CNMI and Guam Stormwater Management Criteria

Phase I Final Report

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Prepared for:
Commonwealth of the Northern Mariana Islands
Territory of Guam

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1.0 EXECUTIVE SUMMARY

Guam and the Commonwealth of the Northern Marina Islands (CNMI) receive a lot of rain! The average annual rainfall exceeds 100 inches per year in many locations. During the rainy season, typhoons can drop 10-15 inches of precipitation in one storm event.

These climatic conditions combined with the region's unique limestone, volcanic geologic formations, sensitive water resources and significant land development forces make stormwater a very significant environmental and economic issue.

Historically, stormwater has been viewed as strictly a drainage issue and has been routed to the nearest discharge location, has been infiltrated into the highly-permeable limestones with little or no pre-treatment, or has been conveyed directly to receiving waters.

Along with development comes increased amounts of impervious surfaces, precluding the natural infiltration of rainwater into the underlying groundwater system. As a result, the groundwater "lens" (which serves as the principle drinking water source) is depleted. Or, in the instances where stormwater is infiltrated without adequate pre-treatment, groundwater quality is degraded.

This report presents an analysis of these important issues and presents a recommended approach to improve upon current stormwater management practices. Management strategies and technologies, which have been implemented in other areas, have been reviewed and where appropriate have been incorporated into recommendations for consideration in Guam and CNMI.

A set of unified "criteria" is recommended as a framework for comprehensive management of stormwater. These criteria provide proposed standards to augment groundwater recharge to achieve water quality protection, prevent accelerated stream channels, prevent erosion, reduce flooding threats, and preserve sensitive habitats.

Specific design standards are recommended for sensitive environmental resources areas such as drinking water supplies and wetlands and a set of tiered standards are provided to match freshwater and coastal water classifications that have already been developed for Guam and CNMI.

Finally, the report provides an overview of existing governmental programs and regulations, which are relevant to stormwater management. Preliminary recommendations are provided for regulatory amendments, where appropriate, to incorporate the proposed design criteria and standards.

2.0 INTRODUCTION

Stormwater management has evolved dramatically throughout the United States and its territories and commonwealths since it was first adopted and applied in several regions of the country as early as the late 1970's. Much has been learned about what works in the field and what doesn't. The ultimate goal of the Guam and the Commonwealth of the Northern Mariana Islands (CNMI) Stormwater Management Manual is to compile this hard-won knowledge and experience into a single comprehensive design handbook that is useful to engineers, plan reviewers and the regulated community. Most importantly, the Manual should provide a framework to ensure the effective implementation of stormwater management practices to protect the vital water resources of Guam and the Northern Mariana Islands.

The CNMI Division of Environmental Quality (DEQ) and the Guam Environmental Protection Agency (GEPA) have identified a need for a new guidance manual to assist the local engineering and development communities and local government agencies in developing and implementing stormwater and erosion control plans that adequately address nonpoint source pollution through the use of currently accepted Best Management Practices (BMPs). As part of the development of the Guam and the Commonwealth of the Northern Mariana Islands Stormwater Management Manual, GEPA and the CNMI DEQ commissioned Horsley Witten Group (formerly Horsley & Witten, Inc.) to develop comprehensive stormwater criteria for review and comment by the public prior to developing the Final Manual itself.

This report represents this first phase to develop a Manual for Guam and CNMI, and provides the technical foundation and supporting information for a Guam and CNMI stormwater program. The purpose of the report is to describe and resolve the numerous technical and policy issues that may ultimately be incorporated into the Stormwater Management Manual, prior to the development of a detailed document. The report should be considered a working draft and subject to review and input from interested parties. The proposed methods, sizing criteria, acceptable stormwater treatment practices, and other technical guidance contained herein were developed by Horsley Witten Group (HW) and are subject to change and modification, and do not necessarily reflect current or future policy.

3.0. PRECIPITATION CHARACTERISTICS

Rainfall data has been collected on Guam since 1906 (CDM, 1982). The mean annual rainfall ranges from slightly more than 100 inches at the northern tip of the island and in higher mountainous areas of the south to approximately 85 to 95 inches along the central and southern coasts (Duenas & Associates, 1996).

Rainfall data has been collected on Saipan since 1901 (Carruth, 2003). However, there is confusion regarding the location of some rain gauges and no long-term records are available for any one location. The lowest recorded annual rainfall on the island was approximately 34 inches in 1998 and the highest recorded annual rainfall was about 145 inches in 1978, the year of tropical storms Carmen, Winnie, and Tess. Generally, Saipan receives approximately 80 inches of rain per year, with a large percentage of the annual rainfall contributed by tropical storms (Carruth, 2003).

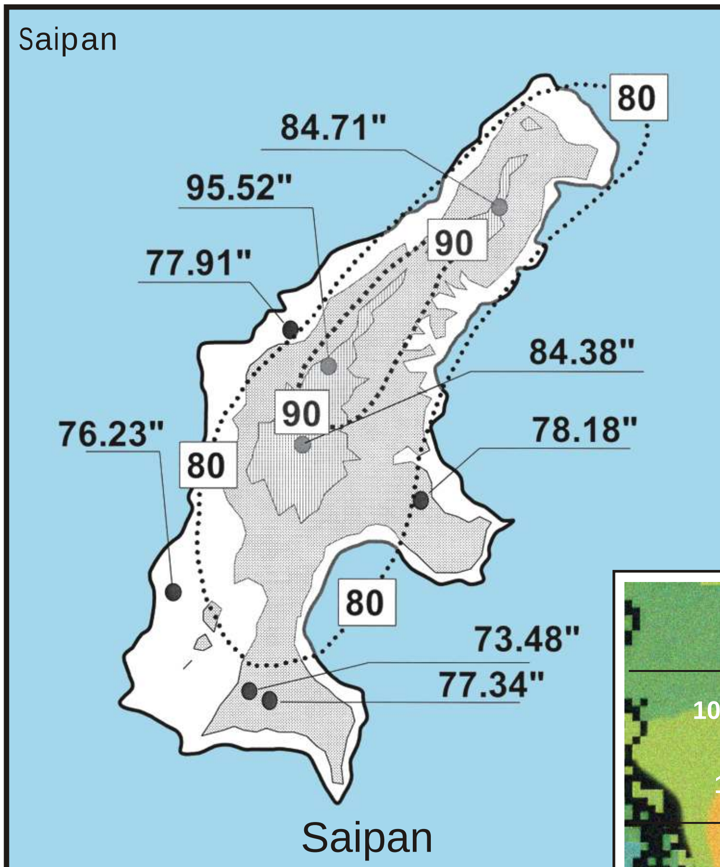
Figure 3.1 depicts the distribution of annual rainfall across Guam and the CNMI. In general, annual average rainfall amounts are greatest at the equator (south of Guam) and taper off to the north.

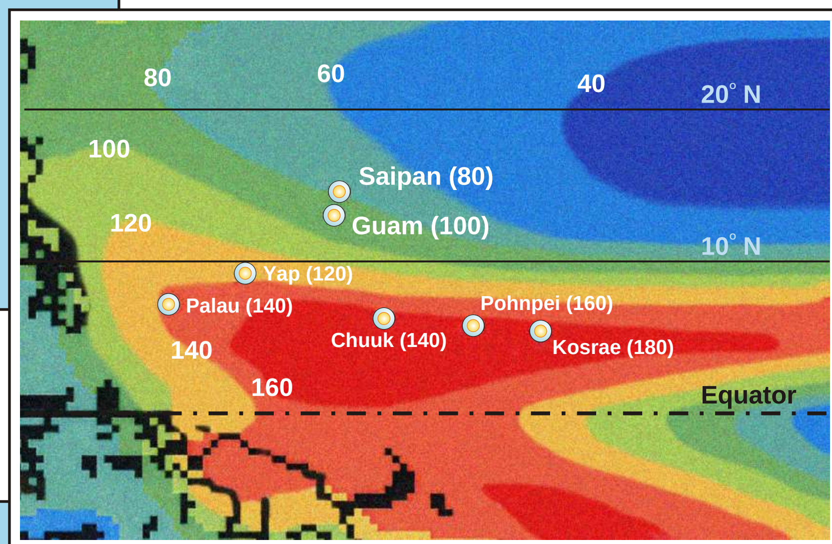
3.1 Seasonal Precipitation Distribution Characteristics

Two distinct climatic seasons occur on Guam and the CNMI: wet and dry (Duenas & Associates, 1996). The wet season on Guam, also known as the typhoon season, typically occurs from August to October, and the dry season usually occurs from December to June. November and July are considered to be the transitional months, with November marking the transition from wet to dry, and July marking the transition from dry to wet.

In northern Guam, the seasonal average rainfall during the wet season is about 12 inches per month (CDM, 1982). During the dry season, the seasonal average rainfall is about 5 inches per month on the northern portion of the island.

Distinct wet and dry seasons occur in the CNMI as well. The months of July through November are considered to be the wet season and the months of January through May are considered to be the dry season (Carruth, 2003). December and June are considered to be the transitional months. On Saipan, 67% (about 53 inches) of the rainfalls during the wet season and 21% (about 17 inches) of the rain falls during the dry season. The transitional months receive the remaining 12% (about 10 inches) of the annual rainfall. Figure 3.2 compares the monthly mean rainfall data between Guam and the CNMI (Saipan), clearly showing the marked wet/dry seasonal difference in rainfall distribution in the two locations. It should be noted that Saipan's annual rainfall is about 20 inches less than that of Guam (Lander, unpublished report).





Mean annual over-water rainfall (in inches) in Micronesia.
(adapted from Lander, unpublished report)

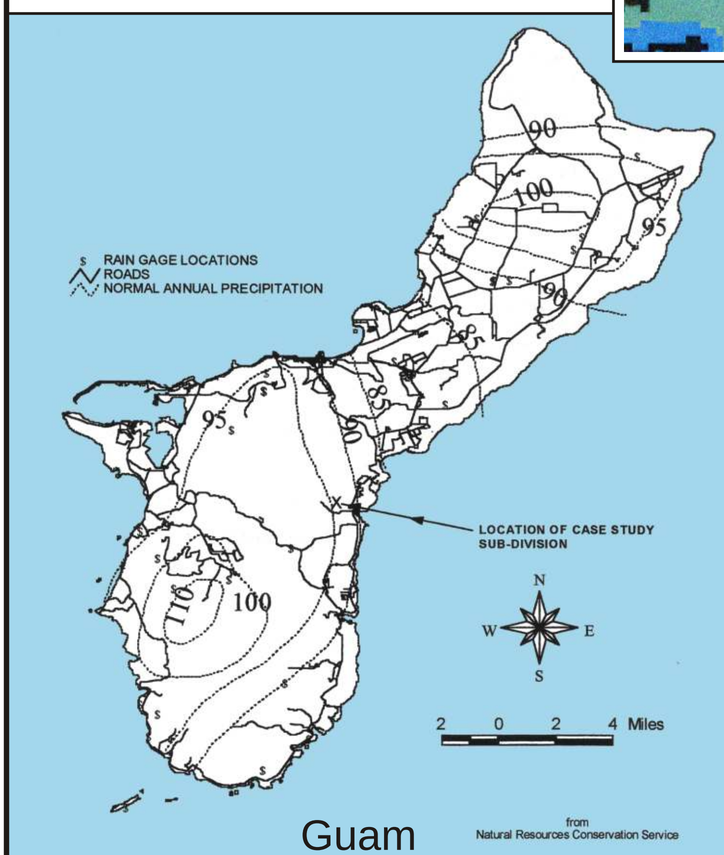


Figure 3.1 Annual precipitation values in Saipan (CNMI) and Guam
(adapted from Lander, unpublished report)

3.2 Return Intervals of 24-Hour Precipitation Events

Since 1980, Guam has used the *Guam Storm Drainage Manual* developed by the U.S. Army Corps of Engineers to provide technical guidance for stormwater planning and design (U.S. Army Corps, 1980). Since 1989, the Commonwealth of the Northern Mariana Islands (CNMI) has used the *Stormwater Control Handbook* developed by the Soil and Water Conservation Districts of Saipan and Northern Islands, Tinian and Aguiguan, and Rota to guide stormwater planning and design.

Lander (unpublished report) noted that in Guam the peak short-term rainfall rates achieved during typhoons generally greatly exceed the existing values for the 100-year return period as noted in the *Guam Storm Drainage Manual* (U.S. Army Corps,1980). In December of 1996, a letter from the University of Guam to the CNMI Natural Resources Conservation Service indicated that the CNMI annual rainfall maps developed by the US Soil Conservation Service of the Department of Agriculture (and contained in the *Stormwater Control Handbook*) may not be entirely accurate, especially in the less mountainous and coastal areas of Saipan. The letter explains that the typhoon core rainfall regime rainfall rates are dictated by the large-scale vertical motion of a typhoon, and are mostly uninfluenced by Saipan's relatively low topography. Therefore, maximum 24-hour rainfall events of 9 inches or more and return periods of 9 years or more should be based on the expectation that a typhoon will produce the rain. In these events, rainfall distribution is likely not to adhere to the current CNMI return frequency rainfall maps, but instead will be much more uniform across the island, despite topography. Extreme rainfall totals, caused by typhoons, are not a function of elevation on either Saipan or Guam (Lander, unpublished report).

Currently, Guam and the CNMI are working to produce a single technical guidance document to govern stormwater planning and design in both Guam and the CNMI. This effort will take advantage of the geographic proximity of the islands and their similar climatic regimes, and the observations of Lander and the University of Guam. The return intervals for typical design frequencies from the *Manual* and the *Handbook* are presented in Tables 1 and 2 below.

As can be seen in Figure 3.3, there is a mixed distribution of 24-hour rainfall events on Guam and the CNMI, creating two distinct relationships.

On Guam, the first relationship defines those 24-hour rainfall events of less than 10 inches, generally caused by phenomena such as thunderstorm cells, mesoscale convective systems, squall lines, and convective cloud bands in the peripheral flow of a tropical cyclone. The second relationship, on the other hand, defines those 24-hour rainfall events in excess of 10 inches, almost always caused by the direct passage of typhoons over the island.

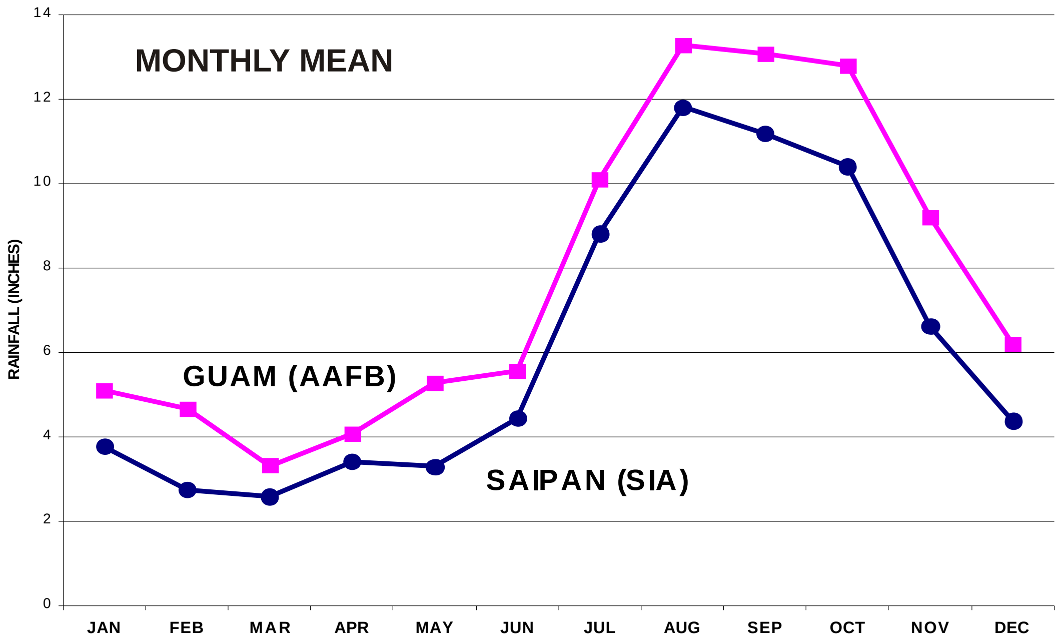


Figure 3.2 Monthly mean rainfall at Saipan International Airport and Guam's Anderson Air Force Base (in inches). Source: Lander (unpublished report)

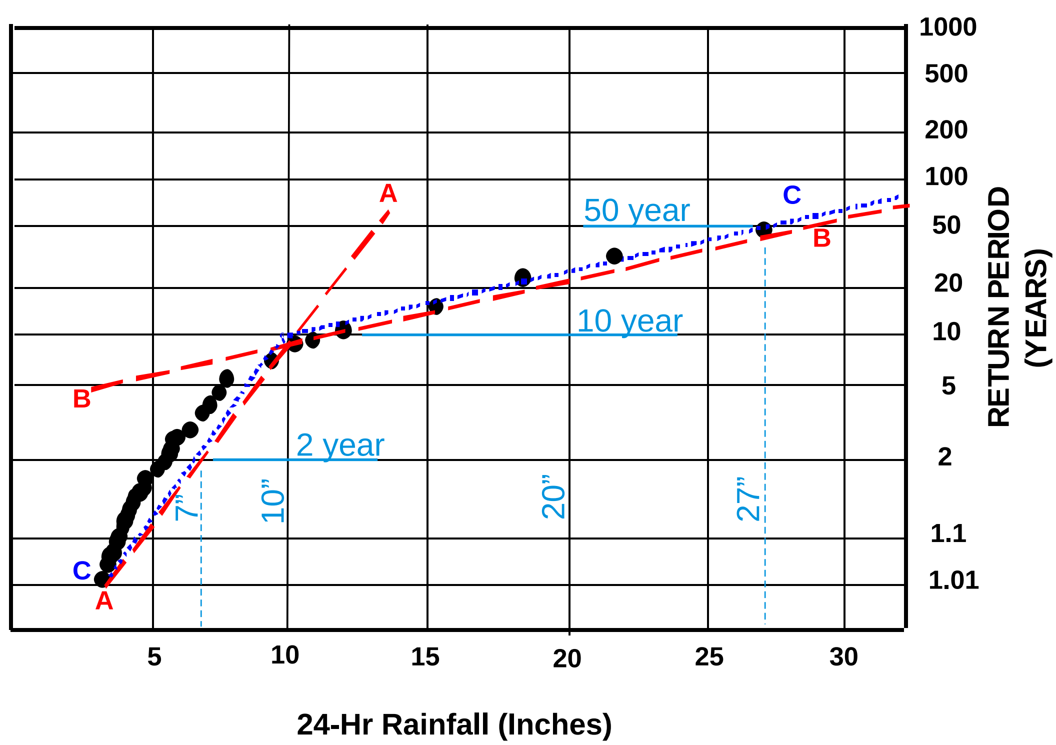


Figure 3.3 Estimated return period for different frequency storms for Guam.
Source: Landers (unpublished report)

Table 3.1 below summarizes 24-hour rainfall events on Guam as currently characterized. Lander (unpublished report) has noted that 24-hour rainfall events from typhoons may not be adequately accounted for in the table.

Table 3.1 Guam, 24-hour Rainfall Events (adapted from the Guam Storm Drainage Manual, 1980).

Recurrence Interval (years)	Exceedance Frequency (%)	Average Rainfall Amount (inches)	
		Northern Guam	Southern Guam
2	50	6.0	5.5
10	10	10.5	9.0
20	5	12.5	11.0
50	2	17	12

Since the rainfall records for the CNMI are short or incomplete, calculations of return periods of extreme rain events are fairly crude (Lander, unpublished report). More complete data from Guam can be used to make a comparison, but this is not ideal as Guam receives about an additional 20 inches of rain per year as compared to Saipan. Figure 3.3 shows the comparison. Table 3.2 below summarizes 24-hour rainfall events on Saipan as currently characterized. As with Guam, Lander (unpublished report) has noted that 24-hour rainfall events from typhoons may not be adequately accounted for in the table.

Table 3.2 Saipan, 24-hour Rainfall Events (adapted from the Storm Water Control Handbook, 1989).

Recurrence Interval (years)	Exceedance Frequency (%)	Average Rainfall Amount (inches)
2	50	5.5
10	10	10.8
25	4	13.0
50	2	14.2

Given the potential shortcomings of the data represented in the above two tables with respect to 24-hour typhoon derived rain events and the lack of consistent precipitation data records from the CNMI, consideration must be given to revising the above tables.

Using the curves developed for Guam in Figure 3.3, Table 3.1 can be revised as shown in Table 3.3 below.

Table 3.3 Guam, Revised 24-hour Rainfall Events (adapted from Lander, unpublished report).

Recurrence Interval (years)	Exceedance Frequency (%)	Average Rainfall Amount (inches)
1	100	3.5
2	50	7.0
10	10	10.0
25	4	20.0
50	2	27.0

The lack of a consistent, long-term precipitation data record for Saipan and the other islands of the CNMI hinders the development of revised tables for the CNMI. One could simply apply a percentage factor based on the observed differences in annual average precipitation records. For example, if average annual rainfall in Guam is 100 inches and average annual rainfall in Saipan is 80 inches, the average rainfall amounts in Table 3.3 above could be reduced by 20%. For conservative planning purposes, the values in Table 3.3, developed for Guam, could also be directly used in Saipan and the other islands of the CNMI. As the rainfall data record in the CNMI becomes more extensive and reliable, then separate tables for the CNMI could be developed.

4.0 ENVIRONMENTAL RESOURCE AREAS AND SENSITIVE RECEPTORS

Guam and CNMI contain a broad range of environmental resource areas, which are sensitive to stormwater discharges. Critical resource areas include groundwater, streams, lakes, wetlands, coastal embayments, bathing beach areas and coral reefs. They are impacted by both hydrologic and water quality aspects of stormwater management.

Hydrologic impacts include reductions of recharge to groundwater as a result of impervious surfaces and changes in freshwater inputs to wetland systems. Water quality impacts are numerous and include pathogens (bacteria and viruses), nutrients (nitrogen and phosphorus), metals, hydrocarbons and sediments (total suspended solids or TSS).

The purpose of this section of the report is to explain the sensitivity of the various resource areas and their potential response to stormwater management strategies, practices, and to identify key criteria and thresholds that can be utilized in developing an integrated stormwater management program, which can then be tailored to a resource-specific basis.

4.1 Groundwater

Groundwater serves as the primary source of drinking water to Guam and CNMI. Groundwater is stored in highly-permeable limestone aquifers, which were originally formed as coral reefs (Figure 4.1). In some areas, these limestone aquifers have been uplifted (and elevated) by the underlying volcanic rocks (these are called “high-level limestone aquifers”).

The only source of groundwater is precipitation, which infiltrates to the subsurface and recharges the underlying water table (the upper surface of the groundwater system). Saipan receives approximately 80 inches of precipitation per year, while Guam receives approximately 90-100 inches per year. A significant portion of this is lost to evapotranspiration; some is lost to surface runoff, and the remaining portion is available as “recharge” to groundwater. This recharge is the only source of replenishment to the groundwater system.

In Guam, the average annual recharge rate is estimated at 35 inches/year (Barrett et al., 1982). The thickness of the groundwater lens is directly related to the recharge rate and to water withdrawal rates.

As land development occurs, impervious surfaces preclude the natural infiltration of this rainwater, thereby reducing the recharge rate. This results in a lowering of the water table, a reduction of the thickness of the groundwater lens, and, ultimately, depletion of groundwater resources and increased salt water intrusion to drinking water wells.

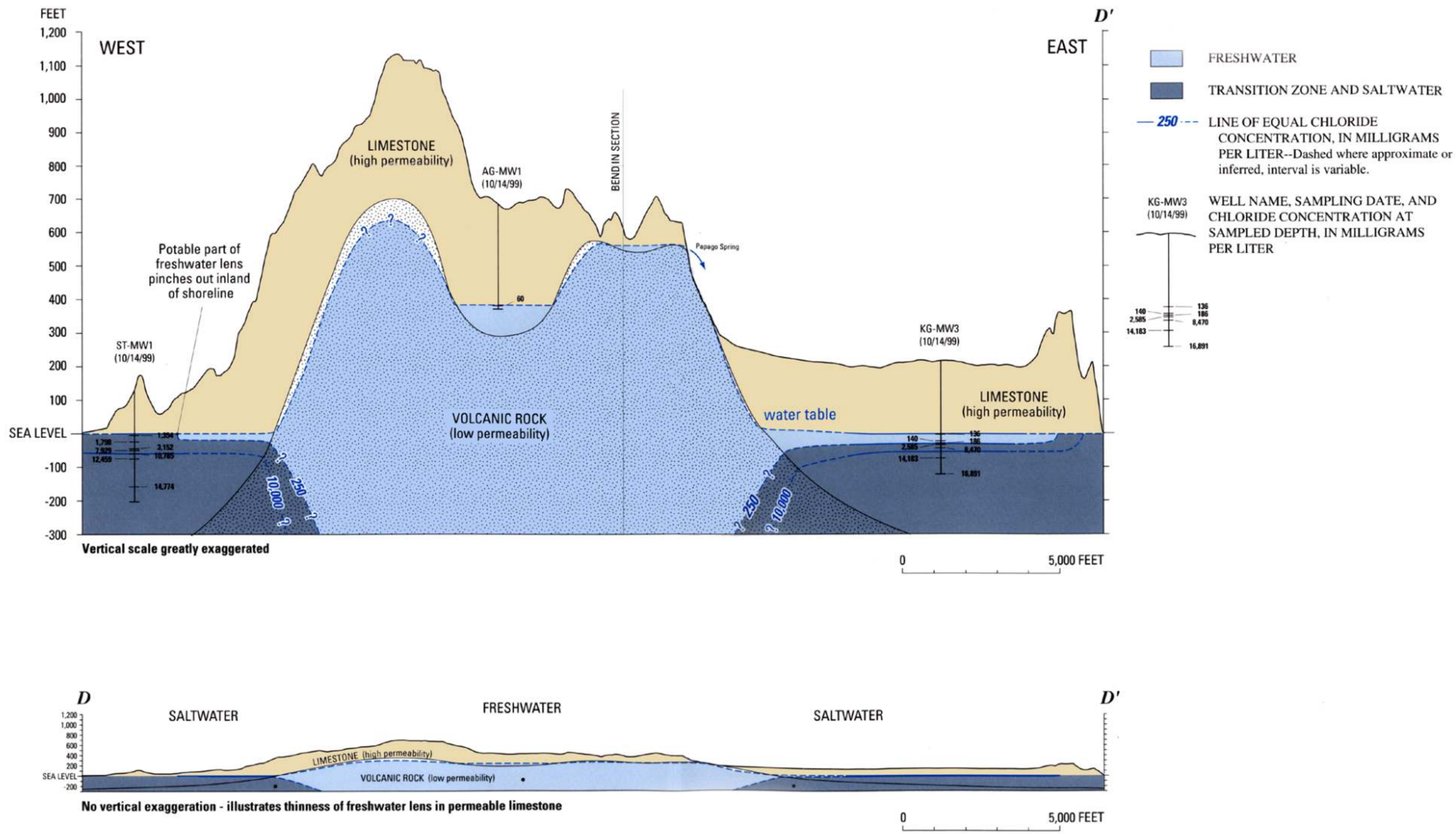


Figure 4.1 Geologic and groundwater resource characteristics of Saipan (CNMI)
(Source: USGS, Robert L. Carruth)

While some wells exist in the central mountainous regions (in “high-level limestone aquifers”), most of the wellfields are located in the lower limestone plateaus where the groundwater resource (referred to as the “basal aquifer”) is limited by a relatively thin groundwater lens, which actually “floats” on underlying saline groundwater due to its lighter density, and therefore is susceptible to saltwater intrusion, which is a significant problem for many production wells (see Figure 4.2). Therefore, the maintenance and protection of the groundwater lens is critical.

Water withdrawals for drinking water and irrigation also deplete the groundwater lens and result in declining water table elevations and corresponding decreases in the thickness of the groundwater lens. The Ghyben-Herzberg principle suggests that for each foot that the water table declines, the lens thickness decreases by 40 feet (based upon the 1:40 density ratio between fresh and salt water). Therefore, relatively small reductions in recharge and declines in the water table elevation represent significant depletion of the groundwater system.

A potential remedy for this “de-watering” impact is to collect stormwater runoff and to infiltrate it to help restore (or enhance) natural recharge rates. To some degree this already occurs in current stormwater management implementation. It is possible to collect and infiltrate enough stormwater to match the natural (pre-development) recharge rates. In many mainland U.S. locations, managers have applied measures to make it possible to infiltrate enough stormwater to actually exceed natural recharge rates. This may be a viable option to mitigate and compensate for other sources of water consumption and groundwater de-watering, such as groundwater withdrawals for drinking water and irrigation purposes on CNMI and Guam.

However, the infiltration of stormwater raises some important water quality issues. Stormwater is commonly polluted with a broad range of pollutants. Secondly, the limestone aquifers are highly permeable and, therefore, very susceptible to contamination. Thus, depending on the land use stormwater will require significant pre-treatment prior to infiltration to protect the quality of groundwater resources. This may be accomplished with certain stormwater BMPs that provide comprehensive treatment.

Wellhead protection areas have been delineated showing the specific groundwater areas that contribute to the pumping water supply wells. These areas require the highest level of protection to ensure a safe drinking water supply.

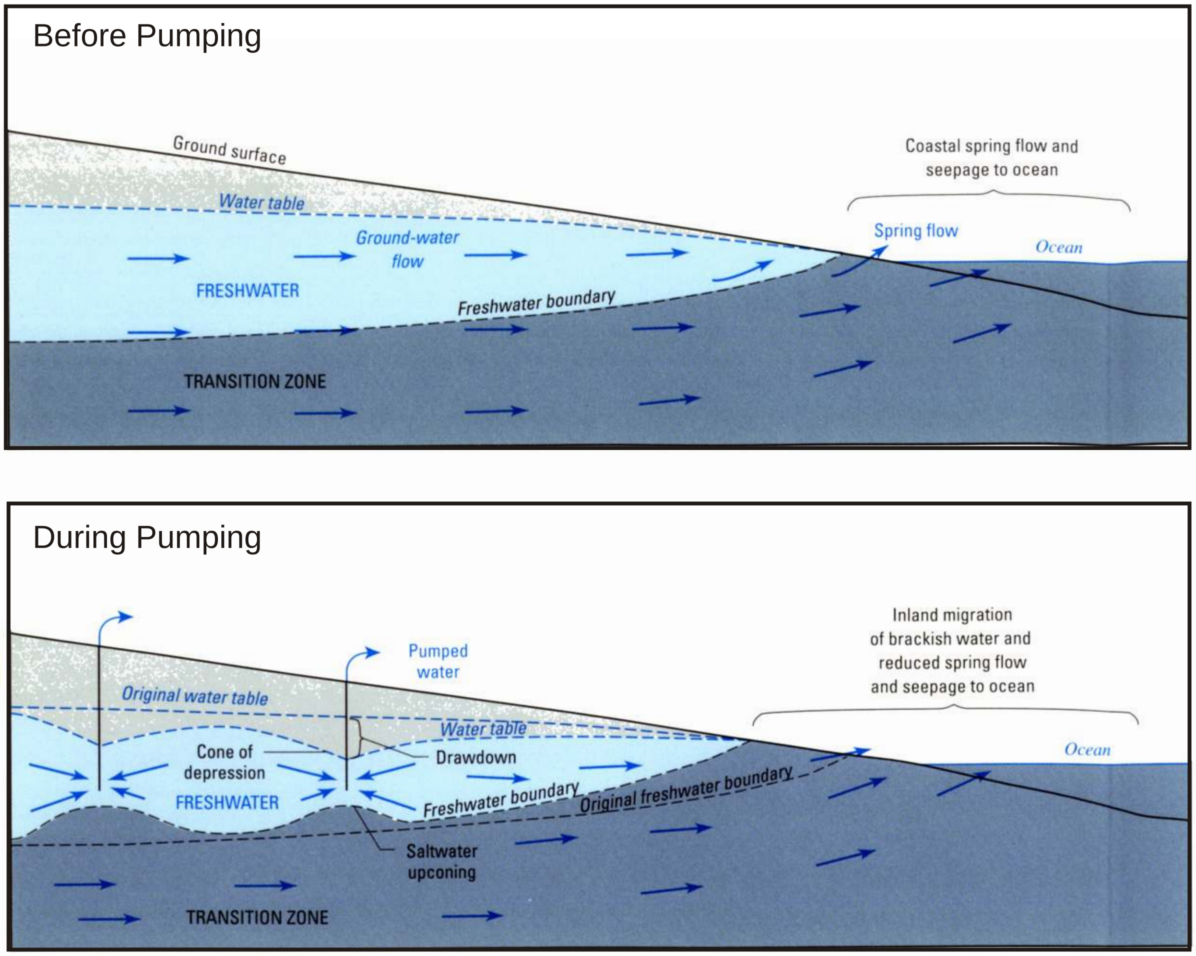


Figure 4.2 Effects of ground-water withdrawal on the potable part of the freshwater lens in a high permeability island aquifer. (Source: USGS Robert L. Carruth)

4.2 Soils and Geology

The opportunity to infiltrate stormwater to replace natural recharge lost to impervious surfaces is dependent upon the soils and geologic characteristics of the land. Generally speaking, soils strongly influence the natural recharge characteristics associated with land in its natural state and the underlying geology provides the capability for the infiltration of stormwater at shallow depths beneath the land's surface.

