CHAPTER 2.
PROPOSED ACTION AND ALTERNATIVES

The proposed military buildup on Guam associated with the relocation of the United States 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 buildup, utility and roadway alternatives were developed.

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

Interim alternatives would meet the demand for utilities to support the military buildup on Guam and are evaluated in this Draft Environmental Impact Statement/Overseas Environmental Impact Statement (EIS/OEIS) in a project-specific manner. For interim alternatives, no additional National Environmental Policy Act (NEPA) analysis, other than what is included in this Draft EIS/OEIS, would be conducted.

Basic alternatives would meet the demand for utilities to support the military buildup on Guam for both the near-term and long-term, and are evaluated in this DEIS in a project-specific manner. For basic alternatives, no additional National Environmental Policy Act (NEPA) analysis, other than what is included in this DEIS, would be conducted.

Long-term alternatives would meet the demand for utilities over the long term, in the event that interim alternatives are found to be insufficient in the future. Long-term alternatives are presented conceptually, as much of the detail related to them is yet unknown and would require substantial study, planning coordination, and budgeting. Because long-term alternatives are not ripe for detailed, project-specific environmental impact evaluation at this time, they would require additional NEPA analysis in the future should they be pursued.

Interim and Basic Alternatives

The following interim and 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.

- Power:
  - Interim Alternative 1—recondition up to four existing Guam Power Authority (GPA) generating facilities and continue to operate within existing permitted capacity and upgrade transmission and distribution (T&D) systems
  - Interim Alternative 2—recondition up to three existing GPA generating facilities and increase permitted capacity and upgrade T&D systems
  - Interim Alternative 3—recondition up to three existing GPA generating facilities, upgrade one DoD generating facility, increase permitted capacity, and upgrade T&D systems

- Potable Water:
  - Basic Alternative 1—develop new water system for Marine Corps relocation assuming Cantonment Alternatives 1 and 2, and install up to 22 new wells on DoD property
  - Basic Alternative 2—develop new water system for Marine Corps relocation assuming Cantonment Alternatives 3 and 8, and install up to 31 new wells on DoD property

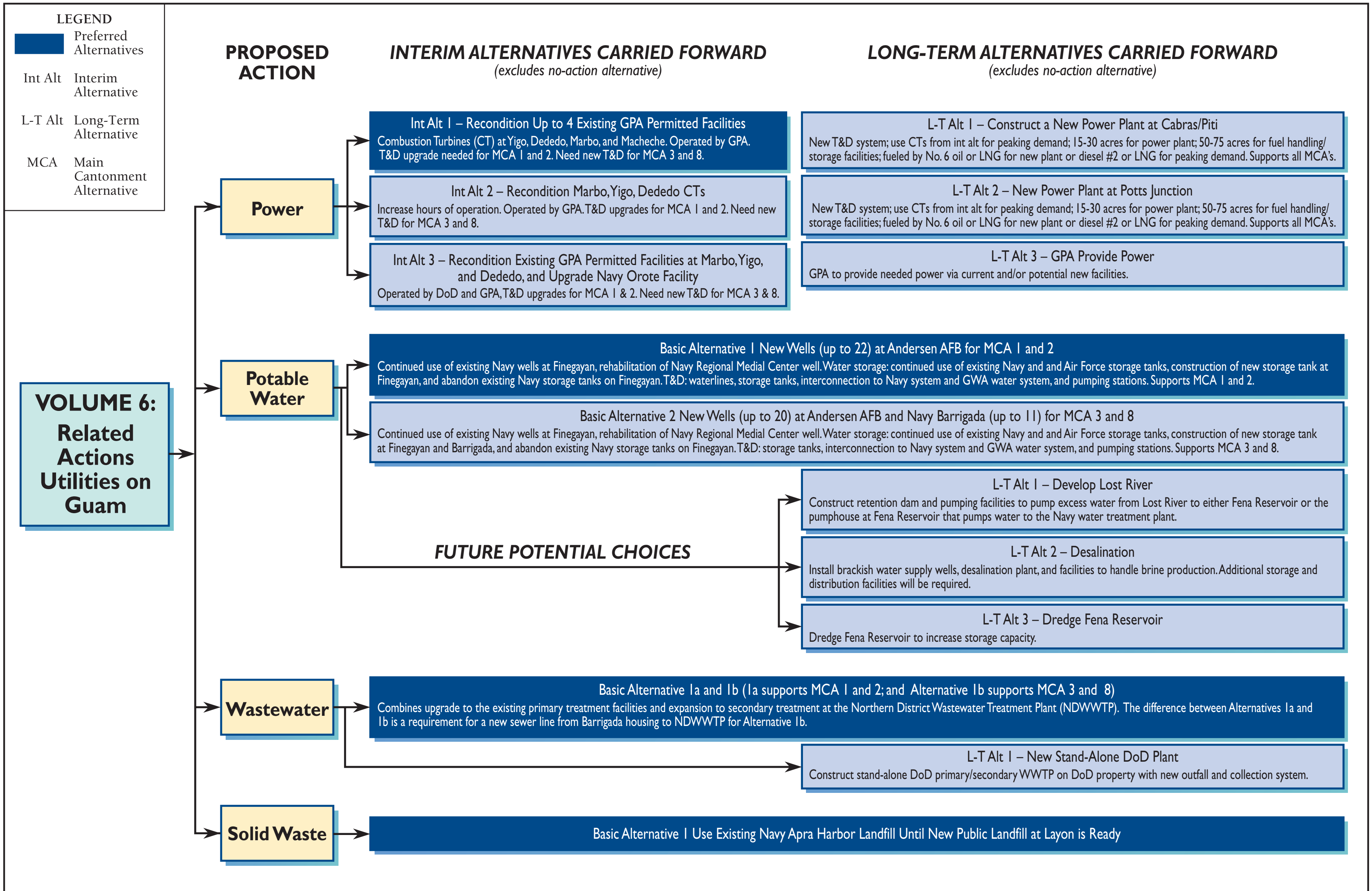


Figure 2.0-1
Summary of Proposed Action and Alternatives Carried Forward for Utilities, Guam

- Wastewater:
  - Basic Alternative 1 (1a supports Main Cantonment Alternatives 1 and 2; and 1b supports Main Cantonment Alternatives 3 & 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 a requirement for a new sewer line from Barrigada housing to NDWWTP for 1b.
- Solid Waste:
  - Basic Alternative 1—continue to use the Navy landfill until the new GovGuam Layon Landfill at DanDan is available for use

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 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 1— There are 49 GRN projects that would be required for Alternative 1. They are listed in Table 2.5-3, with the exception of GRN #38, 39, 41, 47, 48, 49, 49A, 63, and 74. These projects consist of 29 pavement strengthening, 8 roadway widening, 14 intersection improvements (includes 8 MAPs), 5 bridge replacements, 1 road relocation, and 1 new road.

Alternative 2— There are 49 GRN projects that would be required for Alternative 2. They are listed in Table 2.5-3, with the exception of GRN #38A, 39A, 41A, 47, 48, 49, 49A, 63, and 74. These projects consist of 29 pavement strengthening, 8 roadway widening, 14 intersection improvements (includes 8 MAPs), 5 bridge replacements, 1 road relocation, and 1 new road.

Alternative 3— There are 51 GRN projects that would be required for Alternative 3. They are listed in Table 2.5-3, with the exception of GRN #20, 31, 38A, 39A, 41, 41A, and 124. These projects consist of 29 pavement strengthening, 10 roadway widening, 17 intersection improvements (includes 11 MAPs), 5 bridge replacements, and 1 road relocation.

Alternative 8— There are 51 GRN projects that would be required for Alternative 8. They are listed in Table 2.5-3, with the exception of GRN #38, 39, 41, 47, 48, 49, 63, and 74. These projects consist of 28 pavement strengthening, 8 roadway widening, 15 intersection improvements (includes 9 MAPs), 5 bridge replacements, 1 road relocation, and 1 new road.

Long-Term Alternatives

As mentioned previously, a programmatic approach is taken in this DEIS 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 DEIS. 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.

Some long-term solutions have not been finalized because it is anticipated that special purpose entities will be formed to operate, manage, upgrade or develop utility plants and associated infrastructure such as collection or distribution systems. The precise manner in which these private business entities would operate is not known but the Navy anticipates they will receive financing from the Government of Japan under the agreement reached between the U.S.. and Japan regarding relocation of Marines from Okinawa to Guam. The Navy will not exercise any authority or control over the SPEs but is committed to facilitate discussions between GOJ, the SPE and Guam to focus SPE efforts on addressing utility impacts associated with the short-term construction work force and long term population growth. For example, private entities might develop, construct, and manage a power plant or a wastewater treatment plant. The U.S. government would then agree to purchase utilities from that plant as a fee that provides payback to the SPE on its investment. Given that these SPEs have yet to be formed, these long-term alternatives are not currently defined in detail.

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

- **Power:**
  - Long-Term Alternative 1—New Power Plant at Cabras/Piti Location
  - Long-Term Alternative 2—New Power Plant at Potts Junction Location
  - Long-Term Alternative 3—Power supplied by GPA
- **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:**
  - 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. Breakpoints (when utility demand would exceed capacity) were estimated to assess the potential effect on Guam public utilities of the combined DoD population increases and construction workforce increases, with specific discussion of impacts on the NDWWTP, the Guam Waterworks Authority (GWA) water system, and the Guam Power Authority (GPA) Island-Wide Power System (IWPS).

A socioeconomic analysis performed in support of this EIS projected that in addition to direct increases in DoD personnel, the on-base civilian workforce, and the temporary construction workforce, the proposed military buildup would likely affect civilian population growth. The population loadings developed by the socioeconomics team and assumed for analysis in this DEIS are summarized in Volume 1, Table 2.1-2. The population loading assumptions for direct DoD personnel, the on-base civilian workforce, and the construction workforce do vary somewhat from what was assumed in the utility reports. Specifically, the following differences are noted:

- Personnel by service is changed (fewer permanent Air Force and Navy personnel).
- Transient personnel not previously identified were added (Navy and Marine Corps).
- The construction workforce numbers are slightly higher.
- The population flow was revised.

A qualitative assessment of the population changes determined that increases in Marine Corps transient personnel would be offset by reductions in the permanent contingent of Air Force and Navy personnel. The Navy transient personnel are all shipboard, and the ships would not require support services during the interim period (i.e., would not initially contribute to demands on public utilities), with the exception of wastewater. The wastewater flows generated from the Navy's transient population would be sent to the Navy's Apra Harbor WWTP. With consideration for these additions and reductions, a determination was made that the on-base demand for the population described in Table 2.1-2 below would not differ substantially from the demand calculated in the utility studies, and the general conclusions and recommendations made in the utility studies would still be valid for the current population being considered in this EIS/OEIS.

The utility studies did not consider the potential impact associated with civilian growth. The socioeconomic analysis projected that induced civilian growth as a result of the military buildup could increase the island-wide population of Guam by approximately 40,000 in the peak year of 2014. The increased demand associated with this induced civilian growth was estimated by extrapolating the results and methodology used in the utility studies. However, these revised demands have not been confirmed by a detailed utility study. These demand increases would affect GovGuam utilities more than the DoD utilities.

In addition, non-project population increases for the Air Force, Navy, and Coast Guard are considered in the utilities analyses in order to ensure adequate services and capture the entire impact for the foreseeable future.

Other differences between the original utility studies and this DEIS include:

- The elimination of the growth factor from the Uniform Facilities Criteria (UFC) during the interim period for power and potable water. It is not reasonable to assume a growth factor during the buildup period since growth would already be integral to the buildup.
- Consideration for energy and water conservation as required by numerous executive orders.
- Leadership in Energy and Environmental Design (LEED) and sustainability initiatives being pursued during the planning and design for this buildup, which will reduce power and water demand.
- Local Guam factors that reduce utility demand from that prescribed by the UFCs, such as natural precipitation being adequate for properly designed landscaping, thus eliminating irrigation.
- More accurate current wastewater flow data from both Andersen AFB and GWA for NDWWTP was received in February 2009 due to erroneous flow measurements.
- More accurate power requirements for the future "Ford" class of aircraft carrier became available. This reduced the power demand for this transient condition.

All of these differences between the original utility studies and are discussed in supplementary analysis letter reports for power, water, and wastewater. The reasons for differences in the proposed alternatives in this DEIS and the studies are also discussed in the supplementary analysis letter reports.

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 buildup, including the AMDTF. The estimated total Marine Corps demand is 20.94 megawatts (MW) and total DoD demand is 123.63 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 UFC planning criteria, but does not include additional capacity for future growth, which will be used for the long-term power generation planning. .

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	18.10	8.64	0.46	27.20
Northwest Field	0.50	1.08	0.00	1.58
Andy South	1.00	0.00	0.00	1.00
NCTS Finegayan (plus utilities)	1.20	2.82	14.47	18.50
South Finegayan Housing Area	1.50	0.00	5.87	7.37
Barrigada	1.30	0.00	0.00	1.30
Naval Hospital	3.20	1.66	0.00	4.86
Naval Base Guam	20.75	1.12	0.14	22.01
Total Demand (excludes transient)	**47.55**	**15.32**	**20.94**	**83.81**
Naval Base Guam (max. transient demand) [a]				39.82
Total Electrical Demand (MW) [b]				**123.63**

Legend: AFB = Air Force Base; DoD = Department of Defense; MW = megawatts; NCTS = Naval Computer and Telecommunications Station.
[a] 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) .
[b] For 19 service locations.
Source: NAVFAC Pacific 2008b.

Power requirements presented are based on planned facilities to meet the needs of the projected population. Different Main Cantonments will require different transmission and distribution 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.

DoD estimates a future peak demand of 123.63 MW. This includes 47.55 MW of current DoD demand at existing DoD facilities on Guam, a total of 15.32 MW from other planned non-project DoD actions, a total of 20.94 MW from the proposed Marine Corps relocation, and a net total of 39.82 MW of transient demand.

A transient power demand will occur when either the proposed berthing and embarkation of a transient aircraft carrier and escorts or the ships that make up an Expeditionary Strike Group (ESG) are 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 123.63 MW.

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 expected operating requirements. Base load power generation is expected to operate continuously except for periods of maintenance or equipment failure and typically has a higher cost per MW of installed capacity as the facility is expected to operate more than 85% of the time in any given year. Also using peaking power units for short time periods is more economical than operating a larger base load generation facility.

The non-transient DoD demand increase is estimated to be 36.26 MW (123.63 MW – 39.82 MW – 47.55 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. Applying the 90/10 ratio of base demand to peak demand to the anticipated future DoD demand results in a required increased base demand of 32.63 MW, with 3.63 MW plus the transient load of 39.82 MW resulting in a new peaking demand of 43.45 MW.

Although the above analysis of power requirements does include power required for the transient ships, the interim alternatives presented do not include this power requirement. This is because the berthing of the transient ships would not include going cold iron (e.g. when ship provided power would be turned off and total power supply from shore would be required) before 2015 or when the long-term power solution would be in place.

Two other types of demand are expected to increase overall 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 DoD buildup 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 DoD buildup on Guam.

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

GPA Power System	*Demand (MW)*									
	Interim Period without 25% Growth Factor					*Long-Term without 25% Growth Factor*				
	2010	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Islandwide, including DoD and GPA baseline projected growth										
Existing Guam	281	287	294	299	303	306	309	312	315	318
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	6.70	4.43	1.38	0.00	0.00	0.00
DoD Increase (less 39.82 MW load from transient aircraft carriers)	1.83	2.18	5.04	11.35	17.99	33.31	35.29	35.29	35.29	36.26
Total Demand	288.94	304.42	324.21	340.29	356.93	365.82	356.90	355.03	358.03	362.14
Total Available Supply	490.00	490.00	550.00	550.00	550.00	630.00	630.00	630.00	630.00	630.00
Future Supply Accounting for 1.52 Reliability Factor	322.37	322.37	361.84	361.84	361.84					
Future Supply Accounting for 1.52 Reliability Factor						414.47	414.47	414.47	414.47	414.47
Supply – Demand (net excess or shortfall without transient loads)	33.43	17.95	37.63	21.55	4.91	48.66	57.58	59.44	56.44	52.33
Transient Load Highest requirement with CVN group)						39.82	39.82	39.82	39.82	39.82
Supply – Demand (net excess or shortfall with transient loads)	33.43	17.95	37.63	21.55	4.91	8.84	17.76	19.62	16.62	12.51

Source: NAVFAC Pacific 2008d. Guam Power Authority Integrated Resource Planning (IRP 2008) for existing Guam growth projections.

The majority of the construction activities associated with the proposed Marine Corps relocation are expected to be completed between 2012 and 2015. The proposed military buildup on Guam coincides with Guam Power Authority (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 Island-Wide Power System (IWPS) reserve analysis is based on the GPA *Reliability Manual* (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 interim system supply capacity is indicated in Table 2.1-2 as 322.37 MW and 361.84 MW and is based on a system generation capacity of 490 MW and 550 MW, respectively, for the years from 2010 to 2014.

GPA's supply forecast is based on an installed generation capacity of 550 MW. A review of 1 year of GPA's actual generation capacity indicates an average daily generation capacity of 490 MW, or nearly 15% less than its stated capacity. This appears to be largely related to units out of service for extended periods of time and units simply not available or not needed and are thus 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 combustion turbines (CTs) had been out of service with no specific return-to-service dates identified. 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.

Planning indicates that new power generation capacity would be available by approximately 2015 to support the additional demand and power supply required for long-term power consumption. This new power capacity would be approximately 80 MW. It is planned to have the reconditioned CTs used as peaking/standby capacity once the long-term generation facility is available. Generation of the base load by the new power plant would be expected to provide a lower energy cost than the CTs.

2.1.2 Screening Process

The following power generation alternatives were evaluated in the *Guam Power Generation Study Report for Proposed U.S. Marine Corps Relocation* (NAVFAC Pacific 2008b). These alternatives were evaluated for their ability to provide a long-term permanent solution to meet anticipated DoD 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 (Number [No.] 6) fuel oil
- Liquefied natural gas (LNG)
- 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 powe 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.

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 • 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 on a scale of 1 of 5 with 5 being the best) • Few installed applications with similar typhoon exposure; therefore, not a reliable technology • Not suitable for base load power (wind is not consistent)	Eliminated
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) 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 support 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

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

Power System Alternative	*Evaluation Considerations*	*Recommendation*
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)
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 reserves 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 SPE-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 SPE 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

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

Power System Alternative	*Evaluation Considerations*	*Recommendation*
Construct a New SPE-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
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	Retained
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	Retained

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

Power System Alternative	*Evaluation Considerations*	*Recommendation*
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.	Retained

Source: NAVFAC Pacific 2008b, letter report update to July 2008 study.

2.1.3 Alternatives Dismissed

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

2.1.3.1 Construct a New Special Purpose Entity-Owned/Operated Base load Power Plant on DoD-Provided Land with the Ability to Sell Excess Power to GPA

This alternative anticipates that an SPE 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%.
    - o The SPE 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 Special Purpose Entity-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 standalone 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 generation impact could require installation of twice the firm capacity to meet expectations for reliability. 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 be supported with a competitive cost for electricity 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 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 pH.]) 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 United States, 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 United States.

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 United States 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. Combustion turbines 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 combustion turbine (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 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. Either way, neither the aircraft carrier nor ESG requirements are included in short-term solutions, but rather are addressed among the options for long-term solutions.

<u>Ocean Thermal Energy Conversion</u>

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 either 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 [km]) 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 miles (161 km) 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 Interim Alternatives

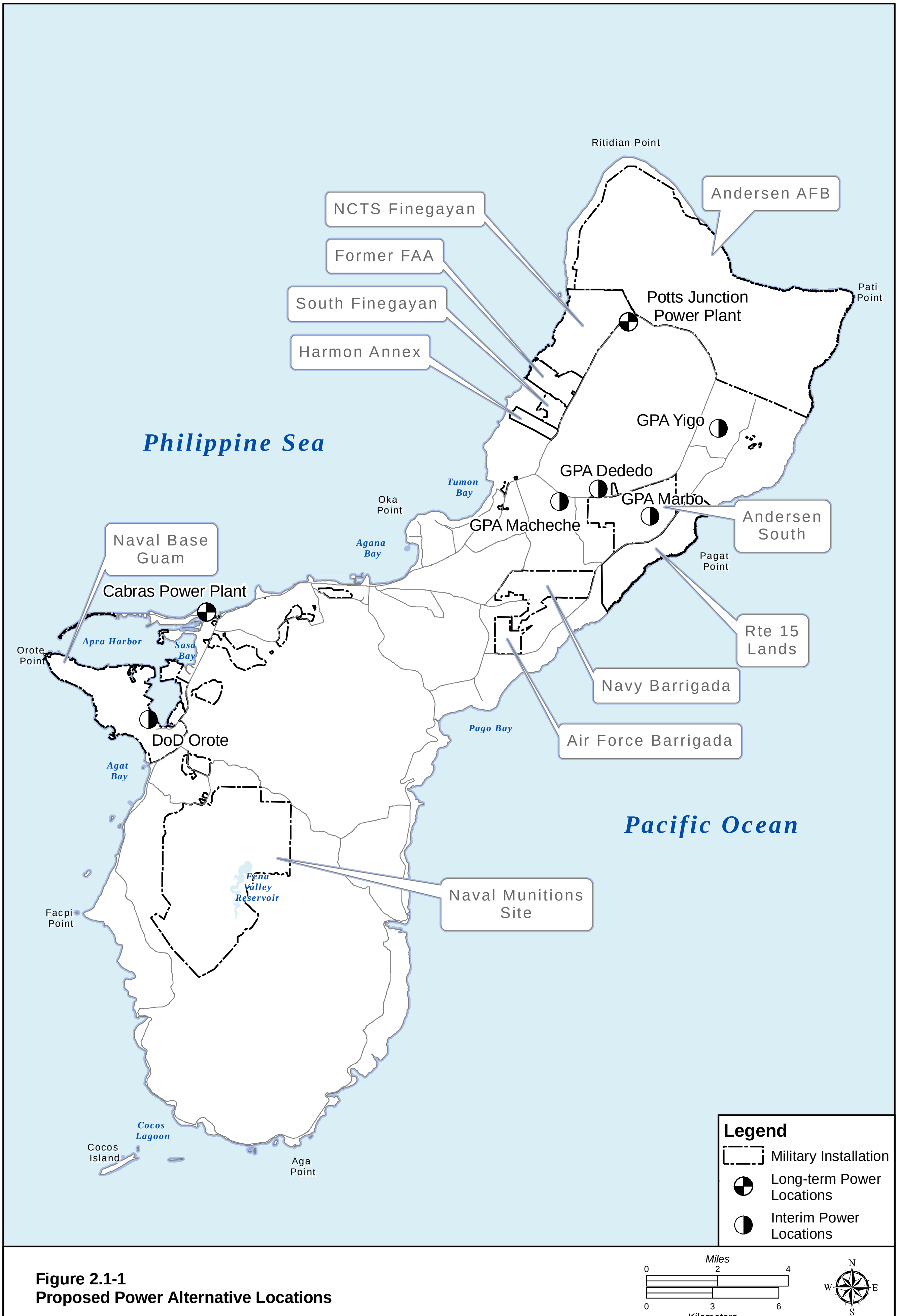
It is assumed that new interim power generation facilities would consist of the same system capacity and upgrades for all four Main Cantonment alternatives, and only the cantonment locations of the planned DoD facilities would be different. Main Cantonment Alternatives 1, 2, 3, and 8 would require different transmission and distribution (T&D) upgrades to support substantially different load locations. The locations of the currently proposed interim power generation alternatives are shown in Figure 2.1-1.

2.1.4.1 Interim Alternative 1 (Preferred Alternative)

This alternative would recondition up to four existing permitted GPA combustion turbines to restore the system to its original design capacity and support interim-load demands with no modifications to air permits. This alternative would recondition up to four existing combustion turbines that are not current in their maintenance requirements and cannot be reliably used to their permit limits. Units to be reconditioned would include the combustion turbines at Yigo, Dededo Unit No. 1, Marbo, and Macheche. An additional combustion turbine (Dededo Unit No. 2) was recently reconditioned by GPA and would also be utilized under this alternative.

This alternative supports Main Cantonment Alternatives 1 and 2. For Main Cantonment Alternatives 3 and 8, the reconditioned combustion turbines selected would remain the same but require additional upgrades to the T&D system to support these Main Cantonment locations.

The evaluation of power generation considered islandwide power capacity and requirements. The DoD load calculations include DoD facilities only and do not consider construction workers or induced growth directly. However, the effects of construction workers and induced civilian growth were considered when evaluating the IWPS demands as shown in Table 2.1-2 and also in Chapter 3 of this volume. The estimated time that increased capacity would be required includes a power demand estimate for the construction workforce. This additional power capacity would be available to the IWPS at that time. The location of this housing is currently unknown and the necessary localized T&D upgrades to support the housing should be coordinated by the contractor with GPA.



Printing Date: Jun 18, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.1-1.mxd

Figure 2.1-1
Proposed Power Alternative Locations

Present requirements for T&D upgrades required during the interim period of construction associated with the military buildup 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 interim facilities are expected to support the USMC relocation by 2015 and include the following major components identified as part of Cantonment Alternatives 1 and 2:

- North Finegayan USMC facilities
- South Finegayan USMC facilities
- ESG facilities at Main Base Navy

The interim period includes direct and indirect impacts to the island wide power system (IWPS). The demand increases require a series of T&D upgrades to support transmission of the increased power. Those T&D upgrades are summarized in Table 2.1-4 and include capacity for interim and long-term loads.

Table 2.1-4. T&D Upgrades

Item	*Project Description*	*System Overhead/Underground*	*Voltage*	*Interim*
1	Upgrade Piti X20 to Orote X35 line (currently overhead)	Underground	34.5kV	Y
2	Upgrade Harmon X87 to Andersen X73 line (currently overhead)	Underground	34.5kV	Y
3	Upgrade Piti X21 to Orote X31line Double Circuit (currently overhead)	Underground	34.5kV	Y
4	Upgrade Dededo CT X150/155 to Andersen X71line Double Circuit (currently underground)	Underground	34.5kV	Y
5	Upgrade Harmon X88 to Dededo X151/154 line Double Circuit (currently overhead)	Underground	34.5kv	Y
6	Upgrade Harmon X82 to Yigo X160 line and Yigo X161 to Andersen X (currently overhead)	Underground	34.5kv	Y
7	New 24 MVAR Capacitor Bank at Orote 13.8kV	N/A	13.8kv	Y
8	New 3 MVAR Capacitor Bank at SRF 13.8kV	N/A	13.8kV	Y
9	New 24 MVAR Capacitor Bank at Andersen 13.8kV	N/A	13.8kV	Y
10	New 18 MVAR Capacitor Bank at NCTS	N/A	13.8kV	Y
11	New Harmon to Andersen line	Overhead	115kV	N
12	New Andersen Substation With 112 MVA Power Transformer	Overhead	115kV	Y
13	New Piti Orote line	Overhead	115kV	N
14	New Orote Substation With 112 MVA Power Transformer	Overhead	115kV	Y
15	Upgrade Harmon X87 to Andersen X73	Overhead	115kV	Y
16	Piti X20 to Orote X35 line	Overhead	115kV	Y
17	New 24 MVAR Capacitor Bank at Orote 13.8kV	N/A	13.8kv	Y
18	New 3 MVAR Capacitor Bank at SRF 13.8kV	N/A	13.8kV	Y
19	New 24 MVAR Capacitor Bank at Andersen 13.8kV	N/A	13.8kV	Y
20	New 18 MVAR Capacitor Bank at NCTS	N/A	13.8kV	Y
Additional Electrical Distribution Upgrades to Support Cantonment Alternatives 3 and 8				
Item	*Project Description*	*System Overhead/Underground*	*Voltage (kV)*	*Interim*
1	AF Barrigada (Eagle Field) Substation located at AF Barrigada	N/A	34.5	Y
2	Line from Barrigada to AF Barrigada (Eagle Field)	Overhead	34.5	Y
3	Line from AF Barrigada (Eagle Field) to Pulantat	Overhead	34.5	Y

Item	Project Description	System Overhead/Underground	Voltage	Interim
	(essentially re-routing Barrigada to Pulantat 34.5 kV line to go through Eagle Field Substation first)			
4	Apra to Talofofo Line	Overhead	34.5	Y
5	12 MVAR capacitor bank at AF Barrigada (Eagle Field) for voltage support.	N/A	13.8	Y
6	6 MVAR capacitor bank at Navy Barrigada for voltage support	N/A	13.8	Y

Each of the listed upgrades was identified while coordinating between GPA during preparation of the Power System Study Report (July 2008, revision 1). These upgrades were identified as necessary to meet system requirements for voltage and capacity while maintaining two sources of power to each area. The items identified as required for interim power would upgrade T&D for northern Guam circuits north of the existing Harmon Substation that impact Dededo, Yigo, Andersen, Pott's Junction and NCTS. These upgrades would be sized to support all future projected loads for both Finegayan and Andersen to avoid upgrading the same lines twice within a short period of time. The lines follow existing utility distribution and will require underground trenching.

