trips.

The Core Bus System would also provide direct service between the Naval Base and Tumon Bay, which is the major tourist area on the island. A total of 50 buses are needed to operate this service, and GovGuam is pursuing a Federal Transit Administration Section 5309 discretionary grant to fund the acquisition of these vehicles. The proposed mass transit fixed-route network is depicted in Figure 2.5-4 and Figure 2.5-5.

2.5.1.6 Safety

Transportation safety on Guam is managed by the GDPW Office of Highway Safety which is funded through the National Highway Traffic Safety Administration to provide leadership by: developing, promoting, and coordinating programs; influencing public and private policies; and, increasing public awareness of highway safety. Highway safety means the reduction of traffic crashes, deaths, injuries, and property damage resulting on Guam’s highways.

With the impact of the island’s roadway expansion, the GDPW would be responsible for increasing enforcement activities and public awareness campaigns for highway safety. Outreach programs would continue and expand to educate the public on important laws pertaining to highway safety. Educational efforts would focus on: the dangers of driving under the influence, using cell phones and texting; use of seatbelts, safe bicycling; and, pedestrian educational training on crosswalks.

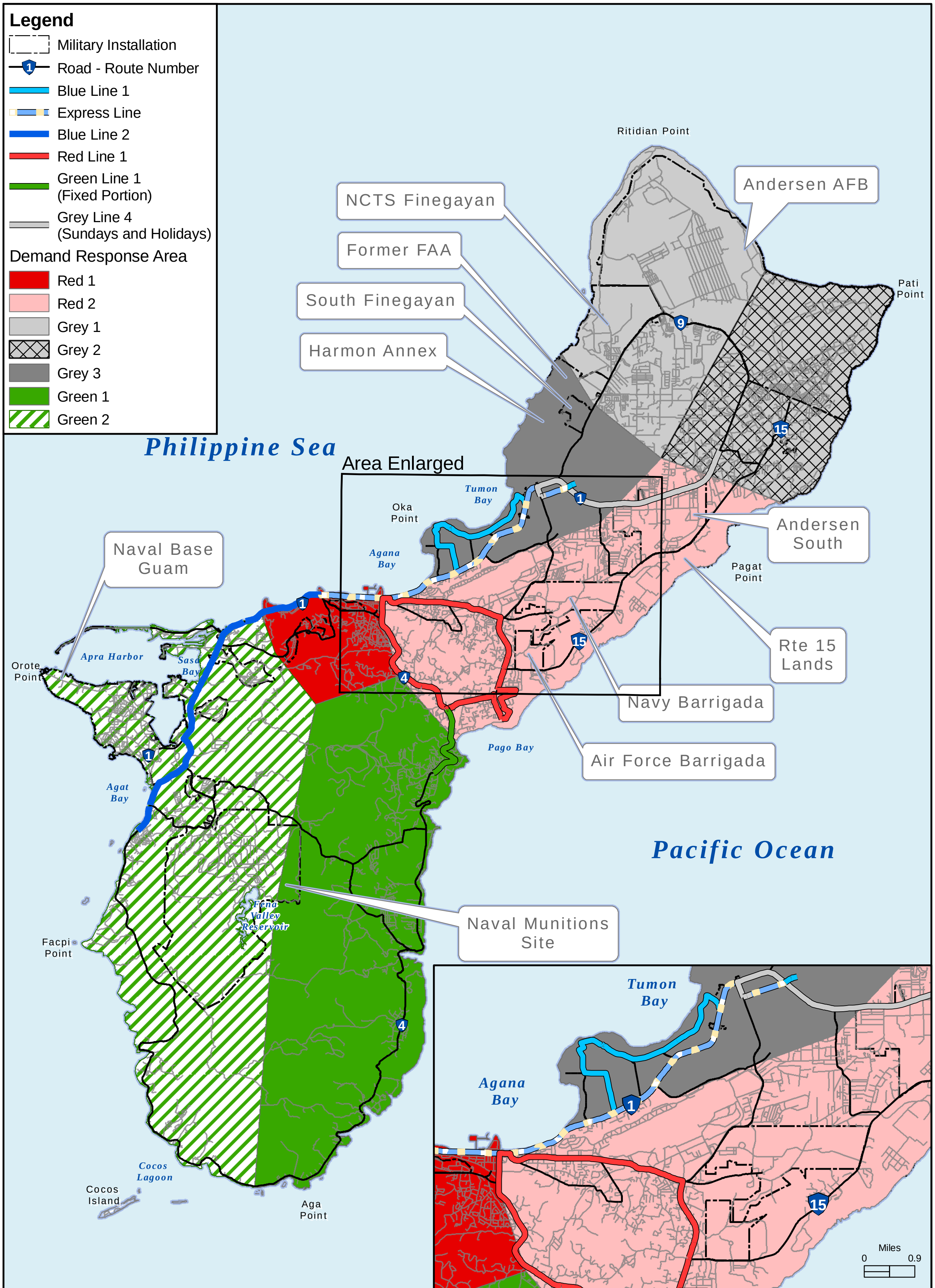


Figure 2.5-3
Existing Mass Transit Network and Demand Service Areas on Guam

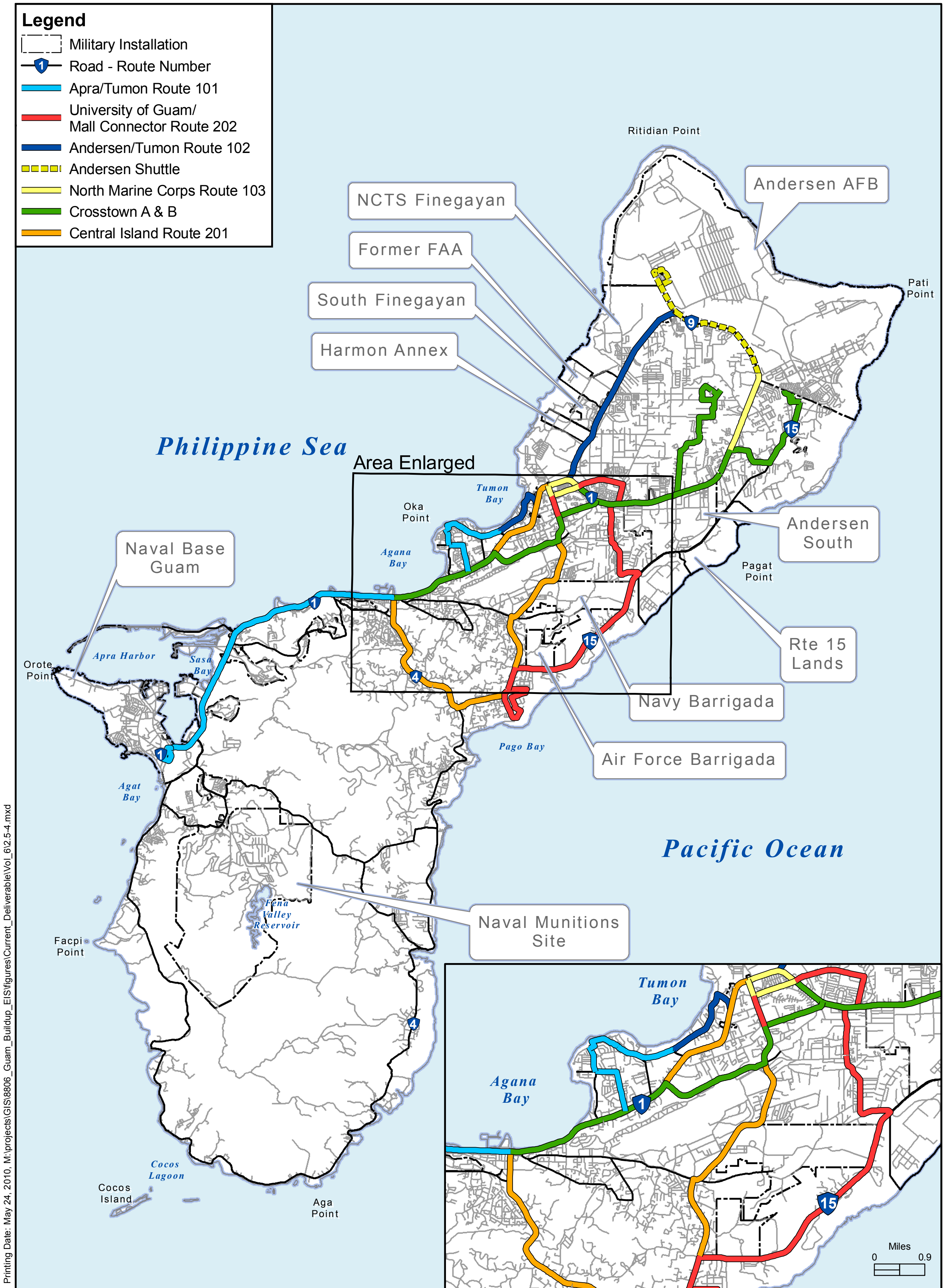
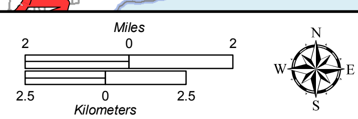