Soil surveys for both Guam and CNMI have been prepared by the U.S. Department of Agriculture, Soil Conservation Service (now known as the Natural Resources Conservation Service) (USDA, 1988 and 1989, respectively). These reports provide soil descriptions and maps. They include a narrative description of each soil type beginning at the land's surface and proceeding downwards. The nature of the soil composition, grain size and slope determine the capability of the soil to infiltrate surface water. For this purpose, four hydrologic soil classifications are used, A, B, C and D, with A providing the most infiltration and D the least.

The amount of recharge, which naturally replenishes the underlying groundwater, is largely dependent upon precipitation and soil type (more specifically, hydrologic soil classification).

To determine the potential for infiltrating stormwater in Guam and CNMI, surficial geologic information is needed in addition to soils information. This is because the hydrologic soils classification is based upon the nature of the uppermost soil "horizons" and not the underlying geologic material. Some Guam and CNMI soils become considerably more permeable at fairly shallow depths beneath the lands' surface. For example, the "Guam" soil series, which comprises most of Northern Guam, is described as "clayey loam" in the upper 10-20 centimeters, underlain by very permeable limestone.

Most stormwater infiltration practices are (or can be) constructed below the land's surface in these higher permeability materials. The infiltration capacity of these materials is better described by the surficial geology, which can be considered to be the "parent" material for the uppermost soil horizons.

Two major classifications of surficial geologic materials exist in Guam and CNMI: limestone and volcanic rock. Limestone is highly-permeable and capable of infiltrating relatively large quantities of water. Volcanic rocks have a significantly lower potential for infiltration.

For the purpose of this project two broad classifications of the surficial geologic units have been identified: 1) limestone and beach deposits, and 2) volcanic rock. Limestone occurs as the upper-most geologic unit throughout most of Saipan and most of Northern Guam. Volcanic rock appears as the most widespread surficial geologic outcrop in Southern Guam and several more isolated higher elevations on Saipan.

The limestone and beach deposits provide a significant opportunity to infiltrate large quantities of stormwater to accomplish two objectives: to balance natural on-site recharge rates, and to mitigate consumptive groundwater withdrawals used for drinking water and irrigation supplies. Providing this mitigation value will help to restore the thickness of groundwater levels and to decrease salt-water intrusion into wells.

As an example, groundwater withdrawal rates in Northern Guam are estimated to be 40 million gallons per day (MGD). Some of this groundwater is returned to the aquifer through septic systems. If we assume that 50% of this pumped water is “consumed”, the net loss from the groundwater system is approximately 20 MGD. According to an “Aquifer Management” study (CDM, 1982), this consumptive use might result in a two-foot decline in water table elevation and a corresponding 80-foot rise in the underlying salt-freshwater transition zone, representing a significant depletion of the groundwater lens thickness.

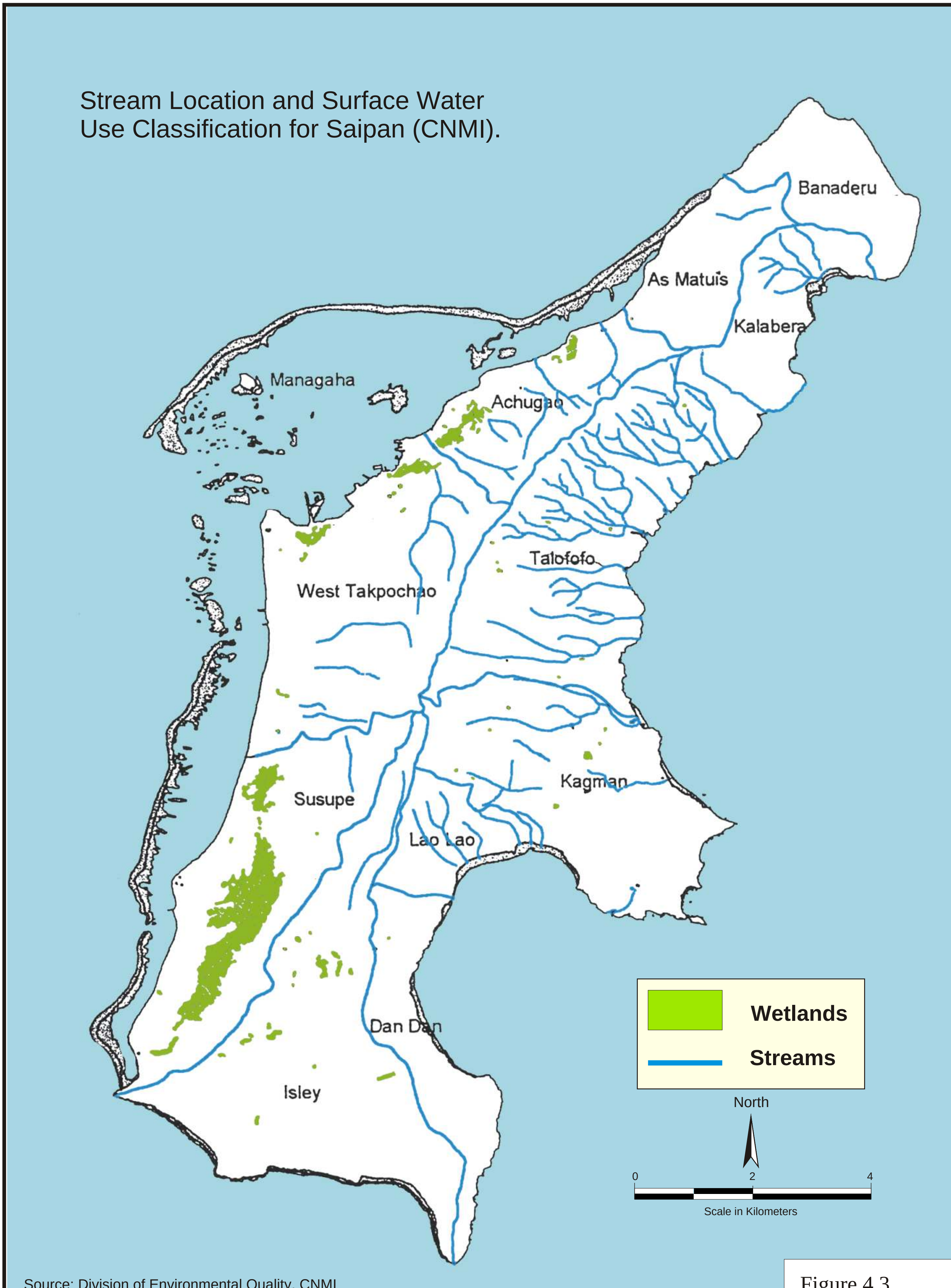
The recommended stormwater recharge criteria (See section 5) are intended to match current natural recharge rates and supplement current drinking water withdrawals to enhance and replenish the natural groundwater lens.

4.3 Freshwater Streams, Ponds and Wetlands

There are numerous streams (perennial and intermittent), ponds, and wetlands throughout Guam and CNMI (see Figures 4.3 and 4.4). They provide important aquatic habitat for a broad range of fish, amphibian, mammal and bird species, and as recreational resources for humans.

Stream flow is derived from both overland runoff and baseflow from groundwater, which discharges into streambeds (see Figure 4.3). If baseflow is continuous throughout the year, the stream is perennial. If groundwater elevations fall below the natural stream bed elevation, the stream is intermittent. In either case, stream ecosystems are very dependent upon the maintenance of natural groundwater levels and corresponding groundwater discharges to the streams.

Each stream ecosystem is adapted to its natural flow regime, which is a mixture of surface runoff events and groundwater baseflow. Stormwater management practices associated with land development within surface water stream watersheds can significantly alter the timing and rates of surface flow and groundwater discharge, thereby impacting stream ecosystems. In some cases, naturally occurring perennial streams may dry up seasonally in a developed watershed, significantly altering the habitat. Similarly, water quality changes including temperature, nutrients, and sedimentation can significantly impact streams ecosystems. Finally, streams particularly, small first and second order streams, are especially susceptible to increased channel erosion associated with altered hydrology and land development.



Source: Division of Environmental Quality, CNMI

Figure 4.3

Surface Water Streams of Guam

Figure 4.4

Ponds provide unique habitats and are also sensitive to stormwater discharges within their watersheds. Eutrophication is a common problem in fresh water ponds, and is the result of excessive phosphorus loading, which can cause excessive weed or algal growth and ultimately can cause depleted oxygen levels, fish kills, and noxious odors. Although both phosphorus and nitrogen contribute to excessive plant growth, phosphorus is the nutrient of concern in pond environments. A water quality standard of ten parts per billion total phosphorus and orthophosphate has been established for freshwater bodies in CNMI.

Wetlands provide a broad range of habitat and recreational values. They too are susceptible to impacts from stormwater in terms of both hydrology and water quality changes. Wetlands are defined and entirely dependent upon surface and near surface hydrologic conditions (water levels to within 12 inches of the surface of the ground), which support hydrophytes (wetland vegetation) and hydric soils. Similar to the other freshwater resource areas discussed above, wetlands are very sensitive to water level changes and to alterations in water inputs. Therefore, stormwater must be managed within the watersheds to wetlands in a manner that preserves natural flow regimes. Wetlands are also susceptible to pollutant loading increases particularly phosphorus.

All fresh surface waterbodies (including wetlands) in the CNMI have been designated as Class 1, requiring that "these waters should remain in their natural state with an absolute minimum of pollution from any human-caused source" (DEQ, Water Quality Standards, 1997).

A classification system has also been designated for Guam as defined in the Guam Water Quality Standards (GEPA, 2001), which shows three categories of surface water, S1, S2, and S3, which are defined as "high", "medium", and "low". Guam also has two categories of groundwater, G1 and G2, which are defined as a "Resource Zone" and a "Recharge zone."

4.4 Coastal Waters

Coastal waters surround each of the fifteen CNMI islands and Guam, and serve as the ultimate "discharge area" for all surface runoff. They are valuable for the support and propagation of shellfish and other marine life, conservation of coral reefs, oceanographic research, and serve as a very significant recreational resource for humans. Coastal water quality issues include eutrophication, damage to coral reefs (including sedimentation), and bacterial/viral pollution of swimming beaches.

According to the "305(b)" reports for Guam and CNMI, coastal waters are most significantly impacted by sedimentation and nutrients. Sediments cause physical damage including decreased water clarity and smothering of coral and other marine resources. Nutrients (typically nitrogen for coastal environments) cause eutrophication, which results in excessive algae and weed growth, depleted dissolved oxygen levels, and foul odors.

CNMI has developed a classification system, implemented through their "Water Quality Standards", for coastal waters. Class AA waters are to "remain in their natural pristine state as nearly as possible with an absolute minimum of pollution or alteration of water quality from any human-related source or actions." Class A waters are to be managed for "their use as recreational purposes and aesthetic enjoyment."

Similarly, Guam has developed a three-tiered classification system for marine waters as defined in the Guam Water Quality Standards (GEPA, 2001). The categories include M1, M2, and M3, which are defined as "excellent", "good", and "fair".

Summary

Each of the critical resource areas discussed within this section has unique susceptibilities to stormwater discharges. Ideally, each resource area needs to be managed in accordance with resource-specific criteria and thresholds. Table 4.1 provides an overview of the most critical variables for each of the resource areas and suggests broadly-defined design criteria for consideration as the recommended management measures presented in Section 5 of this report.

Table 4.1 Critical Resource Areas and Unique Criteria

Resource Areas	Critical Variables	Recommended Management Criteria
Groundwater	Recharge Volume Water Quality Loading	Post-Dev ≥ Pre-Dev Post-Dev ≤ Pre-Dev
Freshwater Streams	Recharge Volume Channel Erosion	Post-Dev ≥ Pre-Dev Post-Dev ≤ Pre-Dev
Freshwater Ponds	Phosphorus Loading	Post-Dev ≤ Pre-Dev
Wetlands	Recharge Volume	Post-Dev ≥ Pre-Dev
Coastal Waters	Microbiological Loading Nitrogen Loading Sediments/TSS Loading	Post-Dev ≤ Pre-Dev Post-Dev ≤ Pre-Dev Post-Dev ≤ Pre-Dev

5.0 RECOMMENDED DESIGN CRITERIA FOR CONSTRUCTION SITE RUNOFF CONTROL AND POST CONSTRUCTION STORMWATER MANAGEMENT

In Section 4, the critical resource areas and the potential threats to these resources were defined. Table 4.1 suggests a broad range of criteria to help mitigate any adverse impacts associated with development and redevelopment projects. In this section a set of specific recommended criteria is offered to manage and control stormwater runoff during the construction and post-construction phase of the development process.

Sections 5.1 and 5.2 present general performance criteria for construction site runoff control and specific sizing criteria for temporary erosion and sediment control practices that would be employed during the construction phase of a project. Section 5.3 presents general performance criteria for post-construction stormwater management practices. The general performance criteria are intended as overall guidance to protect environmental resources on CNMI and Guam. The specific sizing criteria for post construction measures are presented in Section 5.5. Section 5.4 introduces and defines the concept of hotspot land uses, or those lands uses that generate a higher than average pollutant load and therefore must be managed in a different manner than other uses.

Section 5.5 contains what is termed a "unified sizing" approach for post construction BMPs. The unified sizing approach provides designers, reviewers, regulators, and the general public with consistent sizing rules for most projects and best management practices. The methodology is intended to manage all storms from the smallest, most frequent events up to the largest most infrequent events. While the methodology is consistent across all land uses and all receiving water types, the specific sizing requirements are different for differing geology, land use, and receiving waterbody sensitivity.

Specific BMP design criteria, such as the minimum permanent pool size for a wet pond, the required surface area for a sand filter, or the minimum landscaping requirement for a bioretention system, will be provided in the CNMI and Guam Stormwater Management Manual (“Final Manual”). Schematic illustrative details of the recommended Stormwater BMPs for CNMI and Guam are presented in Appendix A.

5.1 General Performance Criteria for Construction Site Runoff Control

To prevent adverse impacts from construction site runoff, the following general performance standards (designated as erosion and sediment control standards or E&SC Standards) are recommended for all new development and redevelopment construction sites. These narrative performance criteria shall be applied to the maximum extent practicable. If in the view of the approving authority, it is impracticable or infeasible to apply one or more of the E&SC criteria to a given project, a waiver may be granted on a case-by-case basis.

E&SC Standard 1 Minimize unnecessary clearing and grading from all construction sites. Clearing and grading shall only be performed within areas needed to build the project, including structures, utilities, roads, recreational amenities, post-construction stormwater management facilities, and related infrastructure. Clearing should be minimized during the wet season and should strive to occur in the dry season.

E&SC Standard 2 Rivers, streams and waterways shall be protected by limiting clearing within the riparian corridor (minimum of 25 feet) and applying perimeter sediment controls between disturbed areas and this riparian corridor. Existing and proposed drainage ways should also be protected by ensuring that flow velocities are non-erosive.

E&SC Standard 3 Whenever practicable and feasible, construction shall be phased to limit disturbance to only one area of active construction at a time. Future phases shall not be disturbed until construction of prior phases are complete and the land area is stabilized.

E&SC Standard 4 Disturbed areas shall be stabilized as soon as feasibly possible after construction is completed within a designated construction area, and in no case longer than 14 days after completion of active construction.

E&SC Standard 5 Steep slopes shall be protected from erosion by limiting clearing of these areas in the first place or, where grading is unavoidable, by providing special techniques to prevent upland runoff from flowing down a steep slope and through immediate stabilization to prevent gullying. A steep slope is defined as any slope over 20% in grade over a length of 100 feet.

E&SC Standard 6 Perimeter sediment controls shall be applied to retain or filter concentrated runoff from disturbed areas to trap or retain sediment before it leaves a construction site. Upland runoff should be diverted around excavations where possible.

E&SC Standard 7 Sediment trapping and settling devices shall be employed to trap and/or retain suspended sediments and allow time for them to settle out in cases where perimeter sediment controls (e.g., silt fence and hay bales) are deemed to be ineffective in trapping suspended sediments on-site.

E&SC Standard 8 All construction site managers (or superintendents) shall provide documentation that they have received adequate training in the application and maintenance of erosion and sediment control practices.

E&SC Standard 9 All construction site managers must participate in a pre-construction meeting with the applicable authority to review the provisions of the erosion and sediment control plan and make any field adjustment necessary to implement the intent of the plan to minimize erosion and maximize sediment retention on-site throughout the construction process.

E&SC Standard 10 The timing of construction should strive to minimize soil exposure in the rainy season (July 1st–Nov. 30th). If construction will occur in the wet season, the temporary stormwater controls must be designed in accordance with post-construction standards for sediment treatment (ie. 1.5" precipitation event).

E&SC Standard 11 Erosion and sediment control practices shall be aggressively maintained throughout all phases of construction. All erosion and sediment control plans shall have an enforceable operation and maintenance agreement to ensure that practices are maintained during the construction process.

5.2 Specific Design Criteria for Construction Site Runoff Control

All construction site measures shall be designed to accommodate (safely convey without creating erosive conditions) the 10-year frequency storm. The 10-year frequency storm is one that is widely used in the mainland U.S. because it represents a large event that will certainly produce significant runoff and yet has a relatively high chance of occurring in any given year (i.e., 10%).
Thus, managers have deemed this event to be a significant threat to erosion through the failure of on-site E&SC measures at construction sites. It is recommended that the 10-year frequency storm serve as the basis for channel and hydraulic design of all on- site erosion and sediment control measures.

All temporary sediment trapping devices shall be designed to retain runoff from a minimum of the 0.5-inch precipitation event. Again, The 0.5-inch storm is one that is widely used in the mainland U.S. because it represents a very frequent event that generates a reasonable runoff volume and potential sediment load. On Guam, the 0.5-inch event is equal to or greater than approximately 70% of precipitation events (see Figure 5.1) and therefore, a design criteria that requires the capture of this event will capture at least 70% of the annual sediment load from construction sites. It is recommended that the 0.5-inch storm serve as the basis for retention design for construction site sediment trapping devices deployed during dry season construction. Where practices will be deployed within the wet season (July 1st -Nov. 30th) practices shall be designed to retain runoff from the 1.5" rain storm.

5.3 General Post Construction Stormwater Management Performance Criteria

To prevent adverse impacts of stormwater runoff, the following performance standards are recommended for all new development sites and redevelopment sites.

Standard 1 Site designs shall strive to reduce the generation of stormwater runoff and utilize pervious areas for stormwater treatment. For development sites over 1 acre, impervious cover shall not exceed 70% of the total site area.

Standard 2 Stormwater management shall be provided through a combination of the use 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 Annual groundwater recharge rates shall be maintained by promoting infiltration through the use of structural and non-structural methods.

Standard 5 For new development, structural stormwater best management practices (BMPs) shall be designed to remove 80% of the average annual post development total suspended solids load (TSS). It is presumed that a BMP complies with this performance standard if it is:

1. sized to capture the prescribed water quality volume (WQ_v),
2. designed according to the specific performance criteria outlined in the Design Manual,
3. constructed properly, and
4. 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, a channel protection volume (Cp_v) shall be provided by means of 24 hours of extended detention storage for the one-year frequency storm event.

Standard 8 Stormwater discharges to critical areas with sensitive resources (i.e., nutrient sensitive embayments, swimming beaches, wellhead protection areas, designated sensitive ecosystems) will be subject to additional performance criteria, and will need to utilize or restrict certain BMPs.

Standard 9 All BMPs shall have an enforceable operation and maintenance agreement to ensure the system functions as designed. In addition, every BMP 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% are deemed to meet both the recharge and water quality requirements (Std # 4 and 5 above). If the impervious cover reduction is less than 40%, water quality and recharge must be provided for that portion of the site's imperviousness that exceeds the 40% reduction threshold. Peak flow attenuation and channel erosion control are not required where there is a net reduction in impervious cover.

Standard 11 Certain industrial sites are required to prepare and implement a stormwater pollution prevention plan.

Standard 12 Stormwater discharges from land uses or activities with higher potential pollutant loadings, defined as hotspots (see section 5.4), are required to use specific structural BMPs and pollution prevention practices. In addition, stormwater from a hotspot land use may not be recharged to groundwater without pretreatment of 100% of the water quality volume (WQ_v).

5.4 Designation of Stormwater "Hotspot" Land Uses

A stormwater hotspot is defined as a land use or activity that typically generates higher concentrations of hydrocarbons, trace metals and other pollutants than are typically found in stormwater runoff, based on monitoring studies. Table 5.1 provides a list of designated hotspots. If a site is designated as a hotspot, it has important implications for how stormwater is managed. First, stormwater runoff from hotspots cannot be allowed to infiltrate into groundwater without prior water quality treatment. Second, a greater level of stormwater treatment is needed at hotspot sites to prevent pollutant wash off after construction. This will involve preparing and implementing *a stormwater pollution prevention plan* that involves a series of operational practices at the site that reduce the generation of pollutants from a site or prevent contact of rainfall with the pollutants. In addition, hotspot land uses must manage runoff in accordance with the 90% Rule for water quality treatment (see Section 5.5.2).

If a site falls into a "hotspot" category outlined in Table 5.1, a pollution prevention plan will also be required by the appropriate reviewing authority.

Table 5.1 Classification of Stormwater Hotspot Land Uses

The following land uses and activities are considered *stormwater hotspots:*

- vehicle salvage yards and recycling facilities
- vehicle fueling stations
- vehicle service and maintenance facilities
- vehicle and equipment cleaning facilities
- fleet storage areas (bus, truck, etc.)
- industrial sites
- marinas (service and maintenance)
- outdoor liquid container storage
- outdoor loading/unloading facilities
- public works storage areas
- facilities that generate or store hazardous materials
- commercial container nursery
- other land uses and activities as designated by the appropriate permitting authorities of CNMI and Guam

5.5 Unified Sizing Criteria for Post Construction Stormwater Management in CNMI and Guam

This section presents a unified approach for sizing stormwater treatment practices (BMPs) in the CNMI and Guam to meet pollutant removal, groundwater recharge, channel protection and flood control objectives at new development sites. The section is organized as follows:

5.5.1 Recharge Criteria (Re_v)
5.5.2 Water Quality Criteria (WQ_v)
5.5.3 Channel Protection Criteria (Cp_v)
5.5.4 Extreme Flood Control Criteria (Q_{p25})
5.5.5 Hydrologic Basis for Design

Each of the following sections outlines the options for sizing BMPs, provides a technical review of the advantages and disadvantages of each option and makes recommendations on the technical procedures and methods needed to apply individual sizing criteria, including exemptions and other special considerations.

The unified sizing approach is intended to manage the entire frequency of storms anticipated over the life of the stormwater practice and the development it is designed to manage. Consequently, storms range from the smallest, most frequent events that produce little or no runoff, but make up the majority of individual events and are responsible for a significant portion of groundwater recharge, up to the largest, infrequent events that can cause catastrophic damage and even loss of life (see Figure 5.1).

Data for the development of the unified sizing criteria were derived from the precipitation frequency analysis from the long-term continuous meteorological observatory on northern Guam at Taguac, Finegayan, (Lat. 13º33'23"N, Long. 144º50'12"E). As illustrated in Section 3 of this report, annual rainfall varies across CNMI and Guam both as a function of latitude and altitude. It is recommended that the design values for locations other than northern Guam use a ratio based on annual rainfall to derive the final design values for recharge, water quality, overland erosion/channel protection and overbank flood control. For example, the average rainfall at Taguac, Finegayan is approximately 102 inches per year. In coastal Saipan, the average rainfall is approximately 80 inches per year. Therefore, the design of criteria for BMPs on coastal Saipan would apply a factor of 0.78 (80"/102") to the values presented in the following section. The Final Manual will provide a list of design values for various locations across CNMI and Guam.

Figure 5.1 illustrates a rainfall frequency analysis for northern Guam. As stated above, the data are from the National Weather Service Meteorological Observatory (WSMO) at Taguac, Finegayan (Station 4229), Guam, for the period September 1982 through September 1992. The Water and Energy Research Institute (WERI) of the Western Pacific, University of Guam published a report entitled "Sizing of Surface Water Runoff Detention Ponds (Heitz, et al., 1997), where the researchers investigated the appropriate sizing criteria of detention ponds based on rainfall characteristics of Guam. The researchers conducted four separate storm frequency analyses based on sorting continuous precipitation data as related to the time between storms (TBS) of 1 hour, 6 hours, 12 hours and 24 hours. The rainfall frequency curve illustrated in Figure 5.1 is for a TBS of 12 hours and is believed to be the most representative situation of long-term precipitation characteristics in applying post-construction stormwater management measures for CNMI and Guam. The calculated average time between precipitation events at WSMO was determined to be 11.33 hours. (Heitz et al, 1997)

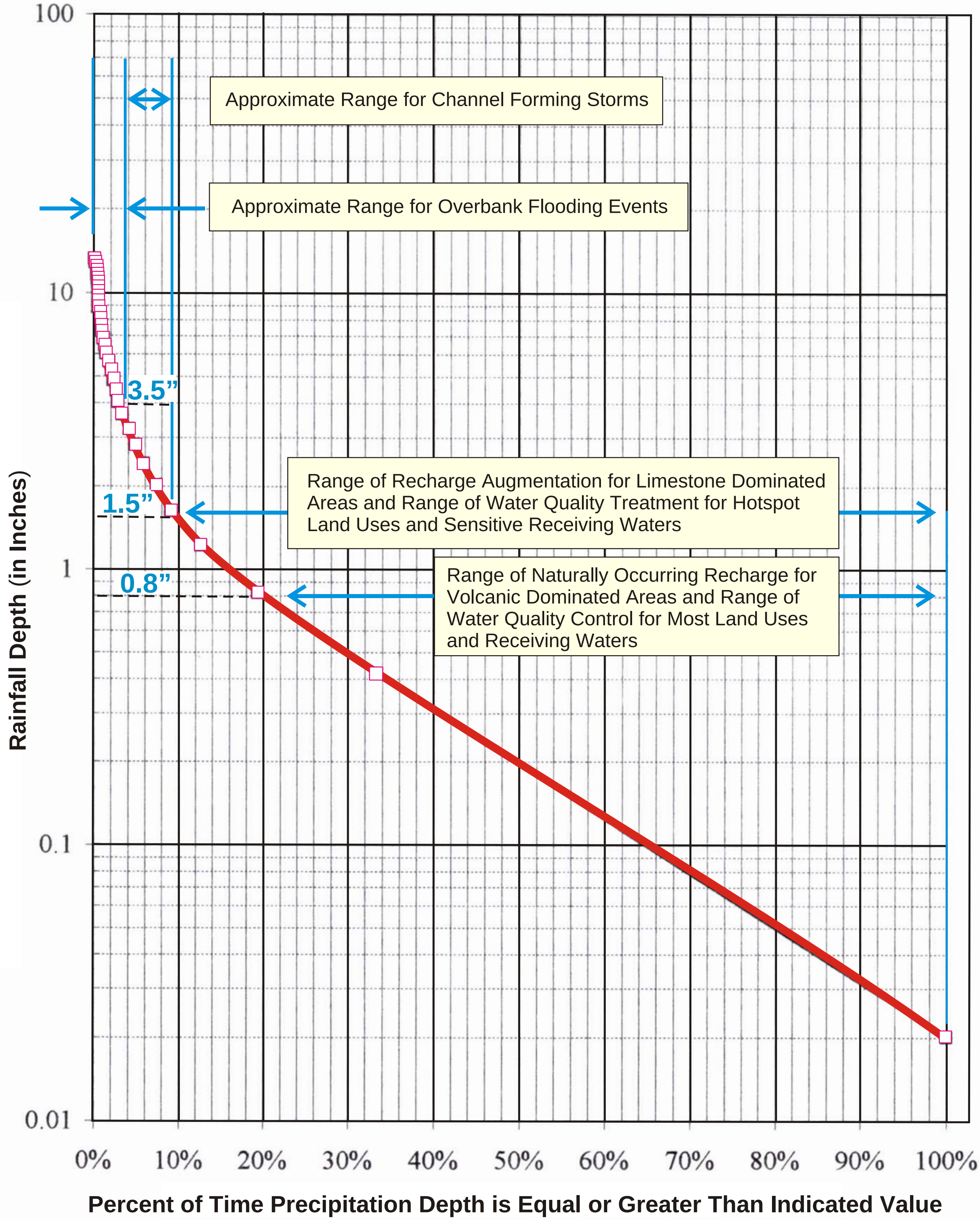


Figure 5.1 Approximate Range for Storms Comprising the Unified Sizing Criteria

5.5.1 Recharge Criteria (Re_v)

The intent of the recharge criterion is to maintain groundwater recharge rates at development sites to preserve or augment existing groundwater levels, thereby helping to support baseflow to streams and wetlands, and to maintain overall groundwater supplies. Under natural conditions, the amount of recharge that occurs on a site is a function of rainfall intensity and duration, slope, soil type, underlying surficial geology, vegetative cover, precipitation and evapotranspiration characteristics. Locations with natural ground cover, such as forests and rangelands, typically exhibit higher recharge rates due to less runoff. Since development increases impervious surfaces and total runoff volume, a net decrease in recharge rates is inevitable.

Annual recharge rates on CNMI and Guam vary in large part due to the underlying geologic formations. In limestone areas (northern Guam, and most of CNMI), natural recharge is in the range of approximately one-third of the annual precipitation or approximately 33 inches per year for northern Guam (CDM, 1982). In volcanic dominated areas, recharge is more restricted as only a small amount of rainfall infiltrates into the usually dense underlying rock strata (Duenas and Associates, 1996).

As discussed in Section 4 of this report, the quality and quantity of groundwater resources are critical to both environmental quality of the surface waters as well as the maintenance of a viable drinking water supply. A specific recharge criterion is a relatively recent concept in the arena of stormwater management. Several mainland U.S. states have adopted criteria in their stormwater programs where the objective is to maintain the pre-development hydrologic water balance on a site in the post developed condition (see proposed General Stormwater Management Performance criteria No.4).

Two basic approaches to implementing groundwater recharge criteria have been employed in the recent past. One is based on applying a recharge volume using the natural soil characteristics as a basis for estimating recharge, while the other method uses runoff characteristics combined with annual precipitation and evapotranspiration rates to "reverse-calculate" a recharge volume. Under this section, a third method is presented based on the natural recharge characteristics of limestone areas within CNMI and Guam.

In order to derive a recharge criterion that would be specific to the limestone dominated regions of CNMI and Guam, the rainfall frequency curve developed by Heitz, et. al.(1997) (see Figure 5.1) was used to derive an annual precipitation volume-based curve as a function of rainfall depth. The raw data from Figure 5.1 was used to develop an equation for the curve (actually two equations were needed to characterize the data), which was integrated to determine the area under the curve as related to rainfall volume. For a variety of rainfall depths, the fractional percent of total area under the curve was calculated and plotted. Finally, the fractional areas were converted into actual rainfall inches and plotted for Northern Guam, assuming an annual precipitation of 102 inches. (See Figure 5.2).

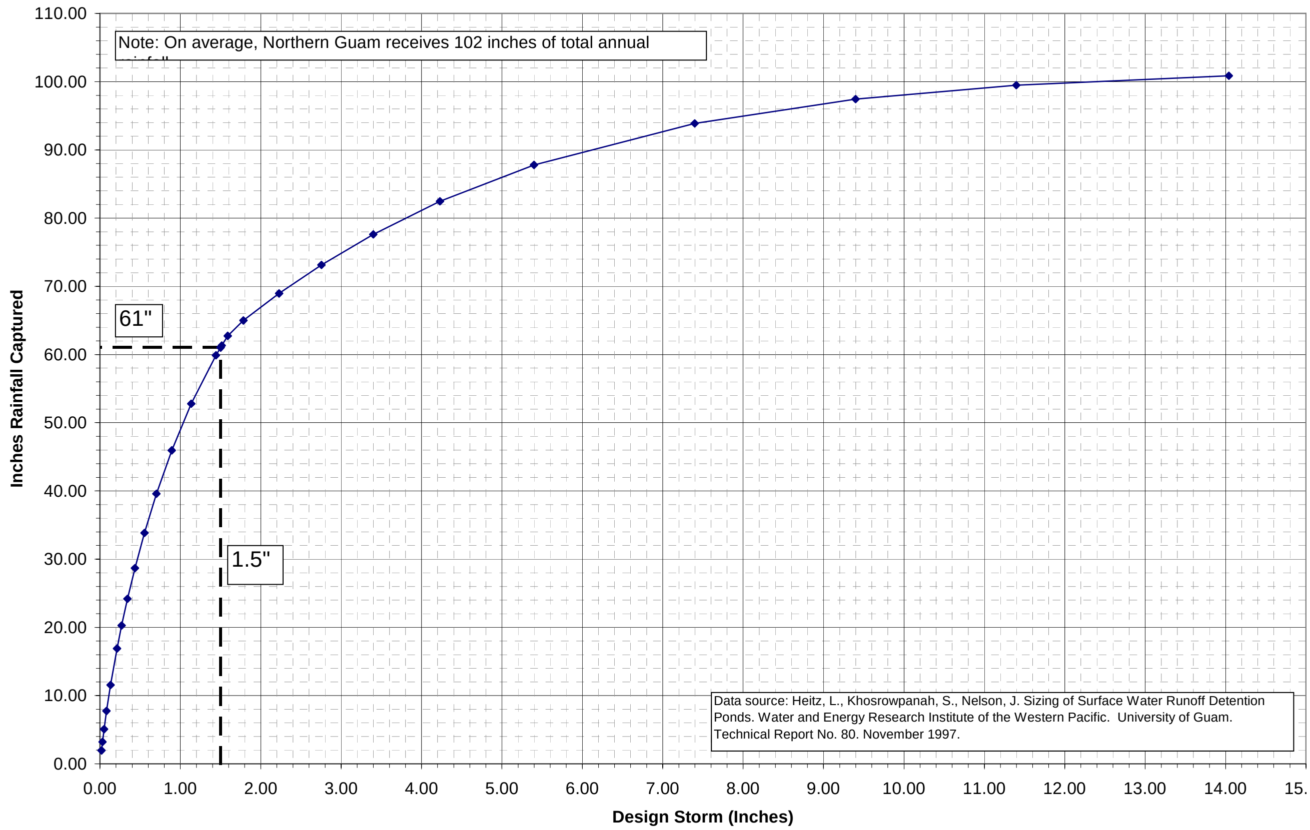


Figure 5.2 Annual Rainfall Volume Captured as a Function of Design Precipitation Event

Using Figure 5.2, it is then possible to project the annual volume of recharge as a function of rainfall amount. For example, the natural recharge volume of 33 inches in northern Guam corresponds to a design rainfall capture amount of approximately 0.6 inches. A criterion that would require the capture and recharge of 0.6-inch rainfall and less would likely match the existing recharge characteristics in northern Guam.