The 115kV lines are expected to be installed overhead while 34.5kV lines would be installed underground to improve resistance to typhoons. The capacitor banks will be installed at existing facility locations (substations, switchgear or similar locations) and connected to the circuits to improve system voltage regulation. The existing GPA T&D system for Guam is shown in Figure 2.1.-2

The interim generation reconditioning would be at existing facilities and would not require new generating units; however, reconditioning would ensure reliability for longer periods of operation to meet the increased demand.

2.1.4.2 Interim Alternative 2

This alternative would be an action for GPA and consists of a phased reconditioning of existing generating units to improve existing permitted facilities. The intent of this interim power solution would be to provide additional capacity for 24-30 months plus use of GPA's currently available interruptible supply capacity to meet the anticipated phased interim power needs before the long-term alternative would be available.

It is anticipated that the power would be from reconditioned existing permitted facilities at Marbo, Yigo, and Dededo Unit No. 1. These combustion turbine sites are 15-20 years old and have an anticipated combined capacity of approximately 60 MW, but are not identified as available for service in the daily GPA capacity report. These units would require general reconditioning, capabilities testing, and controlled startup, which together would take an estimated 12 months. An additional combustion turbine (Dededo Unit No. 2) was recently reconditioned and would also be utilized under this alternative. The anticipated implementation timeline for this option would be a 12-month period for each unit for reconditioning to support base load or intermediate-load generation requirements. The final timeline would be coordinated with GPA, but it is anticipated that Dededo Unit No. 1 would be first, followed by Yigo and then Marbo. Distribution system upgrades would be required, consisting of new 34.5-kilovolt (kV) lines for Yigo to Harmon and Dededo to Andersen and Harmon. Construction of the above T&D upgrades would take an estimated 18 months with a crew of approximately 25 workers.

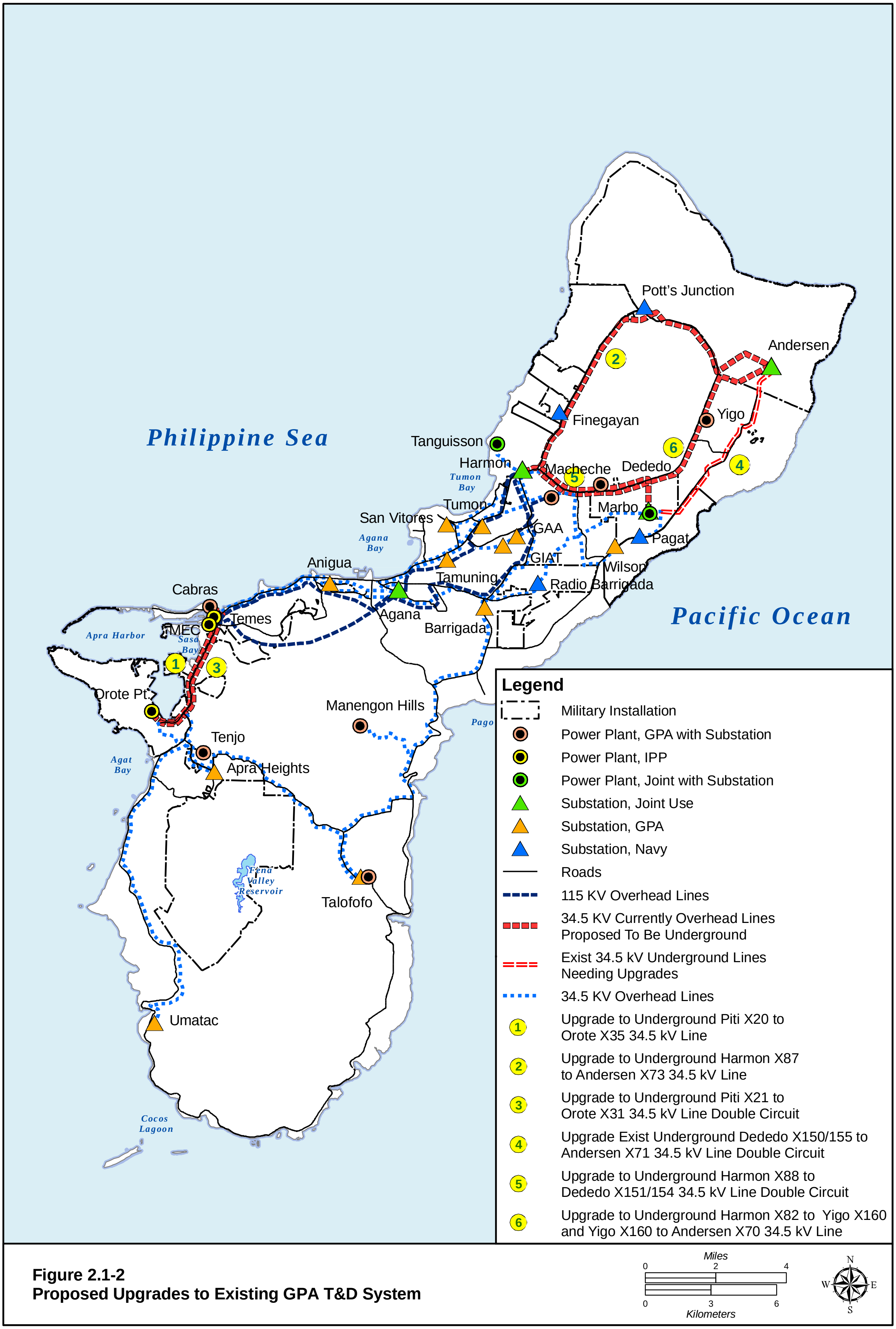


Figure 2.1-2
Proposed Upgrades to Existing GPA T&D System

Printing Date: Oct 28, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.1-2.mxd

This alternative would increase operational hours for existing combustion turbines and is expected to require a permit modification for Yigo (currently permitted at 4,280 hours per year).

This alternative supports total power requirements for all four Main Cantonment alternatives because the power would be available to the islandwide grid. Table 2.1-4 present requirements for T&D elements required during the interim period of construction associated with the military buildup on Guam for the Main Cantonment Alternatives 1 and 2, in addition to elements required for the Main Cantonment Alternatives 3 and 8.

Additionally, this alternative provides most of the increased power requirements for the construction workforce within the appropriate timeline. The electrical demand for the construction workforce and induced civilian growth is discussed in Chapter 3 of this volume.

2.1.4.3 Interim Alternative 3

This alternative would be a combined effort by DoD and GPA to implement a phased combination of reconditioning existing GPA permitted generation facilities and upgrading the DoD facility at Orote. The intent of this interim power solution would be to provide additional capacity for 24-30 months to meet the anticipated phased interim power needs before the operation of the final long term power solutions.

The main source of power generation would be from reconditioning of existing GPA-permitted facilities at Marbo, Yigo, and Dededo Unit No. 1. An additional combustion turbine (Dededo Unit No. 2) was recently reconditioned and would also be utilized under this alternative. Additionally the Navy-permitted Orote generation facility located on the Navy base will serve as a backup. These units have not been historically identified as available for service in the GPA daily-capacity report. As such, the three GPA combustion turbines sites are not currently viable for base load power generation. However, these units are 15-20 years old and have a combined rated capacity of approximately 59 MW that would become available for the interim period after reconditioning. It is anticipated that they would require general reconditioning, capabilities testing, and controlled startup, a process that could take up to 1 year for each systems; the systems could be worked on concurrently or sequentially. The extent of reconditioning necessary to provide base load or intermediate-load power generation would not be fully known until the units had been inspected and tested.

The anticipated timeline for this option would be a 12-month period to recondition each of the GPA generating units, and approximately 12 months for Orote to support base load or intermediate-load generation requirements. Orote would require a new fuel storage tank to enable longer run time between fuel deliveries. The final timeline would be coordinated between GPA and the Navy. It is anticipated that Dededo would be first, then Yigo, Orote, and Marbo. Upgrades to the latter three units would be scheduled concurrently to shorten the overall duration while allowing time to address permitting issues.

Upgrades would be required to the distribution system consisting of a new 34.5-kV line for Yigo to Harmon, and for Dededo to Andersen and Harmon. For Orote, distribution upgrades would consist of a 34.5-kV line and a 115-kV line to Piti, a new capacitor bank at the Orote substation (13.8 kV), and a new Orote substation with a 112-megavolt ampere power transformer. Construction of the above improvements would take an estimated 18 months with a crew of approximately 30 workers.

This alternative would increase operational hours of use for the existing combustion turbines and is expected to require a permit modification for Yigo (currently permitted at 4,280 hours per year) and Orote power plant (permitted for 450 hours per year per unit).

The Orote Power Plant is in an attainment area but may require mitigation of current and new air pollutant emissions. Air quality modeling for this alternative has been performed and is discussed in Volume 6, Chapter 7 and Volume 9, Appendix I.

This alternative supports the total power requirements for all Main Cantonment alternatives because the power would be available to the IWPS and would be the same for each alternative. Table 2.1-4 present requirements for T&D elements required during the interim period of construction associated with the military buildup on Guam for the Main Cantonment Alternatives 1 and 2, in addition to elements required for the Main Cantonment Alternatives 3 and 8.

Additionally, this alternative provides most of the increased power requirements for the construction workforce and induced civilian growth within the appropriate timeline. The projected electrical demand for the construction workforce and the induced civilian growth are discussed in Chapter 3 of this volume. Local T&D improvements may be needed depending on where the imported construction workforce would be housed. It is expected that the developer will coordinate with directly with GPA.

2.1.5 Long-Term Alternatives

Numerous alternatives to meet the power demand associated with the proposed military buildup on Guam were evaluated. However, nine of the alternatives evaluated were dismissed for the reasons provided in Section 2.1.3. Most of the dismissed alternatives are based on alternative energy sources and are not suitable for providing on-demand generation required by the electrical system on Guam. After careful evaluation, three long-term alternatives for power solutions were identified and are being considered. Two of the long-term power solution alternatives are relatively the same concept (building a new power plant), but at either different proposed site locations or supported by different types of fuels; the third alternative is to eliminate the SPE and make GPA responsible for the process and decisions related to providing additional generation for the IWPS.

The long-term power alternatives include using OTEC or geothermal power as a potential option for baseload renewable alternative energy sources. These are sustainable sources of energy and would lessen reliance on fossil fuels. A brief description of the renewable-energy options are provided above in Section 2.1.3.10. These nonfossil-fuel-alternative power sources would also assist the Marine Corps in meeting the energy requirements mandated by the Energy Policy Act of 2005 and the Energy Independence and Security Act of 2007, and in compliance with Navy/DoD policies.

The first two long-term alternatives, as described below, are similar concepts that would recapitalize and modify the existing GPA system to support part of the proposed base load and peak load from the GPA grid, and provide a new generating facility to support the remainder of the required loads. The added generation would be provided by a private entity in the form of an SPE. The long-term power solutions would involve GPA and may possibly be undertaken as joint ventures. These long-term solutions would require close coordination between DoD and GovGuam to ensure that planned facilities would provide capacity for total projected power demands from both military and civilian sources. The third long-term alternative would place the responsibility for an SPE or power purchase agreement with GPA and eliminate DoD involvement.

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

2.1.5.1 Long-Term Alternative 1

This alternative would involve constructing a new power plant at Cabras/Piti and a distribution system, and recondition the existing Dededo Unit No. 1 and Yigo generation units (20-40 MW), which would most likely have been accomplished during implementation of the interim alternative. The base load generation would be fueled by No. 6 oil or LNG, and peaking generation would be fueled by diesel No. 2 or LNG.

This long-term alternative offers the potential to use a different fuel source near the Cabras/Piti location. Investment in infrastructure would be required to receive, handle, and store the fuel (either No. 6 oil or LNG). Using LNG in an initial generation facility would establish a base of LNG usage that would result in lower fuel costs as the use of LNG expands to other generation units.

Water use for this power plant would be independent of the fuel source used. The freshwater demand would be approximately 225 gallons per minute (gpm) (851 liters per minute [lpm]) using a closed-loop system with water tower coolers. The water demand would be driven by evaporation and losses in the system. Trucks and heavy equipment would not be anticipated to leave the site because the fuel (whether No. 6 oil or LNG) would be delivered via ship to fuel storage facilities (including a vaporization facility for LNG, if chosen) and transported through piping systems. Other chemicals and materials would not require heavy equipment or large trucks (limited chemical delivery in vehicles smaller than tractor/trailer units).

The potential for hazardous waste is limited to typical industrial paints, solvents, oils/industrial lubricants, and similar compounds. Use of gaseous ammonia or chlorine is not anticipated.

Site security would be provided by one or more perimeter and internal cameras and perimeter fencing with security card access or on-site staff authorization.

Anticipated site area requirements would be 15-30 acres (ac) (6-12 hectares [ha]) for the generation facilities, not including new fuel handling and storage facilities that may require an additional 50-75 ac (20-30 ha). Securing an adequate land area for generation and storage/delivery/handling facilities within the Cabras/Piti area would be a concern. Some demolition of existing but abandoned facilities would be required to provide adequate space for these new facilities. Coastal areas would require coastal use permits and possible land reclamation to provide sufficient area.

Construction and operating permits would be required. The site would require minimal cut/fill because the facility would be at grade and the site is relatively flat. Subgrade construction would be limited to process piping, minimal subgrade structures, and utility distribution lines (electrical, communications, water, and wastewater).

Main exhaust stacks would be approximately 100-150 ft (30-46 m) tall and 4-8 ft (1-2 m) in diameter, depending on detailed design and fuel choice. A distribution interconnection to GPA's transmission system would be required between the power generation facility and the Cabras/Piti Substation. This alternative would require construction or upgrade of the existing GPA electrical substation at Cabras/Piti.

2.1.5.2 Long-Term Alternative 2

This alternative would involve constructing a new power plant at Potts Junction and associated distribution system improvements to deliver the power, and recondition existing generation units (20-40 MW). The base load power generation would be fueled by No. 6 oil or LNG, and peaking generation would be fueled by diesel No. 2 or LNG. This alternative would not have the same air pollutant emission concerns as Long-Term Alternative 1 because it would not be located in an area with current air pollution compliance issues. This alternative would likely still require the use of advanced emission control technology for oil-based generators. The location would create a need to transfer fuel oil from the harbor to the power plant site via tanker truck or new and lengthy pipeline. Other attributes would be similar to those of Long-Term Alternative 1, except for the following:

- The site area would be less constrained by existing air pollution concerns.
- A new electrical substation adjacent to the new power plant would be required instead of potential upgrades to an existing substation.

2.1.5.3 Long-Term Alternative 3

This alternative would involve GPA providing the financing and planning for the power generation required to serve planned loads and meet system reliability requirements. GPA would be responsible for planning and implementing the necessary generation expansion to support DoD planned loads based on the proposed implementation schedule.

2.1.5.4 Transmission and Distribution Upgrades for Long-Term Alternatives 1, 2, and 3

Each of the long-term alternatives described in Sections 2.1.5.1, 2.1.5.2, and 2.1.5.3 would require and include T&D upgrades as shown in Table 2.1-5. Note that some of these T&D upgrades would have already been completed during the chosen interim alternative as shown in Table 2.1-4.

Table 2.1-5. Electrical Distribution Upgrades to Support DoD Planned Facilities

Project Description	*System Overhead/Underground*	*Voltage (kV)*
New Harmon-to-Andersen line	Overhead	115
New Andersen substation with 112-MVA power transformer	Overhead	115
New Piti-to-Orote line	Underground	115
New Orote substation with 112-MVA power transformer	Overhead	115
Upgrade to Harmon-to-Andersen line	Underground	115
Upgrade to Piti-to-Orote line	Underground	115
New 24-MVAR capacitor bank at Orote 13.8 kV	NA	13.8
New 3-MVAR capacitor bank at SRF 13.8 kV	NA	13.8
New 24-MVAR capacitor bank at Andersen 13.8 kV	NA	13.8
New 18-MVAR capacitor bank at NCTS	NA	13.8
NCTS substation, Barrigada substation, Marbo substation, Yigo line upgrades	NA	34.5/13.8 (primary/secondary)
Additional Electrical Distribution Upgrades to Support Cantonment Alternatives 3 and 8		
Project Description	*System Overhead/Underground*	*Voltage (kV)*
AF Barrigada (Eagle Field) Substation located at AF Barrigada	NA	34.5
Line from Barrigada to AF Barrigada (Eagle Field)	Overhead	34.5
Line from AF Barrigada (Eagle Field) to Pulantat (essentially re-routing Barrigada to Pulantat 34.5 kV line to go through Eagle Field Substation first)	Overhead	34.5
Apra to Talofofo Line	Overhead	34.5
12 MVAR capacitor bank at AF Barrigada (Eagle Field) for voltage support.	NA	13.8
6 MVAR capacitor bank at Navy Barrigada for voltage support	NA	13.8

Source: NAVFAC Pacific 2008b.

Both long-term alternatives support Main Cantonment Alternatives 1, 2, 3, and 8 in terms of total power generation. Main Cantonment Alternatives 3 and 8 may require more or different T&D upgrades than those indicated in Table 2.1-5. Those upgrades would be determined before the follow-on NEPA documentation.

2.2 POTABLE WATER

2.2.1 Overview

The proposed military buildup on Guam would be located at Andersen AFB, Naval Computer and Telecommunications Station (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

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* (HPE 2006) are the basis for the calculation of anticipated on-base water demand below, with modifications as necessary.

The water demand for the Marine Corps relocation was calculated using the UFC 3-230-19N report, *Unified Facilities Criteria (UFC) Design: Water Supply Systems* (DoD 2005). Demand calculations include total requirements for domestic, industrial, fire protection, and unaccounted-for water (UFW) demands for the Marine Corps relocation population in year 2019. UFW is water that is not metered (such as that lost in leaks or unmetered usage) and is not accounted for in billing by the water utility. UFW is derived by subtracting the amount of water measured by meters and billed to customers from the water that is supplied by the treatment plants and wells, and also accounting for net changes in water storage tank inventories. The current UFW estimates for the Navy from the 2005 utility technical study report (NAVFAC Pacific 2005) are used in calculating baseline demand. Demand for additional population on the Navy bases is calculated using 15% UFW. It is assumed that the current UFW for Andersen AFB is 15%. Based on state standards summarized in the 2005 utility technical study report (NAVFAC Pacific 2005), a UFW of 15% is assumed for the current design. For the Marine Corp base at Finegayan, the UFW is estimated at 5% because the majority of the system will be newly constructed and water meters will be installed to identify and repair leaks as the system ages.

Population loadings used to calculate the projected future demand included active duty 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. Table 2.2-1 lists the DoD populations for the military buildup. The future induced civilian population and construction workers are not included in the DoD populations. The induced population and construction workers are expected to be housed off base. The estimated impact to the GWA water system is examined and discussed in Volume 6 Chapter 3.

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	0	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**

Table 2.2-1. Department of Defense Population Increases

Population Type	*Baseline*	*2010*	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*
Nonproject-Related Cantonment Alternatives 1, 2, and 3 and 8											
Active duty	2,145	0	0	0	0	0	0	0	0	0	0
Dependents	2,950	0	0	0	0	0	0	0	0	0	0
Transient	0	900	900	1,256	1,256	1,256	1,256	1,256	1,256	1,256	1,780
Civilian Work Force	805	0	0	0	0	0	0	0	0	0	0
Andersen AFB Total	**5,900**	**900**	**900**	**1,256**	**1,256**	**1,256**	**1,256**	**1,256**	**1,256**	**1,256**	**1,780**
Active duty	4,490	80	80	80	130	170	250	250	250	250	450
Dependents	5,410	118	118	118	148	240	290	290	290	290	50
Transient	0	0	0	0	0	0	0	0	0	0	0
Civilian Work Force	1,684	17	17	17	27	35	38	38	38	38	45
Navy Bases Total	**11,584**	**215**	**215**	**215**	**305**	**445**	**578**	**578**	**578**	**578**	**785**

Notes:
1. 7,222 transients at Apra Harbor not included in water demand—they are housed on ships.
2. Civilian workforce does not include construction workers.

Per capita (person) requirements for domestic uses including drinking water, household uses, and household lawn irrigation are as follows for permanent and temporary installations (DoD 2005), 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 Workers (per shift), 45 gpcd

The average 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:

(a) Large systems (5,000 population or greater), 1.25.

(b) Small systems (populations less than 5,000), 1.50.

Total average demand is the sum of averages 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.

The demand calculation for GWA is provided in Section 2.2.2.2. 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
- 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

It is assumed that housing for the Marine Corps would be either entirely within the Finegayan Base Complex (Main Cantonment Alternatives 1 and 2) or 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, air conditioning, and boiler makeup water. Demands 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 to facilities within the existing Navy bases. The future estimated average daily industrial use is 1.4 million gallons per day (MGd) (5.3 mld) at the Finegayan Base Complex. The industrial demands for Main Cantonment Alternatives 3 and 8 are similar to the industrial demands estimated for Main Cantonment Alternatives 1 and 2. This demand includes 250 gpm (946 lpm) for use in a power generation. Aircraft carrier–related water demand of 0.14 MGd (0.53 mld) is included in the Navy demands. The water demand related to construction is not included in the DoD water demand estimates. The construction-related demand is relatively low and is assumed to be supplied by the contractor through the GWA water system. DoD may provide the construction-related demand through the DoD water system. The anticipated DoD water demands are summarized in Table 2.2-2.

Table 2.2-2. 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	0.12	0.32	0.99	1.39	1.78	4.68	4.97	4.97	4.97	4.97	5.89
Andersen AFB	1.86	1.99	2.08	2.19	2.28	2.28	2.28	2.28	2.28	2.28	2.60
Navy	7.57	8.29	8.49	8.64	8.82	8.82	8.85	8.85	8.85	8.85	9.48
Total	9.56	10.60	11.56	12.22	12.87	15.78	16.10	16.10	16.10	16.10	17.97
Cantonment Alternatives 3 and 8											
Finegayan and Barrigada	1.08	1.28	2.06	2.56	3.05	6.04	6.33	6.33	6.33	6.33	7.28
Andersen AFB	1.86	1.99	2.08	2.19	2.28	2.28	2.28	2.28	2.28	2.28	2.60
Navy	6.61	7.32	7.52	7.68	7.85	7.86	7.89	7.89	7.89	7.89	8.52
Total	9.55	10.60	11.67	12.42	13.18	16.18	16.50	16.50	16.50	16.50	18.40
Maximum Daily Demand (MGd)											
Cantonment Alternatives 1 and 2											
Finegayan	0.14	0.59	1.60	2.00	2.39	8.07	8.64	8.64	8.64	8.64	10.48
Andersen AFB	2.85	3.10	3.19	3.32	3.41	3.41	3.41	3.41	3.41	3.41	4.05
Navy	9.41	10.63	10.76	10.96	11.20	11.28	11.32	11.31	11.31	11.31	12.58
Total	12.40	14.32	15.56	16.28	17.00	22.76	23.38	23.37	23.37	23.37	27.11
Cantonment Alternatives 3 and 8											
Finegayan and Barrigada	1.14	1.61	2.74	3.23	3.73	9.58	10.17	10.17	10.17	10.17	12.07
Andersen AFB	2.85	3.10	3.19	3.32	3.41	3.41	3.41	3.41	3.41	3.41	4.05
Navy	8.44	9.66	9.79	9.99	10.23	10.31	10.35	10.34	10.34	10.34	11.61
Total	12.43	14.37	15.73	16.55	17.37	23.30	23.93	23.93	23.93	23.93	27.72

Legend: MGd = million gallons per day

Demand Adjusted to Reflect Federal Mandates to reduce consumption

The potable water demand assumptions presented in Section 2.2.2.1 are based on UFC (UFC-3-230-19N dated 8 June 2005) that 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, EPAct 2005, EISA 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 dated 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. The disconnect is that with the mandated reductions in usage, we are left with a UFC compliant water source in excess of the actual need. 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, it was decided to incorporated 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 in order 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.

The reduction in on-base water demand for the new Marine Corps base is expected to be in the order of 22% on for the average daily demand, and 40% for the maximum daily demand if conservation measures, sustainability principles, and Guam site-specific conditions are applied. Modifications to the potable water demand estimates are still being finalized at the time of this DEIS publication; however, as discussed in more detail below, the reduced demand presented in this DEIS provides a realistic estimate of the expected demand currently being presented to the Guam Water Authority (GWA) for planning purposes.

<u>Sustainability Principles</u>

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 2005Energy Independence and Security Act of 2007
- 10 United States Code (USC) 2866, " Water Conservation at Military Installations"
- 10 USC 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)

Additionally, the existing Navy and Air Force bases are subject to water conservation goals, such as those in EO 13423. Implementation of this order would require a reduction in water usage of 16% by 2015 on the existing bases, this percent reduction is included in the modified potable water demand estimates presented in this DEIS. The water conserved on the existing bases would either reduce the stress on the Northern Guam Lens Aquifer or be made available via interconnects to support off-base developments related to the buildup via a formal request by GWA to the Navy (Naval Facilities Engineering Command Marianas). For more information on sustainability policies and guidance, refer to Volume 8, Chapter 6.

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. Examples include the following:

- 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 water softeners only as needed
- Use of wastewater recycling in industrial washing and rinsing of aircrafts and vehicles
    - Water-efficient cooling systems
    - Minimal landscape irrigation
    - Rainwater collection and reuse

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 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 respect 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 will allow water users to have full awareness of their water usage. For housing residents meters will support billing of water usage directly to the residents. Water conservation will be a key program that will receive command level attention and follow-up.

<u>Site Specific Water Conservation Measures</u>

Because the proposed Marine Corps base is 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 in the rainy season. As described above, the facility design is expected to implement water conservation equipment that is likely to produce at least a 22% water savings compared to conventional equipment. This water savings is mandated by regulation (EO 13514). No irrigation will be utilized for housing and will be used minimally elsewhere on the base. Landscaping throughout the base will be restricted to the use of native plants that can survive without watering. A common components manual to guide the development of the new Marine Corps base at Finegayan will address which local plants can be utilized in landscaping. Improved leak detection, extensive metering and management systems are expected to reduce the amount of unaccounted for water (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 original water demand calculation used a 15% UFW based on current experience at the Navy base. 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 the mainland and other locations.

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 2.2-3.

Table 2.2-3.Water Demand Comparisons Using Conservation/Sustainability Measures

Water Demand Criteria(Existing and Proposed)	*Water Demand (in MGd)*			
	Marine Corps Finegayan	*Andersen AFB*	*Navy*	*Total*
Average Daily Demand using UFC Guidance	5.9	2.6	9.5	18
Average Daily Demand using Sustainability Principles	4.6	2.2	8.7	15.5
Potential Percent Reductions for Average Daily Demand	**22%**	**15%**	**8%**	**14%**
Maximum Daily Demand using UFC Guidance	10.5	4	12.6	27.1
Maximum Daily Demand using Sustainability Principles	6.3	2.8	10.1	19.2
Potential Percent Reductions for Maximum Daily Demand	**40%**	**30%**	**20%**	**29%**

Incorporating these assumptions, the daily demand for the Marine Corps base is estimated to be reduced by approximately 22% of the current estimated average daily demand and 40% of the maximum daily demand. Impacts of these potential water demand reductions is discussed in Chapter 3 of this volume.

