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STORMWATER STUDY
IN SUPPORT OF THE
COMMONWEALTH OF THE NORTHERN MARIANA ISLANDS JOINT MILITARY TRAINING ENVIRONMENTAL IMPACT STATEMENT

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June 2026

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1 INTRODUCTION

1.1 PURPOSE

The purpose of this study is to provide planning-level concepts for stormwater management in support of the Commonwealth of the Northern Mariana Islands (CNMI) Joint Military Training (CJMT) Environmental Impact Statement. This comprehensive assessment encompasses existing site hydrology and hydraulics and potential impacts of the Proposed Action. Cut and fill required for construction activities would be balanced on each site, eliminating the need for import or export of soil. Mitigation includes Low Impact Development (LID) integrated management practices to manage stormwater. This analysis is based on applicable United States (U.S.) and local regulations governing the collection, conveyance, storage, treatment, infiltration, and/or disposal of stormwater.

The following design storms are analyzed in this study:

- 1-year recurrence interval, 24-hour storm event
- 25-year recurrence interval, 24-hour storm event
- 24-hour detention time, including sediment storage volume
- 95th percentile storm event

2 REGULATORY FRAMEWORK

This chapter provides a brief overview of the pertinent regulations that apply to the Proposed Action and discusses how each is used in the stormwater study.

2.1 ENERGY INDEPENDENCE AND SECURITY ACT OF 2007 SECTION 438

The Energy Independence and Security Act of 2007 requires “the sponsor of any development or redevelopment project involving a Federal facility with a footprint that exceeds 5,000 square feet shall use site planning, design, construction, and maintenance strategies for the property to maintain or restore, to the maximum extent technically feasible, the predevelopment hydrology of the property with regard to the temperature, rate, volume, and duration of flow.” This statutory requirement promotes the use of sustainable stormwater management strategies—such as green infrastructure and Low Impact Development to reduce runoff impacts from federal projects.

Section 438 was previously supported and reinforced by Executive Order 13693, *Planning for Federal Sustainability in the Next Decade* (signed in 2015). However, Executive Order 13693 was revoked by Executive Order 13834 in 2018. Despite these changes in Executive Orders, the requirements of Section 438 remain in effect as federal law and continue to guide agency compliance related to stormwater management on federal properties.

Technical guidance issued by the United States (U.S.) Environmental Protection Agency for implementing Section 438 remains applicable and is still used by federal agencies to inform project planning and design in accordance with the law

2.2 TECHNICAL GUIDANCE FOR THE ENERGY INDEPENDENCE AND SECURITY ACT SECTION 438 IMPLEMENTATION

This document recommends that projects reduce hydrologic impacts by implementing green infrastructure or Low Impact Development techniques designed to either retain the 95th percentile storm event on-site or maintain pre-development runoff conditions through site-specific hydrologic analysis (U.S. Environmental Protection Agency 2009). The 95th percentile storm event is used as a design criterion, as discussed in Chapter 5.

2.3 DEPARTMENT OF THE NAVY LOW IMPACT DEVELOPMENT POLICY FOR STORMWATER MANAGEMENT

This policy document aligns with federal mandates on Efficient Federal Operations, emphasizing stormwater management through a Low Impact Development approach. The goal is to prevent any net increase in stormwater volume, sediment, or nutrient loading from major renovation and construction projects. To achieve this, the policy mandates that Low Impact Development be incorporated into the design of all projects with a stormwater management component (Department of Defense [DoD] Unified Facilities Criteria 3-210-10, 2023).

This requirement is also based on the Department of the Navy’s 2007 Low Impact Development Policy for Stormwater Management, issued by the Assistant Secretary of the Navy (Installations and Environment), which mandates no net increase in stormwater volume, sediment, or nutrient loading from construction and major renovation activities

This policy provides guidance for reviewing and selecting Low Impact Development strategies for proposed stormwater management systems, ensuring compliance with the Energy Independence and Security Act Section 438 and Executive Order on Efficient Federal Operations. Further details are included in Chapter 6.

2.4 DEPARTMENT OF DEFENSE IMPLEMENTATION OF STORM WATER REQUIREMENTS UNDER THE ENERGY INDEPENDENCE AND SECURITY ACT SECTION 438

This DoD requirement is the overall design objective for each project and should maintain pre-development hydrology and prevent any net increase in stormwater runoff. The design requirement further states if this design objective cannot be met within the project footprint, Low Impact Development measures may be applied at nearby locations on DoD land. (DoD 2023). This policy further supports the evaluation of Low Impact Development, as described in Chapter 6.

2.5 UNIFIED FACILITIES CRITERIA 3-201-01, CIVIL ENGINEERING

This document provides requirements for all aspects of civil site development for proposed U.S. military facilities, including grading and drainage (DoD 2022).

2.6 UNIFIED FACILITIES CRITERIA 3-210-10, LOW IMPACT DEVELOPMENT

This document provides guidelines for planning, designing, constructing, and maintaining Low Impact Development strategies for stormwater management. The manual presents basic guidance for Low Impact Development design with an overview of the associated operation, cost, and maintenance considerations (DoD 2023).

2.7 NATIONAL POLLUTANT DISCHARGE ELIMINATION SYSTEM PERMIT ADMINISTRATION

The U.S. Environmental Protection Agency (EPA) Region 9 retains primary responsibility for administering and enforcing the National Pollutant Discharge Elimination System (NPDES) permit program in the CNMI. While CNMI agencies may assist in permit compliance activities, the EPA is the permitting authority and has ultimate oversight over all NPDES permitting and enforcement actions in the territory.

2.8 CNMI AND GUAM STORMWATER MANAGEMENT MANUAL

The *CNMI and Guam Stormwater Management Manual* (Horsley Witten Group, Inc. 2006) provides additional stormwater guidance and standards. Applicable standards for CJMT include:

- **Standard 1.** Site designers shall strive to reduce the generation of stormwater runoff and use pervious areas for stormwater treatment. For development sites over 1 acre, impervious cover shall not exceed 70 percent of the total site area. Impervious areas are hard surfaces that prevent water from infiltrating into the ground and include paved and coral surfaces such as roads, driveways, parking lots, and yards, as well as rooftops.

- **Standard 2.** Stormwater management shall be provided through a combination of structural and non-structural practices.
- **Standard 3.** All stormwater runoff generated from new development shall be adequately treated prior to discharging into jurisdictional wetlands or inland and coastal waters of CNMI and Guam.
- **Standard 4.** Pre-development annual groundwater recharge rates and runoff rates to coastal waters shall be maintained by promoting infiltration using structural and non-structural methods.
- **Standard 5.** New development shall use structural best management practices designed to remove 80 percent of the average annual post-development total suspended solids load and match or exceed pre-development infiltration rates, as possible. It is presumed a best management practice complies with the standard if it is:
    - Sized to capture the prescribed water quality volume.
    - Designed to match or exceed pre-development infiltration rates.
    - Designed according to the specific performance criteria outlined in the *CNMI and Guam Stormwater Management Manual* (Horsley Witten Group, Inc. 2006).
    - Constructed properly.
    - Maintained regularly.
- **Standard 6.** The post-development peak discharge rate frequency shall not exceed the pre-development peak discharge rate for the 25-year frequency storm event.
- **Standard 7.** To protect stream channels from degradation, channel protection shall be provided by means of 24 hours of extended detention storage for the 1-year frequency storm event.
- **Standard 8.** Stormwater discharges to critical areas with sensitive resources (i.e., coral reefs, swimming beaches, wellhead protection areas, designated sensitive ecosystems) would be subject to additional performance criteria, and would need the use or restriction of certain best management practices.
- **Standard 9.** All best management practices shall have an enforceable operation and maintenance agreement to ensure the system functions as designed. In addition, every best management practice shall have an acceptable form of water quality pretreatment.
- **Standard 10.** Redevelopment projects are governed by special stormwater sizing criteria depending on the amount of increase or decrease in impervious area created by the redevelopment. Redevelopment projects that reduce impervious cover (from existing conditions) by at least 40 percent are deemed to meet both the recharge and water quality requirements (Standards 4 and 5, above). Where site conditions prevent the reduction in impervious cover, stormwater management practices shall be implemented to provide stormwater controls for at least 40 percent of the site's impervious area. When a combination of impervious area reduction and stormwater management practice implementation is used for redevelopment projects, the combination of impervious area reduction and the area controlled by a stormwater management practice shall equal or exceed 40 percent.

- **Standard 11.** For sites meeting the definition of an "infill development project," the stormwater management requirements would be the same as for other new development projects with the important distinctions that the applicant can meet those requirements either on-site or at an approved off-site location and that the 70 percent impervious cover requirement may be waived. An approved off-site location must be identified in accordance with CNMI/Guam review. The applicant must also demonstrate that no downstream drainage or flooding impacts would occur as a result of not providing on-site management. The intent of this provision is to allow flexibility to meet the goals of improved water quality and channel protection to receiving waters while still promoting infill development.
- **Standard 12.** Certain industrial sites are required to prepare and implement a stormwater pollution prevention plan. All sites with disturbance over 1 acre are required to prepare and implement a stormwater pollution prevention plan in accordance with the National Pollutant Discharge Elimination System Phase II Stormwater Program.
- **Standard 13.** Stormwater discharges from land uses or activities with higher potential pollutant loadings, defined as hotspots, are required to use specific structural best management practices and pollution prevention practices. In addition, stormwater from a hotspot land use may not be recharged to groundwater without pretreatment of 100 percent of the water quality volume or the recharge volume, whichever is greater.

2.9 RANGE ENVIRONMENTAL VULNERABILITY ASSESSMENT

The Range Environmental Vulnerability Assessment program is a proactive and comprehensive initiative that serves as a baseline assessment of operational ranges across U.S. Marine Corps installations. The Range Environmental Vulnerability Assessment program operates outside of regulatory requirements, aiming to proactively address potential environmental concerns and to promote sustainable range practices. This aligns with the DoD Instruction 4715.14, *Operational Range Assessments*, which outlines key requirements for responsible range management.

3 EXISTING CONDITIONS

3.1 TOPOGRAPHY

Tinian consists of a series of limestone plateaus separated by steep slopes and cliffs. The major plateaus are generally level. Tinian consists of four major surface geologic units (physiographic regions) (Gingerich 2002) (Figure 1):

- **Tinian Pyroclastic (Volcanic) Rock.** These fine-grained to coarse-grained ash and angular fragments represent explosive materials ejected from an ancient volcano that forms the core of the island. These rocks are exposed on the North-central Highland and Southeastern Ridge and cover approximately 2 percent of the surface of the island. These materials generally appear to be highly weathered and altered in surface exposures. This rock unit has low permeability due to its texture and density.
- **Tagpochau Limestone.** These highly weathered rocks are exposed on about 15 percent of the island’s surface and are generally located in the North-central Highland and the southern part of the Southeastern Ridge. These rocks reach up to 600 feet in thickness. Surface exposures are composed of fine- to coarse-grained, partially recrystallized broken limestone fragments, and about 5 percent are reworked volcanic fragments and clays. This unit consists of highly permeable and fractured material.
- **Mariana Limestone.** These rocks cover approximately 80 percent of the island’s surface forming nearly all of the North Lowlands, the Central Plateau, and the Marpo Valley. These rocks reach up to 450 feet in thickness and 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. The Mariana Limestone has a higher coral content than the Tagpochau Limestone; however, is also highly permeable.
- **Beach Deposits, Alluvium, and Colluvium.** These deposits cover less than 1 percent of the island’s surface and reach up to 15 feet in thickness. The deposits consist of poorly consolidated sediments, mostly sand and gravel deposited by waves; however, they contain clays and silt deposited inland beside Lake Hagoi and Makpo Marsh as well as loose soil and rock material at the base of slopes.

3.2 EXISTING SLOPE

Much of the relatively flat land across the Military Lease Area was previously used for agriculture and then for military facilities during World War II. Steeper-graded areas are primarily limited to coastal bluffs, native limestone forests, and a few steep areas in and around localized depressions.

Figure 1 Island of Tinian – Physiographic Regions

3.3 SOILS

Soils are divided into four different hydrologic soil groups (Hydrologic Soil Groups A through D) based on a soil's runoff potential and infiltration capabilities. Generally, soils composed of limestone upland soils in relatively flat areas are classified as Hydrologic Soil Group A and infiltrate well, resulting in less runoff. Hydrologic Soil Group B is classified as soils having moderate infiltration rates when thoroughly wetted. Soils that belong to the Hydrologic Soil Group C have a moderate potential for runoff when they are completely wet and include silt loam, sandy clay loam, clay loam, and silty clay loam. Soils composed of basalt are classified as Hydrologic Soil Group D and infiltrate poorly, resulting in greater runoff. Soils in the project area are entirely Hydrologic Soil Group B. The Hydrologic Soil Group regions are shown in Figure 2.

The U.S. Department of Agriculture Soil Conservation Service identified soil classes across Tinian in 1985 (U.S. Department of Agriculture Soil Conservation Service 1989).

3.4 CLIMATE AND HYDROLOGY

Rainfall on Tinian averages 83 inches per year, based on the 50-year rainfall database (Lander and Guard 2003). The wet season, which typically occurs between July and November, receives 65 percent of the annual precipitation, while 16 percent typically occurs during the dry season from January to April (Lander and Guard 2003). The remaining transitional months (November, December, January, May, and June) receive approximately 19 percent of the rainfall (Carruth 2008). Tropical storms comprise a significant percentage of the total annual rainfall. Most of the precipitation on Tinian evaporates, transpires, or percolates into openings in the limestone and volcanic rock beneath the thin soil surface (Gingerich 2002).

The surface hydrology on Tinian includes minimal overland flow, except during intense rainfall events. The drainage is primarily groundwater transport with precipitation percolating quickly into porous rock. As a result, there are no permanent streams or major overland conveyance systems, and no particular drainage problems (Doan et al. 1960).

Figure 2 Island of Tinian – Hydrologic Soil Groups

4 STORMWATER CONSIDERATIONS

This chapter describes the design assumptions including grading, drainage, and Low Impact Development, as well as existing physical conditions, used in evaluating stormwater quantity.

4.1 ASSUMPTIONS

- Comply with Unified Facilities Criteria 03-201-01, *Civil Engineering* (DoD 2022) for minimum and maximum grading slopes.
- Apply Low Impact Development Integrated Management Practices in accordance with Unified Facilities Criteria 3-210-10 (DoD 2023).
- Comply with design-level guidance for grading and drainage systems in accordance with Unified Facilities Criteria 03-201-01 (DoD 2022).
- Use Section 3 of Unified Facilities Criteria 03-201-01, *Civil Engineering* (DoD 2022), for storm drainage system design criteria.
- Convey drainage primarily via overland sheet and channelized flow; avoid the use of culverts and gray infrastructure (pipes and inlets), if feasible.
- Avoid/minimize impacts to depressional areas and karst/fractured surface geology due to the potential for conduits for stormwater flow and contamination of freshwater lens.
- Avoid/minimize impacts to wellhead protection areas and associated buffers.
- Avoid/minimize impacts to ecologically sensitive areas (marine environments, wetlands, and protected habitat) and associated buffers.
- Avoid/reduce impacts to culturally sensitive areas and areas of historical significance.
- Avoid downstream impacts on existing non-DoD areas.
- Avoid/minimize impacts to existing operational facilities and associated utilities, including any communications sites, Francisco Manglona Borja/Tinian International Airport, and other facilities, as applicable.
- Expand the existing stormwater berm on the east, north, and south sides of the main transmitter building to increase runoff containment and peak flow reduction. The scope also includes a new berm along the northern edge of the support facilities area to redirect offsite water flows eastward, away from the warehouse and maintenance facility. Modifications include an increase in crest elevation and possibly additional armoring for erosion protection.
- Expand engineered stormwater berms to prevent external runoff from impacting the project area along the perimeter of key training areas, such as the Multi-Purpose Maneuver Range and Explosives Training Range. These berms would redirect off-site flows away from operational areas, ensuring that runoff modeling focuses solely on project-specific impervious area increases. Additionally, channelized flow systems would be integrated in identified high-concentration drainage pathways to reduce erosion and peak discharge rates.

4.2 DEPRESSIONAL AREAS

Landlocked and/or isolated depressional areas potentially contain direct conduits to the underlying freshwater lens aquifer. As a result of the high soil porosity and karst, fractured surface geology, these depressions are believed to facilitate rapid stormwater infiltration, preventing stormwater from staging up and spilling downstream. The specific history of geologic creation of these depressions is unknown, but they are believed to be manmade. The depressions are treated as closed basins/sinkholes with respect to stormwater, and these depressional areas should be avoided. Preliminary analysis indicates that stormwater would not have any detrimental impact on depressional areas.

4.3 PROTECTED SURFACE WATERS

All new development projects must treat stormwater runoff properly before discharging it into CNMI and Guam waters or wetlands, per Standard 3 (*CNMI and Guam Stormwater Management Manual*). For stormwater management purposes, surface waters in freshwater areas, ephemeral ponds, potential wetlands, or non-delineated wetlands are considered wetlands. Any potential impacts on these areas, such as those caused by grading, drainage, disturbance, or stormwater conveyance elements, should be avoided or minimized. Three potential wetland areas in Hagoi, the Mahalang Complex, and Bateha would fall under this protection. Stormwater runoff would be captured and treated before reaching these wetland habitats of Tinian to avoid any adverse effects.

4.4 FAULT LINES

Fault lines may act as direct conduits for surface water runoff to drain directly to the freshwater lens aquifer. For this reason, fault lines would be buffered and proposed stormwater management facilities would be kept a reasonable distance away. Typically, best management practices for setbacks include 150 feet for stormwater ponds and infiltration devices and 250 feet for permanent, critical facilities.