As stated in Section 4, groundwater resources are critical to the maintenance of the quality of life and environmental quality on CNMI and Guam. It is possible and cost-effective to use a stormwater recharge criterion to maintain and possibly augment groundwater resources. Again, using Figure 5.2, it is possible to select the optimum design rainfall event to maximize recharge. A standard approach for this is to use the "knee of the curve" value as the most cost effective rainfall to augment groundwater supplies. This optimum design value for northern Guam is 1.5 inches and corresponds to approximately 61 inches of annual rainfall, or approximately 60% of the annual precipitation. The criterion would be to require infiltration of 1.5 inches of precipitation from all impervious surfaces. The equation would be as follows:

$$Re_v = (1.5" * I_a)/12$$

where: **Re_v = the recharge requirement, in acre-feet**
I_a = the impervious cover created at a site, in acres
12 = conversion from inches to feet

This criterion would only apply to limestone-dominated recharge areas of CNMI and Guam (see Figures 5.3 through 5.6).

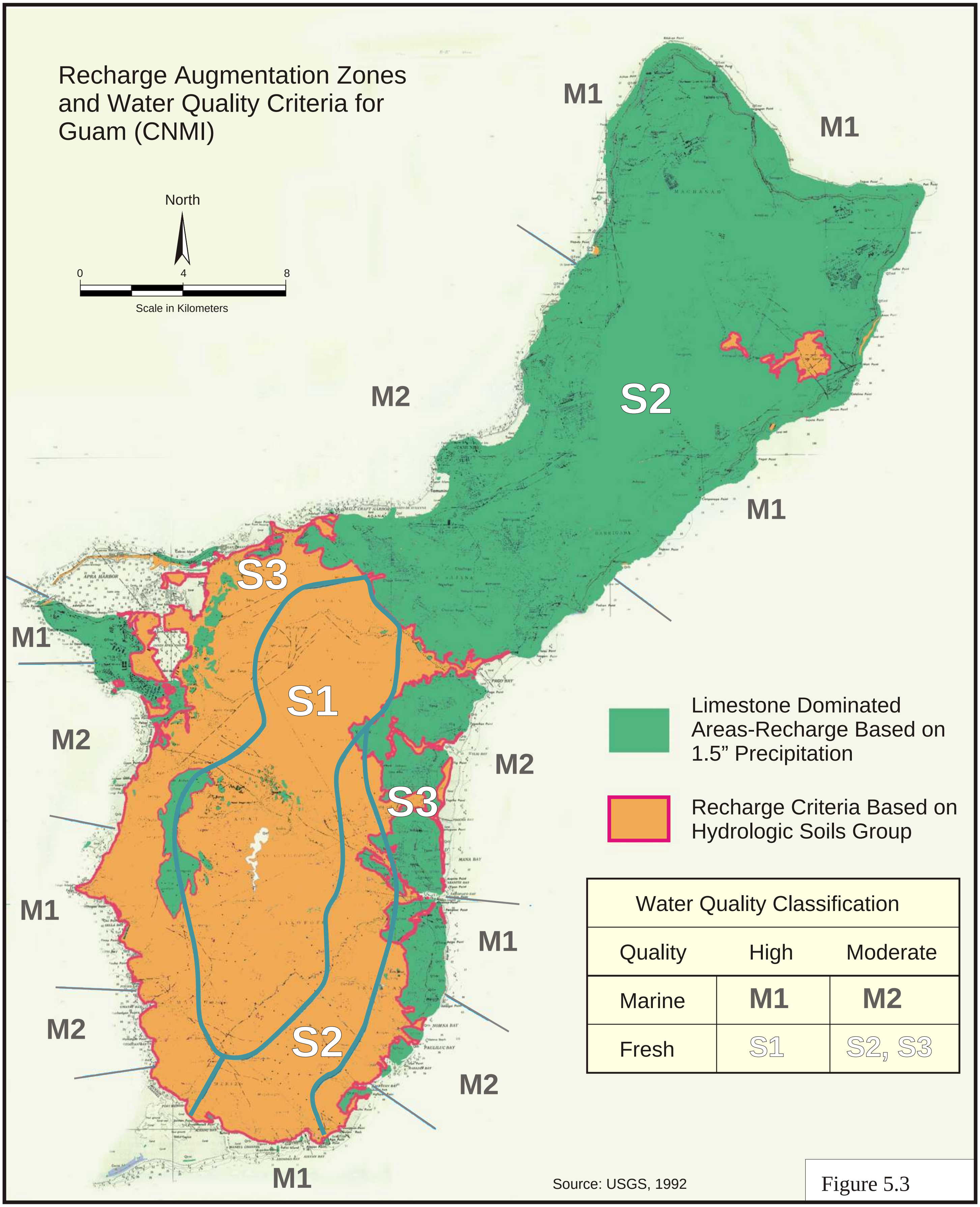
In volcanic-dominated areas, the soil-based recharge criteria used in the mainland U.S. would be the most appropriate approach to meet the General Stormwater Management Performance Criteria to maintain natural annual recharge rates. This approach to determining recharge volume is currently implemented in the mainland U.S. in the states of Maryland, Massachusetts, Georgia and Vermont. The design approach involves determining the average annual recharge rate based on the prevailing hydrologic soil group (HSG)[1] present at a project site from the Natural Resource Conservation Service (NRCS) Soil Surveys. The method was developed based on the amount of annual recharge that occurs as a function of HSG types and utilizes the following predevelopment recharge percentages to be assigned based on NRCS soil types for humid climates.

Hydrologic Soil Group	Annual Recharge (% of annual precipitation)
A	41%
B	27%
C	14%
D	7%

The objective of the criterion is to mimic the average annual recharge rate for the prevailing hydrologic soil group(s) present at the development site. Therefore, the recharge volume can be determined as a function of annual predevelopment recharge for a given soil group, average annual rainfall volume, and amount of impervious cover at a site. Being a function of site impervious cover, the criterion provides incentive to planners and developers to reduce site imperviousness. In addition to determining soil groups from the NRCS Soil Surveys, designers should confirm the characteristics of the soils at a given site through test pits.

A summary of the recommended recharge criteria is presented in Table 5.2 for each of the dominant geologic regions in CNMI and Saipan.

[1] HSG is an NRCS designation given to different soil types to reflect their relative surface permeability and infiltrative capability. Group A soils have low runoff potential and high infiltration rates. They consist chiefly of deep, well drained sands or gravels. Group B soils have moderate infiltration rates and consist chiefly of soils with fine to coarse textures. Group C soils have low infiltration rates and fine textures that impede the downward movement of water. Group D soils have high runoff potential with very low infiltration rates and consist chiefly of clay soils (NRCS TR-55, 1986).

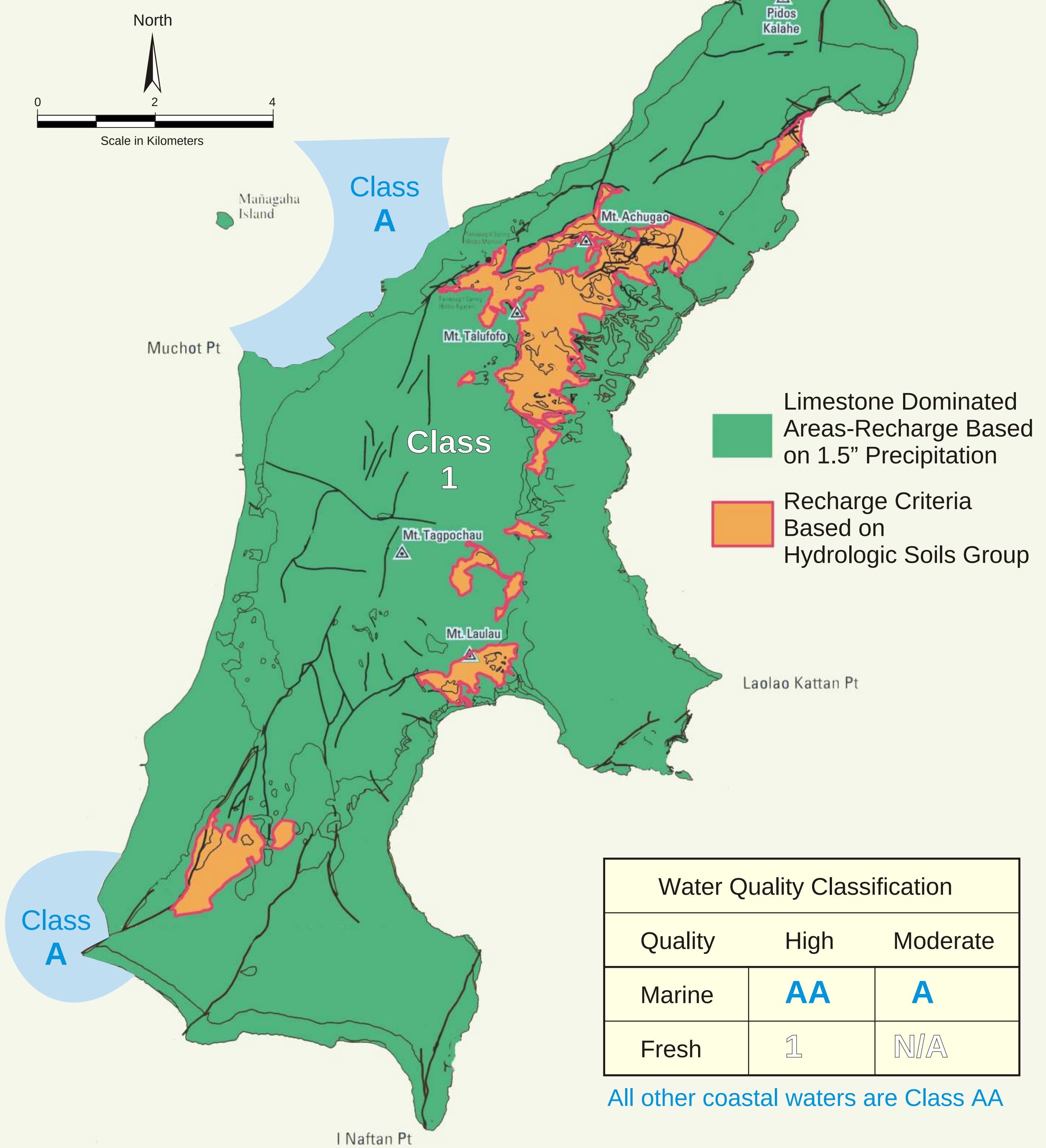


Water Quality Classification

Quality	High	Moderate
Marine	M1	M2
Fresh	S1	S2, S3

Figure 5.3

Recharge Augmentation Zones
and Water Quality Criteria for Saipan (CNMI)



Water Quality Classification		
Quality	High	Moderate
Marine	AA	A
Fresh	1	N/A

All other coastal waters are Class AA

Source: USGS, Robert L. Carruth

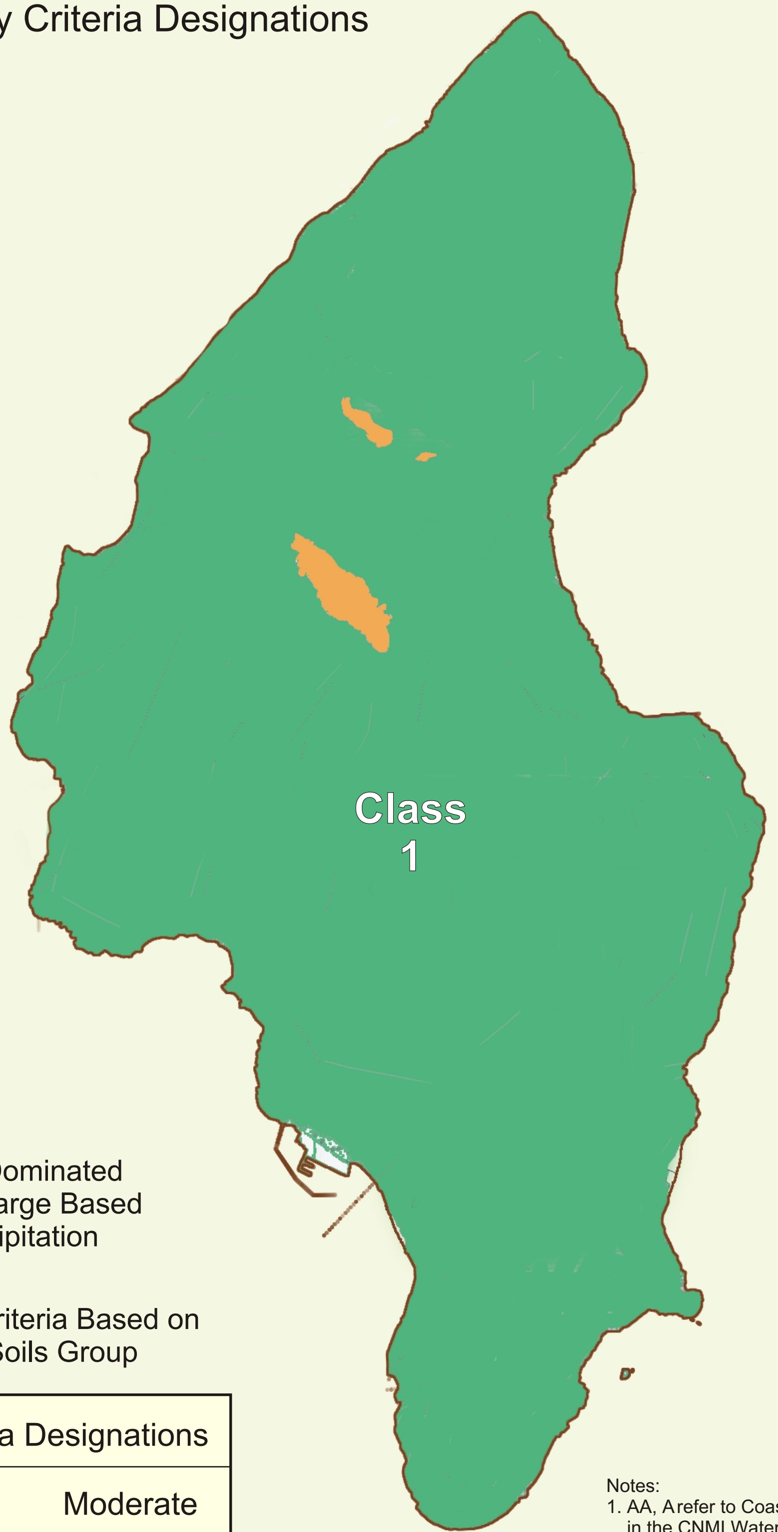
Figure 5.4

Recharge Augmentation Zones and Water Quality Criteria Designations for Tinian (CNMI)

North

0 2

Scale in Kilometers



Limestone Dominated Areas-Recharge Based on 1.5" Precipitation

Recharge Criteria Based on Hydrologic Soils Group

Water Quality Criteria Designations		
Quality	High	Moderate
Coastal[1]	AA	A
Fresh[2]	1	N/A

Notes:
1. AA, A refer to Coastal Water Categories as defined in the CNMI Water Quality Standards (CNMI DEQ,1997)
2. **1** refers to Fresh Water Categories as defined in the CNMI Water Quality Standards (CNMI DEQ,1997)

All coastal waters are Class AA

Source: USGS

Figure 5.5

Recharge Augmentation Zones and Water Quality Criteria Designations for Rota (CNMI)

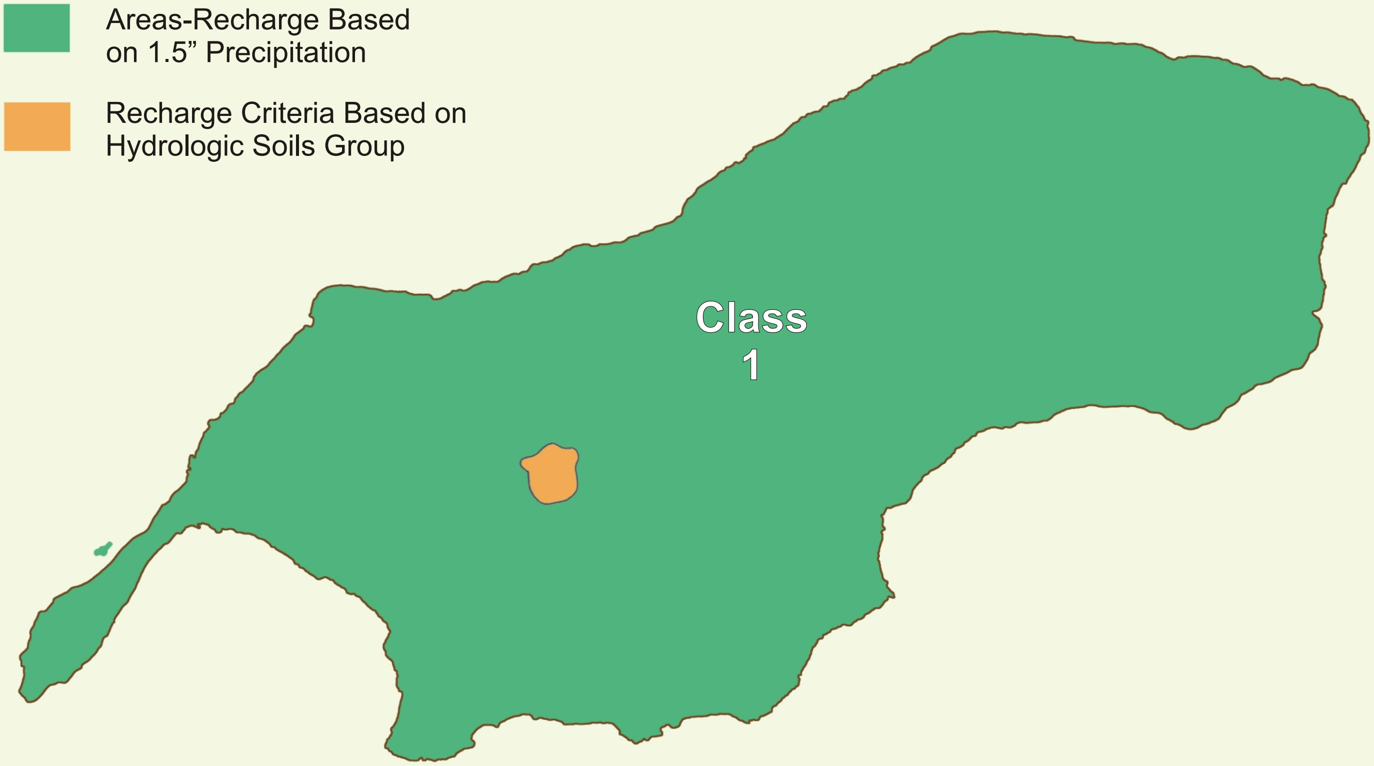
North

0 2

Scale in Kilometers

Limestone Dominated Areas-Recharge Based on 1.5" Precipitation

Recharge Criteria Based on Hydrologic Soils Group



Water Quality Criteria Designations		
Quality	High	Moderate
Coastal[1]	AA	A
Fresh[2]	1	N/A

Notes:
1. AA, A refer to Coastal Water Categories as defined in the CNMI Water Quality Standards (CNMI DEQ,1997)
2. **1** refers to Fresh Water Categories as defined in the CNMI Water Quality Standards (CNMI DEQ,1997)

All coastal waters are Class AA

Source: US Department of Agriculture, Soil Conservation Service

Figure 5.6

Again, referring to Figure 5.2, and using the cited percentages above, the recharge requirement for volcanic-dominated regions of CNMI and Guam would result in the following volumes:

Hydrologic Soil Group	Recharge Volume
A	0.80 inches x impervious area
B	0.50 inches x impervious area
C	0.20 inches x impervious area
D	0.10 inches x impervious area

These recharge volumes correlate well with the results of a recharge analysis conducted for the upper Pago River Basin in Guam (CDM, 1982), and the soils in this watershed (5.7 square miles) are predominantly hydrologic class B. Based upon the precipitation rates and stream discharge data recorded at a USGS gage, an average annual recharge rate of 30 inches/year was determined. This correlates to the cumulative volume, which would be infiltrated by the design storm of 0.5 inches.

An example calculation using the HSG method is provided below.

Example: A 30-acre site is to be developed as a residential subdivision near Taguag on the Island of Guam. The impervious area for the development will be 10 acres. Half of the impervious area overlays HSG "B" soils (Akina silty clay) and half of the impervious area overlays HSG "C" soils (Pulantat clay). The recharge requirement would be calculated as follows:

For B soils = [(0.50 in)(5 ac)]/12 in/ft = 0.21 ac-ft
For C soils = [(0.20 in)(5 ac)]/12 in/ft = 0.08 ac-ft

Total recharge requirement for site = 0.21 ac-ft + 0.08 ac-ft = 0.29 ac-ft

Table 5.2 Summary of Recommend Recharge Criteria for CNMI and Guam based on Surficial Geology

Surficial Geologic Classification (See Figure 5.3 and 5.4)	Recommended Recharge Requirement
Limestone-dominated areas	1.5 watershed inches x % impervious area
Volcanic-dominated areas	Match natural rate based on HSG

Figure 5.7 graphically illustrates the recommended recharge volume requirements for both limestone-dominated areas and volcanic-dominated areas as a function of site impervious cover (expressed in watershed inches).

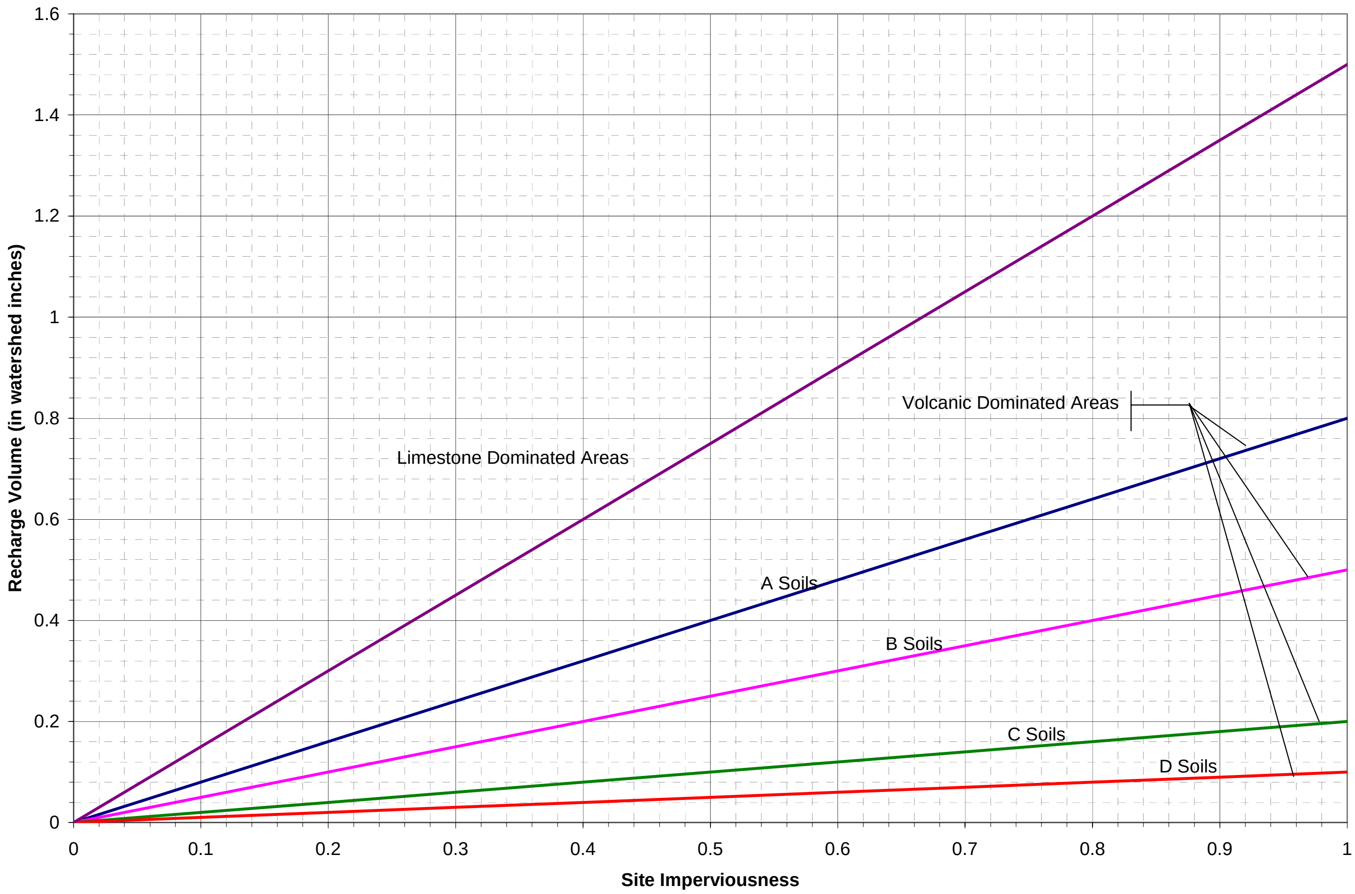


Figure 5.7 Relationship Between Recharge Requirement and Site Impervious Cover

The recharge volume is considered as part of the total water quality volume that must be provided at a site (i.e., Re_v is contained within WQ_v) and can be achieved either by a structural practice (e.g., infiltration, bioretention, filters- see Section 5.6 for a description of each practice and Appendix A for a sample schematic), a non-structural practice (filtration of sheet flow from disconnected impervious surfaces), or a combination of both.

There are a limited number of structural practices that will meet the recharge requirement. Infiltration, bioretention, dry swales, and other media filters (where infiltration is designed to occur from the bottom of the filter bed) are the only structural practices that meet the criterion. Bioretention for example, is a structural BMP to manage and treat stormwater runoff using a conditioned planting soil bed and planting materials to filter runoff stored within a shallow depression. The method combines physical filtering and adsorption with bio-geochemical processes to remove pollutants. It can be designed as a pure filter or as a component of an infiltration system (see Figures 5.8 and 5.9).

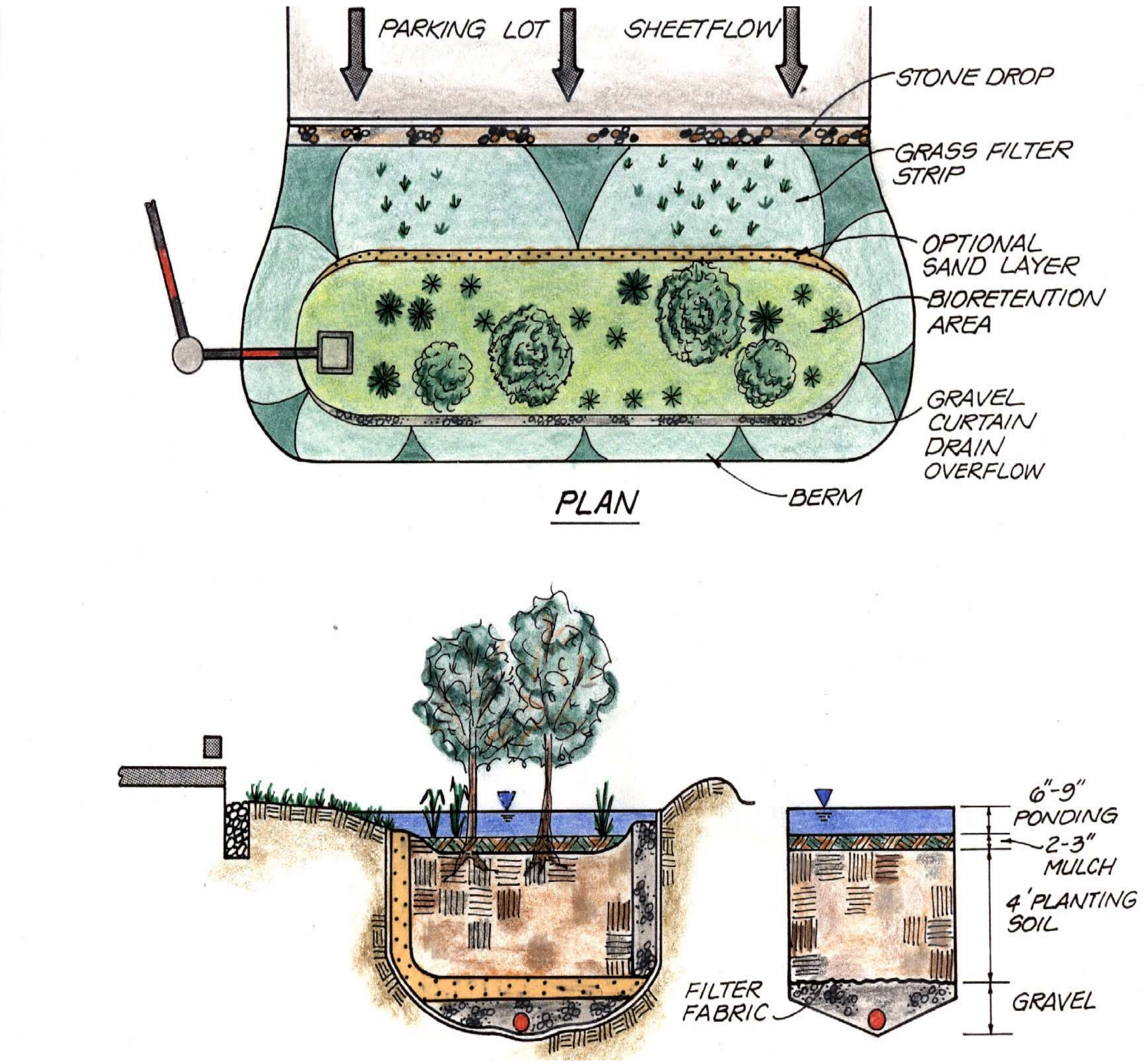


Figure 5.8 Schematic of a Bioretention Filter
(Source: Claytor & Schueler, p.96)

Photo by L. Gavin

Figure 5.9 Typical Application of a Bioretention Filter

Ponds and wetlands do not meet the criterion because the bottom of these facilities typically "seal up" as the result of sediment deposition over time, are designed with an impermeable liner, or are already excavated to the groundwater table to sustain a permanent pool. The limited number of structural practices will promote: (1) the use of better site design techniques[2] to reduce the amount of impervious surface, (2) disconnection of impervious surfaces to minimize flow concentration and facilitate infiltration, (3) management of runoff with diffuse overland methods such as filter strips and grass channels, and (4) the dedication of significant natural areas for permanent protection. The Final Manual will provide sufficient guidance to designers and reviewers on how the recharge criterion can be satisfied with nonstructural approaches.

[2] Better site design is a recently advanced alternative approach to residential and commercial development that seeks to accomplish three goals: (1) reduce the amount of impervious cover, (2) increase natural lands set aside for conservation, and (3) use pervious areas for more effective stormwater treatment (CWP, 2000). Other names for this design approach include Lower Impact Development (LID), and Conservation Design

Exemptions to Recharge Requirement

Some exemptions to the recharge criteria are necessary to ensure public safety, avoid unnecessary threats to groundwater quality, and avoid common nuisance issues. Stormwater runoff from hotspots should not be allowed to infiltrate into groundwater without appropriate pretreatment equivalent to 100% of the water quality volume (see Section 5.2.2). The stormwater recharge requirement may be specifically waived if an applicant can demonstrate a physical limitation that would make implementation impracticable or where unusual geological features may exist such as marine clays or areas of documented slope failure.

5.5.2 Water Quality Criteria (WQv)

It is widely recognized that in order to meet various water quality standards and classifications, treatment of stormwater runoff is necessary. There is conclusive water quality and biological data that show the toxic effect of untreated nonpoint source pollution. There is some debate about what the optimal treatment volumes and/or minimum detention times should be.

Water Quality Criteria Options

There are several sizing options that have been used by municipalities on the mainland U.S and elsewhere. Examples of sizing options for defining the volume of runoff needed for stormwater quality treatment are presented below.

A) The Ninety Percent Capture Rule: The 90% capture rule is based on an analysis of the rainfall frequency spectrum (see Figure 5.1). It is equivalent to the 90th percentile annual rainfall event multiplied by a site's impervious cover[3] (expressed as a decimal). The technical basis for the 90% capture rule is that the stormwater treatment practice is explicitly designed to capture and treat 90% of all runoff events, or in other words, capture the rainfall depth at the 10% exceedance value where events are equal to or greater than the derived value. As such, this sizing rule targets the treatment of the long-term pollutant load, as opposed to an event-based load such as the first flush approach (often thought of as the first one half inch of runoff from a site). In addition, the 90% rule results in an increasing volume with greater site impervious cover.

