FINAL
(VERSION 4)
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS JOINT MILITARY TRAINING
UTILITIES STUDY
VOLUME III: POTABLE WATER

Department of the Navy
Naval Facilities Engineering Command, Pacific
258 Makalapa Drive, Suite 100
JBPHH HI 96860-3134

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LIST OF ACRONYMS AND ABBREVIATIONS

°C	degrees Celsius
°F	degrees Fahrenheit
BECQ	Commonwealth of the Northern Mariana Islands Bureau of Environmental and Coastal Quality
CFR	Code of Federal Regulations
cm	centimeter(s)
CNMI	Commonwealth of the Northern Mariana Islands
CPA	Commonwealth Ports Authority
CUC	Commonwealth Utilities Corporation
DEQ	Commonwealth of the Northern Mariana Islands Division of Environmental Quality
DoN	Department of the Navy
f/d	foot/feet per day
ft	foot/feet
gpd	gallon(s) per day
gph	gallon(s) per hour
gpm	gallon(s) per minute
GWUDI	groundwater under the direct influence of surface water
hp	horsepower
in	inch(es)
km	kilometer(s)
lpd	liter(s) per day
lph	liter(s) per hour
lpm	liter(s) per minute
LWP	lightweight water purifier
m	meter(s)
MCL	maximum contaminant level
m/d	meter(s) per day
MGd	million gallons per day
mg/L	milligram(s) per liter
mi	mile(s)
MLA	Military Lease Area
MLd	million liters per day
mm	millimeter(s)
MSA	Munitions Storage Area
Msl	mean sea level
NAVFAC	Naval Facilities Engineering Command
NMIAC	Northern Mariana Islands Administrative Code
No.	number
ppm	part(s) per million
PP&D	Pacific Planning and Design Consultants
PVC	polyvinyl chloride
SCS	Soil Conservation Service
TWDS	tactical water distribution system
TWPS	tactical water purification system
U.S.	United States
UFC	Unified Facilities Criteria
UFW	unaccounted-for water
USACE	United States Army Corps of Engineers
USDA	United States Department of Agriculture
USGS	United States Geological Survey

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CHAPTER 1. INTRODUCTION

1.1 OVERVIEW

The purpose of this report is to provide information regarding the overall potable water demand and requirements associated with a proposed action to establish a series of live-fire and maneuver ranges, training areas and supporting facilities, within the Commonwealth of the Northern Mariana Islands (CNMI) to address the U.S. Pacific Command Service Components' unfilled training requirements in the Western Pacific. These live-fire ranges, training courses, and maneuver areas collectively constitute a Range and Training Area (RTA). Under the proposed action a unit level RTA is proposed for Tinian and a combined level RTA is proposed on Pagan. The proposed action includes construction, range management, expanded training and operations (to include combined-arms, live-fire, and maneuver training at the unit and combined levels), establishment of danger zones, designation of special use airspace, and acquisition and/or lease of land to support simultaneous and integrated training. The CNMI Joint Military Training (CJMT) *Environmental Impact Statement/Overseas Environmental Impact Statement* (DoN 2014b) is being prepared to assess the proposed action. This report focuses on existing ground, air, and marine infrastructure capacity and facility requirements, proposed projects, and methodology focusing on the condition and capacity of the existing potable water utility and solutions to meeting potable water and fire protection demand to meet the proposed action. Figure 1.1-1 provides an overview of the CNMI, and Figure 1.1-2 and Figure 1.1-3 provide overviews of Tinian and Pagan, respectively.

There are two different training tempos proposed for both Tinian and Pagan. The first training tempo is the proposed action presented in the CNMI Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement, consisting of 20 weeks per year on Tinian and 16 weeks per year on Pagan. In the future, the training tempo might be increased to 45 weeks per year on Tinian and 40 weeks per year on Pagan and is addressed by the CNMI Joint Military Training Environmental Impact Statement/Overseas Environmental Impact Statement as a potential future action. This study addresses both training tempos.

1.1.1 Goals and Objectives

There are two scenarios for the training on Tinian and Pagan. The first scenario covers the proposed action for 20 weeks per year of live-fire training on Tinian and 16 weeks of live-fire training on Pagan. The proposed facilities under the proposed action on Tinian would include a base camp, Munitions Storage Area (MSA), port facilities, and expeditionary use of the Tinian International Airport. 20 weeks of additional, pre-training and post-training activities may occur outside live-fire training. The second scenario covers the future potential training tempo of 45 weeks of live-fire training on Tinian and 40 weeks of live-fire training on Pagan. The second scenario includes the end state construction of additional permanent airport facilities on Tinian and the breakwater and pier on Pagan.

The objectives of this Volume III potable-water-utility study are as follows:

- Analyze the condition and capacity of the existing potable water system and the required supply and demand for potable water associated with the proposed training facilities and their operation on Tinian and Pagan.
- Make recommendations for providing the required service for potable water.

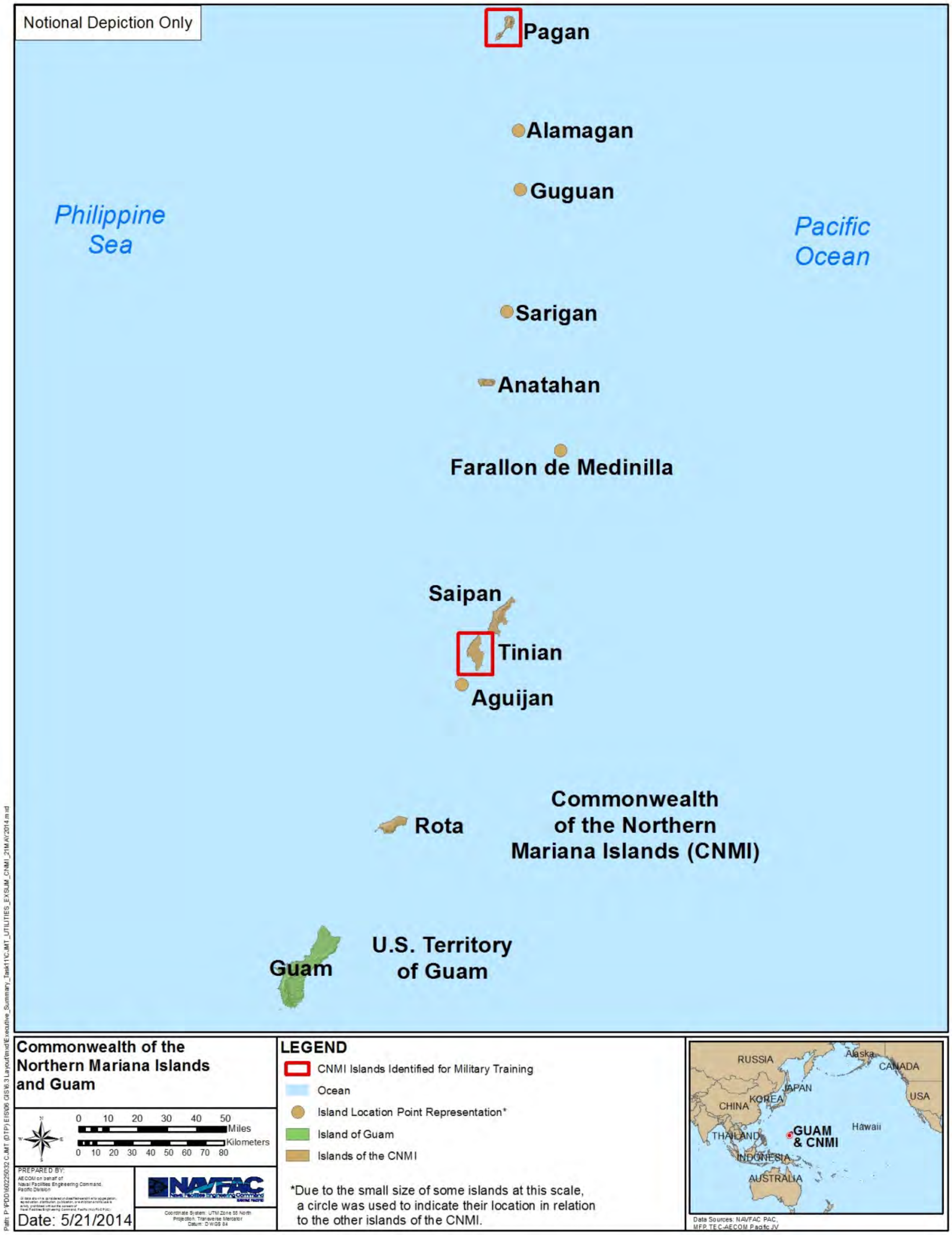

Figure 1.1-1. Commonwealth of the Northern Mariana Islands and Guam
Source: DoN 2014.

Figure 1.1-2. Island of Tinian and the Military Lease Area
Source: DoN 2014.

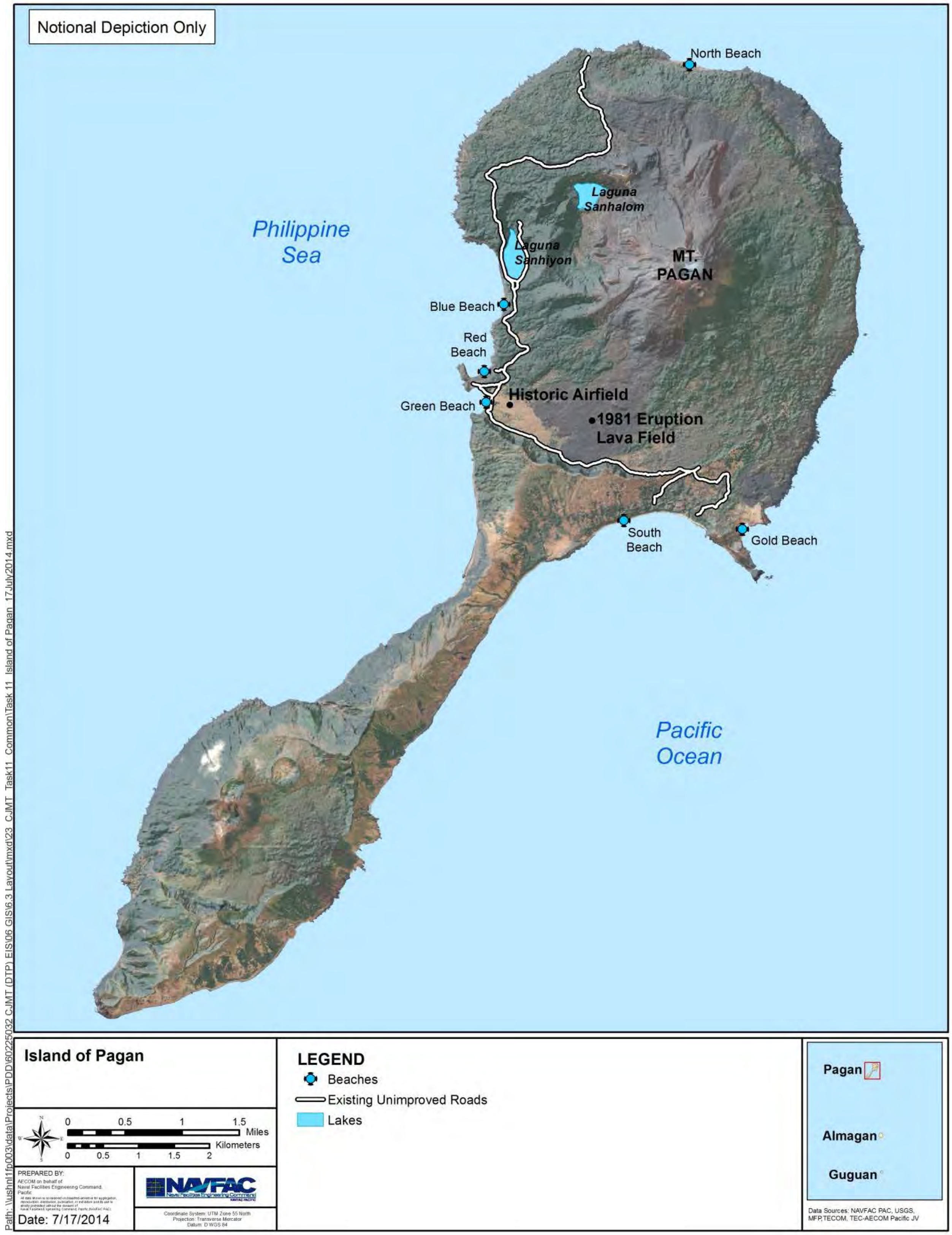

Figure 1.1-3. Island of Pagan
Source: DoN 2014.

1.2 BACKGROUND INFORMATION

The assumptions used for this study are consistent with Version 1, Commonwealth of the Northern Mariana Islands Joint Military Training, Unconstrained Training Concept for Tinian and Pagan (DoN 2014a), and the proposed action as defined in the master-planning documents available at the time this study was performed. A site visit to Tinian was made in December 2013 to meet with local regulatory agencies responsible for the potable water utility to gather existing water system status and condition information. Data requests were made to the local water utility and regulator. A summary of meeting minutes and follow-up data requests can be found in Appendix A. All of the requested information was not available at the time this report was published.

1.3 FUTURE DEMAND

1.3.1 Tinian

The future potable water demand would be affected by the population increase and new facilities associated with the proposed action. The population on Tinian would increase with the arrival of construction workers, a new population that would come to Tinian for employment supporting the proposed action, and military trainees. Because of the small construction workforce currently present on Tinian, it is assumed that most members of the construction workforce, some with dependents, would come from off-island and thus would temporarily add to the population. Construction workers are expected to be housed in a work camp near and associated with the Dynasty hotel, which is located in the public areas outside of the MLA. Construction managers and their dependents would not reside in the construction worker housing camp; instead, they are expected to find housing in properties on Tinian. A total temporary increase of up to 597 construction workers, construction managers, and their dependents per year is projected by the most recent published socioeconomic impact assessment study (DoN 2014c). These workers, managers and dependents would generate a total average daily demand of 58,699 gallons per day (gpd) (222,085 liters per day [lpd]) and a total maximum daily demand of 132,005 gpd (499,692 lpd) on the existing public potable water system. The operations personnel requirements assumed for the proposed action on Tinian include 95 permanent operations personnel to manage/maintain the base camp and training facilities (DoN 2014c). The water calculations use 95 maintenance personnel, as this is the latest number from the socioeconomic impact analysis while other utilities might use "approximately 100." For utility requirements, this difference is inconsequential since it represents a minor percentage difference (5% for maintenance workers, 0.3% for maximum normal training population, and 0.16% for maximum surge training population) and is within the accuracy of estimated utility requirements. Up to 87 of the 95 operations personnel, along with up to 155 dependents, could come from off-island and are expected to live in housing on Tinian. This would generate a total average daily demand of 52,938 gpd (200,390 lpd) and a maximum daily demand of 119,109 gpd (450,878 lpd) on the public potable water system. Civilian demand for utilities is considered because the proposed action could cause a shortfall in potable water service to the civilian sector. From the socioeconomic impact assessment study, the population increase from the civilian population and average daily visitors was estimated at 396 and 184 respectively on the high end of the projection. (DoN 2014c) The increase in civilian and average daily visitor population would generate a total average daily demand of 121,971 gpd (461,709 lpd) and maximum daily demand of 274,434 gpd (1,038,846 lpd) on the public potable water system.

Military personnel training is expected to involve the potential cyclical presence of up to 1,500 trainees for 20 weeks per year, and a potential temporary surge of an additional 1,500 trainees on a modified-bivouac basis for approximately 2 weeks at a time up to several times per year during part of the 20-week annual training duration. Military training under the proposed action on Tinian, assuming the maximum of 3,000 trainees at a given time, would generate a total daily average water demand of 240,013 gpd (908,550 lpd) and a total maximum daily water demand of 459,758 gpd (1,740,375 lpd) (Appendix B). The potential exists to ramp up the training tempo to 45 weeks per year in the future along with the construction of airport facilities. However, since the number of trainees at a given time remains constant, the total daily average and maximum water demand would remain the same but the additional potable water demand for the airport facilities in this scenario is 978 gpd (3,703 lpd).

1.3.2 Pagan

The assumption about personnel requirements for the proposed action on Pagan is that training would be conducted on an expeditionary basis, requiring only minimal permanent infrastructure. For planning purposes, the *Version 1, Unconstrained Training Concept for Tinian and Pagan* (DoN 2014a) anticipates a training on Pagan of 3,000 persons for about 16 weeks per year, with a maximum potential of up to 4,000 persons on a 2-week cycle up to several times per year within those 16 weeks. The proposed action on Pagan would generate a total average daily water demand of 21,680 gpd (82,068 lpd) and a maximum daily water demand of 48,780 gpd (184,683 lpd) (Appendix B). The possibility exists to ramp up the training tempo to 40 weeks per year in the future. Under that training tempo, different options for water supply and demand could be considered; however, the total daily demand remains unchanged. There are currently no legal residents on Pagan and no potable water system exists there. Thus, it is not necessary to consider current or projected future demand from civilians on Pagan.

1.4 PHYSICAL ENVIRONMENT

Relevant physical environment aspects include topography, climate, geology, hydrogeology, and the sustainable yield of the aquifers to support the general design of the proposed water supply systems.

1.4.1 Topography

1.4.1.1 Tinian

Tinian is the second largest CNMI Island. It is about 12 miles (mi) (19 kilometers [km]) long and 6 mi (10 km) wide. It is located approximately 5 mi (9 km) from Saipan. Tinian comprises a series of limestone plateaus separated by steep slopes and cliffs (USDA SCS 1989). The surface landforms (Figure 1.4-1) can be divided into five major physiographic areas based on topography and spatial relations as described below (U.S. Geological Survey [USGS] 1999).

- *Southeastern Ridge.* This land area is the southernmost and highest part of the island, which is 614 feet (ft) (187 meters [m]) at Mount Katiyu. It is characterized by steep slopes and cliffs as much as 500 ft (150 m) high on the southeast.
- *Median or Marpo Valley.* This land area is a low, broad depression north of the Southeastern Ridge with a maximum elevation of 150 ft (46 m). In the valley, the land surface intersects the water table, resulting in a small potential wetland complex known as the Makpo Wetland.
- *Central Plateau.* This land area extends northward from the Marpo Valley and includes all of central Tinian and portions of northern Tinian. The plateau is broad and gently sloping, with most of the vertical relief at its southern and northern boundaries.

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Figure 1.4-1. Tinian Physiographic Areas

Source: DoN 2014.

- *North-Central Highland.* This land area is located within the northern part of the Central Plateau and midway between the east and west coasts of the island. The maximum elevation of the highland at Mt. Lasso is 545 ft (166 m).
- *Northern Lowland.* This land area is located at the northern tip of Tinian. It is generally flat, with an average elevation of about 100 ft (30 m), except for the Lake Hagoi wetland, where the elevation is approximately at sea level

1.4.1.2 Pagan

Pagan is the fourth largest island in the CNMI. It is located about 200 mi (320 km) north of Saipan and has an area of about 18.5 square mi (48 square km). The island consists of two active stratovolcanoes connected by a low, narrow isthmus. Stratovolcanoes are built up by many layers of both hardened lava and tephra (including pumice and volcanic ash). They are characterized by a steep profile and periodic explosive eruptions and quiet eruptions (USGS 1998). Mount Pagan, also known as the North Pagan Volcano, is about 4 mi (7 km) in diameter and has a height of 1,870 ft (570 m). The South Pagan Volcano is about 2.5 mi (4 km) in diameter and has a height of 1,798 ft (548 m) (USGS 2006).

Mount Pagan is located at the center of a caldera that encompasses most of the northern part of the island. The northern and southern slopes of Mount Pagan are covered with lava flows from the large Plinian eruption that occurred on May 15, 1981. The western flank of Mount Pagan includes a maar (a crater formed by violent explosion) with two natural lakes containing brackish water: the eastern inner lake, Lake Sanhalom, and the western outer lake, Lake Sanhiyon.

The steepest slopes are located at Mount Pagan (sloping to the west toward the two lakes), along the isthmus leading to the South Pagan Volcano, and much of the South Pagan Volcano itself. The gentlest slopes are located immediately south and southwest of Mount Pagan.

A well-defined valley system exists, but no perennial streams are associated with these valleys. Most large valleys are directed down the original volcanic slopes in a radial pattern away from the tops of the calderas. Terrain features described by Corwin et al. (1957) include plains and basin floors, lava fields, caldera backslopes, dissected ridges, cinder cones, volcanoes, rugged highlands, and major escarpments.

1.4.2 Climate

1.4.2.1 Tinian

The seasons on Tinian are defined by distinct seasonal differences in rainfall. During the wet season, which occurs between the months of July and October, the island receives roughly 60% of its annual precipitation. February through May comprise the dry season, when only about 10% of Tinian's annual rainfall occurs. The remaining months (November, December, January, and June) are the transitional months, when the island receives the remaining 30% of its rainfall. Rainfall from tropical storms and typhoons make up a significant percentage of the total annual rainfall, and a lack of storms can significantly contribute to drought conditions. Typical temperatures range from between 76 degrees Fahrenheit (°F) and 88°F (24 degrees Celsius [°C] and 31°C).

Precipitation averaged about 81 inches (in) (206 centimeters [cm]) per year at the airport weather station during 1988 to 1994 and 1996, years for which complete daily rainfall records were available. Because the highest point on Tinian is only 614 ft (187 m) above sea level, orographic effects (increased rainfall related to mountain ranges) appear to be minimal. Stephen B. Gingerich and Daniel S. Yeatts measured rainfall at four sites on Tinian from 1993 to 1996 and the measured amounts ranged from 7282 in (183-208 cm) across the island (USGS 2000). Gingerich used an average rainfall of 82 in (208 cm) per year in his water budget (USGS 2002a).

1.4.2.2 Pagan

The climate of Pagan is tropical, with humidity and temperature generally varying only slightly throughout the year. The average temperature ranges between 75° and 80° F (24° and 27°C). Precipitation is seasonal with a rainy season from July to October (USGS 2010). The average annual rainfall is about 7080 in (178–203 cm) (USGS 2006); however, heavy showers can occur throughout the year as a result of relatively constant northeast trade winds, typhoons, and tropical storms (USGS 2010).

1.4.3 Geology

1.4.3.1 Tinian

Tinian is a composite island (see Jenson et al. 2006) comprising geologically young coralline and algal limestone strata overlying an older core of volcanic tuff and breccias, small portions of which crop out at the surface in two small places on the island (Figure 1.4-2). The limestone retains substantial primary porosity, but also regional- to local-scale fractures associated with regional tectonic stresses and local loading/unloading from uplift-subsidence and deposition-erosion cycles. Regional high-angle normal faults result in offset limestone plateaus that characterize the island (Figure 1.4-1).

Figure 1.4-3 shows geologic cross sections of Tinian. Tinian comprises the following four major geologic units (USGS 2002a):

- *Tinian Pyroclastic Rocks:* Of Late Eocene age (approximately 38 million years ago), Tinian Pyroclastic rocks are the oldest exposed rocks on the island, and they likely underlie all other exposed rock units there. These fine-grained to coarse-grained ash and angular fragments represent explosive volcanic materials ejected from an ancient volcano that formed the core of the island. These rocks are exposed on the North-Central Highland and Southeastern Ridge and occupy about 2% of the surface of Tinian. Surface exposures are generally highly weathered and are often altered to clay.
- *Tagpochau Limestone:* Of Early Miocene age (approximately 23–20 million years ago), Tagpochau Limestone rocks are exposed on about 15% of Tinian's surface, generally in the North-Central Highland and the southern part of the Southeastern Ridge. These rocks range up to about 600 ft (183 m) in thickness; they are composed of fine to coarse-grained, partially recrystallized broken limestone fragments, and about 5% reworked volcanic fragments and clays. Surface exposures are highly weathered. As shown on the generalized geologic map (Figure 1.4-2) and in the cross sections (Figure 1.4-3), this unit extends from the unconformity with the volcanic rocks below to the ground surface in two areas mentioned above. Across most of the island, this unit is capped by the Mariana Limestone.

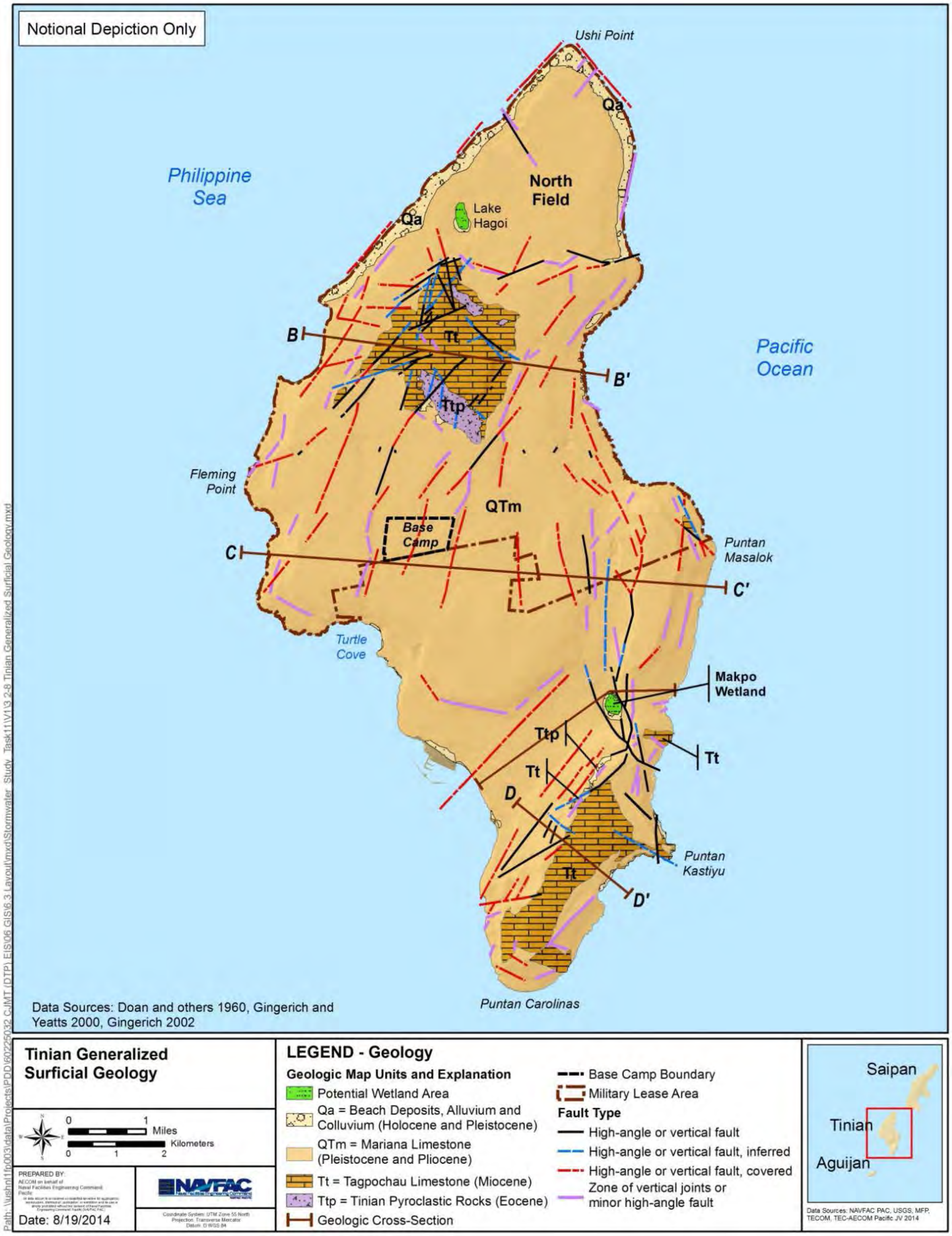

Figure 1.4-2. Tinian Generalized Surficial Geology
Source: DoN 2014.

Geographic location of these cross sections is shown in Figure 1.4-2

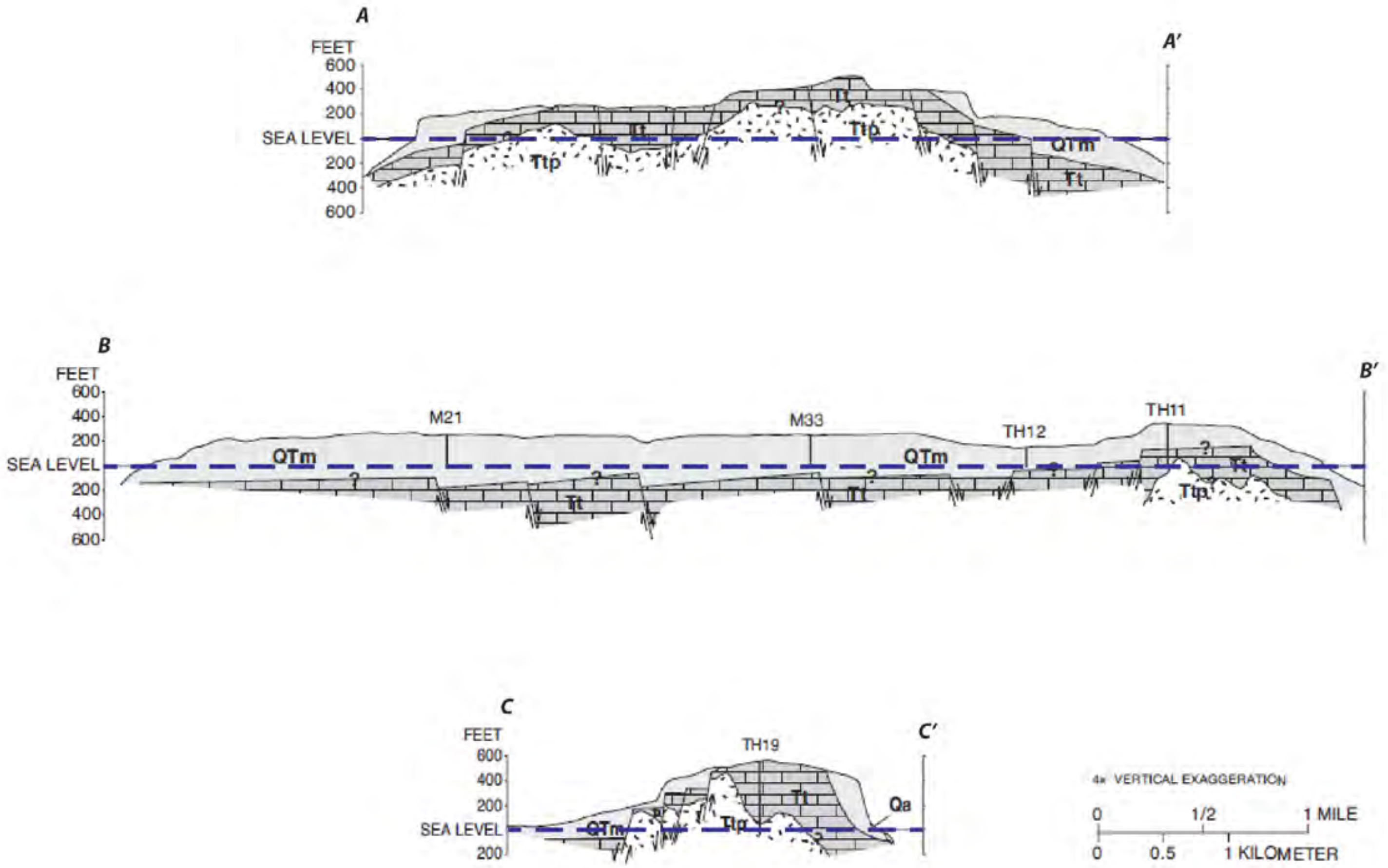

Figure 1.4-3. Tinian Geologic Cross Sections

Source: USGS 2002a (after Doan et al. 1960).

- *Mariana Limestone:* Of Pliocene to Pleistocene age (approximately 5–3 million years ago), Mariana Limestone rocks cover approximately 80% of Tinian's surface, forming nearly all of the Northern Lowlands, the Central Plateau, and the Marpo Valley. These rocks range up to about 450 ft (137 m) in thickness. They are composed of fine to coarse-grained fragmented limestone, with some fossil and algal remains, and small amounts of clay particles. Small voids and caverns are common in surface exposures. Overall, the Mariana Limestone has a higher coral content than the Tagpochau Limestone.
- *Beach Deposits, Alluvium, and Colluvium:* Of Pleistocene to Holocene age (approximately 2 million years ago to the present), these deposits cover less than 1% of Tinian's surface and range up to approximately 15 ft (5 m) in thickness. The deposits are made up of poorly consolidated sediments; these are mostly calcareous sand and gravel deposited by waves. However, they do contain clays and silt deposited inland surrounding Lake Hagoi and the Makpo potential wetland complex, as well as loose soil and rock material (talus) found at the base of slopes.

1.4.3.2 Pagan

Mount Pagan is the largest and one of the most active Mariana Islands volcanoes. Mount Pagan was probably formed during the early Holocene Epoch period (past 10,000 years), but most of the radiocarbon ages date to a few hundred years old, indicating frequent eruptions and rapid growth (USGS 2010). Mount Pagan and the South Pagan Volcano are both stratovolcanoes, with almost all of the historical eruptions dating to the 17th century originating from Mount Pagan. The USGS notes reports of eruptions in the 1600s, 1872–73, and the 1920s (USGS 2006). The largest and latest eruption occurred on May 15, 1981, and resulted in the evacuation of the island. Figure 1.4-4 displays the geology of Pagan.

A generalized geologic map was prepared by Corwin et al. (1957). Geologic units mapped included Quaternary-age lavas and ash deposits that predate and postdate the existing Mount Pagan and South Pagan volcanoes. Limited portions of the shoreline included recent raised reef deposits (i.e., sedimentary deposits also shown in Figure 1.4-5. A more recent effort by the USGS (USGS 2006) mapped and conducted age-dating of various deposits on the northern portion of the island (also shown in Figure 1.4-4). All units and surface deposits of Mount Pagan are either basalt, andesite, or a combination of the two. Rock outcrops include cinder or spatter cones, lava flows (‘a‘ā or pahoehoe [Photo 1.4-1 and Photo 1.4-2]), or consolidated or unconsolidated pyroclastic (ash) deposits.

Photo 1.4-1. View of a‘ā Lava Just North of the Pagan Airstrip

Photo 1.4-2. Close-up View of Pahoehoe Lava
Source: USGS via San Diego State University 2014.