2.2.2.2 Off-Base Water Demand

Off-base water demand would be met by GWA. Population estimates are provided in Table 2.2-4. The population consists of the baseline growth (the expected growth in the Guam population without military buildup) in the existing population, the population induced by the Marine relocation, and the construction workers. A separate estimate is provided for the population located in northern and central Guam, where the water demand is met through groundwater resources. The islandwide off-base population would peak in 2014 at 247,897.

Table 2.2-4. Off-Base Population Estimates

Year	*All of Guam*				*Portion Served by Wells (North and Central)*			
	Baseline	*Construction Workers*	*Induced*	*Total*	*Baseline*	*Construction Workers*	*Induced*	*Total*
2010	180,692	3,238	6,651	190,582	175,271	3,238	6,651	185,161
2011	183,081	8,202	16,538	207,820	177,589	8,202	16,538	202,328
2012	185,435	14,217	26,989	226,641	179,872	14,217	26,989	221,078
2013	187,754	17,834	31,646	237,234	182,121	17,834	31,646	231,601
2014	190,042	18,374	39,481	247,897	184,341	18,374	39,481	242,196
2015	192,302	12,140	29,809	234,251	186,533	12,140	29,809	228,482
2016	194,541	3,785	15,165	213,491	188,705	3,785	15,165	207,655
2017	196,757	-	10,462	207,219	190,854	-	10,462	201,317
2018	198,942	-	10,462	209,404	192,974	-	10,462	203,436
2019	201,095	-	10,639	211,734	195,062	-	10,639	205,701

The off-base water demand is estimated using Equation 1 assuming 125 gpd per person per day (473 mld), 50% UFW (e.g., leakage and unmetered usage), and a fixed industrial demand of 10 MGd (38 mld) islandwide. No other factors are included in the estimate (e.g., growth factor). The approach for estimating GWA's water demand is based on information in the GWA *Water Resources Master Plan* (WRMP) (GWA 2007). The off-base water demand estimate is provided in Table 2.2-5. Off-base water demand peaks in 2014 at 61 MGd (231 mld).

Table 2.2-5. Off-Base Water Demand

MGd	*All of Guam*				*Portion Served by Wells (North and Central)*			
Year	*Baseline*	*Construction Workers*	*Induced*	*Total*	*Baseline*	*Construction Workers*	*Induced*	*Total*
2010	49	0.6	1.2	51	47	0.6	1.2	49
2011	49	1.5	3.1	54	48	1.5	3.1	53
2012	50	2.7	5.1	58	48	2.7	5.1	56
2013	50	3.3	5.9	59	49	3.3	5.9	58
2014	51	3.4	7.4	62	49	3.4	7.4	60
2015	51	2.3	5.6	59	50	2.3	5.6	58
2016	51	0.7	2.8	55	50	0.7	2.8	54
2017	52	0.0	2.0	54	50	0.0	2.0	52
2018	52	0.0	2.0	54	51	0.0	2.0	53
2019	53	0.0	2.0	55	51	0.0	2.0	53

2.2.3 Water Supply Sources

Water supply sources considered to meet on-base and off-base water demands are described below. Development of groundwater resources would require coordination between DoD, GWA, and the Guam Environmental Protection Agency (GEPA). This coordination is a necessary part of the well permitting and construction process, and proper management of the Northern Guam Lens Aquifer (NGLA), a designated sole source aquifer. During use of the wells, coordination would continue between DoD and GWA. Groundwater monitoring for chloride content would continue to be measured as an indicator of saltwater intrusion in the NGLA subbasin. Modification of well usage would be evaluated jointly to maximize use of the resource.

The NGLA, located directly underneath northern Guam, is a sole-source aquifer. 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. northern Guam is underlain by a karst limestone plateau with high water conductivity that results both in low retention times between injection wells and withdraw wells, and in a minimum of soil aquifer treatment.

2.2.3.1 DoD Water Supply Sources

The current water supply and additional supply required to meet future on-base DoD demands are summarized in Table 2.2-6. The existing DoD water supply is sufficient to meet current on-base DoD demands. Additional supply to meet future Marine Corps, Army, Air Force, and Navy demands would be required for the military buildup. The future Navy-required supply described in Table 2.2-6 includes up to 4 MGd (15 mld) transferred to GWA. However, due to GWA's planned system expansion, it is expected that less than the full 4 MGd (15 mld) available for transfer from the Navy will be required by GWA in 2019.

Table 2.2-6. Current and Future On-Base DoD Potable Water Supply and Demand

Site	*Current Maximum Demand (MGd)*	*Current Supply (MGd)*	*Current Supply Description*	*Future Maximum Demand (MGd)*	*Additional Supply Needed (MGd)[a]*
Main Cantonment Alternatives 1 & 2					
Finegayan	0.1	0	Navy Islandwide System including Wells on Finegayan	10.5	10.5
Andersen AFB	2.9	4.7	Marbo Wells in Andersen South Five Wells on Andersen AFB	4.0	-
Navy	9.4	10.1	Navy Islandwide System minus 4 MGd for GWA transfer	12.6	2.5
Total DoD	**12.4**	**14.8**		**27.1**	**13.0**
Cantonment Alternatives 3 and 8					
Finegayan and Barrigada	1.1	0	Navy Islandwide System including Wells on Finegayan	12.1	12.1
Andersen AFB	2.9	4.7	Marbo Wells in Andersen South Five Wells on Andersen AFB	4.0	-
Navy	8.4	10.1	Navy Islandwide System minus 4 MGd for GWA transfer	11.6	1.5
Total DoD	**12.4**	**14.80**		**27.7**	**13.6**

Notes: [a] additional required supply = (future maximum demand – current supply); [b] includes 4 MGd available for transfer to Guam Waterworks Authority. [c]The transfer amount to GWA is projected to be less in 2019 due to planned GWA system expansion and continuing improvement efforts.
Source: NAVFAC Pacific 2008c

The year when the anticipated water demand would exceed the current on-base DoD water supply was estimated, and is called the "breakpoint year." This analysis assumes no DoD-planned water supplies are put on line. The capacity of the existing water supply is compared to the required capacity of the water supply which is the maximum daily demand plus the size of the largest well for groundwater based systems. Table 2.2-7 shows two sets of breakpoint years. Both assume that construction workers would be housed off base. The first set shows the breakpoint years using current DoD UFC demand calculations as described previously. The second set shows the breakpoint year using the modified demand calculations once anticipated water conservation measures are implemented and sustainability principles are applied to the design of on-base buildings and facilities.

Table 2.2-7. Estimated Breakpoint Years for DoD Water System

Location	*Breakpoint Year (UFC demand estimate)*	*Breakpoint Year (modified demand estimate)*
Finegayan Base Complex	2013	2014
Andersen AFB	-	-
Navy Islandwide System (excluding water transferred to GWA)	2010 [a]	2019
DoD Combined Resources	2011	2014

If the Preferred 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. This coincides with the start of construction of the proposed water system. Although the maximum daily demand is not met by the existing supply on Finegayan in 2013, with the installation of a subset of the DoD-planned wells there will 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). If there is a shortfall, then adaptive management principals will be implemented such as reducing the pace of construction activity. For more information on adaptive management, see Volume 7.

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 2.2-8. Potable water is mainly supplied to the northern system by 119 deep wells. Collectively, these wells have a daily average production rate of approximately 41.8 MGd (158 mld). The current production rates are approximately equal to the design and permitted rates, indicating that the wells are running at full capacity. The GWA WRMP also assumed that the active wells were running 24 hours per day.. In addition to the deep wells, the northern system also receives approximately 3.6 MGd (13.6 mld) from the Navy Water Treatment Plant (WTP) in southern Guam, which is supplied by surface water from Fena Reservoir. According to the current memorandum of understanding, GWA can receive up to 4 MGd (15 mld) of supply from the Fena Reservoir.

The GWA WRMP discusses options for expanding the well system in the Agana subbasin to produce an additional 2.7 MGd (10.2 mld) and the system in the Agafa-Gumas subbasin to produce an additional 2.9 MGd (11.0 mld). These expansions are identified as being in areas that are outside of DoD boundaries and available to GWA. During the ongoing meetings between DoD and GWA, installation of 30 wells was proposed by GWA (GWA 2008), bringing the proposed well expansion throughout the NGLA for non-DoD use to 16.9 MGd (64.0 mld). The total future water supply for GWA is 63.2 MGd (239 mld) including the water transferred from Fena Reservoir. Between the existing non-DoD water supply sources and GWA's rehabilitation and expansion plans, there is sufficient water supply to meet the anticipated non-DoD water demand, provided that the proposed system expansion is operational in time to meet increased demand.

Table 2.2-8. Guam Waterworks Authority Water Supplies

	Current Production Rate (MGd)	*Future Expansions (MGd)*	*Total (MGd)*
North			
Deep Wells	41.8	13.1	54.9
Navy GWA Transfer (purchased)	4		4
South			
Ugum Water Treatment Plant	2.2	1.8	4.0
Santa Rita Spring	0.2		0.2
Nonpotable Deep Wells	0.1		0.1
Total	**48.4**	**14.9**	**63.2**

2.2.3.3 Development of Alternatives to Increase DoD Water Supply Sources

As shown in Table 2.2-6, 13.0 MGd (49.2 mld) of additional water supply would be required to meet future on-base DoD demands projected for the military buildup for Main Cantonment Alternatives 1 and 2 utilizing UFC requirements.

Several alternatives for increasing DoD water supply sources are carried forward for analysis in this DEIS, 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 2008c) 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 U.S. Marine Corps Relocation* (NAVFAC Pacific 2008c). 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 DEIS/OEIS, as discussed in Section 2.2.4. Table 2.2-8, shown in Section 2.2.4 below, summarizes the various options listed above that were retained and that were used to build the alternatives.

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/OEIS.

<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 use of the existing Navy wells at Finegayan that produce up to 2.3 MGd (8.7 mld). 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 Complex 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 underperforming 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 system 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 result in approximately an additional 4 MGd (15 mld) if adequate yield in the aquifers were available. Preliminary review indicates that there is adequate available yield in the subbasins.

This option has the potential to add to the reliability of a DoD water supply. The development and implementation of this option would be managed by DoD, avoiding uncertainties in timely implementation through direct and proper management. Coordination with GWA is important in the development of new 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 km) 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 Northern Aquifer 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 additional funds for transportation. 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 milligrams per liter (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, remineralization, and disinfection), 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 transmission and distribution 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 Northern Aquifer near the Finegayan Base Complex, water supply from implementation of this option would not support the Marine Corps relocation. However, this option is carried forward as a long-term alternative to supplement water supply to DoD in southern Guam.

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 DEIS/OEIS.

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 wastewater treatment plant 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 United States. All reclaimed water that is treated by wastewater treatment plants 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 buildup in 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. Should the supply provided by the chosen alternative need 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 2.2-9.

Table 2.2-9. Summary of Potable Water Alternatives

Alternative	*Components*				*Comments*
	Water Supply	*Water Treatment*	*Water Storage*	*Distribution System*	
Basic Alternative 1	• Up to 22 new water supply wells on Andersen AFB • Continued use of existing Navy wells on Finegayan • Rehabilitation of a well at the Naval Hospital	• Disinfection and fluorination at the wellhead	• Construction of new storage tank 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 Andersen AFB water system with Navy islandwide system • Connection to GWA water system	• Supports Main Cantonment alternatives 1 and 2 • Preferred alternative • Revised UFC reduces demand
Basic	• Up to 20 water	• Disinfection	• Construction of	• Waterlines:	• Supports Main

Table 2.2-9. Summary of Potable Water Alternatives

Alternative	Components				Comments
	Water Supply	Water Treatment	Water Storage	Distribution System	
Alternative 2	supply wells located on Andersen AFB • Up to 11 water supply wells located on Navy Barrigada	and fluorination at the wellhead	new storage tank on Finegayan • Construction of new storage tank at Air Force Barrigada • Use of existing Barrigada tank • Abandonment of existing Navy storage tanks on Finegayan	transport of water to storage tanks • Improvements and interconnect Andersen AFB water system with Navy islandwide system	Cantonment alternatives 3 and 8
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

Either basic alternative would fully meet the DoD water demand for the Marine Corps relocation. The schedule for construction would need to be accelerated to meet the increasing DoD water demand during the period of construction. 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.

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

Basic Alternative 1 would include options for new water supply wells (up to 22 wells at Andersen AFB), rehabilitation of existing wells, transmission and distribution system upgrades, and interconnection with GWA. Basic Alternative 1 would require water supply, water treatment, water storage, and water distribution components to meet the demand of the buildup as summarized in Table 2.2-10 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 2.2-11.

Table 2.2-10. Basic Alternative 1—Proposed Water System Components

Component	*Description*
Water Supply	• Development of up to 22 new water supply 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 Regional Medical Center wells
Water Treatment	• Disinfection and fluorination at the well heads
Water Storage	• Continued use of existing Navy and Air Force storage tanks • Construction of new storage tank 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 • 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 • A connection to the AF water system • A connection to the GWA water system

Source: NAVFAC Pacific 2008c

Table 2.2-11. Basic Alternative 1—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 1 & 2				
Current Surface Water Supply			11.0	11.0
Current Groundwater Supply		4.7	3.1	7.8
Development of new water supply wells	11.1			11.1
Rehabilitation of existing Navy well			0.5	0.5
GWA Transfer Projected Need in 2019			-3.3	-3.3
Planned Supply Cantonment Alternative 1 & 2	**11.1**	**4.7**	**11.3**	**27.1**
Maximum Daily Demand using UFC Guidance	10.5	4.0	12.6	27.1
Planned Supply Cantonment Alternative 1 & 2 using Sustainability Principles	**6.9**	**4.7**	**11.3**	**22.9**
Maximum Daily Demand using Sustainability Principles	6.3	2.8	10.1	19.2

Note: MGd = million gallons per day
Source: NAVFAC Pacific 2008c

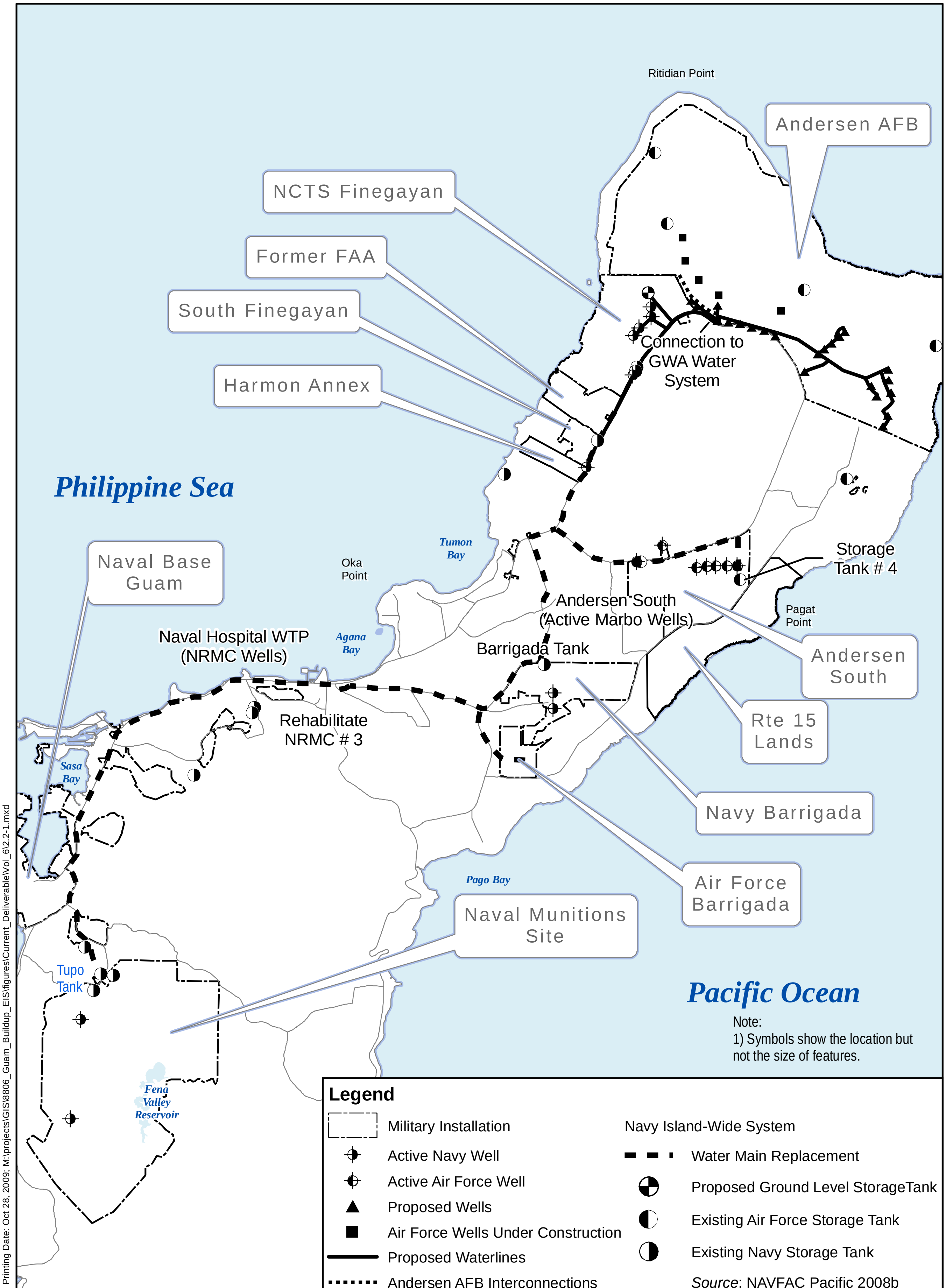


Figure 2.2-1
Basic Alternative 1 - Proposed Water System Components

This alternative would result in excess water of 0.6 MGd (2.3 mld) at Marine Corps Finegayan and a deficit of 1.3 MGd (3.0 mld) for the Navy's islandwide system for Main Cantonment Alternatives 1 and 2. The excess water from Marine Corps Finegayan could supply the additional water to the Navy's islandwide system. The water demand estimates are based on the conservative assumptions presented in the UFC water supply guidance (DoD 2001, 2005, 2006). Under average demand conditions, the Navy water supply is adequate. However, assuming the modified demand shown in Table 2.2-11, the capacity of the Navy water supply is sufficient.

<u>Water Supply</u>

Basic Alternative 1 would develop water supplies in northern Guam (water supply wells), central Guam (rehabilitation of the Navy Regional Medical Center's well), and southern Guam (Navy Reservoir improvements), and would include the capability to distribute water from north to south. The proposed locations for new water supply wells to be constructed under Alternative 1 are based on information regarding the sustainable and available yield of aquifer subbasins and other siting constraints as discussed below.

Potential Well Locations

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 will 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 property, 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.

- The areas in Figure 2.2-2 that are excluded from use to avoid Andersen AFB land uses do not include a buffer to account for explosives arcs. Three of the proposed well locations fall within the inhabited building distance (IBD) explosive safety quantity distance (ESQD) arc. The planned Andersen AFB wells are located within the IBD EQSD arc. 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.

Figure 2.2-2 also presents the location of the well constraints. Additional constraints are listed in Table 2.2-12.

Table 2.2-12. Well Location Constraints

Location Constraint	*Comments/Approach to Well Placement*
DoD Property	• Wells are located on DoD property.
Sustainable Yield	• The combined capacity of the existing and planned wells is less than the 1991 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 (305 m) 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 (244- to 305-m) 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.
ESQD	• Wells are located outside all ESQD arcs, except three wells that fall inside the IBD arc.
Potential Contaminant Sources: - Fuel Pipeline in the Utility Corridor - Fuel Storage - Dry Cleaners - 78 IRP Sites including Active and Inactive Landfills - UIC Wells in the Main Base Area	• Maintain an approximately 800- to 1,000-ft (244- to 305-m) 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 Main Base Area UXO/MEC	• 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. • Precautions would be taken during construction for UXO/MEC.
Sewer Main along Route 9	• DoD would consider conducting a study to evaluate the integrity of sewer mains.
Runway Approach	• DoD/Air Force requirements for design would be observed. • Well heads would be flush with the ground or frangible.
-Cultural Resources Sensitive Habitat	• Location specific studies are being conducted by DoD. Facility locations would be adjusted as required.

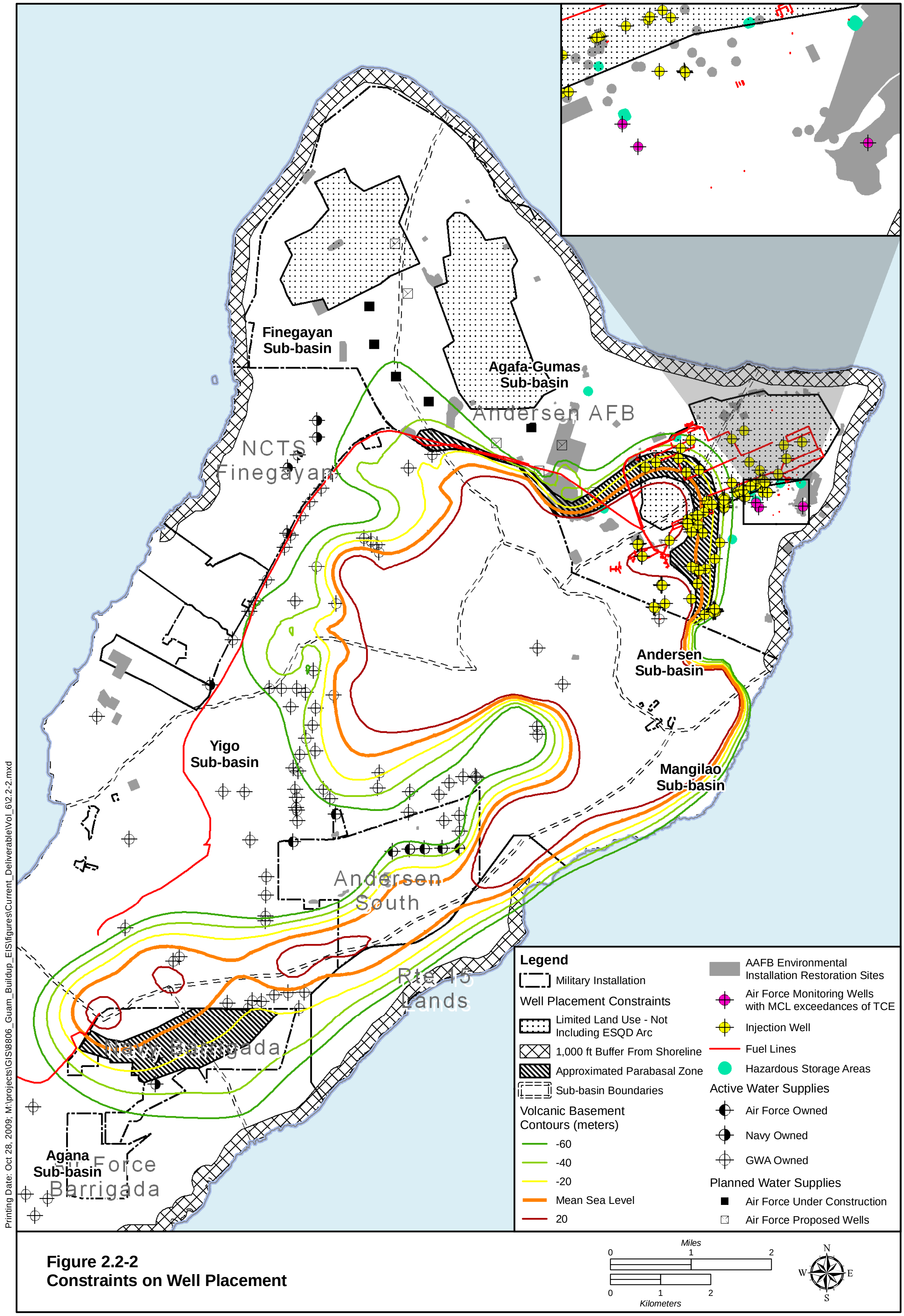


Figure 2.2-2
Constraints on Well Placement

Potential Contaminant Impacts on Sources of Drinking Water

Potential sources of contamination exist on or near Andersen AFB. These include the installation restoration sites, a utility corridor including a sewer line, and storm water injection wells. The proposed wells would be located away from these sites where possible. All well locations would be tested for water quality before installation. It is assumed that DoD would comply with all necessary stormwater requirements. Because the primary military buildup area would not be at Andersen AFB, impacts on stormwater resulting from the buildup would be minimal. 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 perchlorethylene (PCE) levels greater than the 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.

Unexploded ordnance and munitions and explosives of concern may be found at Andersen AFB. Provisions would be made as part of construction to address them.

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 Northern Aquifer 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.

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 1991).

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 are a construct to optimally manage well fields within the basin.

The second estimate of sustainable yield was prepared by Barrett (1991), 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 70-80 MGd (265-303 mld).

Table 2.2-13 compares sustainable yield estimates of the NGLS (CDM 1982) and Barrett (1991) 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 property (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 (1991) 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 a construct used 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.

Barrett (1991) argued that the increased estimate is supported by increased withdrawals in the past decade along with the relative stability of the basal portions of the aquifer, especially in the heavily exploited Yigo and Finegayan subbasins. However, McDonald and Jensen (2003) suggest that there has been a distinct increase in chloride over time, which they interpreted as indicating overpumping in some subbasins.

Table 2.2-13. Estimates of Sustainable and Available Yield for Subbasins in the Northern Guam Lens Aquifer

Subbasin	*Well Production*	*Northern Guam Lens Study (CDM 1982)*		*Barrett (1991)*	
		Sustainable Yield	*Available Yield*	*Sustainable Yield*	*Available Yield*
Agana	10.7	11.7	1.0	20.5	9.8
Mangilao	1.9	3.9	2.0	6.6	4.7
Andersen	1.2	6.2	5.0	9.8	8.6
Agafa-Gumas	3.9	10.1	6.2	12.0	8.1
Finegayan	8.1	6.4	-1.7	11.6	3.5
Yigo-Tumon	23.5	19.1	-4.4	20.0	-3.5
TOTALS	**49.3**	**57.4**	**8.1**	**80.5**	**31.3**

Sources: CDM 1982, Barrett 1991, Personal communications, GWA and Navy, 26 July 2009.

Based on these estimates, it is clear that groundwater resources are underdeveloped within the Andersen and Agafa-Gumas subbasins, compared to the southern subbasins. 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 2.2-14 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 Complex resulting from the military buildup on Guam. Additional planned wells at Andersen AFB are needed to meet demand at the base. DoD would work with GWA during design and implementation of the DoD wells and during well operation to maximize use of the aquifer.

Table 2.2-14. 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	400	Agafa-Gumas
8	450	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	300	Agafa-Gumas
21	450	Andersen
22	300	Agafa-Gumas

Legend: gpm = gallons per minute.
Source: NAVFAC Pacific 2008c.

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. Geophysical surveys and 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 Regional Medical Center Wells

Water from one of the three wells at the Navy Regional Medical Center is biologically contaminated. The existing disinfection process would be evaluated and improved.

Water Treatment

Groundwater would be extracted and disinfected and fluorinated at the well head.

Water Distribution and Storage

Pumps at each well station would pump water from the wells to a storage tank after disinfection and fluorination. It is assumed that high-lift pumping equipment would not be required to pump treated water to the ground storage tanks.

Well Pumping Stations

Each well station would include a submersible well pump with an aboveground discharge pipe that would need to be protected. The discharge pipe would have an air/vacuum relief valve, check valve, surge relief valve, and flow meter. The well houses would be constructed with decorative concrete block walls and wood-truss-supported roofs with asphalt shingles. Standby generators would be provided at 11 well houses to provide power to pump water at average-daily-demand levels during power outages. The standby generators would be installed outside the well houses. 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 WTP. The mains would range from 8 to 30 inches (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 distribution system. The treated water would be distributed throughout the Main Cantonment through both 8-inch (in) (20-cm) and 12-in (30-cm) water mains with valves and hydrants spaced at intervals of approximately 500 ft (152 m). Interconnections with Andersen AFB 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

A network of water distribution pipes would be constructed in the Main Cantonment service area. For planning purposes, it is assumed that the pipes would follow the preliminary street layout, and pipe diameters would range between 8 and 12 in (20 and 30 cm). 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

Approximately 5 million gallons (MG) of ground storage would be needed in the distribution system. The ground storage would be located in the northern end of the Marine Corp base. The tank would have a minimum of two sections to allow continuous operation during maintenance or repairs.