Figure 2.5-4
Proposed Mass Transit Network on Guam



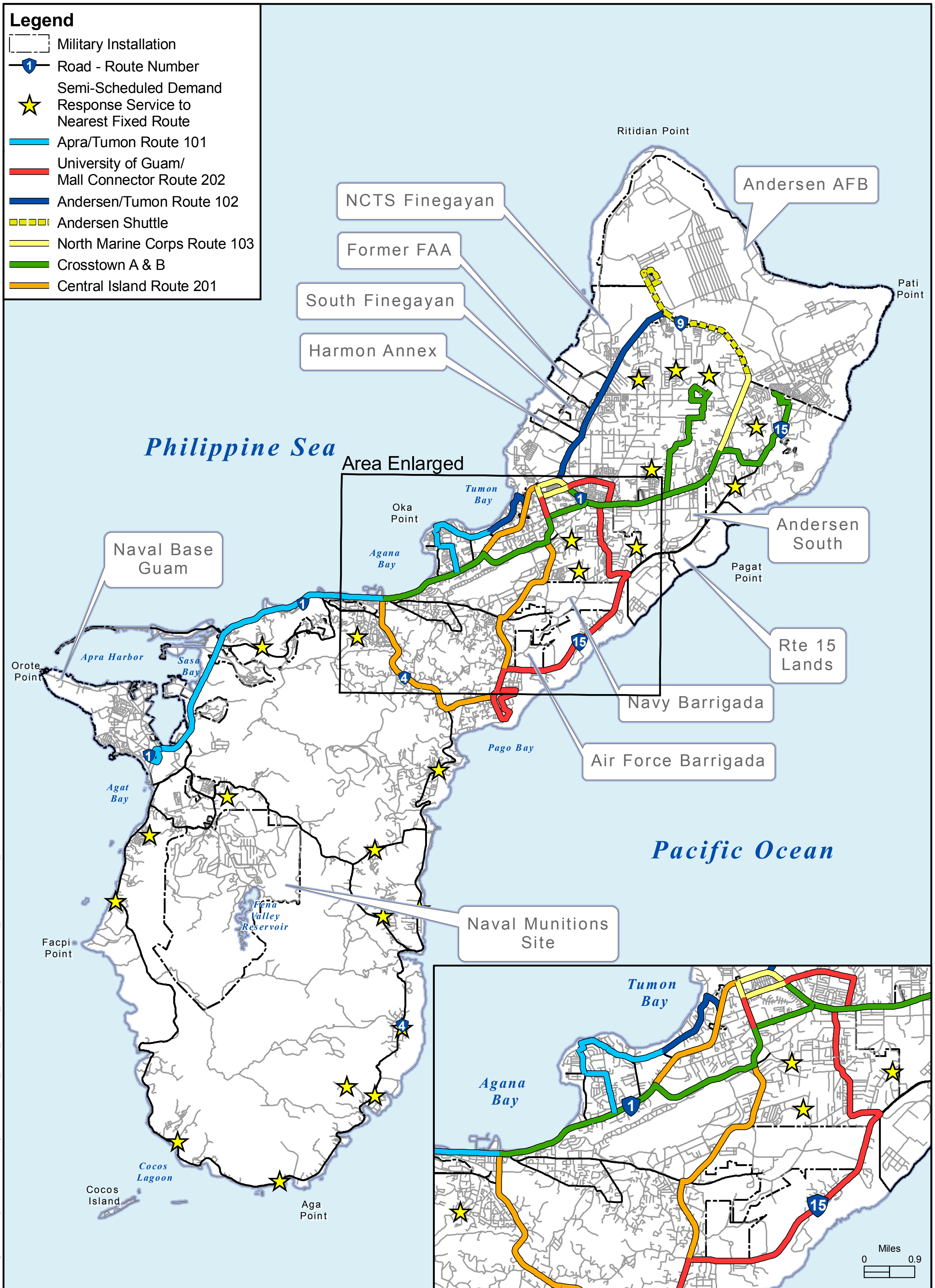


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Figure 2.5-5
Mass Transit Network on Guam

Miles 2 0 2
Kilometers 2.5 0 2.5
N S E W

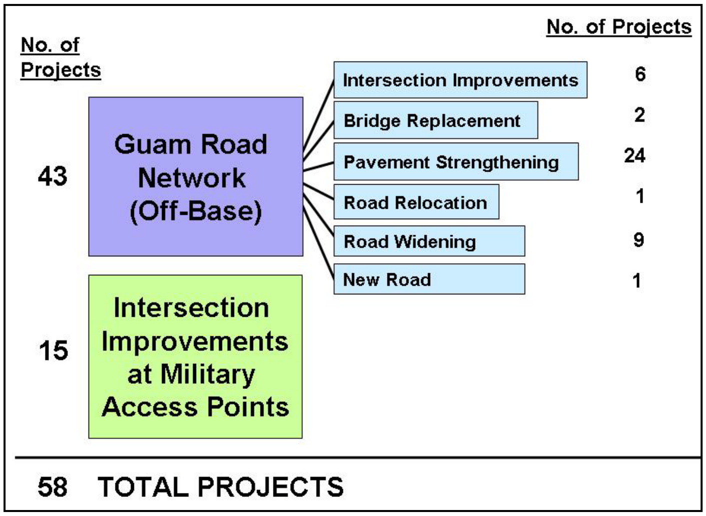
The 2030 Guam Transportation Plan (GDPW 2008) recommends that traffic information and data management systems are completely overhauled and upgraded with computerized systems and equipment. To provide efficient and safe access to military lands during the construction of relocation facilities, the proposed Guam road improvements would be designed in accordance with standards that would improve traffic safety. The Safe, Accountable, Flexible, Efficient Transportation Equity Act: A Legacy for Users (23 U.S. Code 148) identifies key objectives of the core highway safety improvement plan. The GDPW is in the process of identifying hazardous traffic locations on the island and implementing safety on island roadways. The Guam Territorial Transportation Improvement Program (GovGuam 2009) contains 16 hazard elimination projects. Six of these projects are site-specific:

- Route 4, Jeff's Pirate Cove
- Route 14 Resurfacing
- Route 1 Pedestrian Safety Fence at John F. Kennedy High School
- Route 1 John F. Kennedy Pedestrian Underpass/Overpass
- Route 15 Santa Rosa Yigo, Road Hardening
- Route 1 Deadman's Curve
- The remaining 10 projects are islandwide:
- School zone signs
- Village road safety signs (newly paved local roads) and regulatory/warning signs
- Seashore protection
- Highway hazard elimination project
- Pavement markers for primary roads and Phase I markings replacement
- Construction for safety improvements
- Route sign installation
- Anti-skid surfacing and traffic signalization
- Skid-resistant surfacing and guardrails for Route 4 in Yona
- Highway barrier and rail rehabilitation

Hazard elimination projects on Route 1 (Jeff's Pirate Cove) and Route 4 (Deadman's Curve) are the only two specific location projects that have been funded. There is an existing safety hazard with key roadways on Guam and a need for safety improvements.

2.5.1.7 Proposed Action

The proposed action would enable and improve roadway connectivity, capacity, and pavement strength for military construction and deployment in support of the relocation. Logistical routes for construction-related transport would connect the Port of Guam with Navy and Air Force bases, the Finegayan area, the Naval Munitions Site, concrete batch plants, rock quarries, and precast concrete panel fabrication sites associated with the military relocation on the island. In addition to improvements to the construction routes,



traffic associated with the presence of the military personnel and their dependents would require roadway modifications, thus the collective roadway projects are called the GRN (see overview in Figure 2.5-6).

As shown in the adjacent chart, 58 individual projects have been identified from recent transportation and traffic studies on the island of Guam. These consist of 43 GRN (off base) projects and 15 intersection improvement projects at MAPs (gates). The 43 GRN (off base) projects are composed of six types of roadway improvements:

- Intersection improvement projects
- Replacement of five bridges and replacement of box culverts at three other bridges
- Pavement strengthening (combined with roadway widening at some locations)
- Roadway relocation (Route 15)
- Roadway widening
- Construction of a new road (Finegayan Connection)

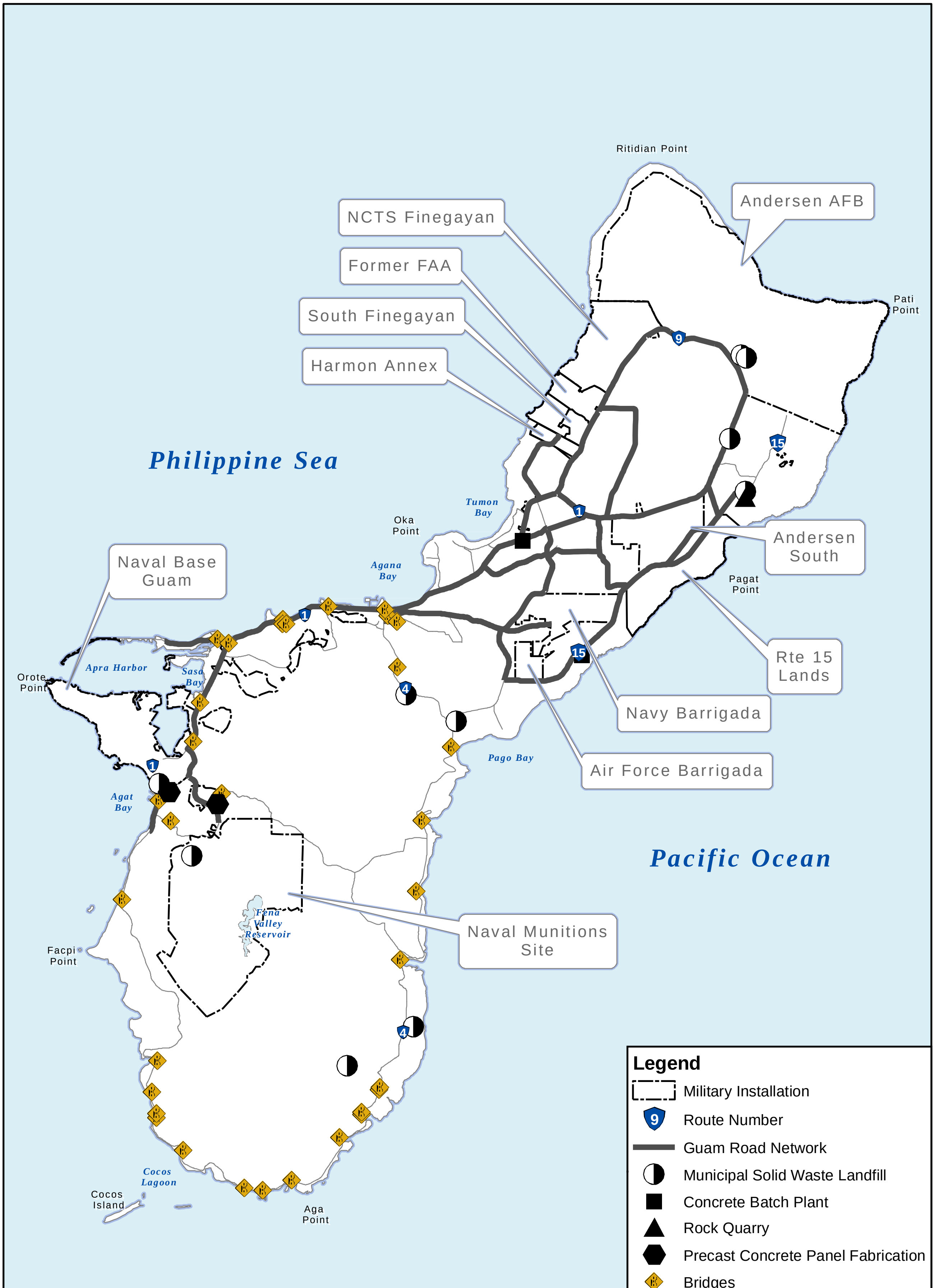


Figure 2.5-6
Overview of Guam Roads Network

Miles 0 2 4
0 3 6 Kilometers

N W E S

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These 58 projects cover four geographic regions on Guam: North, Central, Apra Harbor, and South (Figure 2.5-7). The characteristics of each of the 58 projects are summarized in Table 2.5-3 (with each project assigned a GRN number). The locations of these GRN projects are shown in Figure 2.5-8.