The rainfall frequency curve illustrated in Figure 5.1 defines the 10th percentile event (or the event that falls within the "knee" of the curve (i.e., inflection point) at 1.5 inches of rainfall.) It is at the inflection point that the optimization of treatment volume occurs. In other words, as you move past the inflection point, the required treatment volume

[3] Impervious cover is recommended as a surrogate for runoff coefficient (Rv). Many mainland U.S. communities use the Rv, which is nearly equal to the impervious cover, to calculate the water quality volume. Rv is derived from the following equation: $Rv = 0.005 + 0.9(I)$, where I is the impervious cover of a site, expressed as a decimal. Impervious cover, expressed as a decimal provides less confusion and provides nearly the same results as Rv.

typically increases significantly with little increase in the total number (or volume) of storms treated. Although it is also important to note that some portion of the runoff volume for storms bigger than the 10th percentile event will receive portion treatment by a recommended BMP.

B) One-Inch Times the site Impervious Cover: This approach applies an arbitrary rainfall volume that for northern Guam is approximately the 16th percentile of time the depth is equal to or greater than 1.0 inch (or 84% of events are less than this value). This approach would provide slightly less pollutant removal capability than the 90% capture rule and treatment volume requirements would also be reduced by approximately one-third.

C) Eighty Percent Capture Rule: Similar to the 90% rule, the 80% capture rule is based on the same analysis of the rainfall frequency spectrum but it is equivalent to the 80th percentile annual rainfall event multiplied by a site's impervious area.

The 80% capture rule is targeted at capturing and treating 80% of all runoff events, or in other words, capturing the rainfall depth at the 20% exceedance value where events are equal to or greater than the derived value. The rainfall frequency curve illustrated in Figure 5.1 defines the 20th percentile event at approximately 0.8 inches of rainfall. The Denver Urban Drainage and Flood Control District utilizes the 80% capture rule for design of stormwater practices (see www.udfcd.org/usdcm/vol3.htm). Again, like the 90% rule, the 80% rule results in an increasing volume with greater site impervious cover.

D) Half-Inch Rule: This option is based on the "first flush" concept that has been widely applied on the mainland U.S and which states that the majority of the pollutants carried in urban runoff are carried in the first half-inch of runoff. For example, the US EPA estimates that 90% of pollution are contained in the first one-half inch of runoff. The half-inch rule simply requires that one-half inch of runoff be treated from the total area of the site. It is calculated by multiplying 0.5 inches by the total site area. While this method is simple to calculate, it is not a function of impervious cover, which removes an incentive to minimize the impervious cover at a site.

E) Half-Inch per Impervious Area Rule: This rule is a slight variant on the half-inch rule, where the water quality volume is defined as one-half inch times the impervious area of the site. The half-inch per impervious area rule provides an incentive to reduce impervious cover; however, the required volume is significantly less than the 90% rule and does not provide adequate treatment for a substantial portion of the long-term pollutant load, because it fails to account for storm variability when high intensity rainfalls occur later in an event after the first ½" of rain has already fallen.

Criteria Recommendation

Based on the above discussion of the various methods used to calculate the water quality volume requirement, it is recommended that the criteria for CNMI and Guam adopt the 90% rule for lands uses draining to *high quality* resource areas and for all hotspot land uses. It is recommended that all non-hotspot land uses that drain to *moderate quality* resources areas adopt the 80% rule. Table 5.3 lists the recommended water quality volume requirement as a function of land use and receiving water quality. Figures 5.3 through 5.6 depict the delineation of high quality resource areas and moderate quality resources for Guam and CNMI. In association with these criteria, it is recommended that a minimum WQ_v value of 0.2 watershed inches be used to capture the runoff from pervious surfaces on sites with very low impervious cover. In summary, this criterion:

- Captures between 80% and 90% of the runoff events providing water quality treatment for all but the largest storms but recognizing that even the larger storms will receive some degree of treatment;
- uses a variable scale of treatment that is a function of land use and receiving water quality;
- captures and treats a larger portion so called, "first flush";
- ensures fairly high level of treatment at highly impervious sites such as parking lots and convenience stores that often have elevated pollutant loads, but are not specifically designated as hotspots;
- is a function of site impervious cover, which provides an incentive to developers to reduce total imperviousness; and
- is inclusive of the recharge volume, so in many areas, the WQ_v requirement may be met in part, or in whole, by providing Re_v.

Table 5.3 Recommended Water Quality Volume (WQ_v) Requirement as a Function of Land Use and Resource Quality

Land Use Classification	**Resource Quality Designation[1]**	
	High	**Moderate**
All Conventional Land Uses	1.5" (90% Rule)	0.8" (80% Rule)
Hotspots	1.5" (90% Rule)	1.5" (90% Rule)

1. Resource quality is defined as both freshwater resources and coastal resources. In Guam, resource areas are designated as M1 and M2 for marine and S1, S2 and S3 for fresh waters (M1 and S1 would receive the high quality designation). In CNMI, coastal waters are designated as AA (high quality) and A (moderate quality). All fresh surface waters in CNMI have been designated as Class 1 (high quality). Refer to Section 4 for more specific information regarding resource classification.

It is instructive to illustrate the storage volume requirements for the recommended water quality volume criteria (i.e., the 80% rule which yields a rainfall depth of 0.8 inches and a 90% rule which yields a rainfall depth of 1.5 inches) compared to the other options discussed earlier in this Section. Figure 5.10 graphically depicts this by showing storage volume (expressed in watershed inches) as a function of impervious cover.

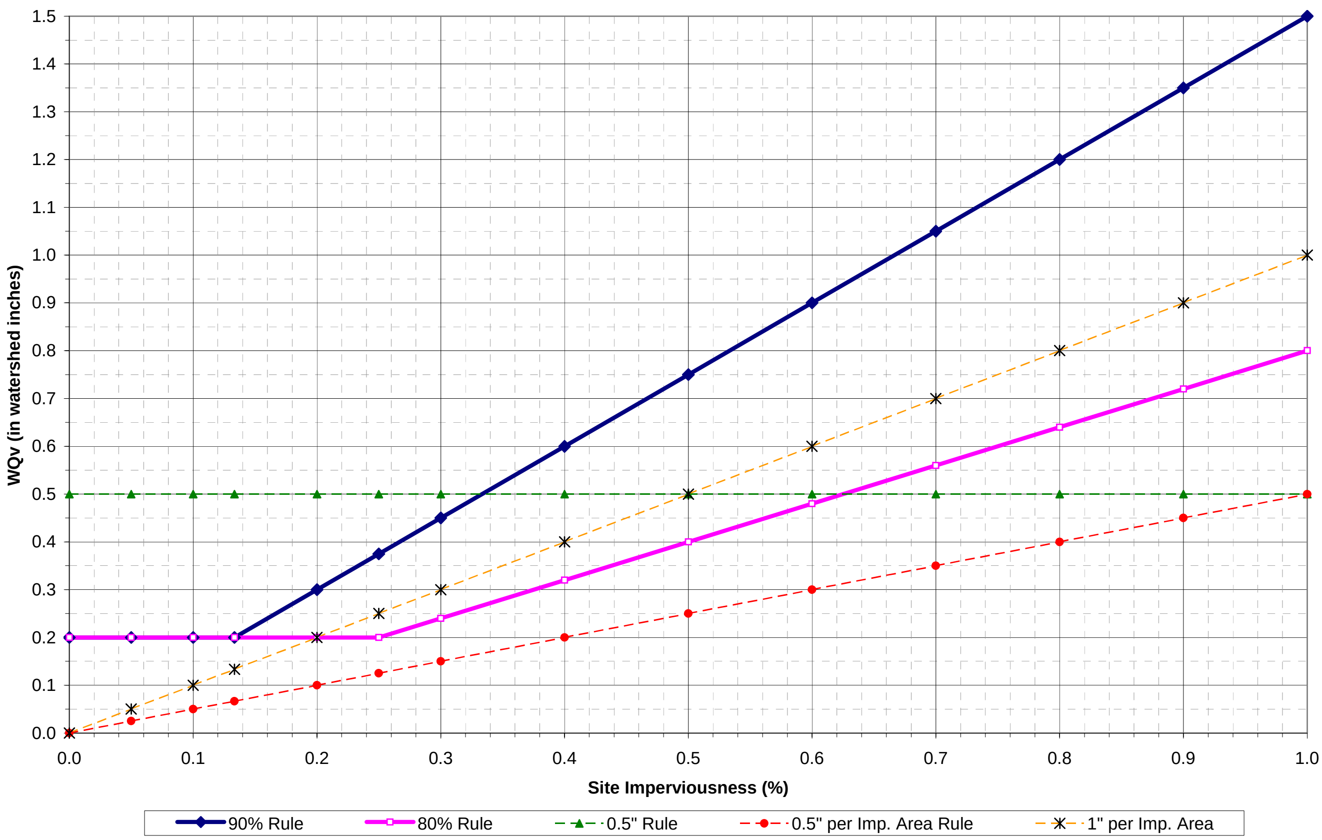


Figure 5.10 Comparison of Water Quality Volume Requirements (recommended criterion of 0.8" and 1.5", are in bold)

5.5.3 <u>Overland Erosion and Channel Protection Criteria (Cp_v)</u>

Overland erosion and channel protection in stormwater management attempts to minimize overland erosion (gullying) and downstream channel expansion and erosion that normally occurs with urbanization of a watershed. As pervious surfaces such as rangeland and forests are converted to impervious surfaces, the volume and frequency of runoff is increased significantly. Research indicates that urbanization causes gullies to form and channels to expand two to five times their original size, depending on their erodability, to adjust to the increased volume and frequency of runoff from impervious surfaces and the increased conveyance efficiency of curbs, gutters and storm drains (Moriwasa and LaFlure, 1979, Allen and Narramore, 1985 and Booth, 1990).

Options for Overland Erosion and Channel Protection Criteria

Many different design criteria have been suggested by researchers, stormwater program managers and designers to protect downstream channels from erosion caused by development. Most have relied on controlling a given flow rate and have not addressed the issue of sediment transport. Over time, practitioners have developed a better understanding of the key parameters to provide adequate downstream channel protection. With the advent of sophisticated computer software, much of the analysis of channel geomorphology and protection criteria has been based on hydrologic and hydraulic modeling of streams. In addition, the limited field data that have been collected for some of the methodologies are favorable and support the use of these methodologies to protect channels and overland areas from accelerated channel erosion. Generally speaking, the newer methodologies require more control (i.e., a larger required storage volume) than traditionally has been allocated to channel protection. Potential channel protection approaches include:

A) Two-Year Control: This was the first and most widely applied control criteria, which attempted to attenuate runoff from the 2-year storm for a period of time for channel protection. Under this control criterion, post-development peak flows are held to two-year pre-development rates with the goal of minimizing overland and channel erosion. This is commonly referred to as *"2-year" peak flow attenuation."* The strategy is based on the assumption that the bankfull discharge for most streams and conveyance channels has a recurrence interval of between 1 and 2 years, with approximately 1.5 years as the most prevalent (Leopold et al, 1964 and 1994).

Research studies indicate that this method frequently does not protect channels from downstream erosion and may actually contribute to accelerated erosion since banks are exposed to a longer duration of erosive bankfull and sub-bankfull events (MacRae, 1993 and 1996, McCuen and Moglen, 1988). Facilities with two-year control often release water above a critical discharge for effective work (Q_{crt}) for a longer period of time, which results in greater transport of sediment and bedload (see Figure 5.11). MacRae also documented that facilities employing two-year control can cause channel expansion by as much as three times the pre-development condition. The primary reason is that while the magnitude of the peak discharge doesn't change under developed conditions, the duration and frequency of erosive flows sharply increases. As a result, "effective work" on the channel is shifted to more frequent runoff events that range from the half-year event up to the 1.5-year runoff event (MacRae, 1993).

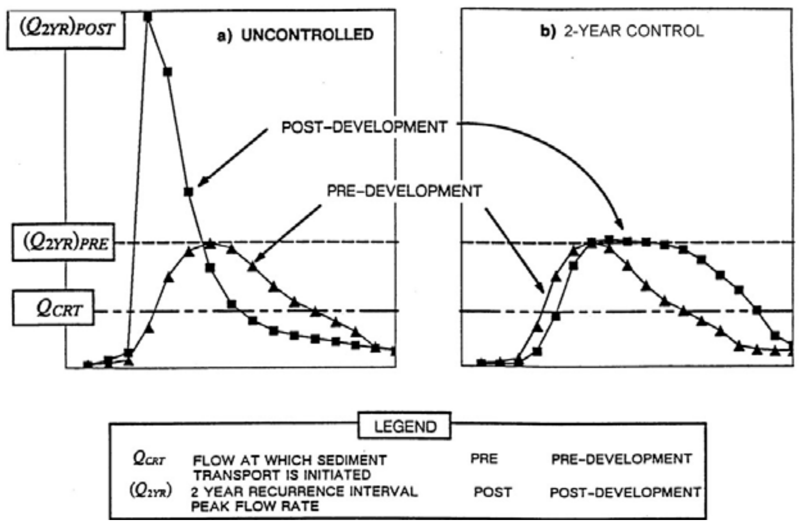


Figure 5.11 Hypothetical hydrograph of No Stormwater Controls versus the Typical Two-year Peak Attenuation Control Strategy (MacRae and Rowney, 1992)

B) Two-Year Over-Control: This second method (proposed by McCuen, 1979) is based on controlling the post-development peak flow rate to 50% or less of the pre-development 2-year level. This design approach recognizes the inherent limitations of two-year control. The approach emphasizes "over-control" of the two-year storm. Another variation on this strategy is to control the two-year post-development discharge rate to the one-year pre-development rate, using the 24-hour storm event. Subsequent analysis by MacRae (1993), however, indicated that this design criterion is still not fully capable of protecting the stream channel from erosion. Modeling suggests that depending on the bed and bank material, the channel may either degrade (downcut where soft boundary material is present) or aggrade (build up where firm boundary material is present) with an over-control management strategy (MacRae, 1993).

C) Distributed Runoff Control (DRC): This method was developed by MacRae (1993) and has been adopted in Ontario, Canada (Aquafor Beech, Ltd. 1999), Austin, Texas, and as an option in Vermont. It involves some detailed field assessments and hydraulic and hydrologic modeling to determine the hydraulic stress and erosion potential of bank materials. The criterion states that channel erosion is minimized if the erosion potential of the channel bank materials are maintained constant to pre-development conditions over the range of flows at which sediment transport of bed or bank material occurs (i.e., from mid-bankfull to full bankfull flow events). The DRC requires assessing downstream channel parameters generally within a reach length of similar geomorphic characteristics at the location most susceptible to erosion. While the method holds great promise and has been applied and tested recently in Ontario and Austin, Texas, it requires some detailed field work at each site. The DRC hydrograph attempts to mimic the pre-development hydrograph for the area above Q_{crt} shown in Figure 5.12

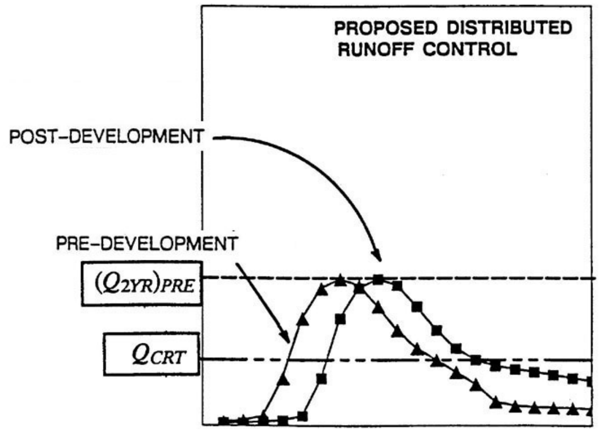


Figure 5.12 Distributed Runoff Control (DRC) vs. Predevelopment Hydrograph (MacRae and Rowney, 1992)

D) 24-Hour Extended Detention of the One-Year Storm: This design method calls for holding the runoff volume generated by the one-year, 24-hour rainfall to be gradually released over a 24-hour period. The rainfall depth will likely vary slightly depending on location throughout CNMI and Guam. According to Lander (2003), the one-year, 24-hour rainfall is in the range 3.5 inches for northern Guam. The premise of this criterion is that runoff would be stored and released in such a gradual manner that critical erosive velocities would seldom be exceeded in downstream channels. Modeling based on a Maryland development site demonstrated that 24-hour extended detention approximated the Distributed Runoff Control well for storms in the range of a three-inch rainfall (Cappuccitti, 2000).

The 24-hour extended detention (ED)[4] of the one-year storm event has been recently adopted in Maryland, Vermont, New York and Georgia as the base overland erosion and channel protection criterion. The criterion has been implemented in Maryland for state and federal projects for the last 10 years.

Recommendation for Channel Protection Criteria:

To protect stream channels from erosion, it is suggested that 24-hour Extended Detention of the 1-year storm event be used as a base criterion.

[4] Extended detention involves providing temporary storage of a given volume of water to be gradually released over a specified period of time. In this case, runoff from the post-developed one-year storm is proposed to be released over a 24 hour period.

The Baseline Criterion Recommendation Is Based On The Following Factors

- Modeling suggests that 24-hour extended detention of the 1-year, 24-hour storm event approximates the more rigorous DRC for events up to the 2-inch rainfall (which is approximately 60 % of the 1-year, 24-hour event in CNMI and Guam).
- It is easy to compute the runoff volume and determine storage requirements. This also makes it easy for reviewers to verify and designers to implement.
- The criterion is being applied in other locations in the mainland U.S. and has been recognized by stormwater practitioners as a viable and more effective alternative to the standard 2-year peak discharge control.
- The criterion balances the need to use a scientifically valid approach with a methodology that is relatively easy to implement in the context of a region-wide program.

Exemptions to Channel Protection Requirement

Since there are practical limitations on minimum orifice or weir sizes needed to control Cp_v, the requirement would be waived for:

1. small sites (i.e., less than or equal to one acre of impervious cover).
2. direct discharges (after treatment) to a stream or river with a contributory drainage area greater than 5-square miles, large lakes or reservoirs, any coastal waters subject to tidal action, or where the development area is less than 5% of the watershed area upstream of the development site.

5.5.4 Overbank Flood Protection Criteria (Qp)

The primary purpose of this sizing criterion is to prevent an increase in the frequency and magnitude of out-of-bank flooding (i.e., flow events that exceed the bankfull capacity of the channel, and therefore must spill over to the floodplain. One of the key objectives of an out-of-bank flooding requirement is to protect downstream structures (houses, businesses, culverts, bridge abutments, etc.) from increased flows and velocities from upstream development. The intent of this criterion is to prevent increased flood damage from infrequent but very large storm events, maintain the boundaries of the predevelopment floodplain, and protect the physical integrity of a stormwater management practice itself. Nationally, many localities require storage to control the post development 100-year, 24-hour peak discharge rate to predevelopment rates.

Currently, CNMI requires management of the 25-year 24-hour event. On Guam, stormwater is designed for the 20-year event. On the mainland U.S., modeling has shown that control of the 10-year storm coupled with control of the 100-year storm effectively attenuates storm frequencies between these two events (e.g., the 25-year storm), and therefore, many mainland U.S communities have adopted 10- and 100-year peak flow attenuation management criteria, instead of a 25-year criteria. But on the mainland, a typical difference in precipitation between the 10-and 100-year storm ranges in size from 6 inches to 10 inches. On northern Guam, at least, the difference in precipitation between the 10- and 100-year storm is a whopping 23 inches (ranging from about 10 inches to 33 inches) (Lander, 2003).

Based on the current policy of 25-year management, a lack of research on CNMI and Guam regarding a 10/100-year criteria, the fact that designing for a 100-year event of over 30 inches would be cost prohibitive, it is recommended that the current criterion for stormwater management of 25-year be maintained for CNMI and added as a criterion Guam, but that the criterion specifically specify attenuation of post-development flows to the pre-developed level (i.e., Provide "*25-year peak flow attenuation*"). In addition, it is recommended that the following conditions would apply to the overbank flood protection criterion.

1. Future development is excluded from designated floodplains and no existing downstream structures are within a designated floodplain;
2. The Overbank Flood Control criterion can be waived if the site discharges directly to a large reservoir or lake, a stream or river with a contributory drainage area greater than 5-square miles, or coastal waters subject to tidal action;
3. A flood model indicates that 25-year control would not be beneficial or would exacerbate peak flows in a downstream tributary of a particular site (i.e., through coincident peaks).

Table 5.4 summarizes the recommended unified sizing criteria for Guam and CNMI to meet stormwater management control options for groundwater recharge (Re_v), water quality (WQ_v), overland erosion and channel protection (Cp_v) and overbank flood control (Q_{p-25}).

Table 5.4 Proposed CNMI and Guam Unified Sizing Criteria for Stormwater Management Practices

Criteria	Recommendation
Recharge (Re_v)	**<u>Limestone-Dominated Regions:</u>** All land types: 1.5 inches x impervious area **<u>Volcanic-Dominated Regions:</u>** Hydrologic Soil Group — Annual Recharge Volume A — 0.80 inches x impervious area B — 0.50 inches x impervious area C — 0.20 inches x impervious area D — 0.10 inches x impervious area Note: Stormwater runoff from hotspots should not infiltrate into groundwater without appropriate pretreatment equivalent to 100% of the water quality volume
Water Quality (WQ_v)	**<u>90% Rule:</u> (Discharge to High Quality Waters & Hotspot Land Uses)** $WQ_v = [(P)(I_a)(A)] / 12$ expressed in acre-feet when A has units of acres where: P = 1.5 inches[5] I_a = Impervious area percentage of site area (decimal) A = Site area **<u>80% Rule:</u>(Discharge to Moderate Quality Waters)** $WQ_v = [(P)(I_a)(A)] / 12$ expressed in acre-feet when A has units of acres where: P = 0.8 inches[5] I_a = Impervious area percentage of site area (decimal) A = Site area Note: Minimum WQ_v = 0.2 inches
Channel Protection (Cp_v)	Cp_v = 24 hours extended detention of post-developed 1-year, 24-hour rainfall event.
Extreme Storm (Q_{p25})	Control the peak discharge from the 25-year storm to 25-year pre-development rates.

[5] Precipitation is based on a rainfall frequency spectrum for a 12-hour time between storms at either the 10% exceedance frequency (discharge to high quality waters or hotspot land use), or the 20% exceedance frequency (non-hotspot land uses discharging to moderate quality waters).

5.5.5 Hydrologic Basis for Design

For facility sizing criteria, the basis for hydrologic and hydraulic evaluation of development sites should be as follows:

Water Quality Volume - WQ_v

- Impervious cover is measured from the site plan and includes all impermeable surfaces (i.e., paved and gravel roads, rooftops, driveways, parking lots, sidewalks, patios, and decks).
- The final WQ_v shall be treated by an acceptable stormwater best management practice (BMP), with consideration to the management priorities of the given receiving waters. The list of acceptable BMPs and receiving waters management criteria are presented in Section 5.6 and 5.10.
- Where non-structural practices are employed in the site design, the WQ_v volume can be reduced in accordance with a “Stormwater Credit” system (this will be presented in the Final Manual).
- Off-site areas shall be assessed based on their “pre-developed condition” for computing the water quality volume (i.e, treatment of only on-site areas is required). However, if an offsite area drains to a proposed BMP, flow from that area must be accounted for in the sizing of a specific practice.
- The water quality requirement can be met by providing 24 hour extended detention of the WQ_v (provided a “micro-pool” is specified, see Section 5.6 and Appendix A).

Channel Protection Volume - Cp_v

- The models TR-55 or TR-20 (or approved equivalent) shall be used for determining peak discharge rates.
- Rainfall depths for the one-year, 24-hour storm event are provided (3.5” on Northern Guam).
- Off-site areas shall be modeled as “present condition” for the one-year storm event.
- The length of overland flow used in time of concentration (t_c) calculations is limited to no more than 100 feet for post-developed conditions.
- Detention time for the one-year storm is defined as the center of mass of the inflow hydrograph and the center of mass of the outflow hydrograph.
- Cp_v is not required at sites where the resulting diameter of the Cp_v orifice is too small. A minimum of one acre of impervious cover is necessary to apply the Cp_v requirement (this results in about a 1" minimum orifice size).

Overbank Flood Control *(Qp_{25})*

- The models TR-55 and TR-20 (or approved equivalent) will be used for determining peak discharge rates.

- The standard for characterizing pre-development land use for on-site areas shall be woods, meadow, or rangeland. For agricultural land, use a curve number representing rangeland.
- Off-site areas should be modeled as "present condition" for peak-flow attenuation requirements.
- If an off-site area drains to a facility the applicant must demonstrate safe passage of the 25-year event. Under this condition, off-site areas should be modeled, assuming an "ultimate buildout condition" upstream.
- The length of overland flow used in time of concentration calculations is limited to no more than 150 feet for predevelopment conditions and 100 feet for post development conditions.

5.6 Acceptable Stormwater Management and Treatment Options

This section presents a list of practices that are acceptable for water quality treatment and therefore will meet the WQ_v management criteria identified on Section 5.2.2. The practices on this list are selected based on the following criteria:

1. Can capture and treat the full water quality volume (WQ_v)
2. Are capable of approximately 80% total suspended solids (TSS) removal[6]
3. Are capable of meeting management objectives for specific resource protection areas through elevated total phosphorus (TP), total nitrogen (TN) and/or fecal coliform bacteria (FC) removal[7]
4. Have acceptable longevity in the field.

A second group of practices is set forth to explicitly provide stormwater detention to meet Cp_v, and /or Qp_{25} requirements. These "storage" practices are explicitly designed to provide stormwater detention and include: (1) dry ponds, (2) underground vaults, and (3) infiltration chambers. These practices are not considered as acceptable practices to meet the water quality volume requirement (WQ_v), and must generally be combined with a separate facility to meet these requirements[8].

Presented below are data supporting the use of the proposed practices as well as minimum criteria for potential additions of future practices to the list.

[6] The 80% removal target is a management measure developed by EPA as part of the Coastal Zone Act Reauthorization Amendments of 1990. It was selected by EPA for the following factors: (1) removal of 80% is assumed to control heavy metals, phosphorus, and other pollutants; (2) a number of mainland U.S. states including DE, FL, TX, MA, ME, MD, and VT require/recommend TSS removal of 80% or greater for new development; and (3) data show that certain BMPs, when properly designed and maintained, can meet this performance level.

[7] The TP, TN and FC removal capabilities for those practices that are also capable of removing 80% TSS will dictate their application for those conditions where additional nutrient and/or bacteria removal is required (see section 5.10).

[8] Infiltration trenches and chambers are acceptable BMPs for meeting the WQ_v assuming the bottom of the infiltration system is within the B or C soil horizon as depicted on the NRCS Soil Surveys for CNMI and Guam.

Recommended Stormwater BMP List

In the Final Manual, a proposed list of practices will be presumed to meet water quality requirements (WQ_v). Acceptable practices are divided into five broad groups, including:

- Stormwater Ponds — Practices that have a combination of permanent pool and extended detention capable of treating the WQ_v.
- Stormwater Wetlands — Practices that include significant shallow marsh areas, and may also incorporate small permanent pools or extended detention storage to achieve the full WQ_v.
- Infiltration Practices — Practices that capture and temporarily store the WQ_v before allowing it to infiltrate into the B and/or C soil horizons. Runoff that discharges directly into limestone areas requires treatment via another approved management practice.
- Filtering Practices — Practices that capture and temporarily store the WQ_v and pass it through a filter bed of sand, organic matter, soil, or other media.
- Open Channel Practices — Practices explicitly designed to capture and treat the full WQ_v within dry or wet cells formed by check dams or other means, or within the channel itself through a slow velocity and relatively long resistance time.
- Proprietary Practices — Practices that utilize a propriety technology and can demonstrate through independent monitoring a capability to treat the WQ_v at a removal efficiency of 80% TSS. These practices are currently not recommended for the approved BMP list, but may be added if independent monitoring results demonstrate removal efficiently of 80% TSS in accordance with Section 5.9.

Table 5.5 summarizes the specific practices within each of these broad categories that are presumed to meet water quality goals. It is important to note that several practices that are not on the list may be of value as pretreatment, or to meet water quantity requirements (see discussion below). Example schematics of each of the recommended practices are provided in Appendix A (Figures A1-A23). These figures are for illustrative purposes only. The specific design components of each practice will be set forth as performance criteria in the Final Manual. The Final Manual will provide design and performance specifications for each practice group in six major areas that include: feasibility, conveyance, pretreatment, treatment, landscaping, and maintenance.

Table 5.5 Proposed List of BMPs Acceptable for Water Quality

Group	Practice	Description
Ponds	Micropool[9] Extended Detention Pond	Pond that treats the majority of the water quality volume through extended detention[10], and incorporates a micropool at the outlet of the pond to prevent sediment resuspension.
	Wet Pond	Pond that provides storage for the entire water quality volume in the permanent pool.
	Wet Extended Detention Pond	Pond that treats a portion of the water quality volume by detaining storm flows above the permanent pool for a specified minimum detention time.
	Multiple Pond System	A group of ponds that collectively treat the water quality volume.
	Pocket Pond	A pond design adapted for the treatment of runoff from small drainage and which has little or no baseflow available to maintain water elevations and relies on groundwater to maintain a permanent pool.
Wetland	Shallow Marsh	A wetland that provides water quality treatment primarily in wet shallow marsh.
	Extended Detention Wetland	A wetland system that provides a portion of the water quality volume by detaining storm flows above the marsh surface.
	Pond/ Wetland System	A wetland system that provides a portion of the water quality volume in the permanent pool of a wet pond that precedes the shallow marsh wetland.
	Gravel Wetland	A wetland system composed of a wetland plant mat grown in a gravel or rock matrix.
Infiltration	Infiltration Trench	An infiltration practice that stores the water quality volume in the void spaces of a gravel trench before it is infiltrated into underlying soils within the B or C soil horizons.
	Infiltration Basin	An infiltration practice that stores the water quality volume in a shallow surface depression, before it is infiltrated into the underlying soils within the B or C soil horizons.

[9] Micropool is the term to define a small permanent pool 4-8 feet deep, typically with a minimum storage of 0.1 inches per impervious acre of drainage.

[10] Extended detention involves providing temporary storage above the permanent pool or micropool that is released over a specified period of time (i.e., 24 hours).

Group	Practice	Description
Filtering Practices	Surface Sand Filter	A filtering practice that treats stormwater by settling out larger particles in a sediment chamber, and then filtering stormwater through a sand matrix.
	Underground Sand Filter	A filtering practice that treats stormwater as it flows through underground settling and filtering chambers.
	Perimeter Sand Filter	A filter that incorporates a shallow sediment chamber and filter bed as parallel vaults adjacent to a parking lot.
	Organic Filter	A filtering practice that uses an organic medium such as compost in the filter, or incorporates organic material in addition to sand (e.g., peat/sand mixture).
	Bioretention	A shallow depression that treats stormwater as it flows through a soil matrix, and is returned to the storm drain system, or infiltrated into underlying soils or substratum.
Open Channels	Dry Swale	An open vegetated channel or depression explicitly designed to detain and promote the filtration of stormwater runoff into an underlying fabricated soil matrix.
	Wet Swale	An open vegetated channel or depression designed to retain water or intercept groundwater for water quality treatment.
	Grass Channel	An open vegetated channel or depression designed to convey and detain the water quality volume at a maximum velocity of 1 foot per second with an average residence time of 10 minutes.

5.7 Basis of Recommendation for Proposed Practices

Proposed practices were selected primarily on their ability to remove at least 80% of total suspended solids (TSS) from stormwater runoff. Some of these practices also tend to have the highest removal capabilities for other common pollutants such as nutrients, trace metals and bacteria. The primary data source for removal efficiencies is the Center for Watershed Protection's *National Pollutant Removal Performance Database* (Winer, 2000; Table 5.6)[11]. In some cases, practices with a reported removal of less than 80% are

[11] In 2000, the Center Watershed Protection completed a national pollutant removal performance database for stormwater management treatment practices. The database contained entries from 139 performance monitoring studies for ponds, stormwater wetlands, infiltration, filters and open channel practices. The database includes data from studies where at least five storm events were sampled. In addition, data fields with pertinent information such as drainage area, impervious cover, total treatment storage volume, pollutant effluent concentration, and other factors helpful for statistical analysis are included.

included. This is particularly true when the reported removal is impacted by some poorly-designed practices. In other cases, while there are no monitoring data available, there is a presumption of performance based on similarity in design to other practices with performance data. The "notes" column in Table 5.6 documents these considerations and assumptions.