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 transmission and distribution systems would be upgraded. Basic Alternative 2 would require water supply, water (disinfection), water storage, and water distribution components, as summarized in Figure 2.2-3 and Table 2.2-15.

Table 2.2-15. Basic Alternative 2—Proposed Water System Components

Component	*Description*
Water Supply	• Development of up to 20 new water supply wells (including one contingency well) at Andersen AFB • Development of up to 11 new water supply wells (including one contingency well) at Navy Barrigada • Continued use of existing Navy wells at Finegayan
Water Treatment	• -Disinfection and fluoridation at the well heads.
Water Storage	• Continued use of existing Navy Barrigada storage tank • Construction of new storage tank at Finegayan • Construction of 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) • Pumping stations

Source: NAVFAC Pacific 2009.

Alternative 2 addresses the water demands in northern Guam. Water requirements at Andersen AFB and the Navy bases are projected to be currently adequate 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 2.2-16, this alternative would result in excess water of 0.7 MGd (2.7 mld) at Marine Corps Finegayan and 0.4 MGd (1.5 mld) at Air Force Barrigada.

Table 2.2-16. Basic Alternative 2—Proposed DoD Water Supply and Demand

	Marine Corps Relocation Areas		
Units: MGd	*Finegayan Base Complex*	*Navy Barrigada*	*Air Force Barrigada*
Minimum Required (MDD + largest well)	7.0	5.7	3.6
MDD	6.4	5.7	3.3
Largest Well	0.65		0.29
Existing Supply	2.3		0.4
Additional Required	12.7		3.2
Future Planned Capacity	13.4		3.2
Total Future Capacity	13.4		3.6
Excess Water	0.7		0.4

Legend: MGd = million gallons per day
Source: NAVFAC Pacific 2009.

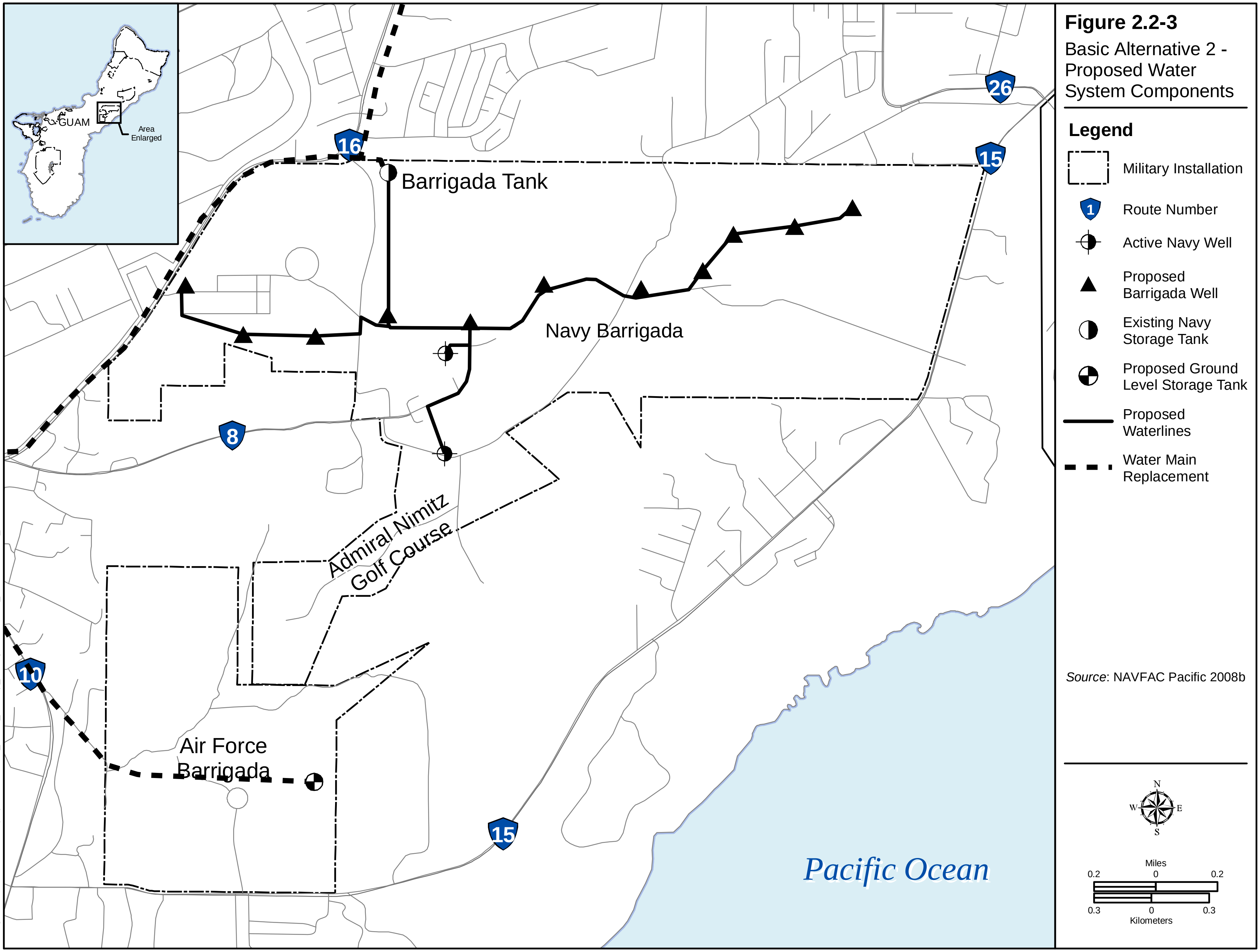


Figure 2.2-3
Basic Alternative 2 - Proposed Water System Components

Printing Date: Oct 28, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.2-3.mxd

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 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 2.3.6.1. Wells would be placed on Navy Barrigada within the parabasal region (Figure 2.2-3).

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 1991 estimate of sustainable yield (Table 2.2-12), sufficient yield remains available to meet the 2.8 MGd (10.6-mld) demand at 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 water demand. The causes of the higher water demand are as follows: additional industrial demand on Navy Barrigada and Air Force Barrigada, a higher growth factor from UFC requirements for Navy Barrigada and Air Force Barrigada due to their system size being smaller than the Finegayan system, 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 2.2-3 and Table 2.2-17 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 buildup on Guam.

Table 2.2-17. Alternative 2—Proposed Well Details

Well Number	*Proposed Capacity (gpm)*	*Subbasin*
Located on Andersen AFB		
1	450	Agafa-Gumas
2	450	Andersen
3	150	Finegayan
4	450	Agafa-Gumas
5	450	Agafa-Gumas
6	450	Agafa-Gumas
7	450	Agafa-Gumas
8	270	Finegayan
9	450	Agafa-Gumas
10	450	Andersen
11	450	Andersen
12	450	Agafa-Gumas
13	450	Andersen
14	450	Agafa-Gumas
15	288	Agafa-Gumas
16	150	Finegayan
17	450	Andersen
18	450	Andersen
19	450	Agafa-Gumas
20	300	Agafa-Gumas
Located on Navy Barrigada		
1	200	Mangilao
2	200	Mangilao
3	200	Mangilao
4	200	Mangilao
5	200	Mangilao
6	200	Agana
7	200	Agana
8	200	Agana
9	200	Agana
10	200	Agana
11	200	Agana

Legend: gpm = gallons per minute
Source: NAVFAC Pacific 2009

Well Construction

Wells would be constructed in limestone as discussed for Alternative 1. Please see Section 2.3.6.1.

Water Treatment

Water treatment would be the same as discussed for Alternative 1. Please see Section 2.3.6.1.

Water Distribution and Storage

Water distribution and storage would be constructed in limestone as discussed for Alternative 1 in Section 2.3.6.1, 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 island-wide system (NIW) (30-in [76-cm] main) and a planned connection from the NIW 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 NIW main. The cost includes replacement of the NIW 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

At Finegayan, approximately 3.6 MG of ground level storage would be needed in the distribution system. The ground level storage tank would serve two pressure zones and have at least two chambers to facilitate maintenance.

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

For Air Force Barrigada, a new 1-MG ground level tank is planned to meet the 0.95-MG 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 are presented in the following subsections, impacts related to these long-term alternatives are not assessed in this DEIS because they are not ripe for analysis.

<u>Long-Term Alternative 1</u>

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 U.S. Geological Survey (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 have 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.

<u>Long-Term Alternative 2</u>

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 up to 31 new potable water supply wells at Andersen AFB and Barrigada.

Under the desalination option, a water treatment plant would produce up to a total of 14 MGd (53 mld) of potable water. The plant would accept 2.3 MGd (8.7 mld) of freshwater from the existing Navy wells at Finegayan. 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 gpm. 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 transmission and distribution systems. Desalination would require water supply, water treatment, water storage, and water distribution components as summarized in Table 2.2-18 and presented in Figure 2.2-4.

Table 2.2-18. 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 14-MGd (53-mld) WTP at Andersen AFB
Water Storage	• Potential construction of new storage tank 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 • -Pumping stations

Source: NAVFAC Pacific 2008c.

Water Supply

Brackish-water wells would be planned to supply the treatment plant with enough water to produce a total of 14 MGd (53 mld) of potable water. The plant would accept the 2.3 MGd (8.7 mld) of freshwater from the existing Navy wells at the Finegayan Base Complex. To supply the remaining approximately 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 gpm, 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.

Proposed brackish-water supply well locations are shown in Figure 2.2-4. 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. 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 2.2-4 or other limitations to be specified by the base.

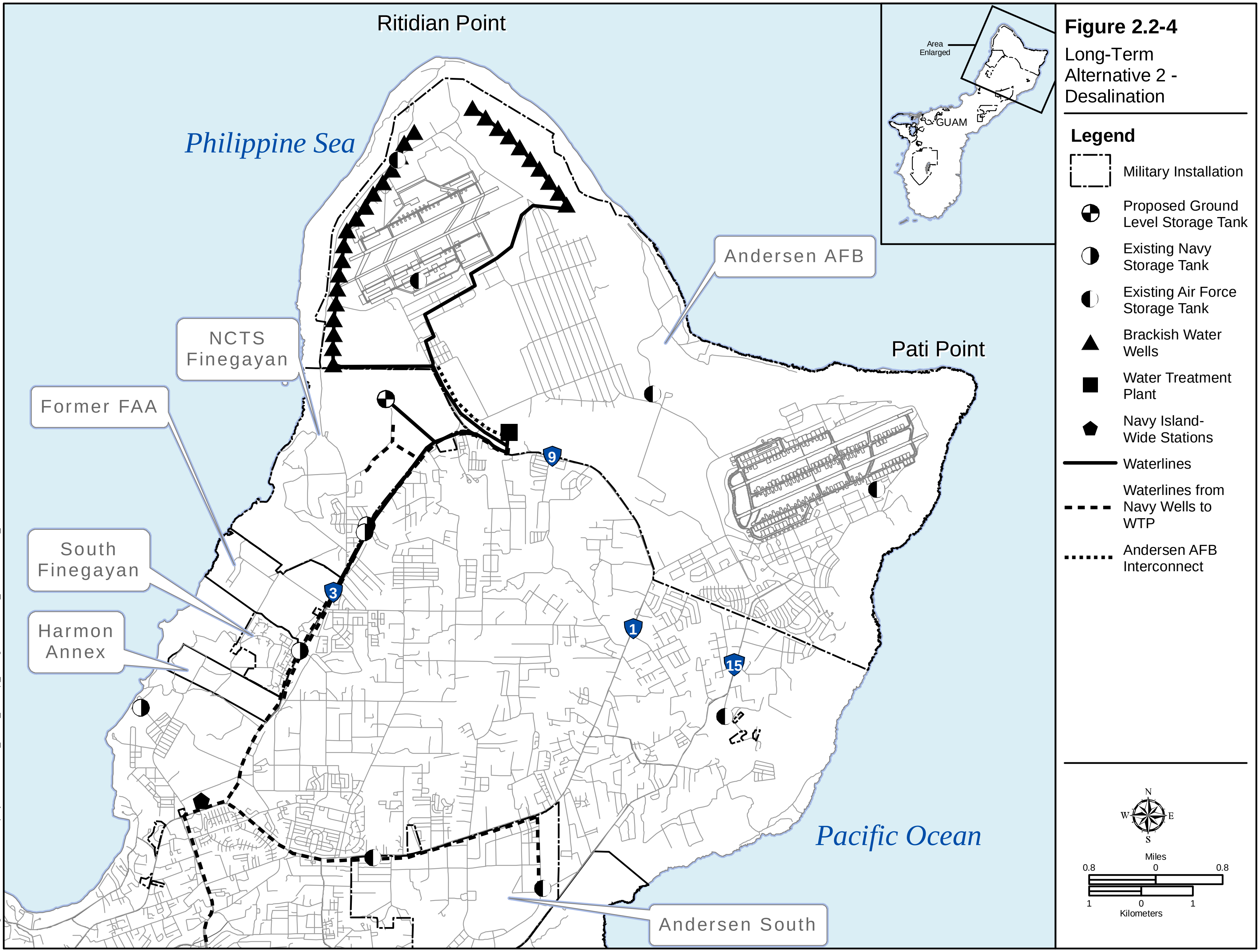


Figure 2.2-4
Long-Term Alternative 2 - Desalination

Printing Date: Oct 28, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.2-4.mxd

Components of the Water Systems

Water system requirements would be the same as described for Alternative 1 in Section 2.3.6.1 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 2.3.6.1, 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 14 MGd (53 mld). Before design, the water quality of the brackish water should 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 225,100 ft^2 (20,900 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 discharges 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

Sediment dredging of 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 (July 2009)
- Barrigada Utility Study to Support USMC Off-Base Housing Facilities Requirements (September 2009)
- Guam Potable Water Supplementary Analysis Letter Report (October 2009)
- 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 (September 2009)
- Guam Water Well Testing Study
- NGLA GWUDI Evaluation
- USGS NGLA 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 (July 2008)

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/OEIS process. In 2007, AECOM Technical Services staff visited NAVFAC Pacific facilities on Guam and met with respective decision makers within NAVFAC and several other agencies on Guam to understand the regulatory requirements and design features for this project. This 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 September 14, 2006. Water supply for Main Cantonment Alternatives 1 and 2 and DoD water requirements throughout Guam are addressed in this 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 1991. Alternative 1 is based on this report.

A Potable Water Supplementary Analysis letter report (October 2009) has revised results presented in the *Guam Water Utility Study* as follows:

- The demand calculations would be based on the February 2009 DoD and Guam civilian population estimates.
- Ground storage would replace elevated storage at the Marine Corps base.
- Water treatment plants would be eliminated from the water systems because the GWUDI determination has not been made.
- Reduced UFW and no growth factor would be applied to demand estimates during the interim (or construction) period.
- Sustainability initiatives and water conservation requirements issued outside of the UFCs are considered.

This draft EIS/OEIS incorporates the planned revisions noted above for these documents.

2.2.5.2 Barrigada Utility Study to Support USMC Off-Base Housing Facilities Requirements (September 2009)

This study develops a detailed alternative to address water demand for Main Cantonment Alternatives 3 and 8. The water demand estimates are based on the February 2009 population estimates. The recommended alternative consists of groundwater resource development and well rehabilitation. Proposed well placement incorporated the sustainable yield estimates from Barrett 1991. Alternative 2 is based on this report.

2.2.5.3 Guam Potable Water Supplementary Analysis Letter Report

The report concludes that despite some differences in the DoD and civilian populations used in the water study report and the DEIS/OEIS, the description of the proposed Marine Corps water system and the evaluation of the GWA system are still valid.

2.2.5.4 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 (September 2009)

This 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 study report and the Barrigada water utility study 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 1991 to estimate the sustainable yield are still valid. The recommendations in Barrett 1991 are appropriate for initial planning.
- The Barrett 1991 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, the draft on 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 are required based on the conclusions of this report.

2.2.5.5 Guam Water Well Testing Study

This study would determine optimal well and well field configurations needed to meet the future Marine Corps base water demands. This study would develop groundwater source well-design criteria used in developing the Marine Corps base water supply system. Ten test wells would be installed to characterize the production capacity of well fields in the areas of interest: eight wells on Andersen AFB and two wells on Navy Barrigada. Geophysical logging of boreholes would be performed. Step-drawdown and 24-hour pumping tests at appropriate pumping rates would be performed to determine well capacities. Salinity and basic water quality parameters would be measured in the saturated zone. At the conclusion of pump tests, samples of the well water would be taken and analyzed by an EPA-certified laboratory for primary and secondary drinking water standard contaminants. One of the test wells would be further developed by reaming, installation of screen and filter pack, casing and seal, and additional subsequent-step drawdown testing and constant-rate testing. At the conclusion of well testing, the wells would be covered. The remaining test wells may eventually be converted to production wells.

Completion of the study with report documentation is anticipated at the end of 2010 with preliminary results available in time for the Final EIS/OEIS.

The results of this study could change the location and number of wells on Andersen AFB and Navy Barrigada or the water treatment requirements. This information would be incorporated into the NEPA process through a supplemental NEPA submission.

2.2.5.6 Northern Guam Lens Aquifer (NGLA) GWUDI Evaluation

Groundwater under the direct influence of surface water 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 bacteria or contaminants in the soils. 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 sub-basins are identified as GWUDI well, then treatment requirements maybe imposed on individual wells that includes filtration and/or disinfection.

The results of the GEPA study are expected in late 2010. This DEIS/OEIS is developed assuming that the proposed and existing DoD wells are not subject to GWUDI. If the GWUDI determination is made in the future for the DoD well, a separate NEPA document would be developed to address the additional water treatment requirements.

2.2.5.7 USGS NGLA Study

DoD plans to support 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 would not be completed for 3-5 years. Given this time frame, the model is expected to be used in the long-term maintenance of the NGLA groundwater resource. If possible, a preliminary analysis using a finer grid model in the area of the proposed well locations as a tool for well siting.

2.3 WASTEWATER

2.3.1 Overview

The proposed military buildup on Guam would be 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 wastewater treatment plants. Two of these wastewater treatment plants are owned and operated by the Guam Water Authority (GWA): the Northern District Wastewater Treatment Plant (NDWWTP), and the Hagatna WWTP. One of the wastewater treatment plants is owned and operated by the Navy: the Apra Harbor WWTP Figure 2.3-1 shows the locations of these wastewater treatment plants. Table 2.3-1 shows the areas that these treatment plants service.

Table 2.3-1. Wastewater Treatment Facilities Servicing Areas of the Proposed Military Buildup on Guam

Area of Proposed Military Buildup	*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

Source: GWA 2007.

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

- The plant must meet minimum standards for removal of pollutants
- The plant cannot discharge pollutants into a waterbody 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 Guam EPA (GEPA)in reports called Discharge Monitoring Reports (DMRs).

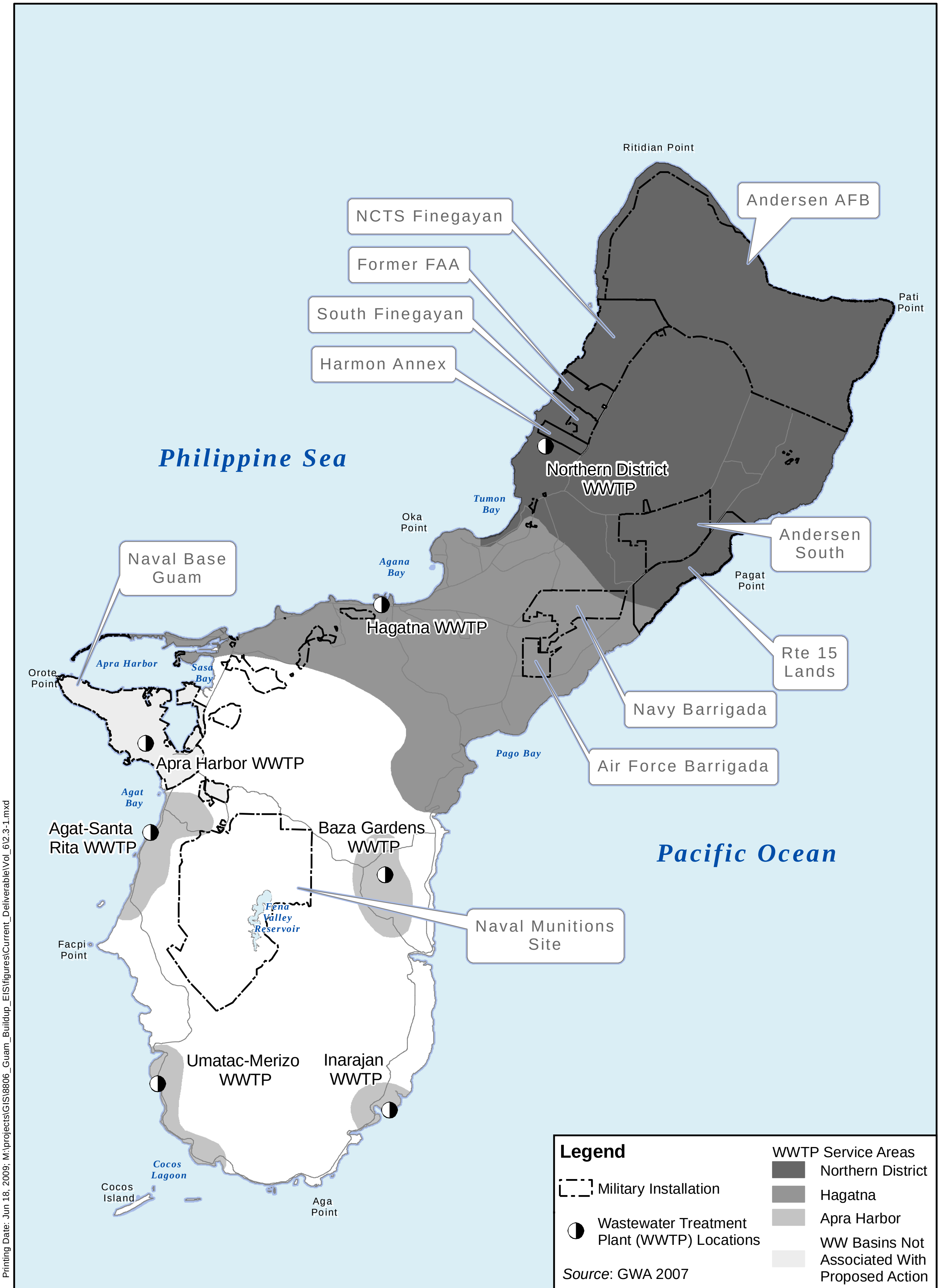


Figure 2.3-1
Wastewater Treatment Plant Locations and Service Areas, Guam

Table 2.3-2. Existing Wastewater Treatment Capacities and Demand within the Areas of Proposed Military Buildup

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
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)

2.3.2 Available Wastewater Facilities

2.3.2.1 DoD Wastewater Facilities

Apra Harbor WW Treatment Facility

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 buildup activities in the Apra Harbor area.. Therefore, no additional wastewater treatment capacity is needed at the Apra Harbor WWTP, and no changes to the NPDES permit would be necessary.

2.3.2.2 Non-DoD Wastewater Facilities (GWA Wastewater System)

As shown in Table 2.3-1, the Hagatna WWTP and the NDWWTP are GWA plants that service the areas where much of the military buildup will occur. GWA holds two NPDES permits: one for the NDWWTP and one for the Hagatna WWTP. Both permits were issued by USEPA Region 9 in June 1986. Both the Hagatna WWTP and NDWWTP each discharge to the Philippine Sea through an ocean outfall.

The NPDES permits for the Hagnata WWTP and the NDWWTP expired in 1991. Since that time USEPA Region 9 administratively extended the permit. The permits contained a variance that allows each 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. Sewage treatment facilities that are granted a 301(h) secondary treatment variance must demonstrate that their discharge does not have an impact on the environment or water quality. They must also demonstrate that they adequately control industrial wastes that could enter their plants, and they must meet minimum standards for removal of pollutants in their treatment processes.

On September 30, 2009, USEPA Region 9 made a decision to deny the secondary variance for these plants, which effectively requires GWA to install full secondary treatment at both the Hagnata WWTP and the NDWWTP. This recent decision by USEPA was issued at the same time this DEIS/OEIS was in final preparation for release to the public. The alternatives presented in this DEIS/OEIS were adjusted to recognize this secondary variance denial, and reflect the need for secondary treatment plant upgrades for all alternatives evaluated.

DoD is consultating with USEPA, GEPA, and GWA concerning wastewater requirements from the Guam military buildup. The purpose of the consultation is to achieve a common understanding of the requirements for treatment plant upgrades that address not only the military buildup on Guam, but also address requirements associated with the recent secondary treatment Section 301(h) variance denial. All parties are committed to working collaboratively to develop solutions to satisify common goals. While these discussions may ultimately lead to modifications to specific timeframes for treatment plant upgrades and treatment plant permit modifications, they are not expected to result in significantly different facilities than those respresented in the wastewater alternatives presented in this EIS/OEIS.

2.3.3 Projected Wastewater Flows

The total projected wastewater flow generated from the proposed Marine Corps relocation and associated activities 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
- Off-base civilian workers, 35 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 of 120 gpcd was applied to estimate wastewater flow generated by the off-base nonmilitary population, which includes the local Guam population, Marine Corps relocation–related construction workforce, and induced population. The construction workforce was assumed to be two-thirds in northern Guam and one-third in central Guam, while induced population was assumed to be evenly distributed over the island. 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 to be generated at NCTS Finegayan, South Finegayan, and Andersen AFB. Table 2.3-3 shows the current population in these areas of northern Guam and the projected population at the end of the military buildup in 2019 if Main Cantonment Alternatives 1 and 2 were to be selected.

Table 2.3-3. Current and Projected DoD Population at Completion of Buildup in Northern Guam for Main Cantonment Alternatives 1 and 2

Service	*Active Duty*	*Dependents*	*Transient*	*On-Base Civilian*	*Civilian Workforce (living off base)*
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

Source: Socioeconomic analysis in support of this DEIS.

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 under Main Cantonment Alternatives 1 and 2 are summarized in Table 2.3-4.

Table 2.3-4. Current and Projected Civilian and DoD Flows at Completion of Buildup for Main Cantonment Alternatives 1 and 2

Source	*Current Wastewater Flow (MGd)*	*Projected Increase in Wastewater Flow (MGd)*	*Total Projected in 2019 Average Daily Flow (MGd)*
Northern District Wastewater Treatment Plant			
Civilian	5.20	2.69	7.88
Military	0.53	3.12	3.65
Marine Corps	0.00	2.71	2.71
Navy	0.15	0.00	0.15
Air Force	0.36	0.21	0.57
Army	0.01	0.21	0.22
Total	**5.73**	**5.81**	**11.54**

Sources: GWA 2008, NAVFAC Pacific 2008d.

As a result of the proposed military buildup, the total year 2019 average daily flow to the NDWWTP from military sources is projected to increase by 3.65 MGd (13.81 mld). This would result in a total average flow to the NDWWTP in year 2019 of 11.54 MGd (43.67 mld) from both military and civilian sources. The year 2019 peak daily flow to the plant would be calculated at 25.97 MGd (98.30 mld) (based ona ratio of 2.25 to 1 of peak flow to average flow from the original design calculations of the NDWWTP). Based on 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 average flow in order to meet the 11.54 MGd total projected flow shown in Table 2.3-2. Also, the NPDES permit would need to be modified to allow the original design treatment capacity of 12 MGd (45 mld) average daily flow and 27 MGd (102 mld) maximum daily flow in order to accommodate the projected ultimate flow from the planned Marine Corps relocation at completion of buildup for Main Cantonment

Alternatives 1 and 2. Currently the NPDES permit allows only a 6 MGd flow at the plant discharge, even though the plant design flow is 12 MGd.

A socioeconomic analysis of the proposed military buildup has estimated that induced civilian growth as a result of the military buildup could increase the islandwide population on Guam by up to approximately in the peak year of 2014, which includes populations from the construction workforce and associated induced population.This corresponds to a total wastewater peak average daily flow of up to 12.75 MGd (48.25 mld) at the NDWWTP in year 2014.