5 WATER QUANTITY ANALYSIS

To simulate stormwater runoff within the representative sub-basins, the analysis followed the *CNMI and Guam Stormwater Management Manual* (Horsley Witten Group, Inc. 2006) and used HydroCAD Version 10.00-20 stormwater modeling software published by HydroCAD Software Solutions LLC. The HydroCAD model was used to determine peak discharge rates and preliminarily size various types of surface, subsurface, and conveyance best management practices. Using the Natural Resources Conservation Service Technical Release No. 20: Project Formulation – Hydrology procedures, the model provided hydrograph generation and routing for a given rainfall event. Runoff hydrographs were developed from rainfall using the dimensionless unit hydrograph, drainage areas, times of concentration, and Natural Resources Conservation Service runoff curve numbers.

The initial runoff analysis used the third quartile 24-hour storm event based on National Oceanic and Atmospheric Administration Atlas 14 (2011) assuming soil type Hydrologic Soil Group B. Natural Resources Conservation Service curve number values were selected based on soil group and land use category. The soil groups and land uses were categorized for each sub-basin in the project area.

5.1 DIGITAL ELEVATION MODEL DEVELOPMENT

A digital elevation model is a grid of geospatially referenced coordinates used to create three-dimensional representations of the earth's surface. The software ArcGIS version 10.8.1 by Esri, Inc., was used to create a grid with 3.28-foot on-center spacing using the 5-foot contour interval topographic survey (Geodatabase V1).

The following steps were involved in the development of the digital elevation model:

1. Shapefiles for the 5-foot and 50-foot contours were extracted from the geodatabase.
2. An elevation of 0 was not found in either the 5-foot or 50-foot contours. To resolve this issue, a boundary line was used to separate the gap zone where the 50-foot contours were applied. Everywhere else, the 5-foot elevation line was extended by 5 feet and designated an elevation value of 0. This method ensures there is no overlap between the 5-foot and 0-foot values.
3. Once all the lines were cleaned and ready, a triangulated irregular network was created using the 5-foot contours, 50-foot contours (tied in), and boundary line (the new boundary from the 5-foot contour buffer set to 0-foot elevation) as the elevation data. The new boundary line was converted to a polygon and was used as a hard clip.
4. The triangulated irregular network was converted to a digital elevation model and the cell size was set to 1 meter.
5. For the proposed conditional analysis, a modified digital elevation model was generated by integrating a balanced cut-and-fill analysis with the existing conditions digital elevation model. This combined raster represents the proposed post-project topography.

5.2 FLOW PATH DETERMINATION AND SUB-BASIN DELINEATION

Arc Hydro was used to perform ponding analysis, flow path analysis, and sub-basin area delineation. Arc Hydro typically uses a "fill sinks" approach to identify drainage flow paths. In this approach, flow paths are created by analyzing the elevation of each 1-meter-square digital elevation model cell compared to its eight neighboring cells in the grid and the direction established toward the lowest cell. Because of the karst geology and expansive ponding areas, disabling the "fill sinks" feature in Arc Hydro and establishing unobstructed drainage routes for water to collect and flow toward the location was practical. Ponding and flow path identification does not identify underground conduits or infiltration.

For accurate runoff modeling, two scenarios were considered: (1) assuming off-site flows bypass the study area via engineered berms, and (2) considering off-site contributions where natural depressions and uncontained drainage patterns allow infiltration. Off-site runoff contributions were excluded from primary sub-basin calculations given engineered berm placements along perimeter zones. Consequently, curve number values in Section 5.4 reflect post-development conditions only for on-site impervious areas, aligning with CNMI and Naval Facilities Engineering Systems Command guidelines. The analysis accounted for both pre- and post-development conditions, incorporating expanded impervious areas, revised outflow points, and updated detention storage to optimize stormwater control and to minimize impacts to adjacent areas.

5.3 LAND USE AND LAND COVER

According to the U.S. Forest Service's vegetation mapping of Tinian, updated by the U.S. Fish and Wildlife Service, approximately 90 percent of the island is covered in vegetation. The exceptions are developed areas in San Jose, the Port of Tinian, the airport, roads, and small sections of rock outcroppings, sand, and soil. Most of this vegetation includes non-native tangantangan (*Leucaena leucocephala*), mixed introduced forest, native limestone forest, and herbaceous-scrub. Other vegetation types, wetland habitats, and agricultural areas comprise the remainder. This report focuses on land use cover to understand current and future stormwater flows. Areas with dense vegetation cover are called mixed forest, including tangantangan trees and other species with dense cover, while areas without trees are called shrubs and grassland. Figure 3 shows the general land cover on Tinian.

Figure 3 Land Cover on the Island of Tinian

5.4 TINIAN CURVE NUMBER VALUES

The CNMI Stormwater Management Manual and Naval Facilities Engineering Systems Command guidance guided curve number selection. Pre-development curve numbers were assigned based on Hydrologic Soil Group B, with a base curve number of 22 for undisturbed pervious areas, the lowest possible curve number on Tinian, which is typically associated with Hydrologic Soil Group A, ensuring a conservative pre-development estimate that assumes high infiltration capacity even though Tinian's soils are primarily classified as Hydrologic Soil Group B. Post-development curve numbers for impervious areas used a worst-case value of 98, reflecting new hardscapes. Because off-site flow was explicitly bypassed, external drainage areas were excluded from the composite curve number calculation. This ensures that runoff projections reflect project-specific modifications without artificially inflating results. Post-project sub-basins were included in the composite curve number calculations (Attachment A). Table 1 displays the curve number values selected for Hydrologic Soil Group B and land use cover identification.

Table 1. Curve Numbers Used for Post-project Land Cover and Soil on Tinian

Land Cover ID	*Hydrologic Soil Group B*
Barren	75.6
Other Scrub/Grassland	51.1
Scrub/Shrub	38.5
Leucaena Forest	45.2
Limestone Degraded Forest	45.2
Limestone Native Forest	45.2
Wetland Herbaceous	81.6
Wetland Shrub-Herb	81.6
Developed	98.0

Legend: ID = identification.
Source: AECOM 2014.

5.5 INITIAL ABSTRACTION/STORAGE

The Natural Resources Conservation Service methodology estimates precipitation excess as a function of cumulative precipitation, soil cover, land use, and antecedent moisture content. The maximum retention and the initial abstraction are related through an intermediate parameter, the curve number. The calculation of runoff amount in HydroCAD was completed using Table 2-2 (U.S. Department of Agricultural Soil Conservation Service 1986), which takes into account factors such as soil type, land use, and curve number.

5.6 TIME OF CONCENTRATION

The time of concentration of a watershed is defined as the time required for a drop of water to travel from the most hydraulically distant part of a watershed to the point of discharge or outlet. Time of concentration is computed by summing all the travel times for consecutive drainage system components. The time of concentration for each sub-basin was developed using the TR-55 equations (U.S. Department of Agricultural Soil Conservation Service 1986).

For sheet flow of fewer than 300 feet, Manning's kinematic solution (Overton and Meadows 1976) is used to compute travel time. After 300 feet, sheet flow usually becomes a shallow, concentrated flow. The average velocity for this flow can be determined from the equation shown below, in which average velocity is a function of the watercourse slope and type of cover.

$$T(t) = \frac{L}{60\, k\sqrt{S}}$$

Where:

$T(t)$ = Travel time for open channel flow segments

L = Length of flow segment

k = Intercept coefficient per Table 3-3 of the Federal Highway Administration Hydraulic Engineering Circular No. 22, Third Edition (Federal Highway Administration 2009)

S = Slope of the ground surface as a percentage

5.7 DESIGN STORM FREQUENCY

Pre- and post-development hydrology were analyzed for the following design storm events:

- 1-year and 25-year recurrences, 24-hour storm events
- 95th percentile storm event

These storm events were selected to meet the design requirements established in the *CNMI and Guam Stormwater Management Manual* (Horsley Witten Group, Inc. 2006).

5.8 DESIGN RAINFALL DEPTHS AND DISTRIBUTION

The *Rainfall Data Verification Memorandum*, prepared by the University of Guam, U.S. Department of Agriculture, and National Oceanic and Atmospheric Administration, summarizes precipitation data, distribution curves, and intensity duration frequency curves for Tinian (National Oceanic and Atmospheric Administration 2011). No additional applicable rainfall data that would supersede these values have been published since the *Rainfall Data Verification Memorandum*. Table 2 provides design storm event rainfall depths.

Table 2. Rainfall Data per Design Storm

Location	*Mean Annual Rainfall (in)*	*Water Quality Storm Events*	*24-Hour Rainfall (in) per Recurrence Interval (years)*	
		95th Percentile	*1 yr*	*25 yr*
Tinian	83.4	2.2	4.25	14.88

Legend: in = inch; yr = year.
Source: Lander and Guard 2003.

Temporal distributions of precipitation are provided with precipitation frequency estimates from the National Oceanic and Atmospheric Administration Atlas 14 Volume 5 (National Oceanic and Atmospheric Administration 2011) for the 6-hour, 12-hour, 24-hour, and 96-hour durations. The temporal distributions are expressed in probability as cumulative percentages of precipitation totals at various time steps. For this study, the third quartile 24-hour duration rainfall distribution curve was selected based on data indicating that third quartile distribution occurs most frequently with 24-hour storm events.

5.9 RESULTS OF ANALYSIS

Following the mapping and calculation of baseline hydrologic conditions, the proposed conditions were evaluated to assess the impact of changes in impervious surfaces, land use, and curve numbers. The analysis encompassed the proposed Base Camp (former U.S. Agency for Global Media site), Ammunition Holding Area, Explosives Training Range, and supporting infrastructure, including roads and utility corridors. Stormwater runoff was modeled for the 1-year, 25-year, and 95th percentile storm events to determine changes in runoff volume, peak flow rates, and time of concentration.

The hydrologic model was structured to reflect distinct drainage basins within the Base Camp footprint, accounting for variations in topography, soil permeability, and flow paths. The Base Camp area was delineated based on drainage direction and existing stormwater infrastructure. Each sub-basin was assigned updated curve numbers to reflect the expansion of impervious surfaces, new detention areas, and the revised stormwater berm configuration.

HydroCAD modeling outputs were generated to analyze changes in peak flows and runoff volumes under post-development conditions. The results, summarized in Table 3, highlight adjustments to stormwater parameters based on updated land use classifications, while Table 4 details the pre- and post-development peak discharge rates and runoff volume changes for each design storm event. The purpose of these analyses is to define stormwater routing, detention capacity, and best management practice implementation, aligning with regulatory requirements and site-specific hydrologic conditions.

The drastic decrease in time of concentration is primarily due to the increase in impervious area, which reduced infiltration and accelerated runoff. The replacement of dense vegetation with paved surfaces substantially lowered surface roughness, increasing flow velocity. Additionally, the introduction of engineered drainage features, steeper slopes, and channelized flow paths further expedited runoff travel time. These changes are typical in developed areas, where stormwater moves much faster compared to natural landscapes.

The drainage areas summarized in Table 3 and Table 4 reflect total acreages with potential off-site runoff contributions removed, ensuring that the analysis only considers site-generated stormwater flows. The ETR was explicitly modeled using conservative screening-level assumptions, including representation as 100 percent impervious, to avoid understating potential runoff. Modeling results demonstrated that the ETR contribution to overall runoff volumes and peak flows is negligible relative to Base Camp and MPMR; therefore, ETR results are documented in the appendix but were screened out of the main report and summary tables.

The Surface Radar Site was screened out of quantitative modeling due to its remote location and very small impervious footprint (< 0.05 acre), which is below the CNMI Stormwater Management Manual threshold for detailed analysis and results in a de minimis runoff contribution.

The Ammunition Holding Area, supporting roads, and utility corridors are included in the composite curve number and HydroCAD models due to their larger impervious footprint and hydraulic connectivity to the site drainage network.

Although the ETR contribution was de minimis at the watershed scale, its unique operational characteristics warrant consideration of localized stormwater management measures during final design to address potential runoff concentration and water quality impacts within training areas, consistent with CNMI planning-level guidance.

The HydroCAD software has a built-in function that rounds curve numbers to the nearest whole number. This information is displayed in the table provided in the HydroCAD output.

Table 3. HydroCAD Stormwater Parameters

Parameter	***Base Camp***		***MPMR***	
	Existing	***Proposed***	***Existing***	***Proposed***
95th Percentile Rainfall Depth (in)	2.2		2.2	
1-yr 24-yr Rainfall Depth (in)	4.25		4.25	
25-yr 24-hr Rainfall Depth (in)	14.88		14.88	
Area (ac)	12.63		0.78	
Curve Number	22.5	98	22.5	98
Flow length (ft)	842		233	
Time of Concentration (min)	86.9	7.1	66.7	2.9

Legend: ac = acre; ft = foot or feet; hr = hour; in = inch; min = minute; MPMR = Multi-Purpose Maneuver Range; yr = year.

Table 4. HydroCAD Stormwater Results

Parameter		***Base Camp***			***MPMR***		
		Existing	***Proposed***	***Change***	***Existing***	***Proposed***	***Change***
95th % Water Quality Storm	Runoff Volume (acre-ft)	0.00	2.08	2.08	0.00	0.13	0.13
	Peak Flow (cfs)	0.00	3.29	3.29	0.00	0.20	0.20
1-yr 24-hr	Runoff Volume (acre-ft)	0.00	4.22	4.22	0.00	0.26	0.26
	Peak Flow (cfs)	0.00	6.46	6.46	0.00	0.40	0.40
25-yr 24-hr	Runoff Volume (acre-ft)	1.69	15.40	13.71	0.11	0.95	0.85
	Peak Flow (cfs)	4.13	22.73	18.60	0.26	1.41	1.15

Legend: % = percent; acre-ft = acre-foot or acre-feet; cfs = cubic feet per second; hr = hour; MPMR = Multi-Purpose Maneuver Range; yr = year.

6 STORMWATER BEST MANAGEMENT PRACTICES/INTEGRATED MANAGEMENT PRACTICES

6.1 STORMWATER MANAGEMENT PRACTICES

This chapter identifies stormwater quantity management alternatives for the Proposed Action and explains the application of Low Impact Development, best management practices, and integrated management practices within the stormwater management strategy. Low Impact Development, best management practices, and integrated management practices for the Proposed Action are summarized as follows:

- Low Impact Development focuses on minimizing runoff and promoting infiltration by integrating stormwater controls into the natural landscape through measures such as bioretention basins, vegetated swales, and permeable pavements. Low Impact Development is primarily used to restore pre-development hydrology by reducing runoff at the source and enhancing groundwater recharge.
- Best management practices serve as standardized stormwater control measures that reduce pollution, manage runoff flow, and prevent erosion. Best management practices include detention basins, hydrodynamic separators, sediment traps, and vegetation buffers, which help maintain compliance with environmental standards and prevent sediment transport into water bodies.
- Integrated management practices combine both Low Impact Development and best management practice components to create site-specific stormwater solutions. Integrated management practices are applied in areas with complex stormwater challenges, such as training ranges, and refueling areas, , where standard best management practices alone may not be sufficient. These solutions are designed to accommodate operational constraints while maximizing stormwater treatment efficiency.

This report applies all three approaches of Low Impact Development for runoff reduction, best management practices for pollution control, and integrated management practices for site-specific integration to create a comprehensive, adaptive stormwater management plan at the Base Camp and Multi-Purpose Maneuver Range.

6.2 WATER QUALITY/LOW IMPACT DEVELOPMENT

Conceptual-level stormwater management capabilities were assessed by quantifying various treatment components based on approximate Low Impact Development, best management practice, and integrated management practice footprints. The estimated stormwater capture volume potential was compared to anticipated post-development runoff to determine the most effective treatment solutions. Low Impact Development placement prioritizes on-site stormwater retention, ensuring that infiltration areas do not interfere with critical infrastructure or military operations. By integrating Low Impact Development-based infiltration and structural best management practices, the design balances water quality improvement, groundwater recharge, and flood control, particularly in the high-rainfall CNMI region.

The high-rainfall CNMI region necessitates an approach that balances water quality improvement, groundwater recharge, and peak flow attenuation. Low Impact Development measures would be strategically positioned in high-infiltration areas to promote on-site runoff absorption, while best management practices would be employed to regulate stormwater movement and to prevent excessive flow velocities. In areas with high pollutant loads, such as ammunition holding and refueling zones, integrated management practices would be used to integrate advanced filtration and containment systems to capture contaminants like heavy metals and hydrocarbons before runoff enters natural waterways.

Balancing water quality, groundwater recharge, and 25-year design storm event management necessitates a dual approach that combines integrated management practices with traditional detention basins. While detention basins are necessary for peak flow reduction, integrated management practices ensure that stormwater in high-risk areas receives adequate filtration and pollutant removal. By incorporating these strategies, the project achieves a resilient stormwater management plan that meets operational and environmental requirements.

6.3 WATER QUALITY AND RECHARGE VOLUMES

To determine the appropriate size for the facilities and treatment, the Unified Stormwater Sizing Criteria in the *CNMI and Guam Stormwater Management Manual* (Horsley Witten Group, Inc. 2006) recommends the use of the 95th percentile storm event to calculate the water quality and recharge volumes (Table 5). The water quality volume is intended to improve water quality by capturing and treating 90 percent of the average annual storm events for high-quality resource areas and hotspots and 80 percent for land uses that drain to moderate-quality resource areas. The recharge volume must be achieved through a structural practice like infiltration, bioretention, or filters. According to the *CNMI and Guam Stormwater Management Manual*, any infiltration facility must have a sedimentation basin containing 25 percent of the water quality volume must be provided for sediment. Among the available options, a grass channel or stilling basin would be the most advisable choice depending on the location and preferences. The equation for water quality volume is as follows:

$$WQ_V = \frac{(P)(A)(I)}{12}$$

Where:

WQ_v = Water quality volume in acre-feet

P = 90 percent rainfall event (1.5 inches) for hotspots/high-quality resource areas; 80 percent rainfall event (0.8 inches) for moderate-quality resource areas

A = Site area in acres

I = Impervious area percentage of site area as a decimal

A minimum water quality volume value of 0.0167 feet × total area in acres (also referred to as 0.2 watershed inches) is required to fully treat the runoff from pervious surfaces. Because both the Base Camp drainage unit (≈ 96 percent impervious) and the MPMR pad (≈ 100 percent impervious) exceed the 80-percent impervious threshold described in Section 4-4 of the CNMI

& Guam Stormwater Management Manual, the impervious fraction (I) was conservatively set to 1.0 for sizing Water-Quality (WQv) and Recharge (Rev) volumes.