Table 5.6 Total Suspended Sediment, Total Phosphorus, and Total Nitrogen Removal of Acceptable Stormwater BMPs for Water Quality

Group	Practice	N	TSS Removal	TP Removal	TN Removal	Notes
Ponds	Micropool Extended Detention Pond	0	ND	ND	ND	This practice is presumed to have removal rates similar to the wet extended detention pond. While this practice has not been monitored, the pollutant removal mechanisms are similar.
	Wet Pond	29	79%	49%	32%	Wet pond performance is highly variable, with some practices in the database with poor design features. Practices that follow the recommended criteria will exceed 80% TSS removal consistently (See Final Manual).
	Wet Extended Detention Pond	14	80%	55%	35%	
	Multiple Pond System	1	91%	76%	ND	Although only based on one study, it is presumed that this practice will consistently exceed 80% TSS removal. The design should result in slightly higher removals than the wet pond.
	Pocket Pond	5	87%	78%	28%	Pocket ponds are a subgroup of other pond designs, including all ponds with drainage areas less than 10 acres.
Wetland	Shallow Marsh	23	83%	43%	26%	

Group	Practice	N	TSS Removal	TP Removal	TN Removal	Notes
	Extended Detention Wetland	4	69%	39%	56%	The database is dominated by undersized practices. No ED wetland in the database treats > 0.15 watershed inches. It is presumed that practices designed in accordance with the performance criteria will achieve 80% TSS removal.
	Pond/ Wetland System	10	71%	56%	19%	The current database is biased by poorly designed facilities. Removals similar to the Wet Pond and Shallow Marsh designs are anticipated. Also, removals were highly variable. Four of the 10 practices actually had higher than 90% removals. It is presumed that practices designed in accordance with the performance criteria will achieve 80% TSS removal
	Gravel Wetland	2	83%	64%	19%	
Infiltration	Infiltration Trench	3	ND	100%	42%	Infiltration practices are difficult to monitor, but are presumed to have high removal rates based on filtration processes of the soil and pollutant land application studies.
	Infiltration Basin	0	ND	ND	ND	
Filtering Practices	Surface Sand Filter	8	87%	59%	32%	
	Underground Sand Filter	0	ND	ND	ND	Presumed similar removal to other filtering practices.
	Perimeter Sand	3	79%	41%	47%	Result impacted by one study with very low inflow

Group	Practice	N	TSS Removal	TP Removal	TN Removal	Notes
	Filter					concentrations. Presumed similar removal to other filtering practices.
	Organic Filter	7	88%	61%	41%	
	Bioretention	1	ND	65%	49%	Presumed similar removal to other filtering practices.
Open Channels	Dry Swale	4	93%	83%	92%	
	Wet Swale	2	74%	28%	40%	The two wet swale designs in the database actually achieve relatively low outflow concentrations. Results are biased by relatively low inflow concentrations.
	Grass Channel	3	68%	29%	ND	The current database is slightly biased by poorly designed facilities. Removals similar to the Dry Swale are anticipated with appropriate design.

Notes: Removals represent median values from Winer (2000)
N = number of studies
TSS = total suspended solids; TP = total phosphorus; TN = total Nitrogen
ND = No Data

Removal of other pollutants may be an important consideration for many applications as well. For most pollutants, insufficient data are available to make conclusions about *individual* practices. Therefore, the Final Manual will present data or presumed removals for the practice *groups* as guidance on appropriate BMP selection. Similar to TSS, TP, and TN these data are based on pollutant removals reported in Winer (2000)

Table 5.7 Percent Removal of Key Pollutants by Practice Group

Practice	Metals[1] [%]	Bacteria [%]	Hydrocarbons [%]
Detention Ponds	26	78	N/A
Wet Ponds	62	70	81
Stormwater Wetlands	42	78	85

Filtering Practices	69	37	84
Infiltration Practices	99	N/A	N/A
Water Quality Swales and Grass Channels	61	N/A	62

5.8 Structural Practices That Meet Water Quantity (Cp_v/Q_{p-25}) Requirements and Pre-treatment Functions

Several practices are not recommended for providing the target water quality treatment (i.e., 80% TSS removal) as "stand alone" practices. Many of these practices have little monitoring data, or available data suggest poor pollutant removal capabilities. Some of these practices, such as dry ponds and underground storage vaults (see Appendix A), can be used to meet channel protection and flood control requirements, while others can often be incorporated into a BMP design as pretreatment devices, to treat a small portion of a site, or to meet the recharge criterion. The following practices do not meet the water quality treatment target, but may have some applicability in a site design in conjunction with recommended practices:

For channel protection and flood control requirements:

- Dry Ponds/Underground Vaults/On-Line Storage in the Storm Drain Network (Designed for Flood Control)
- Infiltration Chambers without filtration through the B or C soil horizons

For pretreatment:

- Filter Strips
- Deep Sump Catch Basins and Catch Basin Inserts
- Oil/Grit Separators and Hydrodynamic Structures

Limited design guidance and specifications will be provided in the Final Manual for these practices. In addition, a number of proprietary technologies have been developed in to provide water quality treatment. Some of these have been monitored by independent sources with mixed results. The U.S. EPA, Region 1 and the U.S. NRCS have developed a joint manual and website describing these technologies. Individual fact sheets can be downloaded from the following source (http://www.epa.gov/NE/assistance/ceit_iti/tech_cos/stor.html).

5.9 Criteria for Practice Addition

The stormwater field is constantly evolving, and new technologies constantly emerge. New practices should be capable of meeting water quality goals to the satisfaction of the approval authorities of CNMI and Guam. These goals should include independent scientific verification of the 80% TSS removal target and a proven record of longevity in the field. For a practice to be submitted for consideration, it is recommended that the following monitoring criteria should be met for supporting studies:

- At least five storm events must be sampled
- Concentrations reported in the study must be flow-weighted
- The study must be independent or independently verified (i.e., may not be conducted by the vendor or designer).
- The study must be conducted in the field, as opposed to laboratory testing.
- The practice must have been in the ground for at least one year at the time of monitoring.
- The practice must have been tested in a similar region

5.10 Specific Critical Resource Area and Sensitive Receptor Criteria

The design and implementation of stormwater management control measures is strongly influenced by the nature and sensitivity of the receiving waters. In some cases higher pollutant removal, more recharge or other environmental performance is warranted to fully protect the resource quality, human health and/or safety. Based on the discussions on Section 4 of this draft report, critical resource areas include: *groundwater, freshwater streams, ponds, wetlands, and coastal waters.* Table 5.8 presents the key design variables and considerations that must be addressed for sites that drain to any of the above critical resource areas. Because of the islands' small size, all sites on Guam and in the CNMI can be assumed to drain into one or more of the critical resource areas.

Table 5.8 Specific BMP Criteria by Group for Critical Resource Areas

BMP Group	Critical Resource Area Specific Criteria				
	Groundwater	**Freshwater Streams**	**Freshwater Ponds**	**Freshwater Wetlands**	**Coastal Waters**
Ponds	Pre-treat hotspots. Provide 2' SD from seasonal high groundwater elevation Pretreat hotspots at 100% of WQ_v.	Overland erosion and channel protection necessary (Cp_v).	Design for enhanced TP removal. Use multiple pond system for best TP removal.	Design for enhanced TP removal. Use multiple pond system for best TP removal.	Moderate bacteria removal. Good to moderate TN removal. Provide permanent pools
Wetlands	Same as ponds	Same as ponds.	Same as ponds. Use Pond/wetland system for best TP removal.	Same as ponds. Use Pond/wetland system for best TP removal.	Provide long ED for maximum bacteria dieoff.
Infiltration	100' SD from water supply wells. Pre-treat runoff in limestone regions at 90% Rule for WQ_v.	OK, but soils overlaying volcanic dominated regions may limit application.	OK, if site has appropriate soils	OK, if site has appropriate soils	OK, but maintain 2' SD from seasonal high groundwater. Best TN removal if within B or C soil horizons.
Filtering Systems	OK, ideal practice for pretreatment prior to infiltration.	Practices rarely can provide Cp_v or Q_{p-25}, other detention needed.	OK, moderate to high TP removal.	OK, moderate to high TP removal	OK, moderate to high bacteria and nitrogen removal
Open Channels	Pre-treat hotspots at 90% Rule for WQ_v.	OK, should be linked w/ basin to provide Cp_v or Q_{p-25}.	OK, Dry swale provides the best TP removal.	OK, Dry swale provides the best TP removal.	Poor bacteria removal. Grass Channel also has poor TN removal
Detention	Does not meet WQ_v pretreatment requirements.	Needed to provide Cp_v and Q_{p-25}.	Generally not necessary if directly discharging to lake.		Generally not necessary, Cp_v and Qp_{-25} not required.

SD = separation distance
ED = extended detention

6.0 ANALYSIS OF STORMWATER AND EROSION CONTROL REGULATIONS

This section provides a description of the existing stormwater and erosion control programs in Guam and the CNMI, including both the programmatic and technical elements. This section also addresses other applicable existing environmental programs and how they relate to stormwater management programs and sedimentation control. Finally, this section provides recommendations on how a new stormwater management program would be most effectively and efficiently implemented given the existing regulatory framework.

6.1 Existing Stormwater and Erosion Control Programs

Both Guam and the CNMI have seen tremendous population growth and commercial development over the last several years. In the past, controlling sedimentation from construction sites was the priority with regards to stormwater controls and impacts to receiving water bodies. As a result, existing stormwater and erosion control programs focus heavily on construction-related activities. In addition, other environmental regulations and permitting requirements have helped control pollutants to the water resources of the islands. However, the existing regulations in place may not suffice given the amount of new development facing Guam and the CNMI.

The follow descriptions, as well as Tables 6.1 and 6.2, provide an overview of the regulatory framework related to stormwater and erosion control that exists in Guam and the CNMI today.

6.1.1 Existing Programs In Guam

A) Zoning

The Guam Territorial Land Use Commission (TLUC) and Application Review Committee (ARC), under the Department of Land Management review all projects with respect to the 1996 *Guam Zoning Law and Regulations*. The Zoning regulations currently do not address stormwater management, nor do they have overlay protection districts for resource areas.

B) Subdivisions

Like with Zoning, The Guam Territorial Land Use Commission (TLUC) and Application Review Committee (ARC), under the Department of Land Management review all projects with respect to the 1997 *Guam Subdivision Rules and Regulations*. The Subdivision regulations currently do not address stormwater management other than to state that the design "provide sufficient drainage of the land to provide reasonable protection against flooding. Facilities shall be designed to dispose of normal storm water falling on the subdivision without hazard of flooding, inconvenience of ponding, and the erosion of public or private lands."

C) Erosion Controls

The Guam Environmental Protection Agency (GEPA) administers the 2000 *Guam Soil Erosion and Sediment Control Regulations*, and requires a permit for all clearing, grubbing, grading, embankment or filling, excavating, stockpiling or other earthmoving operations. The regulation only permits the construction phase, with brief reference to the post-construction conditions. Stormwater treatment is not required, and no evaluation or removal rate is stipulated in the design requirements. Less than 20 acres may be disturbed at a time, and there are 10 potential exemptions that may apply upon review and determination by GEPA.

The Regulations are paired with the 1998 Guam EPA *Soil Erosion and Sediment Control Manual*, which provide guidance primarily on construction-related activities. This manual does not describe any post-construction stormwater management BMPs, only those that may be used to manage sedimentation caused by earth-moving activities. The 1998 manual is pre-dated by the 1980 *US Army Corps Guam Storm Drainage Manual* that is still used at times as a reference.

A Grading Permit is also required from the Department of Public Works in conjunction with the building permit process.

Summary of Erosion and Sediment Control Requirements

- Permit applicants must complete an application, which includes a set of plans. These plans must include erosion and sediment control plan in accordance with the Soil Erosion and Control Manual, and a storm water runoff drainage system plan. The Guam Soil Erosion and Sediment Control Manual describes vegetative measures for controlling sedimentation, and structural measures for controlling sedimentation. These plans must both show methods of control prior to and post construction, and the estimated runoff quantities served by each drain and drainage structure.
- Any other required permits must be submitted along with this permit for review, as supplemental background material.
- Information requirements for storm water drainage systems include: runoff during and post construction, drainage area size above cuts and slopes, estimated soil loss volume, methods for trapping sediments, reducing erosion of drainage ways, and for controlling the collection and discharge of storm water during and after construction, method and schedule of construction of waterway crossings.
- Sediment retention structures are required. Sediment basins or ponds are noted as most desirable in allowing sediments in stormwater to settle out.
- All drainage facilities must be designed to carry surface water runoff to a storm drain that will discharge to a catchment facility within the project site.

Design specifications for stormwater drainage systems are:

Diversion Terraces: Temporary diversion channels must convey 1.6 cfs/acre, and permanent diversions must convey 2.75 cfs/acre. All must be grassed or lined, and outlets must be designed to discharge a velocity less than 2.0 ft/s.

Interceptor Channels: Cannot convey water directly to streams, but must go to a sedimentation basin or vegetated area. Outlets to vegetated areas must discharge at velocity less than 2.0 ft/s, and shall be screened.
Conveyance Channels: Velocity must be less than 1.5 ft/s, or where not possible, must be grassed or lined.

Sedimentation Basins: Shall be cleaned when storage capacity is less than 5000 cubic feet per acre (converts to 1.38 inches of runoff). Water from a sedimentation basin shall not be discharged to a natural waterway. It must provide for enough storage to give time for runoff water to be leached into the ground. Outlets must be screened and provide easy access for regular maintenance.

D) Areas of Particular Concern

Flood Hazard and Wetland Areas Rules and Regulations define Flood Zones and Wetlands as Areas of Particular Concern. Any projects that impact a wetland or flood zone area (as designated on official maps), must obtain a permit and approval from the Territorial Land Use Commission (TLUC).

Seashore Permits are required by the Guam Territorial Seashore Protection Commission (TSPC) for any work in a designated Guam Seashore Reserve.

E) Environmental Protection Plan

In conjunction with the Erosion Control Permit, GEPA requires an Environmental Protection Plan (EPP) for most clearing, grading and marine-related construction work. The EPP must describe the proposed work to be done, the potential impacts, and the mitigation measures. The focus of the EPP is primarily the Erosion Control Plan.

F) Environmental Impact Assessment

GEPA may require an Environmental Impact Assessment (EIA) for projects that require a zoning change or a variance, impact wetlands or seashore areas, and must be permitted through Territorial Land Use Commission (TLUC) or the Guam Territorial Seashore Protection Commission (TSPC). An EIA may be required for other significant projects on a case by case basis.

G) Wastewater

GEPA and the Guam Department of Public Works regulate and permit sewer connections and subsurface wastewater systems. Separate permits are required at both the construction and the occupancy stage. The Individual Wastewater System Regulations, as well as its policy standards, provide guidance and specific requirements for sizing, location, materials, testing, inspection, and maintenance of subsurface wastewater systems.

H) Underground Injection

GEPA regulates the underground disposal of non-hazardous liquid wastes, including stormwater, from land. A permit is required for this activity that include an engineering plan, site soil composition, depth of well, and location of well in regard to coastal waters or aquifer recharge points.

I) Well Drilling and Deep Well Operating

GEPA regulates well drilling and deep well operating under the Water Resources Conservation Act. Separate Permits must be obtained for both drilling a well and for operating a well.

J) Aquifer Protection

In accordance with the Federal Safe Drinking Water Act, GEPA requires review and permitting of any project located in Northern Guam over the Principal Source Aquifer.

6.1.2. Existing Programs In The CNMI

A) Zoning

Zoning maps or regulations do not currently exist in the CNMI. In addition, there are no current master plans within the CNMI.

B) Subdivision

Subdivision regulations currently do not exist in the CNMI.

C) Erosion Controls

The CNMI Division of Environmental Quality (DEQ) administers the 1993 *Earthmoving and Erosion Control Regulations*, and requires a permit for all construction, including additions, and clearing of vegetation. The purpose of the regulations is to "establish certain minimum standards and requirements as determined by the Department to be necessary for control of nonpoint source runoff from human-related activities."

However, the regulations apply to earthmoving and land clearing activities, not explicitly to the post-construction conditions resulting from such activities.

In addition to permit application requirements, the erosion control regulation states a number of Discharge Prohibitions, which are divided into four categories. No direct discharges of solid or liquid waste are permitted to surface waters or other people's property. No indirect discharges caused by placement of material near surface waters in such a way that is susceptible to erosion and/or deposition into waters. Erosion and siltation devices are required for all grading and filling, but no specific design requirements are specified for the possible devices. For temporary construction-phase controls, the regulations simply state "Approved temporary erosion and sedimentation control devices, facilities and measures shall be required during construction."

The Regulations are paired with the 1989 *CNMI Stormwater Control Handbook*, which provides guidance primarily on construction-related activities. Other Guidance Manuals include the 1997 *DEQ Improvement and Maintenance Guide for Secondary Roads in the CNMI*, and the 1998 *DEQ Simplified Design of Stormwater Control Systems for Small Buildings.*

The CNMI Storm Water Control Handbook states that it is geared toward developers and farmers, which differs from some other stormwater management manuals in other states. Often, farming practices are addressed separately because they do not fall under the same regulatory requirements as developments. It provides background and guidance information, but few actual design examples, and no connection drawn to actual regulatory requirements. It is written like a stand-alone document rather than a supporting document for regulatory requirements. It includes information about soils, rainfall, urban watershed hydrology (TR-55), principles of erosion control for construction sites, and specifications for stormwater and erosion control practices. However, the specifications do not clarify whether these practices should be used for the construction phase or permanently. There are no treatment or sizing requirements to guide the performance of these practices.

Summary of Earthmoving and Erosion Control Requirements

- The application requirements for a permit are divided into two categories: Commercial Permits versus Non-Commercial, Agricultural and Exploratory Permits. The second category requires less information to be submitted. A permit for commercial sites is required for all earthmoving or land clearing activities on sites that are not both on grades less than 3% and less than 100 square meters.
- Construction of 1 and 2 family residences is considered non-commercial, as does all work by a public agency and clearing for landscaping purposes less than 2,000 square meters if it can be demonstrated that there will be no adverse effects on nearby surface waters. Stormwater drainage control plans are not explicitly required for non-commercial use permits. However, DEQ can request any additional plans or information as deemed necessary to review an application, and in practice, most public agency permits are held to the same standard as commercial permits.

- Plans must be provided for construction erosion control and permanent stormwater systems. The plans must show the location, construction and maintenance of sediment retention structures and equipment, and construction sequencing.
- The regulations require sediment control structures, and site plans showing sediment retention or stormwater management structures, but they do not give specifics about performance of these structures, except that sediment control structures must be designed "based on either minimum of 24 hour detention time including sediment storage volume, or sediment removal rate of not less than 75%." "Plans must be based on the 25 year 24 hour duration storm event." There are no specific guides for any stormwater treatment except that quoted above.
- Erosion and Sediment control plans for commercial use must meet the following design criteria: must be based on the 25 year 24 hour duration storm event; Conveyance structures must be based on the 25 year 24 hour storm event peak discharge; sediment control structures must be designed for the 25 year 24 hour storm event; and designs must be based on either a minimum of 24 hour detention time including sediment storage volume, or sediment removal rate of not less than 75%.
- Grading, filling, clearing and other land disturbances are prohibited during inclement weather and during the coral spawning period. Extra precautions must be taken to eliminate erosion during a 3-week period surrounding the annual coral spawning event (usually June of July), as determined by the Director, and during rain storm periods.

D) Areas Of Particular Concern

The *Coastal Resources Management (CRM) Rules and Regulations*, revised in 2003, regulate work in an Areas of Particular Concern (APC). An APC is a geographically delineated area that has special management requirements. If work is performed in an APC, a coastal permit must be obtained by the CRM agency. CRM will determine if the proposed project will require either a minor siting permit or a major siting permit, dependent upon the scope and location of a project.

The Regulations define the following five APCs:

<u>Shoreline</u> – area between the mean high water mark (MHWM) and 150 feet inland

<u>Lagoon and Reef</u> – area extending seaward from the mean high water mark (MHWM) to the outer slope of the reef

<u>Wetlands and Mangrove</u> - areas that are permanently or periodically covered with water and where species of wetland or mangrove vegetation can be found

<u>Port and Industrial</u> - land and water areas surrounding the commercial ports of Saipan, Tinian, and Rota

<u>Coastal Hazards</u> - areas identified as a coastal flood hazard zone (V&VE) in the Federal Emergency Management Agency (FEMA) Flood Insurance Rate Maps (FIRMS) maps

E) Major Siting

A project reviewed by the Coastal Resources Management (CRM) office may be required to obtain a permit for a "Major Siting." The determination of a Major Siting is based upon the scope of the project and its potential impact to resource areas, either inside or outside the defined Areas of Potential Concern. Major Sitings have specific criteria they must meet, including preparation of an Environmental Impact Assessment (EIA), and undergo a more rigorous review process, as defined in the *CRM Rules and Regulations*.

F) Wastewater

The CNMI DEQ requires permits for on-site wastewater treatment systems, in accordance with the 2002 *Wastewater Treatment and Disposal Rules & Regulations.* Guidance is provided for the siting and design of on-site septic systems. In most cases, any project that generates more than 5000 gallons per day is not allowed to use a septic system, but rather must design a more advanced sewage treatment system.

The CNMI DEQ also requires a land disposal permit for the disposal of wastewater, other than sewage and stormwater, onto land. This permit includes reject from reverse osmosis systems and fuel tank containment berms.

G) Underground Injection Control (UIC) Permits

The CNMI DEQ requires a permit for the disposal of any fluid into the ground via a pipe or man made hole. Usually this type of disposal is prohibited.

H) Drinking Water and Wells Drilling and Water Well Operation

The CNMI DEQ administers and permits Well Drilling and Well Operations as defined under the *Well Drilling and Well Operations Regulations* amended in 1994. Permits are required for wells, including the operation of private wells. Private well systems serving more than 25 people, including reverse osmosis units, require approval. The Well Drilling and Operations regulations provide wellhead protection setback requirements that could impact siting of stormwater management facilities.

I) Groundwater Management

The CNMI DEQ is currently in the process of developing groundwater management zone maps. There currently are no regulatory requirements other than the wellhead protection setback requirements specified in the Well Drilling and Well Operations Regulations, in the Wastewater Regulations, and the Land Disposal of Wastewater regulations. Regulations specific to groundwater management zones are likely in the future.

Stormwater Management relates to the groundwater management in that infiltration should be encouraged. However, potential contaminants should also be avoided from infiltrating into the groundwater.

6.2 Recommendations for New Stormwater and Erosion Control Programs

The existing Guam and CNMI regulatory framework for stormwater management and erosion control focuses primarily on construction-related sedimentation mitigation, with an emphasis on structural practices. Virtually little or no requirements for post-construction controls are regulated other than references to safe conveyance of storm drainage and avoidance of flooding conditions.

Both Guam and the CNMI have adopted specific regulations pertaining to erosion control or earth moving activities. Because technologies are always changing, and for ease of implementation of the new guidance being prepared, the following is recommended:

1) Add brief language for post-construction Stormwater Requirements in the existing erosion and sediment control regulations for both Guam and the CNMI. Reference the new manual being produced as required policy for design criteria of post-construction design methods.

2) Similar to the reference under the erosion control regulations, add the same reference in the Guam Subdivision regulations that all designs must be in accordance with the new guidance manual. The CNMI currently does not have subdivision controls and therefore this does not apply, however, this should be considered in the future.

3) Although the existing construction-related erosion and sedimentation requirements are extensive for both Guam and the CNMI, additional or revised criteria for construction mitigation activities should be reviewed at this time and included in the new design manual.

Table 6.1 Existing Stormwater and Erosion Control Programs in Guam

	Agency	Reference Documents	Description
Zoning	Territorial Land Use Commission (TLUC), Application Review Committee (ARC), Department of Land Management	1996 Guam Zoning Law and Regulations	• Stormwater management not addressed
Subdivision	TLUC ARC Dept of Land Management	1997 Guam Subdivision Rules and Regulations	• Stormwater management not addressed other than to state that the design provide sufficient drainage to protect against flooding.
Erosion Controls	GEPA	2000 Guam Soil Erosion and Sediment Control Regulations 1998 Guam EPA Soil Erosion and Sediment Control Manual	• Requires a permit for all clearing, grubbing, grading, embankment or filling, excavating, stockpiling • The regulation only permits the construction phase • A Grading Permit is also required from the Department of Public Works in conjunction with the building permit process. • Sediment retention structures are required. Sediment basins or ponds are noted as most desirable in allowing sediments in stormwater to settle out. • Design specifications for stormwater drainage systems for: Diversion Terraces, Interceptor Channels, Conveyance Channels, Sedimentation Basins
Areas of Particular Concern	Territorial Land Use Commission (TLUC)	Flood Hazard and Wetland Areas Rules and Regulations	• Flood Zones and Wetlands as Areas of Particular Concern impacted must obtain a permit • Seashore Permits required by the Guam Territorial Seashore Protection Commission (TSPC) for any work in a designated Guam Seashore Reserve.
Environmental Protection Plan	GEPA		• Environmental Protection Plan (EPP) for clearing, grading and marine-related construction work. • The EPP must describe the proposed work to be done, the potential impacts, and the mitigation measures.
Environmental Impact Assessment	GEPA		• Environmental Impact Assessment (EIA) for projects that require a zoning change or a variance, impact wetlands or seashore areas
Wastewater	GEPA and the Guam Department of Public Works	Individual Wastewater System Regulations	• regulate and permit sewer connections and subsurface wastewater systems.
Underground Injection	GEPA		• Permit required for underground disposal of non-hazardous liquid wastes, including stormwater, from land.
Well Drilling and Well Operating	GEPA		• GEPA regulates well drilling and deep well operating under the Water Resources Conservation Act. • Separate Permits must be obtained for both drilling a well and for operating a well.
Aquifer Protection	GEPA		• Permitting of any project located in Northern Guam over the Principal Source Aquifer

Table 6.2 Existing Stormwater and Erosion Control Programs in the CNMI

	Agency	Reference Documents	Description
Zoning	Not Applicable		• No Zoning in the CNMI
Subdivision	Not Applicable		• No Subdivision Regulations in the CNMI
Erosion Controls	CNMI Division of Environmental Quality (DEQ)	1993 Earthmoving and Erosion Control Regulations 1989 CNMI Stormwater Control Handbook	• The regulations apply to earthmoving and landclearing activities, not explicitly to the post-construction conditions resulting from such activities. Permit for all construction, and clearing of vegetation. • Handbook provides guidance primarily on construction-related activities. • The application requirements for a permit are divided into two categories: Commercial Permits versus Non-Commercial, Agricultural and Exploratory Permits. The second category requires less information to be submitted. • Construction of 1 and 2 family residences is considered non-commercial, as does all work by a public agency and clearing for landscaping purposes less than 2,000 square meters. Storm water drainage control plans are not explicitly required for non-commercial use permits. • The regulations require sediment control structures, and site plans showing sediment retention or stormwater management structures • Erosion and Sediment control plans for commercial must meet the following criteria: must be based on the 25 year 24 hour duration storm event; Conveyance structures must be based on the 25 year 24 hour storm event peak discharge; sediment control structures must be designed for the 25 year 24 hour storm event; and designs must be based on either a minimum of 24 hour detention time including sediment storage volume, or sediment removal rate of not less than 75%. • Grading, filling, clearing prohibited during inclement weather and during the coral spawning period.
Areas of Particular Concern	Coastal Resources Management (CRM)	CRM Rules and Regulations, revised 2003	• Geographically delineated areas that have special management requirements. If work is performed in an APC, a coastal permit must be obtained. • Shoreline Lagoon and Reef, Wetlands and Mangrove, Port and Industrial, Coastal Hazards
Major Siting	Coastal Resources Management (CRM)	CRM Rules and Regulations, revised 2003	• Permit for a Major Siting based upon the scope of the project and its potential impact to resource areas, either inside or outside the defined Areas of Particular Concern. An EIA is required.
Wastewater	CNMI DEQ	2002 Wastewater Treatment and Disposal Rules & Regulations	• Permits for on-site wastewater treatment systems, in accordance with the. • DEQ also requires a land disposal permit for the disposal of wastewater, other than sewage and stormwater, onto land.
Underground Injection	CNMI DEQ		• Requires a permit for the disposal of any fluid into the ground via a pipe or man made hole.
Well Drilling and Well Operating	CNMI DEQ	Well Drilling & Well Operations Regulations, 1994	• Permits required for Well Drilling and Well Operations
Groundwater Management	CNMI DEQ		• In the process of developing groundwater management zone maps

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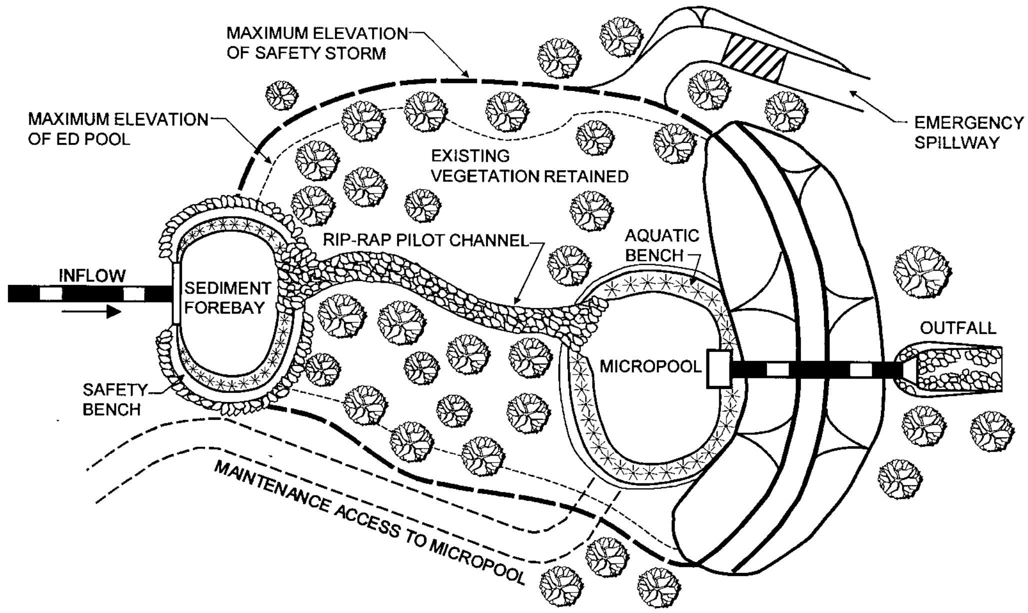
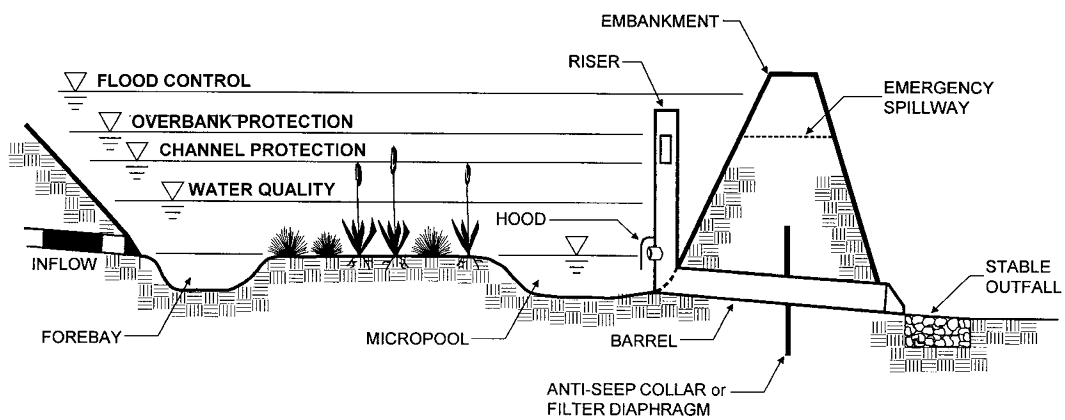
APPENDIX A