Table 2.3-5 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 buildup, increases associated with the imported construction workforce, and civilian increases that could result from induced population growth in northern Guam.

Table 2.3-5. Projected Peak Wastewater Flows for Main Cantonment Alternatives 1 and 2

Source of Wastewater Flow	*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	0.53	0.53	0.53	0.53	0.53	0.53
Guam Civilian Increase	0.42	0.64	0.85	1.06	1.26	1.47
DoD Increase	0.24	0.48	0.53	0.57	2.71	2.95
Construction Workforce	0.26	0.66	1.14	1.43	1.47	0.97
Subtotal Direct DoD and Guam Civilian	**6.65**	**7.50**	**8.25**	**8.79**	**11.17**	**11.11**
Induced Civilian Increase	0.27	0.66	1.08	1.27	1.58	1.19
Total Average Daily Flow—all sources	**6.92**	**8.16**	**9.33**	**10.05**	**12.75**	**12.31**
Total Peak Daily Flow—all sources	**15.56**	**18.37**	**20.99**	**22.62**	**28.69**	**27.69**

Legend: measurements given in million gallons per day.

Peak daily flows in Table 2.3-5 are calculated from the plant-designed peak-to-average flow ratiosfor 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 mld) average daily flow and 27 MGd (102 mld) peak daily flow of, but would far exceed the NPDES permitted flow of 6 MGd (22.7 mld). Based on current conditions of the existing structures and equipments, the plant would need to be refurbished and upgraded to restore its original design capacity to accommodate peak increased flow during the peak period. 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 are 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 mld) average daily flow and 27 MGd (102 mld) maximum daily.

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 not only at Finegayan in northern Guam, but also at Navy Barrigada and Air Force Barrigada in central Guam. Table 2.3-6 shows the current military population in the Barrigada area of central Guam and the projected population at the end of the military buildup in 2019 if Main Cantonment Alternatives 3 and 8 were to be selected.

Table 2.3-6. Current and Projected DoD Population at Completion of Buildup in the Barrigada Area of Central Guam under Main Cantonment Alternatives 3 and 8

Service	*Active Duty*	*Dependents*	*Civilians On Base*
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 DEIS.

Wastewater from DoD Barrigada properties is currently conveyed to the Hagatna WWTP in central Guam for treatment and disposal. The projected DoD wastewater increases associated with the military buildup at Barrigada would be conveyed to northern Guam 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 2.3-7.

Table 2.3-7. Current and Projected Civilian and DoD Flows at Completion of Buildup for Main Cantonment Alternatives 3 and 8

Source	*Current Wastewater Flow (MGd)*	*Projected Increase in Wastewater Flow (MGd)*	*Total Projected in 2019 Average Daily Flow (MGd)*
Northern District Wastewater Treatment Plant			
Civilian	5.20	2.69	7.88
Military	0.53	3.12	3.65
Marine Corps (Finegayan)	0.00	1.63	1.63
Marine Corps (Barrigada)	0.00	1.08	1.08
Navy	0.15	0.00	0.15
Air Force	0.36	0.21	0.57
Army (Finegayan)	0.01	0.21	0.22
Army (Barrigada)	0.00	0.17	0.17
Total	**5.73**	**5.81**	**11.54**

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

Under the proposed Main Cantonment Alternatives 3 and 8, the projected DoD wastewater increases from the proposed Barrigada housing would be conveyed to northern Guam for treatment. If the wastewater flows generated from military buildup, both at Finegayan area and Barrigada area, are still treated at the NDWWTP, the total year 2019 average flow to the NDWWTP would increase to11.54 MGd (43.67 mld).

This is the same flow that is projected for the NDWWTP 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, adding chemical treatment to enhance solids removal during peak flow years, and modifying the NDPES permit to allow for the increased flows.

2.3.3.3 Projected Long-Range Wastewater Flows on Guam

Absent the military buildup in 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 civililan population growth during the period of time of the military buildup - 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 in this EIS that involves using the NDWTP, long-range wastewater flows at the NDWTP beyond the military buildup (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 of 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 an 18 MGd plant capacity at the NDWWTP.

The analysis of wastewater presented in this EIS/OEIS centers on the impacts related to the proposed action that are the responsibility of the DoD to assess; namely the military buildup on Guam during the years 2010 to 2019. Thus, the EIS presents a detailed analysis of potential environmental impacts as they relate to a projected wastewater flow of 12 MGd that could be treated at the NDWWTP during this timeframe. This EIS also includes an analysis of potential environmental impacts that may be associated with upgrades to the NDWWTP to an 18 MGd capacity, but only as they relate to expected changes in water quality that could result from increased pollutant loads in the plant discharge from a larger 18 MGd plant. See Chapter 3 Section 3.2.4.2 for this analysis.

2.3.4 Screening Process

In support of Main Cantonment Alternatives 1 and 2, eight alternatives for increasing the treatment capacity in northern Guam were evaluated. 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:

- Expand 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).
- 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)

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 2.3-8.

Table 2.3-8. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 1 and 2

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Expand 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
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

Table 2.3-8. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 1 and 2

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
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
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

Table 2.3-8. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 1 and 2

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
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
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

Table 2.3-8. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 1 and 2

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
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

In support of Main Cantonment Alternatives 3 and 8, six wastewater treatment solutions for increasing the treatment capacity were evaluated. 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 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:

- Expand 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).
- 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 six wastewater alternatives for Main Cantonment Alternatives 3 and 8 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 3 and 8

Wastewater System Alternative	*Evaluation Considerations*	*Recommendation*
Expand 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
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

Table 2.3-9. Summary of Alternatives Evaluated for Wastewater Systems in Support of Main Cantonment Alternatives 3 and 8

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

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 might be difficult. No direct potable-water-reuse programs currently operate in the United States. 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.

In addition, 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 to the project.

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 buildup 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 ac (2,000 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.

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 buildup 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.

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 buildup 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.

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

This option would build a new secondary treatment plant at the NDWWTP site, and treat the DoD wastewater from the DoD Finegayan properties including proposed USMC housings. The existing NDWWTP will be upgraded to have two separate and independent treatment process trains. The existing primary treatment will 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 will have separate headworks, primary treatment, secondary treatment, UV disinfection, and sludge handling facilities to treat the load from DoD Finegayan properties. 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 will 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 in the DoD Finegayan properties to the NDWWTP site.

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 buildup–related flows from Finegayan area.

The effluent pump station of the Hagatna WWTP would be refurbished to accept the additional DoD flows and military buildup–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 Trreatment

Under this alternative, the existing Hagatan 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 buildup 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 Barrigada properties including proposed USMC housings. The existing Hagatna WWTP will be upgraded to have two separate and independent treatment process trains. The existing primary treatment will 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 will have separate headworks, primary treatment, secondary treatment, UV disinfection, and sludge handling facilities to treat the load from DoD Barrigada properties. 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 will 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 in the DoD Barrigada properties to the Hagatna WWTP site.

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

- The majority of the improvements due to Marine relocation to Guam will 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 will help with efficient utilization of GWA's limited CIP budget resources. This approach also relieves the logistical burden of upgrading two wastewater treatment plants 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 DEIS were adjusted to recognize the secondary variance denial, and reflect the need for secondary treatment plant upgrades for all alternatives evaluated. Based on the evaluation, the following alternative was selected as the Preferred Alternative to meet the interim wastewater needs and to meet the year 2019 projected DoD demand at the completion of the DoD buildup. Under this Preferred Alternative (Basic Alternative 1) , in addition to providing upgrades to NDWWTP's primary treatment system to meet the interim wastewater demand, this basic alternative provides upgrading the NDWWTP to secondary treatment. Two options are provided to support the Main Cantonment Alternatives 1 and 2, and Main Cantonment Alternatives 3 and 8.

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

Induced civilian growth as a result of the military buildup could increase the islandwide population on Guam by up to approximately 40,000 in the peak year of 2014. Therefore, to provide the capacity to treat the interim wastewater flow generated by the construction workforce and induced population growth, this wastewater alternative would address the interim wastewater flow as well as the long-term wastewater flow.

Under 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 buildup–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.

Interim wastewater flows to the NDWWTP from military and civilian sources are projected to increase to a peak of 12.75 MGd (48.25 mld) in 2014, which would slightly exceed the design capacity of 12 MGd (45 mld). Adding chemical coagulants (enhanced primary treatment) or increasing the surface overflow rate (within the normal design range) of the clarifier would improve plant operations so that the primary clarifier would be able to treat the additional 0.75 MGd (2.84 mld) without adverse effect on the NDWWTP. However, the permit limit of 6 MGd (23 mld) would still be exceeded and the plant would still need some refurbishment and upgrades to restore it to the original design capacity.

The existing NPDES permit of the NDWWTP is based on a maximum daily flow of 6 MGd (23 mld). Under this interim alternative, the liquid treatment system of the NDWWTP would be refurbished to restore the plant's originally designed treatment capacity of 12 MGd (45 mld) so that the plant would comply with regulations associated with treating the increased wastewater flow from the military buildup. 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 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 somewhere on Guam could be explored in the future.

Based on the plant's current capacity, to accommodate anticipated interim flow and loadings while still achieving the existing primary-treatment requirement, the following existing components of the NDWWTP would have to be refurbished and upgraded:

- Headworks with odor control
- Two primary clarifiers
- Two anaerobic digesters
- Two centrifuge solids-dewatering systems with odor control
- Two chlorine contact tanks
- Effluent monitoring

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 mld) to the Philippine Sea. This would be enough disposal capacity to handle the increased flow during the peak period.

Under 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 buildup 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.

The condition of the NDWWTP is constantly improving because substantial upgrades are being performed by GWA. The plant's final operational conditions should be based on assessment of the plant's processes with the most recent plant upgrades included.

In accordance with GWA's *Water Resources Master Plan* (GWA 2007), the NDWWTP has already planned and allocated budget for the Capital Improvements Plan (CIP) to achieve the designed treatment capacity of 12 MGd (45 mld) for both liquid and solid treatment processes by the year 2015. With implementation of the recommendations included in the CIP, the NDWWTP would have enough capacity to handle additional wastewater flow generated during the peak flow years.

The Navy would coordinate with GWA to expedite the planned CIP so that the NDWWTP would have enough capacity to bridge the gap between existing conditions and the final long-term wastewater solution. The proposed short-term modifications to the NDWWTP should be completed by 2013. The Navy would also need to coordinate with GWA to request a NPDES permit modification from USEPA Region 9 to increase 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 mld).

Alternative 1a would also upgrade the refurbished primary treatment system at the NDWWTP to secondary treatment, to treat both current wastewater flow and projected future flows from both civilian and military sources. A trickling filter system is proposed as the secondary treatment process. The following new process components and upgrades would be required at the NDWWTP for this alternative:

- Four trickling filters
- Four secondary clarifiers
- Two additional anaerobic digesters (the same size as existing ones)
- One additional centrifuge solids-dewatering system and odor control

The proposed secondary treatment upgrades to the NDWWTP should be completed by 2016. This alternative would require modifications to the NPDES permit from USEPA Region 9 to set new discharge limits and permit conditions.

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

Under 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 interim 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 by 2013.

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 DoD buildup, 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.

2.3.7.1 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 2.3.4.1 in this Volume). The NDWWTP would have been refurbished and the plant's primary treatment capacity <u>would</u> have been upgraded to accept the additional DoD flows and military buildup–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 discussed programmatically.

Interim wastewater flows to the NDWWTP from military and civilian sources are projected to increase to a peak of 12.75 MGd (48.25 mld) in 2014, which would slightly exceed the design capacity of 12 MGd (45 mld). Adding chemical coagulants or increasing the surface overflow rate (within the normal design range) of the clarifier would improve plant operations so that the primary clarifier would be able to treat the additional 0.75 MGd (2.84 mld) without adverse effect on the NDWWTP. However, the permit limit of 6 MGd (23 mld) would still be exceeded and the plant would still need some refurbishment and upgrades to restore it to the original design capacity.

Printing Date: Oct 22, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.3-2.mxd

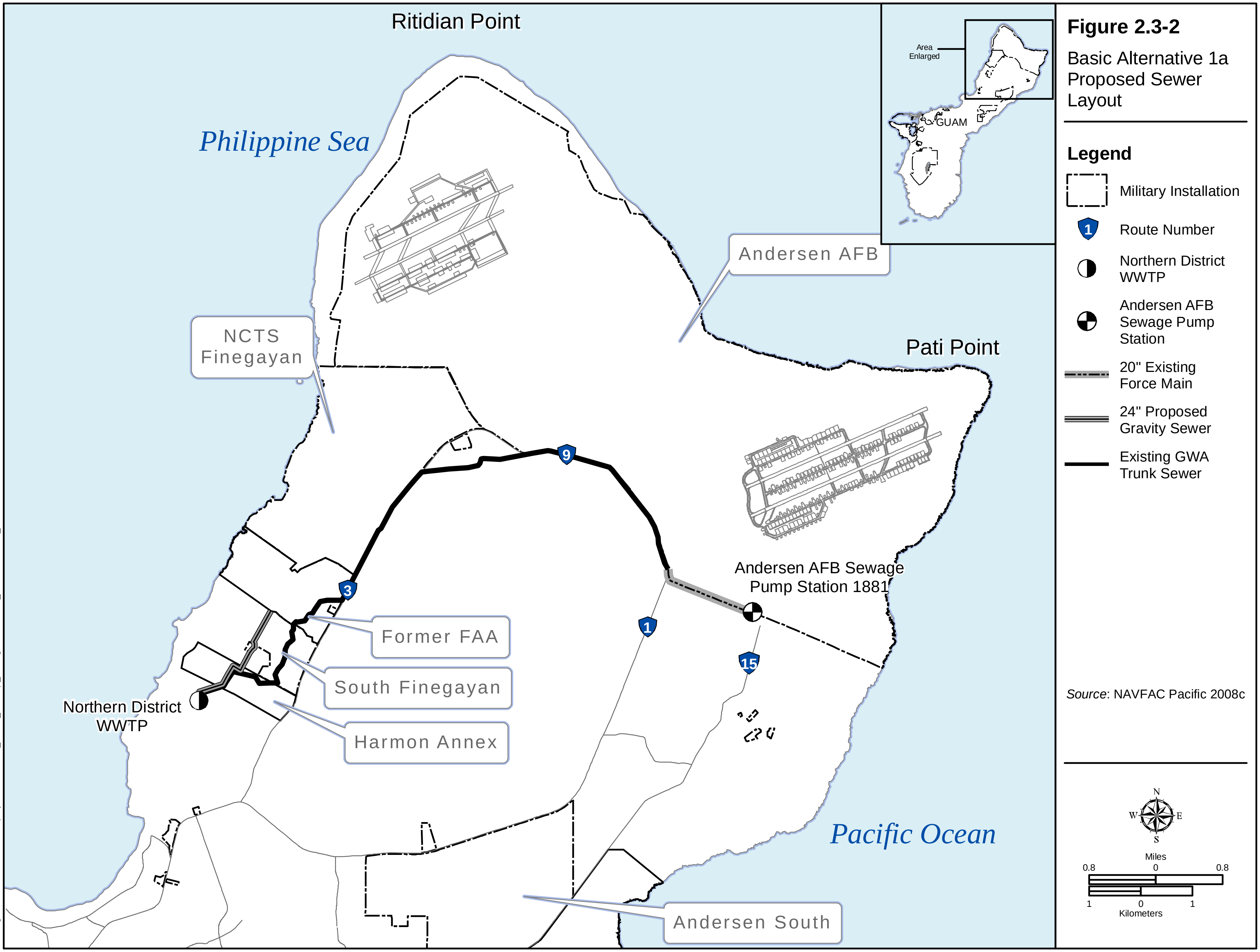


Figure 2.3-2
Basic Alternative 1a Proposed Sewer Layout

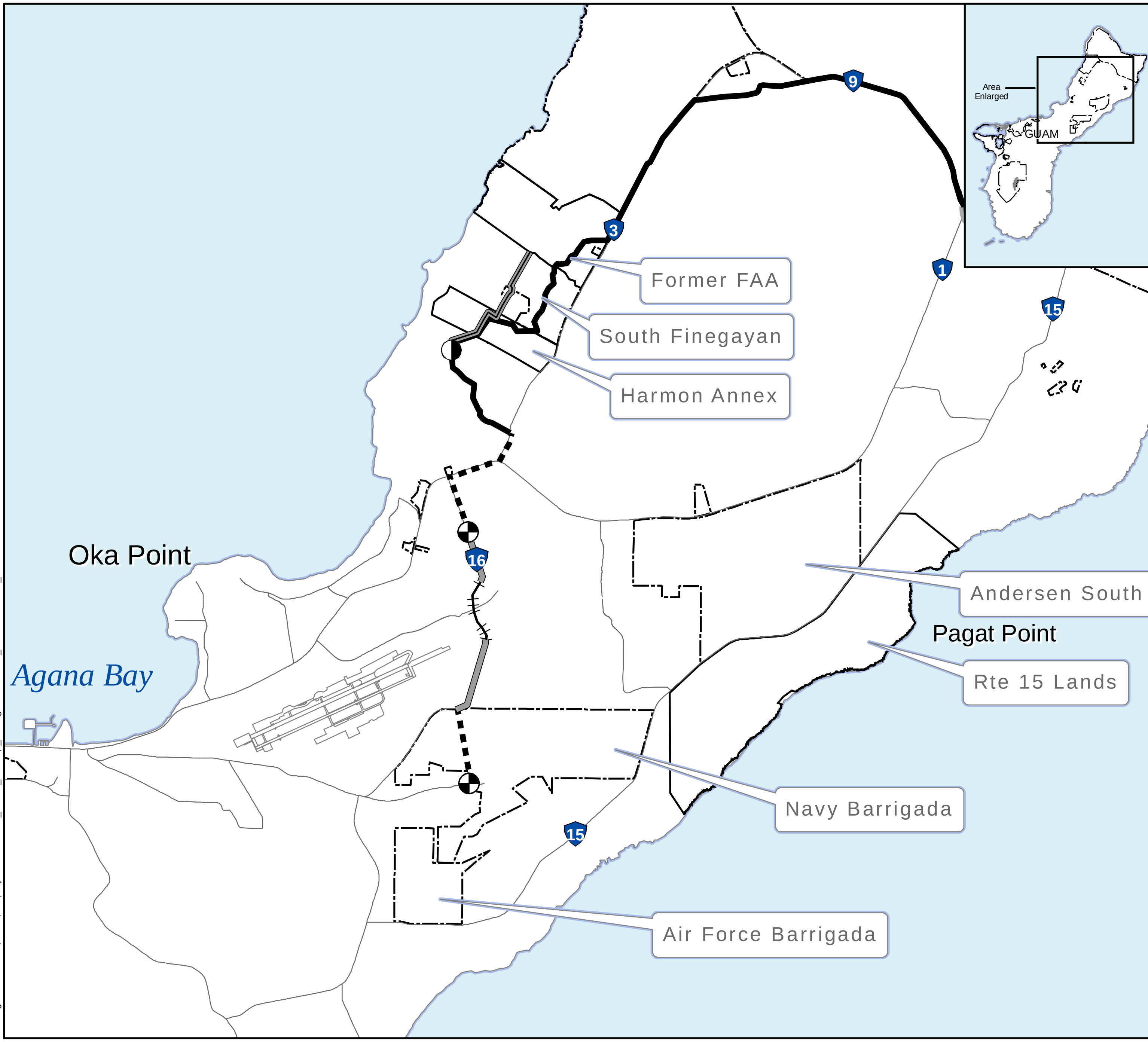


Figure 2.3-3

Basic Alternative 1b Proposed Sewer Layout

Legend

Military Installation

Route Number

Northern District WWTP

Pump Station

15" Proposed Gravity Sewer

18" Proposed Force Main

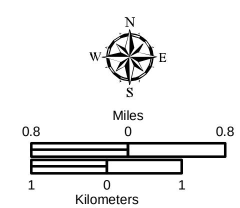
24" Proposed Gravity Sewer

20" Existing Force Main

24" Proposed Gravity Sewer

Existing GWA Trunk Sewer

Source: NAVFAC Pacific 2008c



Printing Date: Oct 23, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.3-3.mxd

The existing NPDES permit of the NDWWTP is based on a maximum daily flow of 6 MGd (23 mld). Under this interim alternative, the liquid treatment system of the NDWWTP would be refurbished to restore the plant's originally designed treatment capacity of 12 MGd (45 mld) so that the plant would comply with regulations associated with treating the increased wastewater flow from the military buildup. 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 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, either to a landfill or for a beneficial use in the future.

Based on the plant's current capacity, to accommodate anticipated interim flow and loadings while still achieving the existing primary-treatment requirement, the following existing components of the NDWWTP would have to be refurbished and upgraded:

- Headworks with odor control
- Two primary clarifiers
- Two anaerobic digesters
- Two centrifuge solids-dewatering systems with odor control
- Two chlorine contact tanks
- Effluent monitoring

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 mld) to the Philippine Sea. This would be enough disposal capacity to handle the increased flow during interim period.

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 buildup 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 (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 on the west side of the planned Marine Corps Finegayan development to the headworks of the NDWWTP. The proposed short-term modifications to the NDWWTP and collection system should be completed by 2013.

The condition of the plant is constantly improving because substantial upgrades are being performed, and the plant's final operational conditions should be based on assessment of the plant's processes with the most recent plant upgrades included.

In accordance with GWA's *Water Resources Master Plan* (GWA 2007), the NDWWTP has already planned and allocated budget for the CIP to achieve the designed treatment capacity of 12 MGd (45 mld) for both liquid and solid streams by the year 2015. With implementation of the recommendations included in the CIP, the NDWWTP would have enough capacity to handle additional wastewater flow generated during the short-term interim construction period.

The Navy would coordinate with GWA to expedite the planned CIP so that the NDWWTP would have enough capacity to bridge the gap between existing conditions and the final long-term wastewater solution. The proposed short-term modifications to the NDWWTP should be completed by 2013. The Navy would also need to coordinate with GWA to request a NPDES permit modification from USEPA

Region 9 to increase 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 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 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.

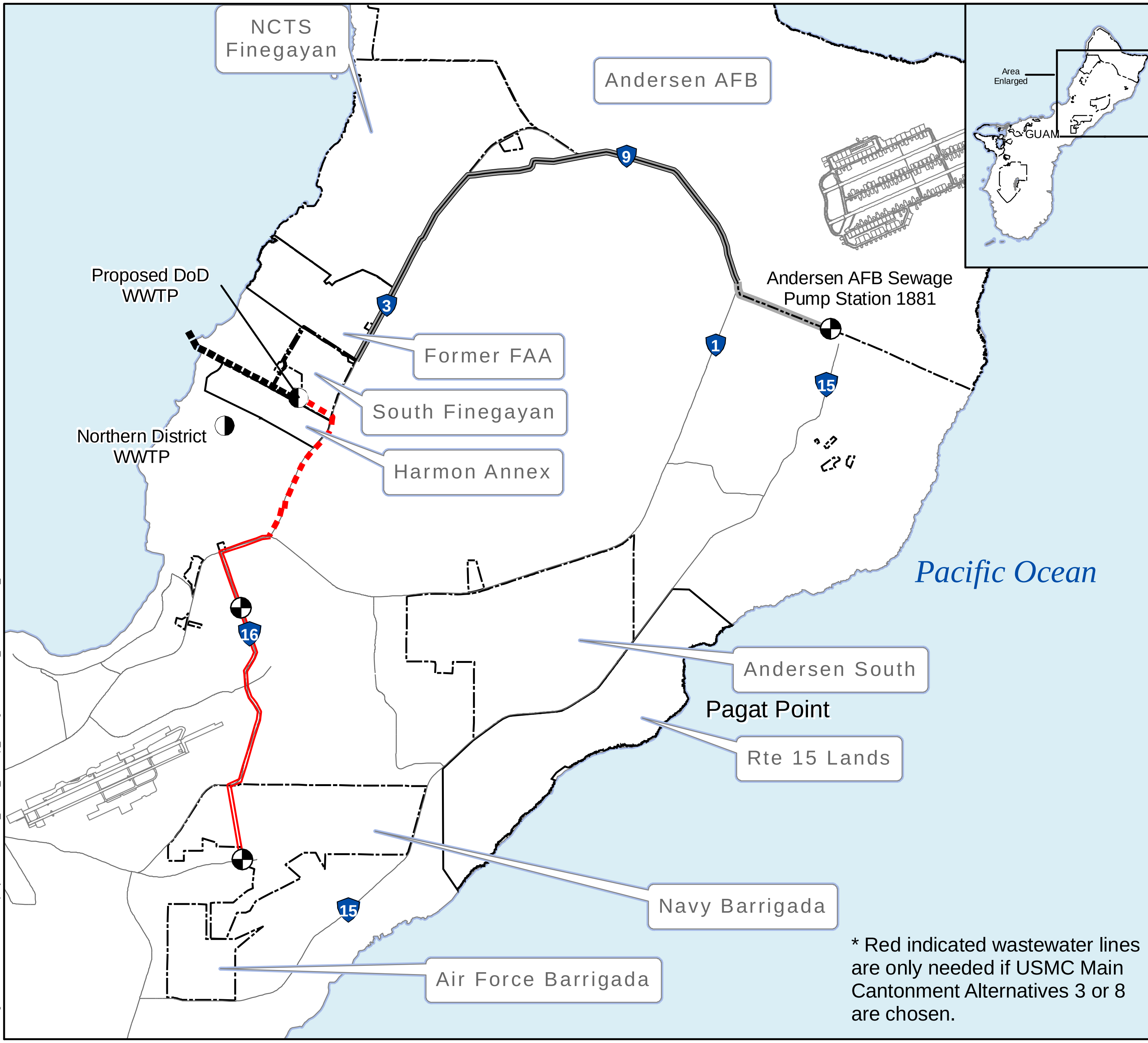


Figure 2.3-4
Long-Term Alternative 1 Proposed Sewer Layout for DoD Secondary Treatment

Legend

- Military Installation
- Route Number
- Proposed DoD WWTP
- Northern District WWTP
- Pump Station
- 30" Proposed Outfall
- 20" Existing Force Main
- 21" Proposed Gravity Sewer
- 24" Proposed Gravity Sewer

Only for Cantonment Alternatives 3 or 8*

- 18" Proposed Force Main
- Proposed Sewer from Basic Alternative 1b

Source: NAVFAC Pacific 2008c

N E S W
Miles 0.8 0 0.8
Kilometers 1 0 1

Printing Date: Oct 23, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.3-4.mxd

2.4 Solid Waste

Chapter 2:
2.1 Power
2.2 Potable Water
2.3 Wastewater
2.4 Solid Waste
2.5 Off Base Roadway Projects

2.4.1 Anticipated Demand

Projections for solid waste generation rates from the proposed military buildup on Guam are presented in Table 2.4-1. The table lists annual tonnages of solid waste resulting from the increased population. The table also provides a breakdown between on-base and off-base quantities of solid waste. These estimates are based on an assumed generation rate of 7.4 pounds (lb) (3.4 kilograms [kg]) per capita per day. The assumed generation rate includes residential, commercial, industrial, and construction waste streams (HDR/Hawaii Pacific Engineers 2008).

Table 2.4-1. Projected Solid Waste Estimates (tons)

Source of Solid Waste	*Year*										
	2010	*2011*	*2012*	*2013*	*2014*	*2015*	*2016*	*2017*	*2018*	*2019*	*Totals (tons)*
On Base											
DoD Baseline and DoD Nonproject Related	25,249	25,249	25,730	25,851	26,040	26,220	26,220	26,220	26,220	27,207	260,205
DoD Proposed Action Related	1,551	4,180	4,180	4,180	28,796	40,772	40,772	40,772	40,772	40,772	246,748
Total On Base	**26,800**	**29,429**	**29,910**	**30,031**	**54,836**	**66,992**	**66,992**	**66,992**	**66,992**	**67,979**	**506,954**
Off Base											
Non-DoD Proposed Action Related	13,356	33,411	55,648	66,823	78,134	56,653	25,592	14,129	14,129	14,368	372,243
Total On and Off Base	**40,156**	**62,840**	**85,558**	**96,854**	**132,970**	**123,644**	**92,584**	**81,121**	**81,121**	**82,347**	**879,197**

Notes: DoD Nonproject Related includes DoD sources of solid waste not related to the military buildup.
Assumes per capita generation rate of 7.4 pounds (3.4 kilograms) per capita per day.
Civilian solid waste generation not related to the military buildup is not included.
Source: HDR/Hawaii Pacific Engineers 2008

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 Figure 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 construction and demolition 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) 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. A Base Operations Support contractor operates and maintains the facility under a current Resource Conservation and Recovery Act (RCRA) 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 would need to further expand the existing landfill or pursue diversional and/or operational measures to maximize landfill life.