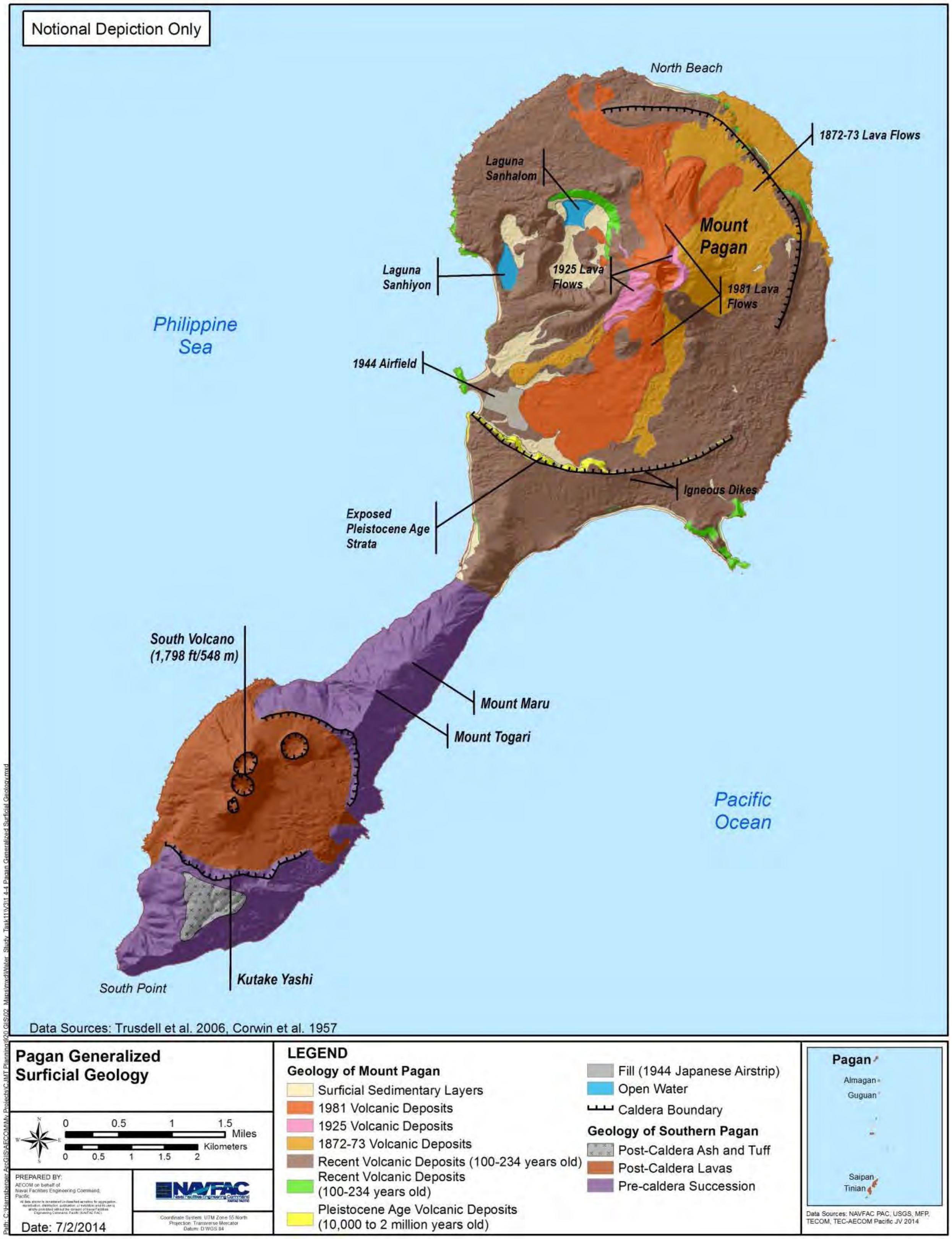

Figure 1.4-4. Pagan Generalized Surficial Geology

Source: DoN 2014.

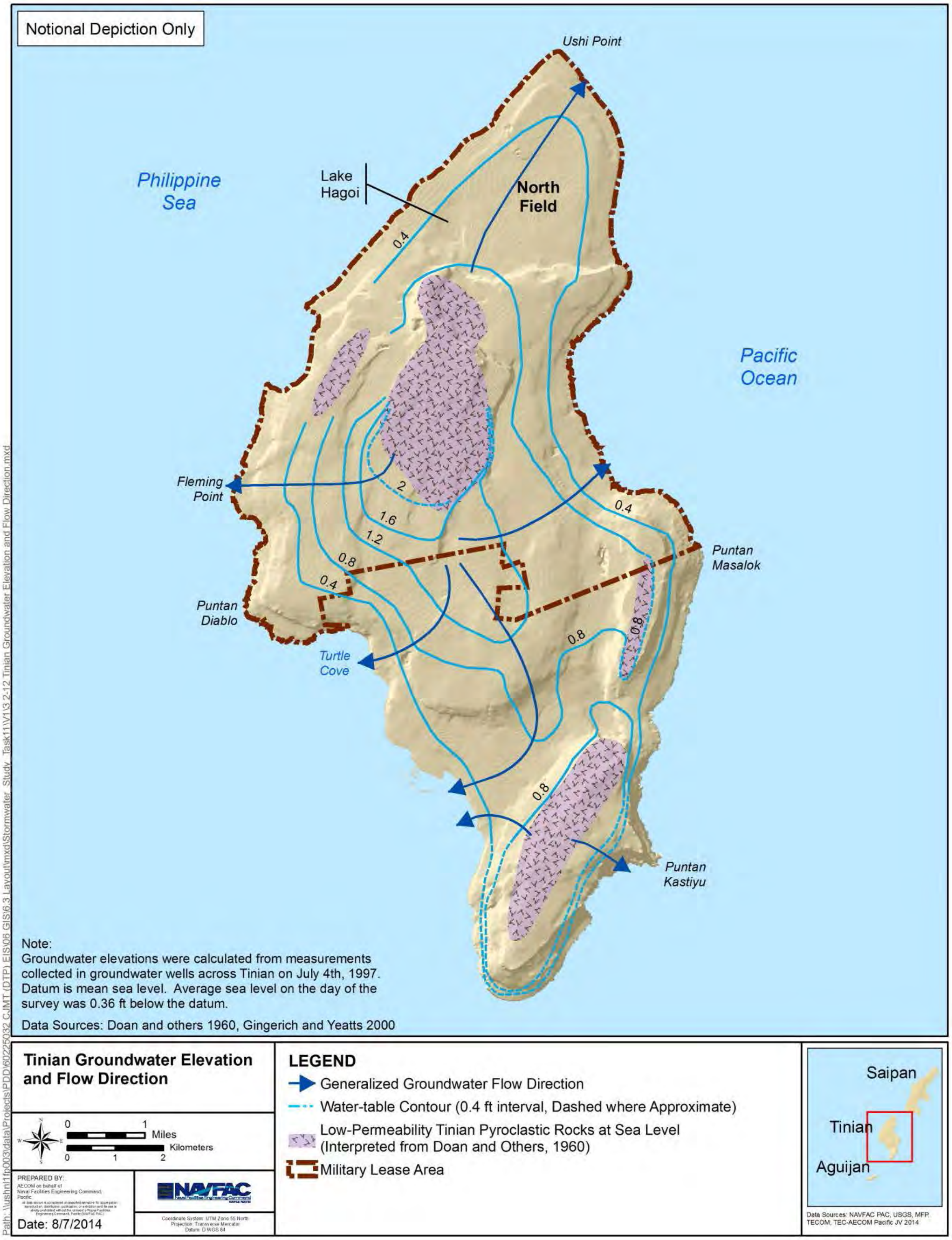

Figure 1.4-5. Tinian Groundwater Elevation and Flow Direction
Source: DoN 2014.

1.4.4 Hydrogeology

Hydraulic conductivity is a quantitative measure of the capacity of a rock to transmit water. Limestone units tend to have high hydraulic conductivities because of the porous and well-washed character of coral reefs, and secondary porosity as a result of dissolution. In contrast, pyroclastic rocks tend to have low hydraulic conductivities as a result of poor sorting and the high susceptibility of some volcanic minerals to chemical weathering and alteration to clays (USGS 2002a). This is particularly the case on Tinian, however, on Pagan higher permeability may be associated with ‘a‘ā flows, lava tubes in pahoehoe, joints, and faults.

Composite island aquifers (Jenson et al. 2006) are triple-porosity karst aquifers. The young limestone retains substantial primary (interparticle or matrix) porosity, which makes the dominant contribution to storage and usually local transmission to wells. Regional transmission is dominated by widened fractures, which may develop along faults, and by tension fractures. Where wells intercept the fracture network, performance can be an order of magnitude higher than for wells that draw their production exclusively from local matrix porosity. The third source of porosity in composite islands is conduits (cave systems) that can develop along the contact between the overlying soluble limestone aquifer and the underlying insoluble volcanic basement. Such conduits can develop along the flanks of the basement rises and ridges where they stand above sea level or have been above sea level during ice-age sea-level low-stands (Vann et al. 2013). Hydraulic conductivities in island karst aquifers can range from local values of $10^{0}10^{+3}$ feet per day (f/d) ($10^{0}10^{+3}$ meters per day [m/d]) to regional values of $10^{3}10^{4}$ f/d ($10^{3}10^{4}$ m/d) (Rotzoll et al. 2013). A‘ā lava is generally more viscous basaltic lava with a rougher surface and broken lava blocks. These jumbled blocks leave void space and generally have the potential for greater permeability than pahoehoe lava. Pahoehoe is generally less viscous lava with a smoother surface and less potential for permeability than a‘ā, but it could exhibit high permeability in lava tubes, interconnected vesicles, and fracturing as a result of cooling and/or fault movement. The USGS has reported values ranging from 10^{-2}-10^{+3} f/d ($10^{-2}10^{+3}$ m/d) for volcanic flows, tuffs, and breccia from scores of tests and Death Valley (USGS 2002b).

1.4.4.1 Tinian

The Tinian Pyroclastic Rocks are generally believed to have much lower permeability than limestone because of their texture and density, and are considered essentially non–water bearing for purposes of this study. The overlying Tagpochau Limestone, where it exists immediately beneath mean sea level (msl), and the Mariana Limestone that overlies it are both considered viable aquifers by this study. The minor beach deposits, alluvium, and colluvium are not situated in areas or at elevations that make them viable as groundwater resources for purposes of this study. Doan and others 1960 reported historic well productions from the military wells ranging from zero100 gpm (379 lpm), with the majority being in the 60100 gpm (227379 lpm) range. Aquifer tests were performed by the USGS on Tinian between 1994 and 2000 to estimate the hydraulic conductivity of the Tinian aquifer. Pumping rates for the tests ranged from 3-165 gallons per minute (gpm) (11625 liters per minute [lpm]). Resulting estimates of hydraulic conductivity in limestone (Tagpochau Limestone and Mariana Limestone) on Tinian ranged from 21-23,000 f/d (67,000 m/d). Groundwater modeling by the USGS used values of 10,500 f/d (3,200 m/d) for highly permeable limestone, 800 f/d (240 m/d) for less permeable limestone, and 0.2 f/d (0.1 m/d) for volcanic rock (USGS 2002a). The information above is presented in Table 2.6-1. Ambient groundwater elevations were monitored and contoured by the USGS (USGS 2000). As shown in Figure 1.4-5, groundwater elevations are highest surrounding the volcanic high of the North-Central Highland and decline radially around the highland toward the sea.

Groundwater is recharged by rainfall infiltration over most of Tinian. Water that recharges the groundwater system flows from zones of higher to lower hydraulic head. Ideally, fresh groundwater (total dissolved solids generally less than 1,000 milligrams per liter [mg/L]) forms a lens in a cross section and is underlain by denser saltwater (total dissolved solids of 32,000-36,000 mg/L); however, the base is distorted where it contacts the relatively impermeable volcanic basement rock. The basement rock is the igneous rock below the limestone. The Ghyben-Herzberg relationship (Baydon-Ghyben 1888–1889, Herzberg 1901) is commonly used to relate the thickness of a freshwater lens in an ocean-island aquifer to the density difference between freshwater and saltwater. A generalized cross-section of a freshwater lens is presented on Figure 1.4-6. Doan and others (1960) report the existence of such a basal freshwater lens, the lens of less-dense freshwater which "floats" above the more-dense salt water just above and extending below sea level, in areas near the north end and center portion of the island. The theoretical interface between freshwater and saltwater will be at a depth below sea level that is 40 times the height of the water table above sea level. Instead of a sharp freshwater/saltwater interface, however, freshwater is separated from saltwater by a transition zone in which salinity grades from freshwater to saltwater. In many field studies, the theoretical Ghyben-Herzberg interface depth within the transition zone is generally defined as the depth of about a 50% mix of freshwater and saltwater. Under equilibrium flow conditions in permeable aquifer systems, the Ghyben-Herzberg relationship may provide a reasonable estimate of freshwater depth if the transition zone is comparatively thin (USGS 2002a). Freshwater-lens thickness is affected by aquifer permeability and recharge rates. A reduction in recharge rate or an increase in permeability will reduce the height of the water table, which will cause the freshwater lens to be thinner. In the most permeable limestone, the water table is no more than a few feet above sea level, and the slope of the water table is nearly flat (USGS 2002a). Based on the Ghyben-Herzberg Principle, the depth to the 50% isochlor should vary from about 80 ft (24 m) below msl (surrounding the Central Plateau where the groundwater stands about 2 ft (0.6 m) (above sea level) to sea level around the perimeter of the island. The portion of the lens that is useful for potable water (i.e., with a chloride concentration of less than 250 mg/L [~1% isochlor]) is thinner than this.

On Tinian, the most important sources of groundwater are from the freshwater parts of this system in the limestone rocks (Figure 1.4-6). Water-level data indicate that groundwater flows radially from the North-Central Highland and the Southeastern Ridge and flows generally seaward (Figure 1.4-6). Most of the fresh groundwater discharges naturally from the aquifer at onshore and submarine coastal springs. Stafford et al. (2004, 2005) documented caves, fractures, and coastal springs on Tinian, which are locally important for groundwater exploration and development. A small amount of groundwater may be lost to evaporation and transpiration at the Makpo potential wetland complex and Hagoi Lake (USGS 2002a).

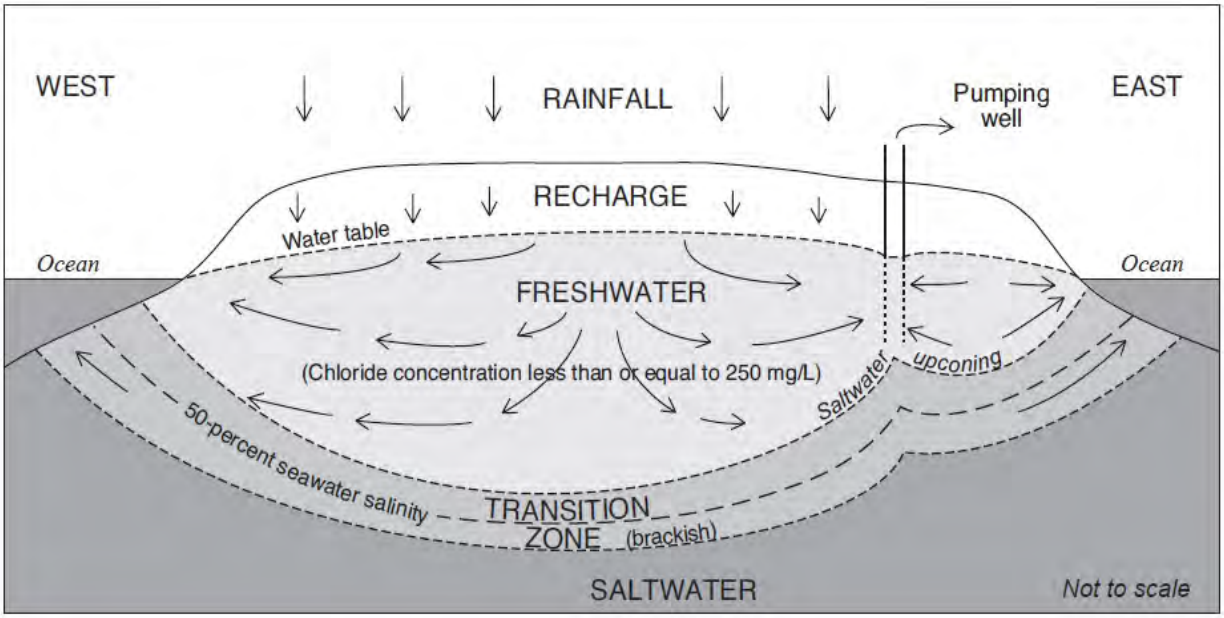

Figure 1.4-6. Generalized Depiction of a Freshwater Lens above Saltwater
Source: USGS 2000.

Salinity in a freshwater lens is gradational, an upper freshwater core through the underlying transition zone to saltwater. On small islands, mixing in the transition zone results mainly from tidal fluctuations superimposed on the gravity-drive flow of freshwater toward the shore. In areas near the coast, where mixing is thorough, a freshwater lens may not form and brackish water may exist, even at the water table. Under conditions of steady recharge, no pumping, and no ocean-level effects, the steady-state lens would have a fixed dimensions. In reality, rainfall is episodic and seasonal, and lens volume fluctuates naturally with time. Tidal fluctuations, variable recharge, and episodic pumping all combine to create a thicker transition zone than would be present without these influences (USGS 2002a). See Figure 1.4-6 for a simple generalized graphic depiction of a freshwater lens above a saltwater wedge on a small island. Based on monitoring performed by the USGS, the transition zones in wells TH08 and TH09 varied from roughly 3050 ft (9-15 m) thick in 1993 and 1994. Doan and others (1960) report 20 pre-pumping chloride concentration results ranging from 16 ppm up to 650 ppm (Table 2.6-1). Only two of the samples exceeded the secondary drinking water MCL for chloride of 250 ppm. Ten pairs of pre-pumping and post-pumping chloride concentration results are also reported. Prior to pumping only one of the ten wells (with pre- and post-pumping data) exceeded the secondary MCL, and after pumping two to three wells exceeded that standard. Note that one of the post-pumping results was simply recorded as “high”, but it is assumed that this refers to a concentration higher than 250 ppm. While the period of pumping is not reported, it is taken as a hopeful sign that seven to eight of 10 wells remained below the secondary MCL at the end of pumping.

1.4.4.2 Pagan

According to the 1978 Physical Development Master Plan, the only freshwater lens potentially capable of producing potable groundwater is in the area of the northern caldera west of Mount Pagan (PP&D 1978). However, Pacific Planning and Design Consultants concluded that convection currents associated with volcanic activity have destroyed parts of the basal lens “such that development of freshwater resources is questionable” (PP&D 1978). Corwin and others (1957) characterized the hydraulic properties of the two major rock types as follows: 1) lavas - the porosity is generally high especially in the clinker layers of a’a flows and on the surfaces between units of pahoehoe flows. Within the massive layers porosity derives primarily from gas vesicles, shrinkage cracks, lava tubes and secondary joints. The thick and massive layers of a'a flows and some thin tabular dikes and sills are the least porous. Similarly, permeability is high in the clinker layers, along surfaces between flows, through tunnels and in other continuous openings within the lava flows. Although porosity might be relatively high in gas vesicles, they are typically not interconnected; 2) pyroclastic rocks and other plastic materials: porosity ranges from fairly high in the loose, moderately well sorted beach sands and gravels and in cinder accumulations to low in compacted, poorly sorted, massive tuff breccias. Joints are common in these rocks and could provide avenues for groundwater movement. Permeability in the pyroclastic rocks (not including the beach sands, which are likely too close to the ocean to be of practical value for potable water supply purposes) is generally much lower than that in lavas. The highest values generally occur parallel to bedding, particularly in cinders.

Field observations of groundwater were based on records from the two lakes, two warm Springs, one seep, nine wells, and several steam vents (Corwin 1957). Water level records were obtained for seven of the wells and both lakes. Corwin and others (1957) concluded that all wells and the outer Lake exhibited tidal fluctuations.

Corwin and others (1957) mapped discontinuous basal lenses on the island with approximately 90% (over 30 billion gallons [114 billion liters]) of the lens underlying the northern caldera. This estimate was based on assumed average porosities and postulated basal water lens configurations. A thermal convection system was opined to be responsible for having destroyed the lens and produced water of poor to non-potable quality in the Inner Lake. Similar convection systems were expected elsewhere. These investigators concluded that the practical water supply from the lens is only a small part of the estimated volume and is limited to the easily accessible and easily developed resources of the western portion of the northern caldera and small segments of the caldera backslope. However, well drilling or comprehensive pump testing and water quality analysis have not been performed to confirm this.

Water quality sampling was performed on 50 surface and groundwater samples collected from the island. Total dissolved solids concentrations from the eight wells tested ranged from 690 ppm to 3,960 ppm. None of the wells had water quality below the secondary MCL of 500 ppm, but three of the wells were below 1,000 ppm. Those same wells had chloride concentrations ranging from 150 to 175 ppm, below the secondary MCL for that parameter (Corwin 1957).

No large bodies of high level (i.e., perched) groundwater were found or mapped above the hypothesized basal water table.

Boring logs, pump specifications, and well testing data from historical wells were not available for review. Without this information, it is difficult to quantify the hydraulic properties of the island's geology.

1.4.5 Sustainable Yield of Aquifer

"Sustainable yield" has traditionally been defined as the rate at which groundwater can be continuously withdrawn from an aquifer without impairing the quality or quantity of the pumped water or the environment. Before the development of groundwater modeling, and in the absence of a reliable model for a given aquifer, sustainable yield has generally been derived as a percentage, typically 20–25%, of estimated recharge. To achieve the hypothetically available sustainable yield, however, the means of water withdrawal must be optimized, which usually does not occur. Therefore, the full capacity of the aquifer, even if it approaches 20–25% of recharge, is generally not available. Moreover, in coastal and island aquifers, water quality (in terms of salinity) degrades in proportion to the amount extracted.

Recognition of these limitations in the sustainable-yield concept, along with the advent of new tools and technologies for aquifer management—such as numerical groundwater modeling, remote monitoring of production and water quality, and variable-rate pumps—has led to its supersession by the "sustainable use" or "sustainable management" concept (Alley and Leake 2004). Reliable models (i.e., USGS 2000, for Tinian) provide useful tools for general estimates of the trade-offs between extraction and water quality. For any given well or well field, however, the most important management technique is measurement of the actual relationship between water quality, extraction, and recharge, with appropriate adjustments of production. It is therefore crucial to obtain baseline data on water quality and well performance for each new well, and for managers to keep a running record of quality in comparison to pumping rates and changes in seasonal and annual total rainfall. Well fields and wells should be constructed so that managers, acting in consultation with hydrologists familiar with the local climate and aquifer properties, can adjust or redistribute the production rates at or between wells and well fields as performance and quality trends dictate.

1.4.5.1 Tinian

The average annual groundwater recharge for Tinian was estimated by the USGS to be about 30 in (76 cm) per year, using the bookkeeping method with daily rainfall data from 1987 to 1997 (USGS 2002a). This would be equal to approximately 37% of rainfall and would translate into approximately 62,000 acre-feet per year in recharge for a total of 55 million gallons per day (MGd) (210 million liters per day [MLd]). However, it should be cautioned that because of the water quality concerns, not all theoretical recharge is available for extraction. In 2010, existing resources were estimated to be capable of supplying up to 7 MGd (27 MLd). Doan and others 1960 report stated that there were two airbases and one naval base on island with a maximum population of about 250,000 personnel near the end of WWII and groundwater resources "were adequate" to supply this entire population. Demand at the time was estimated to be approximately 2.3 MGd, and this was not thought to be the "maximum exploitable yield". The maximum supply with the then-existent wells was 2.5 MGd. It was estimated that a more "ambitious" extraction program (i.e., with additional wells) could yield 34 MGd. Doan and others' cite a study from Piper (1946) that reported a maximum production of 12 MGd at some unstated date.

The *Wastewater Treatment and Disposal Rules and Regulations* (NMIAC 2004) define Class I aquifer recharge areas as areas contributing surface infiltration to a geologic formation, or part of a formation, that is water bearing and transmits, or is believed capable of transmitting, water to supply pumping wells or springs. Class I aquifer recharge areas have not been designated for Tinian. However, it is understood that the CNMI Bureau of Environmental and Coastal Quality (BECQ) has indicated that all of Tinian should be considered a Class I aquifer recharge area.

1.4.5.2 Pagan

While a basal groundwater surface might exist, especially on the western side and back slope of the northern caldera, sparse data are available to confirm the existence of a viable groundwater resource for potable supply. Given the expeditionary nature of the proposed action and significant costs associated with exploration; development and operation of a permanent, permitted drinking water system does not appear to be a viable option on Pagan.

CHAPTER 2. EXISTING ISLAND-WIDE WATER SYSTEMS, CURRENT DEMAND, CURRENT CAPACITY

2.1 COMMONWEALTH UTILITIES CORPORATION PUBLIC WATER SYSTEMS

2.1.1 Tinian

Tinian's public water system is owned and operated by the Commonwealth Utilities Corporation (CUC) and serves the southern third of Tinian where the island's entire population lives. Data about the CUC's customer accounts as of November 2013 are presented in Appendix C. The currently operating public system consists of one horizontal Maui well for water supply, three storage tanks (one owned by the Commonwealth Ports Authority [CPA]), one chlorine injection point, and approximately 38 mi (61 km) of distribution pipes. A small distribution system serving Tinian International Airport is owned by the CPA. The CPA distribution system consists of a 60,000-gallon (227,100-liter) storage tank and a piping system that receives water from the CUC's Maui well subsystem. In the past, additional wells for potable water supply were in operation, but they have been taken off line and not maintained in operable condition. Figure 2.1-1 shows the physical layout of Tinian's public water system. Figure 2.1-2 shows existing wells on the island. Currently one potable water well, one irrigation well, and two agricultural water wells are used on Tinian. As of April 2014, the operating production wells are:

- Maui Well Number (No.) 2 (potable)
- WOP-151/152 (formerly M21) (agricultural)
- UPW-008 (formerly M26) (agricultural)

2.1.1.1 Tinian Water Sources

The sole supply of potable water on Tinian comes from the freshwater Makpo potential wetland complex's basal groundwater lens, covering approximately 28–36 acres (11–15 hectares) in the service area. Water is collected from the lens by Maui Well No. 2.

Maui Well No. 1, also located at the Makpo potential wetland complex, is currently out of service because its equipment is very old and repair parts have been difficult to obtain. The Maui Well No. 1 pump house and pump equipment are shown in Photo 2.1-1 and Photo 2.1-2. The pump house was equipped with two 75-horsepower (hp) pumps and one 50-hp pump, and was originally designed to pump water to the Marpo Heights Tank. Previous plans to refurbish Maui Well No. 1 have been abandoned. Maui Well No. 2 has four 75-hp pumps, each capable of pumping about 350 gpm (1,325 lpm), for a total of 1,400 gpm (5,300 lpm) to both the Marpo Heights and Carolinas Tanks, as well as the CPA Airport Tank. The Maui Well No. 2 pump house and pump equipment are shown in Photo 2.1-3 and Photo 2.1-4. Previously, four deep vertical wells located along the transmission water lines, each with a 50-hp pump, added water and pressure to the system as needed; however, these vertical wells are no longer in use. Currently, Maui Well No. 2 supplies all of the CUC's Tinian water system, operating three of its four pumps almost constantly (CUC 2013). Because one pump is kept on standby for maintenance purposes Maui Well No. 2 is operating near full capacity.

Figure 2.1-1. Commonwealth Utilities Corporation (CUC) Existing Potable Water System
Source: DoN 2014.

Figure 2.1-2. Tinian Existing Wells
Source: DoN 2014.

Photo 2.1-1. Maui Well No. 1 Pump House (left) and Operations Building (right)

Photo 2.1-2. Maui Well No. 1 Pump Equipment

Photo 2.1-3. Maui Well No. 2 Pump House

Photo 2.1-4. Maui Well No. 2 Pump Equipment

2.1.1.2 Tinian Water Treatment

Maui Well No. 2 uses an injection system to add chlorine to the water at the source. This injection system consists of two 150-pound (68-kilogram) chlorine cylinders, a vacuum regulator mounted to the top of each cylinder, and a small pressurizing pump for the chlorination circuit. A similar chlorination system was used for the nonoperational wells. See Photo 2.1-5 for the chlorine injection system at Maui Well No. 2.

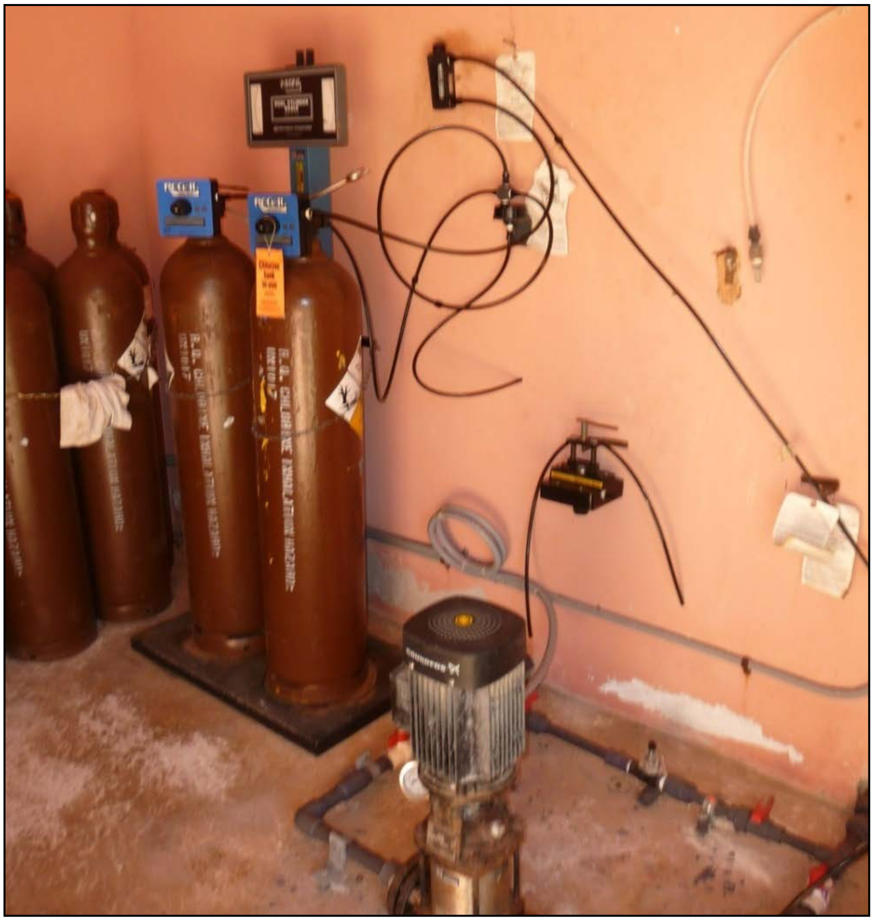

Photo 2.1-5. Chlorine Injection System at Maui Well No. 2

2.1.1.3 Tinian Storage Tanks

Tinian's water system supplies water to three water storage tanks: the Marpo Heights Tank, Carolinas Tank, and Tinian Airport Tank. The Marpo Heights and the Carolinas Tanks are owned and operated by CUC. The Airport Tank, although supplied through the CUC system, it is not owned and operated by CUC. The Marpo Heights Tank, commonly referred to as the Quarter Million Gallon Tank, is a 250,000-gallon (950,000-liter) storage tank that serves the Marpo Valley agricultural area and the Marpo Heights residential area. The largest storage tank, the Carolinas Tank, commonly referred to as the Half Million Gallon Tank, is a 500,000-gallon (1.89-million-liter) tank located above the Carolinas residential area and serves the Carolinas Heights subdivision, San Jose Village, Tinian Dynasty Casino, Carolinas Heights Agricultural Homesteads, and a portion of the Marpo Valley. The 60,000-gallon (227,100-liter) Tinian Airport Tank, which is owned and operated by the Airport facilities, is located along the airport access road and serves only the airport facilities. The three water storage tanks are shown in Photo 2.1-6, Photo 2.1-7, and Photo 2.1-8.

Photo 2.1-6. Marpo Heights Water Storage Tank (Quarter Million Gallon Tank)

Photo 2.1-7. Carolinas Water Storage Tank (Half Million Gallon Tank)

Photo 2.1-8. Tinian Airport Water Storage Tank

2.1.1.4 Tinian Distribution System

The potable water system does not have any solely used transmission mains. The water lines between Maui Well No. 2 and the water storage tanks are also used as distribution mains to users. A 6-in (150-millimeter [mm]) polyvinyl chloride (PVC) water line transmits water to the Marpo Heights Tank and an 8-in (200-mm) PVC water line transmits water to the Carolinas Tank. The existing system for distributing potable water consists of pipes with diameters measuring 12, 10, 8, and 6 in (300, 250, 200, and 150 mm, respectively) to manage six service areas: the Marpo Heights, Marpo Valley, and Carolinas Heights Subdivisions; the Carolinas Agricultural Area; San Jose Village; and the Tinian Dynasty Casino. Most of the system consists of PVC pipe; the remaining distribution lines are old galvanized pipe and transite (asbestos-cement) pipe.

2.1.1.5 Current Water Quality and Reliability

According to the BECQ, the overall potable water quality throughout Tinian meets all U.S. Primary Drinking Water Standards. However, customers have expressed concerns about the water not being very palatable, which could be attributed to high levels of total dissolved solids and chloride. In the past, water main breaks have resulted in occasional water quality exceedances for bacteria. Details of the groundwater quality testing results are described in Section 2.2.

The CUC's current system for storing and distributing potable water is operating in substandard condition. Numerous defects and operational problems were discovered during a December 2013 site visit with the CUC. The telemetry system and altitude valve for the Marpo Heights Tank was broken, so operators must manually check the water level and adjust the supply valve to prevent an overflow of the storage tank, which occurs frequently. The water pressure in the San Jose service area was too high because a pressure-reducing valve was functioning improperly. Follow-up correspondence with CUC in June 2014 indicated that they currently have a design project to rehabilitate the pressure-reducing valve to reduce the high water pressure in the south. Much of the distribution system is old and requires frequent leak repairs, particularly in portions that consist of thin walled asbestos-cement (transite) and galvanized pipes.

The current unaccounted-for water (UFW) rate for the CUC's potable water system is estimated to be about 75%80%, which is extremely high. Most water utilities, policymakers, and associations, such as the American Water Works Association, deem a 10%15% UFW loss as acceptable. The CUC blames the high rate of UFW on numerous leaks, particularly from old galvanized and transite pipes, lack of a dedicated transmission system from production well to tanks, and high pressures throughout the distribution system.

The CUC has identified and planned the following future projects that would improve its current potable water system:

- Install supervisory control and data acquisition system.
- Replace all active meters.
- Improve Maui Well No. 2.
- Disconnect Maui Well No. 1 piping and Marpo Heights Tank/Carolina Tank interconnection.
- Upgrade the Marpo Heights and Carolina Tanks.
- Replace and/or improve various water lines.

2.1.2 Pagan

Pagan currently does not have infrastructure for potable water. Prior to the 1981 volcano eruption, the potable water source was primarily from rainwater, which was captured and stored in underground water storage tanks. Residents would use a bucket-pulley system to retrieve the water from the storage tanks. The location and condition of these storage tanks are unknown. Currently, Pagan has two historical hand-dug wells that provide a limited amount of brackish water. As stated by the CNMI Division of Environmental Quality (now a department within the BECQ), those two wells should be preserved in place and could be used for groundwater quality sampling and monitoring (NAVFAC Pacific 2014).

2.2 TINIAN CURRENT WATER SYSTEM DEMAND AND CAPACITY

Maui Well No. 2 has an estimated capacity of at least 1 MGd (3.8 MLd) of potable water in the dry season and 1.5 MGd (5.7 MLd) in the wet season (USACE 2003).

As of November 2013, the CUC is providing potable water for a total of 833 metered accounts, which include residential, commercial, and government customers (CUC 2013). CUC estimates the UFW for their system to be very high. Data for 2002 was the last year that information was received for both metered water and production water to calculate a UFW value. The average daily demand based on the 2002 metered water data is approximately 675,000 gpd (2,555,200 liters per day). However, the average recorded production for 2002 was 1.2 MGd (4.5 MLd), resulting in a UFW rate of 78%, through the distribution system, which is extremely high (USACE 2003). Since 1994, the CUC has been detecting and correcting water line leakages to reduce the water loss in the distribution system. At a meeting with the CUC in December 2013, it was determined that the estimated UFW remains high at 75%80% and varies seasonally. The average recorded production levels for 2011, 2012, and 2013 were 0.89, 1.01, and 1.14 MGd (3.36, 3.82, and 4.31 MLd), respectively.

2.3 TINIAN GROUNDWATER QUALITY

A concern on Tinian is the potential for high chloride levels in groundwater caused by saltwater intrusion into the freshwater lens from excessive pumping of the aquifer. Although the current chloride levels at the existing municipal well (Maui Well No. 2) do not exceed the U.S. Environmental Protection Agency's secondary maximum contaminant level (MCL) of 250 parts per million, chloride levels could be a concern in the future if groundwater-pumping rates increase. Groundwater aquifers on Tinian also may be susceptible to contamination from surface activities (e.g., sewage spills, leachate from septic systems, leaking underground storage tank, and recharge with polluted stormwater runoff). These sources of contamination are important because the thin surface soils and underlying highly permeable limestone do not significantly impede the passage of contaminants to the aquifer.