Table 5. Water Quality Volumes

Water Quality Criteria, WQ_v	***90% of Average Annual Storm Events – High-quality Resource Areas and Hotspots***	
Precipitation (in), P	1.5	1.5
Parameters	***Basecamp***	***MPMR***
Area (acres), A	12.63	0.78
Impervious area (acres)	12.63	0.78
Impervious area (decimal percent), I	1.00	1.00
WQ_v (90%) (acre-ft)	1.58	0.10
min WQ_v (acre-ft)	0.21	0.01
Sedimentation Volume (acre-ft)	0.40	0.03

Legend: % = percent; acre-ft = acre-foot or acre-feet; in = inch; min = minimum; MPMR = Multi-Purpose Maneuver Range; N/A = not applicable; WQ_v =water quality volume limestone dominated areas.

$$Re_V = \frac{(P)(A)(I)}{12}$$

Where:

Re_v = Recharge volume in acre-feet

P = 90 percent rainfall event (1.5 inches)

A = Site area in acres

I = Impervious area percentage of site area as a decimal

This criterion applies primarily to limestone-dominated recharge areas within the Base Camp footprint, except for locations where soil profiles extend at least 3 feet below the bottom of proposed stormwater facilities. Recharge volume calculations have been updated to account for the full extent of impervious areas due to the increased development footprint and the proximity of potential hotspot locations. Given the reduced extent of pervious surfaces, the entire site has been incorporated into the recharge volume analysis to ensure compliance with stormwater management requirements and to maintain effective infiltration and runoff mitigation strategies.

Table 6 presents these calculations, incorporating changes based on the revised site layout and stormwater management strategy. The impervious surface analysis accounts for new facility footprints, vehicle access routes, and structural best management practices, affecting infiltration potential and runoff patterns. The stormwater infiltration system has been updated to align with these modifications, incorporating engineered recharge zones and additional bioretention basins to support stormwater absorption and groundwater recharge capacity.

The Base Camp stormwater plan incorporates detention and infiltration strategies suited to site-specific hydrology and land use changes.

Table 6. Recharge Volumes

Recharge Criteria, Re_v	***Criterion for Limestone Regions of CNMI Requiring Infiltration of 1.50 Inches of Rainfall***	
Precipitation (in), P	1.5	
Parameters	***Base Camp***	***MPMR***
Area (acres), A	12.63	0.78
Impervious area (acres)	12.63	0.78
Impervious area (decimal percent), I	1.00	1.00
Recharge criteria, Re_v (acre-ft)	1.58	0.10

Legend: acre-ft = acre-foot or acre-feet; in = inch; MPMR = Multi-Purpose Maneuver Range; Re_v = recharge volume.

6.4 LOW IMPACT DEVELOPMENT APPLICATION

Improving drainage in the proposed areas requires creating conceptual integrated management practices for its basins. Drainage basins were identified and conceptual integrated management practices were developed for each. Roof downspout runoff is directed to flow to dry conveyance swales. These swales lead to bioretention cells or dry wells before entering perimeter swales (where applicable). The final design phase should finalize the capture/conveyance scheme of the perimeter swales.

6.5 INTEGRATED MANAGEMENT PRACTICES

Recommendations in this section are adapted from the *CNMI and Guam Stormwater Management Manual* (Horsley Witten Group, Inc. 2006). This discussion explores integrated management practices tailored to address the specific challenges of treating stormwater for an operational Base Camp.

6.6 BASE CAMP TREATMENT OPTIONS

Stormwater management at the Base Camp is designed to reduce runoff impacts, enhance on-site infiltration, and can reduce pollutant loadings.

Key Stormwater Treatment Components:

- **Erosion Control Measures (Best Management Practices).** Vegetative buffers, reinforced swales, and sediment traps would stabilize disturbed areas and prevent sediment transport.
- Stormwater Diversion and Containment (Integrated Management Practices and Best Management Practices).
- Engineered drainage swales and perimeter berms to control velocity and route flows to treatment areas.
- **Detention and Infiltration Basins (Low Impact Development and Best Management Practices).** Shallow detention basins would be strategically placed to capture peak storm events, store runoff temporarily, and allow gradual infiltration, preventing erosion and excessive flow velocities.

- **Hydrodynamic Separators and Filtration Systems (Best Management Practices).** These would be installed at key discharge points to capture suspended solids, hydrocarbons, and other pollutants before runoff enters receiving environments.
- **Permeable Ground Surface Integration (Low Impact Development and Integrated Management Practices).** Selective use of permeable surfaces in high-impact areas would enhance infiltration, reduce runoff velocity, and limit sediment transport.
- **Stormwater Berm Expansion (Integrated Management Practices and Best Management Practices).** Raise and extend the existing berm on the north, south, and east flanks of the transmitter building, plus a new berm along the northern edge of support facilities to redirect flows eastward toward controlled treatment corridors.
- **Operational controls for vehicle refueling & equipment maintenance (BMP**) Conduct refueling ≥ 120 ft from water bodies or stormwater pathways. Perform routine equipment leak inspections; repair before entering storm-sensitive areas. Provide drip pans, spill-response kits, and secondary containment at all fueling areas.
- **Adaptive Management (Best Management Practices and Integrated Management Practices).** Routine visual inspections of LID structures would be conducted after major storm events to confirm performance; corrective maintenance would follow CNMI SW Manual guidelines.

Best Management Practices for Vehicle Refueling and Equipment Maintenance:

To further reduce stormwater contamination risks from training vehicles and equipment, additional best management practices would be enforced, including:

- **Vehicle and equipment refueling** would occur at least 120 feet from water sources or designated stormwater pathways, following established military environmental protection guidelines.
- **Routine equipment inspections** would be conducted to identify leaks of hydraulic fluid, oil, and lubricants, with corrective actions taken before vehicles enter stormwater-sensitive areas.
- **Secondary containment measures** such as drip pans and spill response kits would be deployed at fueling areas to contain accidental leaks and prevent stormwater contamination.

The stormwater management strategy for the Base Camp incorporates a hybrid approach that combines best management practices, Low Impact Development-based infiltration strategies, and site-specific integrated management practices. By expanding the existing stormwater berm, integrating natural drainage features, and using cost-effective stormwater treatment solutions, these measures collectively support a resilient, effective, and low-maintenance stormwater management plan, safeguarding water quality and environmental integrity at the Base Camp.

6.6.1 Multi-Purpose Maneuver Range and Explosives Training Range Treatment

The Multi-Purpose Maneuver Range and Explosives Training Range require an effective stormwater management strategy that minimizes runoff, controls erosion, and prevents potential contamination from training activities. Given the site's unique operational and environmental challenges, the most cost-effective and efficient solution is a hybrid approach that integrates natural drainage features with targeted treatment measures to ensure effective stormwater control with minimal maintenance and cost.

Key Stormwater Treatment Components:

- **Vegetated Swales and Permeable Surfaces (Low Impact Development and Integrated Management Practices).** Grass-lined swales would be used along drainage paths to slow runoff, encourage infiltration, and reduce erosion. Permeable surfaces (e.g., gravel-based training areas) would minimize direct runoff and sediment transport while maintaining operational flexibility**.**
- **Detention Basins (Best Management Practices and Low Impact Development).** Shallow, strategically placed dry detention basins would capture peak storm events, temporarily store runoff, and allow gradual infiltration, reducing flow velocity and preventing downstream erosion without excessive maintenance.
- **Hydrodynamic Separators at High-Risk Areas (Best Management Practices and Integrated Management Practices).** Pretreatment separators would be installed at key outfalls near ammunition impact zones to filter out suspended solids, sediment, and heavy metals before runoff enters receiving environments.
- **Minimal Grading and Firebreak Integration (Integrated Management Practices).** Drainage solutions would be aligned with existing terrain features to minimize earthwork costs while using firebreaks. Firebreaks would serve a dual purpose by acting as linear infiltration zones, slowing runoff and reducing sediment transport while maintaining wildfire prevention capabilities.
- **Targeted Monitoring and Compliance (Best Management Practices and Integrated Management Practices).** Regular inspection and adaptive management would ensure stormwater quality aligns with military environmental protection standards while allowing for adjustments based on site performance.

By integrating best management practices for erosion control with Low Impact Development-based infiltration strategies, the Multi-Purpose Maneuver Range and Explosives Training Range stormwater plan would optimize water management while ensuring cost-effectiveness and ease of implementation. The stormwater berm extension, combined with vegetated swales, detention basins, and hydrodynamic separators, would provide a comprehensive solution that minimizes long-term maintenance requirements, mitigates potential contamination risks, and supports uninterrupted training operations and environmental best practices. This multi-layered approach would help to manage stormwater effectively and sustainably, reducing environmental impact while maintaining training functionality.

7 CONCLUSIONS

The Proposed Action incorporates stormwater management strategies to mitigate the effects of increased impervious surfaces while maintaining pre-development hydrology. The expanded stormwater berm, detention basins, and integrated best management practices would effectively manage runoff by capturing and regulating peak storm events, diverting and containing stormwater, and preventing sediment transport through vegetative buffers and swales. Water quality protection measures, such as hydrodynamic separators and oil-water separators at fueling areas, would help remove contaminants before discharge, while bioswales, bioretention basins, and permeable surfaces would enhance infiltration and groundwater recharge. These measures would collectively support effective stormwater control, reduce runoff velocity, and protect depressional areas, nearshore waters, and wetlands from potential impacts.

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ATTACHMENT A
SUPPORTING CALCULATIONS

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ATTACHMENT A.1
BASE CAMP HYDROCAD RESULTS

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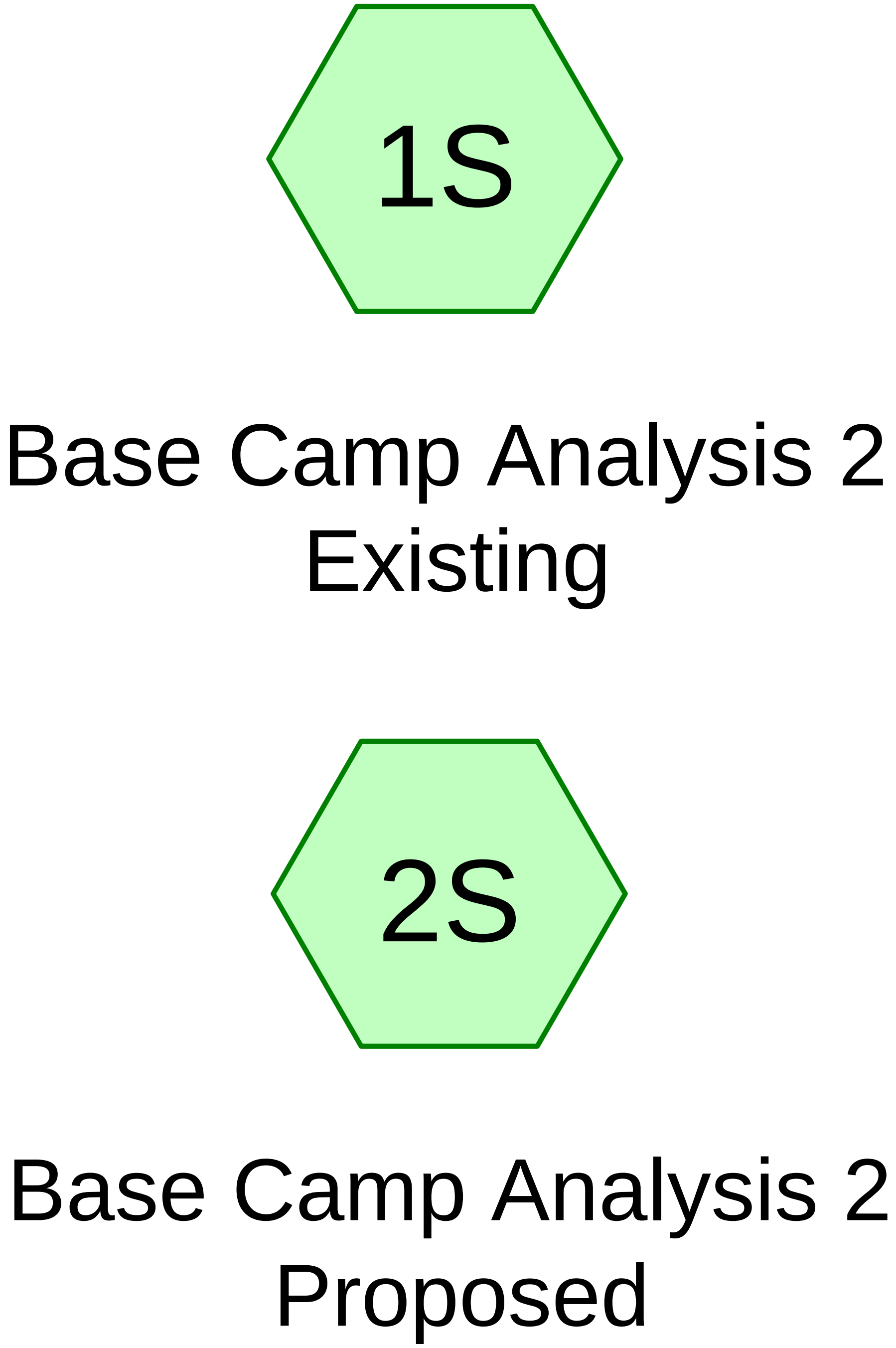
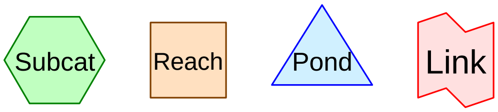




Routing Diagram for CJMT_Tinian_BaseCamp
Prepared by AECOM, Printed 3/12/2025

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	Tinian 1 year 24 hour	Tinian 1 year 24 hour		Default	24.00	1	4.25	2
2	Tinian 25 year 24 hour	Tinian 25 year 24 hour		Default	24.00	1	14.88	2
3	Tinian 95th percentile	Tinian 95th percentile		Default	24.00	1	2.20	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
12.626	23	(1S)
12.626	98	(2S)
25.252	**61**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
25.252	Other	1S, 2S
25.252		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	25.252	25.252		1S, 2S
0.000	**0.000**	**0.000**	**0.000**	**25.252**	**25.252**	**TOTAL AREA**	

Time span=1.00-40.00 hrs, dt=0.01 hrs, 3901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Base Camp Analysis 2 Runoff Area=12.626 ac 0.00% Impervious Runoff Depth=0.00"
Flow Length=842' Tc=86.9 min CN=23 Runoff=0.00 cfs 0.000 af

Subcatchment 2S: Base Camp Analysis Runoff Area=12.626 ac 100.00% Impervious Runoff Depth=4.01"
Flow Length=892' Tc=7.1 min CN=98 Runoff=6.46 cfs 4.224 af

Total Runoff Area = 25.252 ac Runoff Volume = 4.224 af Average Runoff Depth = 2.01"
50.00% Pervious = 12.626 ac 50.00% Impervious = 12.626 ac

Summary for Subcatchment 1S: Base Camp Analysis 2 Existing

[45] Hint: Runoff=Zero

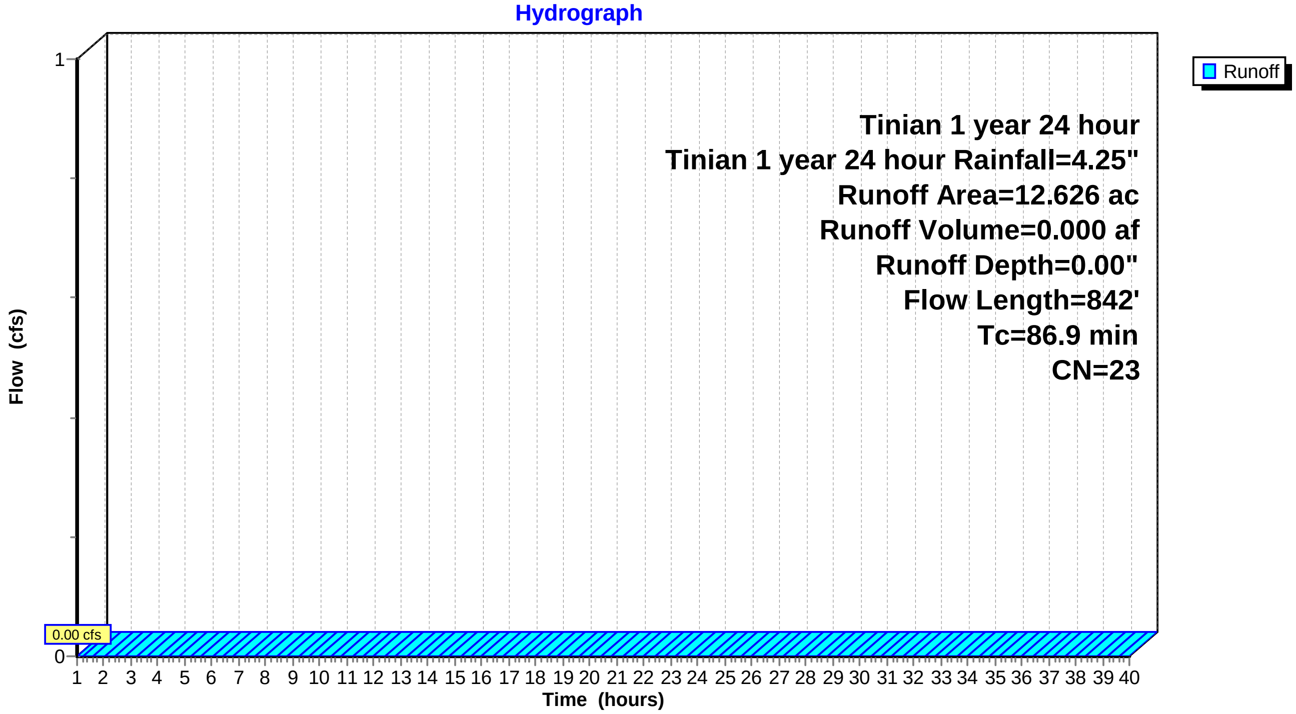
Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-40.00 hrs, dt= 0.01 hrs
Tinian 1 year 24 hour Tinian 1 year 24 hour Rainfall=4.25"