Table 2.5-3. Guam Road Network Projects by Island Region

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
North				
8	3	Route 28 to Route 1	13,500 (4,091)	Pavement strengthening (four lanes), including reestablishment of second southbound through lane at Okkodo High School access.
9	3	NCTS Finegayan to Route 28	11,900 (3,606)	Pavement strengthening (widen from two to four lanes), add median and shoulders. At the Route 3/28 intersection, add an additional southbound left-turn lane and add northbound right-turn lane.
10	3	NCTS Finegayan to Route 9	4,150 (1,258)	Pavement strengthening, widen from two lanes to four lanes, add median and shoulders. At the Route 3/3A intersection, eliminate Y-intersection, provide four-legged intersection with one right-turn lane on Route 3A, and a northbound left-turn lane on Route 3.
22	9	Route 3 to Andersen AFB (North Gate)	6,300 (1,909)	Pavement strengthening (widen from two lanes to four lanes), add median and shoulders.
22A	9	Andersen AFB North Gate to Route 1 (Andersen AFB Main Gate)	9,200 (2,788)	Pavement strengthening (two lanes), add median and shoulders.
23	1	Chalan Lujuna to Route 9 (Andersen AFB)	14,250 (4,318)	Pavement strengthening (four lanes).
38	3	NCTS Finegayan (Commercial Gate)	—	MAP 2, proposed location 0.5 mile (0.8 km) west of Route 9, across from Chalan Kareta would be signalized; eastbound, left-turn lane (300 ft [91 m], combined through/right-turn lane; westbound, left-turn lane (150 ft [46 m]), combined through/right-turn lane; northbound, left-turn lane (480 ft [146 m]), through/right-turn lane; southbound, left-turn (150 ft [46 m]), through, and combined through/right-turn lane.
38A	3	NCTS Finegayan (Commercial Gate)	—	MAP 2, proposed to be a T-intersection 1,215 ft (368 m) south of Flores Para Eso St. Would be signalized; eastbound, left-turn lane (300 ft [91 m]), combined through/right-turn lane; northbound, left turn (480 ft [145 m]), through, combined through/right-turn lane; southbound, through, and combined through/right-turn lane.
39	3	NCTS Finegayan (Main Gate)	—	MAP 3, would be located at Bullard Avenue; would be signalized; eastbound, two left-turn lanes (300 ft [91 m]), free right turn with acceleration lane on Route 3; northbound, two left turns (600 ft [183 m]), two through lanes, southbound two through lanes, right-turn lane (600 ft [183 m]).

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
39A	3	NCTS Finegayan (Main Gate)	—	MAP 3, located across from signalized intersection with Route 28. Eastbound, two left-turn lanes (300 ft [91 m]), one through lane, free right turn with acceleration lane on Route 3; northbound, two left turns (600 ft [182 m]), two through lanes, and right-turn lane, southbound, two left-turn lanes, two through lanes, right-turn lane (600 ft [182 m]), westbound two left-turn lanes, through, and right-turn lane.
41	3	South Finegayan (Residential Gate)	—	MAP 5, aligned with Kamute Avenue, would be signalized; eastbound, two left-turn lanes (200 ft [61 m]), free right turn with acceleration lane on Route 3; northbound, two left turns (700 ft [213 m]), two through lanes, southbound, through and combined through right turn. A southbound left-turn lane for Kamute Avenue would also be needed (150 ft [46 m]).
41A	3	South Finegayan (Residential Gate)	—	MAP 5, located 680 ft (206 m) south of Hahasu Drive. Would be signalized; eastbound, two left-turn lanes (200 ft [61 m]), free right turn with acceleration lane on Route 3; northbound, two left turns (700 ft [212 m]), two through lanes, southbound, through and combined.
42	9	Andersen AFB (North Gate)	—	MAP 6, proposed between Routes 3 and 1 would be stop-controlled with stop for access from base; eastbound left-turn lane (600 ft [183 m]), two through lanes; westbound, one through lane and one right-turn lane (220 ft [98 m]); southbound, left-turn lane, free right-turn lane with acceleration lane (becomes second westbound through lane).
57	28	Route 1 to Route 3	21,000 (6,364)	Pavement strengthening, widen two to three lanes with shoulders. At the Route 28/27A intersection, provide northbound left-turn, through, combined through/right-turn, southbound left turn, through, and combined through/right-turn, eastbound left-turn, through, and right-turn lane.
117	15	Route 15/29 Intersection	—	Intersection improvements to signalize, additional northbound, southbound left-turn lanes, southbound right-turn lane.
124	New Road	Route 1/16 Intersection to South Finegayan	10,641 (3,225)	New two-lane road parallel to Route 3, with left-turn lanes at existing access points, with 4-ft (1.2-m) median and 4-ft (1.2-m) paved shoulders. At the Route 1/16 intersection, improve the existing at-grade intersection.
Central				
1	1	Route 1/8 Intersection	940 (285)	Intersection improvements (0.24 mile [0.24 km] on Route 1 and 0.09 mile [0.14 km] on Route 8) to provide two left-turn lanes and two right-turn lanes for northbound Route 8 approaching Route 1.
2	1	Route 1/3 Intersection	2,400 (727)	Intersection improvements (0.15 mile [0.39 km] on Route 1 and 0.04 mile [0.06 km] on Route 3) to provide southbound left, combined left/right, and free right with acceleration lane; east to north double left-turn lane.
3	1	East of Route 4	85 (26)	Agana Bridge replacement.

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
6	1	Route 27 to Chalan Lujuna	18,200 (5,515)	Pavement strengthening (four lanes). At the Route 1/28 intersection, add an additional eastbound left-turn lane, southbound Route 28 approach to include two right-turn lanes and shared left/through lane. At the Route 1/26 intersection, add an additional westbound left-turn lane, eastbound right-turn lane. Northbound Route 26 approach should include left-turn, combined left-turn/right-turn, and right-turn lane.
7	1	Route 3 to Route 27	4,600 (1,394)	Pavement strengthening (six lanes). At the Route 1/27 intersection, provide double eastbound left-turn lanes, eastbound right-turn lane, and triple westbound left-turn lanes. Northbound Route 27 approach to include left-turn, combined left-turn/through and two right-turn lanes. At the Route 1/27A intersection, add an additional eastbound left-turn lane, additional northbound Route 27A right-turn lane.
11	Chalan Lujuna	Route 1 to Route 15	4,350 (1,318)	Pavement strengthening (two lanes), safety/operational improvements.
12	15	Smith Quarry to Chalan Lujuna	6,100 (1,848)	Pavement strengthening (two lanes), safety/operational improvements.
13	1	Route 11 to Asan River	8,472 (2,567)	Pavement strengthening (four lanes).
14	1	Asan River to Route 6	6,437 (1,951)	Pavement strengthening (four lanes).
15	1	Route 6 (Adelup) to Route 4	9,100 (2,758)	Pavement strengthening (six lanes).
16	8	Tiyan Parkway/Route 33 (east) to Route 1	8,290 (2,512)	Pavement strengthening, widen from four/six lanes to six lanes with median.
17	8	Route 10 to Tiyan Parkway/Route 33 (east)	7,904 (2,395)	Pavement strengthening (four lanes).
18	16	Route 27 to Route 10A	4,505 (1,365)	Pavement strengthening (six lanes). At the Route 16/27 intersection, add an additional northbound lane, southbound left-turn lanes, change westbound right-turn to combine through/right-turn lane.
19	16	Route 10A to Sabana Barrigada Drive	5,448 (1,651)	Pavement strengthening (four lanes). At the Route 16/10A intersection, add additional northbound and southbound off-ramps to provide one left-turn, combined left-turn/through/right-turn, and right-turn lane. Restripe to provide additional westbound left-turn lane.
20	16	Sabana Barrigada Drive to Route 8/10	8,691 (2,634)	Pavement strengthening (four lanes).
21	27	Route 1 to Route 16	5,448 (1,651)	Pavement strengthening (six lanes).
28	26	Route 1 to Route 15	12,900 (3,909)	Pavement strengthening, widen from two lanes to four lanes. At the Route 26/25 intersection, provide northbound left-turn, through, through/right, southbound left-turn, two throughs, and right-turn, eastbound left-turn, left-through, and right-turn lane. Southbound right-turn should have raised island and free right to westbound Route 25 curb lane.

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
29	25	Route 16 to Route 26	8,050 (2,439)	Pavement strengthening, widen from two lanes to four lanes.
30	10	Route 15 to Routes 8 and 16	7,847 (2,378)	Pavement strengthening (four lanes)
31	8A	Route 16 to Navy Barrigada	8,865 (2,686)	Pavement strengthening (two lanes)
32	15	Route 10 to Connector (Chalan Lujuna end)	41,500 (12,576)	Pavement strengthening (two lanes). Signalize the intersection at the Route 15/26 intersection.
33	1	Route 8 to Route 3	31,647 (9,590)	Pavement strengthening (six lanes). At the Route 1/14 North San Vitores intersection, add southbound right-turn lane. At the Route 1/14A intersection, add northbound/southbound left-turn lanes, southbound right-turn lane. At the Route 1/10A intersection, add southbound left-turn lane, northbound right-turn lane. At the Route 1/14B intersection, change eastbound right-turn lane to shared right-turn/left-turn lane. At the Route 1/14 southern intersection (known as the ITC intersection), include southbound right-turn lane. At the Route 1/30 intersection, add an additional northbound left-turn lane, change existing lanes on eastbound approach to combine a left-turn/through, and two right-turn lanes.
35	1	Various	364 (110)	Replace Atantano, Laguas, Sasa, and Fonte bridges. Replace Asan #1, Asan #2 and Agueda box culverts.
36	15	Route 15 Realignment	11,200 (3,394)	Relocate Route 15 onto existing DoD land to allow firing range in vicinity.
44	1	Andersen South (Main Gate)	-	MAP 8 (Turner Street) would be signalized; westbound Route 1 left-turn lane (500 ft [152 m], restripe existing two-way left turn lane); eastbound Route 1 right-turn lane (1,000 ft [305 m]); and northbound two left-turn lanes (300 ft [91 m]) and right-turn lane.
46	15	Andersen South (Secondary Gate)	-	MAP 10, unnamed road, 1.16 miles (1.87 km) east of Route 26 would be stop-controlled with stop for access from base; eastbound Route 15 left-turn lane (250 ft [76 m]); southbound, left-turn lane (150 ft [46 m]) and right-turn lane.
47	16	Barrigada (Navy)	-	MAP 11, approximately 1,315 ft (401 m) north of northerly post office driveway. New four-lane access road connected to Route 16 as a T-intersection. Route 16/Access Road would be signalized. Northbound Route 16, two through lanes and combined through/right lane. Southbound Route 16, two left-turn lanes (one lane 425 ft [130 m], the other lane drop from third southbound through lane), and two through lanes; westbound, two left-turn lanes and free right-turn lane.
48	8A	Barrigada (Navy)	-	MAP 12, extension of north/south road from Route 16/Sabana Barrigada Drive to Route 8A with one lane in each direction.