Total coliform bacteria are naturally present in the environment and are used as an indicator that other potentially harmful bacteria may be present. Primary Drinking Water Standards for Tinian allow only one positive sample of total coliform per month. Total coliform was detected in two samples taken in September 2010 and November 2011. In 2010, inappropriate sample taps were identified as the possible cause of the detections. The CUC installed new proper sample taps and discontinued the use of the improper sample taps. However, test samples in 2011 again exceeded allowable coliform levels. As a result, the CUC repaired leaks and flushed the distribution system, which was thought to be the probable cause of the total-coliform detections. In 2012, no coliform bacteria were detected in any Tinian monitoring samples. Based on this information, the total coliform detections are likely the result of system and/or sample taps issues, not groundwater contamination or contamination of wells (all of this water ultimately came from Maui Well No. 2).

Groundwater sampling conducted between 2010 and 2012 did not detect any other Safe Drinking Water Act violations than the total-coliform violations mentioned previously. Total dissolved solids, which is a secondary constituent and not regulated by the U.S. Environmental Protection Agency or the BECQ, does exceed the secondary drinking water Maximum Contaminant Level (MCL), which is 500 mg/L. However, secondary constituent limits are based on consumer acceptance criteria and not on human health criteria. Table 2.3-1 summarizes the drinking-water-quality results for 2010 to 2012.

Table 2.3-1. Commonwealth Utilities Corporation, Maui Well No. 2 Drinking-Water-Quality Results, 2010–2012

Parameter	*Units*	*MCLG*	*MCL*	*Year Tested*	*Average*	*Range*
Primary Drinking Water Parameters						
Total Coliform Bacteria	NA	0	1	2012	0	ND
Fecal Coliform/*E. coli*	NA	0	0	2012	0	ND
Total Haloacetic Acids	µg/L	NA	60	2012	ND	ND
Total Trihalomethanes	µg/L	NA	80	2012	8.2	8.2
Chlorine	µg/L	4	4	2012	0.9	0.3 –1.4
Barium	µg/L	2,000	2,000	2010	3	3
Chromium	µg/L	100	100	2010	1.6	1.6
Copper	µg/L	1,300	1,300	2010	90th percentile = 45	
Lead	µg/L	0	15	2010	90th percentile = 1.4	
Fluoride	mg/L	4	4	2010	0.1	0.1
Nitrates plus Nitrites as Nitrogen	mg/L	10	10	2012	5.1	4.8 –5.6
Sodium	mg/L	NE	NA	2010	100	100
Trichloroethylene	µg/L	0	5	2010	ND	ND
Gross Alpha Particles	pCi/L	0	15	2010	ND	ND
Dieldrin	µg/L	NA	NA	2010	ND	ND

Parameter	***Units***	***MCLG***	***MCL***	***Year Tested***	***Average***	***Range***
Secondary Drinking Water Parameters						
Chloride	mg/L	NA	250	2012	196	175–223
Hardness, Total as Calcium and Magnesium	mg/L	NA	NA	2012	304	296–316
pH	NA	NA	6.5–8.5	2012	7.1	7.0 – 7.3
Specific Conductance	µS	NA	NA	2012	1,108	1,069–1,155
Total dissolved solids	mg/L	NA	500	2012	631	618–644

Legend: µg/L = micrograms per liter; µS = microsiemens; MCL = maximum contaminant level; MCLG = maximum containment level goal; mg/L = milligram per liter; NA = Not Applicable or Not Available; ND = Not/None Detected; NE = None Established; pCi/L = picocuries per liter.
Sources: CUC 2011, 2012b, 2013.

2.4 TINIAN HISTORIC WELL PUMP TEST DATA

As discussed in Chapter 1, the freshwater lens on Tinian is located primarily in the limestone overlying volcanic bedrock. Geologic cross sections A-A', B-B', and C-C' (Figure 1.4-3) indicate that the limestone at or near sea level is mostly the Mariana Limestone overlying the Tagpochau Limestone. Well yields reported in these units range from about 3 gpm (11 lpm) (TH24) to roughly 165 gpm (625 lpm) (TH01) during aquifer testing (USGS 2002a). The majority of the tests were in roughly the 60–120 gpm (227 454 lpm) range. Doan and others (1960) report the majority of the military wells could produce 60-100 gpm (227-378 lpm). Assuming this range for new wells, it would require three to six new vertical wells (plus one back-up well) to meet the projected total maximum daily demand of 0.460 MGd (1.74 MLd). The results of the USGS pump testing are summarized in Table 2.4-1. Water quality data were not available from the pump tests at the time of this writing. Coordination with the USGS has been occurring to determine what archival records exist that might be useful, but no information has been received.

Table 2.4-1. Pump Testing Results

Well	***Test Duration (days)***	***Well Diameter (inches [cm])***	***Open or Screened Interval Length (ft [m])***	***Pumping Rate (gpm [lpm])***	***Steady-State Drawdown (ft [m])***	***Hydraulic Conductivity (f/d [m/d])***	***Geologic Unit***
M07	3	6 (15)	20 (6.1)	23 (87)	6.73 (2.05)	25 (7.6)	QTm, Tt
M09	3	6 (15)	16 (4.9)	128 (485)	0.17 (0.05)	6,700 (2,042)	QTm, Tt
M11	3	6 (15)	15 (4.6)	124 (469)	1.95 (0.59)	590 (180)	QTm, Tt
M16	2	8 (20)	18 (5.5)	96 (363)	1.07 (0.33)	680 (207)	QTm, Tt
M19	2	6 (15)	16 (4.9)	30 (114)	7.01 (2.14)	38 (11.6)	Tt
M21	3	6 (15)	18 (5.5)	49 (185)	0.19 (0.06)	2,100 (640)	QTm, Tt
TH01	1	12 (30)	12 (3.7)	165 (625)	0.18 (0.05)	8,500 (2,591)	QTm, Tt
TH03	2	8 (20)	23 (7.0)	105 (397)	0.14 (0.04)	4,700 (1,433)	QTm, Tt
TH04	2	8 (20)	19 (5.8)	108 (409)	0.60 (0.18)	1,300 (396)	QTm, Tt
TH05	2	8 (20)	19 (5.8)	92 (348)	0.55 (0.17)	1,200 (366)	QTm, Tt
TH06	3	16 (41)	13 (4.0)	57 (216)	0.02 (0.01)	23,000 (7,010)	QTm, Tt
TH07	2	16 (41)	21 (6.4)	50 (189)	13.5 (4.11)	21 (6.4)	QTm, Tt
TH10	5	8 (20)	17 (5.2)	68 (257)	0.19 (0.06)	2,800 (853)	QTm, Tt
TH11	2	6 (15)	18 (5.5)	63 (238)	4.17 (1.27)	122 (37)	QTm, Tt
TH12	5	8 (20)	14 (4.3)	72 (273)	0.09 (0.03)	7,400 (2,256)	QTm, Tt
TH22	3	8 (20)	17 (5.2)	110 (416)	0.11 (0.03)	8,000 (2,438)	Ttp [b]
TH24	1	8 (20)	10 (3.0)	3 (11)	6 (1.83) [a]	6 (1.8) [a]	Ttp [c]

Notes:
Well locations shown in Figure 2.1-2.
Well loss was not subtracted from steady-state drawdown.

[a] Values are estimates because well went dry after 4 minutes of pumping.
[b] Listed as Ttp in table, but based on text from the original report, it might be limestone instead.
[c] Geology left blank in table, but based on text from original report, it appears to be Tinian Pyroclastic Rocks.
Legend: cm = centimeters; f/d = feet per day; ft = feet; gpm = gallons per minute; lpm = liters per minute; m = meters; m/d = meters per day; QTm = Mariana Limestone; Tt = Tagpochau Limestone; Ttp = Tinian Pyroclastic Rocks.
Source: USGS 2002a.

2.5 WELL FIELD SITING CONSTRAINTS

2.5.1 Tinian

As part of this study, potential areas for new well fields were evaluated in the Military Lease Area (MLA) to fulfill the estimated water demand to support the proposed action. Planning constraints, such as live-fire ranges and maneuvering areas would be incompatible with well/aquifer maintenance needs. Considering the constraints, locations for new potential well fields have been identified and all of the training constraints, along with the potential area for new well fields, are shown in Figure 2.5-1. Likewise, biological constraints were evaluated and are presented in Figure 2.5-2. Figure 2.5-3 presents the new potential well fields along with the superficial geology.

The proposed well fields are located north and east of the existing airport and are underlain by Mariana Limestone over Tagpochau Limestone, which overlies volcanic bedrock (see Figure 1.4-3). Ground surface elevations across this area are approximately 40-80 ft (12–24 m) above sea level and groundwater is mapped to range from about 0.81.6 ft (0.24-0.48 m) above sea level. Assuming an ideal freshwater lens, the 50% isochlor would vary from about 3264 ft (1020 m) below sea level in the center of the island and thinning toward the coast. The wells should draw water primarily from the Tagpochau Limestone and the Mariana Limestone. The freshwater lens thickness can also be expected to vary from wet season to dry season and from years of above-average to below-average rainfall. Past practice on Tinian and elsewhere in the Mariana Islands has been to set wells at 40–50 ft (12–15 m) below msl. However, accumulated experience with drilling and well development elsewhere in the Mariana Islands (see CDM 1982), along with ongoing developments in theory (see Gulley et al. 2012), suggests that most of the production in productive wells comes from the first 15–20 ft (4.66.1 m) below msl. Prospects for saltwater contamination could be reduced by setting wells no deeper than about 20 ft (6.1 m) below msl. Consistent with the sustainable-management concept (Section 1.4.5), a slightly larger number of wells in each well field, set at more shallow depths, and producing at more modest rates than traditionally sought, would enhance the quality of water that could be obtained for any given total production. Therefore, it is recommended that development begin with the installation and testing of some exploratory wells set to no deeper than 20 ft (6.1 m) below msl.

Past military activities on Tinian have resulted in the presence of hazardous-substance contamination and/or munitions and explosives of concern. In response, the U.S. military, the U.S. Environmental Protection Agency, and the CNMI have established mitigation and cleanup activities under a variety of programs. Table 2.5-1 lists sites of potential environmental concerns that were identified in the 1997 environmental baseline survey within the MLA (NAVFAC Pacific, 1997). These areas of environmental concern are shown in Figure 2.5-4. Data requests have been issued to the BECQ for additional environmental information. No additional information has been provided at this time. Some sites are near or within the proposed well fields. Areas of potential environmental concern should be considered during detailed site reconnaissance and mapping before final well locations are selected.

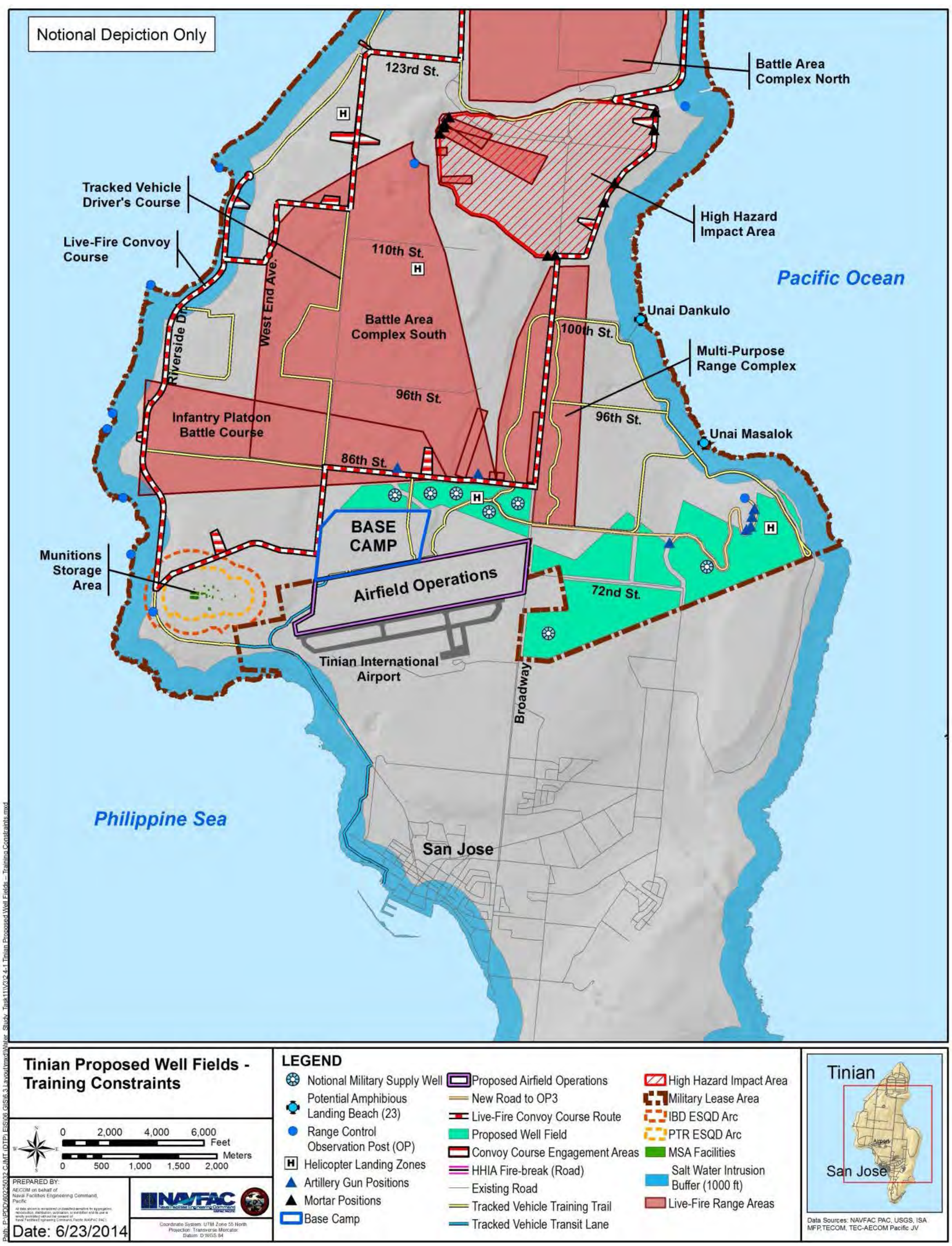

Figure 2.5-1. Tinian Proposed Well Fields – Training Constraints

Source: DoN 2014.

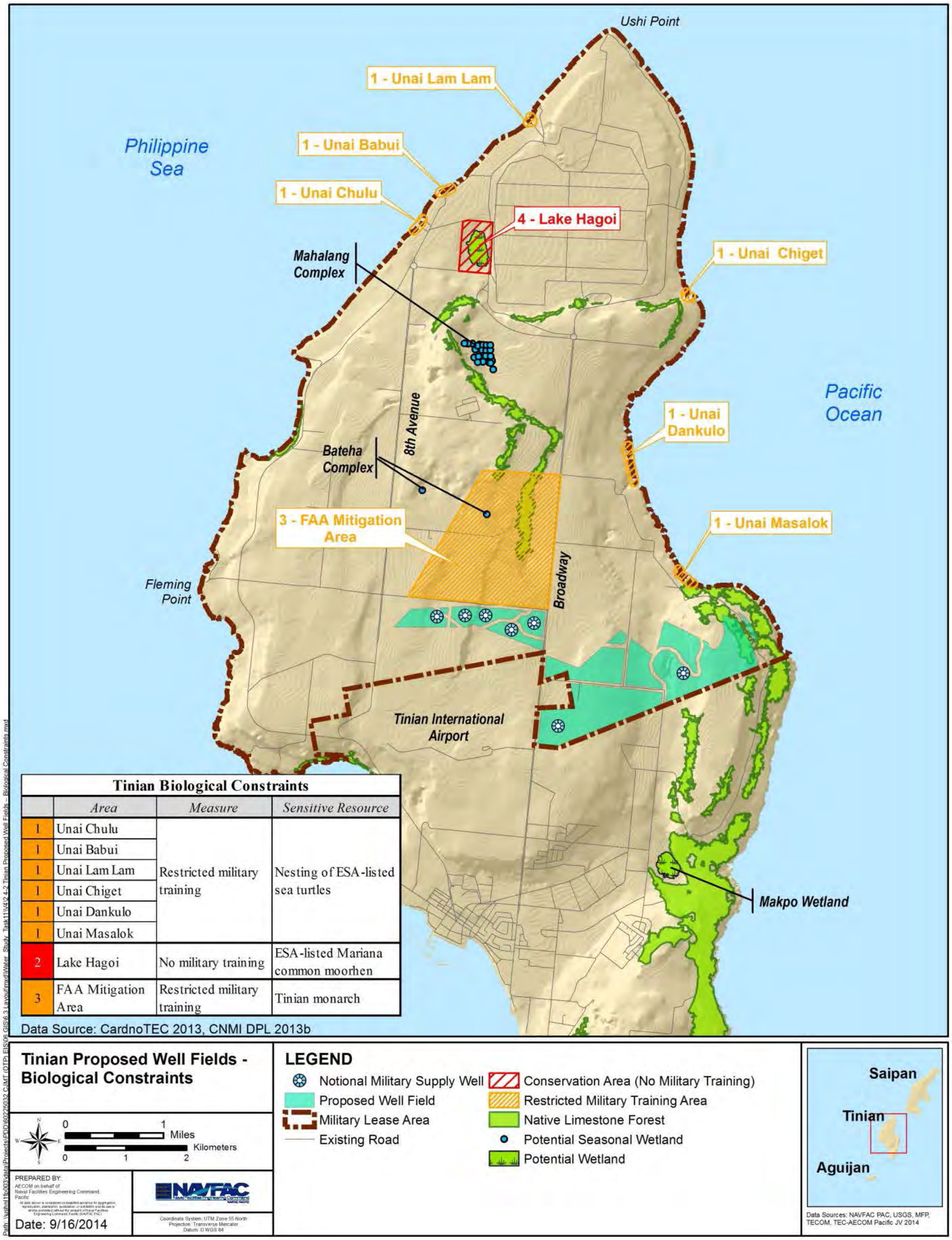

Figure 2.5-2. Tinian Proposed Well Fields – Biological Constraints

Source: DoN 2014.

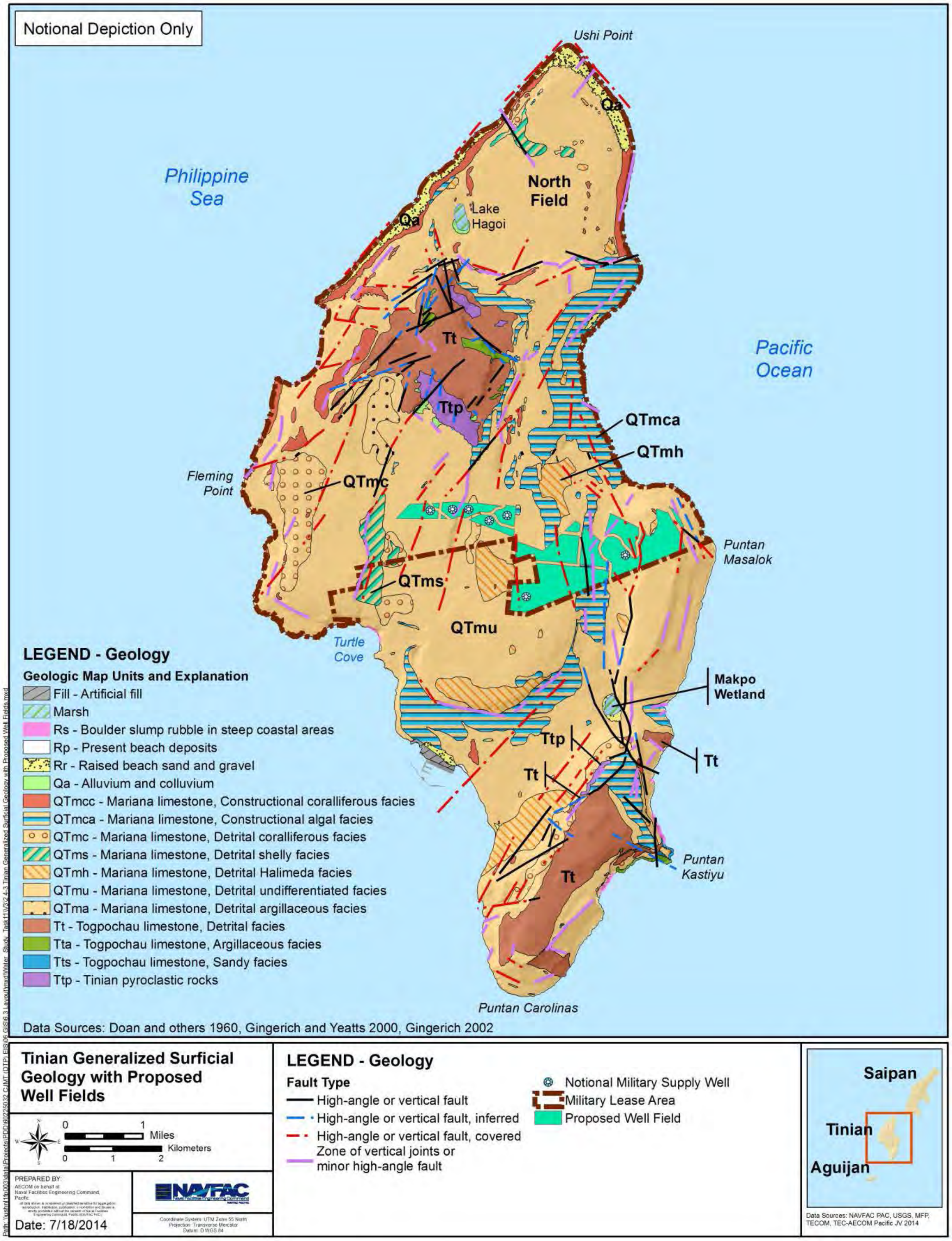

Figure 2.5-3. Tinian Generalized Surficial Geology with Proposed Well Fields
Source: DoN 2014.

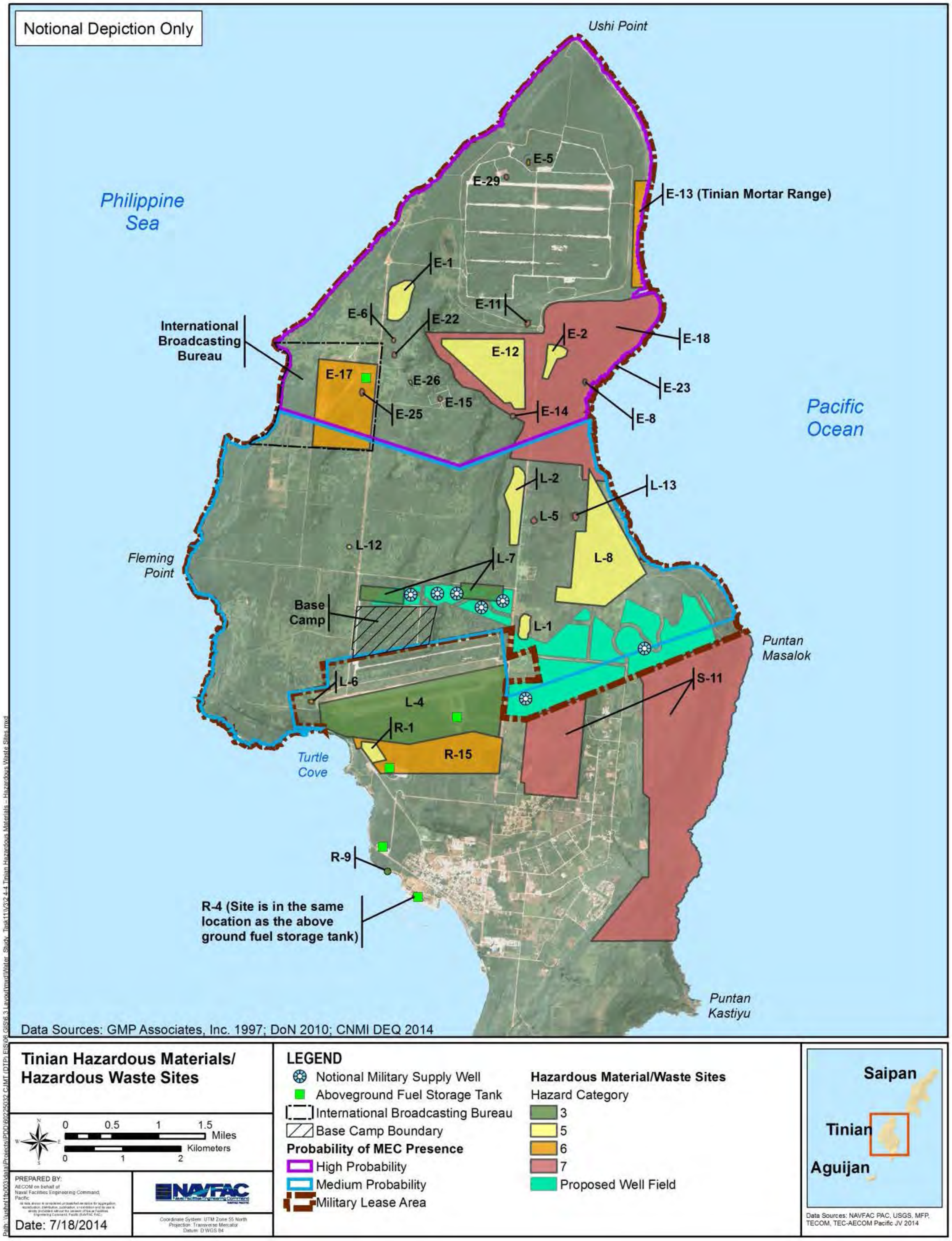

Figure 2.5-4. Tinian Hazardous Materials/Hazardous Waste Sites
Source: DoN 2014.

Table 2.5-1. Sites of Potential Environmental Concern within the Tinian Military Lease Area

Site	*Description/Materials and Location*	*Category/Status*
E-1	12 World War II aviation fuel storage tanks/ordnance east of Eighth Avenue, south of the traffic circle at the intersection of Eighth Avenue and 125th Street	Some but not all of the fuel tanks were removed as scrap metal after World War II. Small ordnance may also remain at this site; this site is considered Category 5.
E-2	19 World War II aviation fuel storage tanks/ordnance east side of Broadway, south of the traffic circle at the intersection of Broadway and 116th Street	Some but not all of the fuel tanks were removed as scrap metal after World War II. Small ordnance may also remain at this site; this site is considered Category 5.
E-5	World War II Japanese fuel bunker/petroleum products, end of a shallow gorge in the northwestern corner of North Field	The fuel bunker was bombed or burned during the war and unburned fuel likely leaked from containers. No subsequent cleanup took place; this site is considered Category 6.
E-6	World War II Asphalt Plant/ asphalt east of Eight Avenue, between 110th and 125th Streets	Because of the presence of asphalt on the ground and metal equipment at the site, this site is considered Category 6.
E-8	World War II mine assembly buildings/ordnance east of Broadway	Historical maps showed a cluster of mine assembly buildings that were not found during the 1997 environmental baseline survey; this site is considered Category 7.
E-11	World War II lube oil storage and dumping unit/petroleum products west of the traffic circle at northern end of Broadway	A historical map showed a lube oil storage and dumping unit at the location indicated. No further information was available and the site was not surveyed during the 1997 environmental baseline survey; this site is considered Category 7.
E-12	World War II central bomb dump/ordnance south of North Field	Historical records show that this facility had storage capacity for 10,000 tons of high-explosive bombs and 15,000 tons of incendiary bombs. However, it is reported that there are no areas on Tinian with concentrated ordnance, so most of the ordnance may have been removed from this location. Because complete removal cannot be confirmed, this site is considered Category 5.
E-13	Tinian Mortar Range/ordnance on the east side of the island, between North Field and the eastern coast (also called Chiget Mortar Range)	The Tinian Mortar Range was part of the World War II battlefield and was used for military live-fire training from 1945 through 1994. During training exercises, small-arms ammunition (up to .50 caliber) 40-millimeter rifle grenades, 60-millimeter mortars, and 81-millimeter mortars were used. The range was closed in 1994 because of the visible presence of 40-millimeter and 60-millimeter unexploded ordnance. The Tinian Mortar Range is unused by the military. The DoN is conducting cleanup operations under the Military Munitions Response Program. A preliminary assessment was completed in 2006. A site inspection (metal detector survey to identify potential locations of munitions and explosives of concern, and soil sampling to determine potential presence of munitions constituents) is planned to take place from May to October 2014; this site is considered Category 6.

Site	Description/Materials and Location	Category/Status
E-14	Caves below Mount Lasso/ordnance caves along the cliffs below the east side of Mount Lasso, used as Japanese defensive positions in World War II	According to archaeological records, multiple ordnance were found at Japanese positions along cliffs. However, no ordnance was found in the Mount Lasso cliff caves during the 1997 environmental baseline survey. A more thorough survey is needed to be sure that no ordnance is present; this site is considered Category 7.
E-15	World War II Army hospital/unknown, 110th Street east of Eighth Avenue	A historical map indicated the presence of an Army hospital at this location. No further information was found, and the site was not analyzed under the 1997 environmental baseline survey; the site is considered Category 7.
E-17	Bio Pacific Agricultural Area/possible pesticide use west of Eighth Avenue, surrounding International Broadcasting Bureau inside Military Lease Area	The Bio Pacific Company stored fertilizers and pesticides at a warehouse outside the Military Lease Area. The amount of fertilizers and pesticides from the warehouse that may have been applied to the agricultural land are not known; this site is considered Category 6.
E-18 [a]	Micronesian Development Company cattle grazing land/possible pesticide use south of North Field and west of Broadway	Land was used primarily for grazing cattle from 1965 through 1994. However, several chemicals including pesticides were inventoried at the Micronesian Development Company in 1990 and it is unknown whether the pesticides were used on the grazing land; therefore, this site is considered Category 6.
E-22 [b]	World War II trash dump site/garbage east of Eighth Avenue and International Broadcasting Bureau	A historical map identified a World War II trash dump. The site is considered Category 7 because it was not assessed during the 1997 environmental baseline survey.
E-23	World War II scrap metal dump site/ordnance on northeastern coast, south of Asiga Point	Scrap metal, bullets, and other evidence of ammunition were found during the 1997 environmental baseline survey. This site is considered Category 6.
E-25 [a]	World War II scrap metal dump site/ordnance west of Eighth Avenue, within Site E-17 described above	This site was identified from a historical map that indicated it contained scrap metal and possibly bombs. It was not viewed during the 1997 environmental baseline survey; therefore, the site is considered Category 7.
E-26	World War II scrap metal dump site/ordnance and petroleum products east of Eighth Avenue and International Broadcasting Bureau south of Site E-22	Fuel containers, bombs, and bomb casings possibly remain at this site after partial removal; therefore, the site is considered Category 5.
E-29	World War II Japanese air traffic control building/unidentified stain on floor, northern boundary of North Field	Stain on floor was not investigated during the 1997 environmental baseline survey. Therefore, the site is considered Category 7.
L-1	World War II fuel storage tanks/ordnance, east of Broadway and northeast of the eastern end of the Tinian International Airport runway	Rusted fuel tanks were noted during the 1997 environmental baseline survey and historical evidence suggests that ordnance may remain; this site is considered Category 5.
L-2	World War II fuel storage tanks/ordnance, west of Broadway across 96th Street	Fuel tanks were removed after World War II, but historical evidence suggests that ordnance may remain; this site is considered Category 5.

Site	***Description/Materials and Location***	***Category/Status***
L-5	Former World War II Japanese communication building now Micronesian Development Company slaughterhouse/potential asbestos and petroleum, northeastern corner of Broadway and 96th Street	Because of broken, suspected friable asbestos, corrugated sheeting, World War II aboveground storage tanks, and a 55-gallon (208-liter) container with unknown contents, the site is considered Category 7.
L-7	World War II-era Service Aprons and Engineering Areas/petroleum, oil, and lubricant products, north of Tinian International Airport	Occasional small spills of petroleum products were likely, but at concentrations that do not require a removal or remedial response. Therefore, this site is considered Category 3.[a]
L-8	Masalog Bomb Dump/ordnance, eastern portion of the island, inland from Unai Masalok	This site historically had 469 compartments for bomb storage and could accommodate 18,800 tons (17,055 metric tons) of high-explosive bombs. All of the historic ordnance may not have been removed, so this site is considered Category 5.
L-12	World War II scrap metal dump site/petroleum products and ordnance, west of Eighth Avenue between 96th and 86th Streets	Historical records indicated that scrap metal, bombs, fuel, and grease from World War II may not all have been removed. The site was not viewed during the 1997 environmental baseline survey. Therefore, the site is considered to be Category 5.
L-13 [a]	West Field "boneyard"/chemicals, east of Broadway at the end of 96th Street	World War II aircraft junkyard where the Micronesian Development Company also disposed waste from the slaughterhouse, as well as an agricultural product, Effective Microorganism-1. This product contains lactic acid, photosynthetic organisms, and yeast and is mixed with drinking alcohol for use as a pesticide. The site is assigned to Category 7.
S-11 [b]	Micronesian Development Company agricultural parcels/pesticides, southeastern portion of island	Most of this land is used for cattle grazing. However, it is unknown whether pesticides were used on these lands. Therefore, the site is considered Category 7.

Notes:
Category 3 = Area where storage or release of hazardous substances has occurred, but at concentrations that do not require a removal or remedial response.
Category 5 = Area where storage or release of hazardous substance has occurred, and removal actions are underway, but all required remedial actions have not yet been taken.
Category 6 = Area where storage or release of hazardous substances has occurred, but required actions have not yet been implemented.
Category 7 = Area not evaluated or that requires additional evaluation.
[a] Possible sampling planned. Note that third possible sampling Site S-12 is not included in Table 2.5-1 because it is outside the Military Lease Area.
[b] Additional evaluation planned.
Sources: NAVFAC Pacific 1997, J. Victorino, NAVFAC Pacific, personal communication 2014; DoN 2014.

Site E-13 as identified in the environmental baseline survey, the Tinian Mortar Range, is being investigated under the Navy's Military Munitions Response Program (Figure 2.5-4) (DoN 2014a). This site is also known as the Chiget Mortar Range. The Tinian Mortar Range is being investigated to address hazards associated with munitions and explosives of concern and munitions constituents. The first step under the Military Munitions Response Program, the preliminary assessment (detailed historical records review and visual site survey) was completed for the Tinian Mortar Range in 2006 (DoN 2014a). The second step, the site investigation (metal detector survey to identify potential locations of munitions and explosives of concern, and soil sampling to determine potential presence of munitions constituents), is planned to take place from May to October 2014 (DoN 2014a).

Three sites (E-18, E-25, and S-11) for which the 1997 environmental baseline survey recommended additional evaluation will also be inspected, separately from the Tinian Mortar Range effort. Three other sites (E-22, L-13, and S-12) from the 1997 environmental baseline survey will be evaluated and sampled (J. Victorino, NAVFAC Pacific, personal communication, 2014). Based on the results of the additional evaluations and sampling, some of the other sites may undergo further investigation/cleanup (J. Victorino, NAVFAC Pacific, personal communication, 2014).

Because of the historical military and wartime activities on Tinian, there is the possibility that munitions and explosives of concern may be encountered at locations other than the ordnance storage and disposal sites described in Table 2.5-1. The 1997 environmental baseline survey listed numerous locations where individual ordnance items, such as artillery shells, bombs, and hand grenades have been found in the MLA (NAVFAC Pacific 1997). Based on historical records, approximately the northern half of the MLA is estimated to have a high probability of munitions and explosives of concern present up to 4 ft (1.2 m) below the ground surface (Figure 2.5-5) (DoN 2010).

Based on review of Figure 2.5-4, sites L-1, L-7 and L-12 are in or near the proposed well fields. L-1 represents World War II fuel storage tanks/ordnance. Although L-7 is listed on the figure, it is not defined in the table provided, so it is not known what environmental issue this might raise. L-12 signifies World War II scrap metal dump site-petroleum products and ordnance. Each of these should be investigated further during the design phase. Contaminant presence should be confirmed or denied and, if confirmed, should then be removed, addressed, and/or mitigated. Final well placement should consider these factors.

2.5.2 Pagan

No environmental investigations are known to exist for Pagan. Data requests have been issued to the BECQ for additional environmental information. If information is provided it will be presented in the final version of this report. Figure 2.5-5 presents general categories for probability of historic surface or near surface munitions and explosives of concern.