BEST MANAGEMENT PRACTICE SCHEMATICS

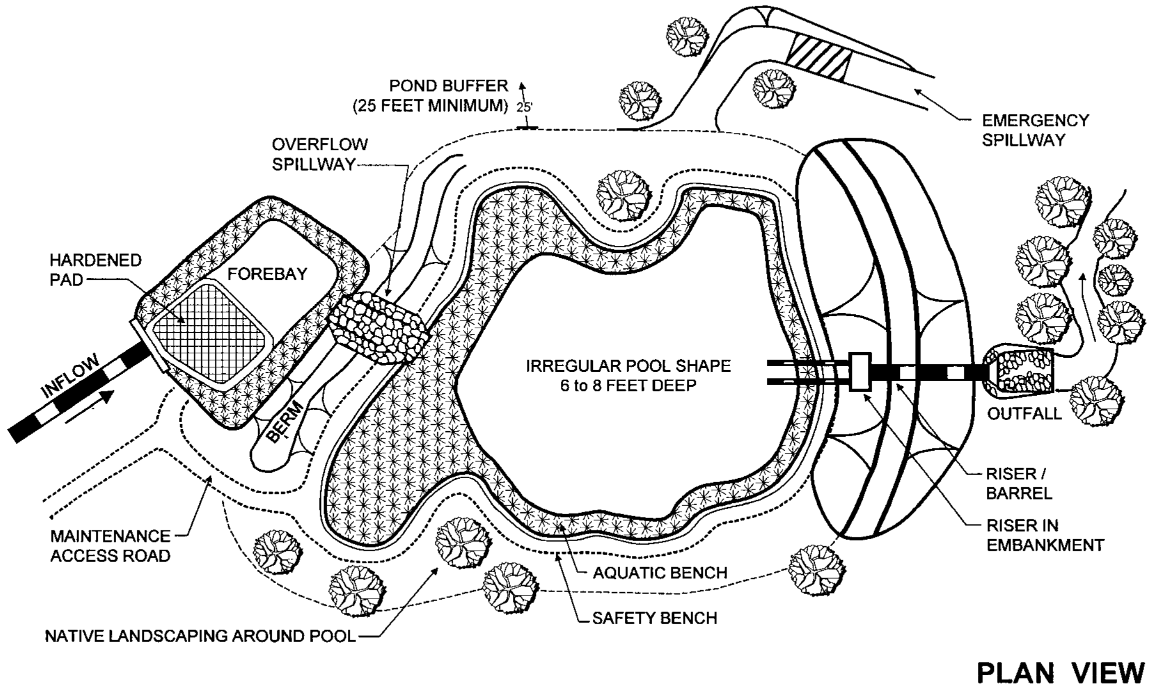


PLAN VIEW



PROFILE

Figure A1 Micropool Extended Detention Pond



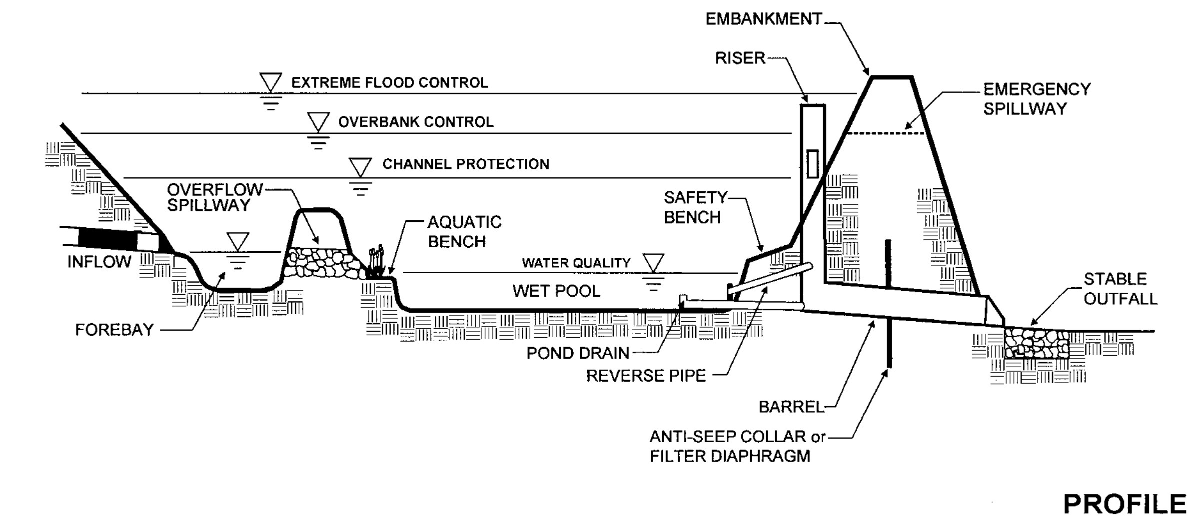
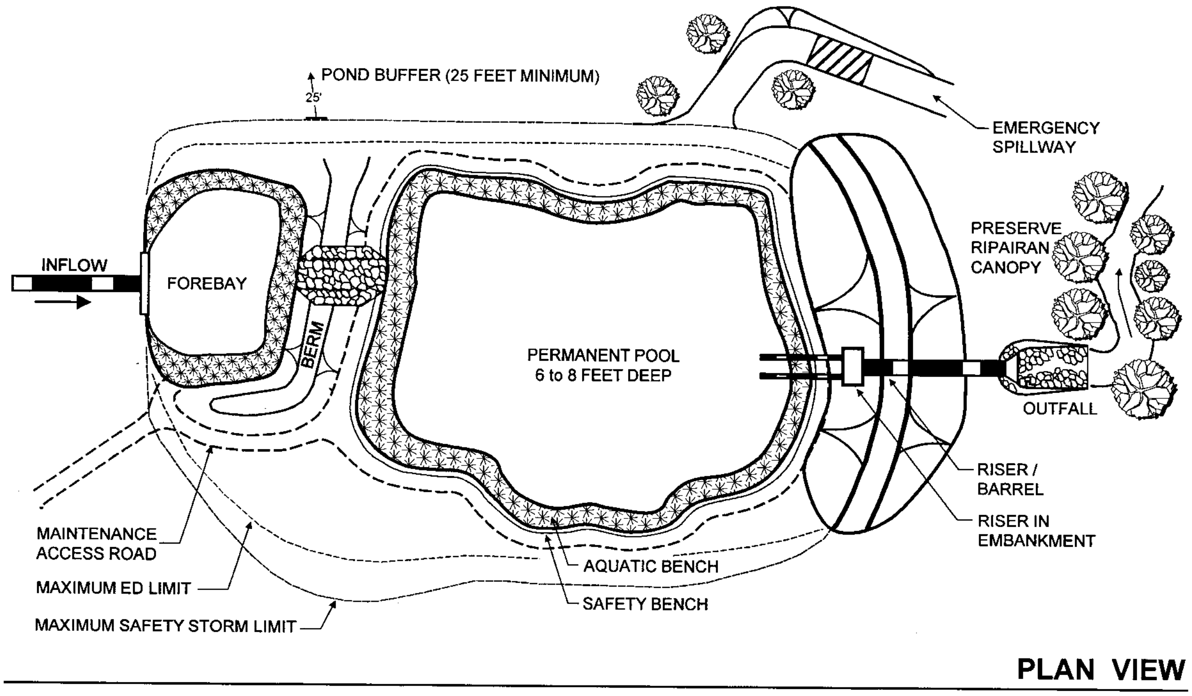


Figure A2 Wet Pond



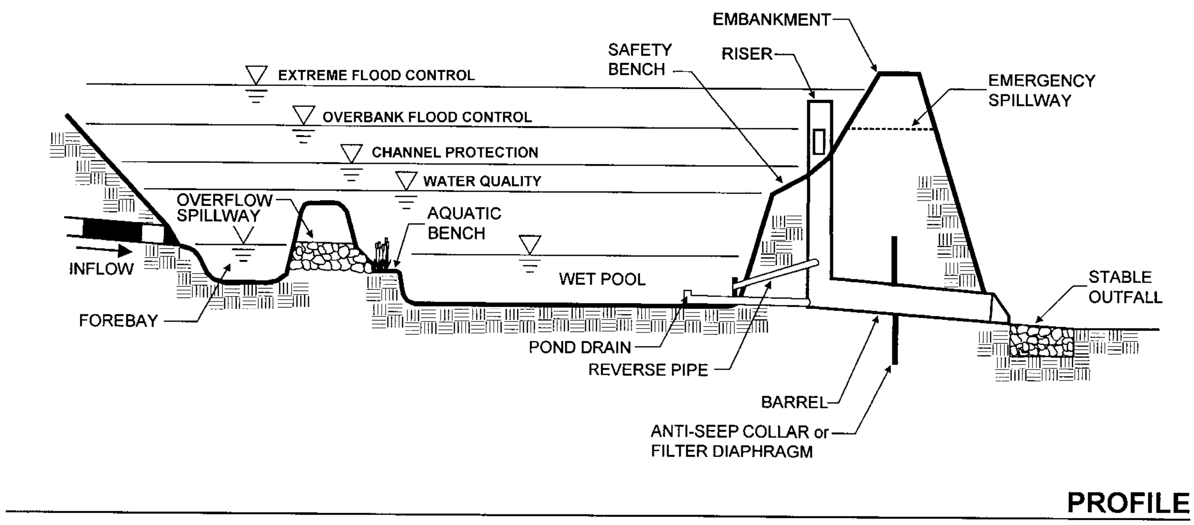
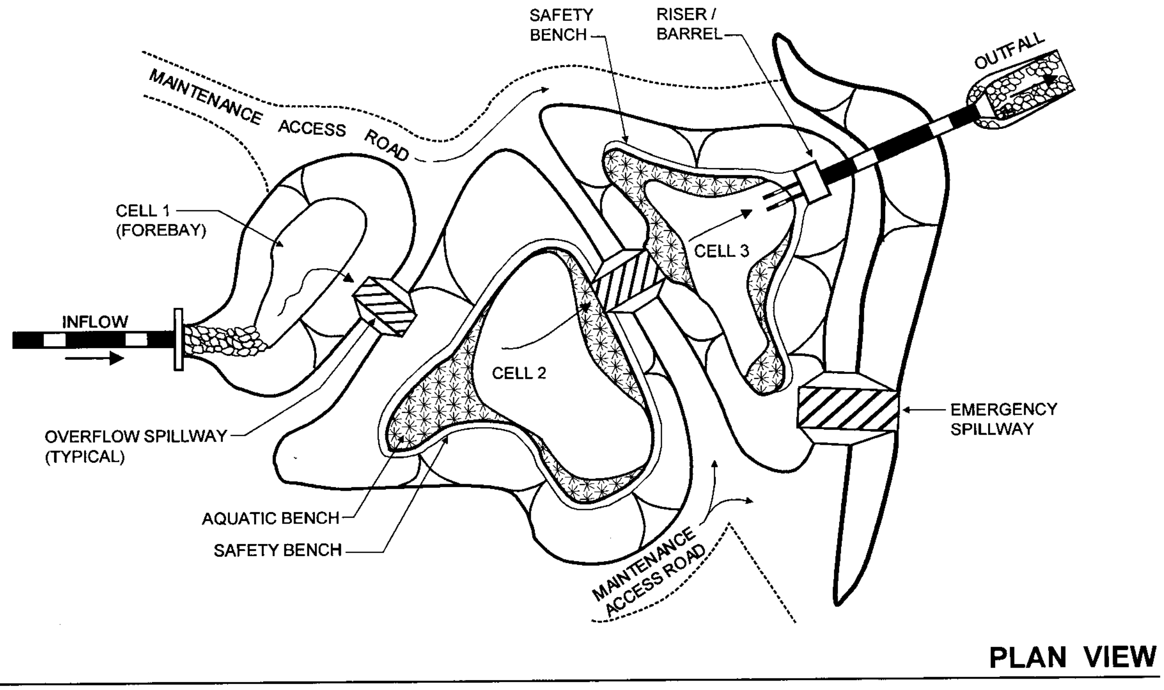


Figure A3 Wet Extended Detention Pond



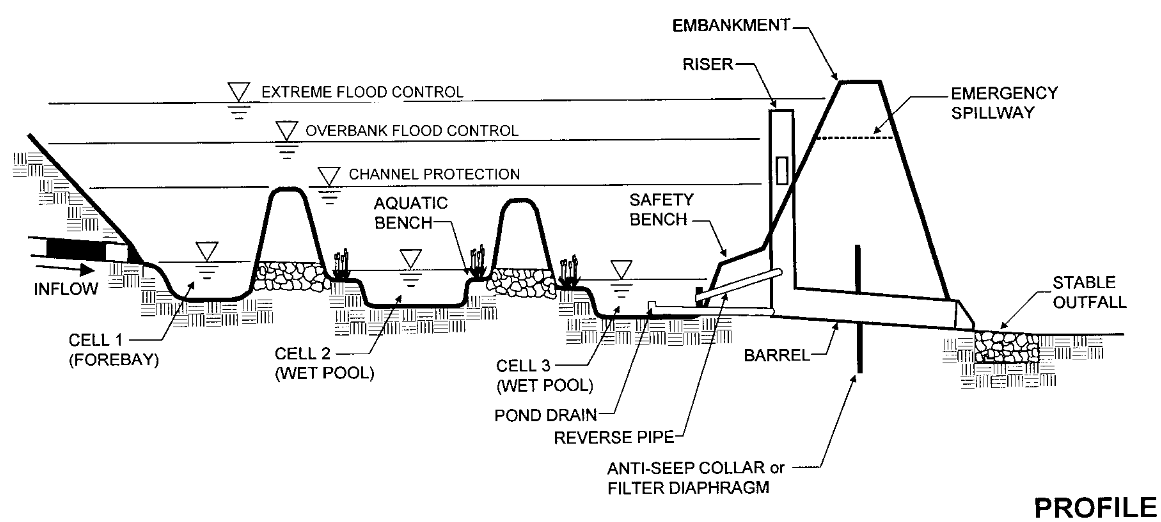
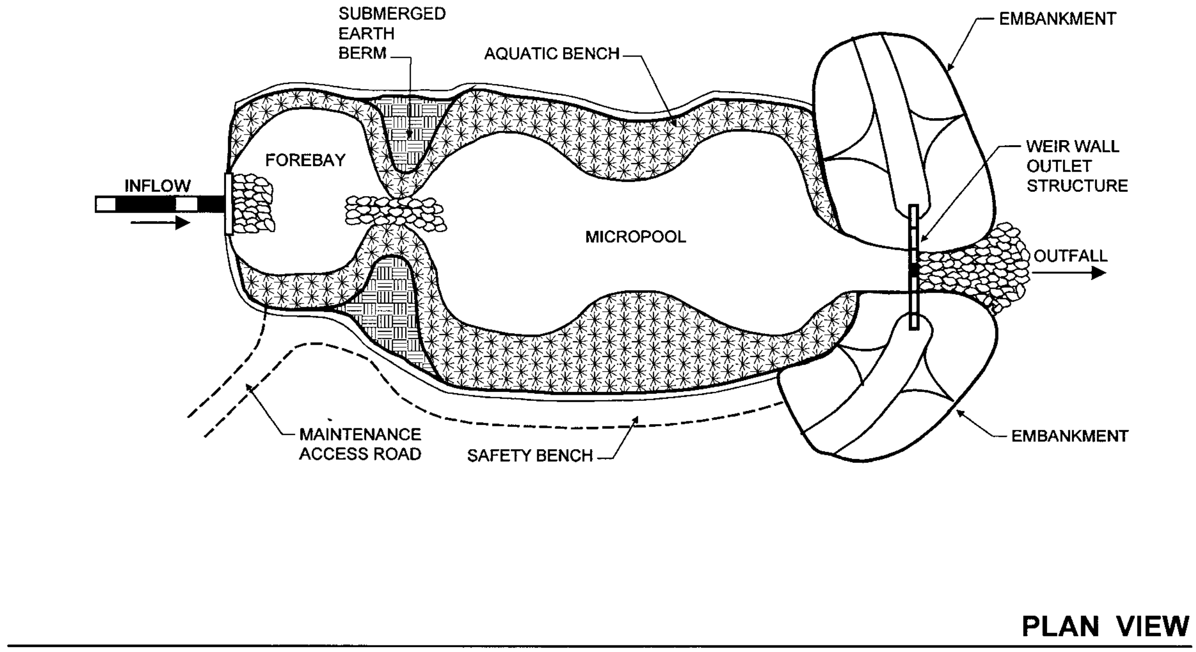


Figure A4 Multiple Pond System



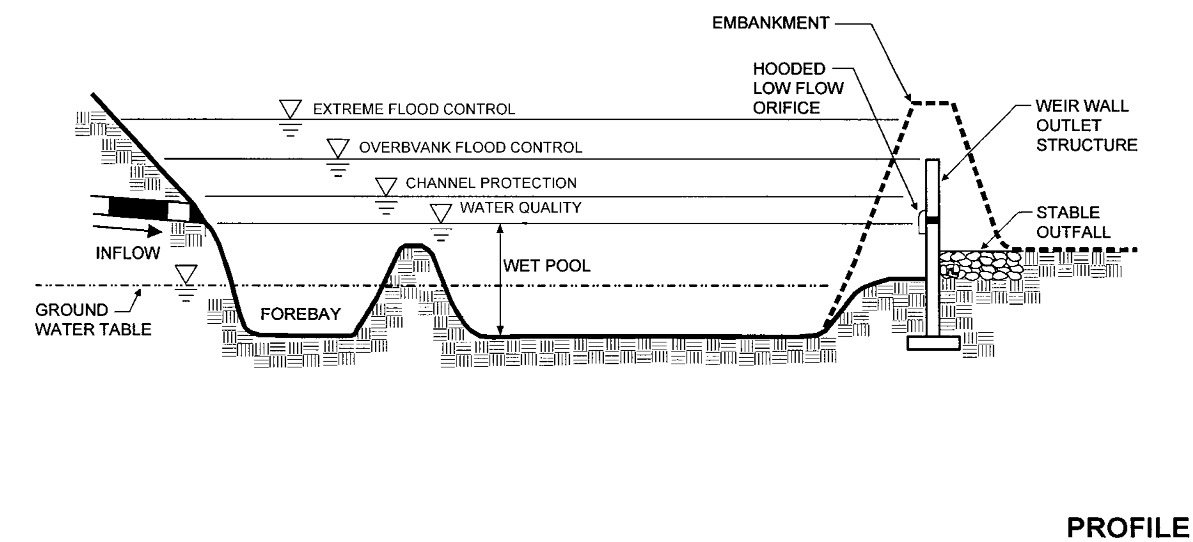
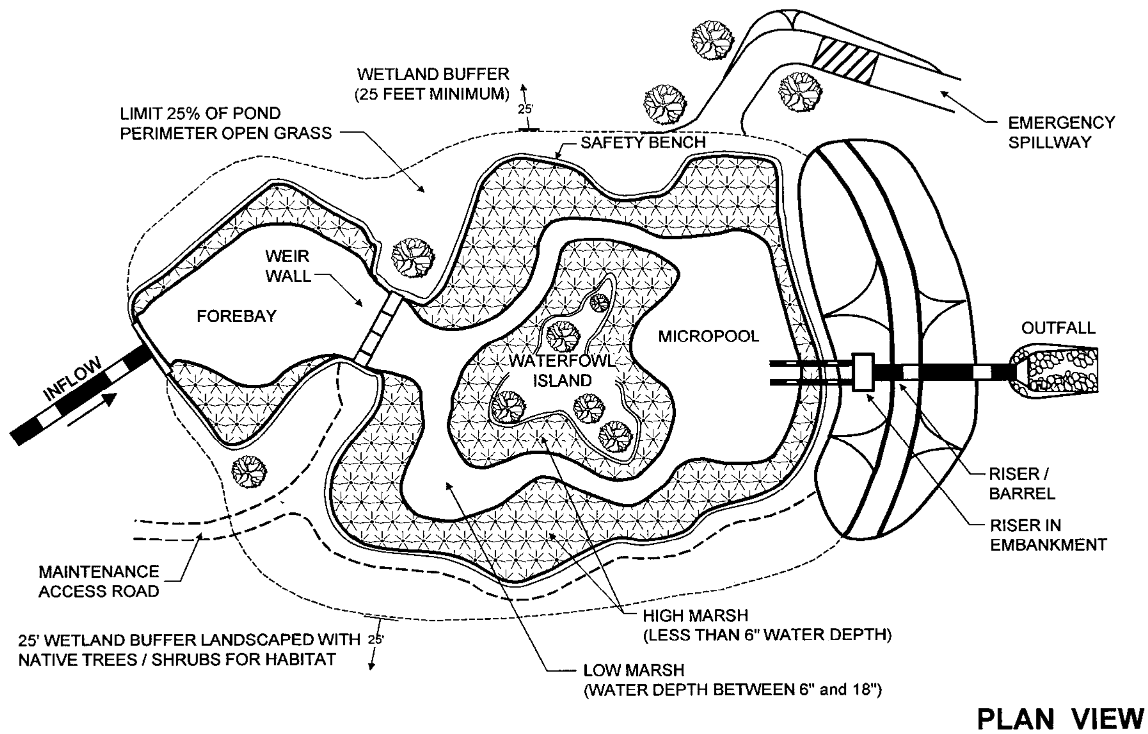


Figure A5 Pocket Pond



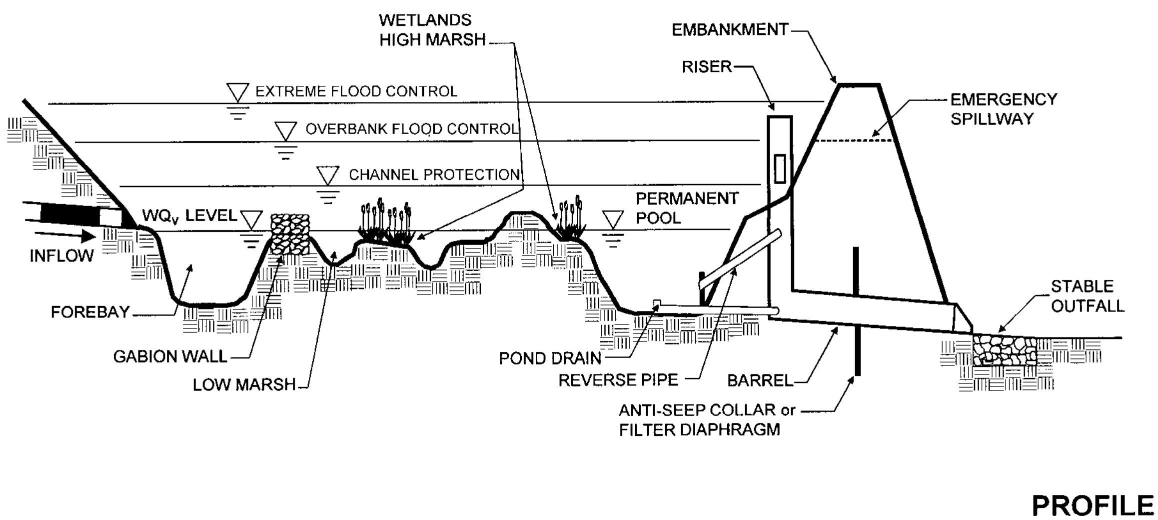
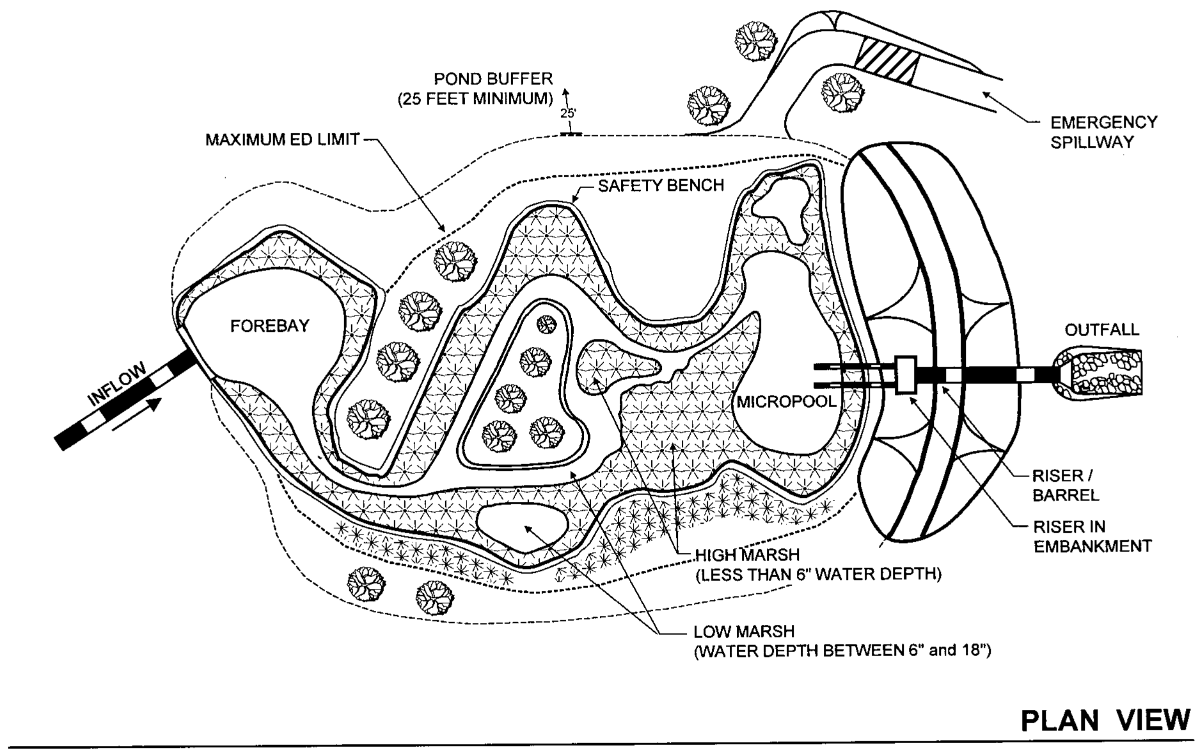


Figure A6 Shallow Marsh Wetland



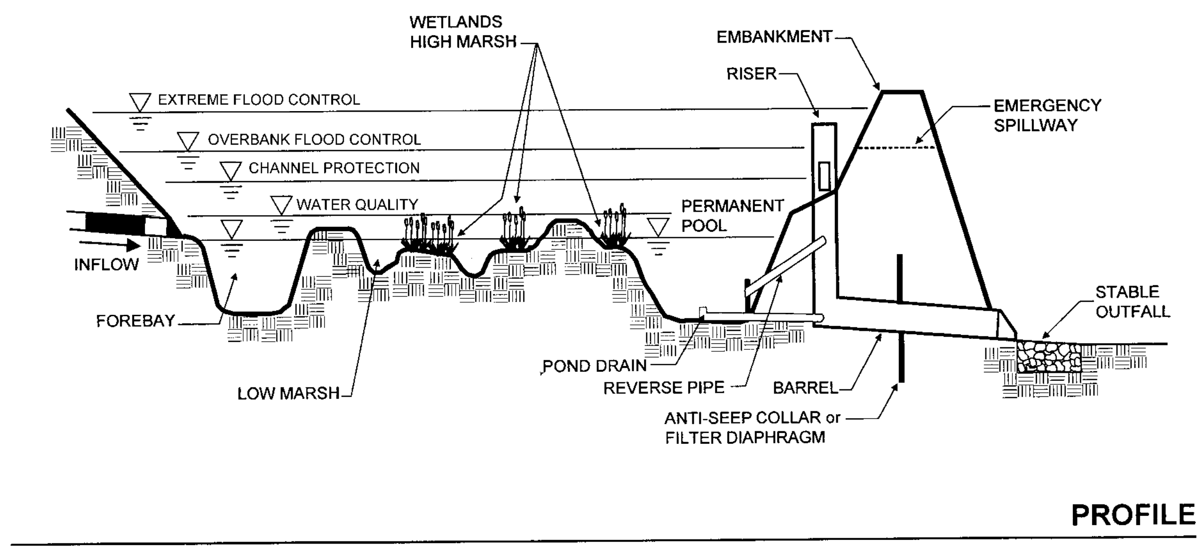


Figure A7 Extended Detention Wetland

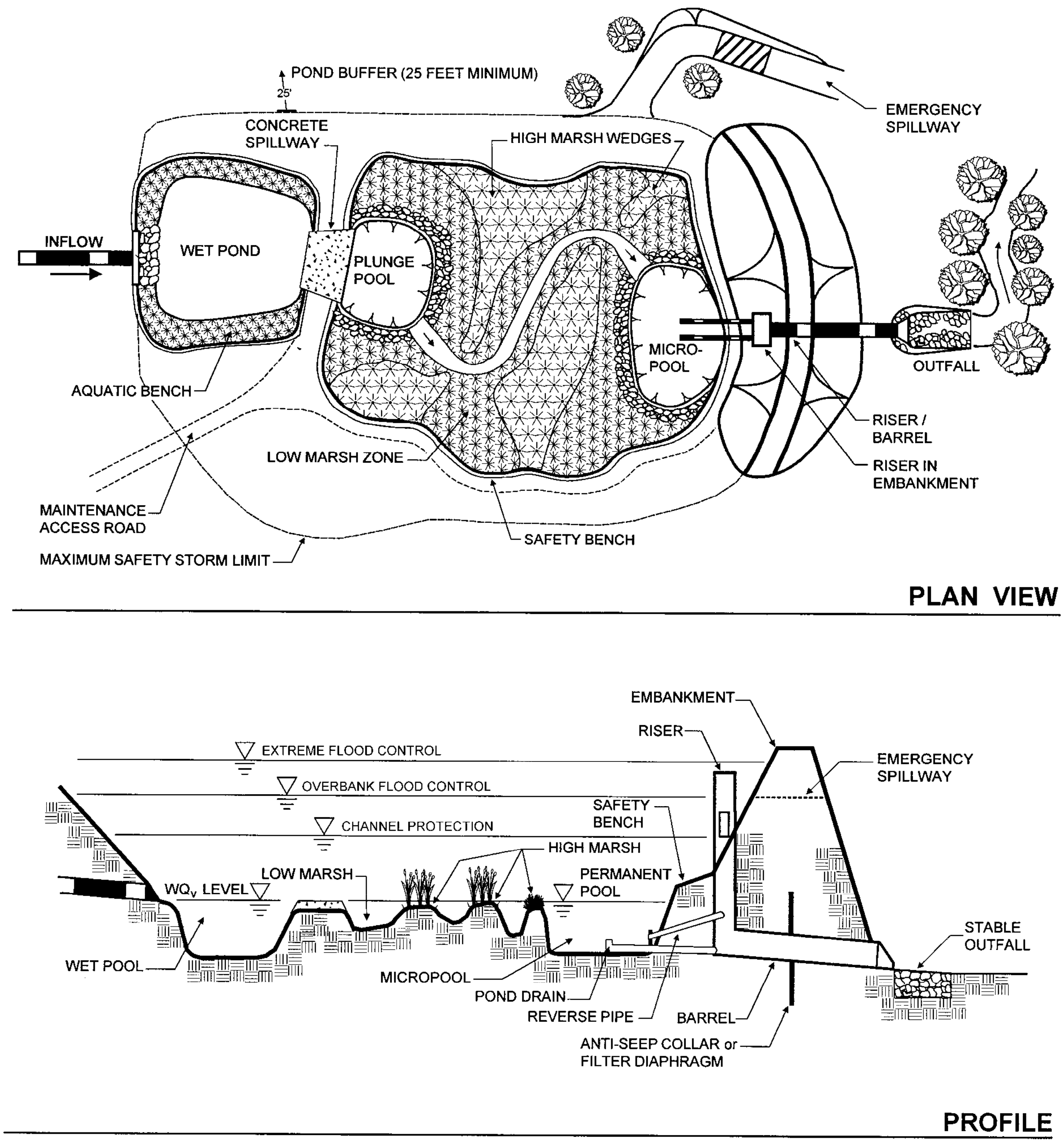


Figure A8 Pond/Wetland System

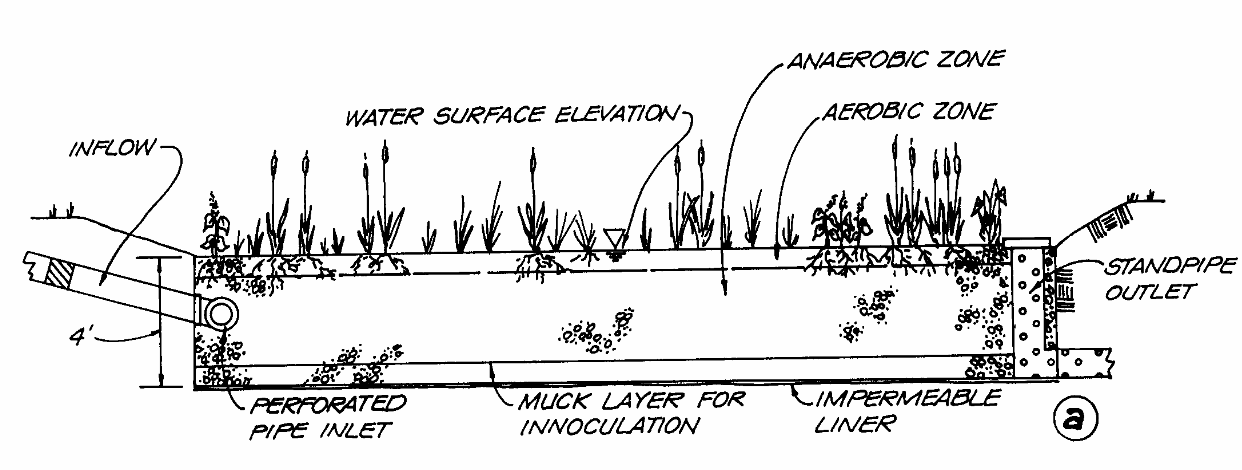
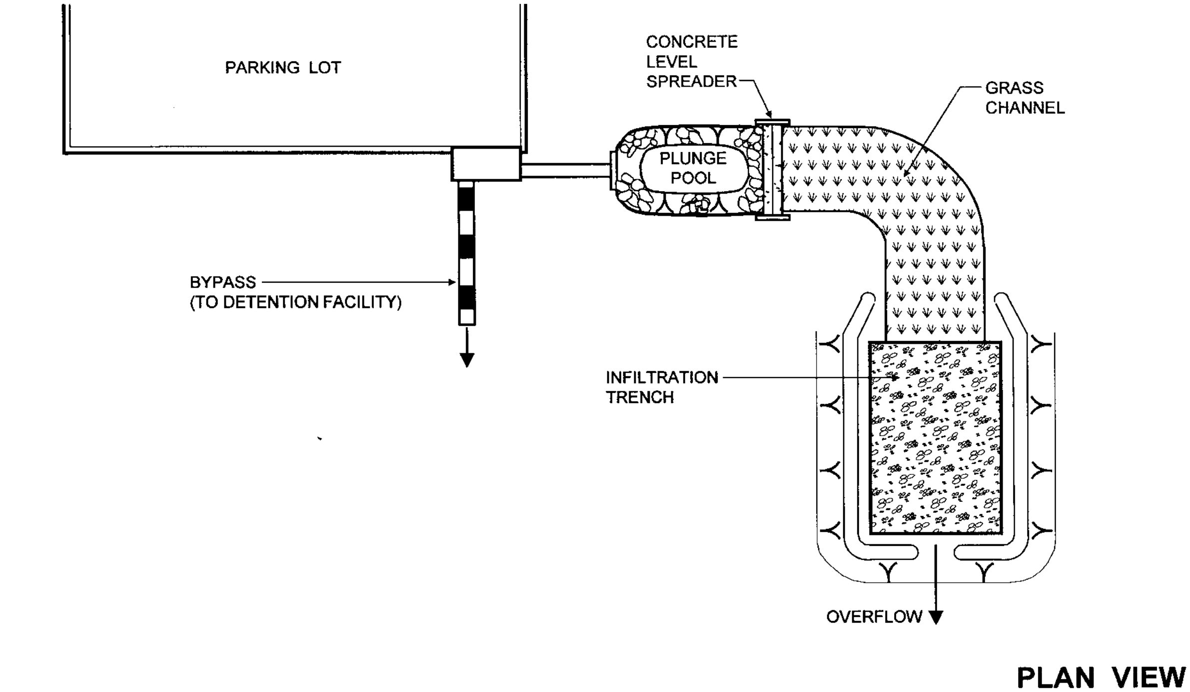