The remaining non-DoD waste stream on Guam is disposed directly at the GovGuam Ordot Dump facility located in central Guam and via citizen drop-off transfer stations. The Ordot Dump does not accept construction or demolition debris; two on-island hardfills (i.e., for construction and demolition debris) are currently permitted and available to accept this type of waste. The Northern Hardfill is a privately owned landfill that accepts construction and demolition debris and is located on Route 15 (back road to Andersen AFB). Another privately owned facility allowed to accept construction and demolition 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 (NASA) 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 2009a). 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 (yd^3) (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 buildup 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 (HDR/Hawaii Pacific Engineers 2008). The projection indicates that the Navy Sanitary Landfill would have the capacity to accommodate the on-base generated solid waste during the military buildup, assuming that the landfill was filled to a maximum height of 54 ft (16 m) above msl.

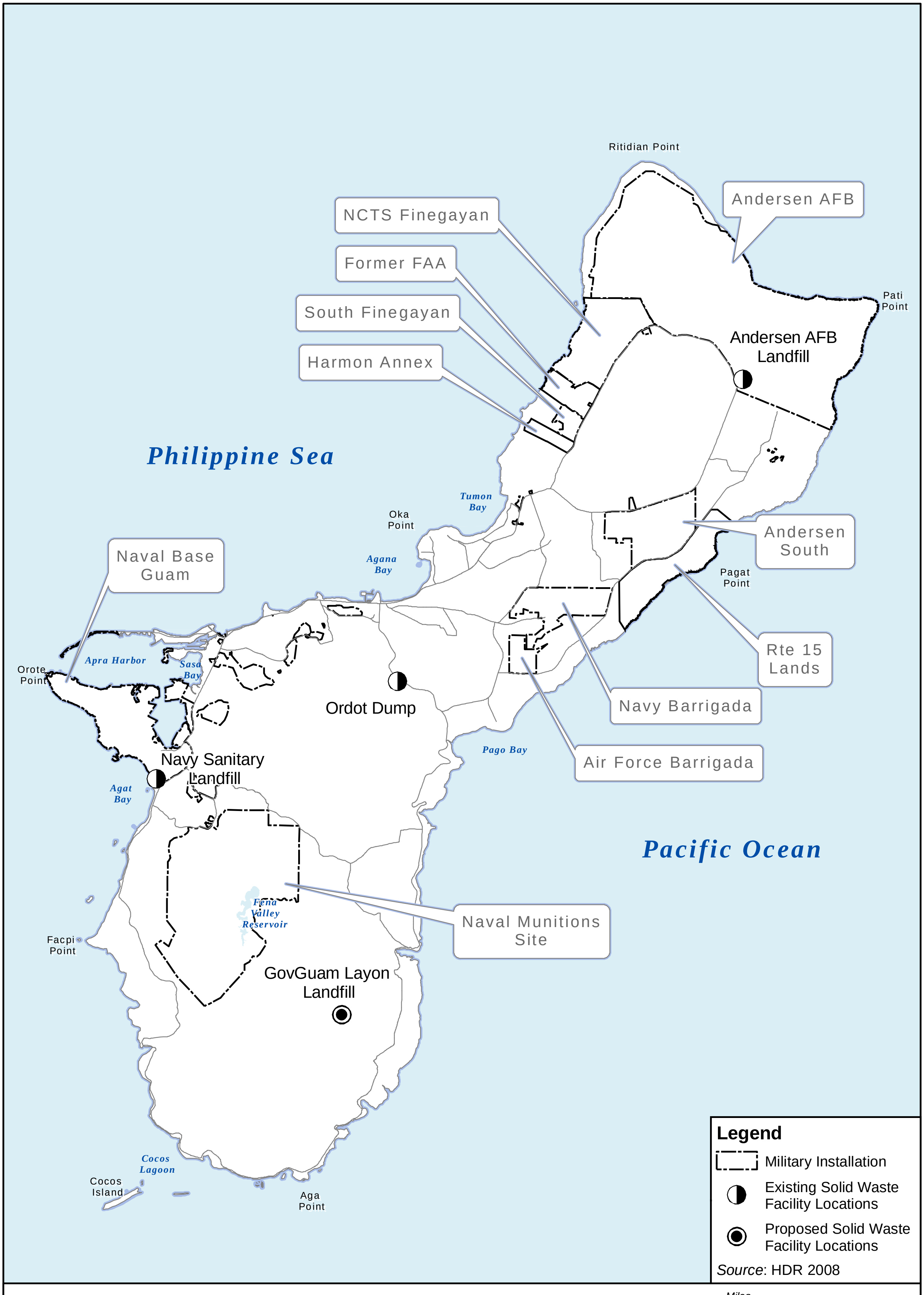


Figure 2.4-1
Solid Waste Facility Locations, Guam

Printing Date: Oct 2, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.4-1.mxd

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*		
237,431 [a]	269,522[a]	506,954	540,000[b]	33,046

Notes: [a] From Table 2.4-1; [b] Based on computed volume from Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation (HDR/Hawaii Pacific Engineers 2008), and converting to weight using an in-place density = 1,200 lb/yd^3 and solid waste to cover material ratio of 3:1.

2.4.3 Screening Process

Although the solid waste disposal demand as a result of the proposed military buildup (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 Gershman, Brickner, & Bratton (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* (HDR/Hawaii Pacific Engineers 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 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 Solid Waste
- 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.

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 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

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

Solid Waste Disposal System Alternative	*Evaluation Considerations*	*Recommendation*
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
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 buildup.	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 DEIS for the solid waste management facility for the Island of Guam concluded that this site location was deficient based on the siting criteria. *Implementation/Policy:* Permits have not yet been obtained, and the process could be long and contentious. *Implementation/Policy:* Funding for the project is uncertain.	Dismissed

2.4.4 Alternatives Dismissed

A description of the alternatives for solid waste solutions that were dismissed, and the rationale for their dismissal, are summarized 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* (HDR/Hawaii Pacific Engineers 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 yd^3 (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.

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 Ordnance Annex. 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 yd^3 (4,855,000 m^3) or 2,860,000 tons (2,595,000 metric tons) (assuming an in-place density of 1,200 lb/yd^3 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* (HDR/Hawaii Pacific Engineers 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 buildup. 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 buildup; 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 DPW 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 would need to further expand the existing landfill or pursue diversional and/or operational measures to maximize landfill life.

Therefore, using the existing landfill at Andersen AFB was judged as nonviable because its remaining site life is very limited; and 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 has implemented a 2-ac (0.81-ha) expansion to provided 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. Further 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

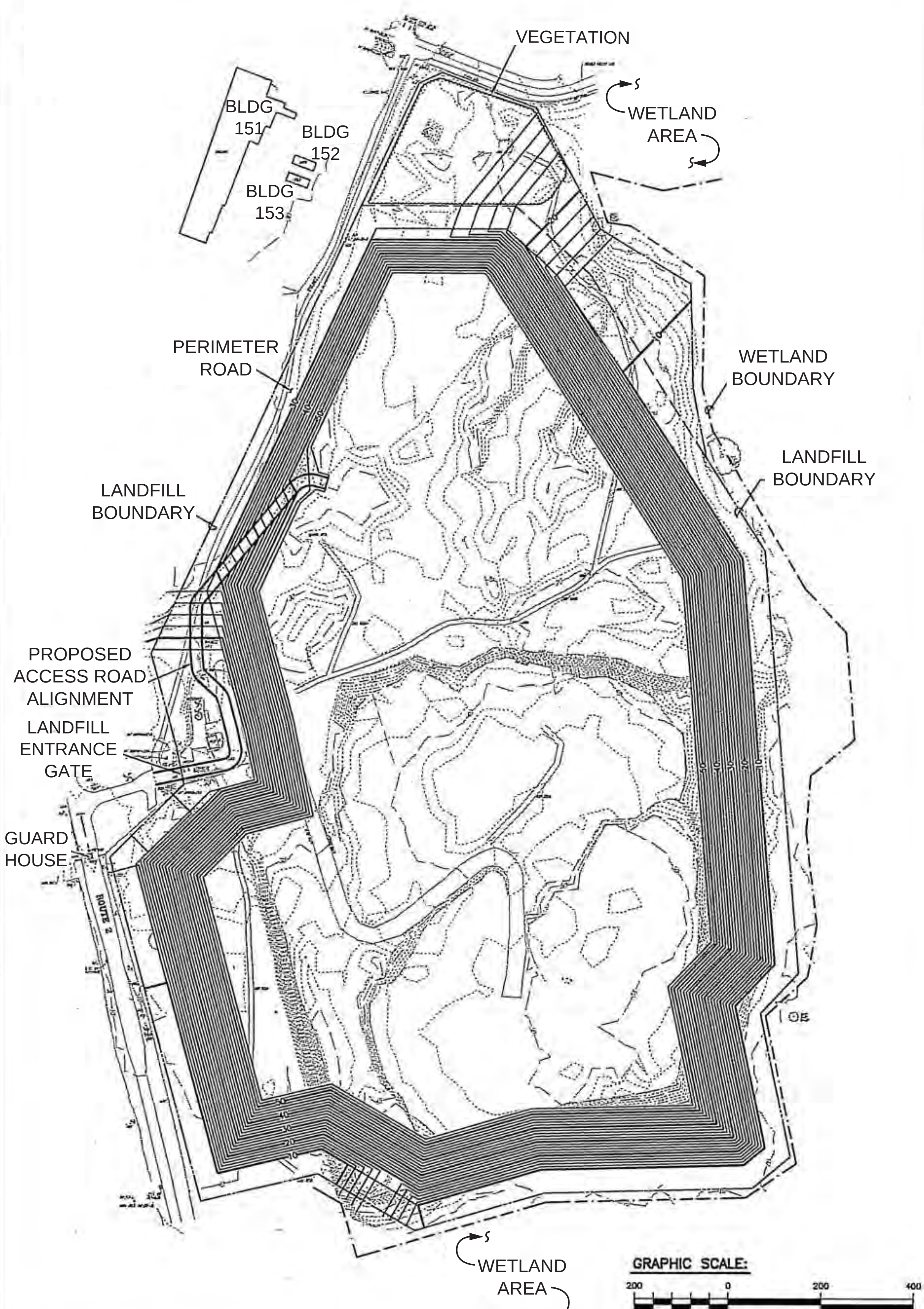
This alternative would involve using a planned WTE facility and landfill owned and operated by Guam Resource Recovery Partners located at Atantano. As described in the *Guam Solid Waste Utility Study for Proposed U.S. Marine Corps Relocation* (HDR/Hawaii Pacific Engineers 2008), the landfill would have 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. This process could be long and contentious given the litigious history of the project and it is not clear how funding for the project would be obtained. 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

The Preferred Alternative would consist of using the Navy Sanitary Landfill at Apra Harbor until the new Layon Landfill is completed by GovGuam in 2011, then using the Layon Landfill for disposal of all DoD solid waste. As described in Section 2.4.2, the Navy Sanitary Landfill has the potential to provide 10 years of capacity (until 2019) based on the computed demand in Table 2.4-1 and a capacity of 1,200,000 yd^3 (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 to that 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.

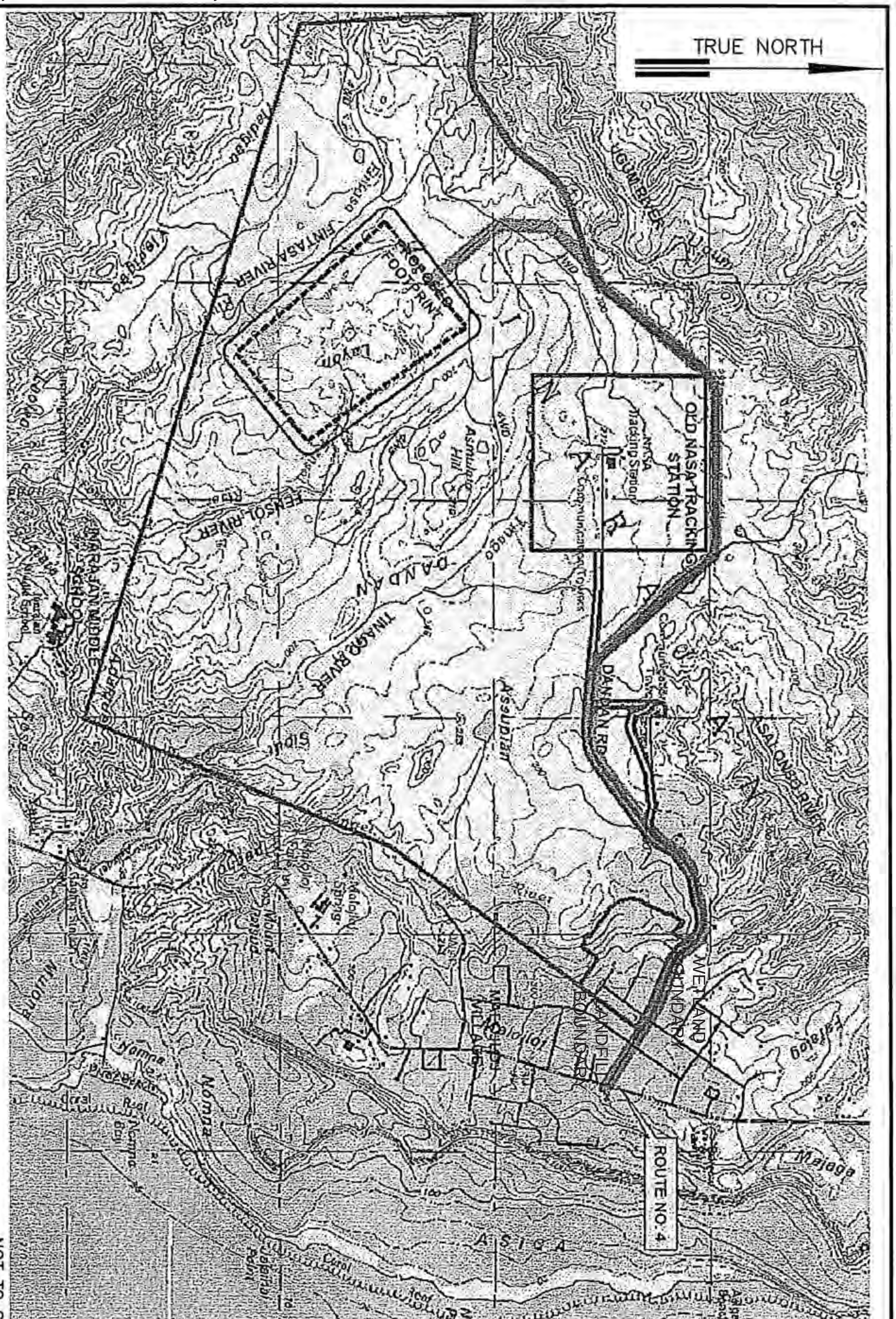
Once the new Layon Landfill is opened, DoD would send its solid waste to the GovGuam Layon Landfill. A site plan of the Layon Landfill is presented in Figure 2.4-3. The site selected for the Layon Landfill is approximately 317 ac (128 ha) in size, with a landfill footprint of 127.4 ac (51.6 ha) and a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



L:\work\ERW\Projects\TEC JV TO 6 EIS Marianas Is\Navy Sanitary Landfill with Max Elevation.ai 10/01/2009 rks

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

Figure 2.4-3
Layon Landfill Location, Guam



The landfill site would be accessed from Route 4 by approximately 3.3 miles (5.4 km) of reconstructed 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

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 ft (4.6 m) below existing grade to provide cover soils. The landfill footprint and shape would be more clearly defined during the design process to further reduce the impacts on the site based on refined geotechnical and hydrogeological surveys and analysis that is specific to the design.

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* (Guam DPW 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 yd^3 (1,075,861 m^3) (GEPA 2009). Table 2.4-4 presents the projected solid waste generation rates from both the military buildup 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 air space capacity of 15,808,794 yd^3 (12,086,690 m^3), the table indicates that the landfill would reach capacity in 2043, 32 years after opening.

Table 2.4-4. Projected Solid Waste Generation

Year	*DoD-Related Solid Waste (tons/yr)* [1, 2]	*Guam General Population Solid Waste (ton/yr)* [1, 3]	*Total Solid Waste (tons/yr)*	*Total Solid Waste (yd^3/yr)* [4]	*Cumulative Total Solid Waste (yd^3)*
2011	62,840	176,417	239,257	398,761	398,761
2012	85,558	178,685	264,243	440,405	839,166
2013	96,854	180,920	277,774	462,956	1,302,123
2014	132,970	183,124	316,094	526,824	1,828,946
2015	123,644	185,302	308,947	514,911	2,343,857
2016	92,584	187,460	280,044	466,740	2,810,598
2017	81,121	189,595	270,716	451,194	3,261,791
2018	81,121	191,701	272,822	454,703	3,716,494
2019	82,347	193,775	276,123	460,204	4,176,699
2020	82,347	195,713	278,060	463,434	4,640,133
2021 to 2041	1,729,297	4,593,692	6,322,989	10,538,315	15,178,447
2042	82,347	243,607	325,954	543,257	15,721,705
2043	82,347	246,043	328,390	547,317	16,269,022

Notes:
[1]Assumes DoD waste generation rate of 7.4 pounds per person per day and a Guam general population waste generation rate of 5.28 pounds per person per day.
[2]Assumes that after 2019 the DoD population would remain constant.
[3]General Guam population after 2019 assumed to increase by 1% per year
[4]Assumes 1,200 pounds per cubic yard
2014 indicates the year which Layon Landfill Cells 1 and 2 would reach capacity.
2043 indicates the year which the Layon Landfill would reach total capacity.

The Layon Landfill is currently projected to be ready for acceptance of solid waste by July 2011 (Gershman, Brickner, & Bratton 2009a). The Layon Landfill has been designed to accommodate solid waste from all current and future DoD sources, as well as civilian and commercial sources.

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 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

Construction and demolition (C&D) debris is expected to be generated as a result of proposed construction and proposed demolition of old structures to facilitate the proposed military buildup. These C&D projects are estimated to generate approximately 501,000 yd^3 (383,000 m^3) of new construction debris and 1,361,000 yd^3 (1,041,000 m^3) of demolition debris for a total of 1,860,000 yd^3 (1,422,000 m^3) of C&D debris. This debris would consist of wood, drywall, metal, concrete, asphalt, plastic/polyvinyl chloride, and other miscellaneous waste.

Very little hardfill capacity is currently available on-island to deal with the large volume of C&D debris that would be generated. The available DoD hardfills include the C&D hardfill at the Andersen AFB Landfill, and a designated C&D debris cell within the current inactive area of the Navy Sanitary Landfill. In 2008, GBB (the receivership firm responsible for GovGuam solid waste operations) enacted a ban on C&D waste at the Ordot Landfill. Currently all non-DoD C&D waste is disposed at privately operated hardfills. There are currently two private hardfill facilities in operation: the Northern Hardfill near Andersen AFB (estimated capacity of 30,000 yd3 [23,000 m3]) and the Eddie Cruz Hardfill (newly permitted at a capacity of 75,000 yd3 (57,300 m3) in Yigo). GovGuam does not own or operate a hardfill at this time.

Recent correspondence with GBB indicates that C&D waste would be accepted at the Layon Landfill for recycling and reuse. The C&D waste would be managed through a process that maximizes recycling and alternative reuse on-site. This process would include receiving and processing C&D (both military and nonmilitary), of which certain types can be used on the landfill site for operation and maintenance purposes (GBB 2009b).

In addition to the disposal option at the Layon Landfill, it is recommended that the military develop new hardfill capacity (such as at the Navy Sanitary Landfill) and upgrade and greatly expand its recycling programs to process solid waste and C&D debris. It is estimated that an efficient recycling program can recycle roughly 50% to 70% of C&D waste generated, thereby diverting it from island landfills and hardfills. Guidance for DoD management of C&D waste is provided in the *DoD Integrated (Non-Hazardous) Solid Waste Management Policy*, presented in the Deputy Under Secretary of Defense for Installation and Environment Memorandum, dated February 1, 2008. The memorandum sets a diversion goal for C&D waste of 50% by 2010.The memorandum also sets a DoD diversion goal for non-hazardous solid waste excluding C&D waste of 40% by 2010. The memorandum requires all DoD component installations to implement integrated solid waste management to achieve the goals set forth in EO 13423 (EO 13423). Additionally, a recent EO dated October 5, 2009, *Federal Leadership in Environmental, Energy, and Economic Performance*, establishes similar diversion goals to be achieved by 2015 (EO 2009).

At Andersen AFB, construction debris such as concrete, asphalt, and rock are piled together and processed through a rock crusher. The crushed debris is then mixed with dirt and used as daily cover for the landfill. Construction and demolition debris that cannot be crushed is disposed of in the hardfill section of the landfill.

Disposal of asbestos and other debris with low levels of contamination (e.g. polychlorinated biphenyls at less than 50 parts per million) can be disposed in a RCRA Subtitle D municipal solid waste landfill. However, it appears that a majority of this type of waste would be classified as “unacceptable” waste and would not be allowed at the Layon Landfill. The draft operations plan for Layon Landfill (TG Engineers 2009) establishes procedures for screening unacceptable waste and how it would be handled if it is brought to the landfill. The operations plan also provides guidance and procedures for handling special wastes such as sewage sludge, sandblast grits, baghouse dusts, inorganic filter cake, empty containers, and treated medical waste. Construction contracts implemented for the military buildup would establish requirements for contractors to test materials before demolition to determine whether materials contain excessive levels of lead-based paint or asbestos. Contractors would then be responsible for segregating the waste and disposing at proper facilities.

2.4.5.3 Solid Waste Reduction Initiatives

The policies and guidance being followed by the Navy for the military buildup require that new development be designed to meet the U.S. Green Building Council's Leadership in Energy and Environmental Design (LEED) Silver Certification for New Construction (LEED-NC). The Navy's goal is to achieve LEED Silver requirements, and initiatives would be built into construction contracts. LEED Silver credits are awarded if more than 50% of nonhazardous construction and demolition debris is recycled or salvaged and additional credit is given if 75% recycling rates are achieved.

Currently two studies are being conducted regarding solid waste reduction. The first study is related to municipal solid waste recycling for long term DoD waste generation on Guam, including waste generated as part of the military buildup. The second study is related to C&D debris associated with the construction phase of the military buildup. The C&D debris study will estimate the quantity of material generated and what portion of the material could be potentially reused.

2.5 OFF BASE ROADWAYS

2.5.1 Introduction

This section provides a detailed description of the proposed action and alternatives comprising the offbase 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. 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 Guam Road Network (GRN), a related action to the relocation activity. The GRN also includes road projects that address organic growth on Guam without the military buildup (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 CVN 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* has programmed projects to address many of the immediate needs of Guam that have not been addressed in many years. The planned military buildup 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. Buildup activities related to military facility construction would occur from 2010 through 2016, with peak construction and population in 2014. Road construction to support the military buildup would also need to commence in 2010 and be complete by 2016.

The existing traffic volumes, physical conditions, and designs of Guam's roads vary widely. As a result of the military buildup 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/PB 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 per month)*
MK48 Front Power Unit with Trailer	99,052	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	75
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	75
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	4
		Finegayan to Andersen AFB (Routes 3 and 9)	8
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	8
MTVR with Howitzer (M777)	68,690	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	14
LVSR MKR18	99,052	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	79
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	
		Finegayan to Andersen AFB (Routes 3 and 9)	
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	
STD MTVR AMK 23/25	64,800	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	TBD
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	
		Finegayan to Andersen AFB (Routes 3 and 9)	
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	
MTVR AMK 27/28	64,800	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	TBD
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	
		Finegayan to Andersen AFB (Routes 3 and 9)	
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	
Armored LVSR Cargo Truck	107,900	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	TBD
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	
		Finegayan to Andersen AFB (Routes 3 and 9)	
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	
Armored LVSR Wrecker	116,500	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	TBD
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	
		Finegayan to Andersen AFB (Routes 3 and 9)	
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	
Armored LVSR Tractor	114,900	Finegayan to Apra Harbor (Routes 11, 1, 8, 16, 27, and 3)	TBD
		Finegayan to Naval Base Guam (Routes 1, 8, 16, 27, and 3)	
		Finegayan to NMS (Routes 11, 1, 8, 16, 27, and 3)	
		Finegayan to Andersen AFB (Routes 3 and 9)	
		Finegayan to Andersen AFB South (Routes 3, 9, and 1)	

Note: TBD = To Be Determined
Source: Marine Corps 2008; Parsons/PB 2008.

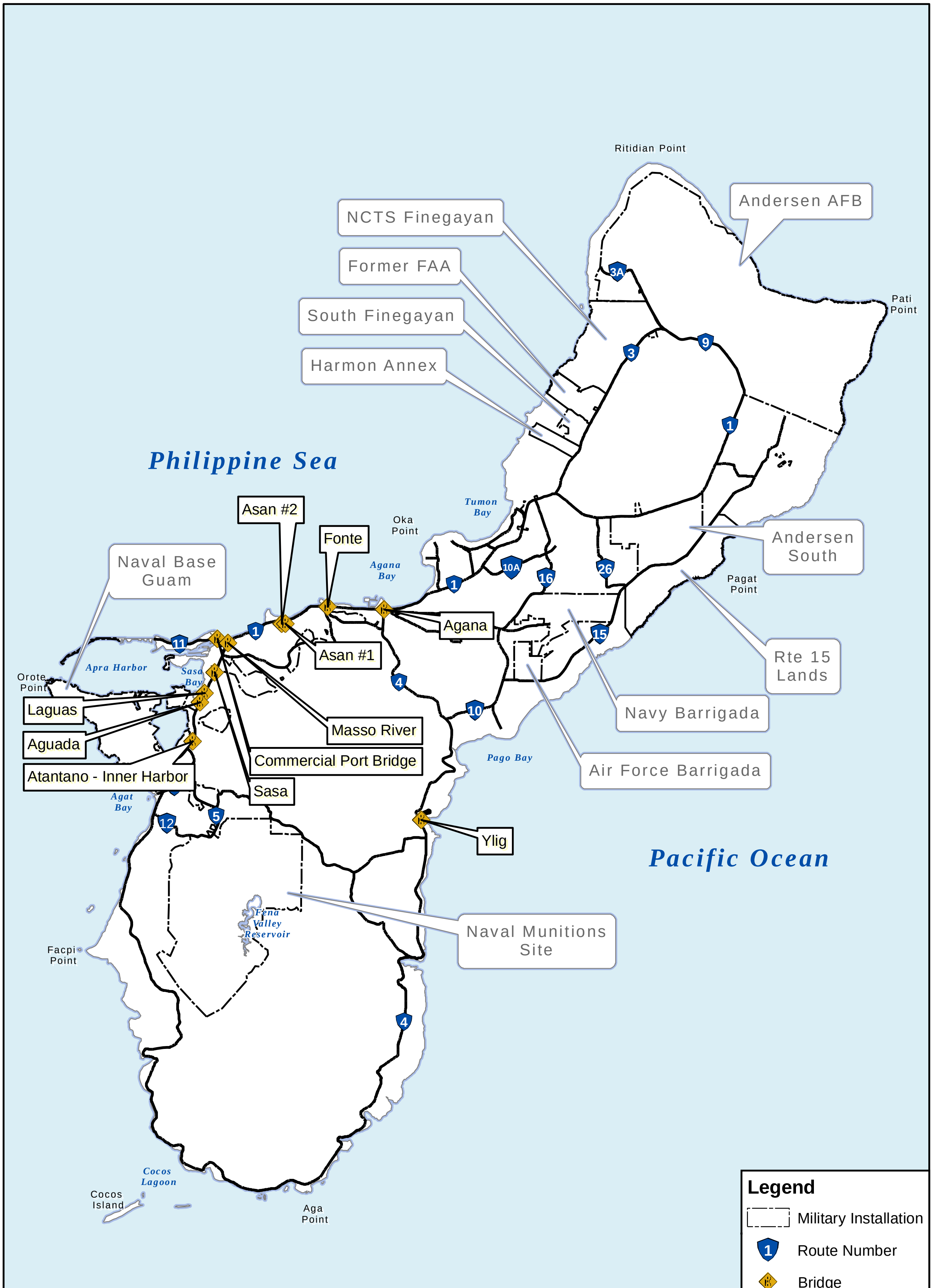
A pavement analysis was conducted to systematically identify and quantify the structural effects on Guam's roadways that would result from military buildup, primarily those activities associated with constructing the infrastructure to support the relocation of Marines to Guam. The pavement analysis focused on the roadways that would be used during the construction and buildup 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 buildup. The bridges were evaluated to determine structural adequacy for military and construction traffic before, during, and after redeployment (Table 2.5-2).