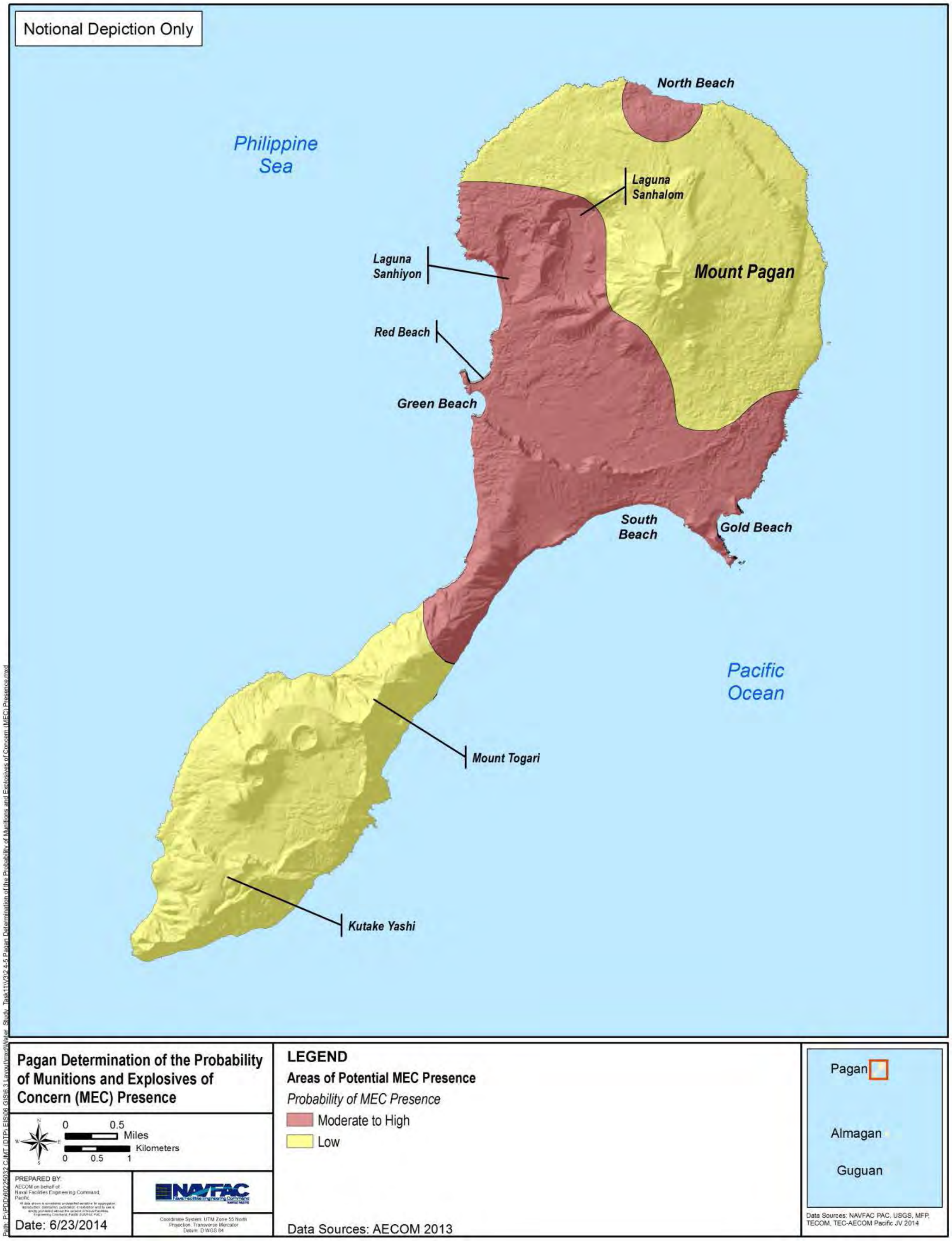

Figure 2.5-5. Pagan Determination of the Probability of Munitions and Explosives of Concern (MEC) Presence

Source: DoN 2013.

2.6 EXISTING AND PREVIOUS WELLS

2.6.1 Tinian

In 1944, the U.S. military captured Tinian from Japan and transformed Tinian into the largest B-29 base in the Pacific. The U.S. military population on Tinian grew to approximately 250,000 by the war's end. The U.S. military drilled 40 wells (M-series wells in Figure 2.1-2), mostly on the Central Plateau and in the North-Central Highland, and constructed a Maui-type horizontal well (Maui Well No. 1) on the northern edge of the Makpo potential wetland complex during 1944–45. These and other wells are shown on Figure 2.1-2 and listed in Table 2.6-1. Peak water usage from the 40 military wells during World War II was estimated to be about 2.3 MGd (8.7 MLd) (Joint Region Marianas 2012).

All 40 wells were abandoned shortly after World War II. The USGS rehabilitated 16 of the 40 wells during 1995–97. The rehabilitated wells originally extended into the freshwater lens and were cased from land surface to well bottom with solid steel casing, and perforated along the bottom 10–20 ft (3–6 m). Rehabilitation by the USGS involved retrieving the old pump and pipe, redrilling if necessary, and cleaning the hole to near the original depth. The well casing remains intact, although some parts are heavily corroded. Well M29 was deepened into the transition zone. Two other military wells (M25 and M26) were rehabilitated by a private corporation around 1987 (USGS 2000). The USGS drilled 17 monitoring wells during 1993–97 in the Median Valley and the adjacent Southeastern Ridge and Central Plateau. Of the 17 wells, 12 are open holes and 5 are cased with PVC pipe and screened below the water table. All wells were drilled into the top of the freshwater lens except wells TH02, TH04X, TH08, and TH09, which were drilled into the transition zone. The transition zone and underlying transition zone fluctuate as a result of seasonal rainfall and groundwater withdrawal (USGS 2000).

Maui Well No. 1 is a Maui-type infiltration gallery constructed in the Median Valley by the U.S. military in 1945. This well is the only well that was not abandoned after World War II, and it supplied all of the potable water for Tinian until 1999 when two vertical wells were added to the system. Maui Well No. 1 produced about 1 MGd (4.5 MLd) from the shallow limestone aquifer. The well draws from the upper part of the aquifer over a large area, which tends to maximize the amount of freshwater that can be withdrawn from an area while minimizing upconing of the saltwater. The infiltration gallery lies in a trench and consists of dual drainage tunnels 300 ft (91 m) in length, covered with 1.5-in (3.8-cm) graded coral gravel. The tunnels were made of 240 steel cylindrical bomb crates, perforated, and connected end to end. A sump at the midpoint of the tunnels constructed of two steel pontoons collects water from the tunnels and houses the pumps used to extract the water (USGS 2000).

At various times other vertical wells – e.g., TH06 (capable of 60 gpm [273 lpm]) and TH04 (50 gpm [227 lpm]) have been in use by the CUC. In 2000–2001, a new 400-ft-long (122-m) infiltration gallery well (Maui Well No.2) was constructed near Maui Well No.1 to replace that well. According to the 2012 Water Quality Report, all CUC water was supplied by Maui Well No. 2 in 2012. M25 and M26 (25 gpm [114 lpm] each) supply water for a private corporation. When used, Ag30 reportedly produced seasonal irrigation water at a rate of 500 gpm (2,273 lpm).

Table 2.6-1. Known Current and Former Wells on the Island of Tinian

Well Name	Other Well Names	Owner	Installed By	Date Well Drilled	Type	Wellhead or Measuring Point Elevation (ft)		Well Depth below MSL (negative values = above msl)		Chloride Content (various sources)		Water Production (gpm) (Doan and Others 1960)		Water Production (gpm) (various sources) [b]		Original Function	Current Status
						ft	meters	ft	meters	Before Pumping (ppm)	After Pumping (ppm)	gpm	Lpm	gpm	Lpm		
Ag20	W-40B, Small Marpo (Japanese) Well	CNMI government	Japanese military	1930s	Dug, Cement-lined trench	7.1	2.2	1.0	0.3							Watering cattle/irrigation	Inactive
Ag30	W-40A, Large Marpo (Japanese) Well	CNMI government	Japanese military	1930s	Dug, Cement-lined trench	5.08	1.5	5.0	1.5	130	130	0	0	500	1893	Watering cattle/irrigation	Active use
HagN	W-43, North Hagoi		Japanese military	1930s	Dug, Cement-lined trench	4.4	1.3	2.0	0.6	622						Watering cattle/irrigation	Inactive
HagS	W-44, South Hagoi		Japanese military	1930s	Dug, Cement-lined trench	7.54	2.3	1.0	0.3	148	360					Watering cattle/irrigation	Inactive
M02 [c]	W-2, Civilian Affairs Well	CNMI government	U.S. military	8/5/1997	Drilled, 6 in (15 cm) solid steel cased well	264.56	80.6	12.0	3.7		20	100	379			Water supply	Inactive
M05 [c]	W-5, Asiga Well	CNMI government	U.S. military	7/31/1997	Drilled, 6 in (15 cm) solid steel cased well	108.8	33.2	13.0	4.0		75	75	284			Water supply	Inactive
M07 [c]	W-7, W 100 St. Well	CNMI government	U.S. military	5/19/1995	Drilled, 6 in (15 cm) solid steel cased well	241.35	73.6	19.0	5.8			100	379	23	87	Water supply	Inactive
M08 [c]	W-8, 110 St. Well	CNMI government	U.S. military	8/14/1997	Drilled, 6 in (15 cm) solid steel cased well	266.07	81.1	16.0	4.9	100	600	100	379			Water supply	Inactive
M09 [c]	W-9, NAB #1	CNMI government	U.S. military	4/24/1995	Drilled, 6 in (15 cm) solid steel cased well	265.08	80.8	15.0	4.6		107			128	485	Water supply	Inactive
M10 [c]	W-10	CNMI government	U.S. military	3/20/1997	Drilled, 6 in (15 cm) solid steel cased well	95	29.0	14.0	4.3		220	60	227			Water supply	Inactive
M11 [c]	W-11, NAB #2	CNMI government	U.S. military	3/14/1995	Drilled, 6 in (15 cm) solid steel cased well	292.03	89.0	14.0	4.3					124	469	Water supply	Inactive
M15 [c]	W-15, Broadway Well	CNMI government	U.S. military	5/29/1997	Drilled, 6 in (15 cm) solid steel cased well	193.84	59.1	17.0	5.2	35	70	70	265			Water supply	Inactive
M16 [c]	W-16, 2nd Ave. Well	CNMI government	U.S. military	2/24/1995	Drilled, 8 in (20 cm) solid steel cased well	153.39	46.8	14.0	4.3	106	45			96	363	Water supply	Inactive
M19 [c]	W-19, 8th Ave. Well	CNMI government	U.S. military	6/5/1997	Drilled, 6 in (15 cm) solid steel cased well	247.92	75.6	14.0	4.3					30	114	Water supply	Inactive
M21 [c]	WOP-151/152, W-21, Mendiola Well, 67th St. Well	CNMI government	U.S. military	1/11/1997	Drilled, 6 in (15 cm) solid steel cased well	243.29	74.2	17.0	5.2	80		60	227	49	185	Water supply	Active agricultural well
M22 [c]	W-22, 90th St. Well	CNMI government	U.S. military	6/30/1997	Drilled, 6 in (15 cm) solid steel cased well	222.73	67.9	8.0	2.4		150	40	151			Water supply	Inactive
M25 [d]	W-25, East Side Well	Unknown	U.S. military	09/19/87?	Drilled, 6 in (15 cm) solid steel cased well	211.94	64.6	88.0	26.8	196		30	114			Water supply	Inactive
M26 [d]	UPW-008, W-26, 59th St. Well	Unknown	U.S. military	1987?	Drilled, 6 in (15 cm) solid steel cased well	340.83	103.9	30.0	9.1	40		35	132			Water supply	Active agricultural well
M29 [c]	W-29, West Field Well	CNMI government	U.S. military	2/12/1997	Drilled, 6 in (15 cm) solid steel cased well	247.04	75.3	168.0	51.2							Water supply	Inactive
M33 [c]	W-33, 72nd St. Well	CNMI government	U.S. military	8/20/1997	Drilled, 6 in (15 cm) solid steel cased well	235.63	71.8	10.0	3.0	50						Water supply	Inactive
M35 [c]	W-35	CNMI government	U.S. military	7/25/1997	Drilled, 6 in (15 cm) solid steel cased well	257.23	78.4	13.0	4.0							Water supply	Inactive
M39 [c]	W-39	CNMI government	U.S. military	5/15/1997	Drilled, 6 in (15 cm) solid steel cased well	238.93	72.8	11.0	3.4		150					Water supply	Inactive

Well Name	Other Well Names	Owner	Installed By	Date Well Drilled	Type	Wellhead or Measuring Point Elevation (ft)		Well Depth below MSL (negative values = above msl)		Chloride Content (various sources)		Water Production (gpm) (Doan and Others 1960)		Water Production (gpm) (various sources) [b]		Original Function	Current Status
						ft	meters	ft	meters	Before Pumping (ppm)	After Pumping (ppm)	gpm	Lpm	gpm	Lpm		
Maui No. 1	W-41, formerly Municipal Well, Marpo Well	CNMI government	U.S. military	1945	Dug, Out-of-service municipal water supply well (Maui-type horizontal construction - constructed of 240 steel cylindrical bomb crates joined end to end and perforated)	9.76	3.0	-9.8	-3.0	97	100			780	2953	Drinking water supply well	Out of service
Maui No. 2	Municipal Well	CNMI government	CNMI government	2000	Municipal water supply well (Maui-type horizontal construction)									875	3312	Drinking water supply well	Active use
ObsB		Unknown	USGS	2/2/1991	USGS 4 in (10 cm) monitoring piezometer (PVC pipe-cased)	7.45	2.3	0.5	0.2							Groundwater monitoring well	Unknown
Pala	W-45	Tinian Palacios family	Japanese military	1930s	3 ft (0.9 m) diameter, hand dug well	65	19.8	3.0	0.9	185	200						Active use
Taga		CNMI government	Ancient Chamorro	Unknown	Shallow-dug well				0.0								Unknown
TH01		CNMI government	USGS	9/17/1996	USGS 12 in (30 cm) monitoring well	117.46	35.8	13	4.0					165	625	Groundwater monitoring well	Unknown
TH02		CNMI government	USGS	4/28/1997	USGS 8 in (20 cm) monitoring well	158.86	48.4	94	28.7							Groundwater monitoring well	Unknown
TH03		CNMI government	USGS	10/24/1996	USGS 8 in (20 cm) monitoring well	109.05	33.2	22	6.7					105	397	Groundwater monitoring well	Unknown
TH04		CNMI government	USGS	12/13/1993	USGS 8 in (20 cm) monitoring well	72.18	22.0	18	5.5					108	409	Groundwater monitoring well	Unknown
TH05		CNMI government	USGS	6/21/1995	USGS 8 in (20 cm) monitoring well	120.85	36.8	18	5.5					92	348	Groundwater monitoring well	Unknown
TH06		CNMI government	USGS	3/2/1995	USGS 6 in (15 cm) monitoring well	309.07	94.2	13	4.0					57	216	Groundwater monitoring well	Unknown
TH07		CNMI government	USGS	1/20/1995	USGS 6 in (15 cm) monitoring well	343.84	104.8	20	6.1					50	189	Groundwater monitoring well	Unknown
TH08		CNMI government	USGS	1/29/1993	USGS 4 in (10 cm) monitoring well	8.24	2.5	92	28.0							Groundwater monitoring well	Unknown
TH09		CNMI government	USGS	2/3/1993	USGS 4 in (10 cm) monitoring well	6.7	2.0	92	28.0							Groundwater monitoring well	Unknown
TH10		CNMI government	USGS	10/9/1996	USGS 8 in (20 cm) monitoring well	163.74	49.9	16	4.9					68	257	Groundwater monitoring well	Unknown
TH11		CNMI government	USGS	2/25/1997	USGS 6 in (15 cm) monitoring well	339.66	103.5	19	5.8					63	238	Groundwater monitoring well	Unknown
TH12		CNMI government	USGS	1/8/1997	USGS 8 in (20 cm) monitoring well	146.41	44.6	13	4.0					72	273	Groundwater monitoring well	Unknown
TH19		CNMI government	USGS	7/26/1995	USGS 8 in (20 cm) monitoring well	550	167.6	29	8.8							Groundwater monitoring well	Unknown
TH1X		CNMI government	USGS	10/1/1996	USGS 6 in (15 cm) monitoring well	116.99	35.7	15	4.6							Groundwater monitoring well	Unknown
TH22		CNMI government	USGS	10/16/1996	USGS 8 in (20 cm) monitoring well	96.61	29.4	16	4.9					110	416	Groundwater monitoring well	Unknown

Well Name	Other Well Names	Owner	Installed By	Date Well Drilled	Type	Wellhead or Measuring Point Elevation (ft)		Well Depth below MSL (negative values = above msl)		Chloride Content (various sources)		Water Production (gpm) (Doan and Others 1960)		Water Production (gpm) (various sources) [b]		Original Function	Current Status
						ft	meters	ft	meters	Before Pumping (ppm)	After Pumping (ppm)	gpm	Lpm	gpm	Lpm		
TH24		CNMI government	USGS	4/10/1997	USGS 8 in (20 cm) monitoring well			9	2.7					3	11	Groundwater monitoring well	Unknown
TH4X		CNMI government	USGS	5/5/1994	USGS 8 in (20 cm) monitoring well	71.89	21.9	268	81.7							Groundwater monitoring well	Unknown
Ushi		U.S. military	U.S. military	9/6/1987	Military water supply well	98.47	30.0	19.0	5.8							Nonpotable water supply well	Unknown
W-1	Masalog	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	255.29	77.8	7.2	2.2	40	85	55	208			Water supply	Inactive
W-12	E 100 St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	184.43	56.2	14.6	4.4	100	High	60	227			Water supply	Inactive
W-13	Park Row Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	59.96	18.3	15.0	4.6							Water supply	Inactive
W-14	42nd St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	242.63	74.0	12.4	3.8	30	40	35	132			Water supply	Inactive
W-17	86th St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	244	74.4	4.0	1.2							Water supply	Inactive
W-18A	98th St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	289.3	88.2	100.7	30.7	38		8	30			Water supply	Inactive
W-18B	98th St. B Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	285	86.9	75.0	22.9	35		8	30			Water supply	Inactive
W-20	New 110th St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	258	78.6	10.0	3.0		600	10	38			Water supply	Inactive
W-23	Mil. Gov. #2	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	294.4	89.7	-126.4	-38.5							Water supply	Inactive
W-24	Central Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	247.27	75.4	15.7	4.8	70						Water supply	Inactive
W-27	Mil. Gov. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	284.5	86.7	30.5	9.3			0	0			Water supply	Inactive
W-28	West Side Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	253.75	77.3	12.3	3.7							Water supply	Inactive
W-3	Lasso	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	202.18	61.6	31.3	9.5							Water supply	Inactive
W-30	84th St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	255.5	77.9	-18.5	-5.6							Water supply	Inactive
W-31	Hilo Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	257.58	78.5	11.4	3.5			0	0			Water supply	Inactive
W-32	113th St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	223	68.0	14.0	4.3							Water supply	Inactive
W-34 [a]	Island Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	298.24	90.9	17.8	5.4							Water supply	Inactive
W-36		U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	125	38.1	12.0	3.7							Water supply	Inactive
W-37		U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	100	30.5	14.0	4.3							Water supply	Inactive
W-38		U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	277.83	84.7	22.2	6.8			0	0			Water supply	Inactive
W-4	Gurguan	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	225.31	68.7	6.7	2.0		35	60	227			Water supply	Inactive
W-46 [a]		U.S. military	U.S. military	WWII Period	Hand dug well	50	15.2	-45.0	-13.7	650						Water supply	Inactive

Well Name	***Other Well Names***	***Owner***	***Installed By***	***Date Well Drilled***	***Type***	***Wellhead or Measuring Point Elevation (ft)***		***Well Depth below MSL (negative values = above msl)***		***Chloride Content (various sources)***		***Water Production (gpm) (Doan and Others 1960)***		***Water Production (gpm) (various sources)*** [b]		***Original Function***	***Current Status***
						ft	***meters***	***ft***	***meters***	***Before Pumping (ppm)***	***After Pumping (ppm)***	***gpm***	***Lpm***	***gpm***	***Lpm***		
W-47 [a]		U.S. military	U.S. military	WWII Period	Hand dug well	35	10.7	-20.0	-6.1							Water supply	Inactive
W-6	96th St. Well	U.S. military	U.S. military	WWII Period	Drilled, 6 in (15 cm) solid steel cased well	239.41	73.0	15.1	4.6	16	100	100	379			Water supply	Inactive
WOP-197-01		CNMI government	Unknown	10/7/2011	4 in (10 cm) Schedule 80 PVC pipe											Groundwater monitoring well (for landfill siting study)	Unknown
WOP-197-02		CNMI government	Unknown	9/24/2011	4 in (10 cm) Schedule 80 PVC pipe									193	731	Groundwater monitoring well (for landfill siting study)	Unknown
WOP-197-03		CNMI government	Unknown	10/3/2011	Schedule 80 PVC pipe well											Groundwater monitoring well (for landfill siting study)	Unknown

Notes:
[a] Present location of this well is unknown.
[b] Rates based on pump test data (mostly USGS 2002a). Values do not necessarily represent maximum sustainable rates.
[c] Rehabilitated by USGS.
[d] Rehabilitated by private party.
Blanks = unknown
Legend: cm = centimeters; CNMI = Commonwealth of the Northern Mariana Islands; ft = foot/feet; gpm = gallons per minute; in = inch(es); lpm = liters per minute; m = meters; msl = mean sea level; NA = not applicable; PVC = polyvinyl chloride; USGS = United States Geological Survey.
Sources: USGS 2002a, USGS 2000, Doan and Others 1960.

The Japanese administration dug more than 100 wells and trenches during its occupation of Tinian in the 1930s. All but a few were abandoned and filled. There are four shallow, cement-lined trenches ranging in length from 10-30 ft (3–9 m) that penetrate the freshwater lens. Trenches Ag20 and Ag30 are both located along the southern edge of the Makpo potential wetland complex. Ag30 continues to be used seasonally as a source of irrigation water. Trenches HagN and HagS are located on the north and south edge of Lake Hagoi, respectively (USGS 2000). As of April 2014, the current operating production wells are:

- Maui Well No. 2 (potable)
- Ag30 (irrigation)
- M21 (also known as (WOP-151/1521) (agricultural)
- M26 UPW-008 (also or formerly known as: UPW-008, W-26, 59th St. Well) (agricultural)

Tetra Tech (Tetra Tech 2012) performed a hydrogeological assessment of groundwater conditions at the planned Tinian Landfill site and surrounding area. The Tinian Landfill was a proposed municipal solid waste landfill northwest of the airport. The scope of work for the assessment included installation of three monitoring wells: WOP-197-01, WOP-197-02, and WOP-197-03.

2.6.2 Pagan

Information about the location, condition, and yield of potable water supply wells on Pagan is limited. Figure 2.6-1 shows possible historical well locations based on the following sources of information:

1. The Japanese dug a well north of the airfield (noted in blue in Figure 2.6-1). Per the text of the 1978 Physical Development Master Plan (PP&D 1978), this well was 30 ft (9.1 m) deep. There is no information about the condition of the well; however, similar-era wells were typically 3 ft (0.9 m) in diameter and set in concrete.
2. Four wells were located during the 2008 archaeological survey (noted in yellow in Figure 2.6-1).
3. Historical groundwater wells may be present (noted in gray with a question mark in Figure 2.6-1).

Data provided by the USGS for one of the existing wells (location to be determined) reports TDS values of 9,230 mg/L in 1983 and 1,840 mg/L in 2001 (USGS 2014). Data are also provided for springs, lakes and other features on island. Notable among these is one spring with a TDS concentration of 326 mg/L. The TDS concentration of the two lakes is reported as brackish. A. Corwin and others (1957) provided water quality data from eight wells and found that three had TDS values greater than 500 but less than 1,000 ppm. These three wells also had chloride concentrations below the secondary MCL for that constituent.

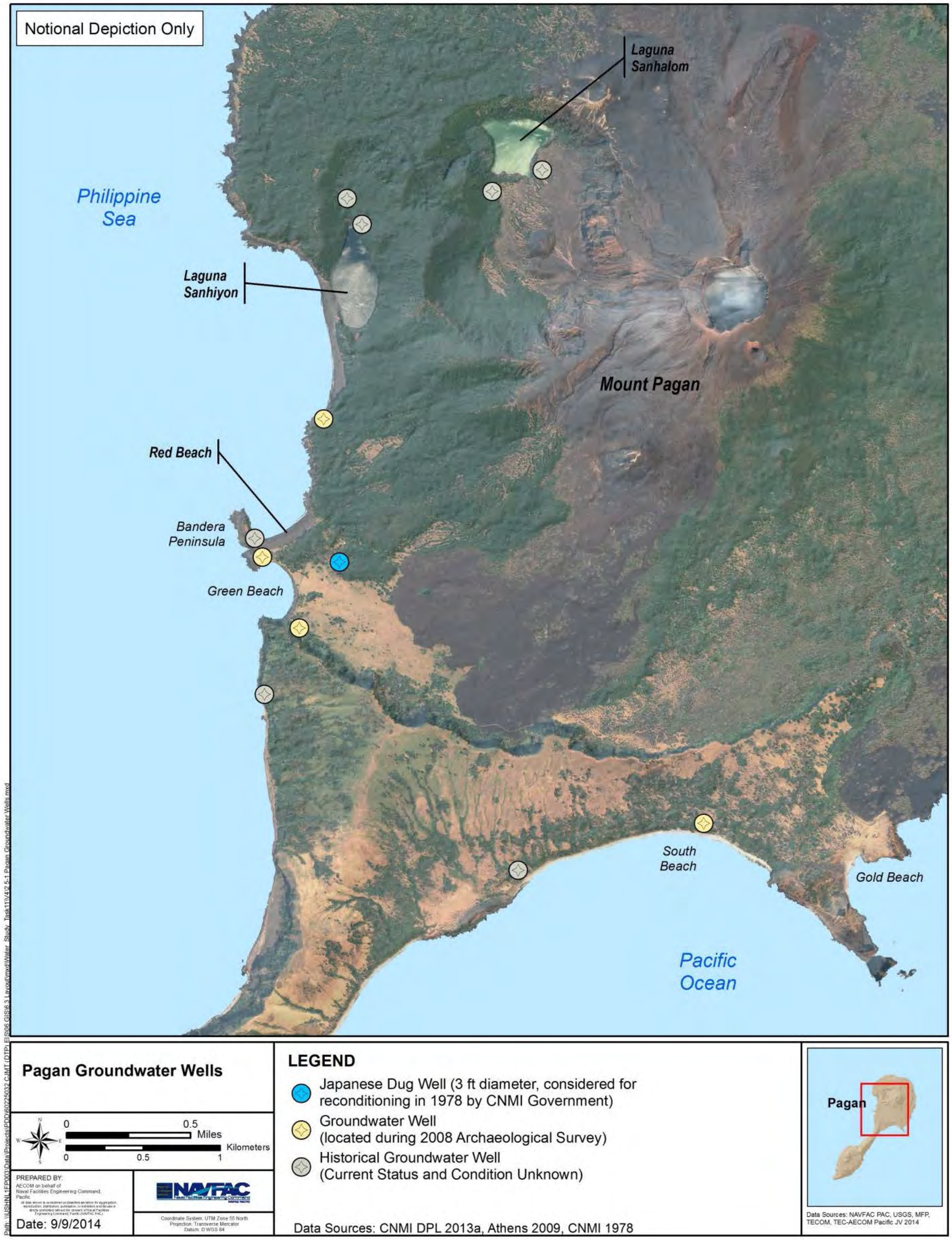

Figure 2.6-1. Pagan Groundwater Wells
Source: DoN 2014.

CHAPTER 3. PROJECTED FUTURE DEMAND AND SYSTEM REQUIREMENTS FOR TINIAN

3.1 UNITED STATES MILITARY REQUIREMENTS

This section presents the estimated future water demand calculations based on Unified Facilities Criteria (UFC) 3-230-01: *Water Storage, Distribution, and Transmission* (Department of Defense 2012a); UFC 3-230-03: *Water Treatment* (Department of Defense 2012b); and UFC 3-600-01: *Fire Protection Engineering for Facilities* (Department of Defense 2013) for the proposed training facilities and support on Tinian. Additional water system design and construction requirements based on the UFC are provided in Appendix D.

For the proposed action, future water demands were estimated for a new water system to provide potable water to the U.S. military facilities including a base camp and Munitions Storage Area (MSA) north of the Tinian International Airport and within the MLA. Future water demands were also estimated that would draw from the existing CUC water system that would include U.S. military port facilities located at the Tinian Port and housing associated for operations personnel and the construction workforce.

Estimates of future water demands from U.S. military airport facilities that are not part of the proposed action were also considered. These potential future end state airport facilities would be located north of the existing Tinian International Airport facilities and could be provided water from the new water system proposed for the base camp.

Estimated future potable water demand has the following components:

- Domestic demand
- Industrial demand
- Fire protection demand
- Unaccounted for water

These components are analyzed and combined for a total demand estimate.

3.1.1 Domestic Demand

Domestic uses include drinking water and typical household uses such as food preparation and showering. The design populations and per-capita requirements associated with the proposed action to be served by a new U.S. military water system are shown in Table 3.1-1.

Table 3.1-1. Daily Domestic Consumption Rates for Base Camp and MSA Facilities on Tinian

Population Type	*UFC Use Category*	*Design Population*	*Consumption Per Capita Rate*
Normal Load Trainees	Military Training Camps	1,500	50 gpcd (189 lpcd)
Surge Load Trainees	Military Training Camps	1,500	50 gpcd (189 lpcd)
Operations Personnel	Nonresident Personnel and Civilian Employees (per 8 hr. shift)	95	30 gpcd (114 lpcd)

Legend: gallons per capita per day = gpcd; liter per capita day = lpcd.
Source: Department of Defense 2012b.

The average daily demand for design purposes, in gpd, is calculated by:

Average daily demand in gpd = gallons per capita per day × design population

The total domestic daily demand is the sum of the average daily demands for each population type.

Other controlling domestic demands (maximum daily demand and maximum hourly flow are calculated by:

Maximum daily demand (gpd) = average daily demand in gpd × K(Controlling Demand Coefficient)

Maximum hourly flow (gpm) = average daily demand in gpd × K/1,440

The data presented in Table 3.1-2 provide the appropriate coefficient, K, to be used in the equations above.

Table 3.1-2. Controlling Demand Coefficient K

Demand	***Units of Demand***	***Coefficient K***	
		Population <5,000	***Population >5,000***
Maximum Daily Demand	gpd (1 gpd = 3.79 lpd)	2.25	2.0
Maximum Hourly Demand	gpm (1 gpm = 3.79 lpm)	4.0	3.5

Legend: gpd = gallons per day; gpm = gallons per minute; lpd = liters per day; lpm = liters per minute.
Source: Department of Defense 2012b.

Details of the domestic demands presented below are provided in Appendix B.

Table 3.1-3 presents the required domestic demand associated with the design population under the proposed action.

Table 3.1-3. Domestic Water Demand for Proposed Action on Tinian

Domestic Demand Category	***Total Daily Domestic Demand***
Average Daily Demand	240,013 gpd (908,550 lpd)
Maximum Daily Demand	459,758 gpd (1,740,375 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

3.1.2 Industrial Demand

Industrial uses typically include cooling, air conditioning, irrigation, swimming pools, shops, laundries, dining, processing, flushing, wash racks, rinse racks, and boiler makeup. Demands were assigned according to the values in Table 3.1-4 from the cancelled UFC 3-230-19N (Department of Defense 2005) for air conditioning, because the new UFC 3-230-03 (Department of Defense 2012b) does not include air conditioning demand guidance. In order to avoid overestimating the total water demand, it is assumed that the water demand associated for laundry and dining is captured by the domestic water flow requirement and associated design population. Details of the industrial demand requirements presented below are provided in Appendix B.

Table 3.1-4. Industrial Water Requirements for the U.S. Military on Tinian

Use	***Unit***	***Requirements***		
		Minimum	***Average***	***Maximum***
Air Conditioning	Gallons per minute per ton	None	0.05	0.10
Wash Racks	Gallons per day per platform	2,000		

Source: Department of Defense 2005.

The future industrial water demands for new U.S. military facilities under the proposed action, which include the base camp and MSA, are presented in Table 3.1-5.

Table 3.1-5. Industrial Water Demand for Base Camp and MSA Facilities on Tinian

Industrial Uses	*Industrial Demand*
Air Conditioning	43,857 gpd (166,018 lpd)
Wash Racks	12,000 gpd (45,425 lpd)
Total Industrial Demand	55,857 gpd (211,443 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Additional industrial water demand for future U.S. military facilities not part of the proposed action which includes the end point airport facilities is presented in Table 3.1-6. This demand could be served by the proposed U.S. military water system.

Table 3.1-6. Industrial Water Demand for End State Airport Facilities on Tinian

Industrial Uses	*Industrial Demand*
Air Conditioning	850 gpd (3,218 lpd)
Total Industrial Demand	850 gpd (3,218 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

3.1.3 Fire Protection Demand

Fire protection demand includes water required for maintaining the fire protection system within the base camp, MSA, and airport end state, and has been developed based on the criteria outlined under UFC 3-600-01 (Department of Defense 2013). Requirements for fire-protection water storage are based on the assumption that only one fire would occur at a time. The quantity of water required is equal to the product of the fire protection water demand (gpm) and the required duration (minutes), and must be available at all times. Water supply for domestic, industrial, and other demands was added to these requirements to determine the total amount of water required in the facility.

The fire flow requirement for each facility was determined by the hazard classification, the facility's status as sprinklered or unsprinklered, and ceiling height for each facility structure and operation. For the current base camp design, assuming a conservative unsprinklered scenario, a maximum of 2,250 gpm (8,518 lpm) for a minimum of 120 minutes is used to determine the fire flow requirement, as referenced from Table C-1 in UFC 3-600-01 (Department of Defense 2013). The base auto shop located farthest from the base camp fire station with an occupancy classification of "Ordinary Group 2" was used as the critical facility to determine the required fire flow. Although many of the facilities to be included in the proposed base camp would fall under Light or Ordinary Group 1, the Ordinary Group 2 designation was selected for the conceptual fire protection demand, assuming that all facilities are single units. The proposed base camp would also include some facilities that fall under the "Extra" classification; however, these facilities have special requirements such as mandatory sprinklers, which have less stringent fire demands.

Appendix B details the calculations of fire protection demand. The peak fire-protection demand projected for 2020 is shown in Table 3.1-7.

Table 3.1-7. Peak Fire Protection Demands for the U.S. Military on Tinian (2020)

Facility	*Peak Fire Protection Demand*
Base Camp	270,000 gallons (1,022,061 liters)

Source: DoN 2014.

3.1.4 Unaccounted-for Water

UFW is water that is not metered (e.g., water lost in leakages, fire hydrant testing if not metered, and unknown uses). UFW is typically derived by subtracting the amount of metered water use from the metered water production at the wells and net changes in water storage tank inventories. Most water utilities, policymakers, and associations, such as the American Water Works Association, deem a 10%-15% UFW loss as acceptable.

A UFW rate of 15% is assumed for application to domestic and industrial demands for the proposed U.S. military water distribution system. This rate was selected as being moderately conservative and assuming a stand-alone new potable water system for the U.S. military under the proposed action.

Appendix B details the calculations for the UFW demands. The future UFW demands for the proposed U.S. military water system are presented in Table 3.1-8 and are based on the design population and facilities associated with the base camp and MSA.

Table 3.1-8. Unaccounted-for Water Demand for Base Camp and MSA Facilities on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	22,928 gpd (86,790 lpd)
UFW for Maximum Daily Domestic Demand	51,610 gpd (195,365 lpd)
UFW for Industrial Demand	8,379 gpd (31,716 lpd)

Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

The UFW demand for future U.S. military airport facilities, not included in the proposed action, is presented in Table 3.1-9.