	Area (ac)	CN	Description
*	12.626	23	
	12.626		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.9	150	0.0120	0.06		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
44.0	692	0.0110	0.26		**Shallow Concentrated Flow, Shallow Concentrated Flow Propose** Forest w/Heavy Litter Kv= 2.5 fps
86.9	842	Total			

Subcatchment 1S: Base Camp Analysis 2 Existing



Summary for Subcatchment 2S: Base Camp Analysis 2 Proposed

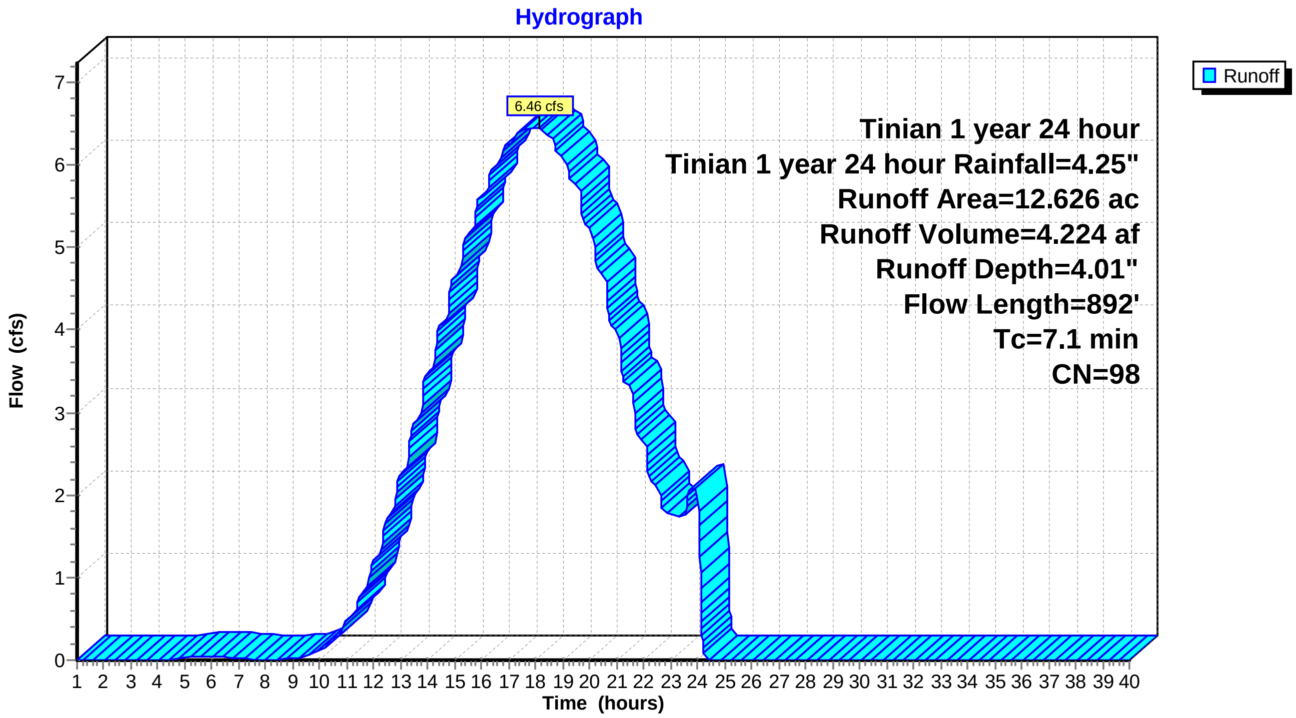
Runoff = 6.46 cfs @ 18.12 hrs, Volume= 4.224 af, Depth= 4.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-40.00 hrs, dt= 0.01 hrs
Tinian 1 year 24 hour Tinian 1 year 24 hour Rainfall=4.25"

	Area (ac)	CN	Description
*	12.626	98	
	12.626		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.5	150	0.0100	1.67		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
5.6	742	0.0120	2.22		**Shallow Concentrated Flow, Shallow Concentrated Flow Propose** Paved Kv= 20.3 fps
7.1	892	Total			

Subcatchment 2S: Base Camp Analysis 2 Proposed



Time span=1.00-40.00 hrs, dt=0.01 hrs, 3901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: Base Camp Analysis 2 Runoff Area=12.626 ac 0.00% Impervious Runoff Depth=1.61"
Flow Length=842' Tc=86.9 min CN=23 Runoff=4.13 cfs 1.692 af

Subcatchment 2S: Base Camp Analysis Runoff Area=12.626 ac 100.00% Impervious Runoff Depth>14.64"
Flow Length=892' Tc=7.1 min CN=98 Runoff=22.73 cfs 15.401 af

Total Runoff Area = 25.252 ac Runoff Volume = 17.093 af Average Runoff Depth = 8.12"
50.00% Pervious = 12.626 ac 50.00% Impervious = 12.626 ac

Summary for Subcatchment 1S: Base Camp Analysis 2 Existing

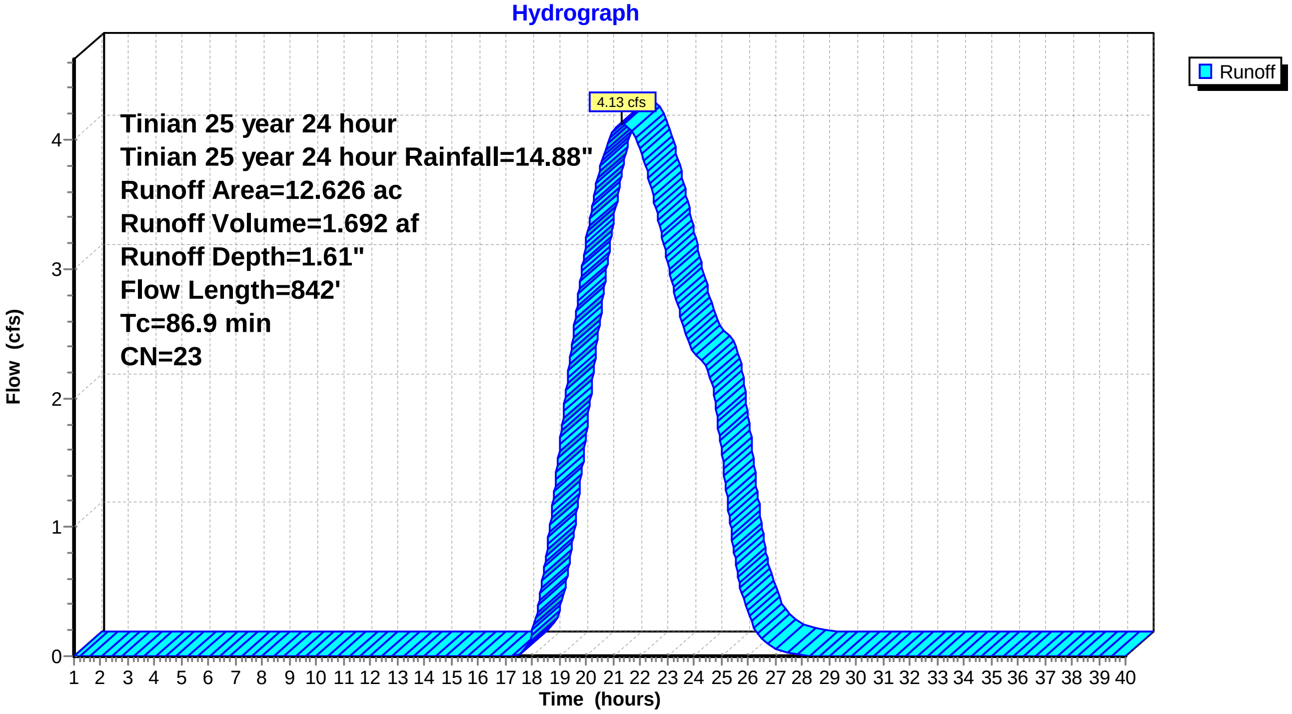
Runoff = 4.13 cfs @ 21.34 hrs, Volume= 1.692 af, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-40.00 hrs, dt= 0.01 hrs
Tinian 25 year 24 hour Tinian 25 year 24 hour Rainfall=14.88"

	Area (ac)	CN	Description
*	12.626	23	
	12.626		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.9	150	0.0120	0.06		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
44.0	692	0.0110	0.26		**Shallow Concentrated Flow, Shallow Concentrated Flow Propose** Forest w/Heavy Litter Kv= 2.5 fps
86.9	842	Total			

Subcatchment 1S: Base Camp Analysis 2 Existing



Summary for Subcatchment 2S: Base Camp Analysis 2 Proposed

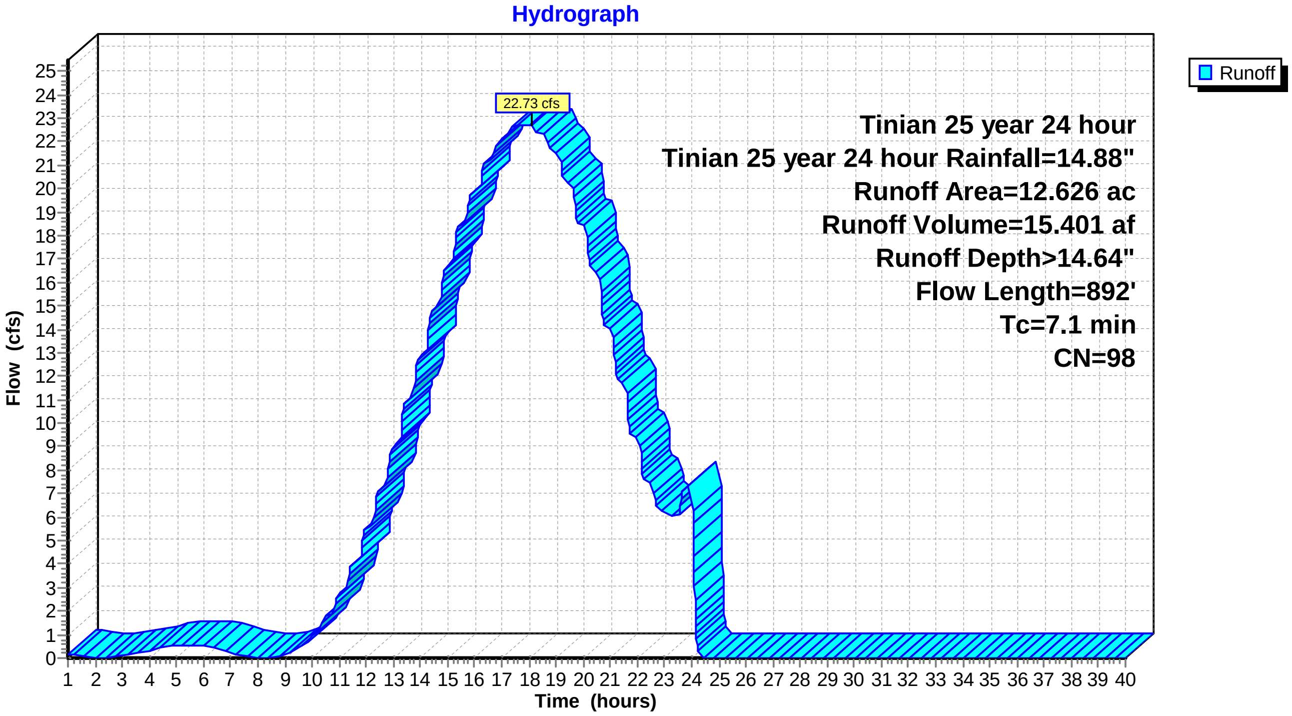
Runoff = 22.73 cfs @ 18.12 hrs, Volume= 15.401 af, Depth>14.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-40.00 hrs, dt= 0.01 hrs
Tinian 25 year 24 hour Tinian 25 year 24 hour Rainfall=14.88"

	Area (ac)	CN	Description
*	12.626	98	
	12.626		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.5	150	0.0100	1.67		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
5.6	742	0.0120	2.22		**Shallow Concentrated Flow, Shallow Concentrated Flow Propose** Paved Kv= 20.3 fps
7.1	892	Total			

Subcatchment 2S: Base Camp Analysis 2 Proposed



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                         Time span=1.00-40.00 hrs, dt=0.01 hrs, 3901 points
                          Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
               Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment 1S: Base Camp Analysis 2    Runoff Area=12.626 ac   0.00% Impervious   Runoff Depth=0.00"
                                        Flow Length=842'   Tc=86.9 min   CN=23   Runoff=0.00 cfs  0.000 af

Subcatchment 2S: Base Camp Analysis    Runoff Area=12.626 ac   100.00% Impervious   Runoff Depth=1.97"
                                        Flow Length=892'   Tc=7.1 min   CN=98   Runoff=3.29 cfs  2.076 af