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
49	15	Barrigada (Air Force)	—	MAP 13, new access across from Chada Street would be signalized; eastbound left-turn lane (250 ft [76 m]), combined through/right-turn lane; westbound, left-turn lane (150 ft [46 m]), combined through/right-turn lane; southbound, left-turn lane (150 ft [46 m]), combined through/right-turn lane; northbound, combined left/through/right-turn lane.
49A	15	Barrigada (Air Force)	—	MAP 13A, new access across from Chada Street would be signalized; eastbound, two left-turn lanes (500 ft [152 m]), combined through/right-turn lane; westbound, left-turn lane (150 ft [46 m]), through lane, right-turn lane (1,000 ft [305 m]); southbound, two left-turn lanes (500 ft [152 m]), combined through/right-turn lane; northbound, combined left/through/right-turn lane.
63	16	Route 10A to Sabana Barrigada Drive	5,448 (1,651)	Pavement strengthening, widening from four to six lanes, with median.
74	8A	Route 16 to Navy Barrigada	8,865 (2,686)	Pavement strengthening (two lanes), widen to provide median and shoulders.
113	7	Route 7/Route 7A	—	Intersection improvements to add signing, striping, and minor intersection construction to establish two-lane circulation around Y-intersection.
Apra Harbor				
4	11	Port to Intersection with Route 1	9,150 (2,773)	Pavement strengthening of two lanes.
5	11	Route 1/11 Intersection	1,480 (448)	Intersection improvements (0.12 mile [0.19 km] on Route 1).
24	1	Route 11 to Route 2A	16,247 (4,923)	Pavement strengthening (four lanes).
26	2A	Route 1 to Route 5	4,577 (1,387)	Pavement strengthening (four lanes)
50	1	Naval Base Guam	—	MAP 14, at existing signalized intersection of Route 1/Route 2A
South				
25	5	Route 2A to Route 17	6.379 (1,944)	Pavement strengthening (two lanes). Route 5/17 intersection. Add right-turn lane on Route 17 approaching Route 5.
27	5	Route 17 to Naval Munitions Site	3,954 (1,205)	Pavement strengthening (two lanes).
52	12	Naval Munitions Site	—	MAP 16, proposed relocation of existing access point to Harmon Road for safety/operational improvements.
110	2	Route 2/12 Intersection	—	Intersection improvements to convert northbound right-turn lane to combine a through/right-turn lane.

Legend: AFB = Air Force Base; DoD = Department of Defense; ft = foot/feet; GRN = Guam Road Network; ITC = International Trade Center; m = meter(s); MAP = Military Access Point; NCTS = Naval Computer and Telecommunications Station.

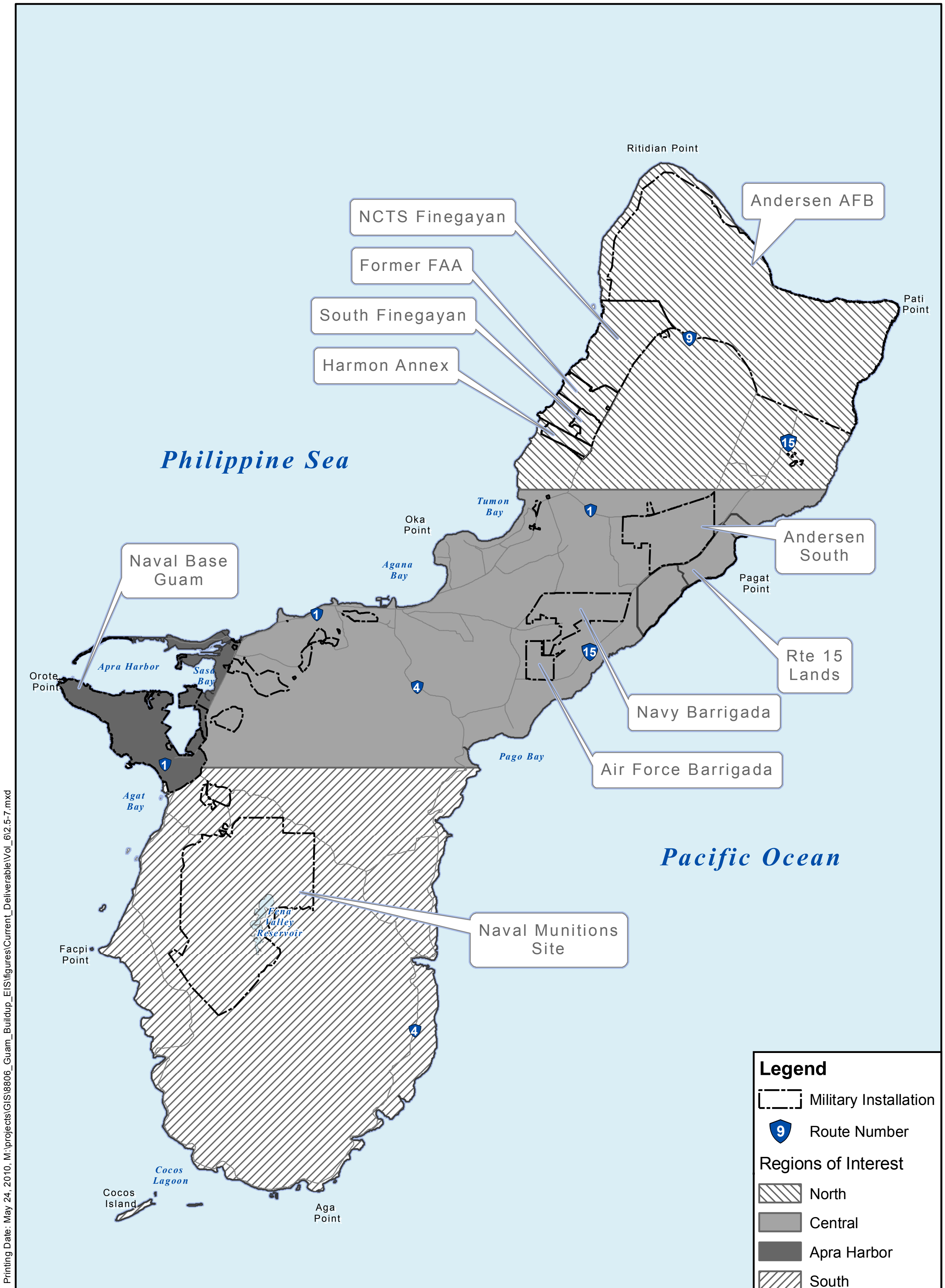

Figure 2.5-7
Geographic Regions of Guam

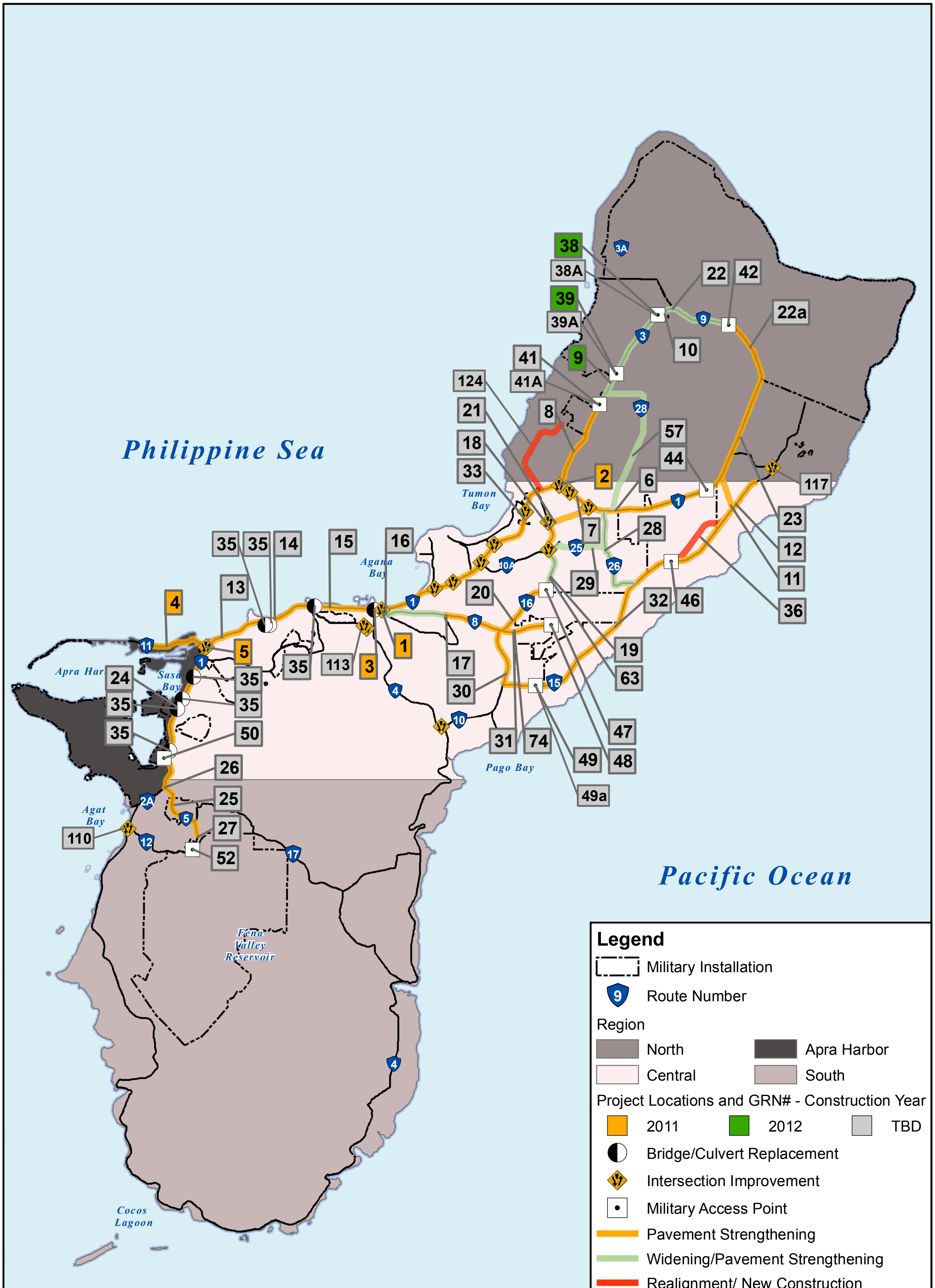

Figure 2.5-8
Guam Road Network Project Locations

Miles 0 2 4
Kilometers 0 3 6
N E S W

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Construction Schedule

To plan for construction of the GRN, islandwide traffic forecasts were prepared to define traffic associated with the increase in off-island construction workers and off-island indirect workers. Construction of the GRN may occur from 2011 to 2017 (a 7-year period pending identified funding). Table 2.5-4 identifies a preliminary schedule of the military-related GRN projects that would be initiated in the first two of seven construction years. This schedule is based on current funding of eight (8) of the total 58 GRN projects (refer to Volume 6, Chapter 1, Table 1.1-1).