Table 3.1-9. Unaccounted-for Water Demand for End State Airport Facilities on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	[a]
UFW for Maximum Daily Domestic Demand	[a]
UFW for Industrial Demand	128 gpd (483 lpd)

Note:
[a] UFW for domestic demands associated with the design population for the future airport facilities are accounted for in the demands presented for the proposed action in Table 3.1-8.
Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

3.1.5 Summary of Calculated System Requirements

The average and maximum daily demands are calculated as the sum of the domestic, industrial, and UFW demands presented in the previous sections. A new U.S. military water system would supply the demand requirements from the base camp and MSA facilities under the proposed action. The new U.S. military water system could also supply the demand requirements of future airport facilities. Details of the demand calculations can be found in Appendix B.

The future average and maximum total daily demands under the proposed action to be served by a new U.S. military water system are summarized in Table 3.1-10.

Table 3.1-10. Total Daily Water Demand for Base Camp and MSA Facilities on Tinian

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	240,013 gpd (908,550 lpd)
Maximum Total Daily Demand	459,758 gpd (1,740,375 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

The average and maximum total daily demands for the end-state airport facilities to be served by the proposed U.S. military water system are summarized in Table 3.1-11. The domestic water demand for the future airport facilities are accounted for domestic water demand estimate for the proposed action. Thus, the total daily demands presented in Table 3.1-11 include only the additional industrial water demand for the future airport facilities.

Table 3.1-11. Total Daily Water Demand for End State Airport Facilities on Tinian

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	978 gpd (3,700 lpd)
Maximum Total Daily Demand	978 gpd (3,700 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

3.2 UNITED STATES MILITARY DEMANDS USING SUSTAINABILITY/WATER CONSERVATION APPROACH

The assumptions for potable water demand presented in Section 3.1 are based on the UFCs, which provide a conservative estimate to plan the potable-water-source demand for a stand-alone system to serve the planned needs of a generic military base located anywhere in the world. Programming for military bases is standardized and is dictated by UFC documents, which provide planning, design, construction, sustainment, restoration, and modernization criteria. UFC documents apply to military departments, defense agencies, and U.S. military field activities. They are relied on during 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. Congressional appropriations require that all relevant UFCs be incorporated into the design.

3.3 DESIGN CAPACITY OF SYSTEM COMPONENTS FOR THE PROPOSED ACTION

3.3.1 Water Supply Sources

The water supply source must be designed to meet the base camp's quantity demands. If inadequate storage existed between the source and the distribution system, the supply would provide maximum-day domestic demand plus industrial-use demand.

For supply wells, sufficient capacity would be included to meet the maximum daily domestic demand, plus industrial use, with the largest pump out of service. For this study, it was assumed the largest pump out of service would have a capacity of 120 gpm (454 lpm) or a daily equivalent of 172,800 gpd (645,119 lpd).

The required future water supply design capacity for the base camp is 632,558 gpd (2,394,494 lpd) as shown in Table 3.3-1, using the UFC requirement described in Section 3.1 and the assumed capacity of the largest well/pump.

Table 3.3-1. Required Water Supply for U.S. Military for Tinian (Proposed Action)

Supply Category	*Supply Required*
Minimum Required (max. daily demand)	459,758 gpd (1,740,375 lpd)
Additional Required (capacity of largest well/pump)	172,800 gpd (654,119 lpd)
Total Supply Required	632,558 gpd (2,394,494 lpd)

Legend: gpd = gallons per day; lpd = liters per day; TBD = to be determined.
Source: DoN 2014.

3.3.2 Water Treatment

Groundwater would be treated by chlorination, before transmission to the storage tank at the base camp, to meet all Primary Drinking Water Standards. There is currently not enough fluoride data to determine if fluoridation will be required. Currently, Maui Well No. 2 does not provide fluoridation, so it is likely fluoride treatment should not be necessary. No centralized water treatment plant is proposed.

3.3.3 Transmission Mains

Transmission mains convey water from the source to the distribution system. Where distribution is pumped from storage, transmission mains would have capacities equal to the maximum daily demand plus industrial demand and fire flow requirement. Without storage, transmission mains must meet maximum hourly demand (Department of Defense 2012a).

3.3.4 Distribution System

Distribution mains must provide for peak-flow and fire-flow requirements. The minimum capacity of the distribution system would be sufficient to meet the greater of these two conditions, while accounting for industrial-use demand (Department of Defense 2012a):

- Maximum hourly domestic demand
- Maximum daily domestic demand plus the fire-flow requirement

The distribution system would be designed using a loop-system pipe network, in which flow to a single source is available from two or more directions to provide redundancy and economical pipe sizes, while minimizing “dead spots” that can cause localized disinfection problems.

3.3.5 Storage Facilities

The water storage tank was sized to meet the required operational, fire, and emergency demands. At a minimum, the total water storage volume-capacity for the base camp, including the Munitions Storage Area (MSA), must be adequate to satisfy the total of the following requirements (Department of Defense 2012a):

- 50% of average total daily domestic requirements
- Any industrial demand that cannot be reduced during a fire period
- Required fire-flow demand

Minimum Storage = 50% Average Daily Domestic Demand + Unrestricted Industrial Demand during a Fire Period + Required Fire Flow Demand

The future water storage-volume required for the proposed action is shown in Table 3.3-2. Details of the storage volume calculations are provided in Appendix B.

Table 3.3-2. Minimum Required Water Storage Volume for U.S. Military on Tinian (Proposed Action)

Supply Category	*Storage Required*
50% Average Daily Domestic Demand	87,889 gallons (341,728 liters)
Unrestricted Industrial Demand	64,236 gallons (243,159 liters)
Required Fire-Flow Demand	270,000 gallons (1,022,061 liters)
Total Minimum Storage Volume Required (Rounded)	430,000 gallons (1,627,727 liters)
Recommended Minimum Storage Volume	500,000 gallons (1,892,706 liters)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

The future water storage-volume required to include the proposed action and future airport facilities is shown in Table 3.3-3. The additional industrial demand from the future airport facilities would increase the minimum storage volume required. However, the recommended storage volume remains the same as the proposed action. Details of the storage volume calculations are provided in Appendix B.

Table 3.3-3. Minimum Required Water Storage Volume for U.S. Military on Tinian (Future)

Supply Category	*Storage Required*
50% Average Daily Domestic Demand	87,889 gallons (341,728 liters)
Unrestricted Industrial Demand	65,213 gallons (345,513 liters)
Required Fire-Flow Demand	270,000 gallons (1,022,061 liters)
Total Minimum Storage Volume Required (Rounded)	430,000 gallons (1,703,435 liters)
Recommended Minimum Storage Volume	500,000 gallons (1,892,706 liters)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

3.4 PROJECTED WATER DEMAND ON THE CIVILIAN SYSTEM

This section presents the estimated future water demand calculations based on Unified Facilities Criteria (UFC) 3-230-01: *Water Storage, Distribution, and Transmission* (Department of Defense 2012a); UFC 3-230-03: *Water Treatment* (Department of Defense 2012b); and UFC 3-600-01: *Fire Protection Engineering for Facilities* (Department of Defense 2013), for the projected civilian water demand associated with the proposed action on the CUC water system on Tinian. Additional water system design and construction requirements based on the UFC are provided in Appendix D.

Future water demands that would draw from the existing CUC water system would include U.S. military port facilities located at the Port of Tinian, housing associated for operations personnel and the construction workforce, and the increase in the future civilian demand from the Tinian residents and tourist visitors.

3.4.1 Domestic Demand

Domestic uses include drinking water and typical household uses such as food preparation and showering.

The design populations and per-capita requirements associated with the port facilities of the proposed action are shown in Table 3.4-1.

Table 3.4-1. Daily Domestic Consumption Rates for Port Facilities on Tinian

Population Type	*UFC Use Category*	*Design Population*	*Consumption Per Capita Rate*
Operations Personnel	Nonresident Personnel and Civilian Employees (per 8 hr. shift)	6	30 gpcd (114 lpcd)

Legend: gallons per capita per day = gpcd; liter per capita day = lpcd.
Source: Department of Defense 2012b.

The design populations and per-capita requirements associated with the operations personnel and construction workers living outside of the MLA are shown in Table 3.4-2 and Table 3.4-3, respectively. The design populations are based on the highest expected population numbers forecast by the Socioeconomic Impact Assessment Study, V2, which will give the most conservative required demand.

Table 3.4-2. Daily Domestic Consumption Rates for Operations Personnel Housing on Tinian

Population Type	*UFC Use Category*	*Design Population*	*Consumption Per Capita Rate*
Operations Personnel [a]	Family Housing	87	125 gpcd (473 lpcd)
Operations Personnel Dependents	Family Housing	155	125 gpcd (473 lpcd)

Note:
[a] Per the Socioeconomic Impact Assessment Study, a conservative estimate that eight of the operations personnel are anticipated to be residents of Tinian and are not included in the design population to estimate the increase the daily domestic demand.
Legend: gallons per capita per day = gpcd; liter per capita day = lpcd.
Source: Department of Defense 2012b.

Table 3.4-3. Daily Domestic Consumption Rates for Construction Workforce Housing on Tinian

Population Type	*UFC Use Category*	*Design Population*	*Consumption Per Capita Rate*
Construction Workers	Military Training Camp	548	50 gpcd (189 lpcd)
Construction Managers	Family Housing	23	125 gpcd (473 lpcd)
Construction Manager Dependents	Family Housing	26	125 gpcd (473 lpcd)

Legend: gallons per capita per day = gpcd; liter per capita day = lpcd.
Source: Department of Defense 2012b.

The design populations and per-capita requirements associated with future increases to the civilian population and tourist visitors are shown in Table 3.4-4.

Table 3.4-4. Daily Domestic Consumption Rates for Civilians on Tinian

Population Type	*UFC Use Category Equivalent*	*Design Population Increase*	*Consumption Per Capita Rate*
Tinian Resident	Family Housing	396	125 gpcd (473 lpcd)
Average Day Visitors	Unaccompanied Personnel Housing	190	110 gpcd (416 lpcd)

Legend: gallons per capita per day = gpcd; liter per capita day = lpcd.
Source: Department of Defense 2012b.

Table 3.4-5 presents the required domestic potable water demand associated with the design population for the port facilities under the proposed action. This demand will be served through the existing CUC water system.

Table 3.4-5. Domestic Water Demand for Port Facilities on Tinian

Domestic Demand Category	*Total Daily Domestic Demand*
Average Daily Demand	180 gpd (681 lpd)
Maximum Daily Demand	405 gpd (1,533 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-6 presents the required domestic potable water demand associated with the design population for the operations personnel and their dependents that would be housed in rental properties outside of the MLA in Tinian. This demand would be served by the existing CUC water system.

Table 3.4-6. Domestic Potable Water Demand for Operations Personnel Housing on Tinian

Domestic Demand Category	*Total Daily Domestic Demand*
Average Daily Demand	30,250 gpd (114,509 lpd)
Maximum Daily Demand	68,063 gpd (257,645 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-7 presents the required temporary domestic potable water demand associated with the design population for the construction workers that could be housed in a work camp outside of the MLA. The work camp is anticipated to be the existing dwellings associated with and adjacent to the Dynasty Hotel, which is served by the existing CUC water system.

Table 3.4-7. Domestic Water Demand for Construction Work Camp on Tinian

Domestic Demand Category	*Total Daily Domestic Demand*
Average Daily Demand	27,400 gpd (103,720 lpd)
Maximum Daily Demand	61,650 gpd (233,371 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-8 presents the required temporary domestic potable demand associated with the design population for the construction managers and their dependents that would be housed in rental properties in Tinian. This demand would be served by the existing CUC water system.

Table 3.4-8. Domestic Water Demand for Construction Manager Housing on Tinian

Domestic Demand Category	*Total Daily Domestic Demand*
Average Daily Demand	6,125 gpd (23,186 lpd)
Maximum Daily Demand	13,781 gpd (52,538 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-9 presents the required domestic water demand of the civilian population and tourist visitors increases on Tinian. This demand would be served by the existing CUC water system.

Table 3.4-9. Domestic Water Demand Increase for Civilians on Tinian

Domestic Demand Category	*Total Daily Domestic Demand Increase*
Average Daily Demand	70,400 gpd (266,493 lpd)
Maximum Daily Demand	158,400 gpd (599,610 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

3.4.2 Industrial Demand

Industrial uses typically include cooling, air conditioning, irrigation, swimming pools, shops, laundries, dining, processing, flushing, wash racks, rinse racks, and boiler makeup. Demands were assigned according to the values in Table 3.1-4 from the cancelled UFC 3-230-19N (Department of Defense 2005) for air conditioning, because the new UFC 3-230-03 (Department of Defense 2012b) does not include air conditioning demand guidance. In order to avoid overestimating the total water demand, it is assumed that the water demand associated for laundry and dining is captured by the domestic water flow requirement and associated design population. Details of the industrial demand calculation presented below are provided in Appendix B.

The future industrial water demands for new U.S. military port facilities under the proposed action is presented in Table 3.4-10. This demand will be served through the existing CUC water system.

Table 3.4-10. Industrial Water Demand for Port Facilities on Tinian

Industrial Uses	*Industrial Demand*
Air Conditioning	495 gpd (1,874 lpd)
Wash Racks	12,000 gpd (45,425 lpd)
Total Industrial Demand	12,495 gpd (47,299 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

3.4.3 Fire Protection Demand

Assuming most of the increased civilian population would be housed in existing structures, it is anticipated that the fire protection requirements provided by the CUC water system would be adequate. The CUC water system currently has two storage tanks with a total storage capacity of 750,000 gallons (2,839,059 liters).

3.4.4 Unaccounted-for Water

For application of domestic and industrial demands that would be supplied by the existing CUC water distribution system, the existing UFW rate for the CUC system of 75% was used. Although the proposed connection for the port facilities would be new, it is realistic and conservative to use an UFW of 75% since the source (Maui Well No. 2) is relatively distant from the port facilities, and many losses would occur between the source and demand point. Appendix B details the calculations for the UFW demands.

The future UFW demands for port facilities included in the proposed action are presented in Table 3.4-11.

Table 3.4-11. Unaccounted-for Water Demand for Port Facilities on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	135 gpd (511 lpd)
UFW for Maximum Daily Domestic Demand	310 gpd (1,173 lpd)
UFW for Industrial Demand	9,371 gpd (35,474 lpd)

Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

The future UFW demands for operations personnel and their dependents housed in rental properties on Tinian are presented in Table 3.4-12.

Table 3.4-12. Unaccounted-for Water Demand for Operations Personnel Housing on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	22,688 gpd (85,882 lpd)
UFW for Maximum Daily Domestic Demand	51,047 gpd (193,233 lpd)
UFW for Industrial Demand	0 gpd (0 lpd)

Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

The future temporary UFW demands associated with the construction workers housed in a work camp are presented in Table 3.4-13.

Table 3.4-13. Unaccounted-for Water Demand for Construction Work Camp on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	20,550 gpd (77,790 lpd)
UFW for Maximum Daily Domestic Demand	46,238 gpd (175,028 lpd)
UFW for Industrial Demand	0 gpd (0 lpd)

Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

The future UFW demands for construction managers and their dependents housed in rental properties on Tinian are presented in Table 3.4-14.

Table 3.4-14. Unaccounted-for Water Demand for Construction Manager Housing on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	4,594 gpd (17,389 lpd)
UFW for Maximum Daily Domestic Demand	10,336 gpd (39,126 lpd)
UFW for Industrial Demand	0 gpd (0 lpd)

Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

The future UFW demands of the civilian population and tourist visitors increases on Tinian are presented in Table 3.4-15.

Table 3.4-15. Unaccounted-for Water Demand for Civilians on Tinian

UFW Demand Category	*UFW Demand*
UFW for Average Daily Domestic Demand	52,800 gpd (199,870 lpd)
UFW for Maximum Daily Domestic Demand	118,800 gpd (449,707 lpd)
UFW for Industrial Demand	0 gpd (0 lpd)

Legend: gpd = gallons per day; lpd = liters per day; UFW = unaccounted-for water.
Source: DoN 2014.

3.4.5 Summary of Calculated System Requirements

The average and maximum daily demands are calculated as the sum of the domestic, industrial, and UFW demands presented in the previous sections. The existing CUC water system would supply the demand requirements for the port facilities under the proposed action along with the demand requirements associated with the housing of operations personnel, construction workforce and their dependents. Details of the future average and maximum total daily demands for the port facilities under the proposed action to be served by the existing CUC water system are summarized in Table 3.4-16.

Table 3.4-16. Total Daily Water Demand for Port Facilities on Tinian

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	22,181 gpd (83,965 lpd)
Maximum Total Daily Demand	22,581 gpd (85,479 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

The future average and maximum total daily demands for the operations personnel and their dependents associated with the proposed action to be served by the existing CUC water system are summarized in Table 3.4-17.

Table 3.4-17. Total Daily Water Demand for Operations Personnel Housing on Tinian

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	52,938 gpd (200,390 lpd)
Maximum Total Daily Demand	119,109 gpd (450,878 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-18 summarizes the temporary future average and maximum total daily demands of the construction workers housed in a work camp that would be served by the existing CUC water system.

Table 3.4-18. Total Daily Water Demand for Construction Workforce Housing on Tinian (Temporary)

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	47,950 gpd (181,511 lpd)
Maximum Total Daily Demand	107,888 gpd (408,399 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-19 summarizes the temporary future average and maximum total daily demands of the construction managers and their dependents housed in rental properties on Tinian that would be served by the existing CUC water system.

Table 3.4-19. Total Daily Water Demand for Construction Manager Housing on Tinian (Temporary)

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	10,719 gpd (40,575 lpd)
Maximum Total Daily Demand	24,117 gpd (91,293 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 3.4-20 summarizes the future average and maximum total daily demands of the civilian population and tourist visitors increases on Tinian that would be served by the existing CUC water system.

Table 3.4-20. Total Daily Water Demand Increases for Civilians on Tinian

Total Daily Demand Category	*Total Daily Demand Increase*
Average Total Daily Demand	121,971 gpd (461,709 lpd)
Maximum Total Daily Demand	274,434 gpd (1,038,846 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

The temporary total average and maximum daily demand increase on the CUC water system associated with the construction workforce is 58,669 gpd (222,085 lpd) and 132,005 gpd (499,692 lpd), respectively. The total average and maximum daily demand increase on the CUC water system associated with the proposed port facilities, operations personnel housing, civilian population and tourist visitor increases is 197,089 gpd (746,065 lpd) and 416,125 gpd (1,575,204 lpd), respectively. The average daily demand would be an increase of approximately 17% above CUC's current production rate from Maui Well No. 2.

CHAPTER 4.
PROJECTED FUTURE DEMAND AND SYSTEM REQUIREMENTS FOR PAGAN

This chapter presents the estimated future water demand calculations based on Navy criteria for the proposed training facilities and support on Pagan. Because of the expeditionary nature of training on Pagan, minimal permanent utility facilities would be provided. Trainees are expected to use a minimal amount of water and must ensure that water conservation and supply discipline are continuously exercised by all personnel. Waste is expected to be minimized and procedures for water supply discipline must be established and enforced. However, water availability and consumption must remain adequate to prevent heat-induced casualties. The majority of the water uses anticipated for the expeditionary training on Pagan would be domestic.

4.1 UNITED STATES MILITARY REQUIREMENTS

4.1.1 Domestic Demand

Domestic uses for training on Pagan include drinking water, personal hygiene, food preparation, heat injury treatment, and medical treatment. Per-capita planning factors for each type of domestic use category are based on the *Water Planning Guide* (United States Army Combined Arms Support Command 2008), and are shown in Table 4.1-1.

Table 4.1-1. Domestic Potable Water Requirements in Volume Per Capita Per Day for Pagan

Use Category		*Flow Requirement (gallons [liters] per capita per day)*
Drinking Water		3.30 (12.5)
Personal Hygiene	Brushing Teeth (3 times/day)	0.22 (0.83)
	Shaving (1 time/day)	0.23 (0.87)
	Washing Hands (6 times/day)	0.83 (3.14)
	Sponge Bath (5 times/week)	0.40 (1.51)
Food Preparation [a]		0.43 (1.63)
Heat Injury Treatment		0.01 (0.04)
Medical Treatment [b]		0.03 (0.11)
	Total Potable Water Requirements	5.45 (20.6)

Notes:
[a] Assumes ration cycle of three Meals Ready to Eat.
[b] Assumes basic potable water needs for cleaning patients, washing instruments, and washing hands of direct patient care providers.
Source: United States Army Combined Arms Support Command 2008.

The flow-requirement planning factors per capita per day presented in Table 4.1-2 include a 10% loss factor – 4% evaporation and 6% waste/spillage.

The required daily domestic demand for the Pagan bivouac-training area in normal conditions, surge conditions, and a total maximum condition as shown in Table 4.1-2, in gpd, is calculated as follows:

Daily domestic demand in gpd = gallons per capita per day × personnel population

Table 4.1-2. Required Daily Domestic Demand for Pagan

Operating Condition	*Flow Requirement (gallons [liters] per capita per day)*	*Personnel Population*	*Demand Volume (gpd [lpd])*
Normal Daily Domestic Demand	5.45 (20.6)	3,000	16,350 gpd (61,891 lpd)
Additional Surge Domestic Demand	5.45 (20.6)	1,000	5,450 gpd (20,630 lpd)
Total Maximum Daily Domestic Demand	5.45 (20.6)	4,000	21,800 gpd (82,522 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

4.1.2 Industrial Demand

There would not be any industrial water use for the training on Pagan. A vehicle wash-down requirement is not anticipated; however, this will need to be validated during the consultation process (J. Victorino, NAVFAC Pacific, personal communication, March 2014).

4.1.3 Fire Protection Demand

No structures would be constructed on Pagan; therefore, calculation of a fire protection demand is not required for Pagan. Fire control for the ranges would be managed by standard expeditionary training procedures.

4.1.4 Unaccounted-for Water

UFW water need not be considered for Pagan because no permanent potable water distribution system would be installed.

4.1.5 Summary of Calculated System Requirements

The total potable-water daily demands under normal conditions and under surge conditions for the training on Pagan are summarized in Table 4.1-3. The total daily demand is calculated as the sum of the domestic and industrial demands. Details of the demand calculations can be found in Appendix B.

Table 4.1-3. Future Total Daily Water Demand on Pagan Under Normal Conditions

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	16,350 gpd (61,891 lpd)
Maximum Total Daily Demand	36,788 gpd (139,256 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

Table 4.1-4. Future Total Daily Water Demand on Pagan Under Surge Conditions

Total Daily Demand Category	*Total Daily Demand*
Average Total Daily Demand	21,800 gpd (82,522 lpd)
Maximum Total Daily Demand	49,050 gpd (185,674 lpd)

Legend: gpd = gallons per day; lpd = liters per day.
Source: DoN 2014.

4.2 DESIGN CAPACITY OF SYSTEM COMPONENTS FOR THE PROPOSED ACTION

4.2.1 Water Supply Source Capacity

The water supply source must be sufficient to meet the bivouac area's quantity demands. The raw-water supply could be provided by groundwater extraction (wells and/or springs) from the ocean, or from rainwater harvesting. Because of ecological concerns, using the brackish water from Lake Sanhiyon or Lake Sanhalom is not likely viable. Development of a permanent potable water supply from groundwater is problematic in that it would require regular maintenance and reporting throughout the year. This is likely to be cost prohibitive.

CHAPTER 5. REGULATORY SETTING

The CUC is the state government corporation responsible for power, water, and wastewater services for the CNMI. Applications and approvals for connection to the water system must be made with the CUC in accordance with Title 50 of the CNMI Administrative Code (CUC 2012a). The public water system and wells are monitored and regulated by the BECQ Safe Drinking Water Branch and must adhere to any federal mandates and regulations as set forth by the U.S. Environmental Protection Agency. Proper design, construction, or abandonment of any drinking water wells must follow BECQ Well Drilling and Well Operation Regulations (DEQ 2005).

For drinking water systems, the CUC is currently subject to Stipulated Order #1 for injunctive relief to address requirements under the Clean Water Act and the Safe Drinking Water Act. Stipulated Order #1 covers three major issues: management and operations of the CUC, the drinking water and wastewater master plan, and short-term construction of wastewater infrastructure. The two issues applicable to potable water infrastructure on Tinian would be the management and operations of the CUC and the water and wastewater master plan. The CUC is required to conduct monitoring and collect any other data and information necessary for the BECQ to make determinations about groundwater under the direct influence of surface water (GWUDI) for additional water sources that have not yet been characterized. A plan for monitoring and sampling of drinking water is also required, with the results reported to the BECQ in a timely manner. The CUC is currently performing an aquifer study and GWUDI for Maui Well No. 2. The CUC is required to develop a comprehensive drinking water master plan to determine current and future infrastructure needs for a 20-year period, and to provide a long-term plan for system improvements on Saipan, Rota, and Tinian. The following assessments are required as part of the master plan:

- Drinking water and drinking water technological alternatives.
- Drinking-water systems condition and improvement alternatives.
- Hydraulic capacity to determine the system's capability as currently configured and future needs for at least a 20-year period to provide sufficient quantity and pressure of drinking water to ensure 24-hour provision of drinking water that meets Safe Drinking Water Act requirements.
- Reliability to ensure the continuous and reliable operation of all components.

The CUC is also required to provide an infrastructure improvement plan based on assessments and a financial plan. The development of the drinking-water master plan is ongoing.

Section 20 of the CNMI Well Drilling and Well Operations Regulations (DEQ 2005) states:

> The Chief may require the installation of permanent groundwater monitoring wells in order to monitor the effects of groundwater withdrawal facilities or potential sources of contamination on the quality of the Commonwealth's groundwater resources, and to determine whether or not such facilities or [*sic*] potential sources of contamination on the quality of the Commonwealth groundwater resources, and to determine whether or not such facilities or potential sources of contamination are preventing the highest beneficial use for which these resources are capable.

Operations that would constitute a potential threat include underground fuel storage, hazardous waste storage, hazardous materials storage, withdrawal of large amounts of groundwater (greater than 0.5 MGd [1.9 MLd]), and wastewater treatment. Therefore, the proposed action would likely fall under this category. The regulations require that:

> [M]onitoring wells shall be constructed under the direct supervision of a qualified hydrogeologist or groundwater engineer, in accordance with Best Engineering Practices, and shall be designed and sited in such a way as to assess any changes to groundwater quality that may be occurring. Determination of the number of monitoring wells, the contaminant parameters for which these wells will be sampled, and the frequency of sampling shall be made by a qualified hydrogeologist familiar with the general hydrogeology of the Commonwealth and the specific threats to groundwater quality posed. Such determinations shall be made as a part of a Comprehensive Hydrogeologic Investigation (CHI) of the project area. Other hydrogeologic investigative tools (e.g., the installation of test wells, ground penetrating radar, specific conductance surveys, and review of existing geologic data) will likely be required to properly conduct such an investigation. The hydrogeologist shall submit to the Chief of [*sic*] scope of work prior to beginning the CHI for review and comment.

CHAPTER 6. ISLAND-WIDE WATER SOLUTIONS FOR FUTURE DEMAND ON TINIAN

This chapter provides a description of potential water solutions to meet the additional required water supply to support the proposed action on Tinian.

6.1 OPTION 1 – UNITED STATES MILITARY STAND-ALONE WATER SYSTEM WITH REHABILITATED WELLS

This option includes installing, operating, and maintaining an independent U.S. military potable-water extraction, treatment, transmission, and distribution system. The water source would require the rehabilitation of the abandoned CUC Maui Well No. 1 located at the Makpo potential wetland complex and the installation of a transmission main, separate from the CUC system, from Maui Well No. 1 to the base camp (Figure 6.1-1).

6.1.1 Potential Wells to Rehabilitate

If Maui Well No. 1 at the Makpo potential wetland complex were rehabilitated, it might meet the increased water supply requirement, but it also might cause unacceptable chloride elevations for both operating Maui wells. Maui Well No. 1 was taken off line in May 2001 when the Maui Well No. 2 construction was completed. Maui Well No. 2 currently supplies the CUC's entire potable water system. Both of these are horizontal Maui-type infiltration galleries located in the Median Valley.

A potential concern about operating both Maui Well No. 1 and Maui Well No. 2 is that the effects of additional extraction on the water quality and saltwater intrusion have not been quantified. The CUC has apparently never operated both wells simultaneously, so the effects would have to be evaluated. An aquifer study has been rcommended to assess the production and quality that might be anticipated as a result of the increased groundwater extraction to meet the demands of the proposed action. A separate study to evaluate GWUDI was recently completed; however, the final determination has not been formalized and should be available in the near future. Should the aquifer or supply wells be deemed GWUDI, additional water treatment may be required.

6.1.2 Water System Components

A new transmission main, approximately 13,120 ft (4,000 m) in length, would be necessary to convey water from Maui Well No. 1 to the base camp. The transmission main is proposed to run east-west along 42nd Street and then north-south along Broadway to the entrance to the base camp maintenance access road.

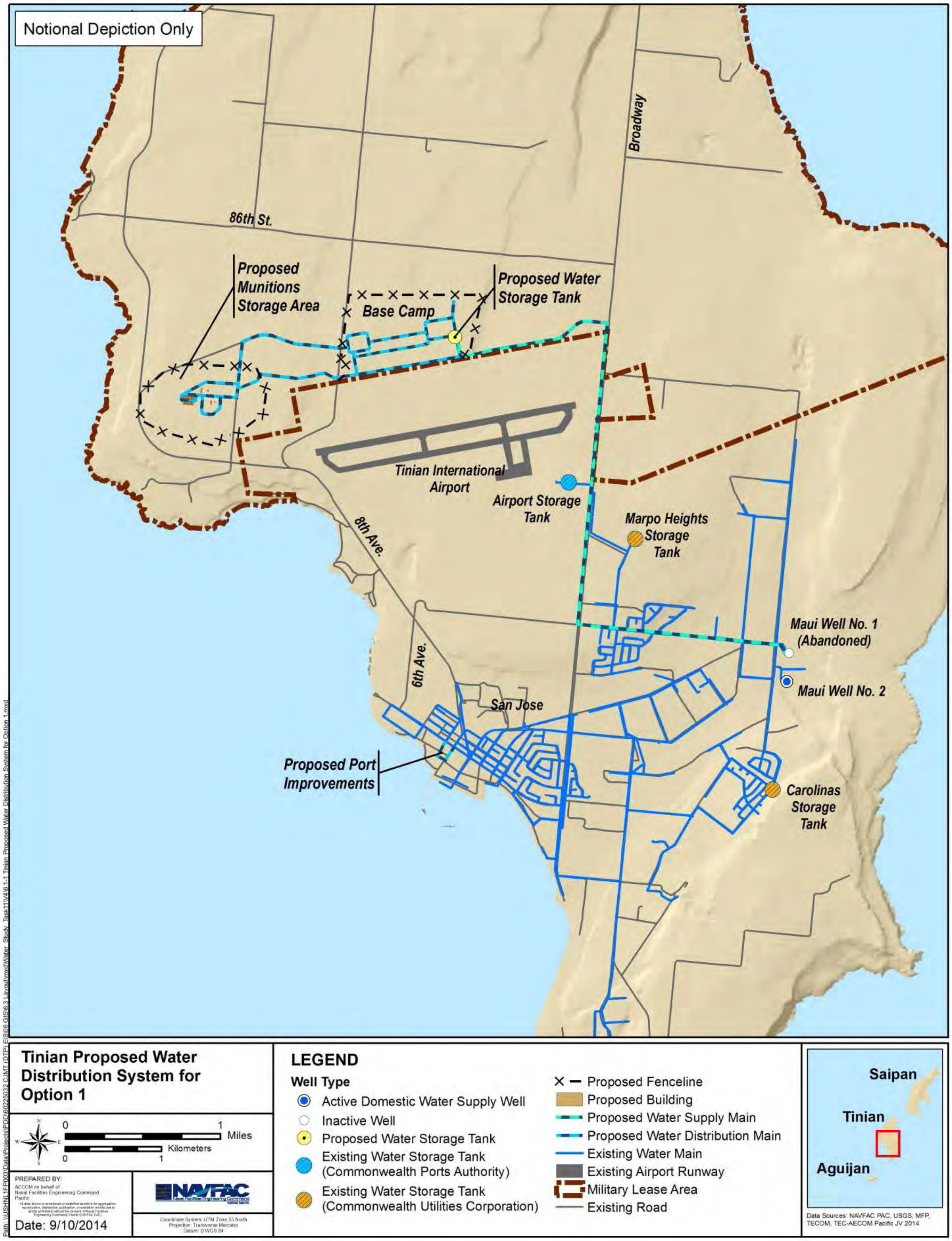

Figure 6.1-1. Tinian Proposed Water Distribution System for Option 1

Source: DoN 2014.

6.1.3 Aquifer/Well Study

To determine the viability of Option 1, an aquifer/well study would be needed to evaluate the condition of Maui Well No. 1 and the hydraulic connection among the two Maui wells and the potential wetland area. The following investigations would be included in the aquifer/well study:

- Video survey of Maui Well No. 1
- Pump testing of Maui Well No. 1
- Collection of water quality samples over time during sequential and simultaneous pump testing of both Maui wells
- Laboratory analysis under static and dynamic conditions
- Engineering and hydrogeological evaluation

6.2 OPTION 2 – UNITED STATES MILITARY STAND-ALONE SYSTEM WITH NEW WELLS

This option includes installing, operating, and maintaining a completely independent U.S. military potable water service, independent of the existing CUC system. In lieu of the rehabilitation of portions of the CUC system, a stand-alone U.S. military system could support the proposed action on Tinian (Figure 6.2-1). New wells would be developed in the MLA for U.S. military use.

6.2.1 Development of New Wells

As discussed in Chapter 2, if new wells are pursued 3 to 6 wells (plus one backup well) would likely be required, each producing 60–120 gpm (227–454 lpm) to meet the total maximum daily demand of 0.46 MGd (1.7 MLd). As discussed in Chapter 2, proposed well fields (Figure 2.5-1, Figure 2.5-2, Figure 2.5-3, Figure 2.5-4, and Figure 6.2-2) have been identified north and east of the airport. The potential water supply wells would be subject to the CNMI Well Drilling and Well Operation Regulations (DEQ 2005). The regulations define the qualifications required of individuals and firms allowed to drill wells, designate setback distances for potential sources of contamination, allow the BECQ to set maximum pump withdrawal rates to minimize saltwater intrusion, and require that semiannual water quality analyses be conducted for all active wells. All new water supply wells must be set back a distance from potential sources of contamination, known as the wellhead protection area. Wellhead protection setback requirements from public water supplies and nonpublic water supplies are summarized in Table 6.2-1 and Table 6.2-2, respectively. To minimize saltwater upconing, well depth would be limited to no deeper than 20 feet msl. Monitoring wells would likely also be required to monitor the effects of groundwater withdrawal and training operations. The locations of these monitoring wells and the monitoring program will be developed as part of the system design.