The analysis found that Agana Bridge #1 has insufficient inventory and operating ratings and would not be able to support the proposed loadings associated with the hauling of construction materials and equipment. (The inventory rating is the load that a bridge can carry for an indefinite number of loading cycles without detriment to the bridge. The operating rating corresponds to a maximum load that can be carried on an infrequent basis without detriment to the bridge.) For this reason, replacement of this bridge would be required. Four of the other bridges have ratings below the appropriate load-bearing capacities for many military vehicles. 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 a retaining wall confines the roadway structure. Ylig Bridge is currently being replaced by GovGuam.



Printing Date: Oct 13, 2009, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.5-1.mxd

Figure 2.5-1
Bridges on Guam

Table 2.5-2. Structural Data for Bridges on Guam

Route	*Structure*	*Year Built*	*Load Ratings**	
			Inventory Rating (tons)	*Operating Rating (tons)*
1	Atantano Bridge	1970	36	60
1	Agueda Bridge	1987	36	60
1	Laguas Bridge	1985	36	60
1	Sasa Bridge	1985	36	60
1	Masso Bridge	1980	36	60
1	Asan Bridge #2	1985	36	60
1	Asan Bridge #1	1983	36	60
1	Fonte Bridge	1982	36	60
1	Agana Bridge #1	1945	20	33

*Notes: * Inventory and operating ratings based on 2004 Federal Highway Administration bridge inspection reports.*

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 military access points along existing roadways. The military access points were identified by the military and are for commercial and/or residential access.

2.5.1.5 Mass Transit

The traffic projections developed by the Guam DPW 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.

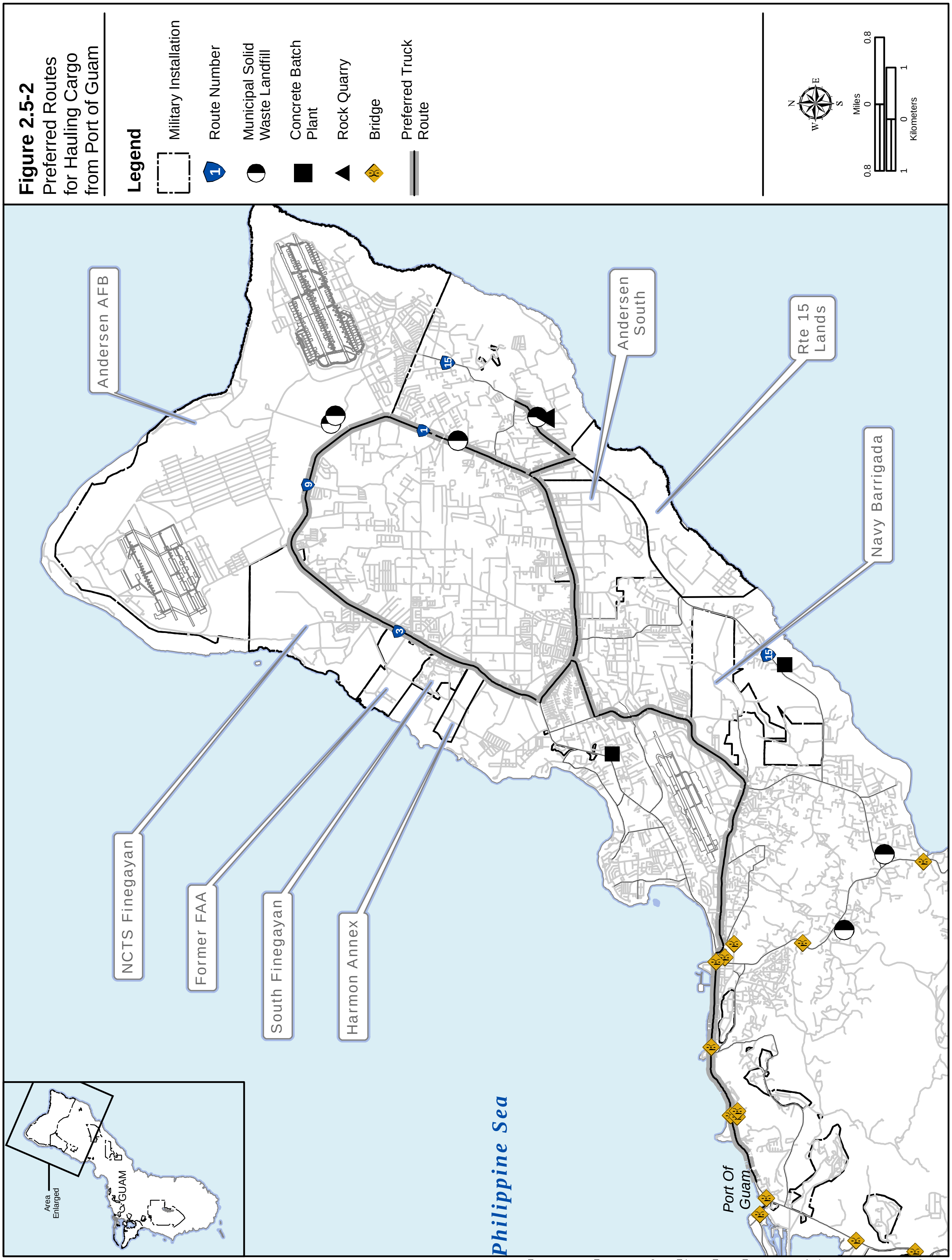


Figure 2.5-2
Preferred Routes for Hauling Cargo from Port of Guam
Legend
Military Installation
Route Number
Municipal Solid Waste Landfill
Concrete Batch Plant
Rock Quarry
Bridge
Preferred Truck Route
Miles
Kilometers
Andersen AFB
Andersen South
Rte 15 Lands
Navy Barrigada
NCTS Finegayan
Former FAA
South Finegayan
Harmon Annex
Philippine Sea
Port Of Guam
Area Enlarged
GUAM
Printing Date: Oct 13, 2009; M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.5-2.mxd

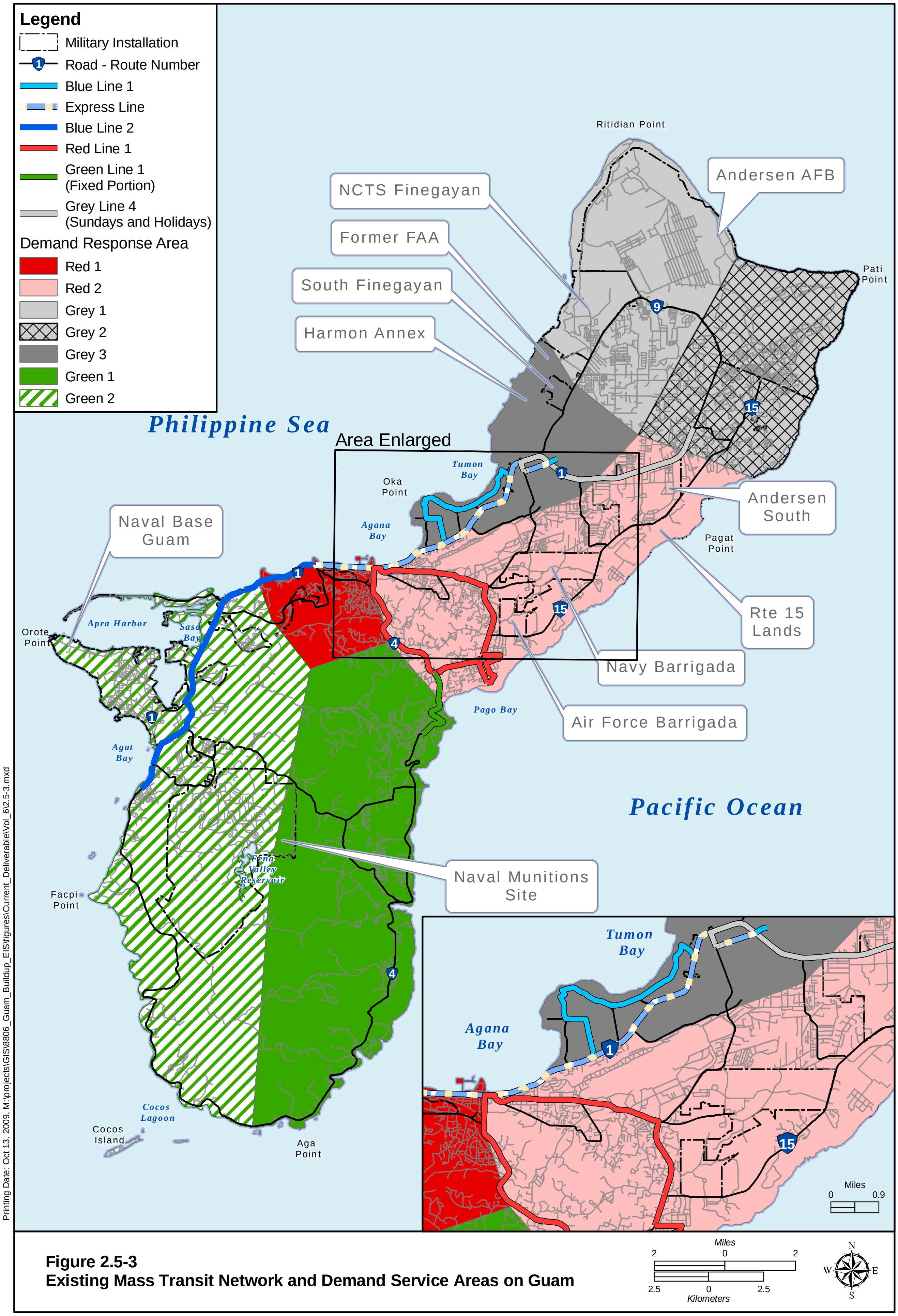


Figure 2.5-3
Existing Mass Transit Network and Demand Service Areas on Guam

As part of the *2030 Guam Transportation Plan*, 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 Guam DPW's Office of Highway Safety and is funded through Federal Highway Administration safety improvement funds. The focus of safety education and enforcement programs has been to prevent accidents related to speed, imprudent driving, and driving under the influence. The *2030 Guam Transportation Plan* recommends that traffic information and data management systems be 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 (SAFETEA-LU) (23 USC 148) requires that U.S. territories develop a strategic highway safety plan as a major part of the core highway safety improvement plan. The Guam DPW is in the process of identifying hazardous traffic locations on the island and implementing safety on island roadways. *The Guam Territorial Transportation Improvement Plan* 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 JFK High School
- Route 1 JFK 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

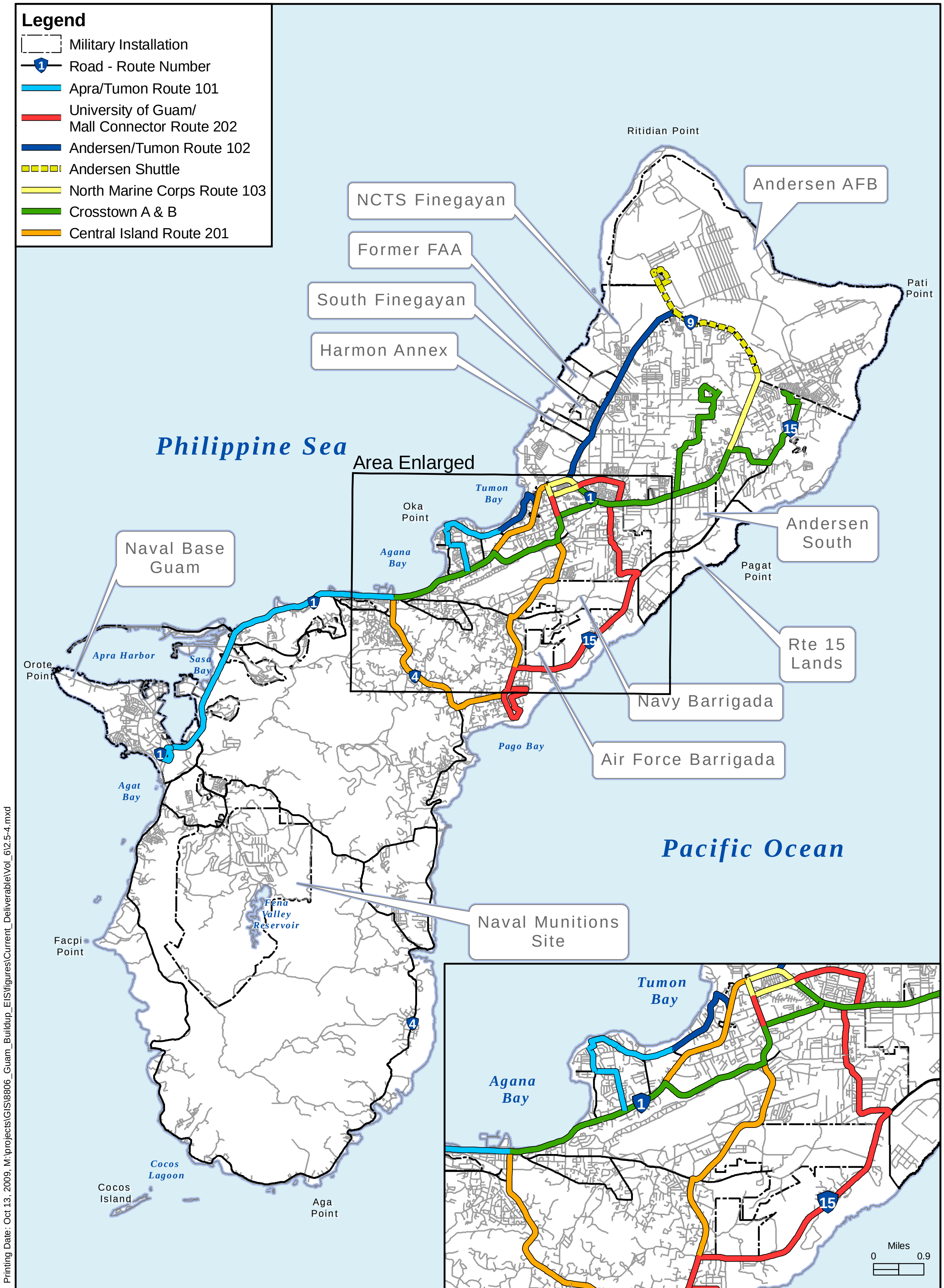


Figure 2.5-4
Proposed Mass Transit Network on Guam

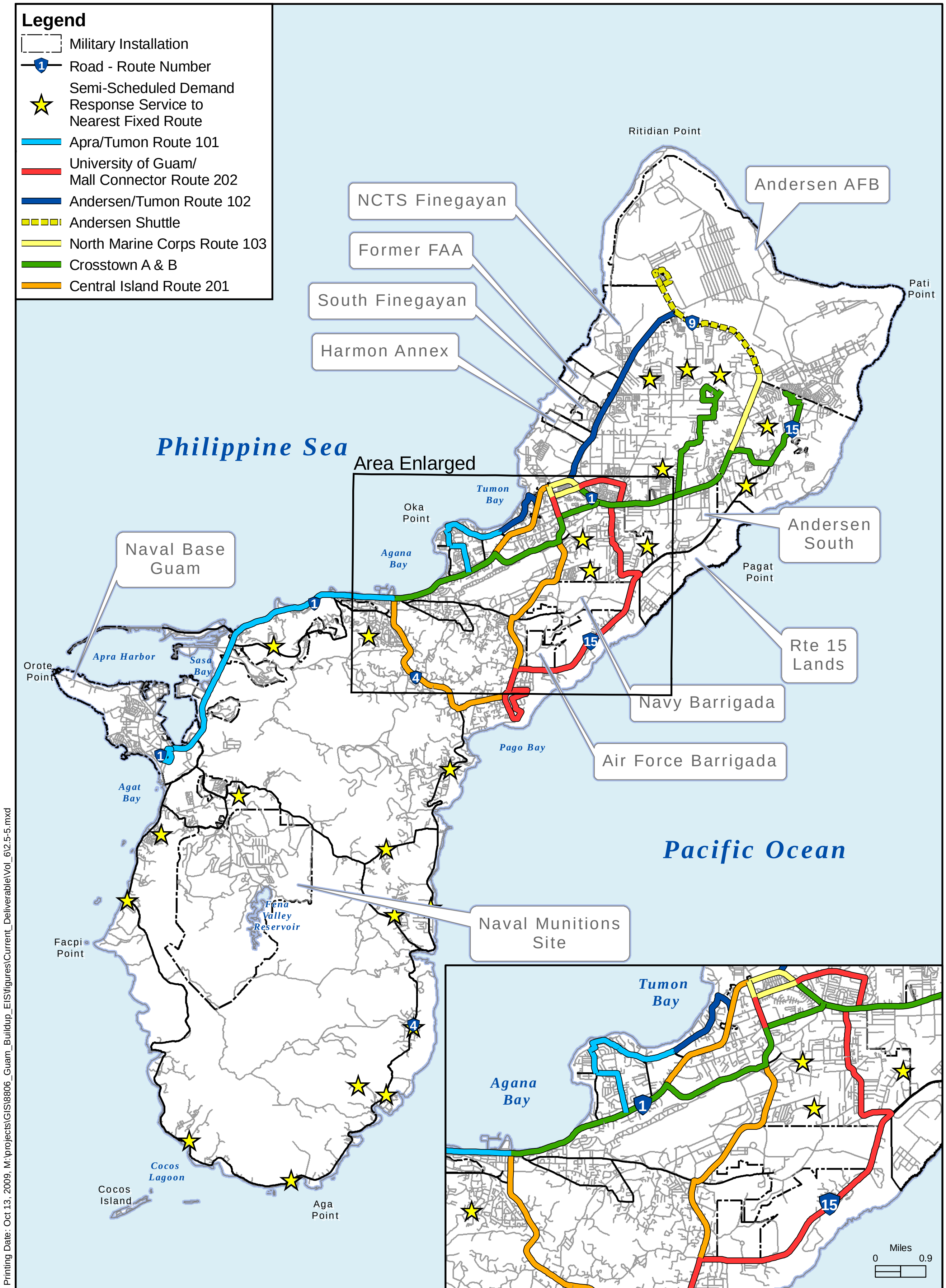


Figure 2.5-5
Mass Transit Network on Guam

- 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

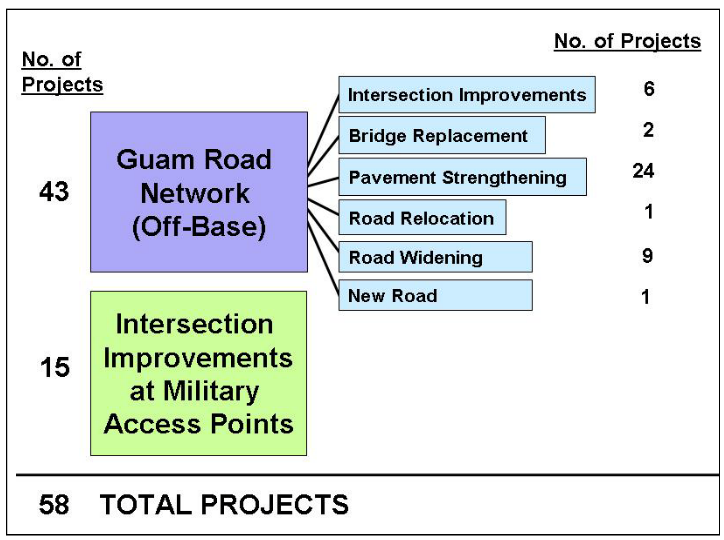
Hazard elimination projects on Route 1 (Jeff's Pirate Cove) and Route 4 (Deadman's Curve) are the only two specific location projects that have been funded. There is an existing safety hazard with key roadways on Guam and a need for safety improvements.

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 buildup 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 military access points (gates). The 43 GRN (off-base) projects are composed of six types of roadway improvements:

- Intersection improvement projects
- Bridge replacement projects (involving five bridges)
- Pavement strengthening (combined with roadway widening at some locations)
- Roadway relocation (Route 15)
- Roadway widening
- Construction of a new road (Finegayan Connection)



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.

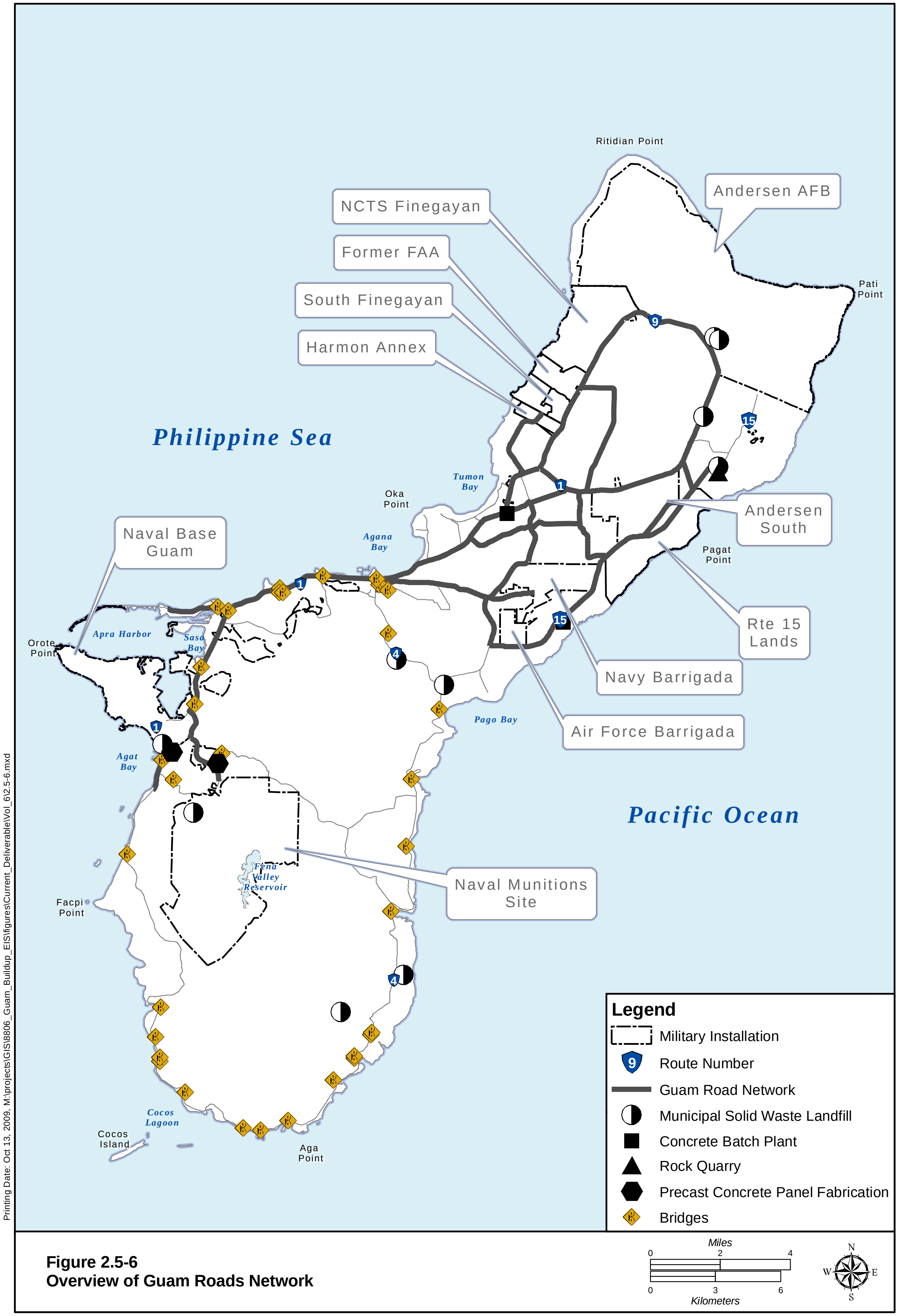


Figure 2.5-6
Overview of Guam Roads Network

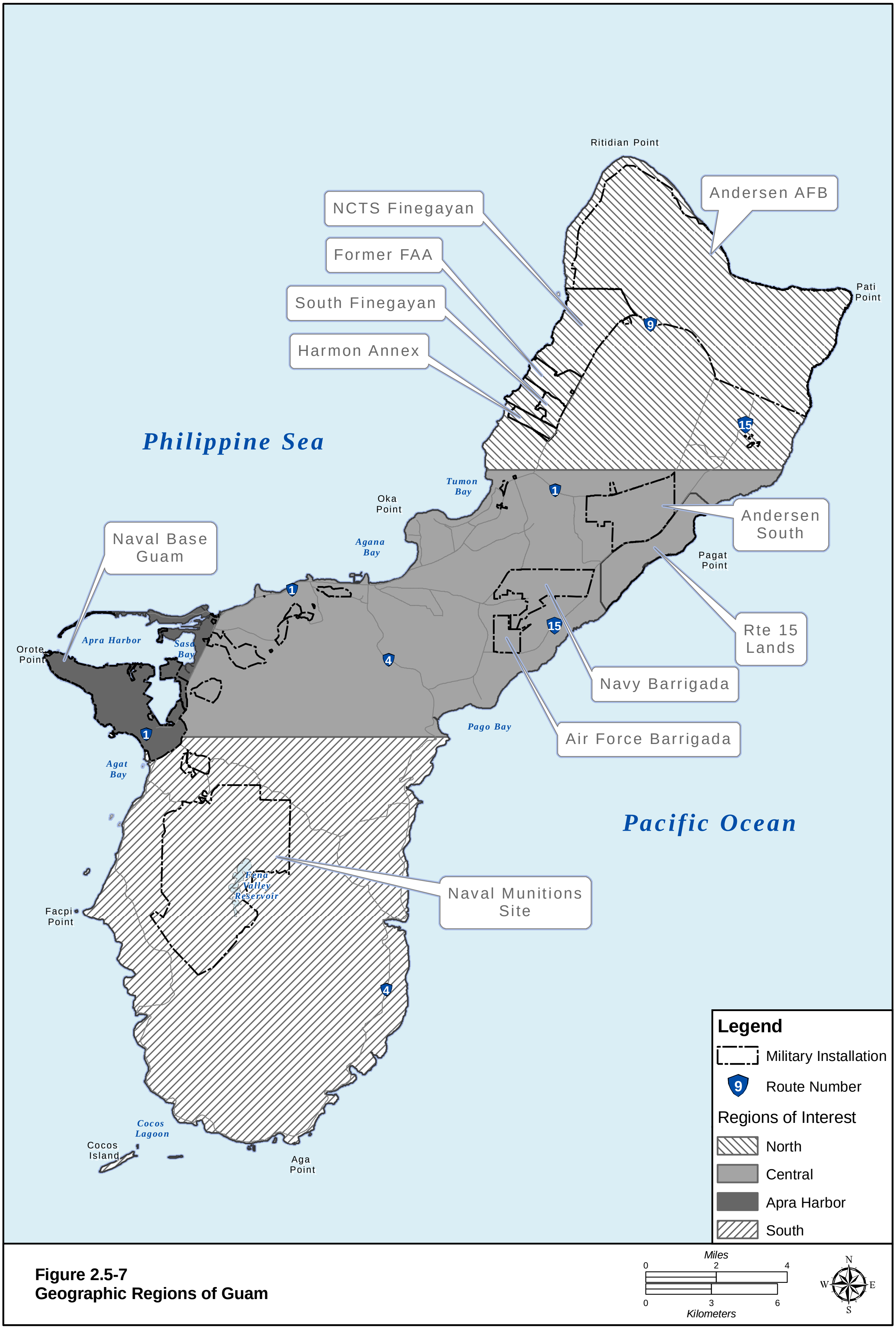


Figure 2.5-7
Geographic Regions of Guam

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]).
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.