               Total Runoff Area = 25.252 ac   Runoff Volume = 2.076 af   Average Runoff Depth = 0.99"
                                        50.00% Pervious = 12.626 ac     50.00% Impervious = 12.626 ac
```

Summary for Subcatchment 1S: Base Camp Analysis 2 Existing

[45] Hint: Runoff=Zero

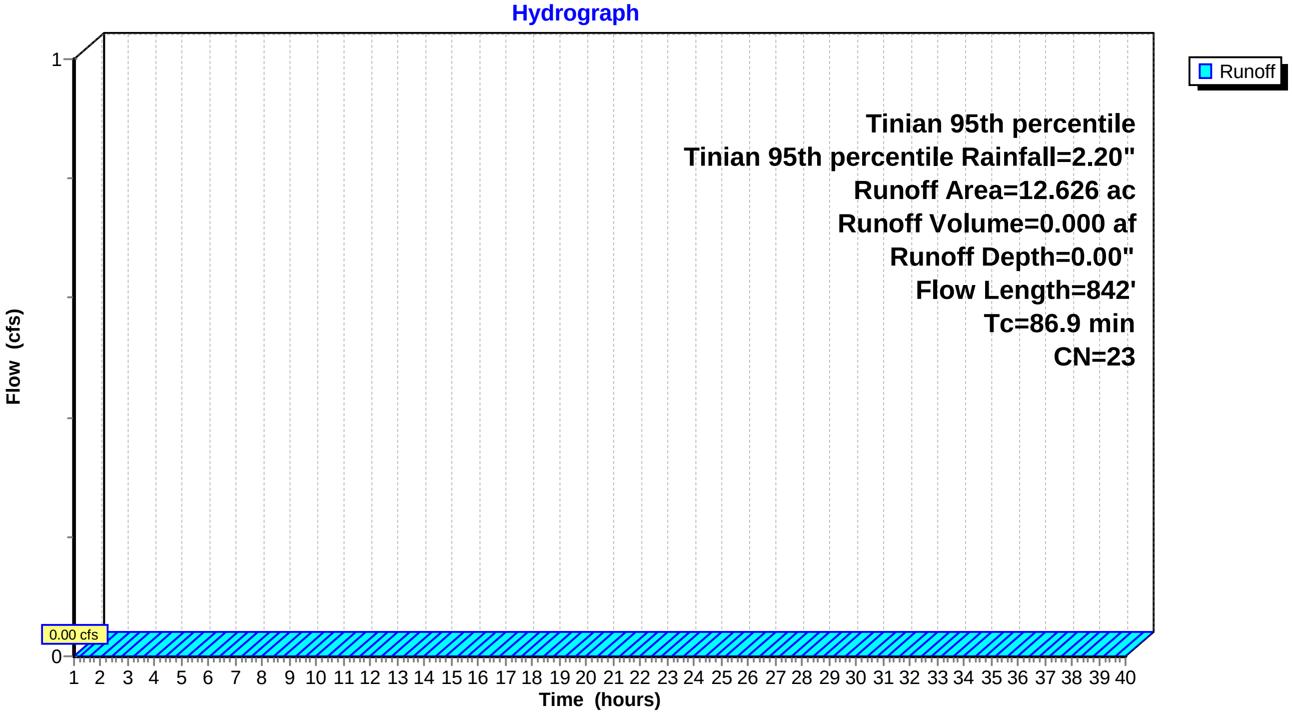
Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-40.00 hrs, dt= 0.01 hrs
Tinian 95th percentile Tinian 95th percentile Rainfall=2.20"

	Area (ac)	CN	Description
*	12.626	23	
	12.626		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
42.9	150	0.0120	0.06		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
44.0	692	0.0110	0.26		**Shallow Concentrated Flow, Shallow Concentrated Flow Proposed** Forest w/Heavy Litter Kv= 2.5 fps
86.9	842	Total			

Subcatchment 1S: Base Camp Analysis 2 Existing



Summary for Subcatchment 2S: Base Camp Analysis 2 Proposed

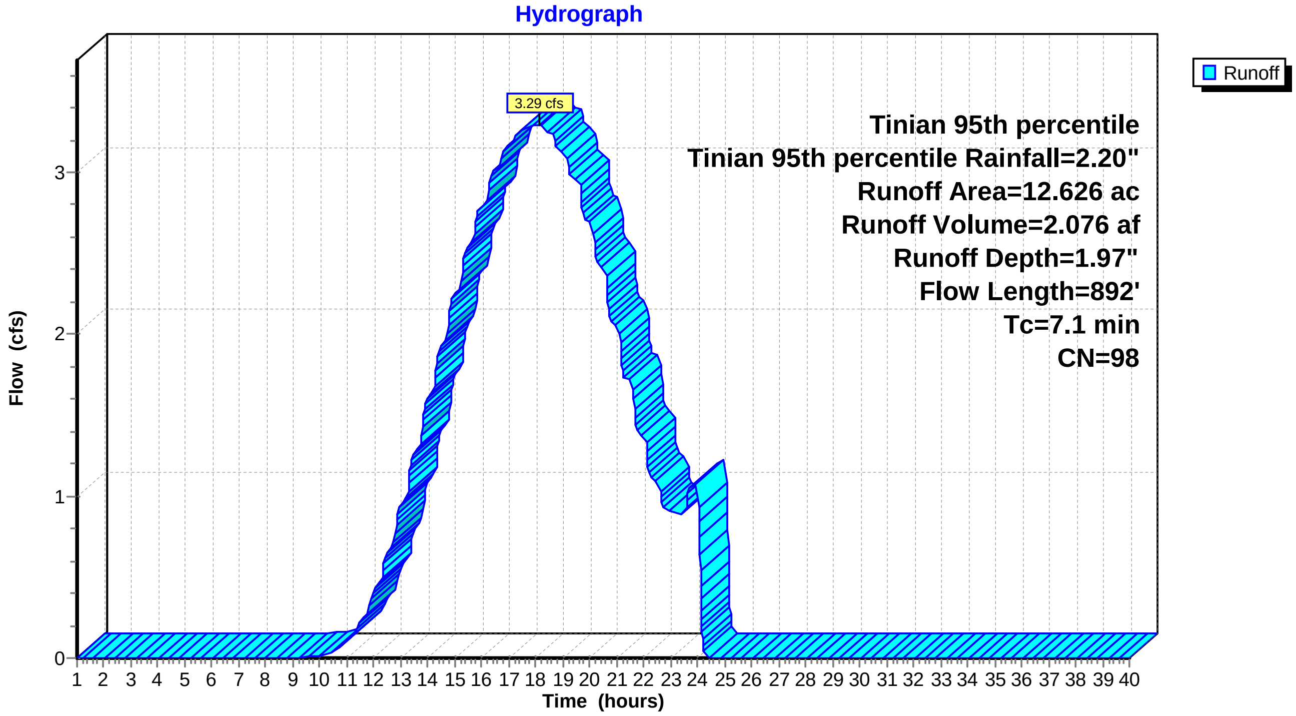
Runoff = 3.29 cfs @ 18.12 hrs, Volume= 2.076 af, Depth= 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-40.00 hrs, dt= 0.01 hrs
Tinian 95th percentile Tinian 95th percentile Rainfall=2.20"

	Area (ac)	CN	Description
*	12.626	98	
	12.626		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.5	150	0.0100	1.67		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
5.6	742	0.0120	2.22		**Shallow Concentrated Flow, Shallow Concentrated Flow Propose** Paved Kv= 20.3 fps
7.1	892	Total			

Subcatchment 2S: Base Camp Analysis 2 Proposed



ATTACHMENT A.2
ETR AND MPMR HYDROCAD RESULTS

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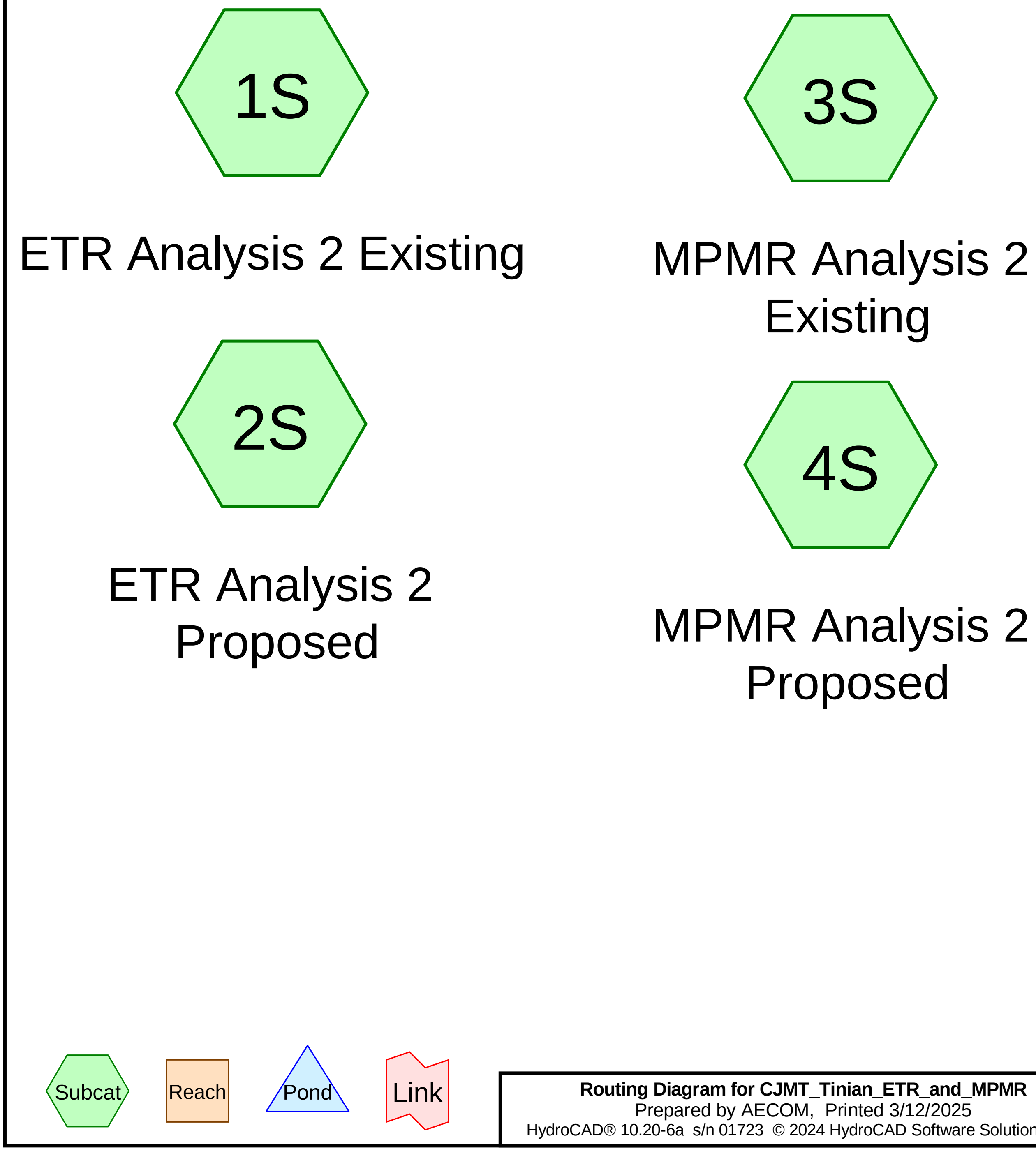


Routing Diagram for CJMT_Tinian_ETR_and_MPMR
Prepared by AECOM, Printed 3/12/2025

Rainfall Events Listing (selected events)

Event#	Event Name	Storm Type	Curve	Mode	Duration (hours)	B/B	Depth (inches)	AMC
1	Tinian 1 year 24 hour	Tinian 1 year 24 hour		Default	24.00	1	4.25	2
2	Tinian 25 year 24 hour	Tinian 25 year 24 hour		Default	24.00	1	14.88	2
3	Tinian 95th Percentile	Tinian 95th percentile		Default	24.00	1	2.20	2

Area Listing (selected nodes)

Area (acres)	CN	Description (subcatchment-numbers)
3.181	23	(1S, 3S)
3.181	98	(2S, 4S)
6.362	**61**	**TOTAL AREA**

Soil Listing (selected nodes)

Area (acres)	Soil Group	Subcatchment Numbers
0.000	HSG A	
0.000	HSG B	
0.000	HSG C	
0.000	HSG D	
6.362	Other	1S, 2S, 3S, 4S
6.362		**TOTAL AREA**

Ground Covers (selected nodes)

HSG-A (acres)	HSG-B (acres)	HSG-C (acres)	HSG-D (acres)	Other (acres)	Total (acres)	Ground Cover	Subcatchment Numbers
0.000	0.000	0.000	0.000	6.362	6.362		1S, 2S, 3S, 4S
0.000	**0.000**	**0.000**	**0.000**	**6.362**	**6.362**	**TOTAL AREA**	

Time span=1.00-60.00 hrs, dt=0.01 hrs, 5901 points
Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
Reach routing by Stor-Ind+Trans method - Pond routing by Stor-Ind method

Subcatchment 1S: ETR Analysis 2 Existing Runoff Area=2.400 ac 0.00% Impervious Runoff Depth=0.00"
Flow Length=402' Tc=59.1 min CN=23 Runoff=0.00 cfs 0.000 af

Subcatchment 2S: ETR Analysis 2 Runoff Area=2.400 ac 100.00% Impervious Runoff Depth=4.01"
Flow Length=402' Tc=3.7 min CN=98 Runoff=1.23 cfs 0.803 af

Subcatchment 3S: MPMR Analysis 2 Existing Runoff Area=0.781 ac 0.00% Impervious Runoff Depth=0.00"
Flow Length=233' Tc=66.7 min CN=23 Runoff=0.00 cfs 0.000 af

Subcatchment 4S: MPMR Analysis 2 Runoff Area=0.781 ac 100.00% Impervious Runoff Depth=4.01"
Flow Length=233' Slope=0.0050 '/' Tc=2.9 min CN=98 Runoff=0.40 cfs 0.261 af

Total Runoff Area = 6.362 ac Runoff Volume = 1.064 af Average Runoff Depth = 2.01"
50.00% Pervious = 3.181 ac 50.00% Impervious = 3.181 ac

Summary for Subcatchment 1S: ETR Analysis 2 Existing

[45] Hint: Runoff=Zero

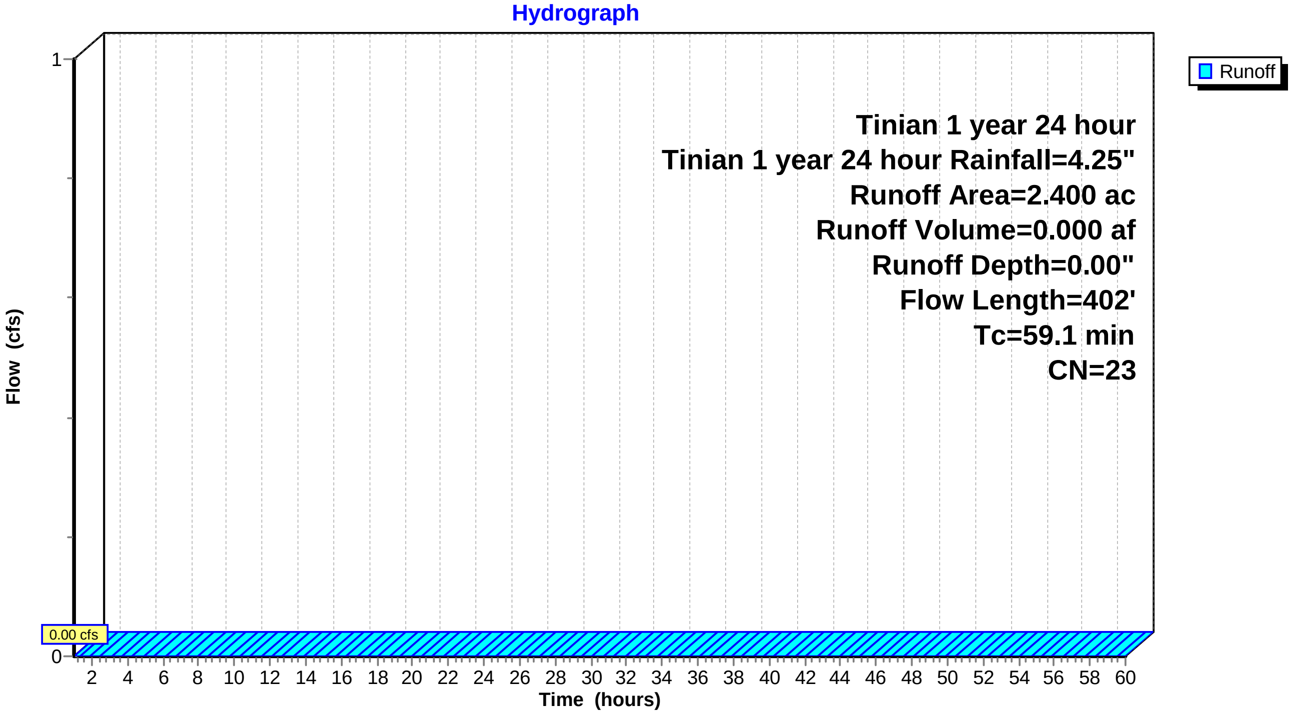
Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 1 year 24 hour Tinian 1 year 24 hour Rainfall=4.25"

	Area (ac)	CN	Description
*	2.400	23	
	2.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
40.3	150	0.0140	0.06		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
18.8	252	0.0080	0.22		**Shallow Concentrated Flow, Shalloe Concentrated Flow Existing** Forest w/Heavy Litter Kv= 2.5 fps
59.1	402	Total			

Subcatchment 1S: ETR Analysis 2 Existing



Summary for Subcatchment 2S: ETR Analysis 2 Proposed

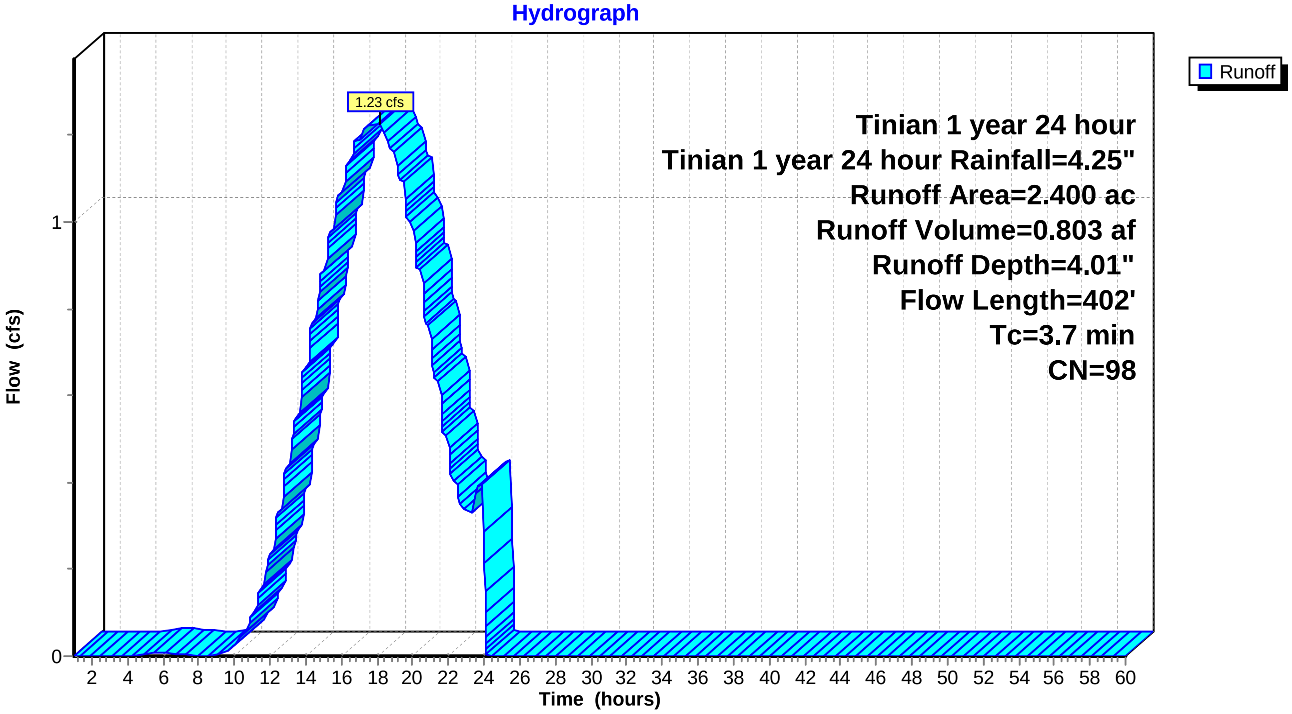
Runoff = 1.23 cfs @ 18.13 hrs, Volume= 0.803 af, Depth= 4.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 1 year 24 hour Tinian 1 year 24 hour Rainfall=4.25"

	Area (ac)	CN	Description
*	2.400	98	
	2.400		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	100	0.0170	1.91		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
2.8	302	0.0080	1.82		**Shallow Concentrated Flow, Shalloe Concentrated Flow Proposed** Paved Kv= 20.3 fps
3.7	402	Total			

Subcatchment 2S: ETR Analysis 2 Proposed



Summary for Subcatchment 3S: MPMR Analysis 2 Existing

[45] Hint: Runoff=Zero

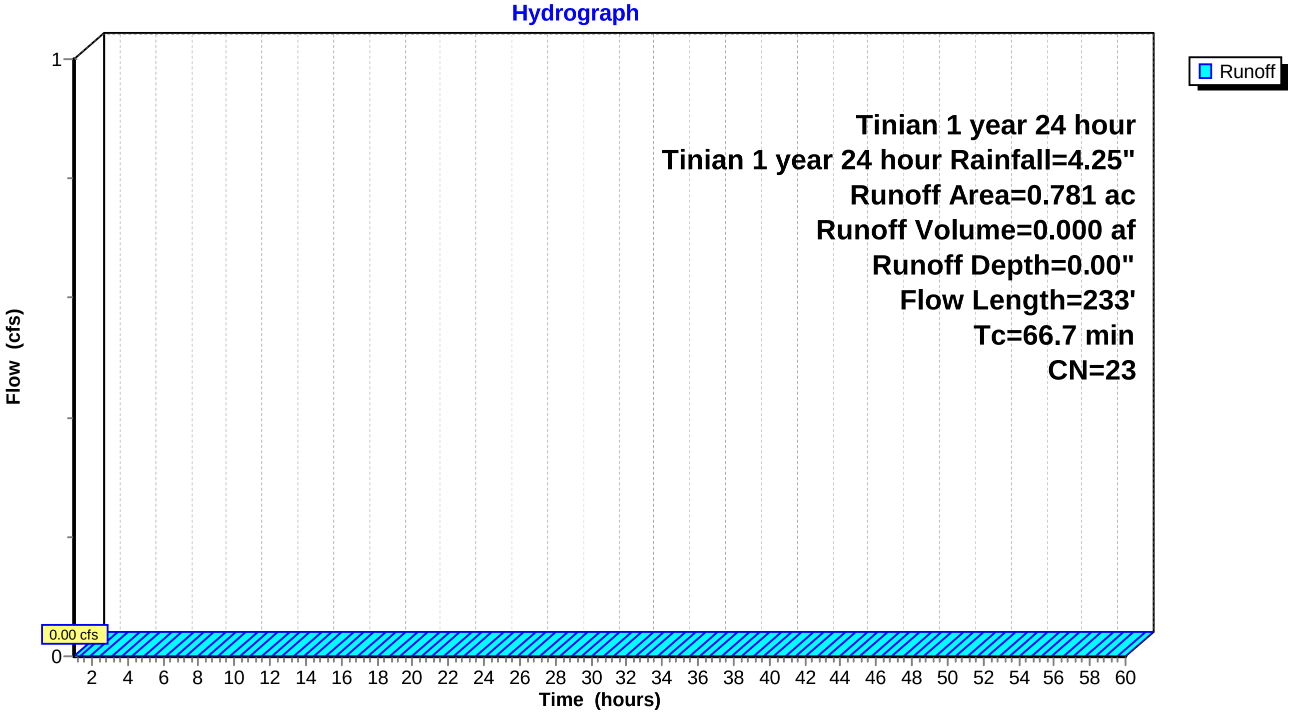
Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 1 year 24 hour Tinian 1 year 24 hour Rainfall=4.25"

	Area (ac)	CN	Description
*	0.781	23	
	0.781		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
56.6	150	0.0060	0.04		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
10.1	83	0.0030	0.14		**Shallow Concentrated Flow, Shallow Concentrated Flow** Forest w/Heavy Litter Kv= 2.5 fps
66.7	233	Total			

Subcatchment 3S: MPMR Analysis 2 Existing



Summary for Subcatchment 4S: MPMR Analysis 2 Proposed

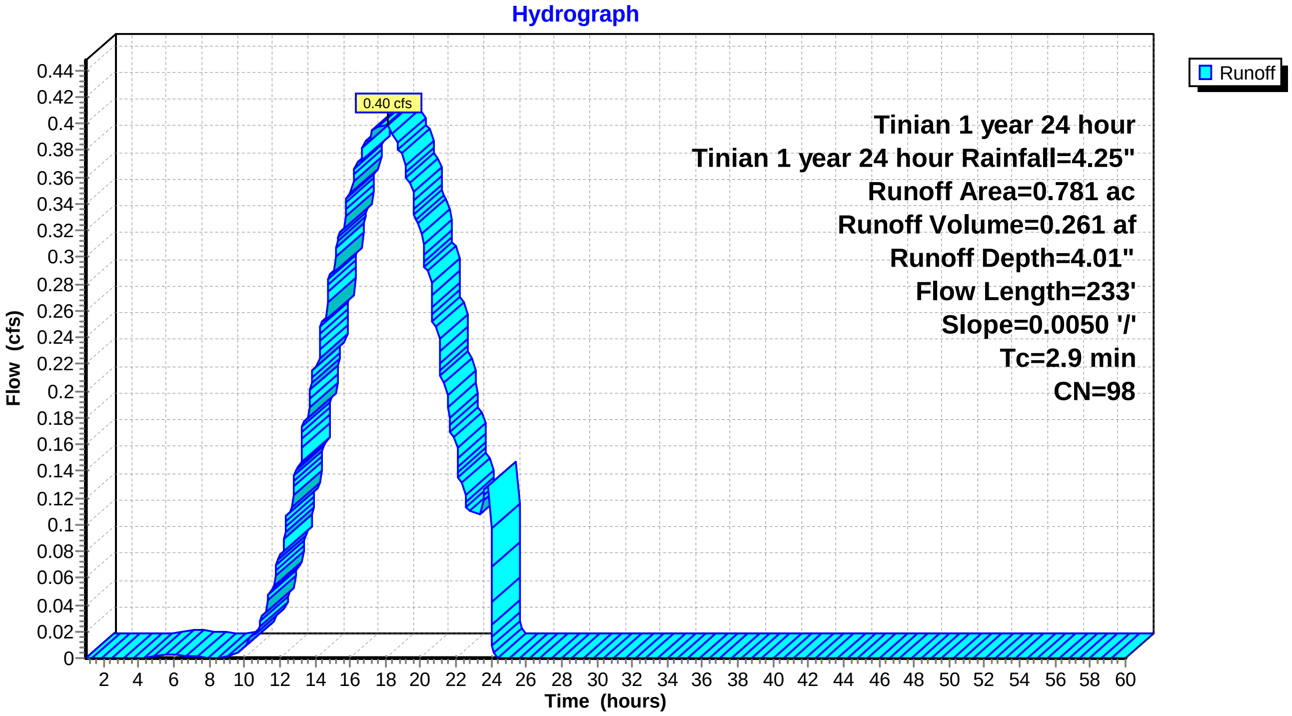
Runoff = 0.40 cfs @ 18.09 hrs, Volume= 0.261 af, Depth= 4.01"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 1 year 24 hour Tinian 1 year 24 hour Rainfall=4.25"

	Area (ac)	CN	Description
*	0.781	98	
	0.781		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	100	0.0050	1.17		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
1.5	133	0.0050	1.44		**Shallow Concentrated Flow, Shalloe Concentrated Flow Proposed** Paved Kv= 20.3 fps
2.9	233	Total			

Subcatchment 4S: MPMR Analysis 2 Proposed



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                         Time span=1.00-60.00 hrs, dt=0.01 hrs, 5901 points
                         Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
              Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment 1S: ETR Analysis 2 Existing    Runoff Area=2.400 ac   0.00% Impervious   Runoff Depth=1.61"
                                           Flow Length=402'   Tc=59.1 min   CN=23   Runoff=0.81 cfs  0.322 af

Subcatchment 2S: ETR Analysis 2           Runoff Area=2.400 ac   100.00% Impervious   Runoff Depth>14.64"
                                            Flow Length=402'   Tc=3.7 min   CN=98   Runoff=4.32 cfs  2.927 af

Subcatchment 3S: MPMR Analysis 2 ExistingRunoff Area=0.781 ac   0.00% Impervious   Runoff Depth=1.61"
                                           Flow Length=233'   Tc=66.7 min   CN=23   Runoff=0.26 cfs  0.105 af

Subcatchment 4S: MPMR Analysis 2          Runoff Area=0.781 ac   100.00% Impervious   Runoff Depth>14.64"
                             Flow Length=233'   Slope=0.0050 '/'   Tc=2.9 min   CN=98   Runoff=1.41 cfs  0.953 af

              Total Runoff Area = 6.362 ac   Runoff Volume = 4.306 af   Average Runoff Depth = 8.12"
                                       50.00% Pervious = 3.181 ac     50.00% Impervious = 3.181 ac
```