Table 2.5-4 Guam Road Network Construction Projects to be Completed Each Year

Funding	*Construction Year*	*Projects to be Completed*
FY 2010	2011	1, 2, 3, 4 and 5[a]
FY 2011	2012	9, 38 and 39[b]
TBD	TBD	10, 11, 22, 35, 36, 44, 46, 52 [c]
TBD	TBD	TBD[d]

Note: Refer to Volume 6, Chapter 1, Section 1.1.4 regarding project funding, and Volume 6, Chapter 2, Figure 2.5-8 for GRN project locations.
[a] These five projects have been DAR-certified, authorized and appropriated.
[b] These three projects have been DAR-certified and are awaiting authorization and appropriation.
[c] These eight projects have been identified to be DAR-eligible. For GRN #35, replacement of box culverts at Aguda and Asan #1 will be funded by DPW.
[d] These remaining 42 GRN projects (GRN #s 6, 7, 8, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22A, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 38A, 39A, 41, 41A, 42, 47, 48, 49, 49A, 50, 57, 63, 74, 110, 113, 117, and 124) are in the process of being identified for DAR eligibility or identifying another funding source. Once funded, these projects will be scheduled into the corresponding construction year.
Legend: FY = Fiscal Year; TBD = To Be Determined.

2.5.1.8 Typical Construction Activities

Construction of the GRN would result in typical roadway and ancillary-facility construction activities at multiple locations. Typical roadway construction work is described in Table 2.5-5.

The types of construction activities might be combined in any particular project. In addition, projects would include matching existing access connections, pavement striping, and signing. As appropriate, intelligent traffic systems, modifications to comply with Americans with Disabilities Act requirements, and safety lighting may be included.

Depending on the road condition and loading, pavement strengthening may consist of one or more of the following methods:

- Full-depth reconstruction (removing the full depth of subbase, base, and asphalt pavement and replacing it with new high-quality crushed base and asphalt pavement to allow the existing and new roadway profile to remain the same).
- Full-depth reclamation and overlay (pulverizing the existing asphalt pavement and base to a depth of 8 in (20 cm) to 12 in (30 cm), followed by removal of the top 4 in (10 cm) to 6 in (15 cm) of pulverized material and stabilization of the remaining 4 in (10 cm) to 8 in (20 cm) of material by adding emulsion, cement, and other additives. A 4-in (10-cm) to 6-in (15-cm) layer of asphalt pavement is placed over the stabilized base.) This alternative provides pavement strengthening while minimizing both demand for natural resources and traffic impacts due to the fast process (roadway profile to remain the same).
- Mill and overlay (plus isolated surface preparation) could include the removal of the top inch of existing pavement and placing a 2-in (5-cm) to 6.5-in (16.5-cm) layer of asphalt. This

process is not valid for most of the routes because the pavement profile of existing curbs, gutters, or roadway approaches cannot be raised.

Table 2.5-5. Typical Construction Activities

Item	*Work Activity*	*Description*
1	Intersection Improvement (including Military Access Points)	Intersection improvements can include construction of additional turning lanes, construction of acceleration or deceleration lanes, construction of channelizing islands, installation of traffic signals and appurtenances, and/or installation of new traffic loop sensors.
2	Bridge Replacement Box Culvert Replacement	Bridge and box culvert replacements to correct structural deficiencies, increase load capacity, and comply with seismic/hydraulic requirements would be conducted in phases. The superstructure for a new bridge could consist of a cast-in-place concrete deck on precast prestressed box beams. The substructure would consist of concrete abutments founded on drilled shaft foundations. Box culverts would be replaced with new single cell or multi cell box culverts. The new 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, as required. A friction course would be applied to the bridge. The final step would be demolition 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. Pavement sections may be widened to include shoulders and would be constructed of residual material from the existing pavement rehabilitation, new material, or a combination thereof, and an asphalt overlay. Pavement strengthening may also include matching existing access connections, pavement striping, signing, intelligent traffic systems, and safety lighting. A project would match the existing horizontal and vertical alignment where practical with adjustments to roadway super elevation as required. Minor realignment of the road may be necessary to accommodate design elements.
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. Realignment would also include the construction of one or more new bridges to grade separate Route 15 and the range 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.
5	Road Widening	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. Bicycles would be accommodated in the outside shoulders of the shared roadway.
6	New Road Construction (Finegayan Connection only)	New roadway would be constructed on a new alignment with new asphalt pavement constructed on compacted base or engineered fill.

2.5.2 Alternatives Development Process

The Navy evaluated alternatives as part of the siting process to identify suitable candidate locations for consideration of primary facility components. The alternatives siting process for the Marine Corps relocation is described in Volume 2 of this EIS. As described in this evaluation, the process resulted in the selection of four alternatives (or action alternatives) that are carried forward in the analysis.

The variation among alternatives is associated with the Main Cantonment and training facility components of the proposed action. The Main Cantonment would be the main base of operations for the Marine Corps, and under two alternatives, it would also be the main base of operations for the Army AMDTF (see Volume 5). The operational components of all four alternatives are as described in Volume 2, Sections 2.3 through 2.5 of this EIS.

2.5.3 Alternatives

Each of the four alternatives was evaluated for two scenarios described below with the assumption that all 58 roadway projects would be funded and constructed. In addition, the no-action alternative was analyzed, taking into consideration only expected natural growth.

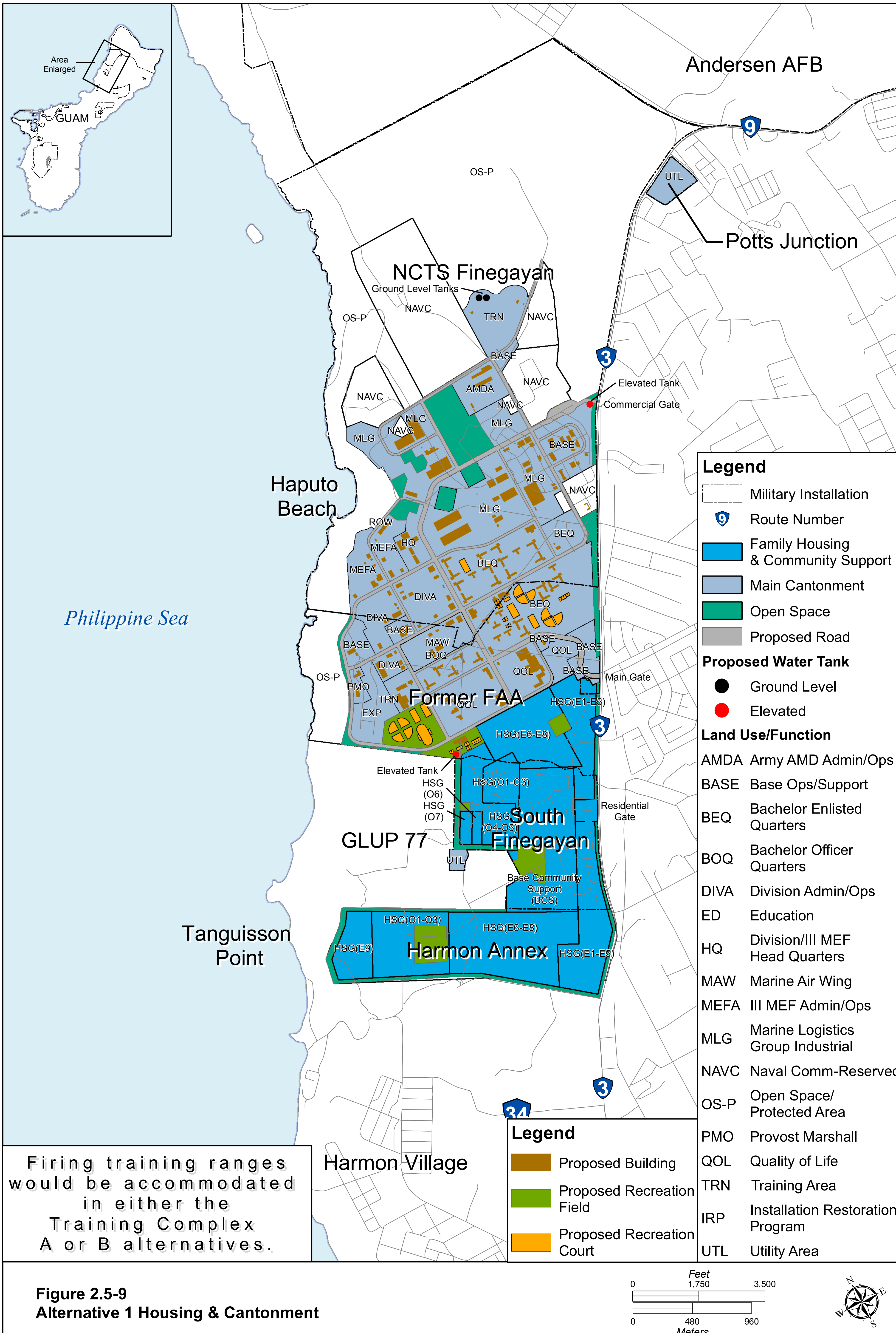
- *2014 (Peak Construction):* Each alternative was evaluated for environmental conditions in future year 2014, which represents peak construction associated with the military relocation. The end of year 2014 would represent full military relocation of active duty Marines Corps and their dependents. The year 2014 also represents the year with the highest estimated number of off-island construction workers for DoD projects.
- *2030:* Each alternative was evaluated for environmental conditions in future year 2030, consistent with the 2030 Guam Transportation Plan, assuming that military relocation has occurred.