Figure A9 Gravel Wetland



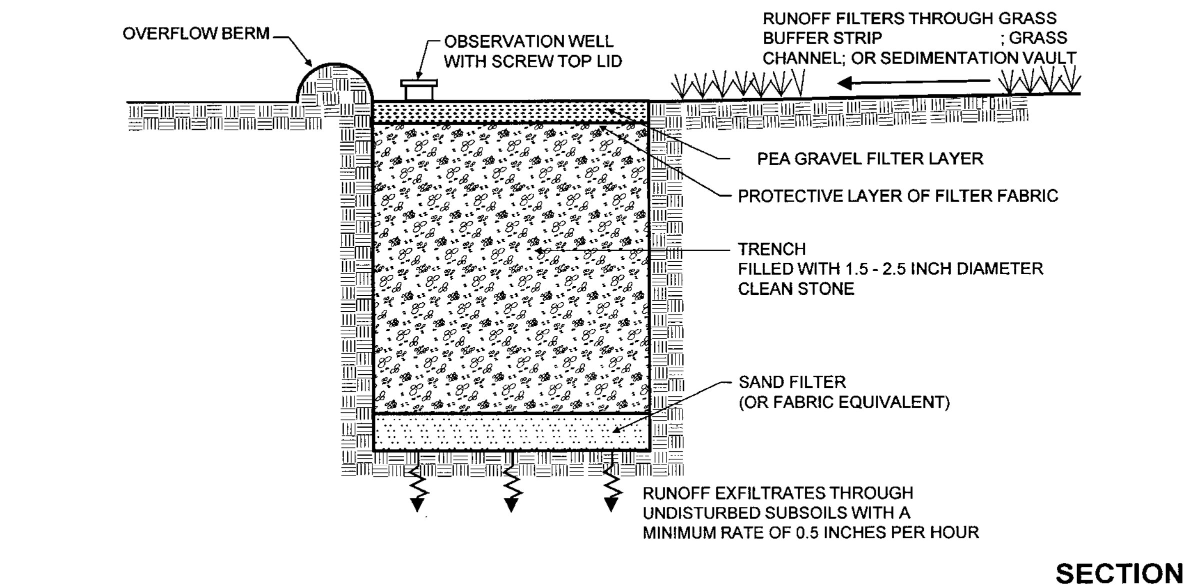
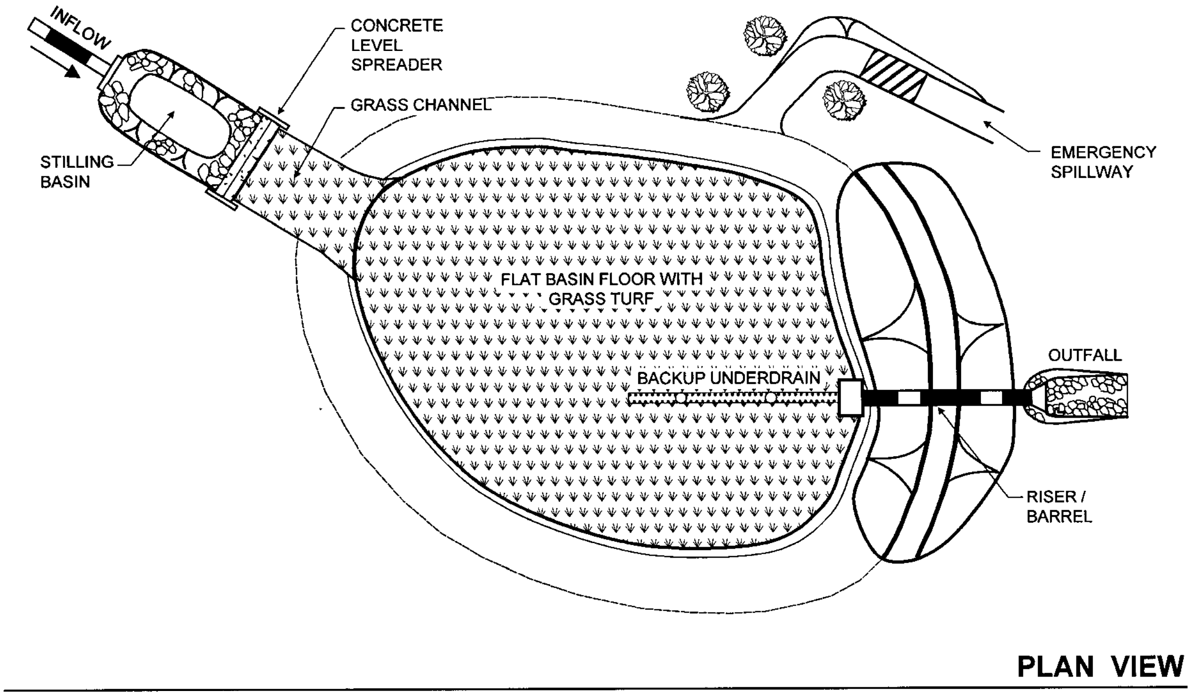


Figure A10 Infiltration Trench



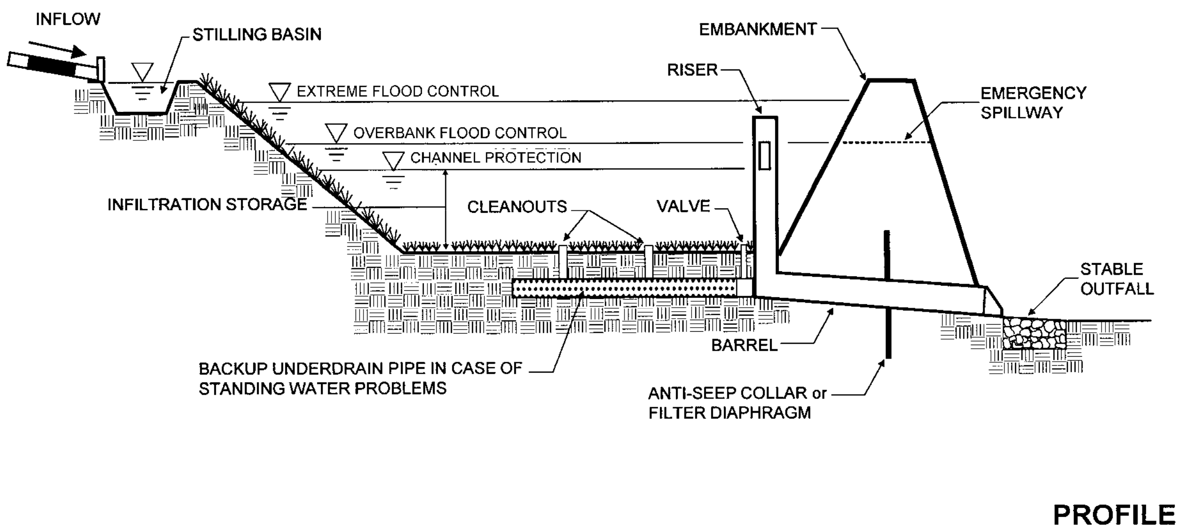


Figure A11 Infiltration Basin

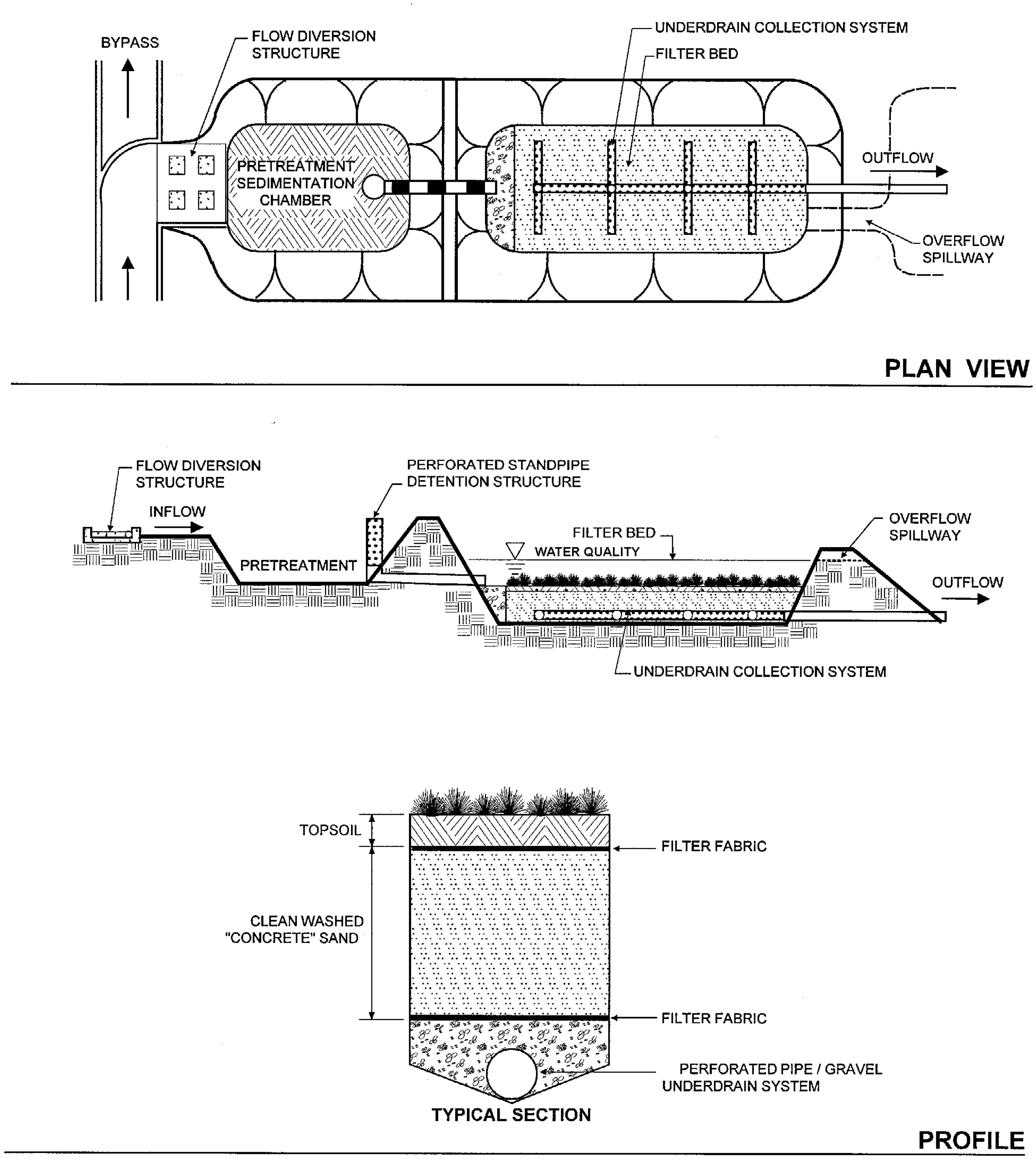


Figure A12 Surface Sand Filter

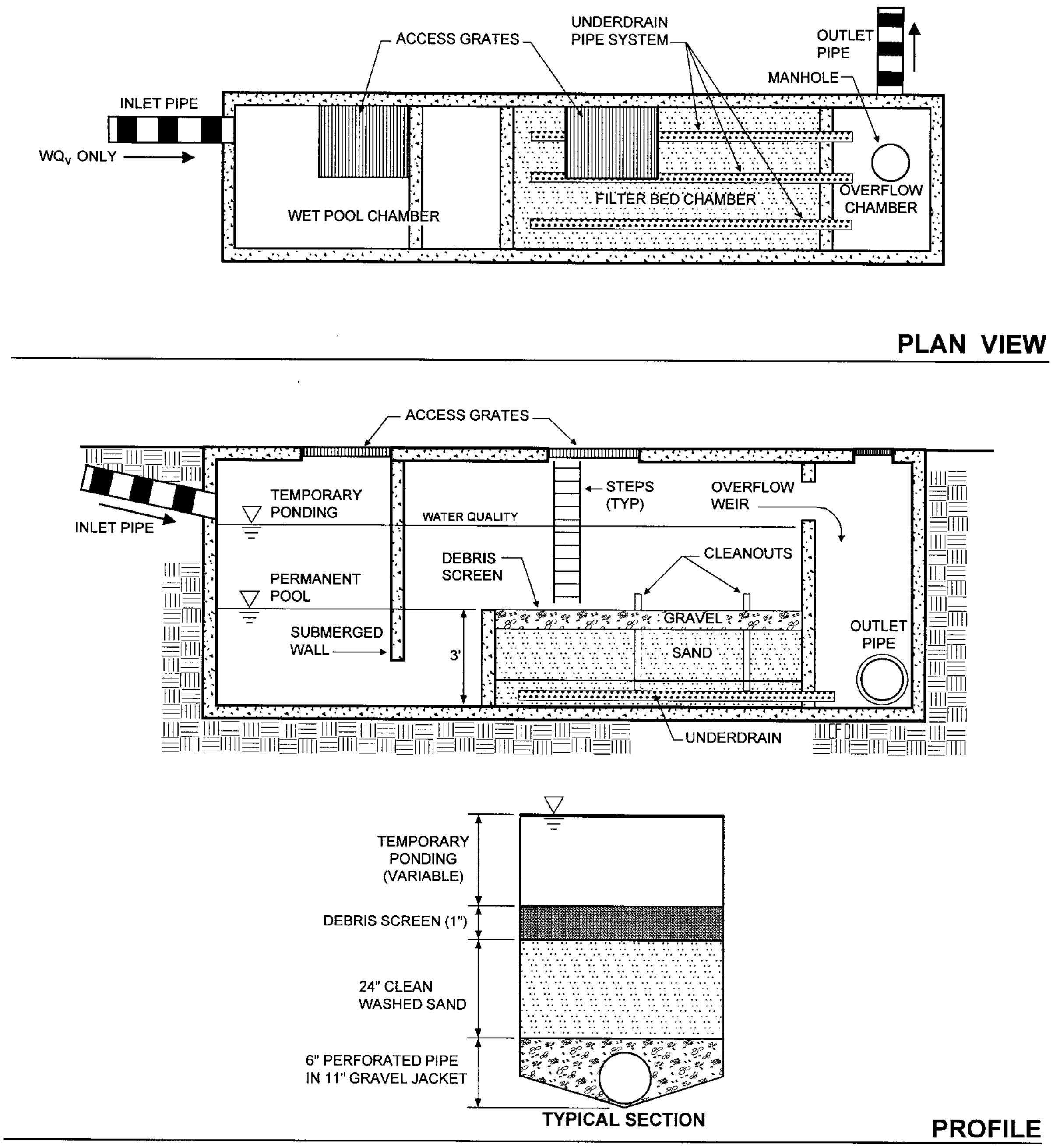


Figure A13 Underground Sand Filter

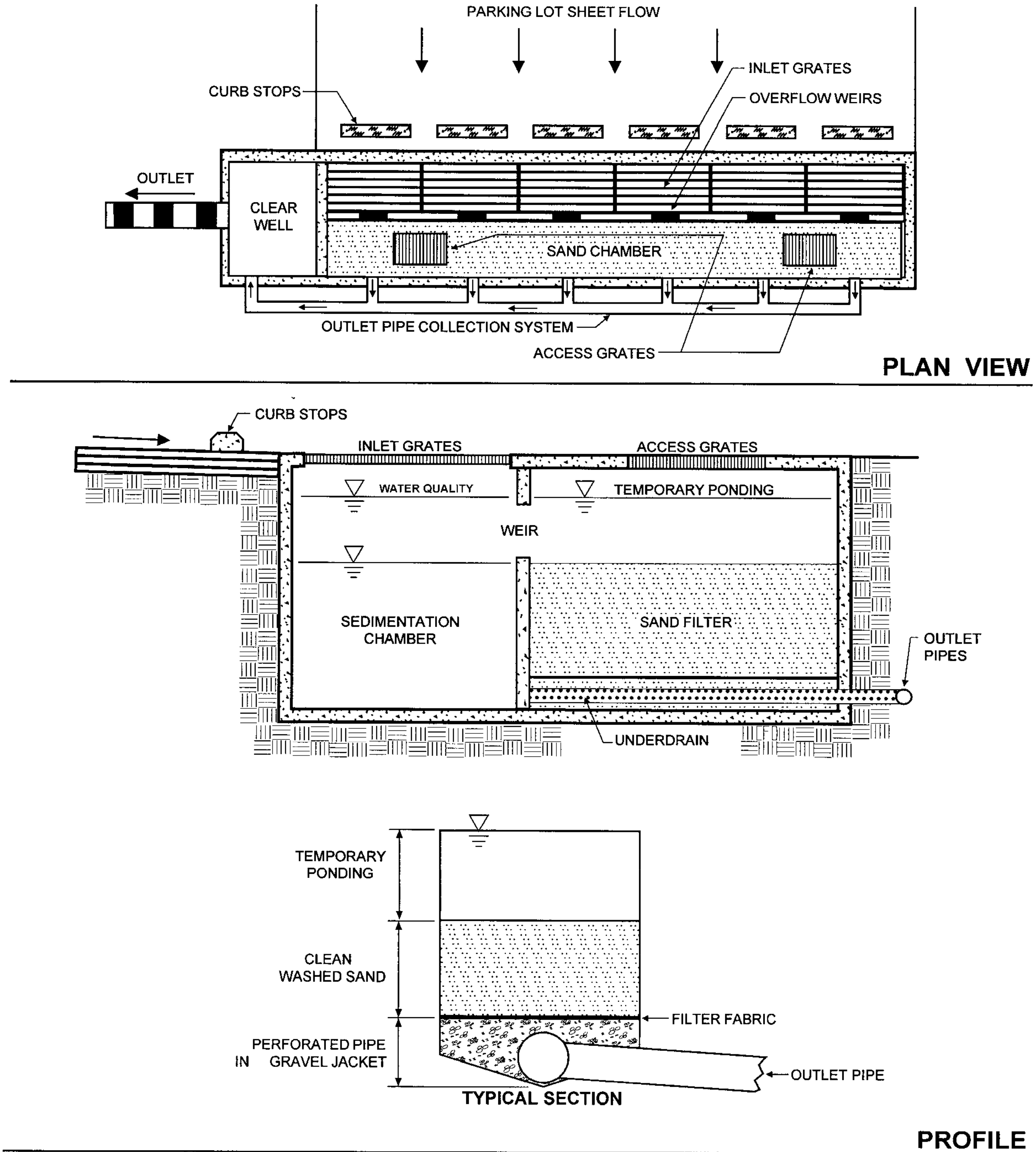


Figure A14 Perimeter Sand Filter

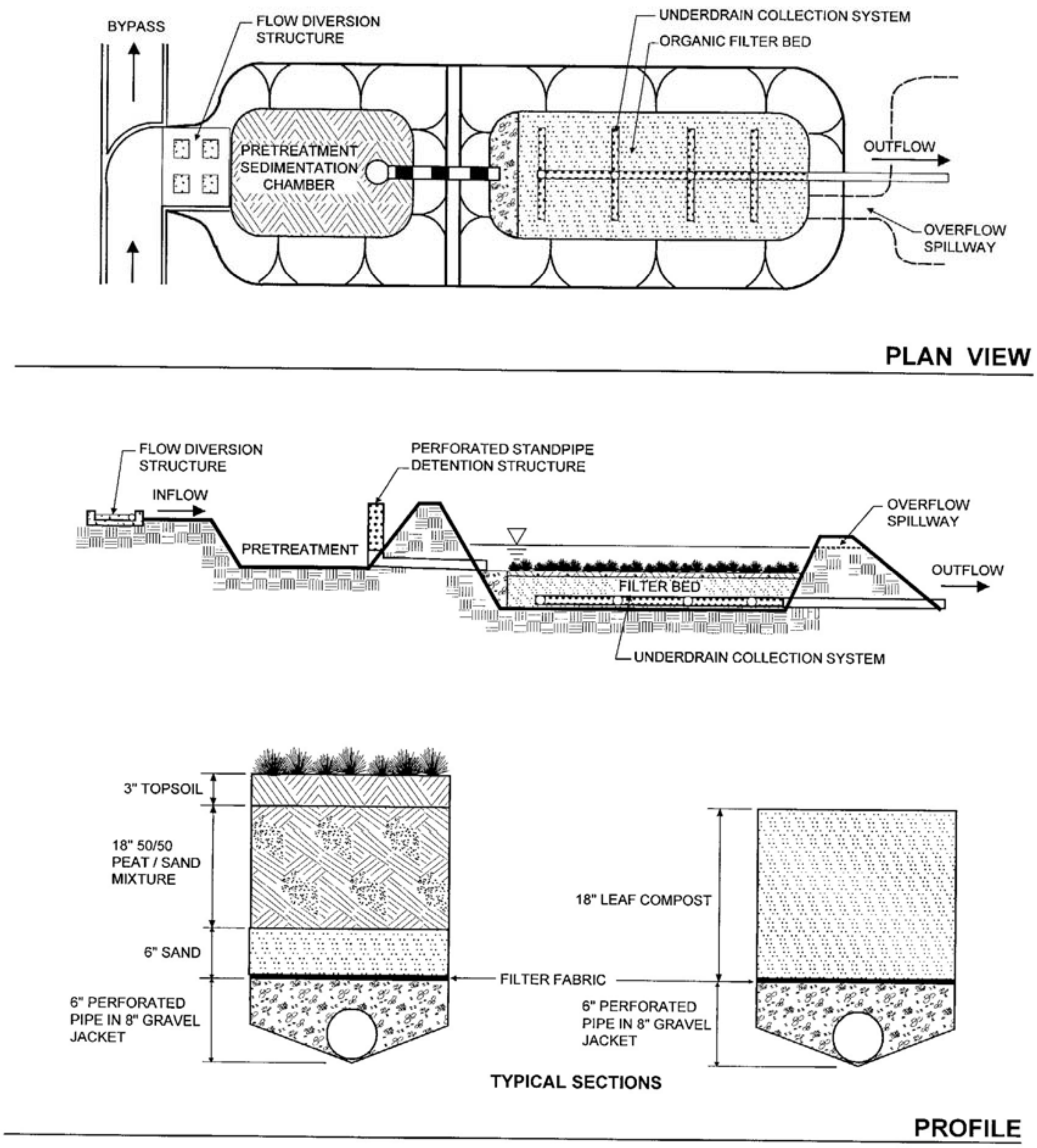


Figure A15 Organic Filter

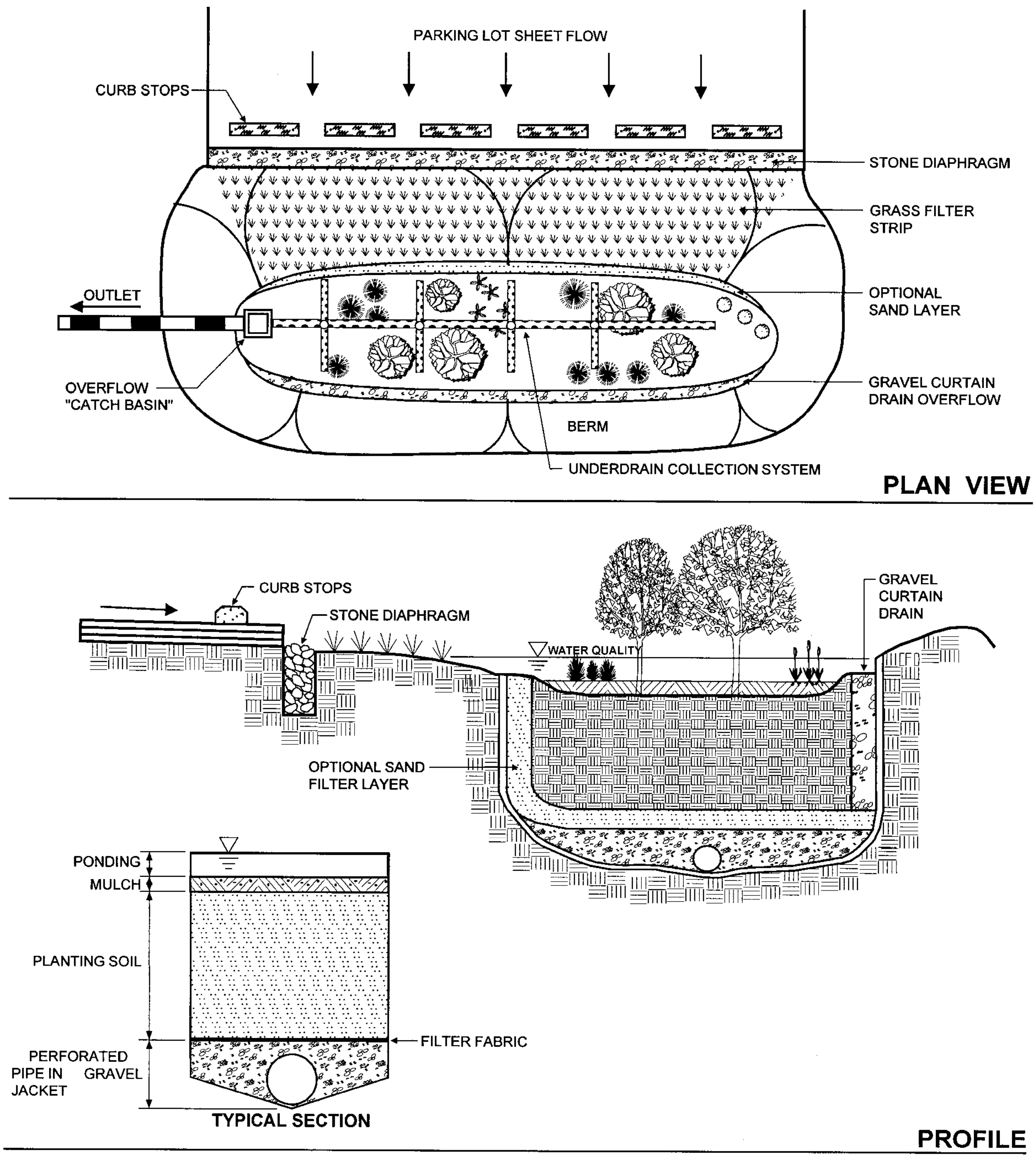
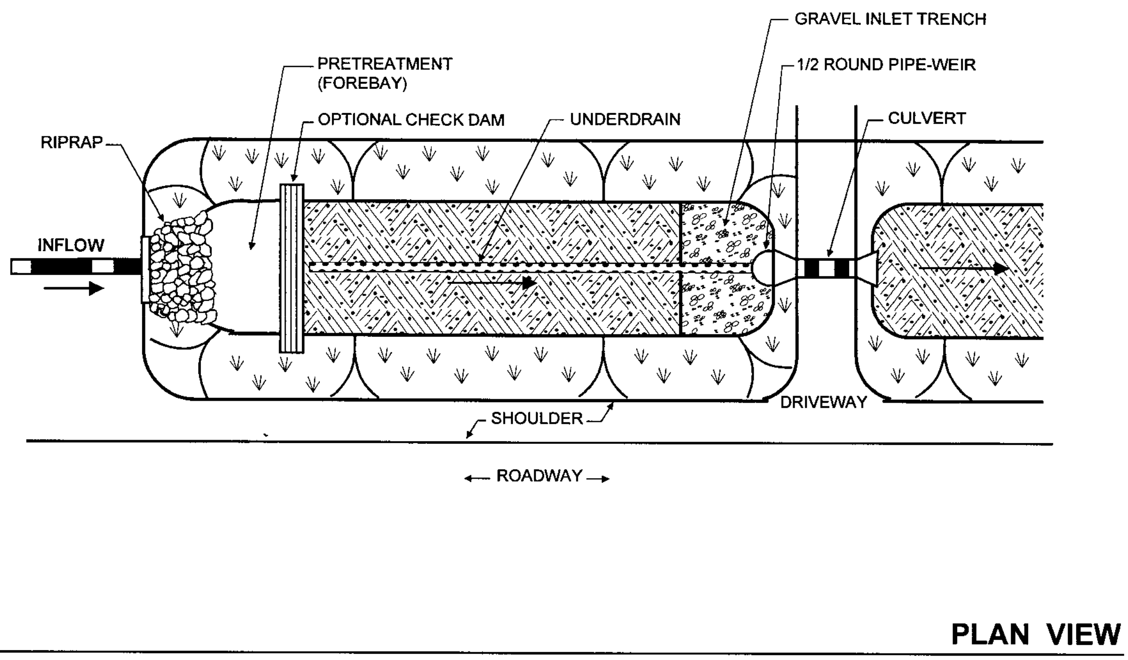


Figure A16 Bioretention



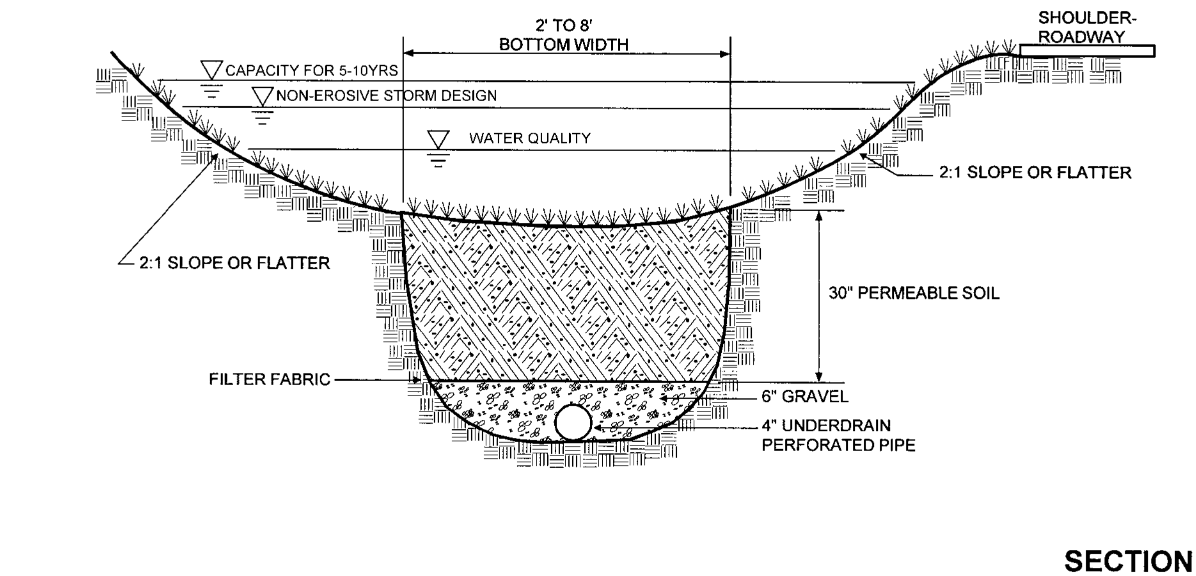
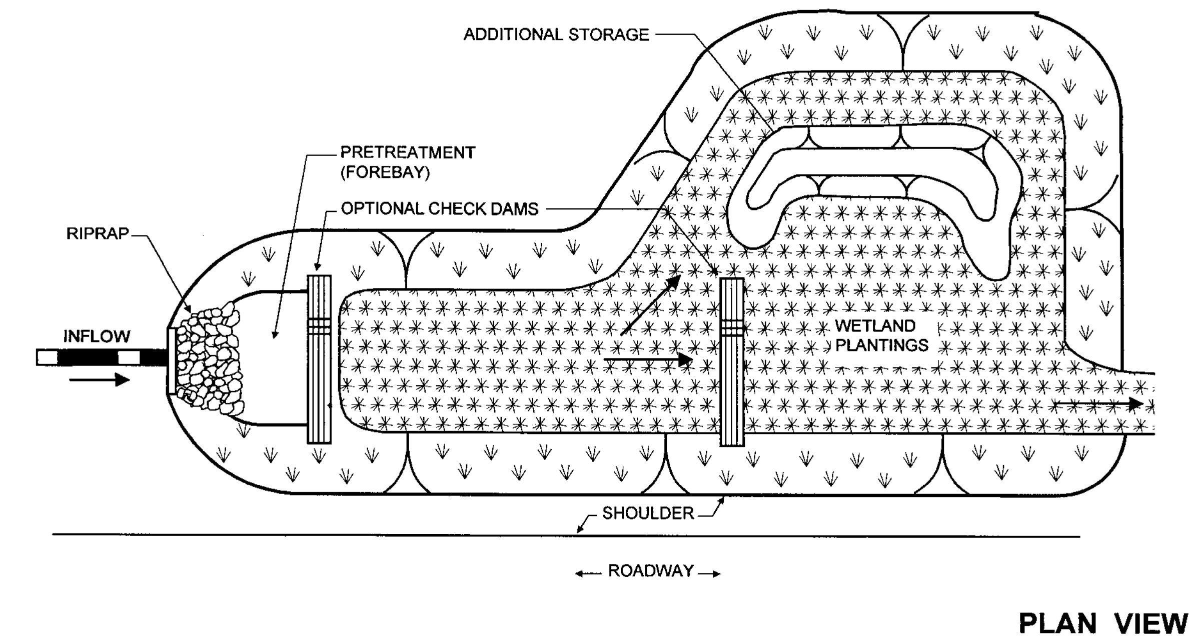