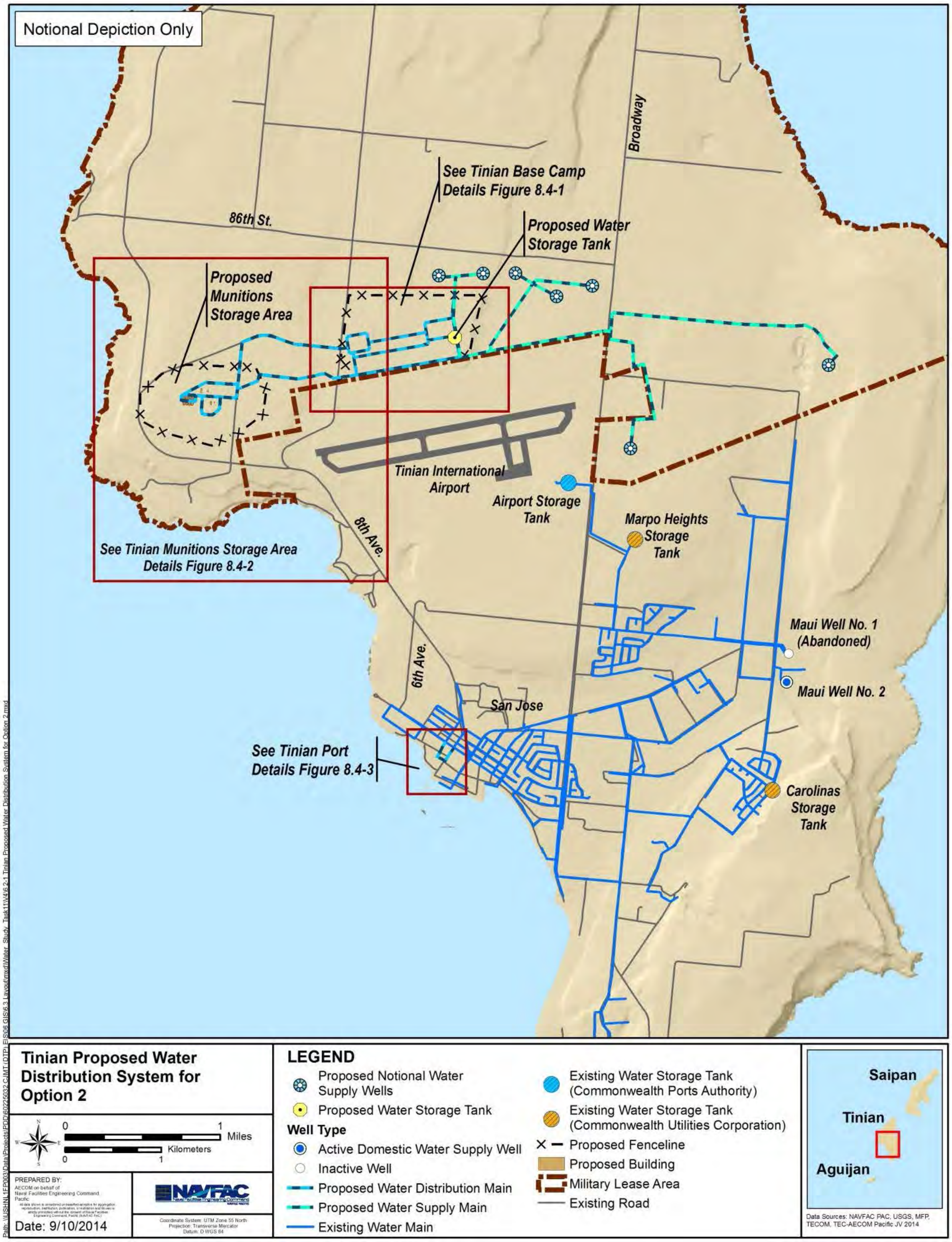

Figure 6.2-1. Tinian Proposed Water Distribution System for Option 2

Source: DoN 2014.

Table 6.2-1. Wellhead Protection Setback Requirements from Public Water Supply

Existing Land Use	*Minimum Down/Up Gradient Dimensions of Wellhead Protection Area*
Above-/Below-grade Structures	10 ft/10 ft (3 m/3 m)
Road Drainage Course/Roadside	50 ft/100 ft (15 m/30 m)
Surface Water Body	150 ft/150 ft (46 m/46 m)
Public/Private Sewer Line	100 ft/200 ft (30 m/61 m)
Sewage Pump Station	150 ft/300 ft (46 m/91 m)
Seepage Pit, Outhouse, Cesspool, Leach Field, Wastewater Treatment Facility	150 ft/300 ft (46 m/91 m)
Underground Fuel Storage Tank	500 ft/500 ft (152 m/152 m)
Auto, Heavy Equipment, Engine Repair Facility	250 ft/500 ft (76 m/152 m)
Underground Injection Well	250 ft/500 ft (76 m/152 m)
IWDS Effluent Disposal (≥5,000 gpd [≥18,927 lpd])	500 ft/500 ft (152 m/152 m)
Above-ground Fuel Storage Facility (≤2,000 gal [≥7,570 liters])	250 ft/500 ft (76 m/152 m)
Above-ground Fuel Storage Facility (>2,000 gal [≥7,570 liters])	1,000 ft/2,000 ft (305 m/610 m)
Above-ground Fuel Storage Facility	500 ft/500 ft (152 m/152 m)
Above-ground Fuel Storage Facility	200 ft/400 ft (61 m/122 m)
Landfill or Hazardous Waste Storage/Treatment Facility	1,000 ft/2,000 ft (305 m/610 m)
Unsewered Industrial Process	1,000 ft/2,000 ft (305 m/610 m)

Legend: ft = feet; gal = gallon; gpd = gallon per day; IWDS = individual wastewater disposal system; m = meter; lpd = liter per day.
Source: DEQ 2005.

Table 6.2-2. Wellhead Protection Setback Requirements from Nonpublic Water Supply

Existing Land Use	*Minimum Down/Up Gradient Dimensions of Wellhead Protection Area*
Road Drainage Course	25 ft/50 ft (8 m/15 m)
Surface Water Body	75 ft/75 ft (23 m/23 m)
Public/Private Sewer Line	75 ft/150 ft (23 m/46 m)
Sewage Pump Station	75 ft/150 ft (23 m/46 m)
All Other Setback Distances as listed in Table 6.2-1	150 ft/300 ft (46 m/91 m)

Legend: ft = feet; m = meter.
Source: DEQ 2005.

The BECQ may require the installation of one or more monitoring wells, and the establishment of a groundwater-monitoring program for water supply wells down gradient of a known or potential source of contamination, if the zone of contribution is occupied by a known or potential source of contamination. The wellhead protection setbacks in Table 6.2-1 and Table 6.2-2 above would not apply to monitoring wells. The setbacks would be determined by the Chief of the BECQ.

6.2.2 Aquifer Study

It is recommended that the following investigations be performed to evaluate this option before implementation:

- Site reconnaissance.
- Mapping of joints/faults and karst features, including sinkholes, pit caves, shafts, fractures, and coastal springs issuing from fractures and/or caves.
- Unexploded ordnance and geophysical avoidance/mapping.

- Drilling, completion, and development of test wells in the eastern, central, and western portions of the potential well fields shown in Figure 6.2-2. The wells would be located outside of proposed training constraints, proposed water disposal/infiltration features, biological constraints, cultural constraints, hazardous waste/hazardous materials constraints, fractures, joints, faults, and karst features.
- Step testing and 24-hour constant-rate pump testing of test wells.
- Video logging of test wells.
- Water quality testing at the beginning and end of pump testing.
- Conductivity and salinity testing every hour throughout pump tests.
- Hydrogeological evaluation.
- Recommendations for future well field development.

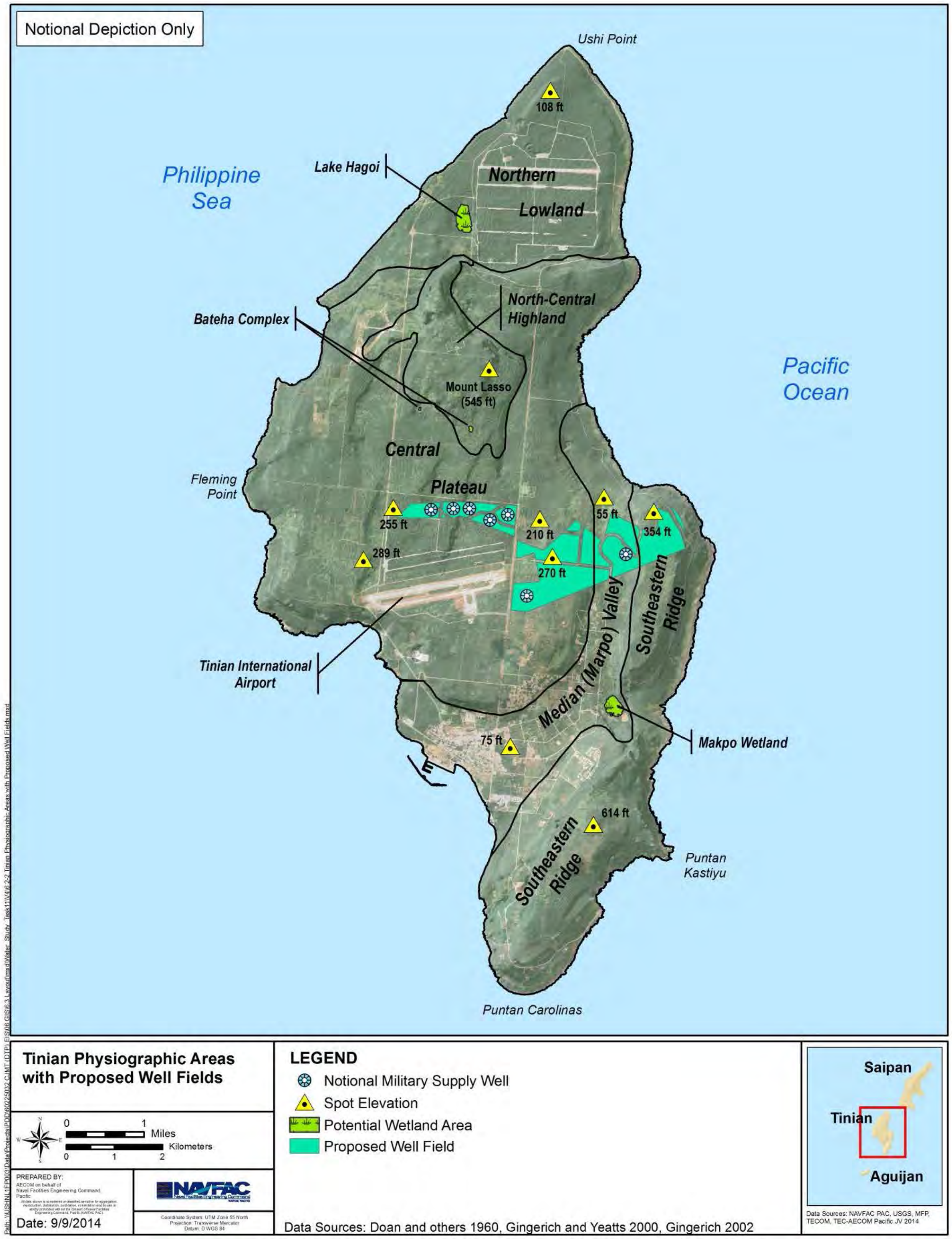

Figure 6.2-2. Tinian Physiographic Areas with Proposed Well Fields
Source: DoN 2014.

6.3 RECOMMENDATIONS AND CONCLUSIONS FOR TINIAN ISLAND-WIDE WATER SUPPLY

Through site investigations and correspondence with the CUC, it was determined that the CUC's existing potable water system has numerous deficiencies, including numerous leaks and an unusually high rate of unaccounted for water throughout its entire system. Thus, it would not be feasible for the U.S. military to connect to the CUC's system at the risk of carrying over these deficiencies to the U.S. military's potable water system. A stand-alone U.S. military transmission and distribution potable water system is recommended, which would be installed entirely within the MLA. The ongoing aquifer study is assessing the production and groundwater quality that might be anticipated due to the increased groundwater extraction. However, it is anticipated that rehabilitating and operating Maui Well No. 1 would have negative water quality effects upon Maui Well No. 2 and the CUC potable water system. In addition, depending on the results of the GWUDI study, surface water treatment may be required for Maui Well No. 1 and/or No. 2. Therefore, it is recommended to drill new U.S. military dedicated wells within the MLA. Based on previous USGS pump testing data from existing wells, it is anticipated that three to six new wells (plus one back up well) would be required to support the water demand for the proposed action. After considering all potential well siting constraints, the new well fields are proposed to be located in the areas just to the north and east of the Tinian International Airport.

Outside of the MLA, future water demands associated with the proposed action, such as the housing of the construction workforce, operations personnel, dependents and increases in water demand for future civilian population growth and visitors to Tinian, would have utility impacts on the CUC water system. The construction workforce demand would be temporary and only required for the construction duration of 8 to 10 years. Due to the port facilities remote location from the MLA it is not feasible to connect to the proposed stand-alone U.S. military water system. The port facilities associated with the proposed action would connect to the CUC water system. It is anticipated that improvements to the CUC water system would be needed in order to meet the future water demands associated with the proposed action that affect the CUC water system. It is recommended that these improvements target reducing the high UFW rather than increasing the pumping capacity of Maui Well No. 2.

CHAPTER 7. ISLAND-WIDE WATER SOLUTIONS FOR FUTURE DEMAND ON PAGAN

This chapter describes potential water solutions to meet the additional required water supply to support the proposed action on Pagan.

7.1 OPTION 1 – GROUNDWATER EXTRACTION

There are two existing, historical hand-dug wells on Pagan, indicating that groundwater wells could possibly be used as a water source. However, because of the expeditionary nature of the training, the absence of available hydrogeological information, the apparent historic unavailability of potable well water, and the cost and regulatory requirements of a permanent potable groundwater system, groundwater is not expected to be a source of potable water on Pagan. The two historical hand-dug wells should be preserved in place and could be used for groundwater quality sampling and monitoring if needed (NAVFAC Pacific 2014).

7.2 OPTION 2 – PORTABLE WATER PURIFICATION SYSTEMS

The demand for potable water could be met by portable tactical water purification systems (TWPS) or lightweight water purifiers (LWP), similar to units recently installed by the U.S. military on Tinian. These units would replace the common, previously used Reverse Osmosis Water Purification Units and would potentially produce up to 1,800 gallons (6,810 liters) of water per hour, depending on the quality of the available water source. Water supply could be provided by the ocean or from rainwater harvesting. Brine generated by the water treatment units would be applied to land, either by evaporation ponds or more typically, by injection wells. Currently, BECQ recommends the use of injection wells for disposal of brine, which is what they requested the U.S. military use during the latest military training on Tinian. There are no existing injection wells constructed on Pagan and obtaining the proper permits to drill an injection well may be difficult and expensive. Injection wells are regulated under the U.S. Safe Drinking Water Act to ensure the waste disposal does not compromise the quality of any underground sources of drinking water.

The portable TWPS can produce potable water that meets Tri-Service Standards from any available source. The system includes a pretreatment system, desalination system, compressed air, chemical injection system, product water distribution, and biological and chemical post-treatment. The desalination system consists of 10 reverse osmosis elements with 99.4% average salt rejection and 50% recovery on freshwater and 40% recovery on seawater. The chemical injection system uses sodium bisulfite for chlorine removal and chlorination to 2 parts per million for disinfection.

The portable LWP can produce potable water that meets Tri-Service Standards from any available sources. The system includes booster and distribution pumps; a diesel-driven pump; treatment by settling, ultrafiltration, and reverse osmosis; chlorine disinfection; injection pumps; and granular activated carbon. The reverse osmosis treatment system includes seven elements with 99.4% average salt rejection, 50% recovery on freshwater, and 30% recovery on seawater.

7.2.1 Source Water – Ocean Water

The TWPS and LWP can produce 1,500 gallons per hour (gph) and 75 gph (6,819 liters per hour [lph] and 341 lph), respectively, on seawater. Using the ocean as a water source could be a viable option pending the amount of waste generated by the system. The optimal locations to harvest ocean water would be Green Beach, Red Beach, or Blue Beach because of their close proximity to the bivouac area. This would reduce the number of tactical water distribution system (TWDS) hose lines.

7.2.2 Source Water – Rainwater Harvesting

The TWPS and LWP can produce can produce 1,800 gph and 125 gph (6,810 and 568 lph), respectively, on freshwater. Using rainwater is a viable solution because the average rainfall is about 70–80 in (178-203 cm; USGS 2006) and generates a higher amount of potable water with a reduced amount of brine compared to using ocean water. Minimal grading and use of volcanic alluvium rocks as filtration would be required to maximize rainwater collection. Rainwater would be stored in either permanently constructed cisterns or open reservoir-type ponds with the bottom lined with an impermeable liner for rainwater runoff collection. Both collection systems would require some form of pre-treatment and periodic maintenance to ensure adequate water quality. The TWPS and LWP could be placed at a location between the cisterns and bivouac areas and the water source for the TWPS or the LWP could be either the cisterns or the ocean, depending on availability.

7.3 OPTION 3 – HAUL IN POTABLE WATER

Due to the small average daily demand of 5.45 gallons per person for training on Pagan, it would be reasonable for training units to haul in their required potable water for the 2-week duration training period. Water could be brought in large water totes and staged in a place where trainees could easily get their own water.

7.4 RECOMMENDATIONS AND CONCLUSIONS FOR PAGAN ISLAND-WIDE WATER SUPPLY

The training proposed on Pagan would be on an expeditionary basis of only 16 weeks per year and minimal information is available about the groundwater quality and viability on Pagan. For a 16-week per year training tempo, constructing and maintaining rainwater collection and storage systems would not be cost effective. Therefore, the recommended water supply solution would be for training units to haul in their potable water or utilize a portable water purification system with ocean water as the source. It is recommended that the portable water purification systems remain on board the ships and the brine waste be collected and taken back to Tinian for proper disposal. Should future training tempo be increased to the 40-week per year rate, rainwater harvesting with permanently constructed cisterns or open reservoir-type ponds should be seriously considered. If water purification systems are to be used, training units deploying to Pagan would be expected to provide and set up these systems as part of their training.

CHAPTER 8.
DISTRIBUTION PLANS FOR NEW FACILITIES ON TINIAN

8.1 GENERAL REQUIREMENTS AND CONSIDERATIONS

The scope of this study involved determining the potable-water system improvements that would be required to provide an adequately operating potable-water distribution system for the base camp, the MSA, and port facilities area. The improvements would include transmission, distribution, water storage, and water treatment infrastructure.

8.2 WATER SYSTEM TRANSMISSION AND DISTRIBUTION

The proposed base camp facilities would be located in areas with an elevation between 245 and 275 ft (75 and 84 m). There are no existing distribution lines in the proposed location for the base camp. Approximately 17,760 ft (5,420 m) of an entirely new distribution system would be required.

The MSA would require fire protection and potable water for the facilities located there. A closed-water loop to the MSA from the base camp would be provided for redundancy. Approximately 10,530 ft (3,210 m) of new distribution pipe would be required to convey water to the MSA.

The port improvements would require fire protection and potable water service for the facilities located at the Port of Tinian. An 8-in (200-mm) distribution main of approximately 1,700 ft (518 m) would be provided from the existing 8-in (200-mm) PVC main along West Street.

8.3 STORAGE FACILITIES

As calculated in Section 3.3.5, a minimum total storage volume of 430,000 gallons (1,627,727 liters), as required by the UFC, would be needed to support the increased demands resulting from the proposed base camp and MSA. A total storage volume of 500,000 gallons (1,892,706 liters) is recommended. This recommended volume would also have the additional capacity to account for the additional demands for the possible future end state airport facilities not included in the proposed action.

A ground-level storage tank with a pressurized pump system and an emergency generator in case of power outages is recommended for Tinian. An elevated tank that would reduce pumping requirements and be able to serve as a source of emergency domestic and fire protection supply in case of power outages is not recommended for Tinian because of potential maintenance and operation difficulties. The entire base camp would operate as one pressure zone and the storage tank would be located on the eastern end of the base camp near the highest elevation. The storage tank’s volume is small enough for the tank to be constructed as one structure; however, the tank should have a minimum of two internal compartments so that a portion of the tank could remain in operation while maintenance procedures are done on the other portion.

8.4 FACILITY DISTRIBUTION PLANS

See Figure 8.4-1 for the water conceptual distribution plan for the base camp, Figure 8.4-2 for the MSA, and Figure 8.4-3 for the port facilities area. Figure 8.4-1 shows a portion of the end state for the Tinian International Airport that would potentially be installed in the future for the increased training tempo of 45 weeks per year.

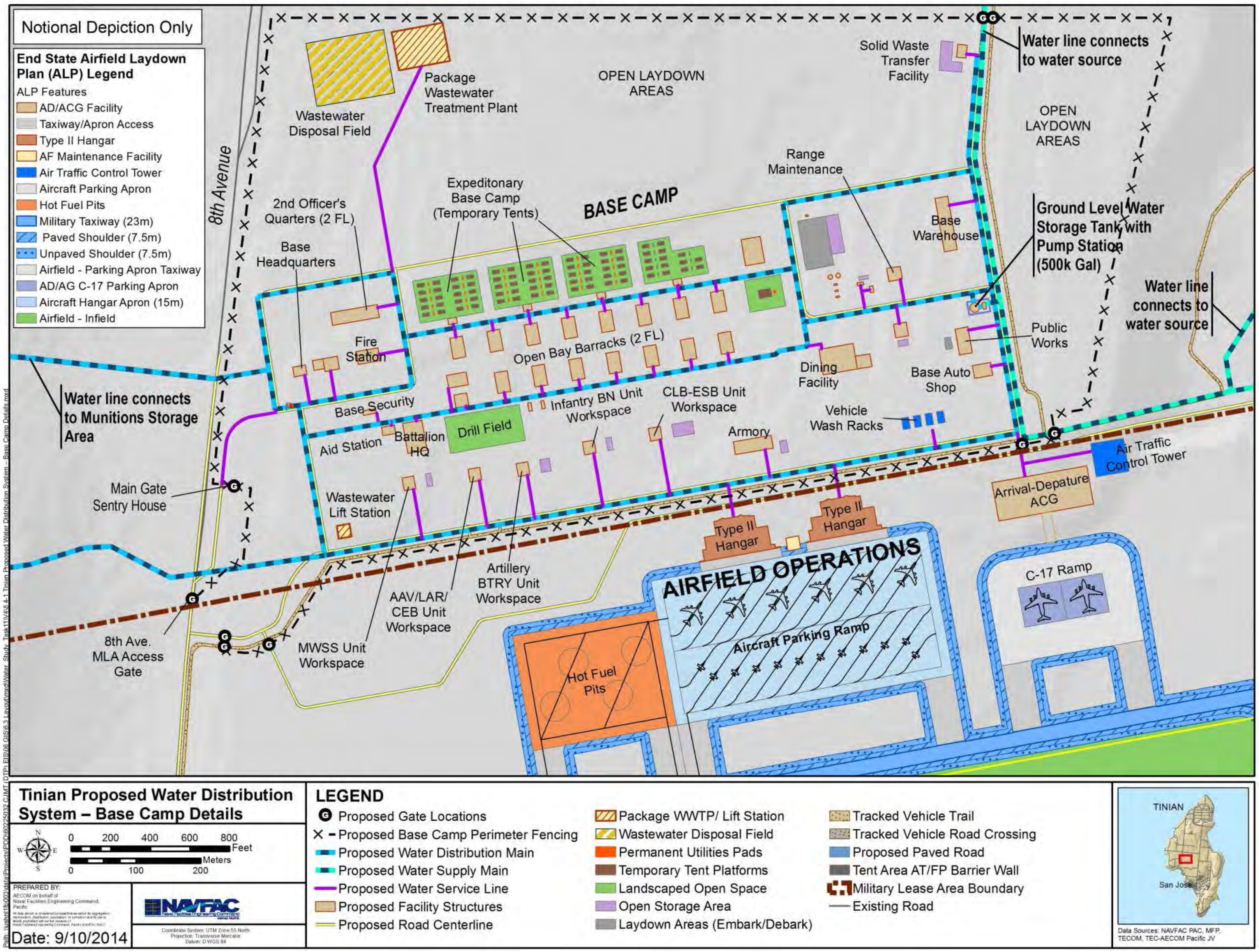

Figure 8.4-1. Tinian Proposed Water Distribution System – Base Camp Details
Source: DoN 2014.

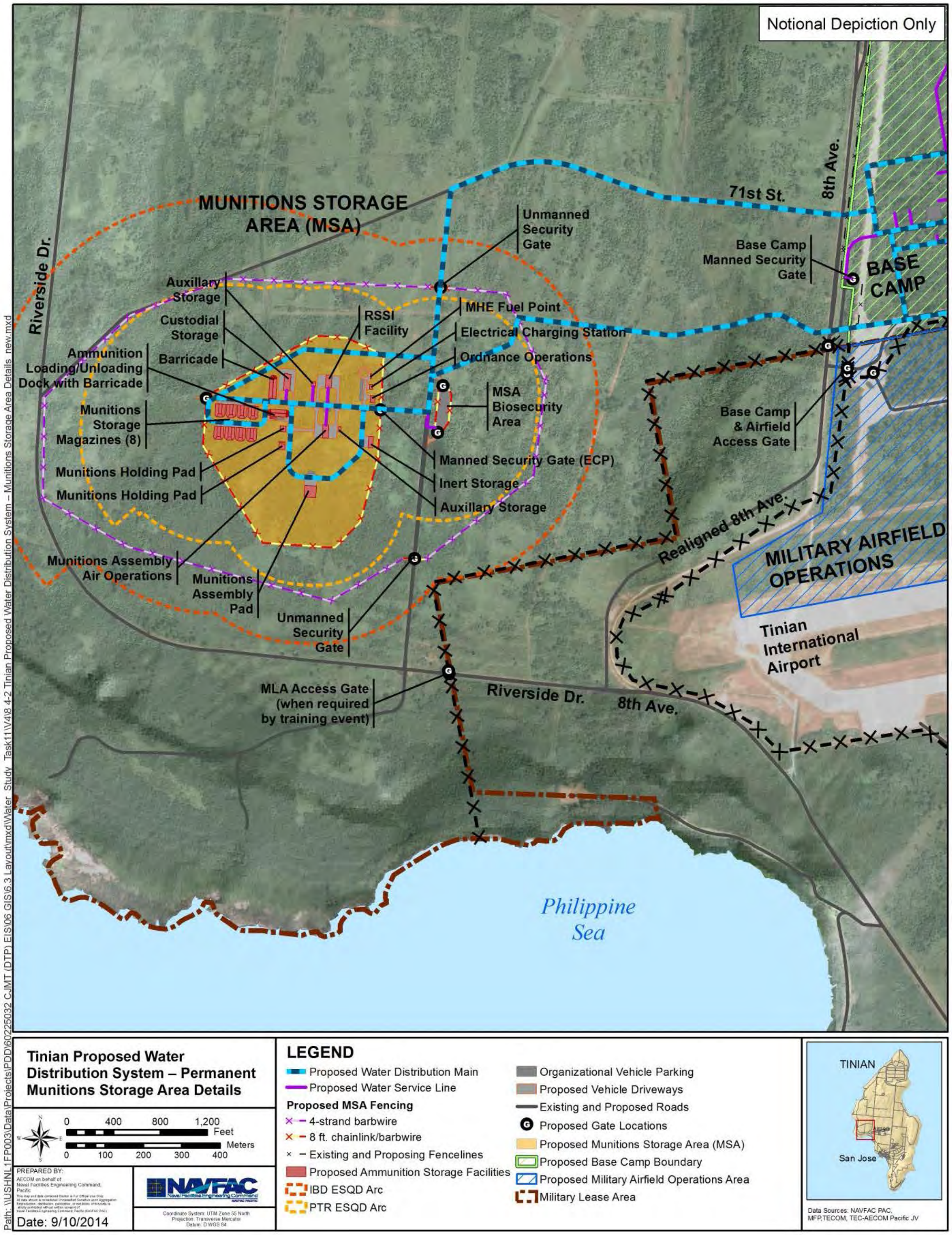

Figure 8.4-2. Tinian Proposed Water Distribution System – Permanent Munitions Storage Area Details

Source: DoN 2014.

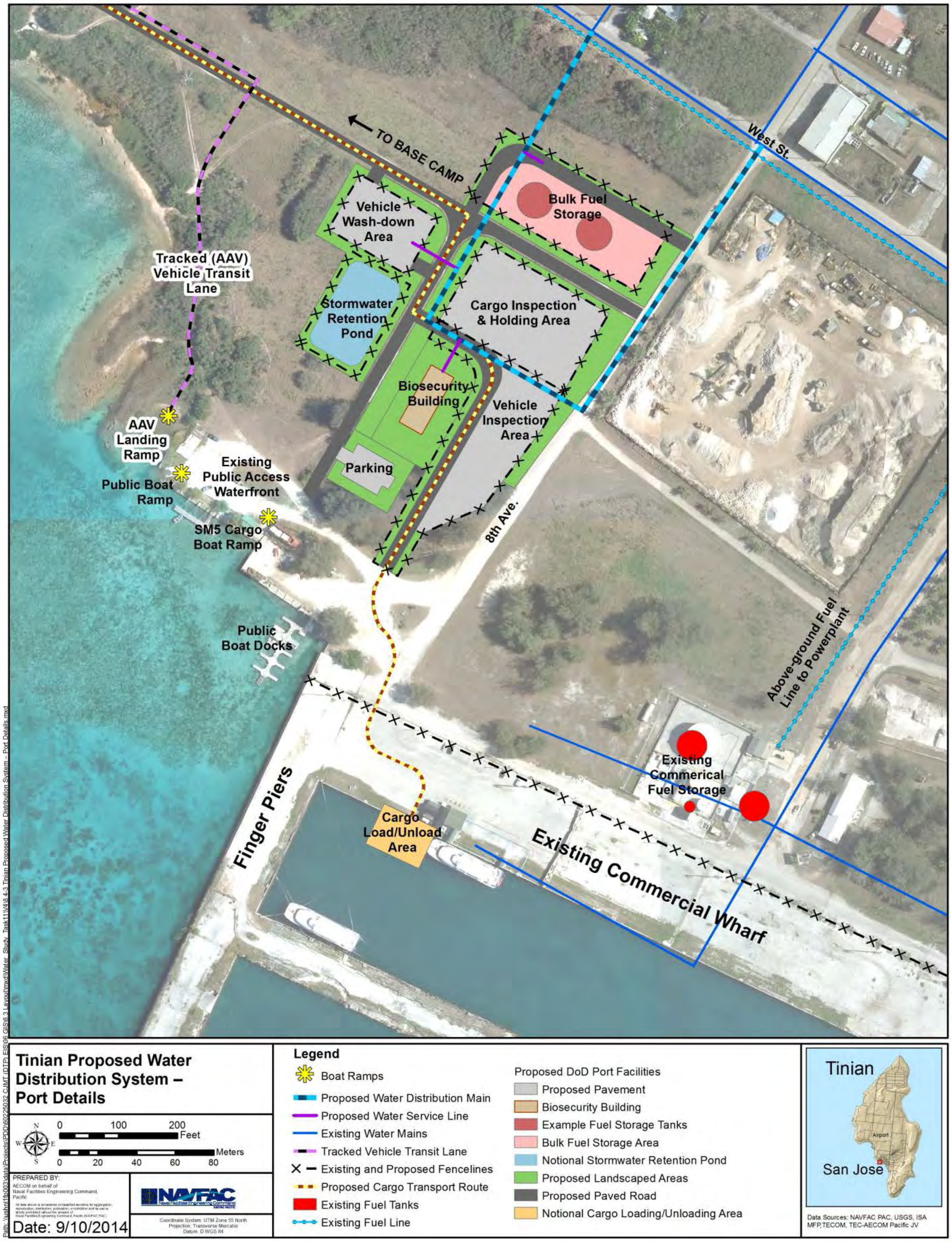

Figure 8.4-3. Tinian Proposed Water Distribution System – Port Details
Source: DoN 2014.

CHAPTER 9.
DISTRIBUTION PLANS FOR NEW FACILITIES ON PAGAN

Various distribution systems are available for use on Pagan. The options are:

- A TWDS that includes 10 mi (16.1 km) of hose line, six 600-gpm (2,271-lpm) pumps, two 20,000-gallon (75,708-liter) storage tanks, and two 125-gpm (473-lpm) pumps
- Semi-trailer-mounted fabric tanks, which are available in 3,000 gallons or 5,000 gallons (11,356 liters or 18,927 liters)
- Forward area water point supply systems that include six 500-gallon (1,893-liter) drums, one 125-gpm (473-lpm) pump, and hoses
- A 400-gallon (1,514-liter) water trailer
- A camel consisting of an 800-gallon (3,028-liter) water trailer
- A hippo, which is a 2,000-gallon (7,571-liter) tank rack

A combination of these distribution systems can be used to supply potable water to the bivouac area, which will be dependent upon the number of military personnel and trainees on Pagan at any given time. The potable water can be stored using storage and distribution systems or onion bags. The storage and distribution systems consist of 50,000-gallon and 20,000-gallon (189,271-liter and 75,708-liter) bags. Onion bags have a capacity of 3,000 gallons (13,638 liters) and are used for temporary storage. The future water storage volume required for the proposed action is shown in Table 3.3-2. Details of the storage volume calculations are provided in Appendix B.

Units deploying to Pagan for training would be expected to provide and set up their own water distribution systems as part of their training.

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CHAPTER 10.
CONCLUSIONS AND RECOMMENDATIONS

10.1 TINIAN

The proposed action on Tinian would require installation of a significant amount of infrastructure for the potable water system. Because of the known deficiencies of the CUC's existing public water system, it is recommended that a completely stand-alone U.S. military water system be installed and constructed to support the proposed action. The disturbed area for construction of the stand-alone U.S. military system, from the supply wells to the distribution system, would remain entirely within the MLA, so easement rights would not be needed from the CNMI government. Approximately 3 to 6 new production wells (plus one backup well) would likely be required, each producing between 60 and 120 gpm (227 and 454 lpm), to meet the total required maximum daily demand. The new production wells would be located in the proposed well field areas, located in areas north and east of Tinian International Airport. A transmission water main would convey the water to the ground-level storage tank located at the base camp and a distribution water main would connect to the proposed facilities. The entire system would be designed for sole U.S. military use to support the proposed action. There are a few active agricultural wells and several unused abandoned wells within the MLA. These wells should be evaluated for use for production and/or monitoring. If these wells cannot be reused as production or monitoring wells, particularly in the near the base camp, the proposed production wells, and the areas where ranges are proposed, they would need to be properly abandoned in accordance with CNMI regulations because they can become conduits for groundwater contamination.

The vehicle wash-down facility and biosecurity facility proposed for the Tinian port area would be supplied water from nearby existing CUC water infrastructure. The use at this location is within the capabilities of the existing CUC system and would be the most expeditious method to supply water for this area. Future indirect water demands associated with the proposed action such as the housing of the construction workforce, operations personnel, dependents and increases in water demand for future civilian population growth and visitors to Tinian would have utility impacts on the CUC water system. It is anticipated that improvements to the CUC water system would be needed in order to meet the future indirect water demands associated with the proposed action. It is recommended that these improvements target reducing the high UFW rather than increasing the pumping capacity of Maui Well No. 2.

10.2 PAGAN

No hydrogeological information is available for Pagan to help determine whether groundwater could be a potential source of potable water for the proposed action. For this reason, and because of the expeditionary type of training for only 16 weeks a year on Pagan, it is recommended that the training units haul in their own potable water or use potable-water-purification systems, with ocean water as the input source. Similar purification systems are currently used on Tinian for bivouac-style training. If possible, it is recommended that the water purification systems remain on board the ships to produce enough water to periodically haul (in water totes) to shore, as needed. The brine waste could remain on the ships and be taken the next port of call where it may be easier to construct, permit and monitor a proper brine disposal system.

Should the training tempo be increased in the future to a potential of 40 weeks per year, more permanent and efficient solutions should seriously be considered. A rainwater harvesting system with permanently constructed cisterns or open reservoir-type ponds should be constructed to be used as the primary water source for the water purifications systems. If the training tempo is increased, treated rainwater would be preferred because it would produce a larger amount of potable water with a smaller amount of brine waste compared to ocean water. Minimal grading and ground disturbance may need to be done to ensure that an efficient, self-operating rainwater harvesting system is installed. Periodic maintenance of the rainwater harvesting system would be required to ensure adequate water quality.

If purification systems are used, the training units would provide them as part of their training. The brine generated from the purification systems would be properly disposed in accordance with appropriate regulations. BECQ recommends the use of injection wells for brine disposal. Currently there are no injection wells on Pagan so new wells would need to be drilled and permitted in accordance with all applicable regulations.