2.5.3.1 Alternative 1

Alternative 1 involves utilizing NCTS Finegayan (1,181 ac [578 ha]), obtaining access to the Former FAA parcel (677 ac [274 ha]) south of NCTS Finegayan, and purchasing non-DoD land in the Harmon area (327 ac [132 ha]) south of South Finegayan, for a total of 2,113 ac (853 ha). A detailed view of the Main Cantonment configuration associated with this alternative is presented in Figure 2.5-9.

The Main Cantonment would include housing facilities, base operations and support facilities, various headquarters and administrative support facilities, quality-of-life facilities (e.g., shops, schools, and recreation), training areas, and open space. Military personnel, including the Army AMDTF, and their dependents would generally live, work, recreate, and shop in the north to northwest part of Guam. Most ground-training activities (i.e., nonfiring and firing) would occur on the east coast of Guam; the principal battalion-level training area would be on Tinian. Waterfront activities would be at Apra Harbor, but most Marine Corps vehicle traffic would be in the northern half of the island, except during embarkation. Amphibious Readiness Group embarkation and berthing would be at contiguous wharves, but the U.S. Coast Guard would need to be relocated to Oscar/Papa Wharves. Under this alternative, the new deep-draft aircraft carrier berth would be at the Former Ship Repair Facility. The water and wastewater proposals under this alternative would provide the greatest capacity and benefit to populations outside of the military relocation. The existing NDWWTP would be upgraded with secondary treatment capacity. Upgrades and improvements to the existing GPA system would be funded, but no new power generation capacity would be provided. Solid waste would be managed on DoD land.

The roadway projects that would be required for Alternative 1 are listed in Table 2.5-6. Individual projects that would not be included in this alternative are GRN #s 38, 39, 41, 47, 48, 49, 49A, 63, and 74.



Firing training ranges would be accommodated in either the Training Complex A or B alternatives.

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Figure 2.5-9
Alternative 1 Housing & Cantonment

Table 2.5-6. Alternative 1 GRN Projects

Item	*Off Base*						*Intersection Improvement at Military Access Point*	*TOTAL*
	Intersection Improvement	*Bridge Replacement*	*Pavement Strengthening*	*Road Relocation*	*Road Widening*	*New Road*		
GRN #(s)	1, 2, 5, 110, 113, 117	3, 35	4, 6, 7, 8, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22A, 23, 24, 25, 26, 27, 30, 31, 32, 33	36	9, 10, 16, 22, 28, 29, 57	124	38A, 39A, 41A, 42, 44, 46, 50, 52	
Subtotal	6	2	24	1	7	1	8	49

Legend: GRN = Guam Road Network.

2.5.3.2 Alternative 2

Alternative 2 involves using NCTS Finegayan (1,250 ac [578 ha]) and the Former FAA parcel (677 ac [274 ha]) for a total of 1,855 ac (751 ha). A detailed view of the Main Cantonment configuration associated with this alternative is presented in Figure 2.5-10.

The roadway projects that would be required for Alternative 2 are listed in Table 2.5-7. Individual projects that would not be included in this alternative are GRN #s 38A, 39A, 41A, 47, 48, 49, 49A, 63, and 74.

Table 2.5-7. Alternative 2 GRN Projects

Item	*Off Base*						*Intersection Improvement at Military Access Point*	*TOTAL*
	Intersection Improvement	*Bridge Replacement*	*Pavement Strengthening*	*Road Relocation*	*Road Widening*	*New Road*		
GRN #(s)	1, 2, 5, 110, 113, 117	3, 35	4, 6, 7, 8, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22A, 23, 24, 25, 26, 27, 30, 31, 32, 33	36	9, 10, 16, 22, 28, 29, 57	124	38, 39, 41, 42, 44, 46, 50, 52	
Subtotal	6	2	24	1	7	1	8	49

Legend: GRN = Guam Road Network.

2.5.3.3 Alternative 3

Alternative 3 involves utilizing NCTS Finegayan (1,250 ac [506 ha]), South Finegayan (283 ac [115 ha]), with portions of military housing and quality-of-life services at Navy and Air Force Barrigada (433 ac and 377 ac, respectively [175 ha and 153 ha, respectively]) for a total of 2,343 ac (848 ha). A detailed view of the Main Cantonment configuration associated with this alternative is presented in Figure 2.5-11.

The roadway projects that would be required for Alternative 3 are listed in Table 2.5-8. Individual projects that would not be included in this alternative are GRN #s 20, 31, 38A, 39A, 41, 41A, and 124.

Table 2.5-8. Alternative 3 GRN Projects

Item	Off Base						Intersection Improvement at Military Access Point	TOTAL
	Intersection Improvement	*Bridge Replacement*	*Pavement Strengthening*	*Road Relocation*	*Road Widening*	*New Road*		
GRN #(s)	1, 2, 5, 110, 113, 117	3, 35	4, 6, 7, 8, 11, 12, 13, 14, 15, 17, 18, 19, 21, 22A, 23, 24, 25, 26, 27, 30, 32, 33	36	9, 10, 16, 22, 28, 29, 57, 63, 74		38, 39, 42, 44, 46, 47, 48, 49, 49A, 50, 52	
Subtotal	6	2	22	1	9	0	11	51

Legend: GRN = Guam Road Network.

2.5.3.4 Alternative 8

Alternative 8 involves using the Former FAA parcel (677 ac [274 ha]), NCTS Finegayan (1,181 ac [578 ha]), South Finegayan (283 ac [115 ha]), with portions of military housing and quality-of-life services at Navy and Air Force Barrigada (433 ac [175 ha]), for a total of 2,574 ac (1,042 ha). A detailed view of the Main Cantonment configuration associated with this alternative is presented in Figure 2.5-12.

The roadway projects that would be required for Alternative 8 are listed in Table 2.5-9, Individual projects that would not be included in this alternative are GRN #s 38, 39, 41, 47, 48, 49, 63, and 74.

Table 2.5-9. Alternative 8 GRN Projects

Item	Off Base						Intersection Improvement at Military Access Point	TOTAL
	Intersection Improvement	*Bridge Replacement*	*Pavement Strengthening*	*Road Relocation*	*Road Widening*	*New Road*		
GRN #(s)	1, 2, 5, 110, 113, 117	3, 35	4, 6, 7, 8, 11, 12, 13, 14, 15, 17, 18, 19, 20, 21, 22A, 23, 24, 25, 26, 27, 30, 31, 32, 33	36	9, 10, 16, 22, 28, 29, 57	124	38A, 39A, 41A, 42, 44, 46, 49A, 50, 52	
Subtotal	6	2	24	1	7	1	9	50

Legend: GRN = Guam Road Network.

2.5.3.5 Firing Range Options

Depending on the selection of the firing range option, the alternatives described for the relocation include the Main Cantonment action alternatives with either a Firing Range Option A or Option B. Option A would require the realignment of Route 15 (GRN #36), while Option B would not require the realignment of Route 15.