Summary for Subcatchment 1S: ETR Analysis 2 Existing

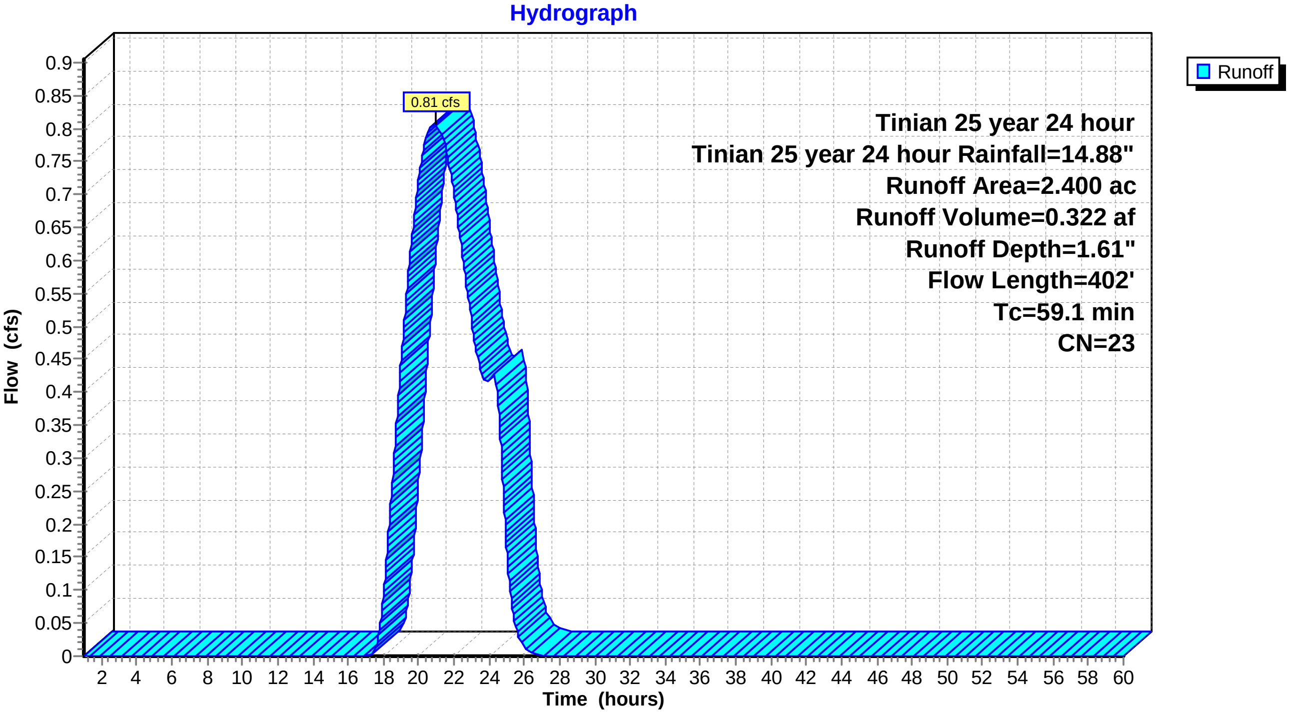
Runoff = 0.81 cfs @ 20.95 hrs, Volume= 0.322 af, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 25 year 24 hour Tinian 25 year 24 hour Rainfall=14.88"

	Area (ac)	CN	Description
*	2.400	23	
	2.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
40.3	150	0.0140	0.06		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
18.8	252	0.0080	0.22		**Shallow Concentrated Flow, Shalloe Concentrated Flow Existing** Forest w/Heavy Litter Kv= 2.5 fps
59.1	402	Total			

Subcatchment 1S: ETR Analysis 2 Existing



Summary for Subcatchment 2S: ETR Analysis 2 Proposed

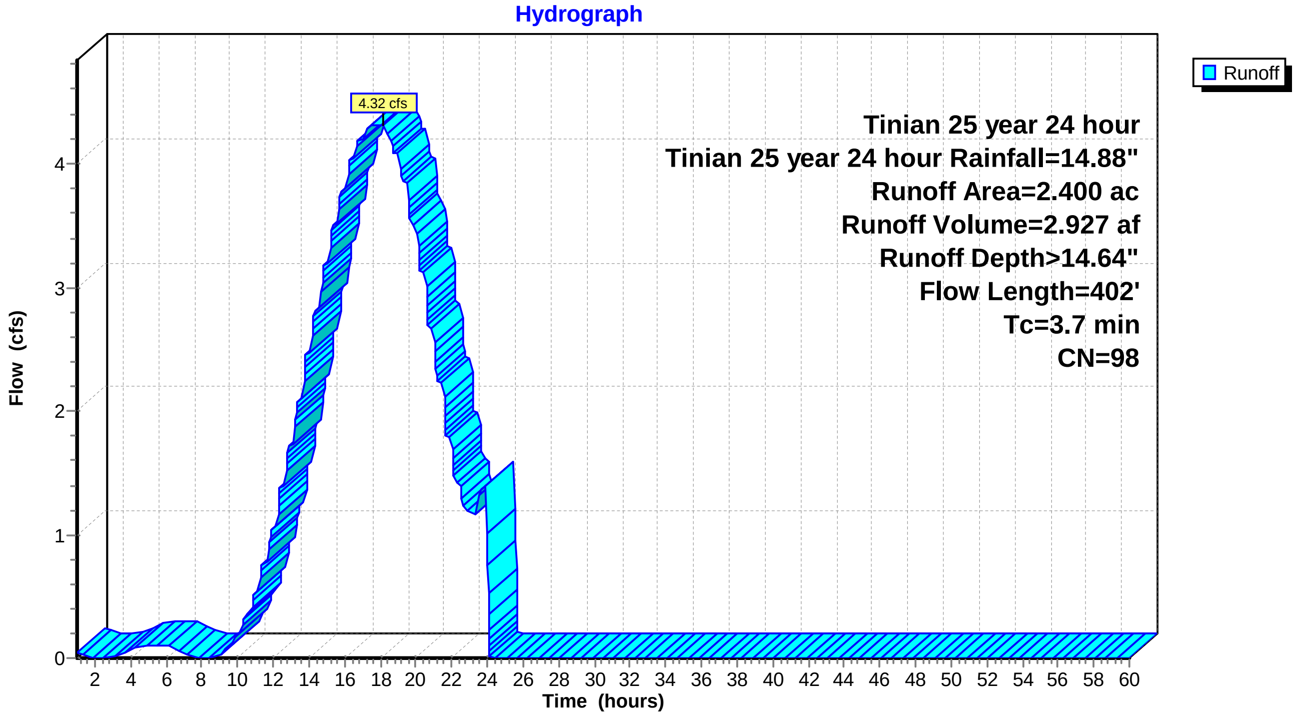
Runoff = 4.32 cfs @ 18.13 hrs, Volume= 2.927 af, Depth>14.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 25 year 24 hour Tinian 25 year 24 hour Rainfall=14.88"

	Area (ac)	CN	Description
*	2.400	98	
	2.400		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	100	0.0170	1.91		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
2.8	302	0.0080	1.82		**Shallow Concentrated Flow, Shalloe Concentrated Flow Proposed** Paved Kv= 20.3 fps
3.7	402	Total			

Subcatchment 2S: ETR Analysis 2 Proposed



Summary for Subcatchment 3S: MPMR Analysis 2 Existing

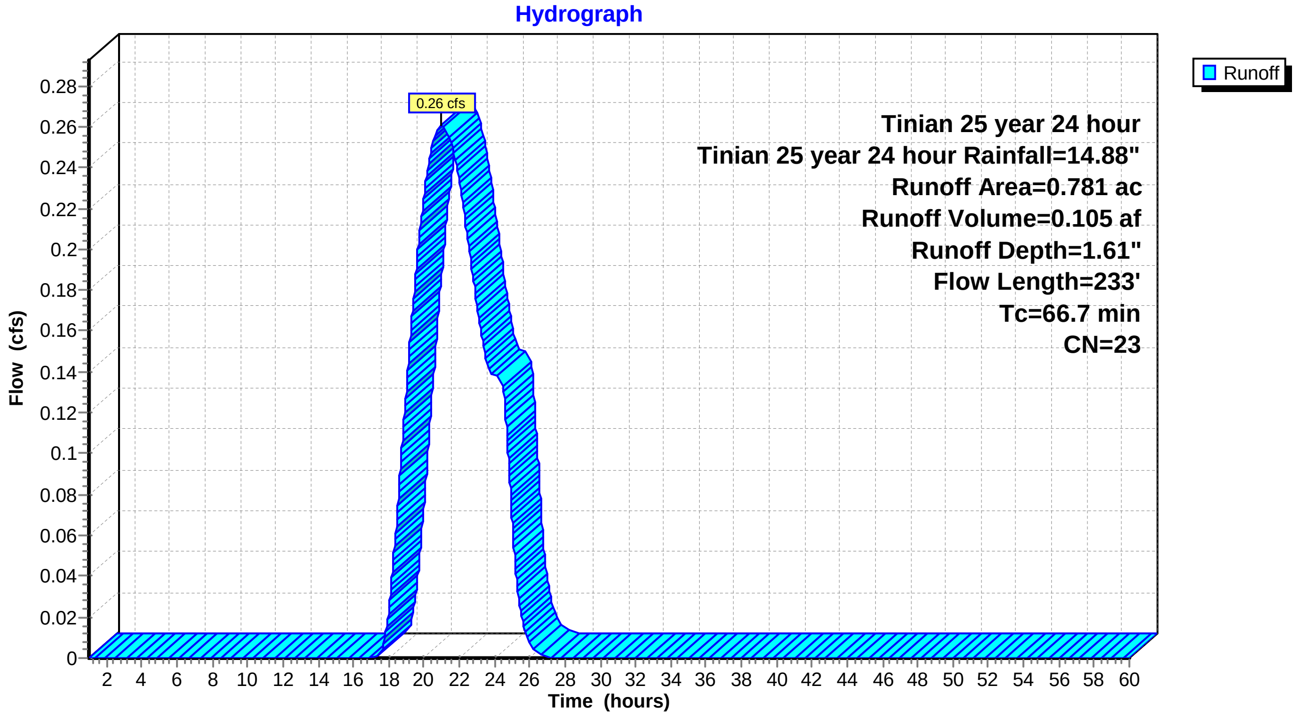
Runoff = 0.26 cfs @ 20.98 hrs, Volume= 0.105 af, Depth= 1.61"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 25 year 24 hour Tinian 25 year 24 hour Rainfall=14.88"