CHAPTER 11. POTENTIAL IMPACTS AND ISSUES

11.1 TINIAN

The increased demand under the proposed action could affect Tinian's groundwater aquifer. Potential issues for each option are presented in Chapter 6. Further impacts will be evaluated in the aquifer study. Construction of the recommended stand-alone U.S. military water system in the MLA would manage projected water demands for the majority of the proposed action, comply with the CNMI regulations, and not have any utility impacts. However, the projected water demands from the port facilities and housing for operations personnel, construction workforce, and their dependents could have a potentially significant impact on the existing CUC water system. The estimated production capacity of the existing CUC system varies seasonally and is at least 1 MGd (3.8 MLd) of potable water in the dry season and 1.5 MGd (5.7 MLd) in the wet season. The average recorded production levels for the CUC system in 2011, 2012, and 2013 were 0.89, 1.01, and 1.14 MGd (3.36, 3.82, and 4.31 MLd), respectively which are all close to or exceed the lower production capacity of the system during the dry season. The estimated permanent increase in the total average and maximum daily demand under the proposed action that would be served by the CUC water system is 0.197 MGd (0.746 MLd) and 0.416 MGd (1.575 MLd), respectively. During the wet season, the CUC water system should be able to meet the increased demand under the proposed action. However, during the dry season, there may not be enough production capacity to meet the estimated demand requirement. To mitigate the potentially significant impact to the CUC water system, DoD could assist the CUC in securing federal funding sources from the Department of the Interior or the Office of Economic Adjustment to make improvements to the CUC water system and reduce the very high UFW. Impacts could result from the installation of transmission and distribution water mains for the proposed action. All the proposed water alignments would be constructed either in or along existing or proposed roadway alignments and need to have proper erosion control and best management practices in place prior to construction. Potential earthwork impacts were quantified by estimating the volume of soil disturbed for trenching to install the proposed water lines, fire hydrants, and related appurtenances. The minimum required cover for water pipes would be 2.5 ft (0.75 m) or sufficient cover to support imposed dead and live loads for the pipe material used, whichever is more stringent (Department of Defense 2012a). Trench width for 6-10-in (150-250-mm) pipes could vary, from 1.52.0 ft (0.50.6 m), depending on the depth of the water line installed. For estimating purposes, a typical depth of 4.0 ft (1.2 m) and a typical width of 2.0 ft (0.6 m) were used. Estimates of the volume of soil disturbed to install the distribution and transmission mains are shown in Table 11.1-1. Valves, meters, and fire hydrants would be in line with the proposed pipe and would require minimal additional disturbance.

Table 11.1-1. Estimated Volume of Soil to be Disturbed during Trenching Activities

Location	*Length*	*Width*	*Area*	*Depth*	*Volume of Disturbance*
Transmission Main (assuming Option 1)	13,120 ft (4,000 m)	2.0 ft (0.6 m)	26,240 ft^2 (2,400 m^2)	4.0 ft (1.2 m)	104,960 ft^3 (2,880 m^3)
Base Camp Distribution Mains	17,760 ft (5,410 m)	2.0 ft (0.6 m)	35,520 ft^2 (3,246 m^2)	4.0 ft (1.2 m)	142,080 ft^3 (3,895 m^3)
Munitions Storage Area	16,350 ft (4,983 m)	2.0 ft (0.6 m)	32,700 ft^2 (2,990 m^2)	4.0 ft (1.2 m)	130,800 ft3 (3,588 m^3)
Port Facilities	1,522 ft (464 m)	2.0 ft (0.6 m)	3,044 ft^2 (278 m^2)	4.0 ft (1.2 m)	12,176 ft^3 (334 m^3)

Legend: ft = feet; ft^2 = square feet; ft^3 = cubic feet; m = meters; m^2 = square meters; m^3 = cubic meters.
Source: DoN 2014.

11.2 PAGAN

The recommended water solutions in Chapter 10 would manage projected water demands from the proposed action, comply with the CNMI regulations, and not have any utility impacts.

Impacts could result from shipping, unloading, installation, and operation of the water purification units. They would be brought to shore at Red Beach by Landing Craft Air Cushion hovercrafts. The TWPSs would be transported on land and set into place by heavy expanded mobility tactical truck load-handling system flatracks. The LWPs would be transported on land and set into place by high mobility multipurpose-wheeled vehicles. The ground transportation of the purification units would cause ground disturbance. However, the areas of ground disturbance would occur in areas already disturbed by the training personnel and equipment. The brine disposal system, whether by evaporation ponds or injection wells, would have a ground disturbance impact. Proper erosion control and best management practices need to be installed prior to the start of construction to minimize the downstream storm water impacts. If injection wells need to be drilled, proper permits and approval should be obtained to avoid any subsurface impacts.

If a permanent rainwater harvesting system were utilized for the possible increased training tempo, construction of the system would have soil disturbance impacts. Proper best management practices should be in place before starting construction of the rainwater harvesting system to avoid possible erosion or downstream water quality effects. A significant amount of grading could be involved, so proper dust control measures must be taken to maintain adequate air quality levels.

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Appendix A
Meeting Minutes from Site Visit and Follow-up Data Requests

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Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training (CJMT) Environmental Impact Statement (EIS)/Overseas EIS (OEIS) Potable Water and Wastewater Meeting Notes December 10, 2013 0900-1030 Chamorro Standard Time (ChST)

Attendees:
Commonwealth Utilities Corporation (CUC): B. Bearden, J. Riegel
TEC-AECOM Pacific Joint Venture (JV): P. Diaz, S. Keith

Purpose

a. The purpose of the meeting was to gather information and site reconnaissance for water and wastewater utility studies to support the CNMI Joint Military Training EIS/OEIS in assessing existing conditions and potential effects of locating range and training areas on Tinian and Pagan.

Attachments

1. Meeting Attendance List
2. Draft Master Plan Project List

Attendees

Name	Representing	E-mail Address	Office Phone	Mobile Phone
Steve Keith	AECOM	stephen.keith@aecom.com	808-220-4598	808-220-4598
Pete Diaz	AECOM	pete.diaz@aecom.com	671-477-8326/7	671-788-6710
Brian Bearden	CUC/USPHS – Water/Wastewater	brian.bearden@cucgov.org	670-235-7025	
John Riegel	CUC – Water/Wastewater	john.riegel@cucgov.org	670-236-4338	

AECOM AECOM Technical Services, Inc.
CUC Commonwealth Utilities Corporation
USPHS United States Public Health Service

General Discussion

a. Class I aquifer recharge areas/groundwater management areas
   i. Currently none defined for Tinian and Pagan; defined only on Saipan.
   ii. Brian Bearden provided a discussion paper on the designation of groundwater management zones for Saipan; Could be used for Tinian and Pagan
   iii. Based on groundwater contour; depends on thickiness of the aquifer lens.
b. Water and Wastewater Master Plan (Stipulated order requirement)
   i. Currently in progress. Draft was reviewed and commented on by USEPA, but the master plan is not currently available for release. CUC estimated revisions to the draft Master Plan would be completed in 6 months, however there is no set deadline.
   ii. CUC provided the following appendices of the Master Plan
      - Appendix T – Complete Project List

- Appendix U – CNMI Safe Drinking Water Infrastructure Grant Program Guidelines
- Appendix V – Saipan Water Project Ranking - Non-EPA Criteria
- Appendix W – Summary of Water Projects (Tinian)
- Appendix X – Tinian Wastewater Projects
- Appendix Y – CNMI Construction Grant Priority System
- Appendix Z – Wastewater Project Ranking - Non-EPA Criteria

c. CUC provided a list of 15 water projects from the Draft Master plan (See Attachment 2; for more detail, refer to Appendix T):
   i. Filtration Plant for Maui Well II
   ii. SCADA Pilot Study
   iii. Valve Installation/Replacement
   iv. San Jose Village Loop Waterline
   v. Upgrade Half Million Gallon Tank (HMT)
   vi. Upgrade of Maui II Well
   vii. Security Fencing of Wetlands
   viii. Marpo Valley Water Distribution System Upgrade/Replacement
   ix. Replace all Active Meters
   x. Carolinas Waterline
   xi. Marpo Heights and Marpo Valley Water Distribution
   xii. Upgrades of Deep Wells
   xiii. Carolinas Agricultural Homestead Water System
   xiv. CPA Transmission line Replacement
   xv. Dedicated Transmission Line from Maui II to HMT

d. Inspections on CUC water systems are conducted by the CNMI DEQ. AECOM to check with DEQ for latest inspection reports/findings.

Potable Water Discussion

a. Aquifer Studies on Tinian and Pagan
   i. No recent studies.
   ii. For Tinian, a 2002 USGS study covered the geohydrology.
   iii. For Pagan, a 2006 USGS study covered the geologic mapping for Pagan; however the study does not address geohydrology.

b. CUC has no plans at this time to refurbish Maui I Well

c. Additional Water Supply
   i. CUC did agree the Maui I Well is a potential option for increased water supply; although reducing the unaccounted for water rate could be more appropriate.
   ii. Maui II Well was built to replace Maui I Well
   iii. Maui I Well was taken out of service when Maui II Well was placed into operation; no record of running both wells at the same time
   iv. Running two wells at lower pumping rates could yield higher quality water
   v. Running two wells at higher pumping rates could also have negative impact such as salt water intrusion.
   vi. CUC has no idea on pumping rate versus water quality.
   vii. Maui I Well would need to be completely rebuilt

d. A water hydraulic model was prepared by a consultant to CUC. CUC recommended contacting the consultant (Duenas, Camacho, & Associates) to provide the hydraulic model. AECOM to make the request.
e. GWUDI Study
   i. Currently in progress.
   ii. If GWUDI is determined then filtration at Maui II Well would be required.
f. Water System Issues
   i. High pressure in distribution system
   ii. No dedicated transmission system from production well to reservoirs – combined transmission/distribution
   iii. Estimated unaccounted for water (UFW) is high at 75%-80%; varies seasonally.
      - CUC provided the following data: 932 gpd water produced, 244 gpd metered use equates to 73.7% UFW.
   iv. Leaks from old galvanized pipes
   v. Appears the Quarter Million Gallon Tank (QMT) does not provide a benefit to the hydraulics of the Tinian water system
   vi. QMT overflows
g. Pressure reducing valve project
   i. CUC is currently studying locations for PRVs to mitigate high pressures experienced by customers
h. There have been no updates to the CAD/GIS data for Tinian and Pagan received on October 30, 2013.
i. Water meter data and water production data
   i. CUC directed AECOM to contact CUC Staff on Tinian for the requested data.
   ii. Point of contacts on Tinian for CUC are Evelyn Manglona and Winston Omar.
j. Water Quality Data
   i. CUC provided AECOM Water Quality Reports 2010-2012
   ii. Also available on line.

Wastewater Discussion

a. Acceptable/proven wastewater treatment system (packaged wastewater treatment)
   i. Membrane bioreactors are used successfully, such as at Managaha Island.
   ii. Lao Lao Golf & Resort uses a wetland type system.
   iii. Sequencing batch reactors (SBRs) could also be good as they can handle varying flow rates.
b. Percolation rates for leach field design criteria
   i. To be verified with DEQ
c. Effluent Disposal
   i. Would depend on location and quantity, not necessarily on effluent quality
   ii. To be verified with DEQ.
d. Sludge Management on Tinian
   i. No sludge management plan
   ii. All sludge on island is disposed of at the noncompliant landfill
   iii. Septic wastes are also disposed of at the noncompliant landfill
e. Status on municipal wastewater treatment plant
   i. No active plans on constructing a municipal plant

Action Items

AECOM to request water model from former CUC consultant DCA; CUC to be cc'd on email.

MEETING ATTENDANCE LIST

CNMI Joint Military Training EIS/OEIS - SITE VISIT DEC 2013

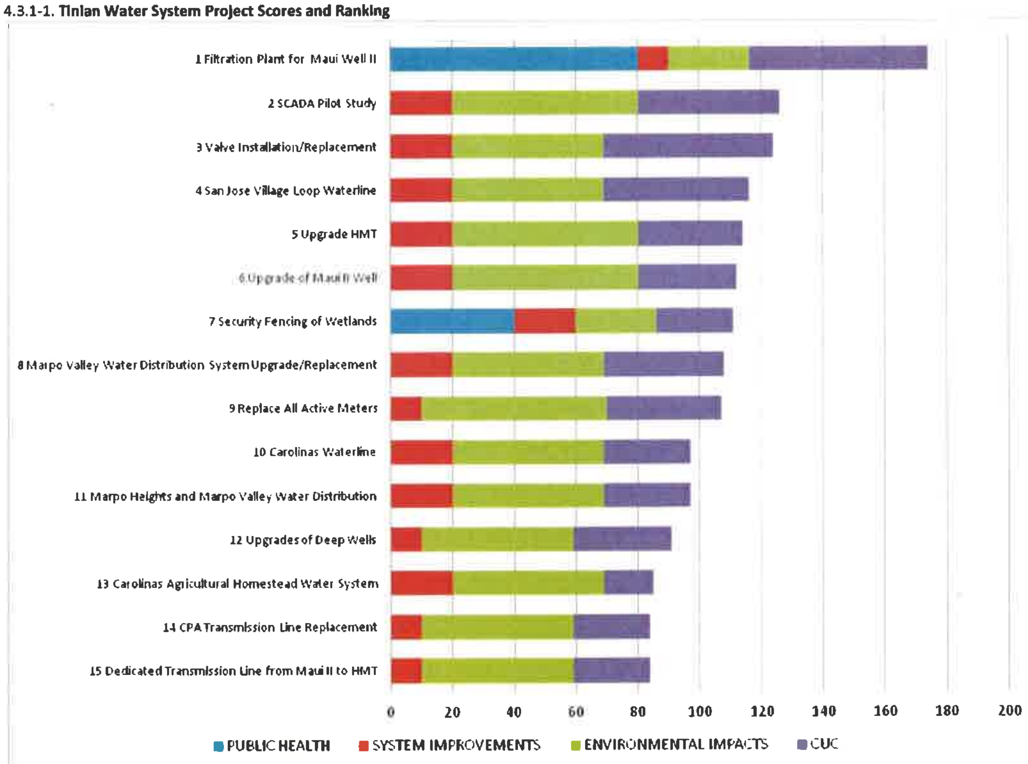
Date/Time: Dec. 10, 2013

Location: CUC office, DanDan Bldg, Saipan

Topic: Water / Wastewater

NAME	ORGANIZATION/TITLE	E-MAIL	OFFICE PHONE	CELL PHONE
BRIAN BEARDEN	CUC / USPHS	brian.bearden~~@gmail.com~~	670-235-7025	670-285-6093
		@cucgov.org		
Stephen Keith	AECOM			
Pete Diaz	AECOM			
John Riegel	CUC		670-236-4338	

4.3.1-1. Tinian Water System Project Scores and Ranking



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Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training (CJMT)
Environmental Impact Statement (EIS)/Overseas EIS (OEIS)
Potable Water System Tour Notes
December 11, 2013
1230-1500 Chamorro Standard Time (ChST)

Attendees:

Commonwealth Utilities Corporation (CUC): E. Manglona, W. Omar
TEC-AECOM Pacific Joint Venture (JV): P. Diaz, S. Keith

Purpose

The purpose of the meeting was to gather information and site reconnaissance for a water utility study to support the CNMI Joint Military Training EIS/OEIS in assessing existing conditions and potential effects of locating range and training areas on Tinian and Pagan.

Attendees

Name	Representing	E-mail Address	Office Phone	Mobile Phone
Steve Keith	AECOM	stephen.keith@aecom.com	808-220-4598	808-220-4598
Pete Diaz	AECOM	pete.diaz@aecom.com	671-477-8326/7	671-788-6710
Evelyn Manglona	CUC-Water, Tinian	evelyn.manglona@cucgov.org	670-433-9265/61	670-285-6098
Winston Omar	CUC-Water, Tinian		670-433-9265/61	

AECOM *AECOM Technical Services, Inc.*
CUC *Commonwealth Utilities Corporation*

General Discussion

a. Met with Evelyn Manglona, Deputy Director of CUC-Water Division in Tinian.
b. Tour of the water system, led by Water Operator, Winston Omar
c. CUC agreed to provide data for the following requests:
    i. Record of water system outages
    ii. Record of boil notices
    iii. Water meter data (2011-2013)
    iv. Water production data (2011-2013)
    v. System pressure data
    vi. Well location data
    vii. Number of customers (power and water)
d. Steve Keith to collect data on Friday, December 13, 2013, 10am
e. Airport Water System
    i. Water tank and distribution system from the tank is owned by the airport.
    ii. CUC provides water to the Airport Water Tank
f. Records.

Potable Water Tour

1. Tour began at Maui I Well

Figure 1: Maui I Well Pump House to the left, operations building to the right

Figure 2: Maui I Pumps

Figure 3: Maui I Wetwell

2. According to CUC operator, the Maui II Well is based on the Maui I design.
3. DEQ requires the wetwell to be covered to prevent contamination of the well from the surface.

Figure 4: Pipe manifold (discharge side of Maui I Well)

4. As shown in Figure 4, the discharged pipe manifold was reconfigured to disconnect Maui I Well. Flow from the large (8"? – PER EMAIL 12/19/2013 THIS IS 10") diameter pipe at the top of the photos is reversed, flow now comes from Maui II Well to the pipe manifold, reduced to a smaller diameter (6"? – PER EMAIL 12/19/2013, THIS IS 8") pipe at the bottom of the photo. Flow along the run of the (8") pipe goes to the HMT. Flow along the branch of the (8") pipe goes to Marpo Valley.
5. The isolation valve (color red) in Figure 4 was leaking during the tour.

Figure 5: Above grade Galvanized pipe near Maui I Well leaking during the tour.

6. CUC Operator stated there are many leaks in the Tinian Water System, especially on the galvanized water pipes.

Figure 6: Maui II Well Facility

Figure 6: Maui II Well Facility

7. As shown in Figure 6, the right corner of the facility is the chlorination room, left corner of the facility is a maintenance room, the remainder of the building is the pump room on the ground level and wetwell on the second level.

Figure 7: Record Drawing of the Maui II Well, Plan and Section

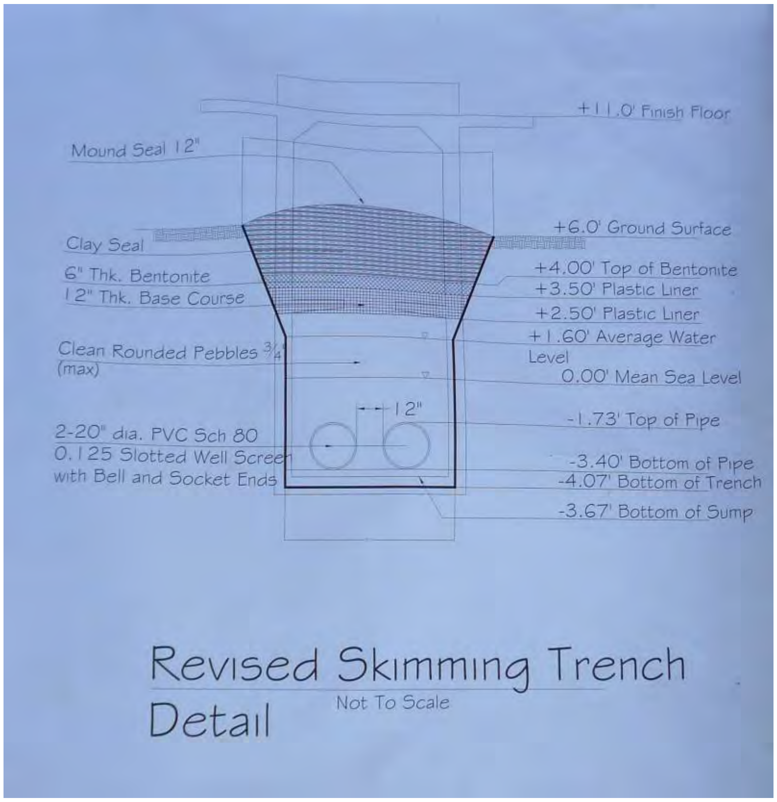

Figure 8: Record Drawing of the Maui II Well, Skimming Trench Cross-section

Figure 9: Pump Room

8. As shown in Figure 9, there are 4 pumps, constant speed, each rated at 350 gpm, Total Dynamic Head (TDH) of 526 ft. Motors were rated at 75 hp, 3PH, 60 HZ, 1780 rpm. See figures 10 and 11.

Figure 10: Typical pump name plate.

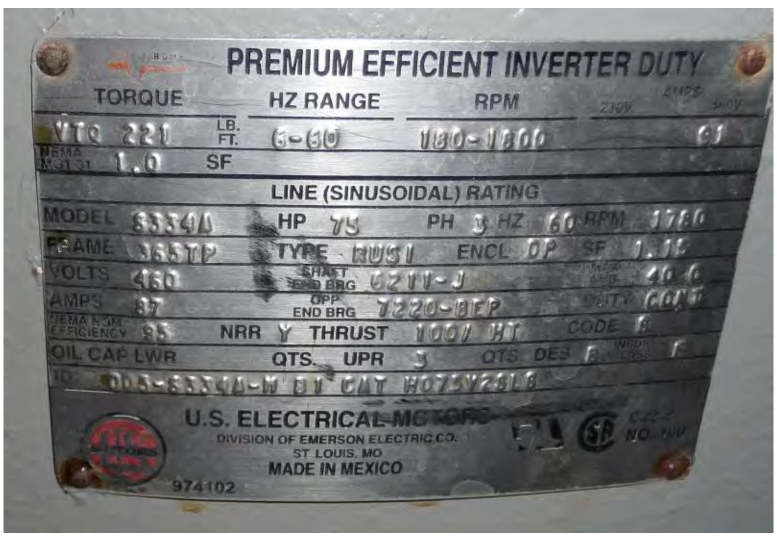

Figure 11: Typical motor name plate.

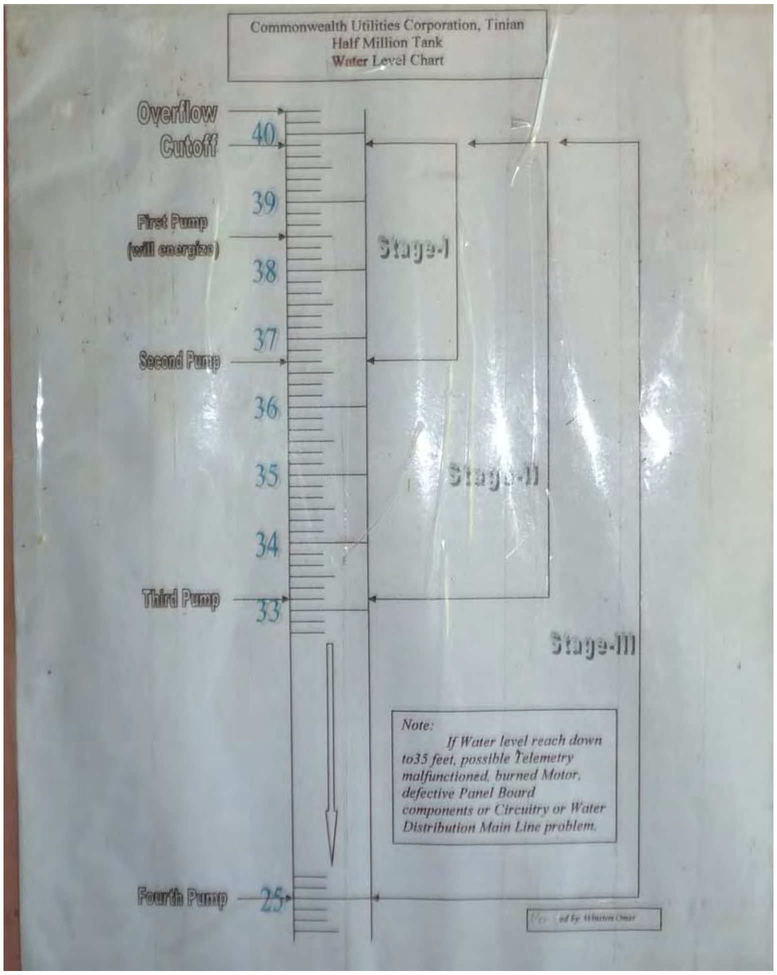

Figure 12: Pump Set Points

9. The pumps in the Maui II Well are operated based on the water level in the HMT, connected through telemetry. As shown in Figure 12, the Maui II Well is designed to operate as follows:
    a. The first pump will energize when the water level in the HMT falls to 38.5 ft.
    b. The second pump will energize when the water level in the HMT falls to 36.7 ft.
    c. The third pump will energize when the water level in the HMT falls to 33.3 ft.
    d. The fourth pump will energize when the water level in the HMT falls to 25.0 ft.

Figure 13: Chlorination system at Maui II Well Facility.

Figure 14: Half Million Gallon Tank (HMT)

10. Tank is cleaned every 3 years. Tank is due for cleaning in 2014.

Figure 15: Quarter Million Gallon Tank (QMT)

11. The QMT has a tendency to overflow. It is not connected to any telemetry system. CUC operators check the tank elevation every day for overflow.
12. According to the CUC Operator, the altitude valve for the reservoir does not work. This would prevent the QMT from overflowing.
13. CUC operators control the overflow by adjusting a valve at the pipe manifold near the Maui I Well.

Action Items

CUC to provide the following items to AECOM:

a. Record of water system outages
b. Record of boil notices
c. Water meter data (2011-2013) – RECEIVED 12/16/2013
d. Water production data (2011-2013) – RECEIVED 12/16/2013
e. System pressure data
f. Well location data – RECEIVED 12/16/2013
g. Number of customers (power and water) – RECEIVED 12/16/2013
h. Photo of the valve pit at the QMT and HMT – RECEIVED 12/13/2013

MEETING ATTENDANCE LIST

CNMI Joint Military Training EIS/OEIS - SITE VISIT DEC 2013

Date/Time: Dec. 11, 2013

Location: CUC-Water, CUC Power Plant, Tinian, CNMI

Topic: Potable Water Tour

NAME	ORGANIZATION/TITLE	E-MAIL	OFFICE PHONE	CELL PHONE
Pete Diaz	AECOM	pete.diaz@aecom.com	671-477-8326	
Stephen Keith	AECOM	stephen.keith@aecom.com	SAME →	808-220-4598
EVELYN B. MANGLONA	DEPUTY DIRECTOR	evelyn.manglona@cucgov.org	~~670-285-6098~~ 670-433-9265/61	(670)285-6098

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Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training (CJMT)
Environmental Impact Statement (EIS)/Overseas EIS (OEIS)
Potable Water and Wastewater Meeting Notes
December 12, 2013
1000-1100 Chamorro Standard Time (ChST)

Attendees:

Commonwealth Utilities Corporation (CUC): D. Chambers, J. Kaipat, D. Rosario
TEC-AECOM Pacific Joint Venture (JV): P. Diaz

Purpose

The purpose of the meeting was to gather information and site reconnaissance for water and wastewater utility studies to support the CNMI Joint Military Training EIS/OEIS in assessing existing conditions and potential effects of locating range and training areas on Tinian and Pagan.

Attachments

1. Meeting Attendance List
2. Tinian GIS Map, Water System (provided by DEQ)
3. USGS Figure showing well location and water table contours (provided by DEQ)
4. Contact Info for consultant who conducted geological hydro-geological study for Tinian Landfill and CUC contact for wastewater treatment plants. (provided by DEQ)

Attendees

Name	Representing	E-mail Address	Office Phone	Mobile Phone
Pete Diaz	AECOM	pete.diaz@aecom.com	671-477-8326/7	671-788-6710
Derek Chambers	DEQ	derekchambers@deq.gov.mp	670-664-8500	
David Rosario	DEQ – Wastewater, Earthmoving,	davidrosario@deq.gov.mp	670-664-8500	
Jose Kaipat	DEQ – Safe Drinking Water Branch	josekaipat@deq.gov.mp	670-664-8500	670-989-8509

AECOM AECOM Technical Services, Inc.
DEQ Division of Environmental Quality

General Discussion

1. Aquifer recharge areas/groundwater management areas
   a. DEQ concurred none have been established for Tinian and Pagan.
   b. Discussed CUC provided guidelines used to establish these areas.

Potable Water

1. Aquifer Studies
   a. Last study on aquifer in Tinian and Pagan were done by USGS.
2. Current Water Supply

   a. Currently Tinian only has one source of water, Maui II Well; other deep water wells have been closed and are currently inactive. CUC had drilled 8 exploratory wells, 4 were put into production.
   b. Originally the plan was to leave the deep wells as standby, but Maui Well II supplied enough water.
   c. All equipment from the deep wells have been removed and the wells have been capped.
3. Increasing Water Supply
   a. DEQ concurs Refurbishing Maui I Well is an option, however, reducing unaccounted for water would achieve the same goal.
4. Water Quality Data
   a. Began collect data in 2000
   b. DEQ to look into water quality data when Maui I Well was in operation, if any. Switch over from Maui I Well to Maui II Well occurred around the same time water quality data collection commenced.
   c. Overall the water quality in Tinian is good (potable) but not very palatable. There have been an occasional hit on bacteria due to a water main break.
5. GWUDI
   a. CUC has contracted CH2M Hill to conduct GWUDI Study.
   b. Started last year, with the rainy season ending, study is wrapping up.
   c. GWUDI findings to be included in the Water and Wastewater Master Plan.
   d. If GWUDI determined for the Maui II Well
      i. Filtration would be required
      ii. Rules would change
      iii. DEQ adopted federal regulation related to GWUDI.

Wastewater

1. Acceptable/proven wastewater treatment system (packaged wastewater treatment)
   a. Membrane bioreactors are used successfully, such as at Managaha Island.
   b. Lao Lao Golf & Resort uses a wetland type system.
   c. Sequencing batch reactors (SBRs) could also be good as they can handle varying flow rates.
2. Percolation rates for leach field design criteria
   a. Percolation rate may have been determined in the hydro-geologic study conducted for the proposed Tinian Landfill.
   b. Verify if document obtained by Patrick Ono contains required percolation data.
3. Effluent Disposal
   a. Would depend on location and quantity, not necessarily on effluent quality
   b. Typically injection wells are used for disposal of brine from reverse osmosis water treatment system.
   c. For leach field systems serving more than 25 people, system is considered an injection well.
   d. If leach field is close to coastal waters, the system would require a USEPA NPDES permit (like Managaha Island WWTP system), otherwise the system would be under DEQ regulations.
   e. DEQ recommends reusing treated effluent for things like irrigation or toilet flushing
      i. On Managaha Island, effluent is reused for toilet flushing, a dye is added to identify it as recycled water.

        ii. Reuse could reduce required leach field size

4. Wastewater Treatment Plant Inspections
    a. DEQ normally waits for EPA to conduct inspections on WWTPs
    b. Owners of WWTPs need to submit Discharge Monitoring Reports to DEQ
5. Existing Septic Tank
    a. Navy is planning to repair the existing leach field
    b. Point of Contact – Mark Cruz, Joint Region Marianas, 671-349-1139; POC between DEQ and exercise training.

Action Items

Jose Kaipat from DEQ to provide the following information:

a. Water quality records prior to the start-up of Maui Well #2, if any.
b. 2013 inspection reports/survey of the CUC water system
c. GIS data/shapefiles indicated in the GIS map provided in today's meeting.
d. UIC permit for Tinian Dynasty WWTP.

David Rosario from DEQ to provide the following information:

a. Write-up on Tinian Dynasty WWTP by Brian Bearden describing the system (provided via email on 12/12/13).
b. Discharge Monitoring Reports for small packaged treatment plants (Tinian Dynasty WWTP, Managaha Island WWTP, Lao Lao Bay Resort WWTP)
c. Permit for Tinian Dynasty WWTP to operate

MEETING ATTENDANCE LIST

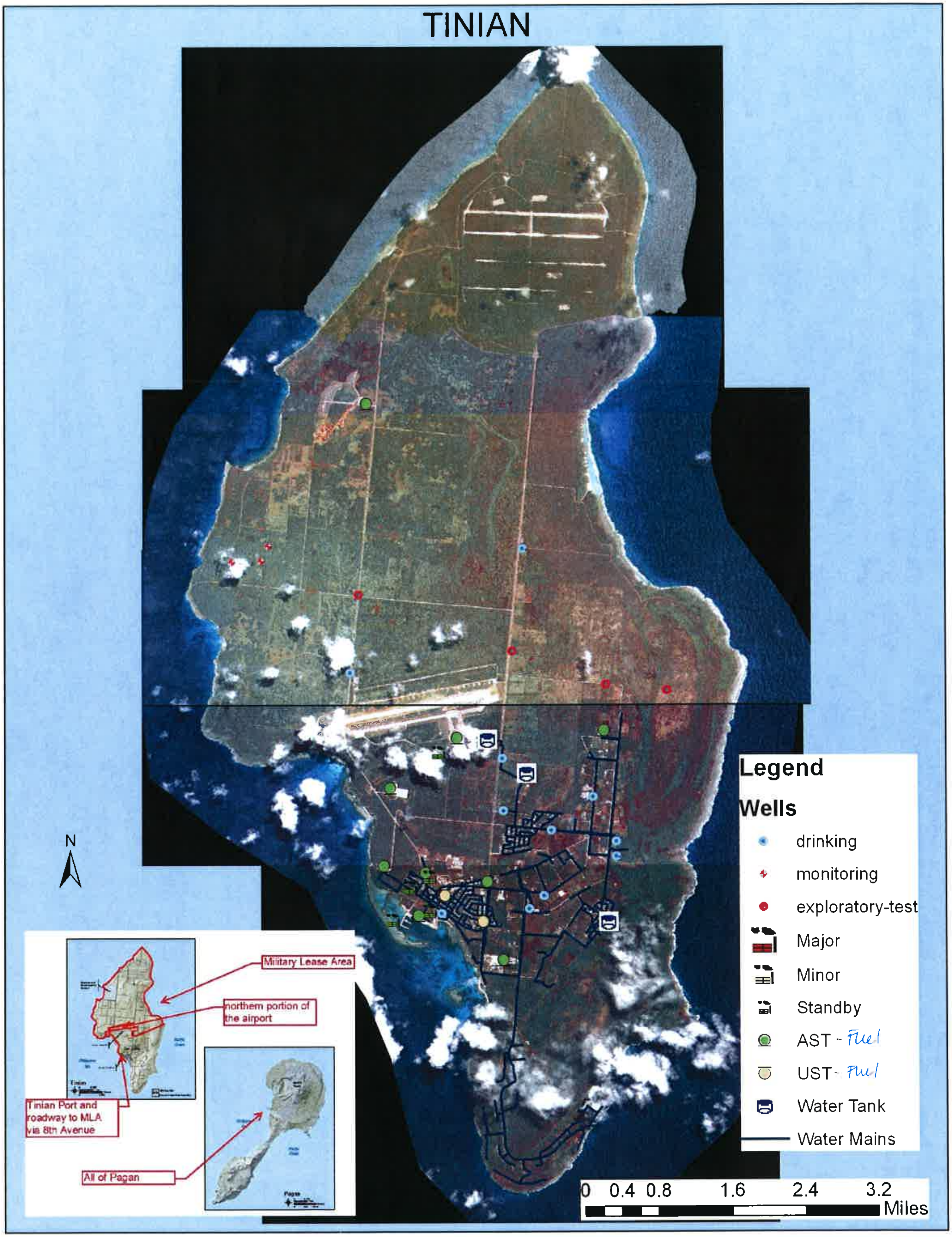
CNMI Joint Military Training EIS/OEIS - SITE VISIT DEC 2013

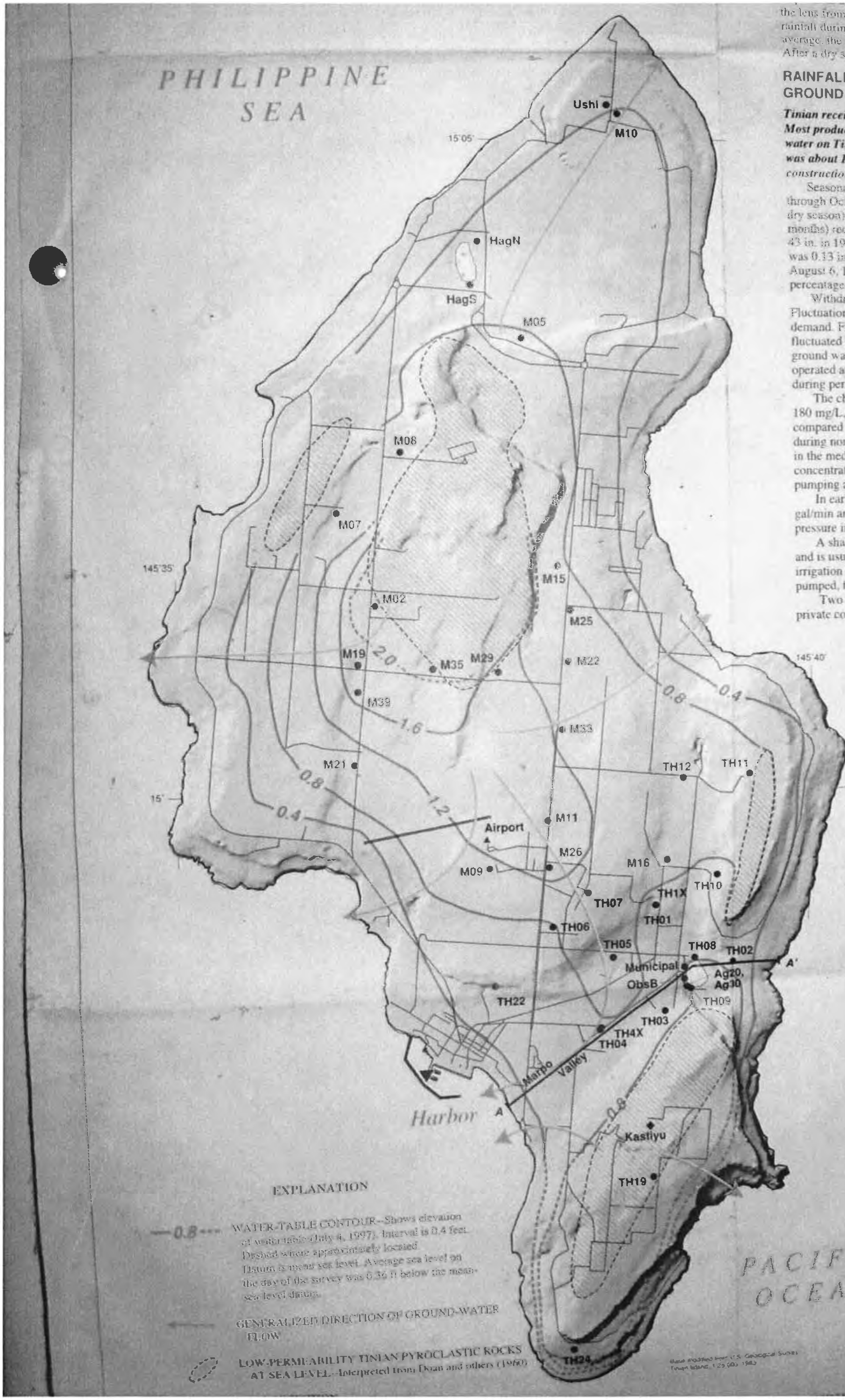
Date/Time: December 12, 2013

Location: CNMI DEQ Office, Saipan

Topic: Water/Wastewater

NAME	ORGANIZATION/TITLE	E-MAIL	OFFICE PHONE	CELL PHONE
Pete Diaz	AECOM	pete.diaz@aecom.com	671-477-8326	671-788-6710
Derek Chambers	DEQ	derekchambers@deq.gov.mp	670 664-8500	
David B. Rosario	DEQ	davidrosario@deq.gov.mp	6644500	—
Jose M. Kaipat	DEQ-SDWP	josekaipat@deq.gov.mp	664-8500	670-787-8509


TINIAN
N
Legend
Wells
drinking
monitoring
exploratory-test
Major
Minor
Standby
AST - Fuel
UST - Fuel
Water Tank
Water Mains
0 0.4 0.8 1.6 2.4 3.2
Miles
Military Lease Area
northern portion of the airport
Tinian Port and roadway to MLA via 8th Avenue
All of Pagan



the lens from November 1993 to May 1994. Rainfall d
rainfall during this same 6-month period for the years
average, the freshwater lens would not be expected to
After a dry season of more typical rainfall, the lens w

RAINFALL, GROUND-WATER WITHDRAW GROUND WATER

Tinian receives about 79 in. of rainfall annually an Most production comes from the Municipal well wh water on Tinian for more than 50 years. The chlori was about 180 mg/L during 1992-97, which is abou construction in 1945.