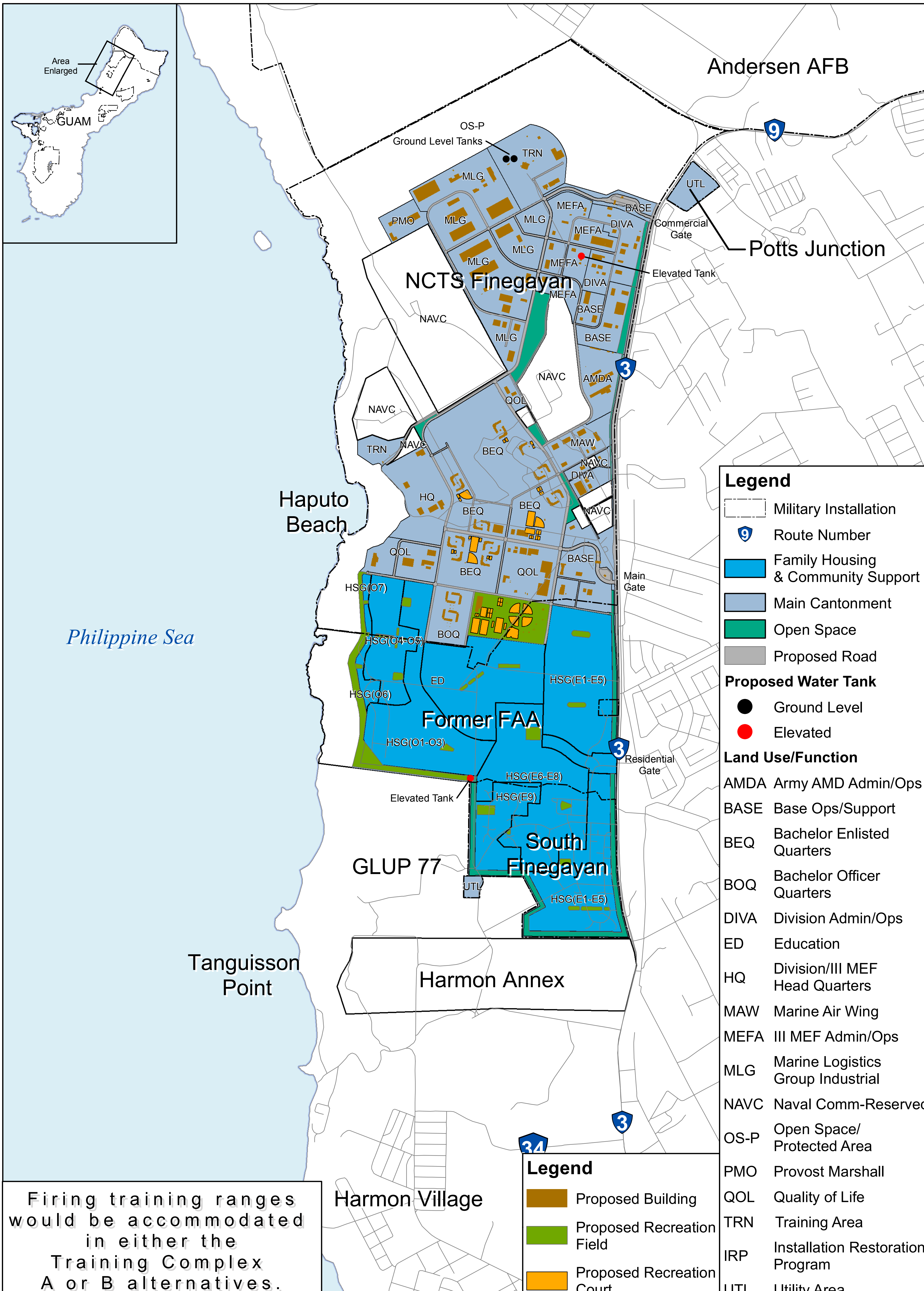

Figure 2.5-10
Alternative 2 Housing & Cantonment

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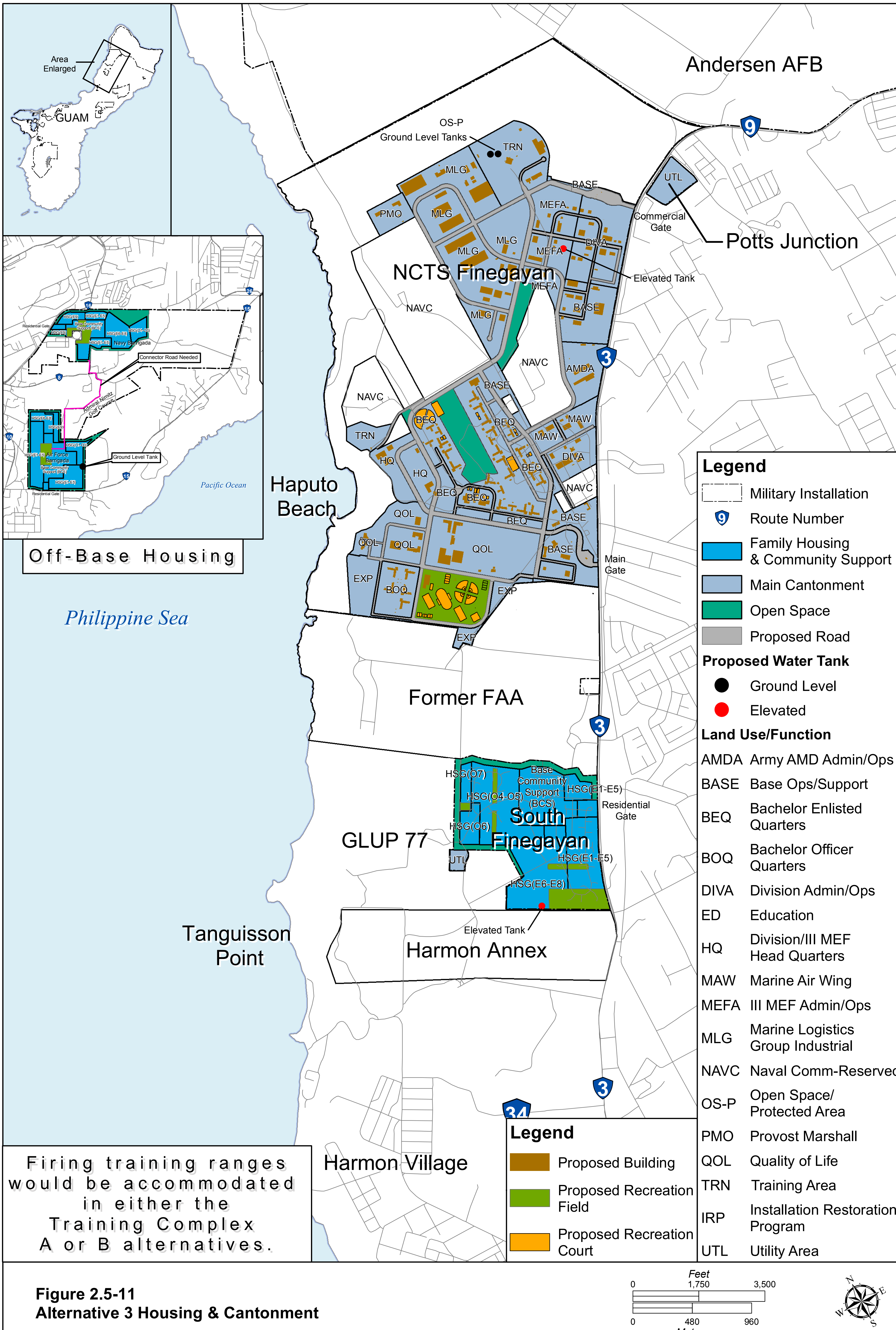

Figure 2.5-11
Alternative 3 Housing & Cantonment

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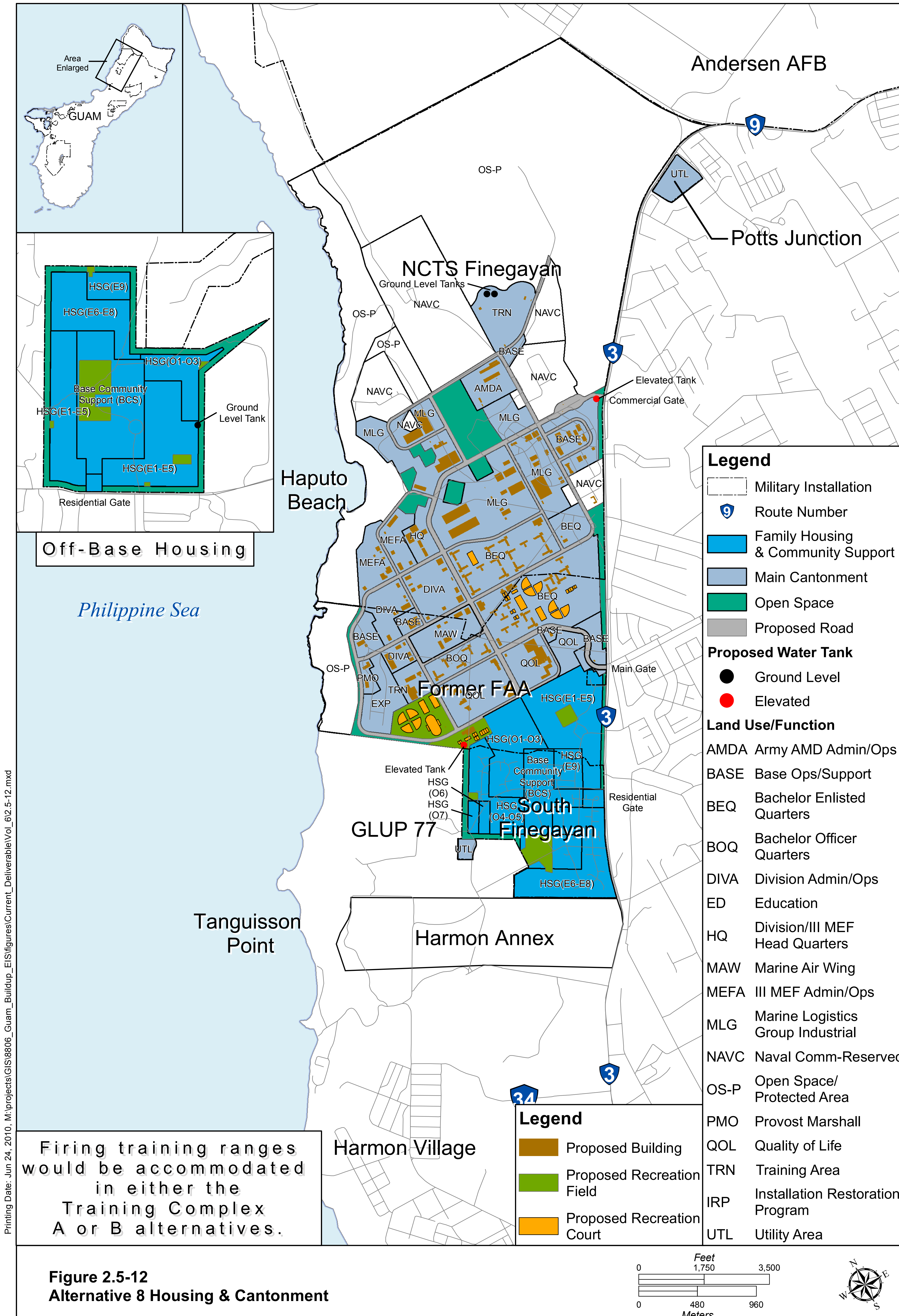

Figure 2.5-12
Alternative 8 Housing & Cantonment

2.5.3.6 No-Action Alternative

Under the no-action alternative, Marine Corps units would remain in Okinawa and not relocate to Guam, the visiting aircraft carrier would berth at Kilo Wharf, improvements to Apra Harbor would occur, and an Army AMDTF would not be positioned on Guam. No additional training capabilities (beyond what is proposed in the Mariana Islands Range Complex EIS and the Intelligence, Surveillance, and Reconnaissance/Strike EIS would be implemented for the Commonwealth of the Northern Mariana Islands or Guam. The project objectives and the U.S. Government/GoJ treaty and associated agreements would not be met. There would be no land acquisition, dredging, new construction, or infrastructure upgrades associated with Marine Corps or Army forces stationed on Guam. There would be no construction costs associated with this alternative. The Air Force military population would grow as projected for Intelligence, Surveillance, and Reconnaissance/Strike (see "Cumulative Projects," Volume 7). The Navy and Army do not project population increases. The no-action alternative does not meet the purpose and need of the proposed action. Although this alternative serves as a baseline, roadway capacity improvement projects would be conducted by the GovGuam to accommodate organic growth on Guam.

<u>Existing (2009) (Preproject)</u>

The no-action alternative evaluates existing environmental conditions for the baseline year of 2009, assuming that no military relocation would occur.

<u>2014 (Peak Construction)</u>

The no-action alternative evaluates environmental conditions for future year 2014, assuming that construction associated with military relocation would not occur. Seven GovGuam roadway capacity improvement projects would occur, as identified in Table 2.5-10 and Figure 2.5-13.

<u>2030</u>

The no-action alternative evaluates environmental conditions for future year 2030, assuming that military relocation would not occur. Twenty GovGuam roadway capacity improvement projects would occur, as identified in Table 2.5-5 and Figure 2.5-13.