	Area (ac)	CN	Description
*	0.781	23	
	0.781		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
56.6	150	0.0060	0.04		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
10.1	83	0.0030	0.14		**Shallow Concentrated Flow, Shallow Concentrated Flow** Forest w/Heavy Litter Kv= 2.5 fps
66.7	233	Total			

Subcatchment 3S: MPMR Analysis 2 Existing



Summary for Subcatchment 4S: MPMR Analysis 2 Proposed

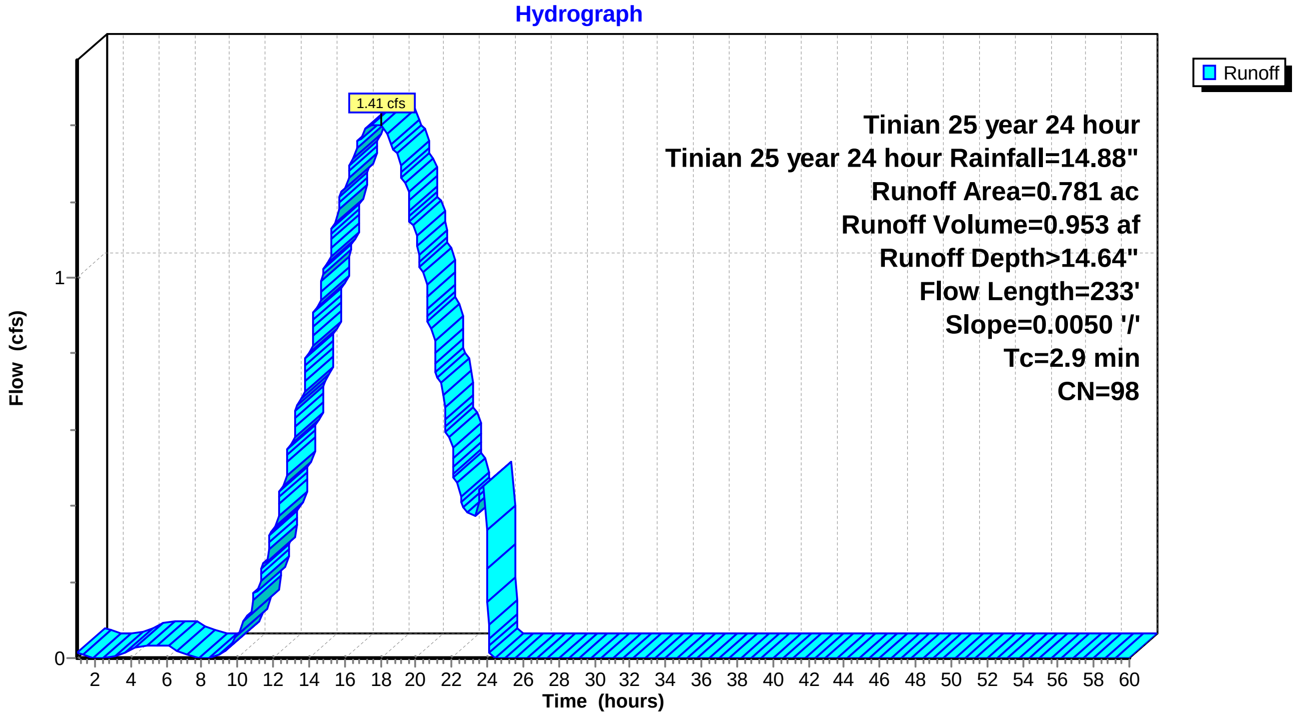
Runoff = 1.41 cfs @ 18.07 hrs, Volume= 0.953 af, Depth>14.64"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 25 year 24 hour Tinian 25 year 24 hour Rainfall=14.88"

	Area (ac)	CN	Description
*	0.781	98	
	0.781		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	100	0.0050	1.17		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
1.5	133	0.0050	1.44		**Shallow Concentrated Flow, Shalloe Concentrated Flow Proposed** Paved Kv= 20.3 fps
2.9	233	Total			

Subcatchment 4S: MPMR Analysis 2 Proposed



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                 Time span=1.00-60.00 hrs, dt=0.01 hrs, 5901 points
                  Runoff by SCS TR-20 method, UH=SCS, Weighted-CN
          Reach routing by Stor-Ind+Trans method  -  Pond routing by Stor-Ind method

Subcatchment 1S: ETR Analysis 2 Existing   Runoff Area=2.400 ac   0.00% Impervious   Runoff Depth=0.00"
                                     Flow Length=402'   Tc=59.1 min   CN=23   Runoff=0.00 cfs  0.000 af

Subcatchment 2S: ETR Analysis 2          Runoff Area=2.400 ac   100.00% Impervious   Runoff Depth=1.97"
                                      Flow Length=402'   Tc=3.7 min   CN=98   Runoff=0.63 cfs  0.395 af

Subcatchment 3S: MPMR Analysis 2 ExistingRunoff Area=0.781 ac   0.00% Impervious   Runoff Depth=0.00"
                                     Flow Length=233'   Tc=66.7 min   CN=23   Runoff=0.00 cfs  0.000 af

Subcatchment 4S: MPMR Analysis 2         Runoff Area=0.781 ac   100.00% Impervious   Runoff Depth=1.97"
                       Flow Length=233'   Slope=0.0050 '/'   Tc=2.9 min   CN=98   Runoff=0.20 cfs  0.128 af