Seasonal differences in rainfall define distinct w through October (the wet season) receive about 61 p dry season) receive 12 percent (10 in.) of the rainfall months) receive 27 percent (21 in.) of the rainfall. F 43 in. in 1998 to a high of 97 in. in 1994. The lowe was 0.13 in. in March 1995. The highest amount of August 6, 1993 during tropical storm Steve. Rainfall percentage of the total annual rainfall and a lack of

Withdrawal and chloride-concentration data fro Fluctuations in withdrawal correlate to changes in s demand. From 1990-97, ground-water withdrawal f fluctuated by about 10 percent over a year. Three 5 ground water from this well. In March, 1996, one n operated at maximum capacity 24 hours per day, ex during periods of lower demand in the wet season.

The chloride concentration at the Municipal we 180 mg/L, and ranging from 160 to 220 mg/L. Chl compared to the dry season. The average chloride c during non-pumping conditions after construction i in the median valley. Monitor wells TH08, TH09, concentrations, near 180 mg/L, indicating that the pumping at the Municipal well.

In early 1999, wells TH04 and TH06 were put gal/min and well TH04 can produce about 50 gal/r pressure in the distribution system (Greg Castro, C

A shallow, 30-ft diameter well (well Ag30) is and is usually operated for about 10 hours on alter irrigation well is estimated to be about 500 gal/mi pumped, from pre-pumping values of 180 mg/L to

Two other wells that are currently in use are private corporation and are each pumped at about

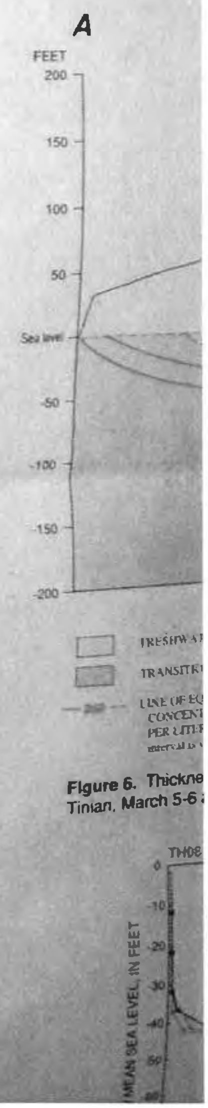


Figure 6. Thickne
Tinian, March 5-6

Municipality of Tinian and Aguiguan

Allied Pacific Environmental Consulting (APEC) was contracted by Tetra Tech. Guam to conduct geological and hydro-geologic study (July 1, 2011) at the purposed Tinian Landfill. Tetra Tech was contracted by CNMI Capital Improvement Project (CIP) (tel: 664-2371). Mr. Robert Jordan, APEC. apeccnmi@pticom.com; robairjordan@gmail.com

Wastewater Treatment Plant, Tinian:
Mr. John Riegel, Chief Engineer, Commonwealth Utilities Corporation (CUC), Tel: 235-7025 to 7030; john.riegel@cucgov.org

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Personal Communication Form

Project Name: CJMT EIS/OEIS

Date: 6/6/14

Subject: Additional Information Request

Type of Communication (fax, email): Email

Interviewee Information (or submit an attendance record – Appendix C)

Name: Brian Bearden

Title: Senior Engineer

Employer: CUC/US Public Health Service

Address: PO Box 501220, Saipan, MP 96950

Phone: (670) 235-7025 to 7030, ext. 325 **Fax:**

Email: brian.bearden@cucgov.org

Summary:

1. The Water and Wastewater Master Plan is still in draft form and is pending comments from USEPA. There are no plans for release of the document for at least 6 months or more.
2. The work camp behind the Tinian Dynasty Hotel and Casino is used for the hotel staff and their families. It is unknown if the housing is currently used. The work camp wastewater system discharges to the hotel WWTP system.
3. Although there were infrastructure upgrades on Pagan in the 1970s, the current status of those systems are unknown. Brian unsure of the potable water sources of the residents on Pagan. Brian suggested asking Jose Kaipat with DEQ as he grew up on Pagan.
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5. Until documentation/ruling from USEPA is released formalizing the findings of the GWUDI Study, CUC will not release the document in case USEPA requests additional edits.
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Personal Communication Form

Project Name: CJMT EIS/OEIS

Date: 6/6/14

Subject: Additional Information Request

Type of Communication (fax, email): Email

Interviewee Information (or submit an attendance record – Appendix C)

Name: Brian Bearden

Title: Senior Engineer

Employer: CUC/US Public Health Service

Address: PO Box 501220, Saipan, MP 96950

Phone: (670) 235-7025 to 7030, ext. 325 **Fax:**

Email: brian.bearden@cucgov.org

Summary:

1. The Water and Wastewater Master Plan is still in draft form and is pending comments from USEPA. There are no plans for release of the document for at least 6 months or more.
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Appendix B
Demand Estimates and Calculations

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Tinian Base Camp - Domestic Water Demand Requirements

	Design Population	Daily Domestic Consumption Rate [gpcd][1]	Average Day Demand [gpd]	UFW Rate[2]	UFW [gpd]	Total Average Daily Demand [gpd]	Max Day Demand Variation Coefficient, K[3]	Max Day Demand [gpd]	Max UFW [gpd]	Total Max Daily Demand [gpd]	Max Hourly Flow Coefficient, K[3]	Max Hourly Flow [gpm]
Domestic Demands												
Personnel Housing (Barracks)	1500	50	75,000	15%	11,250	86,250	2.25	168,750	25,320	194,070	4.0	208.33
Training Personnel (Surges Temporary Tents)	1500	50	75,000	15%	11,250	86,250	2.25	168,750	25,320	194,070	4.0	208.33
Civilian Workers (Non-resident)	95	30	2,850	15%	428	3,278	2.25	6,413	970	7,383	4.0	7.92
Total Demands	***3,095***		***152,850***		***22,928***	***175,778***		***343,913***	***51,610***	***395,523***		***424.58***

[1]Per UFC 3-230-03, dated 1 November 2012, Table 3-1

[2]Assumed acceptable UFW rate for a new potable water system at 15%.

[3]Per UFC 3-230-03, dated 1 November 2012, Table 3-2

Tinian Base Camp, MSA and Airport Facilities - Industrial Demands, including UFW

Building Name	Area [sq. ft]	Industrial Demand [1,2] [gpd]	Unaccounted for Water - Industrial [3] [gpd]	Total Industrial Demand [gpd]	Industrial Demand [1,2] [lpd]	Unaccounted for Water - Industrial [3] [lpd]	Total Industrial Demand [lpd]
Base Camp Training Operations							
Battalion/Squadron Headquarters	15,120	1,512	227	1,739	5,724	859	6,582
Academic Instruction Building	4,375	438	66	503	1,656	248	1,905
Auto Organizational Shop	19,553	1,955	293	2,249	7,402	1,110	8,512
Range Administration and Range Control Center	7,590	759	114	873	2,873	431	3,304
Range Maintenance Building	4,760	476	71	547	1,802	270	2,072
Armory	12,752	1,275	191	1,466	4,827	724	5,551
Base Camp Operations							
Administrative Office	3,250	325	49	374	1,230	185	1,415
Public Works Shop	8,700	870	131	1,001	3,293	494	3,787
General Purpose Warehouse	18,000	1,800	270	2,070	6,814	1,022	7,836
Automotive Vehicle Maintenance Shop	6,140	614	92	706	2,324	349	2,673
Vehicle Wash Platform	4	8,000	1,200	9,200	30,283	4,542	34,826
Grease Rack	2	4,000	600	4,600	15,142	2,271	17,413
Operational Hazardous/Flammable Storage	600	60	9	69	227	34	261
Gate/Sentry House	732	73	11	84	277	42	319
Fire Station	7,320	732	110	842	2,771	416	3,187
Security Building	1,500	150	23	173	568	85	653
Recycling Center	4,525	453	68	520	1,713	257	1,970
Hazardous Waste Storage and Transfer Facility	500	50	8	58	189	28	218
Garbage Room	3,200	320	48	368	1,211	182	1,393
Ready Service Locker	96	10	1	11	36	5	42
Base Camp Support Facilities							
Recruit Type Barracks	210,000	21,000	3,150	24,150	79,494	11,924	91,418
Transient Quarters	31,500	3,150	473	3,623	11,924	1,789	13,713
Garrison Aid Station	2,880	288	43	331	1,090	164	1,254
Austere Dining Facility	22,980	2,298	345	2,643	8,699	1,305	10,004
Cold Storage Warehouse	4,900	490	74	564	1,855	278	2,133
Recreation Center	6,600	660	99	759	2,498	375	2,873
Base Camp Total		51,757	7,764	59,521	195,923	29,388	225,311
MSA Facilities							
Munitions Assembly Shop, Air Operations	5,550	555	83	638	2,101	315	2,416
Munitions Operations	2,400	240	36	276	908	136	1,045
Munitions Assembly Shop	5,550	555	83	638	2,101	315	2,416
Biosecurity Facility	27,500	2,750	413	3,163	10,410	1,561	11,971
MSA Total		4,100	615	4,715	15,520	2,328	17,848
Airport Facilities (Future, Not part of proposed action)							
Two Type II Hangar Bay (assume 4,000 sf office)	4,000	400	60	460	1,514	227	1,741
A/DACG Facility (assume 4,000 sf office)	4,000	400	60	460	1,514	227	1,741
Air Traffic Control Tower (assume 500 sf work area)	500	50	8	58	189	28	218
Airport Total		850	128	978	3,218	483	3,700
TOTAL (Proposed Action)		55,857	8,379	64,236	211,443	31,716	243,159
TOTAL (Cumulative)		56,707	8,506	65,213	214,660	32,199	246,860

Notes

1. Assume A/C usage at 600 sf bldg area/ton. Maximum water demand for A/C is 0.10 gpm/ton (per UFC)

2. For Vehicle Wash Racks, use 2,000 gpd per platform as used in Guam Phase II Roadmap Planning, assume 4 platforms at Base Camp

3. Assumed acceptable UFW rate for a new potable water system at 15%.

Tinian U.S. Military Potable Water Needs
Total Average and Maximum Daily Demand

	Average [gpd]	Maximum [gpd]
Tinian Base Camp and MSA Facilities		
Average Domestic Daily Demand	152,850	343,913
UFW-Domestic	22,928	51,610
Industrial Daily Demand	55,857	55,857
UFW-Industrial	8,379	8,379
Total Daily Demand for a New Water System	*240,013*	*459,758*
Tinian International Airport Improvements [1]		
Average Domestic Daily Demand [2]	-	-
UFW-Domestic [2]	-	-
Industrial Daily Demand	850	850
UFW-Industrial	128	128
Total Additional Daily Demand for a New Water System	*978*	*978*
TOTAL U.S. MILITARY POTABLE WATER NEEDS FOR NEW SYSTEM	**240,991**	**460,736**

Notes:

1. Tinian International Airport Improvements (end-state) are not part of the proposed action.

2. Domestic water demand for the Tinian Airport Improvements are accounted for in the base camp and MSA water demand estimate.

US Military Total Maximum Daily Demand (Proposed Action) [gpd]	Future Additional Maximum Daily Demand [gpd]	Pump Rate (gpm)		Production per day (gpd)		Number of Wells Required		Maximum Daily Production (gpd)	Additional Capcacity beyond Proposed Action Demand (gpd)
		Low	High	Low	High	High	Low		
459,758	978	60	120	86,400	172,800	6	3	518,400	58,642

Fire Protection Demand - Assuming Sprinklered Facilities

Occupancy Classification	Ceiling Height*	Design Density [gpm/ft2]	Design Area [ft2]	Sprinkler Design Demand [gpm]	Safety Factor	Hose Stream Allowance [gpm]	Fire Demand [gpm]	Duration [min]	Volume [gal]
HC-1	Up to 30 ft	0.1	1,500	150	2.0	250	550	60	***33,000***
HC-2	Up to 30 ft	0.2	3,500	700	2.0	250	1,650	60	***99,000***
HC-3	Up to 30 ft	0.3	3,500	1,050	2.0	500	2,600	90	***234,000***

Reference Tables from FM Global Engineering Bulletin 04-12, Data Sheet 3-26, March 2, 2012:

Table 2. Sprinkler Design Demands for Hazard Categories

Hazard Category	*Sprinkler Design Demand (gpm/ft²)/ft² (mm/min)/m²*					
	Ceilings up to 30 ft (9 m)		Ceilings from 30 to 60 ft (9 to 18 m)		Ceilings from 60 to 100 ft (18 to 30 m)	
	Wet	Dry	Wet	Dry	Wet	Dry
HC-1	0.1/1500 (4/140)	0.1/1500 (4/140)	0.2/2500 (8/230)	0.2/3500 (8/330)	See Table 2a	Not an option
HC-2	*0.2/2500 (8/230)	0.2/3500 (8/330)	0.2/2500 (8/230)	0.2/3500 (8/330)	See Table 2a	Not an option
HC-3	*0.3/2500 (12/230)	0.3/3500 (12/330)	0.5/3000 (20/280)	0.5/4000 (20/370)	See Table 2a	Not an option

* For HC-2 and HC-3 occupancies with ceilings up to 30 ft (9 m), reduce sprinkler design demand to 0.3/1500 (gpm/ft²)/ft² (12/140) (mm/min)/m² for wet-pipe systems when using K11.2EC (K160EC) upright sprinkler with temperature ratings of 160°F (70°C).

* For HC-2 & HC-3 occupancies with ceilings up to 30 ft (9 m), reduce sprinkler design demand to 0.3/1000 (gpm/ft²)/ft² (12/90) (mm/min)/m² for wet-pipe systems when using K14.0EC (K200EC) upright sprinkler with temperature ratings of 160°F (70°C).

* Although the sprinkler system protection guidelines use density over demand area as a design format, when using extended coverage sprinkler in facilities with ceilings up to 30 ft (9 m) high ensure the number of sprinklers does not drop below a minimum of 6 sprinklers for K11.2EC (K160EC) and 4 sprinklers for K14.0EC (K200EC).

Table 3. Hose Demand and Duration

Hazard Category	*Hose Demand, gpm (L/min)*		*Duration, min*
	Ceilings Under 60 ft (18 m)	Ceilings Over 60 ft (18 m)	
HC-1	250 (950)	500 (1900)	60
HC-2	250 (950)	500 (1900)	60
HC-3	500 (1900)	500 (1900)	90

Fire Protection Demand - Assuming Unsprinklered Facilities

Building	Occupancy Classification	Response Time	Type of Construction	Number of Stories	Separation Distances	Building Floor Area	Fire Fighting Access	Total Weighted Value	Fire Flow [gpm]	Duration [min]	Volume [gal]
Base Auto Shop	Ordinary Group 2	On-Site (within 1 mile)	V	Single	60 ft or more	6,140 SF	180 to 230 ft	11	2,250	120	***270,000***

Reference Table from UFC 3-600-01 Fire Protection Engineering, dated 1 March 2013:

Table C-1 Water Demands for Unsprinklered Facilities

TOTAL WEIGHTED VALUE						
Occupancy Hazard Classification	Fire Flows (gpm (L/m) at 20 psi (137 kPa) residual pressure)			Duration (minutes)		
	6-10	11-15	16+	6-10	11-15	16+
Light	750 (2840)	1125 (4260)	1500 (5680)	60	90	120
Ordinary Group 1	1000 (3785)	1500 (5680)	2000 (7570)	90	120	150
Ordinary Group 2	1500 (5680)	2250 (8520)	3000 (11,360)	90	120	150
Extra	2500 (9465)	3750 (14,195)	5000 (18,930)	150	195	240

Tinian Base Camp - Water Storage Requirements, Proposed Action [gallons]						
Per UFC 3-230-01, Section 3-2:						
Minimum Storage Requirement	=	50% of Average Daily Domestic	+	Industrial Demand	+	Required Fire Demand
Minimum Storage Requirement	=	87,889		64,236		270,000
Minimum Storage Requirement	=	422,125				
Minimum Storage Requirement (Rounded)	=	430,000				
Minimum Storage Requirement (Recommended)	**=**	***500,000***				

Tinian Base Camp - Water Storage Requirements, Cumulative [gallons]						
Per UFC 3-230-01, Section 3-2:						
Minimum Storage Requirement	=	50% of Average Daily Domestic	+	Industrial Demand	+	Required Fire Demand
Minimum Storage Requirement	=	87,889		65,213		270,000
Minimum Storage Requirement	=	423,102				
Minimum Storage Requirement (Rounded)	=	430,000				
Minimum Storage Requirement (Recommended)	**=**	***500,000***				

Tinian Port Facilities - Domestic Water Demand Requirements

	Design Population	Daily Domestic Consumption Rate [gpcd][1]	Average Day Demand [gpd]	UFW Rate[2]	UFW [gpd]	Total Average Daily Demand [gpd]	Max Day Demand Variation Coefficient, K[3]	Max Day Demand [gpd]	Max UFW [gpd]	Total Max Daily Demand [gpd]	Max Hourly Flow Coefficient, K[3]	Max Hourly Flow [gpm]
Domestic Demands												
Civilian Workers (Non-resident)	6	30	180	75%	135	315	2.25	405	310	715	4.0	0.50
Total Demands	***6***		***180***		***135***	***315***		***405***	***310***	***715***		***0.50***

[1] Per UFC 3-230-03, dated 1 November 2012, Table 3-1
[2] Assumed UFW rate for the existing CUC potable water system at 75%.
[3] Per UFC 3-230-03, dated 1 November 2012, Table 3-2

Tinian Port Facilities - Industrial Demands, including UFW

Building Name		Area [sq. m]	Area [sq. ft]	A/C Factor [gpd/sf]	Industrial Demand [1,2] [gpd]	UFW Rate[3]	Unaccounted for Water - Industrial [gpd]	Total Industrial Demand [gpd]
Port Facilities								
Biosecurity Building			4950		495	75%	371	866
Vehicle Wash Platform				2000	12,000	75%	9,000	21,000
TOTAL (Proposed Action)					**12,495**		**9,371**	**21,866**

Notes

1. Assume A/C usage at 600 sf bldg area/ton. Maximum water demand for A/C is 0.10 gpm/ton (per UFC)

2. For Vehicle Wash Racks, use 2,000 gpd per platform as used in Guam Phase II Roadmap Planning, assume 6 platforms at Port.

3. Assumed UFW rate for the existing CUC potable water system at 75%.

Tinian U.S. Military Potable Water Needs
Total Average and Maximum Daily Demand

	Average [gpd]	Maximum [gpd]
Tinian Port Facilities		
Average Domestic Daily Demand	180	405
UFW-Domestic	135	310
Average Industrial Daily Demand	12,495	12,495
UFW-Industrial	9,371	9,371
Total Daily Demand for Existing CUC System Water System	22,181	22,581
TOTAL U.S. MILITARY POTABLE WATER NEEDS FOR EXISTING CUC SYSTEM	**22,181**	**22,581**

Notes:

1. Tinian International Airport Improvements (end-state) are not part of the proposed action.

2. Domestic water demand for the Tinian Airport Improvements are accounted for in the base camp and MSA water demand estimate.

	Design Population	*Daily Domestic Consumption Rate [gpcd]* [1]	*Average Day Demand [gpd]*	*UFW Rate* [2]	*UFW [gpd]*	*Total Average Daily Demand [gpd]*	*Max Day Demand Variation Coefficient, K* [3]	*Max Day Demand [gpd]*	*Max UFW [gpd]*	*Total Max Daily Demand [gpd]*
Operations Personnel (Off-island)	87	125	10,875	75%	8,156	19,031	2.25	24,469	18,352	42,820
Operations Personnel Dependents	155	125	19,375	75%	14,531	33,906	2.25	43,594	32,695	76,289
Total	**242**		**30,250**		**22,688**	**52,938**		**68,063**	**51,047**	**119,109**

[1]Per UFC 3-230-03, dated 1 November 2012, Table 3-1

[2]Assumed existing CUC UFW rate at 75%.

[3]Per UFC 3-230-03, dated 1 November 2012, Table 3-2

*Population numbers from David Kiernan, email dated 6/5/14 - updated numbers from V1 socioeconomic study, expected to be published in V2 socioeconomic study.

	Design Population	Daily Domestic Consumption Rate [gpcd] [1]	Average Day Demand [gpd]	UFW Rate [2]	UFW [gpd]	Total Average Daily Demand [gpd]	Max Day Demand Variation Coefficient, K [3]	Max Day Demand [gpd]	UFW Rate [2]	Max UFW [gpd]	Total Max Daily Demand [gpd]
Construction Workers	548	50	27,400	75%	20,550	47,950	2.25	61,650	75%	46,238	107,888
Total	**548**	**--**	**27,400**	--	**20,550**	**47,950**	--	**61,650**	--	**46,238**	**107,888**
Construction Managers	23	125	2,875	75%	2,156	5,031	2.25	6,469	75%	4,852	11,320
Construction Manager Dependents	26	125	3,250	75%	2,438	5,688	2.25	7,313	75%	5,484	12,797
Total	**49**	**--**	**6,125**	--	**4,594**	**10,719**	--	**13,781**	--	**10,336**	**24,117**
Total	**597**		**33,525**	--	**25,144**	**58,669**	--	**75,431**	--	**56,573**	**132,005**

[1]Per UFC 3-230-03, dated 1 November 2012, Table 3-1

[2]Assumed existing CUC UFW rate at 75%.

[3]Per UFC 3-230-03, dated 1 November 2012, Table 3-2

*Population numbers from David Kiernan, email dated 6/5/14 - updated numbers from V1 socioeconomic study, expected to be published in V2 socioeconomic study.

Tinian Civilian Demand	***Design Population*** [1]	***Daily Domestic Consumption Rate [gpcd]*** [2]	***Average Day Demand [gpd]***	***UFW Rate*** [3]	***UFW [gpd]***	***Total Average Daily Demand [gpd]***	***Max Day Demand Variation Coefficient, K*** [4]	***Max Day Demand [gpd]***	***UFW Rate*** [2]	***Max UFW [gpd]***	***Total Max Daily Demand [gpd]***
Tinian Resident	396	125	49,500	75%	37,125	86,625	2.25	111,375	75%	83,531	194,906
Average Day Visitors	184	110	20,198	75%	15,148	35,346	2.25	45,444	75%	34,083	79,528
Total	**580**	**--**	**69,698**	--	**52,273**	**121,971**	--	**156,819**	--	**117,615**	**274,434**

[1]From Socioeconomic Study, V2 dated 06-20-2014

[2]Per UFC 3-230-03, dated 1 November 2012, Table 3-1

[3]Assumed existing CUC UFW rate at 75%.

[4]Per UFC 3-230-03, dated 1 November 2012, Table 3-2

Tinian Indirect Potable Water Needs
Total Average and Maximum Daily Demand

	Average [gpd]	Maximum [gpd]	Average [lpd]	Maximum [lpd]
Port Facilities				
Domestic Daily Demand	180	405	681	1,533
UFW-Domestic	135	310	511	1,173
Industrial Daily Demand	12,495	12,495	47,299	47,299
UFW-Industrial	9,371	9,371	35,474	35,474
Total Daily Demand	**22,181**	**22,581**	83,965	85,479
Operation Personnel Housing				
Average Domestic Daily Demand	30,250	68,063	114,509	257,645
UFW-Domestic	22,688	51,047	85,882	193,233
Total Daily Demand	**52,938**	**119,109**	200,390	450,878
Civilian and Tourist Increase				
Average Domestic Daily Demand	69,698	156,819	263,834	593,626
UFW-Domestic	52,273	117,615	197,875	445,220
Total Daily Demand	**121,971**	**274,434**	461,709	1,038,846
Construction Workforce Housing (Temporary)				
Average Domestic Daily Demand	27,400	61,650	103,720	233,371
UFW-Domestic	20,550	46,238	77,790	175,028
Total Daily Demand	**47,950**	**107,888**	181,511	408,399
Construction Manager Housing (Temporary)				
Average Domestic Daily Demand	6,125	13,781	23,186	52,168
UFW-Domestic	4,594	10,336	17,389	39,126
Total Daily Demand	**10,719**	**24,117**	40,575	91,293
Total Daily Demand Increase on CUC System (Permanent)	**197,089**	**416,125**	746,065	1,575,204
Total Daily Demand Increase on CUC System (Temporary)	**58,669**	**132,005**	222,085	499,692

Domestic Potable Water Uses - PAGAN BIVOUAC AREA

Use Category		Gal/person/day	Liter/person/day
Drinking		3.30	12.49
Personal Hygiene	Brushing Teeth 3 Times/Day	0.22	0.83
	Shaving	0.23	0.87
	Washing Hands 6 Times/Day	0.83	3.14
	Sponge Bath 5 Times/Week	0.40	1.51
Food Preparation	Individual Meal (MRE)	0.43	1.63
Heat Injury Treatment		0.01	0.04
Role I and II Medical Treatment		0.03	0.11
Potable Water Total		**5.45**	**20.63**

Reference: Water Planning Guide, Potable Water Consumption Planning Factors, by Environmental Region and Command Level, 25 November 2008.

Notes:

1. Food preparation assumes a minimum operation based on a ration cycle of three MREs per day.
2. Heat injury treatment factor represents the maximum amount of chilled water required for expected daily heat stroke casulties.
3. Role I and II medical treatment include water for cleaning patients, washing instruments and washing hands of direct patient care providers.
4. All factors include a 10% loss factor, comprised of 4% evaporation and 6% waste/spillage.

Pagan Bivouac Area - Domestic Water Demand Requirements

	Design Population	Daily Domestic Consumption Rate [gpcd][1]	Average Domestic Daily Demand [gpd]	UFW Rate[2]	UFW [gpd]	Total Average Daily Demand [gpd]	Max Day Demand Variation Coefficient, K[3]	Max Day Demand [gpd]	Max UFW [gpd]	Total Max Daily Demand [gpd]	Max Hourly Flow Coefficient, K[3]	Max Hourly Flow [gpm]
Domestic Demands												
Training Personnel (Normal Average)	3000	5.45	16,350	-	-	16,350	2.25	36,788	-	36,788	4.0	45.42
Training Personnel (Surges)	1000	5.45	5,450	-	-	5,450	2.25	12,263	-	12,263	4.0	15.14
Total Demands	***4,000***		***21,800***		***-***	***21,800***		***49,050***	***-***	***49,050***		***60.56***

[1]Per UFC 3-230-03, dated 1 November 2012, Table 3-1
[2]Water Loss accounted in daily domestic consumption rate.
[3]Per UFC 3-230-03, dated 1 November 2012, Table 3-2

Appendix C
Commonwealth Utilities Corporation Potable Water System Data

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CUC - TINIAN
CUSTOMER ACCOUNTS
As of November, 2013

POWER:

RESIDENTIAL	
Meter-	571
Prepaid-	136
Flat Rate-	6
Total:	713

COMMERCIAL	
Meter-	95
Total:	95

GOVERNMENT	
Meter-	95
Flat Rate-	2
Total:	97

WATER:

RESIDENTIAL	
Meter-	726
Total:	726

COMMERCIAL	
Meter-	62
Total:	62

GOVERNMENT	
Meter-	45
Total:	45

Total Power Accounts:	905
Total Water Accounts:	833

2011 WATER PRODUCTION REPORT
CUC, TINIAN

DATE:	TOTAL PRODUCTION:
January	31,566,000
February	28,113,900
March	28,183,300
April	26,803,200
May	28,226,800
June	27,625,000
July	25,568,100
August	24,230,500
September	24,549,900
October	25,211,800
November	23,642,100
December	29,457,000
TOTAL PRODUCTION FOR 2011:	323,117,600

2012 WATER PRODUCTION REPORT
CUC, TINIAN

DATE:	TOTAL PRODUCTION:
January	30,017,900
February	30,479,600
March	30,880,900
April	32,894,600
May	32,120,500
June	29,900,700
July	29,014,600
August	31,789,600
September	31,468,400
October	28,194,600
November	30,654,600
December	31,120,600
TOTAL PRODUCTION FOR 2012:	368,536,600

2013 WATER PRODUCTION REPORT
CUC, TINIAN

DATE:	TOTAL PRODUCTION:
January	32,120,500
February	30,017,900
March	29,196,300
April	33,892,800
May	36,012,800
June	34,685,600
July	34,315,700
August	39,003,100
September	37,319,300
October	39,003,000
November	
December	
TOTAL PRODUCTION FOR 2013:	345,567,000

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Appendix D
Additional Unified Facilities Criteria Distribution System Requirements

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ADDITIONAL UNIFIED FACILITIES CRITERIA DISTRIBUTION SYSTEM REQUIREMENTS

Unified Facilities Criteria (UFC) 3-230-01, *Water Storage, Distribution, and Transmission* (Department of Defense 2012):

- Design criteria should be in accordance with the following precedence:
  - State waterworks regulations
  - Utility provider's requirements
  - *Recommended Standards for Water Works*, latest edition
  - Conservation alternatives to meet current Department of Defense conservation policies
- Minimum storage volume required is the sum of 50% of the average daily domestic requirements, plus any industrial demand that cannot be reduced during the fire period and the required fire demand.
- Distribution mains should be sized based on maximum hourly demand or the maximum daily demand plus the fire flow requirement, whichever is greater.
- A pipe network should be provided where flow to a single course is available from two or more directions.
- Demand projections should be based on anticipated demand not less than 5 years in the future.
- The Best Practice documents American Water Works Association Manual M32, *Distribution Network Analysis for Water Utilities*, and Manual M31, *Distribution System Requirements for Fire Protection*, can be consulted for additional guidance.
- Velocities should range from 25 feet (ft) (0.61.5 meters [m]) per second at maximum daily demand and the largest fire-flow requirement.
- Minimum ground-level residual pressures at fire hydrants must be at least 40 pounds per square inch (psi) during normal flow conditions, 30 psi during hourly maximum demand, and 20 psi while supplying fire-flow and hose-stream demand.
- Areas of excessively high or low pressures require that the system be divided into multiple pressure levels.
- Minimum pipe cover must be 2.5 ft (0.8 m).
- When distribution is pumped from storage, transmission mains must have capacities equal to maximum-day demand plus industrial demand and fire-flow requirements.
- Without storage, transmission mains must meet maximum hourly demand.
- Shutoff valve spacing should not exceed 5,000 ft (1,524 m) on long lines and 15,000 ft (4,572 m) on loops.
- Velocities should not exceed 5 ft (1.5 m) per second in transmission mains.

UFC 3-230-03, *Water Treatment* (Department of Defense 2012):

- Domestic uses include drinking water, household uses, and household lawn irrigation.
    - Industrial flows include cooling, issues to ships, irrigation, swimming pools, shops, laundries, dining, processing, flushing, air conditioning, wash racks, rinse racks, and boiler makeup.

UFC 3-600-01, *Fire Protection Engineering for Facilities* (Department of Defense 2013):

- Additional distribution system requirements:
    - Must be sized to accommodate fire flows plus domestic and industrial for flushing demands that cannot be restricted during fires.
    - Must be looped to provide at least 50% of the required fire flow in case of a single break.
    - Must be able to support 150% of the building fire pump–rated capacity with a minimum pressure of 20 psi at the suction side of the pump.
- Hydrant installation requirements:
    - Must be installed adjacent to paved areas, accessible to fire department apparatus.
    - Must not be closer than 3 ft (0.9 m) or farther than 7 ft (2.1 m) from the roadway, shoulder, or curb line.
    - Must be installed with a minimum 6-inch (15-centimeter) connection to the supply main and valved at the connection.
    - Must be in accordance with National Fire Protection Association 24, except as modified by the UFC.
- Hydrant spacing requirements:
    - All parts of the building must be within 350 ft (107 m) of a hydrant.
    - At least one hydrant must be located within 150 ft (46 m) of the fire department connection.
    - Hydrants protecting warehouses must be spaced a maximum of 300 ft (91 m) apart.
    - Hydrants protecting aircraft hangars must be spaced a maximum of 300 ft (91 m) apart with at least one hydrant at each corner of the hangar.
    - Hydrants protecting petroleum oil lubricants storage and distribution facilities must be spaced a maximum of 300 ft (91 m) apart, with a minimum of two hydrants.
    - Hydrants protecting exterior storage must be spaced at 300-ft (91-m) maximum intervals around the perimeter.
    - Hydrant spacing must not exceed 600 ft (183 m) for family housing developments without sprinkler protection and must not exceed 1,000 ft (305 m) for family housing developments with sprinkler protection.