2.5.3.7 Summary of Guam Road Network Projects Required for Each Alternative

All GRN projects identified in Table 2.5-3 would be required for each of the four alternatives, with the following exceptions:

- Alternative 1 would not require GRN #38, 39, 41, 47, 48, 49, 49A, 63, or 74. This alternative would consist of 49 projects.
- Alternative 2 would not require GRN #38A, 39A, 41A, 47, 48, 49, 49A, 63, or 74. This alternative would consist of 49 projects.
- Alternative 3 would not require GRN # 20, 31, 38A, 39A, 41, 41A, or 124. This alternative would consist of 51 projects.
- Alternative 8 would not require GRN #38, 39, 41, 47, 48, 49, 63, or 74. This alternative would consist of 50 projects.

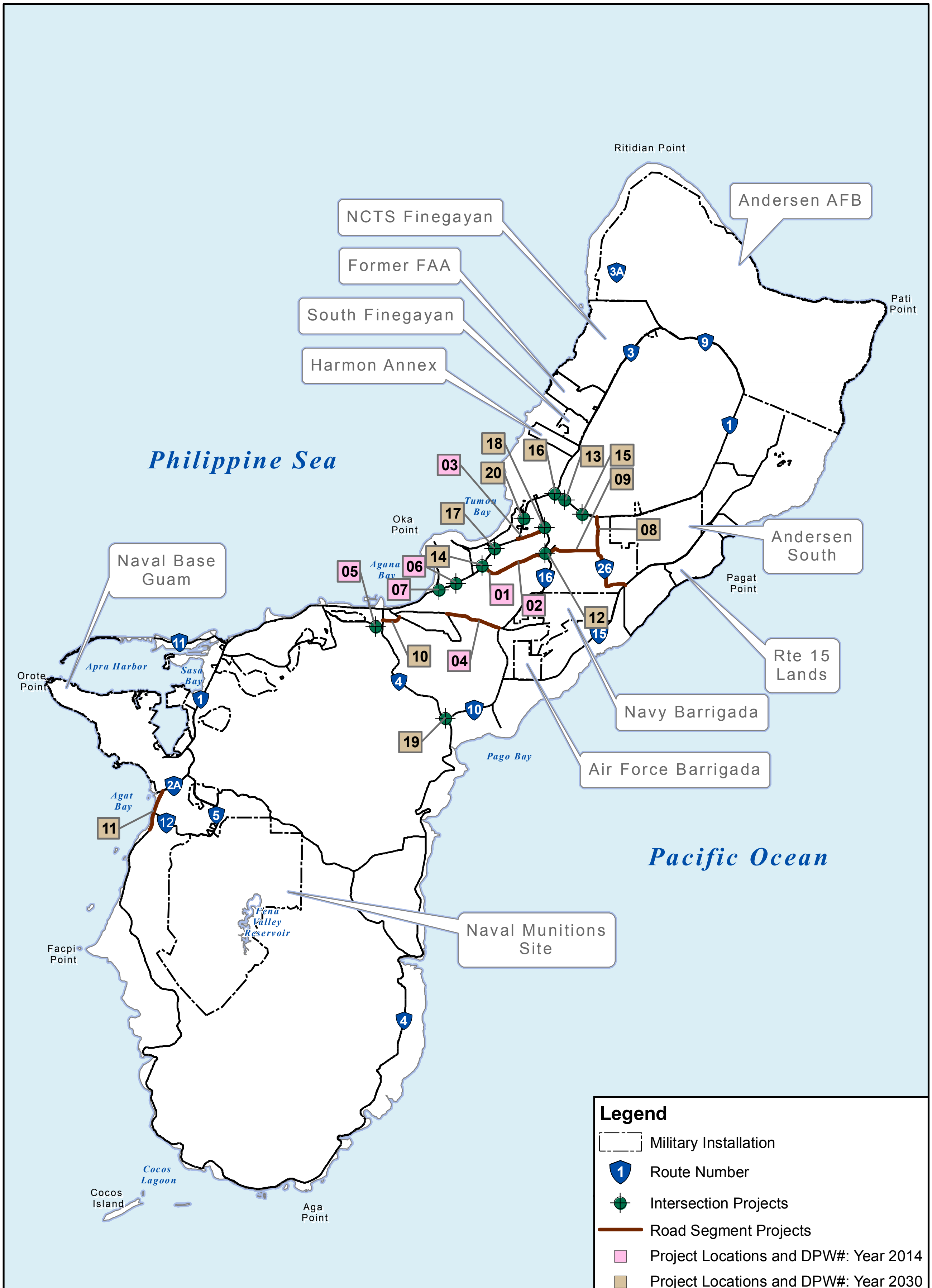

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Figure 2.5-13
Government of Guam Organic Growth Project Locations

Table 2.5-10. Government of Guam Roadway Capacity Improvement Projects

Year	*Project No.*	*Route*	*Segment Limits*	*Requirements*
2014				
Road Segment Projects	01	10A	Route 1 to Airport	Widen two/four lanes to four lanes
	02	10A	Airport to Route 16	Widen two lanes to six lanes
	03	27 Ext.	Route 16 to Route 1	Widen two to four lanes
	04	Tiyan Parkway	Route 10A to Route 8	Widen two to four lanes
Intersection Projects	05	7	Route 7/Route 7A, Route 24	Reconfigure Y-intersection
	06	1	Route 1/Route 14 (ITC)	Add southbound right-turn lane, improve adjacent development access near intersection
	07	1	Route 1/Route 30	Additional turn lanes pending further study
2030				
Road Segment Projects	08	26	Route 1 to Route 15	Widen two to four lanes
	09	25	Route 16 to Route 26	Widen two to four lanes
	10	7A	Route 8 to Route 4	Widen three lanes to four lanes
	11	2	Route 2A to Erskin	Widen two lanes to three lanes (add center left-turn lane)
Intersection Projects	12	16	Route 16/Route 10A	Restripe/sign existing lanes
	13	1	Route 1/Route 27A	Add eastbound right-turn lane
	14	1	Route 1/Route 10A	Add northbound right-turn lane
	15	1	Route 1/Route 27	Add southbound left-turn lane
	16	1	Route 1/Route 3	Add northbound left-turn lane
	17	1	Route 16/Route 14A	Add northbound/southbound right-turn lane
	18	16	Route 16/Route 27	Add turn lanes pending further study
	19	4	Route 4/Route 10	Add southbound through lane
	20	1	Route 1/Route 14 (NSV)	Add northbound left-turn lane

Legend: ITC = International Trade Center; NSV = North Sans Vitores.

2.5.4 Preferred Alternative

The Navy has identified Alternative 2 as the Preferred Alternative. This alternative involves use of NCTS Finegayan and the Former FAA parcel, and includes 49 roadway improvement projects as shown in Table 2.5-7.

At this time, 8 of the 49 roadway improvement projects associated with Alternative 2 are Defense Access Road (DAR)-certified. Of the 8 DAR-certified projects, 5 are funded in Fiscal Year 2010 and would start construction in 2011; the remaining 3 projects are awaiting authorization and appropriation in Fiscal Year 2011 (potentially constructed in 2012). The remaining 41 projects required for Alternative 2 are in the process of being identified for DAR eligibility or identifying another funding source. Once funded, these projects will be scheduled into the corresponding construction years from 2013 through 2017.

As the DoD, FHWA, and GovGuam continue to work cooperatively to develop a funding plan for the off base roadway and intersection capacity projects, the select number of off base roadway projects with funding or reasonable expectation of being funded were further evaluated. A limited traffic analysis was conducted to determine the impact of the housing and additional military base traffic on Guam roadways with only the select number of roadway improvement projects. This separate traffic analysis was completed for the 17 roadways and 42 intersections included in Alternative 2, assuming that only the DAR-certified and DAR-eligible projects were implemented.

As a result of the military relocation, Routes 3 and 9 would receive the majority of the new traffic because most of the relocated military population would reside in the Finegayan area. The evaluation of the limited Alternative 2 scenario included only the eight off base roadway and intersection projects that would involve limited widening of Routes 3 and 9, intersection improvements along Routes 1 and 3 and MAPs to NCTS Finegayan along Route 3.

In the event that funding of the remaining projects is not obtained, severe consequences to the roadway network on Guam would occur. The analysis for Alternative 2 with limited roadway improvements showed that:

- There would be substantial, unmitigated congestion in the North and Central regions (no mitigation available) resulting from traffic associated with the additional housing and base activities without the full recommended off base roadway improvements.
- There would be a reduction in level of service compared to conditions with completion of all roadway improvements. For most of the intersections, the predicted level of service in both 2014 and 2030 would be below the minimum acceptable level. Roadway and intersection capacities in the North and Central regions would be considered severely congested.
- In the year 2030, there would be an increase from 22 to 31 intersections with an unacceptable level of service in at least one peak hour. There would be an increase from 13 to 19 intersections with an unacceptable level of service both peak hours.
- There would be a substantially greater delay at intersections during the morning and afternoon peak hours (even when the level of service is already considered unacceptable).

The limited roadway improvements would be similar for Alternatives 1, 3, and 8, with similar unmitigated traffic impacts. Further impacts to roadways connecting Navy Barrigada and Air Force Barrigada, such as Route 16, would occur if Alternative 3 or 8 were carried forward.

2.5.5 Permits and Regulatory Requirements

Environmental permits and approvals that would be required for the GRN are summarized as follows:

- Endangered Species Act Section 7 consultation with U.S. Fish and Wildlife Service would be required for impacts on habitat for threatened and endangered species. Roadway projects are included in the Section 7 consultation for the entire proposed action.
- Clean Water Act Section 404 permits from the U.S. Army Corps of Engineers would be required for construction activities at bridges and culverts that cross any jurisdictional waters or wetlands. As part of this permit process, the U.S. Fish and Wildlife Service and USEPA would be reviewing any impacts on wetlands and associated mitigation measures.
- Water Quality Certification from GEPA for activities that require a Clean Water Act Section 404 permit.
- Section 106 consultation with the State Historic Preservation Officer would be required for effects on cultural and historic resources that would occur as a result of the proposed action. A separate Section 106 consultation, with a corresponding Programmatic Agreement, would be conducted for the roadway projects.
- A coastal consistency determination from the Guam Bureau of Statistics and Plans would be required to evaluate the effect of the proposed action on coastal resources. Except for federal lands, the entire island of Guam is considered a coastal zone.

Additional permits from GEPA may be required for temporary emissions sources and wastewater discharges. A stormwater pollution prevention plan may be required to address stormwater contamination from storage of hazardous materials, potential for erosion from uncontrolled stormwater, and other stormwater management issues in accordance with the USEPA Technical Guidance on Implementing Stormwater Runoff Requirements for Federal Projects under Section 438 of the Energy Independence and Security Act. FHWA would be responsible for obtaining all permits required for construction of off base roadway projects.