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

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
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.
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.

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

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
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 an 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.
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.

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

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
33	1	Route 8 to Route 3	31,647 (9,590)	Pavement strengthening (six lanes). At the Route 1/14 North San Vitoris 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 combined left-turn/through, and two right-turn lanes.
35	1	Various	364 (110)	Replace bridges (Atantano, Laguas, Sasa, and Fonte).
36	15	Route 15 Realignment	11,200 (3,394)	Relocate Route 15 onto existing DoD property 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.
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.

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

GRN No.	*Route*	*Segment Limits*	*Road Length ft (m)*	*Requirements*
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 combined through/ right-turn lane.

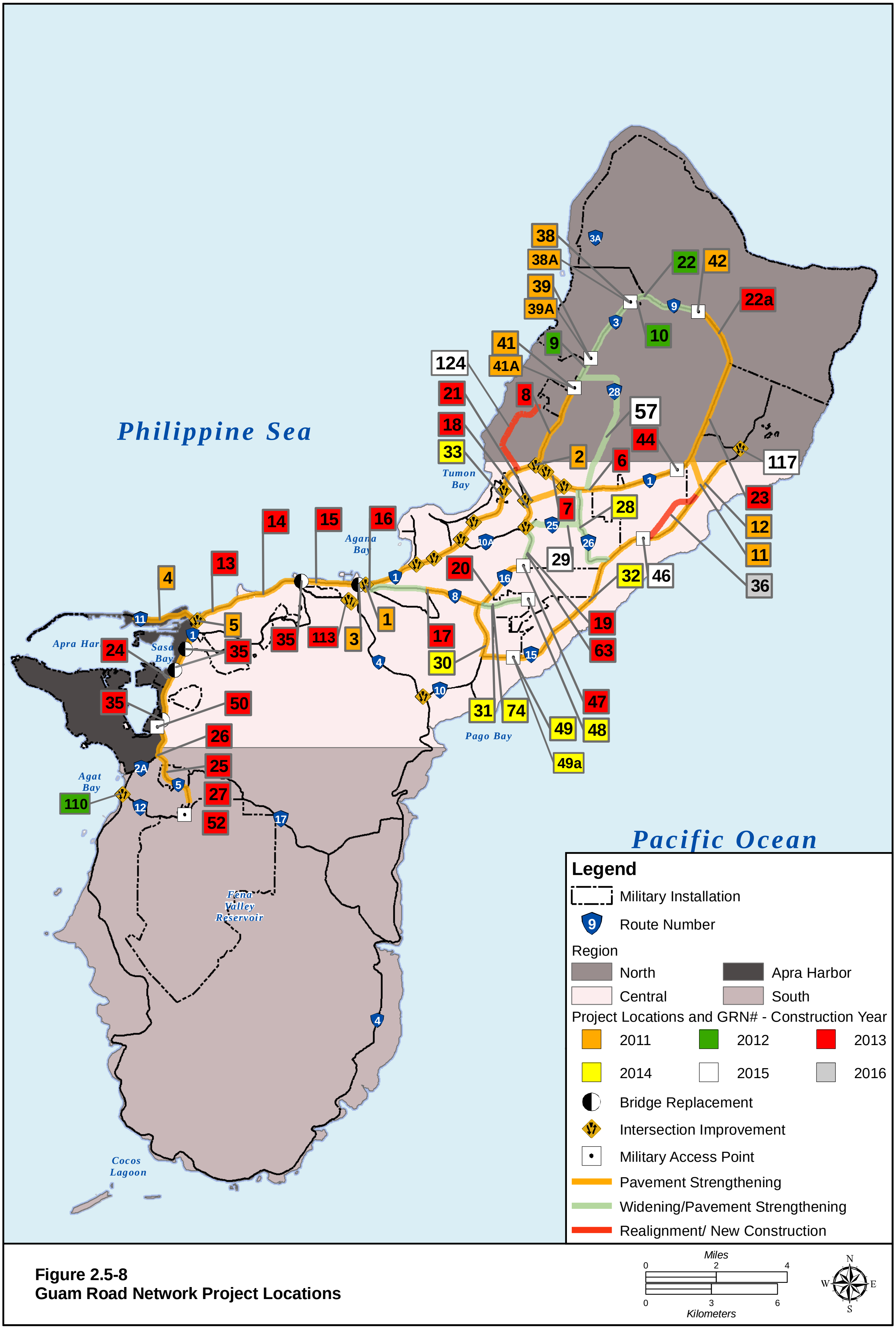


Figure 2.5-8
Guam Road Network Project Locations

2.5.1.8 Construction Schedule

Construction of the GRN would occur from 2010 to 2016 (a 7-year period) with peak construction in 2013. The military buildup associated with the relocation would be complete by the end of 2014.

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. Table 2.5-4 identifies a preliminary schedule of the GRN projects that would be completed in each of the 7 construction years.

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

Construction Year	*Projects to be Completed*
2010	(None)
2011	1, 2, 3, 4, 5, 11, 12, 38, 38A, 39, 39A, 41, 41A, 42
2012	9, 10, 22, 110
2013	6, 7, 8, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22A, 23, 24, 25, 26, 27, 35, 44, 47, 50, 52, 63, 113
2014	28, 30, 31, 32, 33, 48, 49, 49A, 74
2015	29, 46, 57, 117, 124
2016	36

2.5.1.9 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, or installation of new traffic loop sensors.
2	Bridge Replacement	Bridge replacements to correct structural deficiencies, increase load capacity, and comply with seismic 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. 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. The widened pavement section would be constructed of residual material from the existing pavement rehabilitation, new material, or a combination thereof, and an asphalt overlay. Pavement strengthening would also include matching existing access connections, pavement striping, signing, intelligent traffic systems, and safety lighting. 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/OEIS. 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/OEIS.

2.5.3 Alternatives

Each of the four alternatives would be evaluated for two scenarios described below. In addition, the no-action alternative would also be analyzed, taking into consideration only expected natural growth.

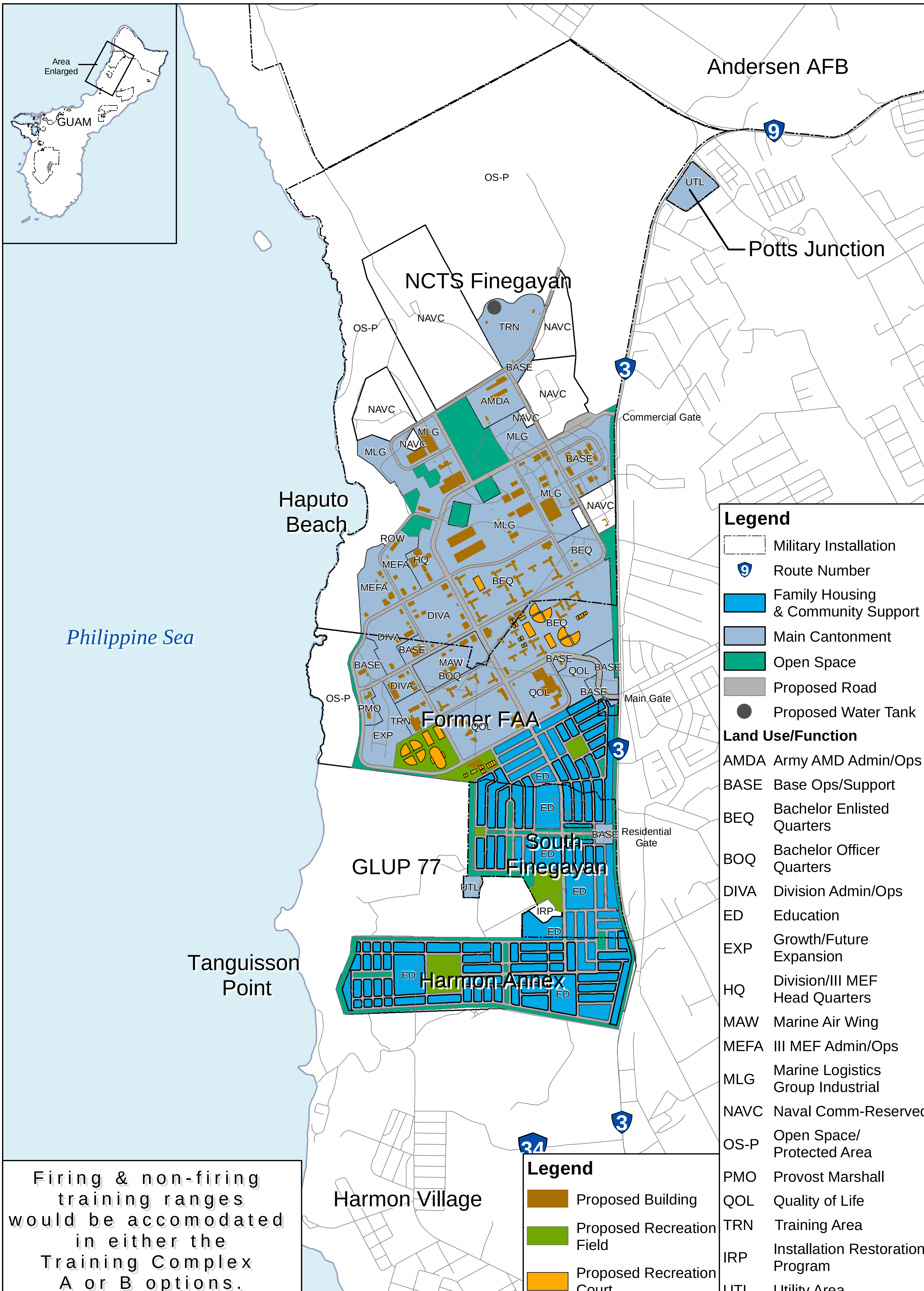
- *2014 (Peak Construction):* Each alternative was evaluated for environmental conditions in future year 2014, which represents peak construction associated with the military buildup. The end of year 2014 would represent full military relocation.
- *2030:* Each alternative was evaluated for environmental conditions in future year 2030, consistent with the 2030 Guam Transportation Plan, assuming that military buildup has occurred.

2.5.3.1 Alternative 1

Alternative 1 involves utilizing NCTS Finegayan (1,181 ac [578 ha]), obtaining access to Federal Aviation Administration land (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 property.

The roadway projects that would be required for Alternative 1 are listed in Table 2.5-3Error! Reference source not found., with the exception of GRN #38, 39, 41, 47, 48, 49, 49A, 63, and 74.



Printing Date: Oct 13, 2009, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.5-9.mxd

Figure 2.5-9
Alternative 1 Housing & Cantonment

2.5.3.2 Alternative 2

Alternative 2 involves using NCTS Finegayan (1,250 ac [578 ha]) and Federal Aviation Administration land (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 2.5-3Error! Reference source not found., with the exception of GRN #38A, 39A, 41A, 47, 48, 49, 49A, 63, and 74.

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 2.5-3Error! Reference source not found., with the exception of GRN #20, 31, 38A, 39A, 41, 41A, and 124.

2.5.3.4 Alternative 8

Alternative 8 involves using Federal Aviation Administration land (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 2.5-3, with the exception of GRN #38, 39, 41, 47, 48, 49, 63, and 74.

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.

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 MIRC EIS/OEIS and the Intelligence, Surveillance, and Reconnaissance/Strike EIS would be implemented for theCNMI or Guam. The project objectives and the U.S. government/Government of Japan 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.

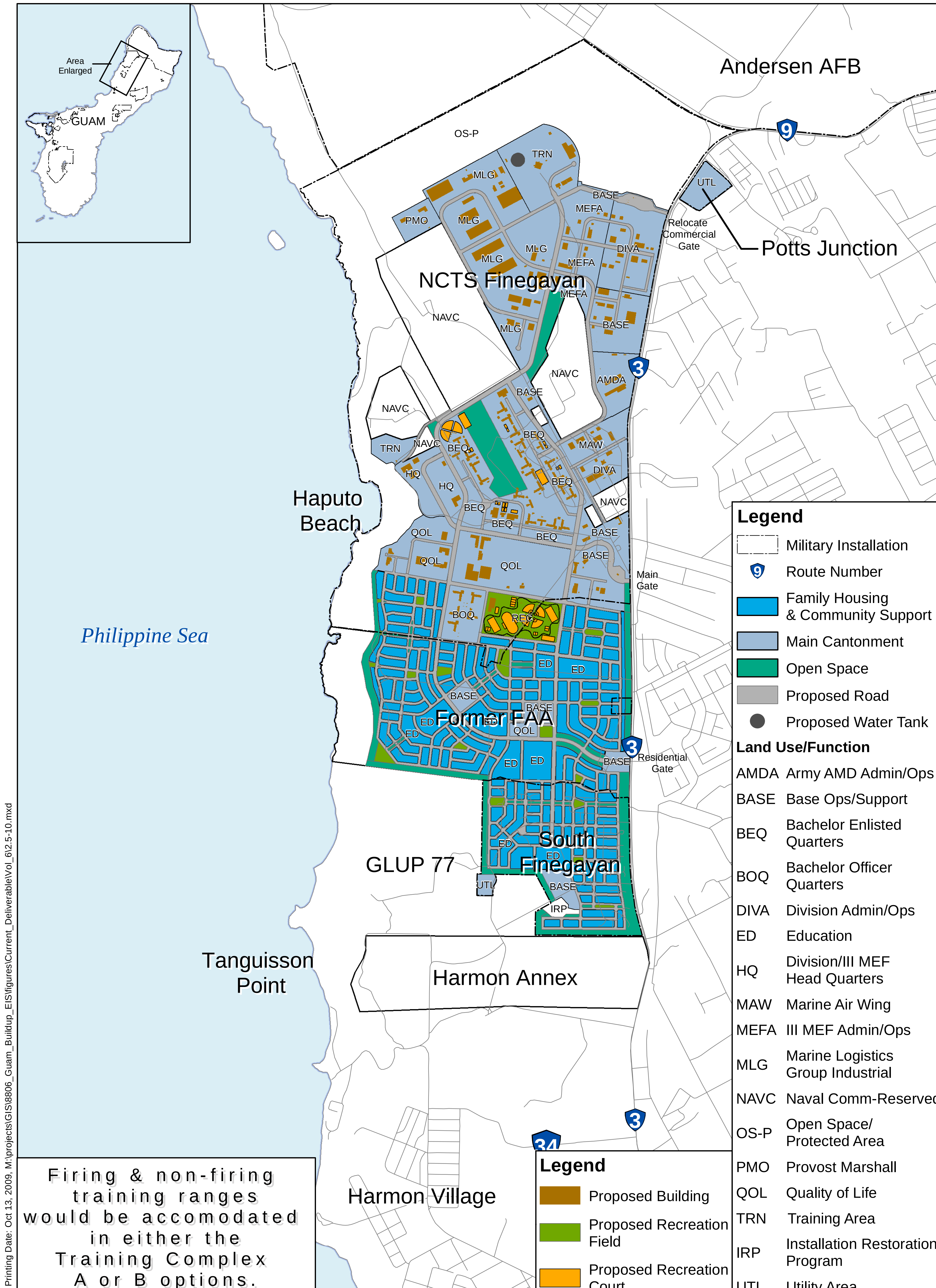


Figure 2.5-10
Alternative 2 Housing & Cantonment

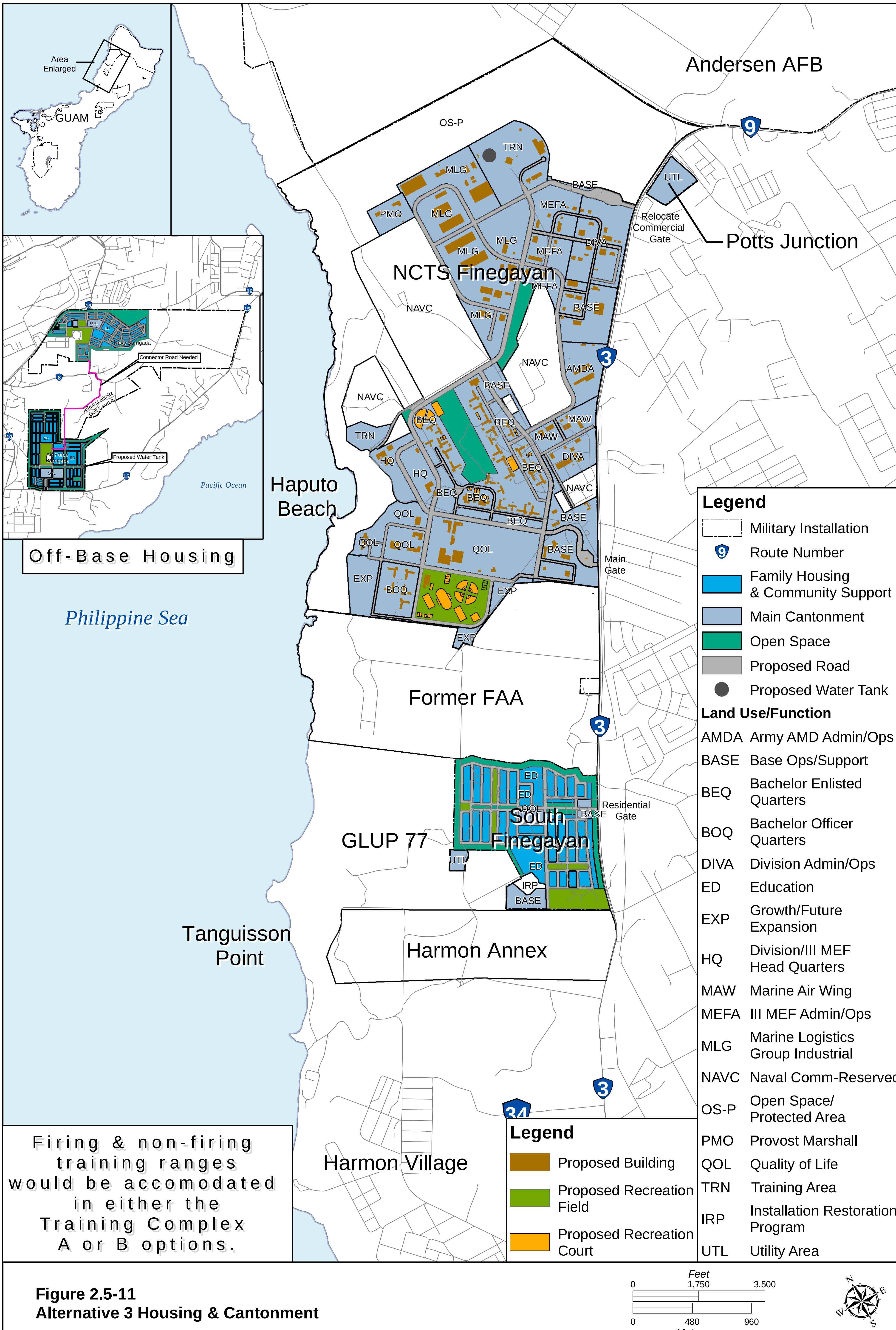
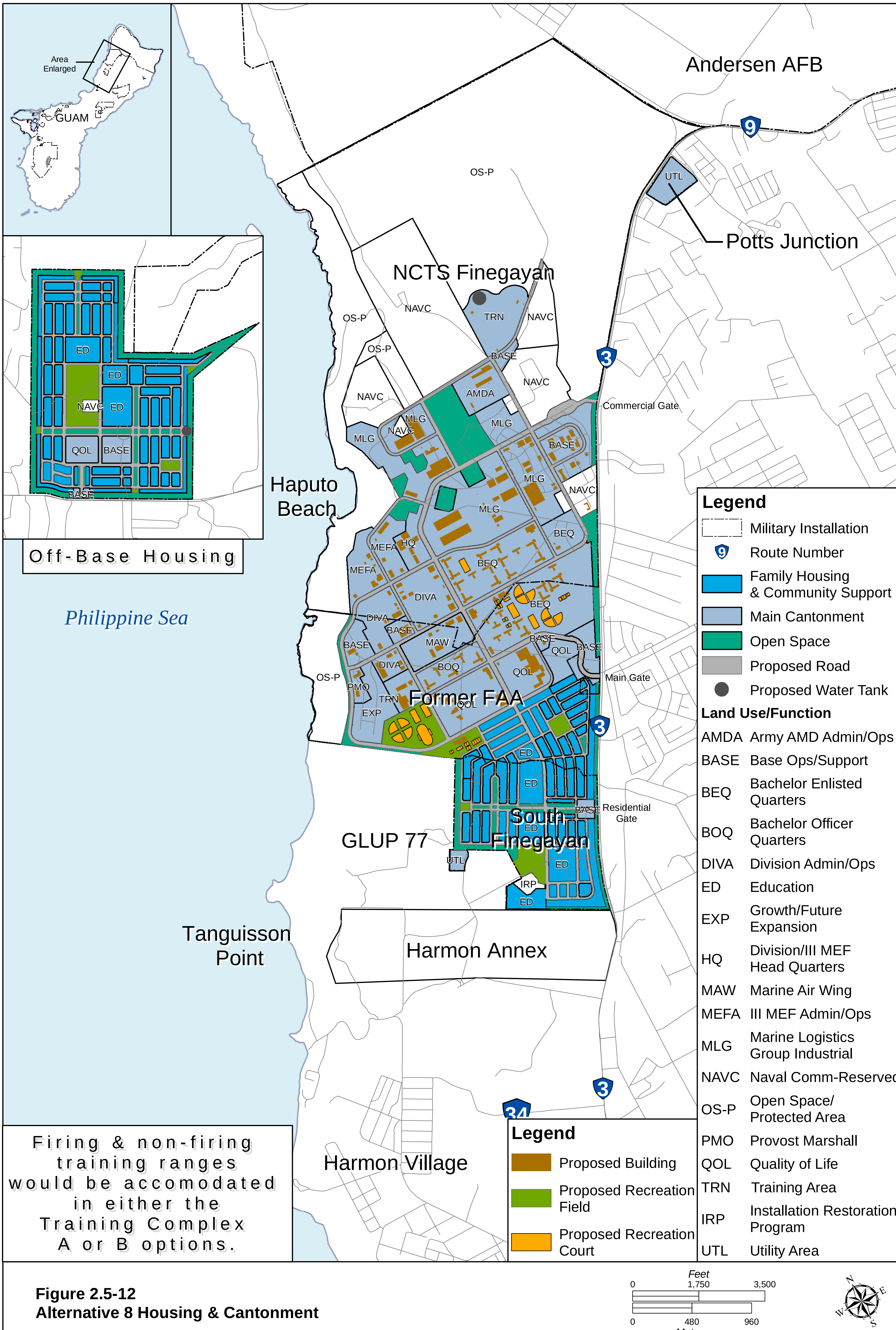


Figure 2.5-11
Alternative 3 Housing & Cantonment

Printing Date: Oct 13, 2009, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.5-11.mxd



Printing Date: Oct 13, 2009, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.5-12.mxd

Figure 2.5-12
Alternative 8 Housing & Cantonment

Existing (2009) (Preproject)

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

2014 (Peak Construction)

The no-action alternative evaluates environmental conditions for future year 2014, assuming that construction associated with military buildup would not occur. Seven GovGuam roadway capacity improvement projects would occur, as identified in Table 2.5-6 and Figure 2.5-13.

Table 2.5-6. 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

2030

The no-action alternative evaluates environmental conditions for future year 2030, assuming that military buildup would not occur. Twenty GovGuam roadway capacity improvement projects would occur, as identified in Table 2.5-6 and Figure 2.5-13.

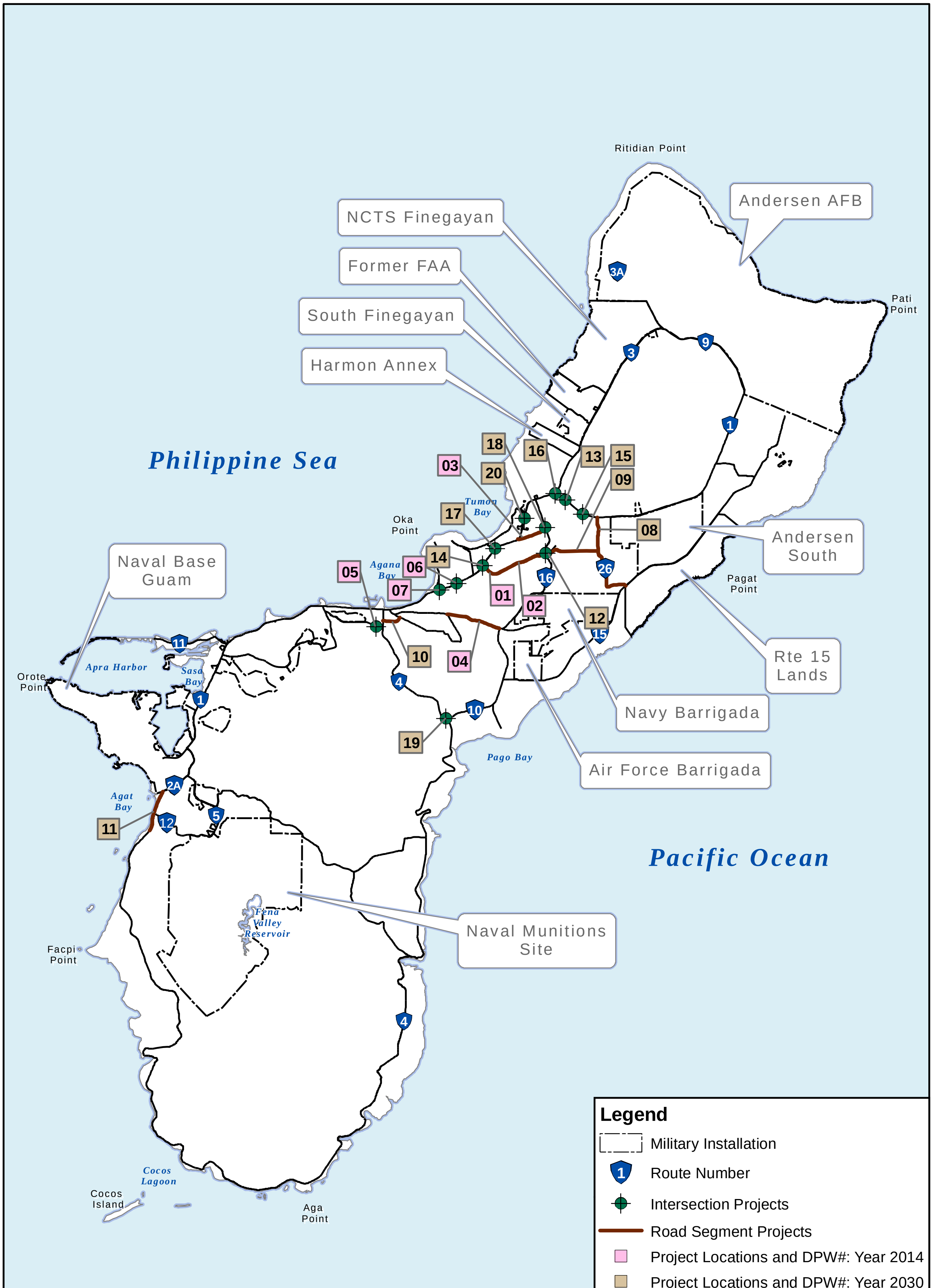


Figure 2.5-13
Government of Guam Organic Growth Project Locations

Printing Date: Oct 13, 2009, M:\projects\GIS\8806_Guam_Buildup_EIS\figures\Current_Deliverable\Vol_6\2.5-13.mxd

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 #19, 20, 31, 38A, 39A, 41, 49A, or 124. This alternative would consist of 50 projects.
- Alternative 8 would not require GRN #38A, 39A, 41, 47, 48, 49, 63, or 74. This alternative would consist of 50 projects.

2.5.4 Preferred Alternative

The Navy has identified Alternative 2 as the Preferred Alternative.

2.5.5 Permits and Regulatory Requirements

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

- ESA 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.
- CWA 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 CWA 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. FHWAwould be responsible for obtaining all permits required for construction of off base roadway projects.