             Total Runoff Area = 6.362 ac   Runoff Volume = 0.523 af   Average Runoff Depth = 0.99"
                                          50.00% Pervious = 3.181 ac     50.00% Impervious = 3.181 ac
```

Summary for Subcatchment 1S: ETR Analysis 2 Existing

[45] Hint: Runoff=Zero

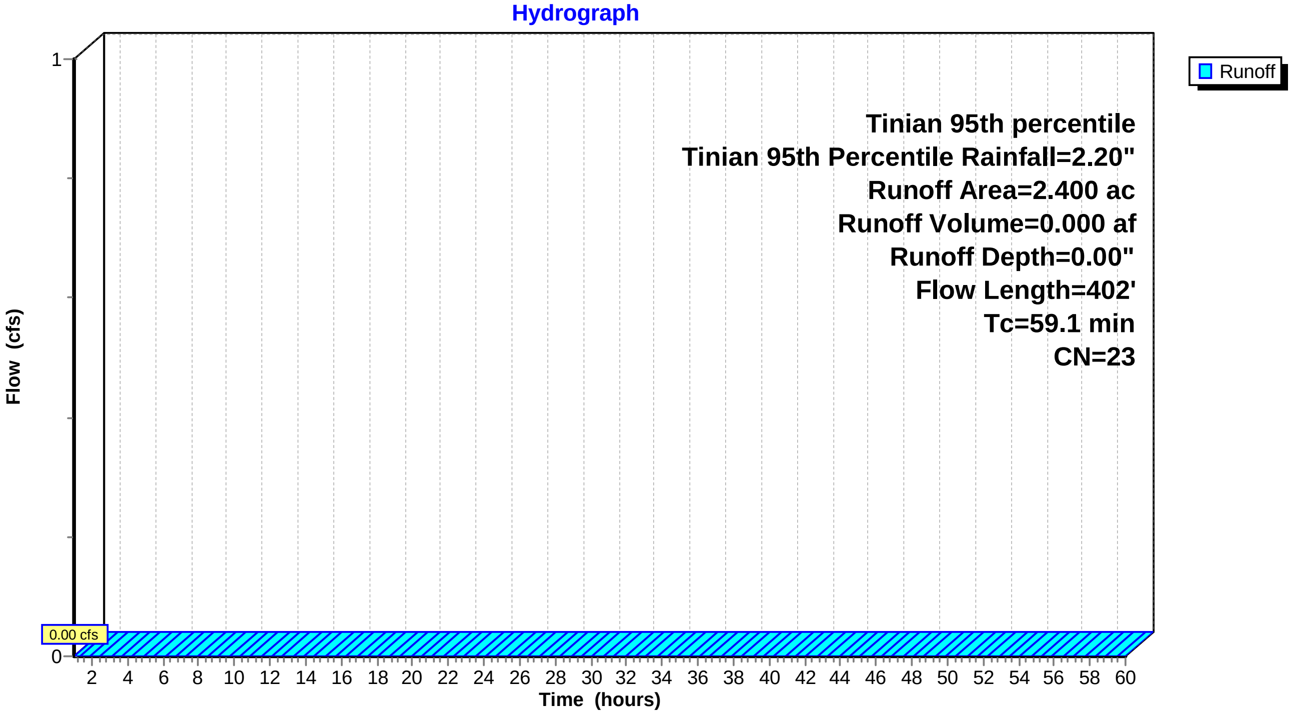
Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 95th percentile Tinian 95th Percentile Rainfall=2.20"

	Area (ac)	CN	Description
*	2.400	23	
	2.400		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
40.3	150	0.0140	0.06		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
18.8	252	0.0080	0.22		**Shallow Concentrated Flow, Shalloe Concentrated Flow Existing** Forest w/Heavy Litter Kv= 2.5 fps
59.1	402	Total			

Subcatchment 1S: ETR Analysis 2 Existing



Summary for Subcatchment 2S: ETR Analysis 2 Proposed

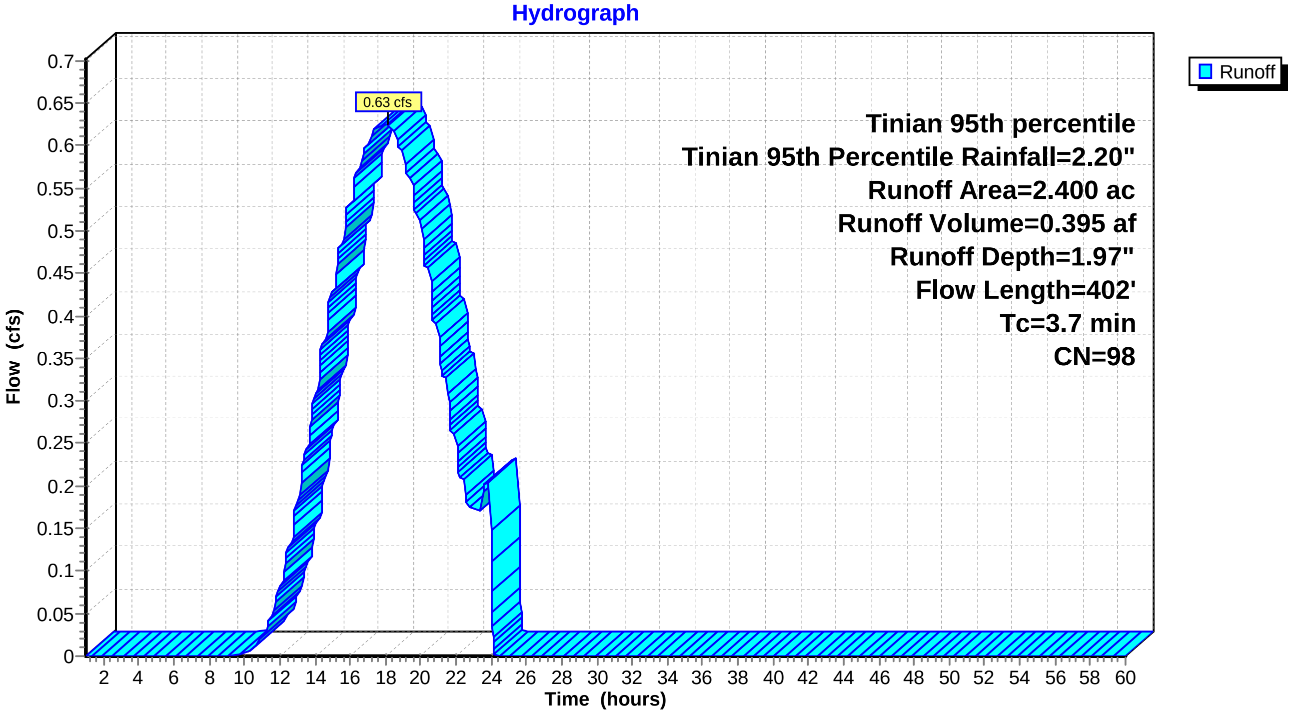
Runoff = 0.63 cfs @ 18.13 hrs, Volume= 0.395 af, Depth= 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 95th percentile Tinian 95th Percentile Rainfall=2.20"

	Area (ac)	CN	Description
*	2.400	98	
	2.400		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
0.9	100	0.0170	1.91		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
2.8	302	0.0080	1.82		**Shallow Concentrated Flow, Shalloe Concentrated Flow Proposed** Paved Kv= 20.3 fps
3.7	402	Total			

Subcatchment 2S: ETR Analysis 2 Proposed



Summary for Subcatchment 3S: MPMR Analysis 2 Existing

[45] Hint: Runoff=Zero

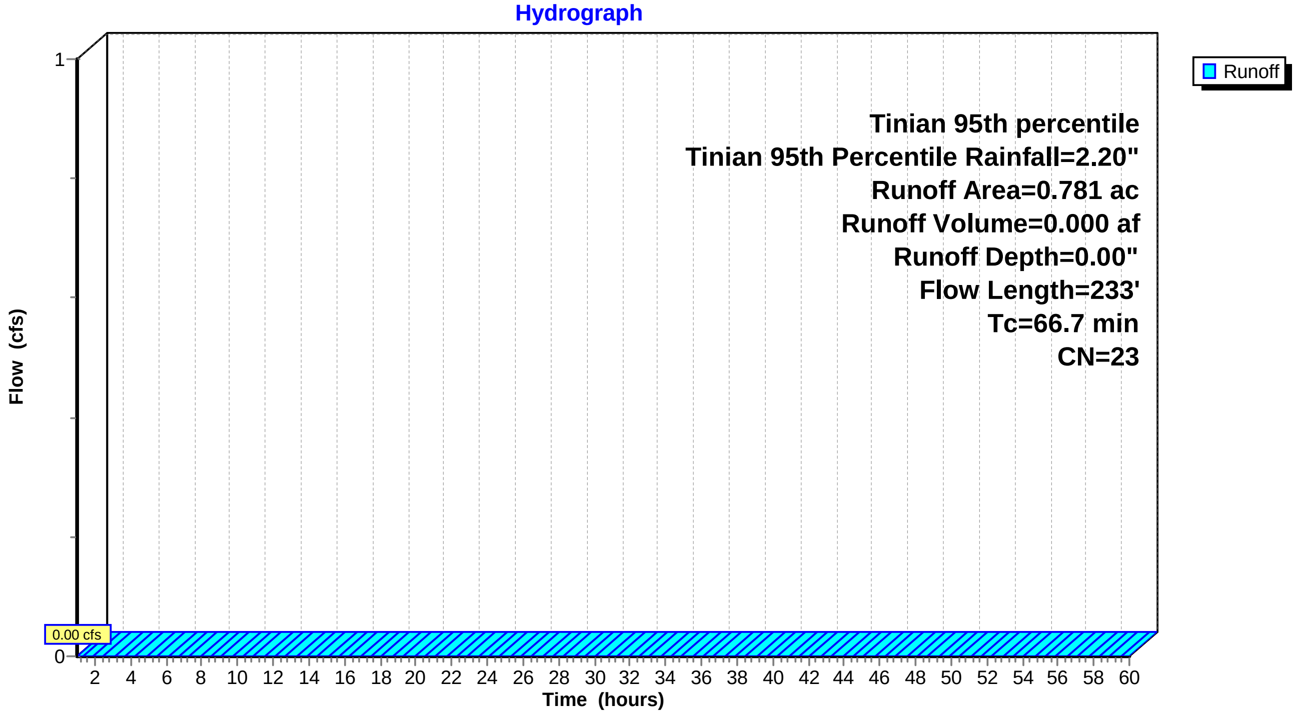
Runoff = 0.00 cfs @ 1.00 hrs, Volume= 0.000 af, Depth= 0.00"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 95th percentile Tinian 95th Percentile Rainfall=2.20"

	Area (ac)	CN	Description
*	0.781	23	
	0.781		100.00% Pervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
56.6	150	0.0060	0.04		**Sheet Flow, Sheet Flow Existing** Woods: Dense underbrush n= 0.800 P2= 7.00"
10.1	83	0.0030	0.14		**Shallow Concentrated Flow, Shallow Concentrated Flow** Forest w/Heavy Litter Kv= 2.5 fps
66.7	233	Total			

Subcatchment 3S: MPMR Analysis 2 Existing



Summary for Subcatchment 4S: MPMR Analysis 2 Proposed

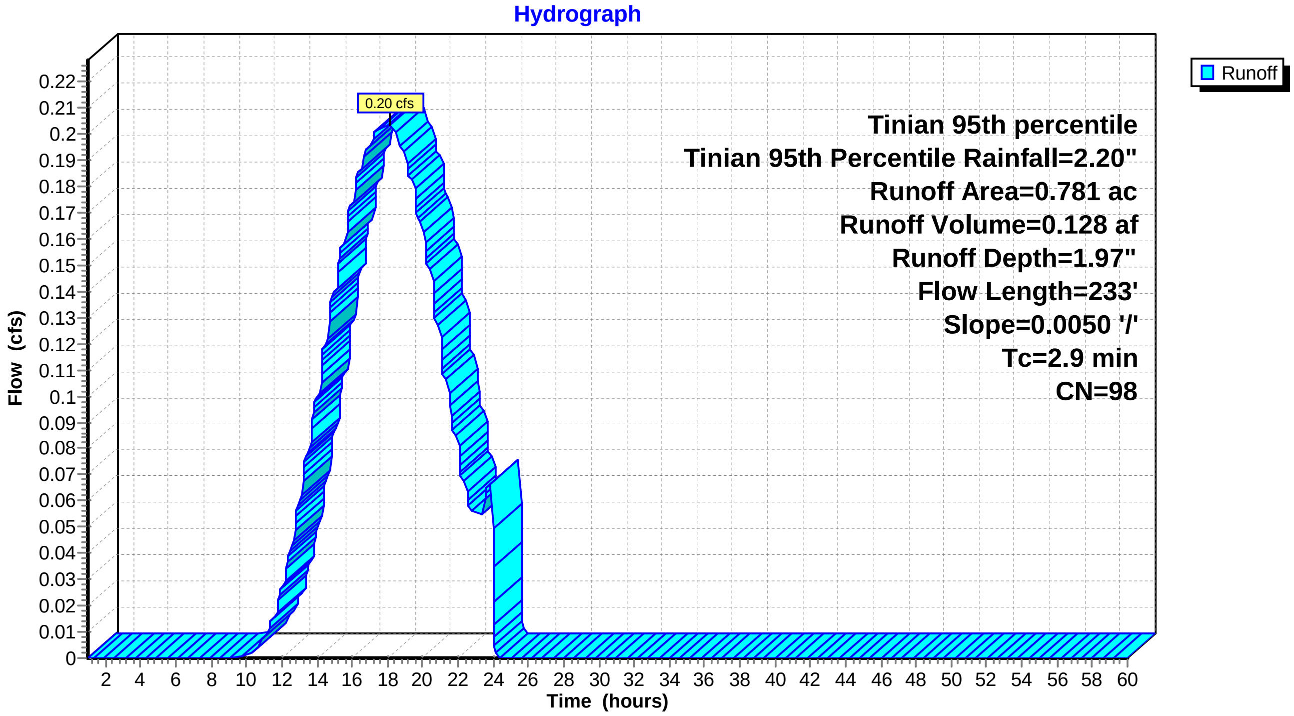
Runoff = 0.20 cfs @ 18.11 hrs, Volume= 0.128 af, Depth= 1.97"

Runoff by SCS TR-20 method, UH=SCS, Weighted-CN, Time Span= 1.00-60.00 hrs, dt= 0.01 hrs
Tinian 95th percentile Tinian 95th Percentile Rainfall=2.20"

	Area (ac)	CN	Description
*	0.781	98	
	0.781		100.00% Impervious Area

Tc (min)	Length (feet)	Slope (ft/ft)	Velocity (ft/sec)	Capacity (cfs)	Description
1.4	100	0.0050	1.17		**Sheet Flow, Sheet Flow Proposed** Smooth surfaces n= 0.011 P2= 7.00"
1.5	133	0.0050	1.44		**Shallow Concentrated Flow, Shalloe Concentrated Flow Proposed** Paved Kv= 20.3 fps
2.9	233	Total			

Subcatchment 4S: MPMR Analysis 2 Proposed



ATTACHMENT A.3
CALCULATIONS

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Base Camp Hydrologic Parameters and Assumptions

Planning-Level Flow Path, Curve Number, and Impervious Area Inputs

Time of Concentration and Flow Path Parameters

Parameter	Units	Existing	Proposed	Notes
Length of longest sheet flow path	ft	150.00	100.00	CNMI max limits
Elevation at U/S of sheet flow	ft	74.03	74.03	—
Elevation at D/S of sheet flow	ft	72.21	73.05	—
Sheet flow slope	ft/ft	-0.01	-0.01	Derived
Length of longest shallow concentrated flow path	ft	691.83	741.83	Forested
Elevation at U/S of shallow concentrated flow	ft	72.21	73.05	—
Elevation at D/S of shallow concentrated flow	ft	64.44	64.44	—
Shallow concentrated flow slope	ft/ft	-0.01	-0.01	Derived

Land Use and Curve Number Assumptions

Parameter	Existing	Proposed
Land Use	Forested	Developed
Curve Number (CN)	22.50	98.00

Impervious Area Summary (Proposed Condition)

Parameter	Value
Total Impervious Area	549,980 sq ft
Total Impervious Area	**12.63 acres**

Reference Curve Number Table

Land Use	A	B	C	D
Bare Ground	68.20	75.60	85.70	90.30
Grassland	30.10	51.10	64.90	71.60
Scrub	23.30	38.50	55.30	61.60
Mixed Forest	22.50	45.20	60.60	68.20
Native Forest	22.50	45.20	60.60	68.20
Wetland	72.8	81.6	85.7	88.8
Commercial	98.00	98.00	98.00	98.00

Source: Stormwater Design Criteria Revised Memorandum (Appendix A.4)

Notes:

1. Time of concentration parameters were developed in accordance with CNMI Stormwater Management Manual criteria, including maximum sheet flow lengths for existing and proposed conditions.

2. The proposed condition was conservatively represented as developed (CN = 98) for planning-level evaluation to bound runoff response.

3. Impervious area represents anticipated MPMR footprint used consistently across runoff, water quality, and recharge calculations.

4. Parameters shown here support the combined stormwater modeling described in the main narrative and summarized in Appendix A.

MPMR Hydrologic Parameters and Assumptions

Planning-Level Flow Path, Curve Number, and Impervious Area Inputs

Time of Concentration and Flow Path Parameters

Parameter	Units	Existing	Proposed	Notes
Length of longest sheet flow path	ft	150.00	100.00	CNMI max limits
Elevation at U/S of sheet flow	ft	22.57	22.57	—
Elevation at D/S of sheet flow	ft	21.71	22.10	—
Sheet flow slope	ft/ft	-0.01	-0.01	Derived
Length of longest shallow concentrated flow path	ft	83.27	133.27	Forested
Elevation at U/S of shallow concentrated flow	ft	21.71	22.1	—
Elevation at D/S of shallow concentrated flow	ft	21.42	21.42	—
Shallow concentrated flow slope	ft/ft	0.00	-0.01	Derived

Land Use and Curve Number Assumptions

Parameter	Existing	Proposed
Land Use	Forested	Developed
Curve Number (CN)	22.50	98.00

Impervious Area Summary (Proposed Condition)

Parameter	Value
Total Impervious Area	34,000 sq ft
Total Impervious Area	0.78 acres

Notes:

1. Time of concentration parameters were developed in accordance with CNMI Stormwater Management Manual criteria, including maximum sheet flow lengths for existing and proposed conditions.

2. The proposed condition was conservatively represented as developed (CN = 98) for planning-level evaluation to bound runoff response.

3. Impervious area represents anticipated MPMR footprint used consistently across runoff, water quality, and recharge calculations.

4. Parameters shown here support the combined stormwater modeling described in the main narrative and summarized in Appendix A.

Source: *CNMI Stormwater Management Manual, Volume 1 (Final)*

Summary of Combined Stormwater Analysis Results

Base Camp and MPMR – Existing and Proposed Conditions

HydroCAD Modeling Inputs

Parameter	Units	Base Camp Existing	Base Camp Proposed	MPMR Existing	MPMR Proposed
95th-Percentile Water Quality Storm	in	2.20	2.20	2.20	2.20
1-yr, 24-hr Rainfall Depth	in	4.25	4.25	4.25	4.25
25-yr, 24-hr Rainfall Depth	in	14.88	14.88	14.88	14.88
Drainage Area	acres	12.63	12.63	0.78	0.78
Weighted Curve Number	—	**22.50**	**98.00**	**22.50**	**98.00**
Flow Length	ft	842.0	842.0	233.0	233.0
Time of Concentration (Tc)	min	86.90	7.10	66.7	2.9

Runoff Results – 95th-Percentile Water Quality Storm

Metric	Units	Base Camp Existing	Base Camp Proposed	Change	MPMR Existing	MPMR Proposed	Change
Runoff Volume	ac-ft	0.00	2.08	2.08	0.00	0.13	**0.13**
Runoff Depth	in	0.00	1.97	1.97	0	1.97	**1.97**
Peak Flow	cfs	0.00	3.29	3.29	0	0.20	**0.20**

Runoff Results – 1-Year, 24-Hour Storm

Metric	Units	Base Camp Existing	Base Camp Proposed	Change	MPMR Existing	MPMR Proposed	Change
Runoff Volume	ac-ft	0.00	4.22	4.22	0.00	0.26	**0.26**
Runoff Depth	in	0.00	4.01	4.01	0	4.01	**4.01**
Peak Flow	cfs	0.00	6.46	6.46	0	0.40	**0.40**

Runoff Results – 25-Year, 24-Hour Storm

Metric	Units	Base Camp Existing	Base Camp Proposed	Change	MPMR Existing	MPMR Proposed	Change
Runoff Volume	ac-ft	1.69	15.40	13.71	0.11	0.95	**0.85**
Runoff Depth	in	1.61	14.64	13.03	1.61	14.64	**13.03**
Peak Flow	cfs	4.13	22.73	18.6	0.26	1.41	**1.15**

Rainfall depths used in the stormwater analysis were based on CNMI Stormwater Management criteria for Tinian, as summarized in Table 1.4, Summary of Data for Use on Tinian and Pagan (Referenced Values for Use in CJMT Task 11m Study). The 95th-percentile water quality storm (2.20 inches) and the 1-year and 25-year, 24-hour rainfall depths (4.25 inches and 14.88 inches, respectively) were applied consistently across the Base Camp and MPMR analyses.

The 25-year, 24-hour storm event was also used for comparison with applicable overbank flood control criteria, which specify that post-development peak discharge rates should not exceed pre-development peak discharge rates for the 25-year event, consistent with CNMI guidance.

Source:

CNMI Stormwater Management Manual; Table 1.4 – Summary of Data for Use on Tinian and Pagan; Stormwater Design Criteria Revised Memorandum (Appendix A.4).

Water Quality Volume (WQv) Calculations

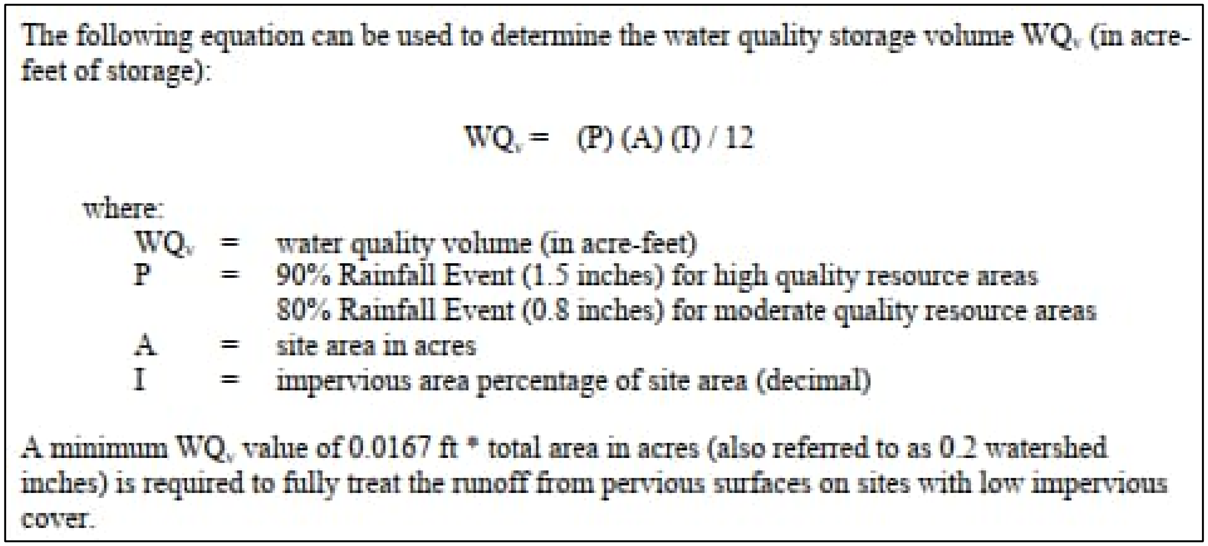
90% of Average Annual Storm – High Quality Resource Areas / Hotspots

Parameter	Units	Base Camp (E)	MPMR
Precipitation, P	in	1.50	1.50
Drainage Area, A	acres	12.63	0.78
Impervious Area	acres	12.63	0.78
Impervious Fraction, I	–	1.00	1.00
Water Quality Volume, WQv (90%)	acre-ft	1.58	0.10
Minimum WQv	acre-ft	0.21	0.01
Sedimentation Volume	acre-ft	0.40	0.03

Source: CNMI Stormwater Management Manual, Volume 1 (Final)

Notes:

1. *WQv values were used to inform planning-level water quality and sedimentation storage requirements and are not intended to represent final design sizing.*
2. *Impervious fraction (I) was conservatively assumed as 1.00 for planning-level evaluation, consistent with bounding assumptions used elsewhere in the combined stormwater analysis.*
3. *The 90-percent average annual storm depth of 1.5 inches was applied in accordance with CNMI stormwater criteria for high-quality resource areas and hotspots.*



The following equation can be used to determine the water quality storage volume WQ_v (in acre-feet of storage):

$$WQ_v = (P)(A)(I) / 12$$

where:

WQ_v = water quality volume (in acre-feet)
P = 90% Rainfall Event (1.5 inches) for high quality resource areas
80% Rainfall Event (0.8 inches) for moderate quality resource areas
A = site area in acres
I = impervious area percentage of site area (decimal)

A minimum WQ_v value of 0.0167 ft * total area in acres (also referred to as 0.2 watershed inches) is required to fully treat the runoff from pervious surfaces on sites with low impervious cover.

Recharge Volume (Re_v) Calculations

CNMI Recharge Criteria – Planning-Level Evaluation

Recharge Volume Summary

Parameter	Units	Base Camp (E)	MPMR
Precipitation, P	in	1.50	1.50
Drainage Area, A	acres	12.63	0.78
Impervious Area	acres	12.63	0.78
Impervious Fraction, I	–	1.00	1.00
Recharge Volume, Re_v	**acre-ft**	**1.58**	**0.10**

Notes:

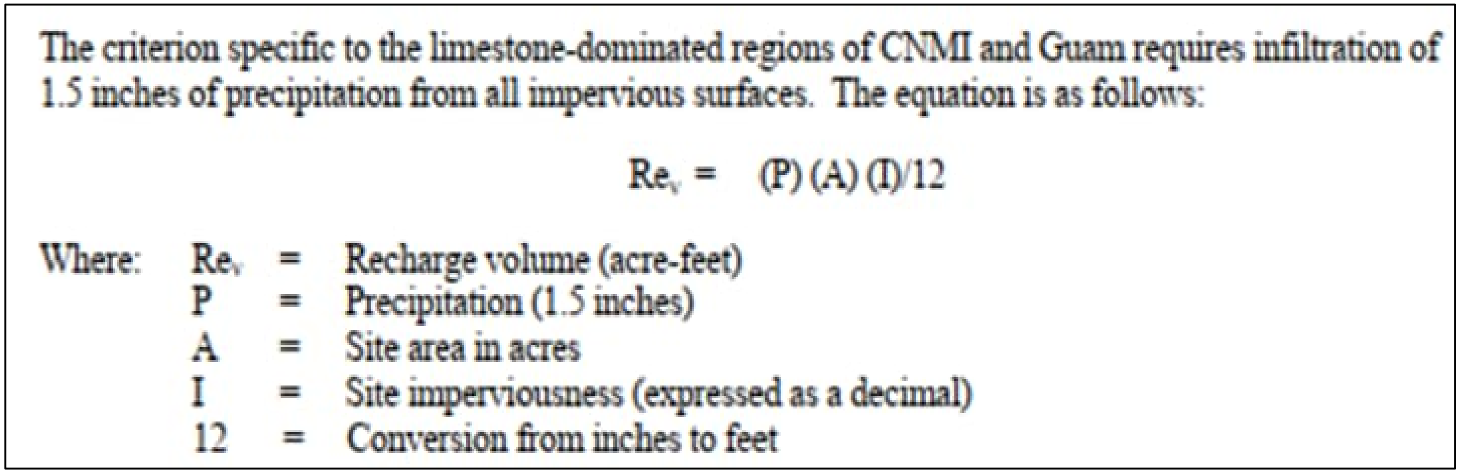
1. Recharge volumes were calculated in accordance with the CNMI Stormwater Management Manual (Volume 1) for limestone-dominated conditions..

2. Impervious fraction (I) was conservatively assumed as 1.00 for planning-level evaluation to bound recharge requirements.

3. The precipitation depth of 1.5 inches represents the CNMI recharge criterion for limestone-dominated areas; volcanic-dominated criteria do not apply.

Recharge Methodology (CNMI Stormwater Manual)

Limestone-Dominated Areas



The criterion specific to the limestone-dominated regions of CNMI and Guam requires infiltration of 1.5 inches of precipitation from all impervious surfaces. The equation is as follows:

$$Re_v = (P)(A)(I)/12$$

Where: Re_v = Recharge volume (acre-feet)
P = Precipitation (1.5 inches)
A = Site area in acres
I = Site imperviousness (expressed as a decimal)
12 = Conversion from inches to feet

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