Figure A17 Dry Swale



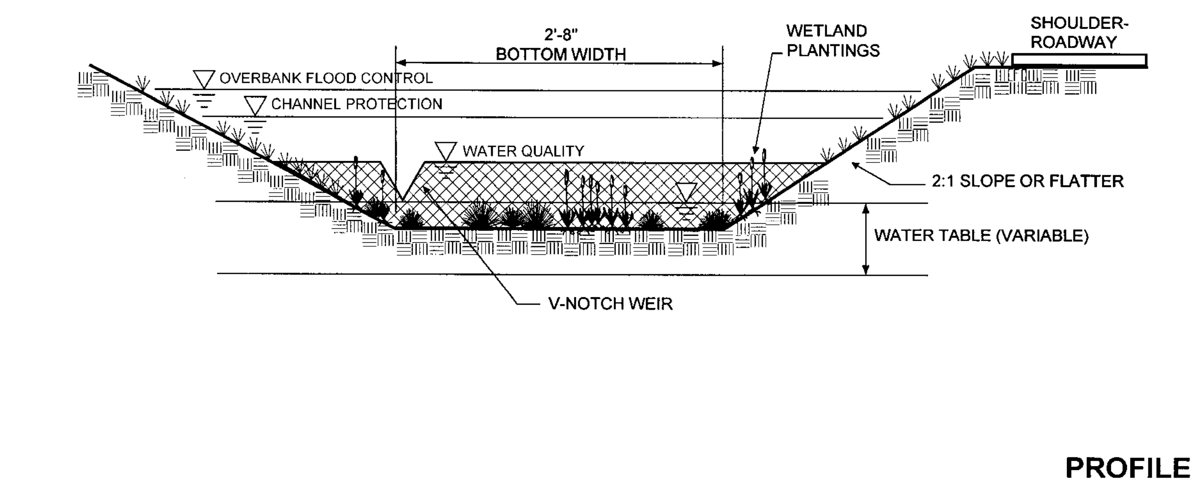
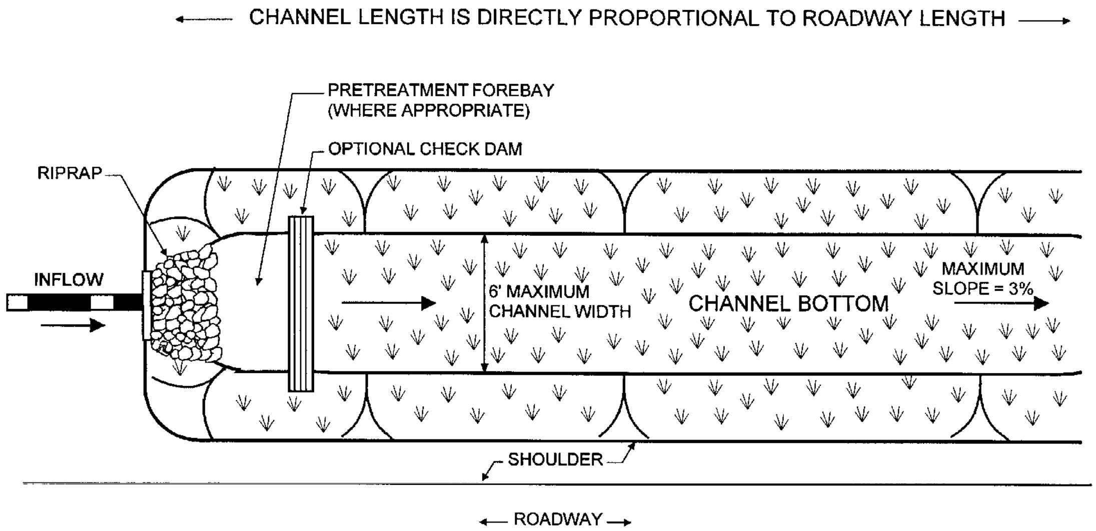
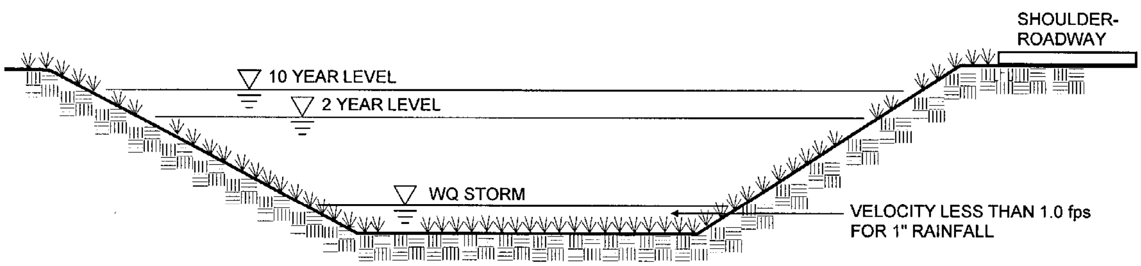


Figure A18 Wet Swale



PLAN VIEW



SECTION

Figure A19 Grass Channel

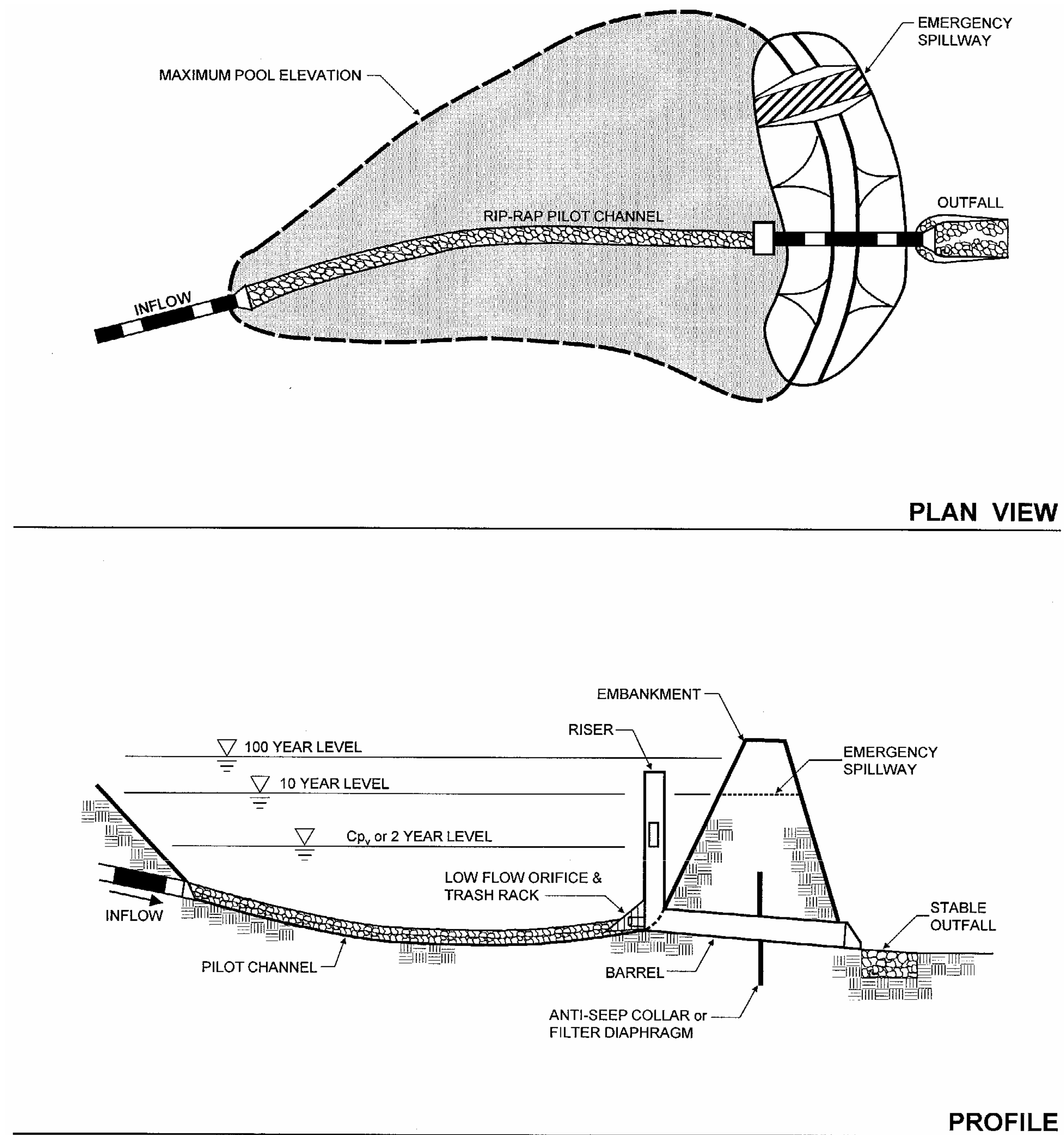


Figure A20 Dry Detention Pond

(Note: this practice does not meet the water quality treatment requirement, but can be used to provide both channel protection and flood control)

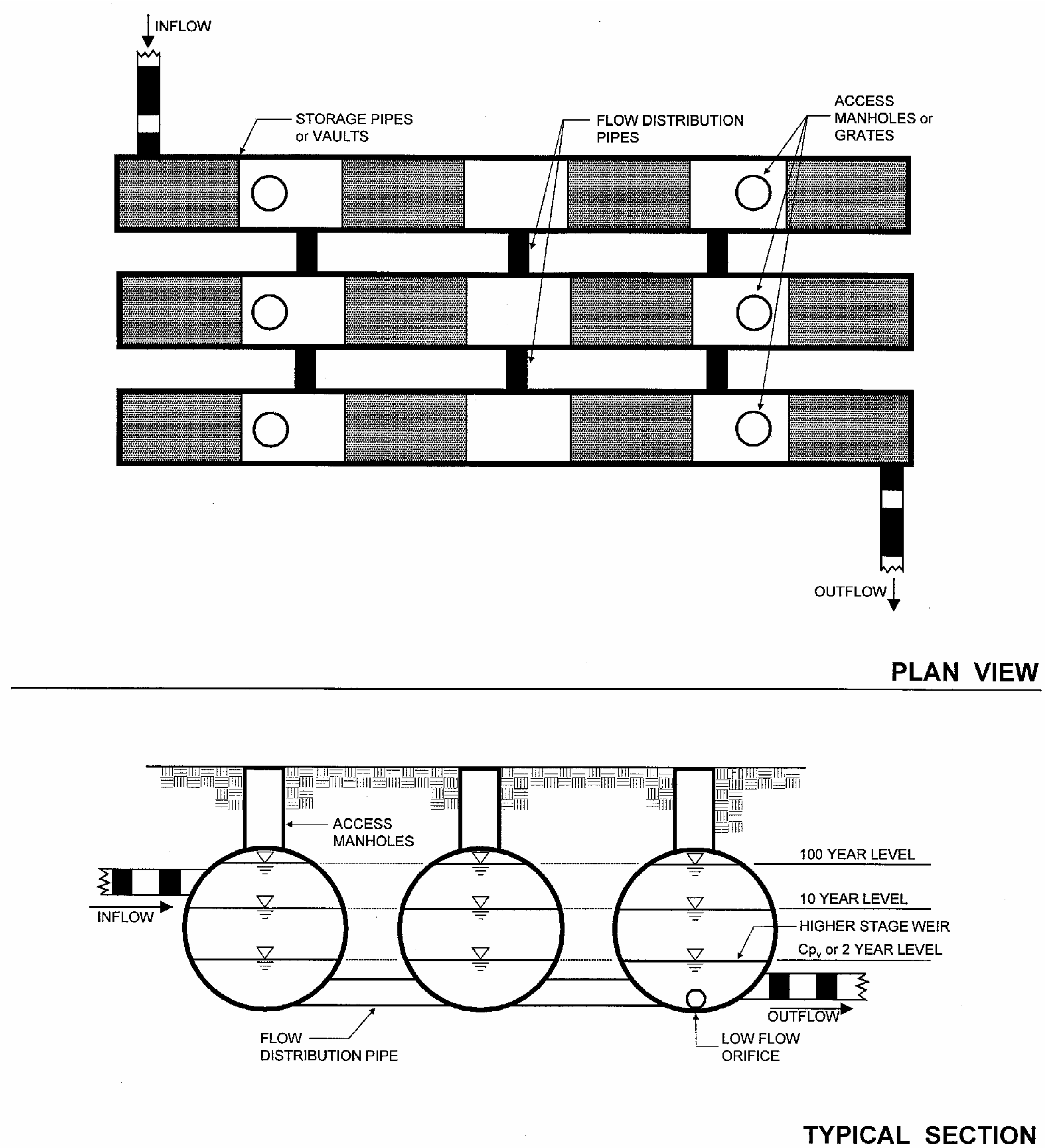


Figure A21 Detention Vault

(Note: this practice does not meet the water quality treatment requirements, but can be used to provide both channel protection and flood control.)

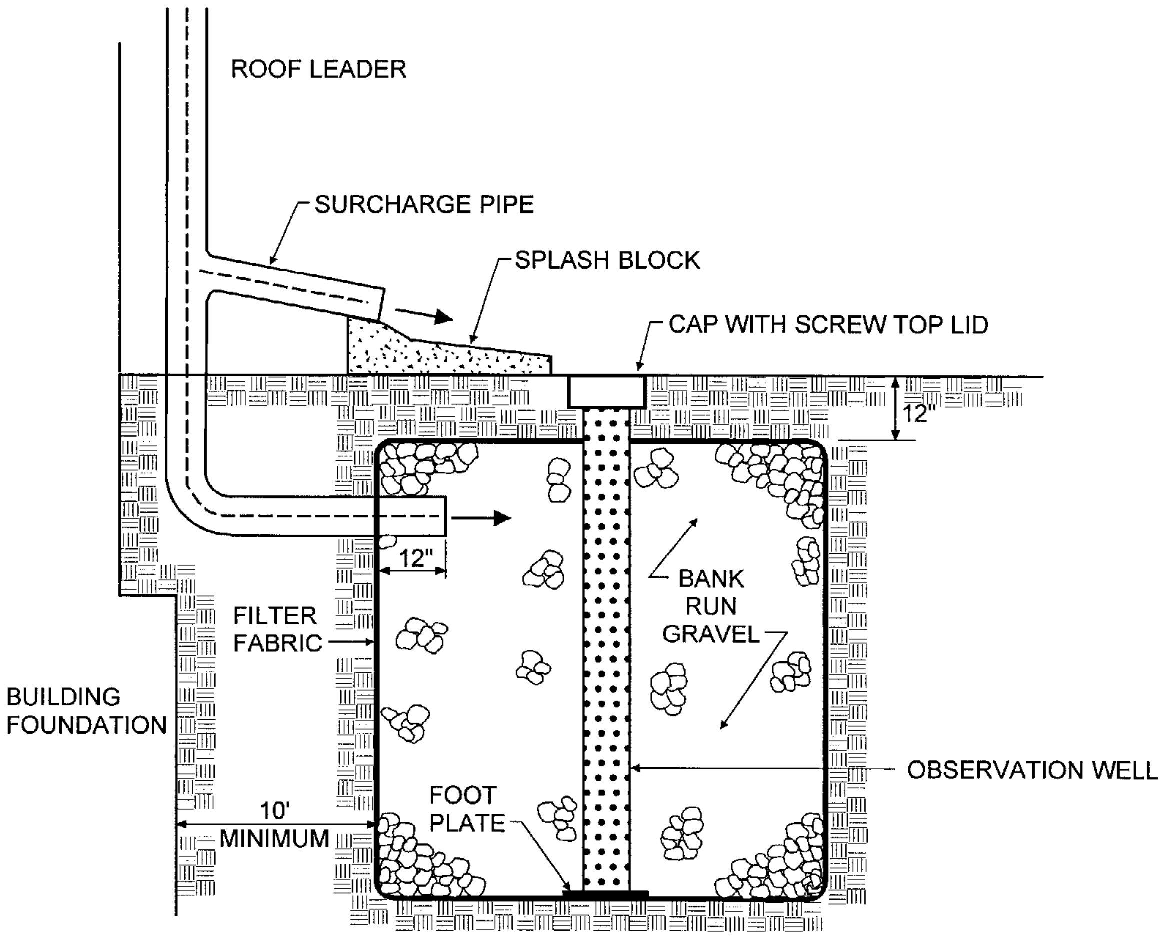
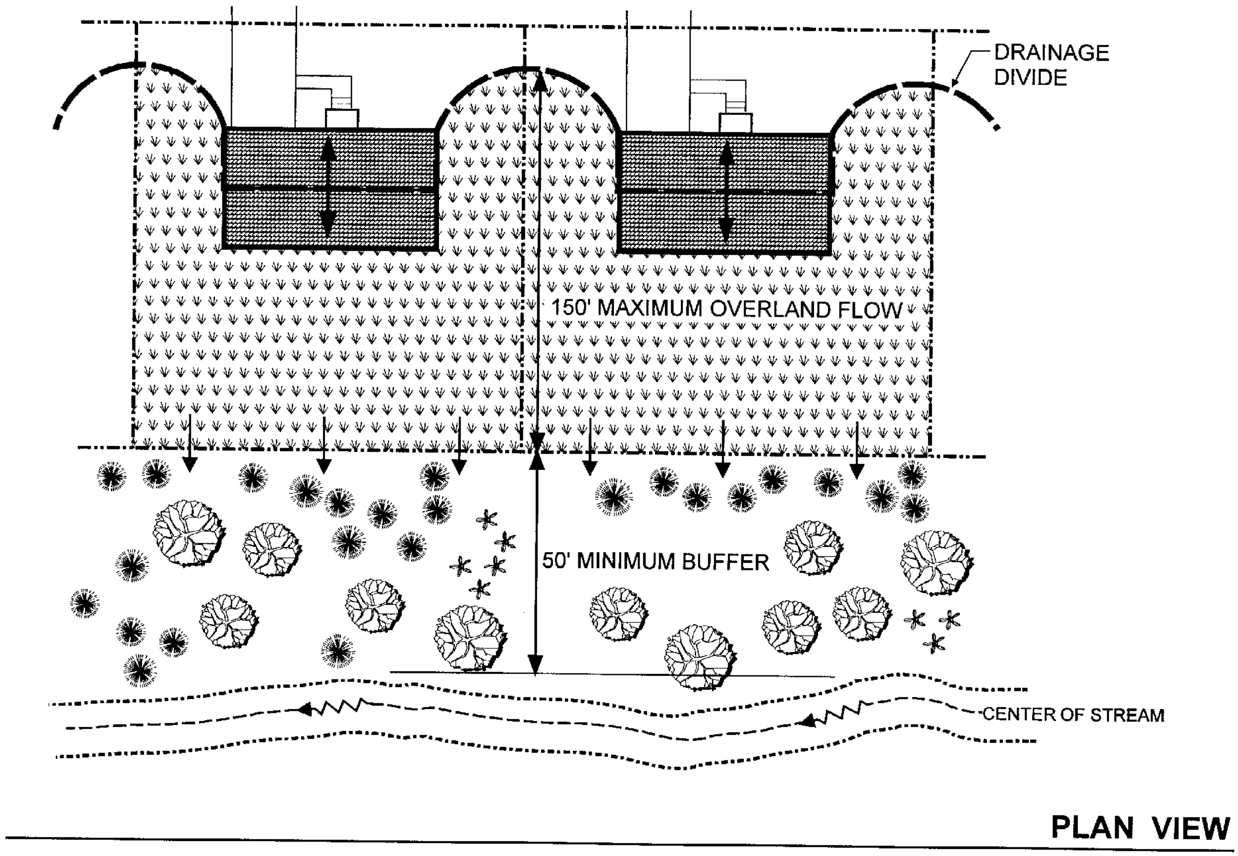


Figure A22 Schematic of Dry Well



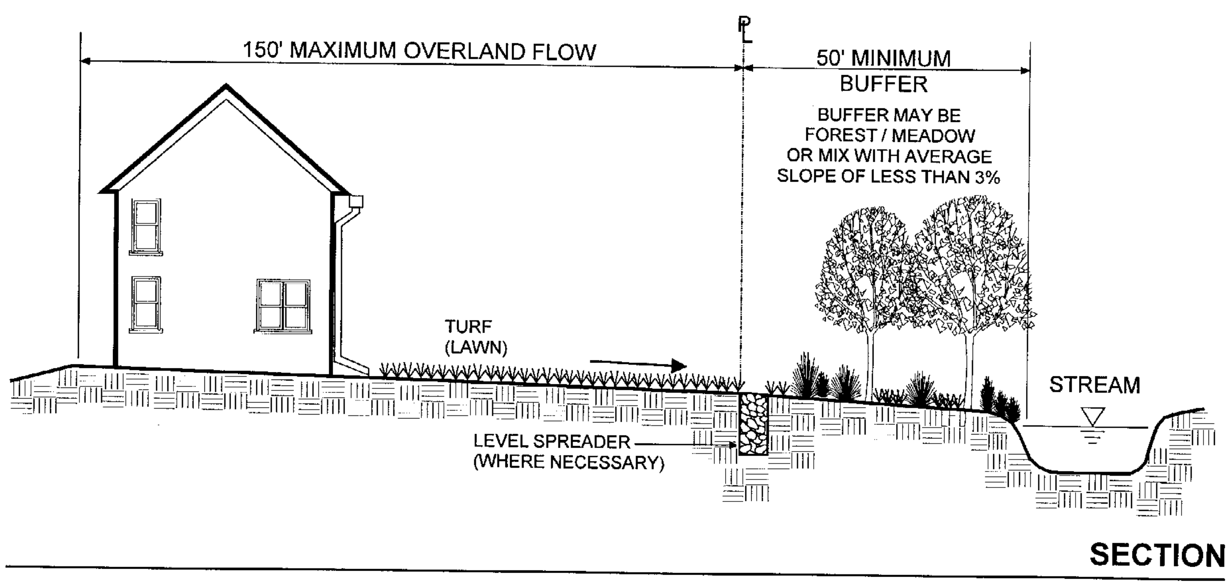


Figure A23 Example of Stream Buffer Credit Option

APPENDIX B

CNMI AND GUAM STORMWATER WORKSHOP AGENDAS

STORMWATER MANAGEMENT PROJECT WORKSHOP

Agenda

Civil Defense Office
Guam
Thursday, March 18, 2004

9:00 a.m.	Welcoming Remarks Mr. Randy Sablan, Deputy Administrator, Guam Environmental Protection Agency
9:05 a.m.	Project Background Mr. Chris Lund, P.E., Chief Engineer, Water Division, Guam Environmental Protection Agency
9:15	Climate Characteristics Dr. Mark Lander, Meteorologist, Water and Environmental Research Institute of the Western Pacific (WERI), University of Guam
10:00	BREAK
10:15	Environmental Resources Areas and Sensitive Receptors Mr. Scott Horsley, Horsley Witten Group
11:10 `	Unified Sizing Criteria for Stormwater BMPs Mr. Rich Claytor, Horsley Witten Group
11:45-12:45	LUNCH
12:45	Resources – Specific Sizing Criteria Mr. Scott Horsley
1:10	Acceptable BMPs to Meet the Criteria Mr. Richard Claytor
2:00	Questions/Answers and Discussion
2:30	Adjourn

STORMWATER MANAGEMENT PROJECT WORKSHOP

Agenda

Pacific Island Club
Saipan
Tuesday, March 16, 2004

9:00 a.m.	Welcoming Remarks Mr. John I. Castro, Jr., Director, Division of Environmental Quality
9:05 a.m.	Project Background Mr. Brian Bearden, Environmental Engineer, Division of Environmental Quality
9:15	Climate Characteristics Dr. Mark Lander, Meteorologist, Water and Environmental Research Institute of the Western Pacific (WERI), University of Guam
10:00	BREAK
10:15	Previous Engineering Studies Speaker TBA
10:45	Environmental Resources Areas and Sensitive Receptors Mr. Scott Horsley, Horsley Witten Group
11:10	Unified Sizing Criteria for Stormwater BMPs Mr. Rich Claytor, Horsley Witten Group
11:45-12:45	LUNCH
12:45	Resources - Specific Sizing Criteria Mr. Scott Horsley
1:10	Acceptable BMPs to Meet the Criteria Mr. Richard Claytor
2:00	Questions/Answers and Discussion
2:30	Adjourn

APPENDIX C

DRAFT REPORT COMMENTS AND RESPONSES

MEMORANDUM

FROM: Horsley Witten Group
DATE: July 30, 2004
RE: Response to Comments
CNMI/Guam Stormwater Management Criteria Report

Horsley Witten Group offers the following responses to comments received on the CNMI/Guam Stormwater Management Criteria Draft Report. Please note that these responses follow the same format as the corresponding original comment letters.

May 10, 2004 Letter from Joan Perry, NRCS, to Fred Castro, Guam EPA

General Comments

1. The comment regarding favoring groundwater recharge over conveyance for stormwater management has been noted.
2. Metric unit conversion for this report was not part of the original scope and therefore only English units are presented. Upon request from the CNMI DEQ or Guam EPA, metric units can be provided.
3. The nature of this document is a report, which concludes the first phase in the development of a stormwater management program for the CNMI and Guam. This report is not intended to be an enforceable regulatory document, but rather provides a summary of technical findings and provides recommendations necessary for developing a set of region-specific stormwater criteria. The next phase in the development of a stormwater management program will include the creation of a Stormwater Best Management Practices manual for the CNMI and Guam. This manual will provide detailed design guidance as well as an enforceable set of stormwater management criteria. The actual implementation and enforceability of the manual will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.
4. All channel terms will be clearly defined in the Final Stormwater Management Manual.
5. Stormwater credits and encouragement of rainwater harvesting will be further addressed in the Final Manual.
6. This report is not intended to be an enforceable regulatory document (see response 3 above). The enforceability of the Final Manual is not within the scope of this report and will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.
7. The rainfall data presented in this report is the best currently available. The Final Manual will be structured so that updated rainfall data is easily incorporated.
8. How previous plans and designs will be affected by the adoption of a new stormwater

management program is not within the scope of this study and will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.

9. The public review of the proposed regulations will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.
10. Review of plans will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.
11. Enforcement will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.

Specific Comments

Section 4.1
The reference to reverse osmosis in this section has been removed.

Section 4.2
Revisions have been made to this section as suggested.

Section 4.3
Revisions have been made to this section as suggested.

Section 4.3-4
Both nitrogen and phosphorus are responsible for causing eutrophication, however, phosphorus is mainly responsible in fresh water systems (lakes, ponds, etc) and nitrogen is mainly responsible in coastal systems. This distinction has been clarified in the report.

Section 5.1-3
The suggested ideas are incorporated into the construction section of this final report. These suggestions will also be further addressed in the Final Manual.

Section 5.3- Standard 1
Revisions have been made to this section as suggested.

Section 5.3- Standard 6
Current standards in Guam and the CNMI require stormwater quantity controls for the 25-year storm, therefore the proposed standard is designed to meet the current standard.

Section 5.3- Standard 10

The control criteria for redevelopment projects have been defined. Redevelopment projects that reduce impervious cover by at least 40% will meet water quality and recharge requirements. Redevelopment projects reducing impervious cover less than 40% will have to provide management controls for at least a portion of the site.

Section 5.5.1
It is agreed that soil surveys are not site specific. The proposed recharge criteria uses the soil surveys as a method to simplify the regulatory review process. Language has been added to the report stating that designers should perform on-site test pits to confirm site-specific soil types. Recommendations or requirements for soil testing will be further addressed in the Final Manual.

References to specific infiltration rates of the hydrologic soil groups have been removed.

Section 5.5.5
The land uses referenced in this section are intended for actual conditions. This section is describing that for the water quality criterion, only impervious areas on-site are to be used in the calculations for determining the required volume. If runoff from an adjacent development reaches the site in existing conditions, the stormwater system is not required to treat the water quality volume from the that site.

For water quantity criteria, the new stormwater system for a given site must take into account all runoff reaching that site.

Section 6.1.1
The implementation and enforceability of the stormwater program will be coordinated through the appropriate regulatory agencies in the CNMI and Guam.

Section 6.1.1.H
How regulations on underground injection in Guam affect the NRCS vertical drain practice will be addressed by the appropriate regulatory agencies in Guam.

Section 6.1.2.G
See the attached June 9, 2004 letter from John Castro of the CNMI DEQ regarding how regulations on underground injection affect the NRCS vertical drain practice.

Appendix A
Filter fabric is considered a geotextile.

June 8, 2004 E-mail from Brian Bearden, CNMI DEQ, to Scott Horsley

Comments from Saipan Workshop

1. Design standards and samples for small home sites will be addressed during the development of the Final Stormwater Manual and the training workshops.

Comments from Guam Workshop

1. Site design examples comparing “old” CNMI and Guam criteria to the new criteria, with size and cost differences, will be addressed during the development of the Final Manual and the training workshops.

Comments from Brian Bearden

1. In the Final Manual, an introduction will be provided to document the need for stormwater controls and will include a statement that effective stormwater management often requires at least some off-site drainage infrastructure. Applicants must ensure that proposed conditions are at a minimum better than existing conditions. Where inadequate off-site drainage infrastructure exists, a downstream drainage analysis may be required to ensure that proposed drainage conditions are at least better than existing conditions.
2. The recharge criteria are designed to mimic actual runoff characteristics for the region to the maximum extent possible.
3. Soil maps of Rota and Tinian have been added in this final report. Rainfall data has not been developed for Rota and Tinian, however, the values to be used for those islands will be similar to those for Saipan unless or until better data are provided. In addition, annual numbers can be used to pro-rate design values.

June 8, 2004 Revisions to Draft Report sent electronically via E-Mail from Brian Bearden, CNMI DEQ, to Scott Horsley

All revisions provided in the electronic file have been incorporated into the Final Report.

June 9, 2004 Letter from John Castro, CNMI DEQ, to Joan Perry, NRCS

This letter is provided in response to the comment in the NRCS May 10, 2004 letter regarding how current underground injection regulations will affect the NRCS vertical drain practice.

NRCS

United States Department of Agriculture
Natural Resources Conservation Service
Pacific Basin Area

FHB Building Suite 301
400 Route 8
Mongmong, GU
96910-2003

Sherman L. White
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Phone (671) 472-7348
Fax (671) 472-7288

May 10, 2004

RECEIVED MAY 2004

Fred M. Castro, Administrator
Guam Environmental Protection Agency
PO Box 22439
GMF, Barrigada, GU 96921

SUBJECT: Comments, Questions and Observations from NRCS on CNMI/Guam Stormwater Management Criteria, Phase I Draft Report of March 5, 2004

Dear Mr. Castro,

Please find enclosed the GEPA solicited input from USDA/NRCS staff. It is the result of a collaborative effort between Jeffrey Wheaton, State Conservation Engineer; Timothy Brasuell, Civil Engineer; Sherman White, Civil Engineer; Peter Bautista, District Conservationist; and Dr. Robert Gavenda, Soil Scientist.

We are happy to assist in and contribute in any way we can to the success of the new stormwater manual. Please keep us posted on the progress. If you have any further questions or we can be of any further assistance do not hesitate to contact us.

Best Regards,

Joan B. Perry, Director
Pacific Basin Area, NRCS, Mongmong, GU

Cc: Christopher A. Lund P.E., Chief Engineer - Water Division, GEPA
PO Box 22439, GMF, Barrigada, Guam 96921
Jeffrey C. Wheaton, State Conservation Engineer, Pacific Basin Area, NRCS, Mongmong, GU
Sherman L. White, Civil Engineer, Pacific Basin Area, NRCS, Mongmong, GU
Dr. Robert T. Gavenda, Soil Scientist, Pacific Basin Area, NRCS, Mongmong, GU
Peter Bautista, District Conservationist, Pacific Basin Area, NRCS, Barrigada, GU
Charles B. Frear, Assistant Director, Pacific Basin Area, NRCS, Mongmong, GU
File

COMMENTARY, QUESTIONS AND OBSERVATIONS

CNMI/Guam Stormwater Management Criteria, Phase I Draft Report, March 5, 2004

By USDA/Natural Resources Conservation Service

Pacific Basin Area:
Jeffrey C. Wheaton, State Conservation Engineer
Timothy B. Brasuell, Civil Engineer
Sherman L. White, Civil Engineer
Peter Bautista, District Conservationist
Dr. Robert T. Gavenda, Soil Scientist

General Comments:

- Overall, we support the idea of favoring groundwater recharge over conveyance for stormwater management.
- Dual units are recommended (add metric) as someday the US will conform to international standard, and land in Mariana Islands is measured in m^2.
- What is the nature of the final document? The ultimate purpose will dictate the document style.
  a. Report—Interesting, useful, but not enforceable.
  b. Regulation—Interesting, useful and enforceable by DEQ, DPW, EPA, etc. once adopted either by legislation or the rule process.
- There is a plethora of channel terms in here and many are confusing: diversion terrace, swale (wet/dry), interceptor channel, conveyance channel, open channel, grass channel. Though a diversity of terms makes for more pleasant reading, it probably increases the opportunity for miscommunication and dispute based on semantics. If the purpose is a report or informational document, the diversity is probably best; if the purpose is to be the body of an enforceable regulation, then clear well defined terms are essential.
- Gap in reasoning—Method of mandatory recharge vs. site runoff post-development no greater in volume or rate than pre-development. The former may significantly discourage water catchments as part of plan, compared to the latter, which does not. We believe rainwater harvesting should be encouraged as much as possible in the battle to conserve water and reduce the amount taken from the reservoir or aquifer in the first place. We therefore recommend modifying the regulation to accommodate this practice. For example, maybe a land user could receive some type of credit from the recharge requirements if he/she is harvesting rainwater.
- Enforceability is a concern. Conformance can be based on positive incentives or the threat of punitive action. The ability to achieve voluntary compliance with the spirit of the regulations should be kept in mind when choosing practice requirements. Homeowners, farmers and business owners responsible for implementing BMPs to comply with regulations should be able to easily see the

benefits (monetary, community good will, lack of complications with regulatory authorities before and during development) derived from installing and maintaining the practices. In the absence of the positive incentives, there is the regulatory option (fines, stop work orders, civil action, etc.). In this case GEPA and DEQ should be provided with the regulatory authority they need to enforce responsible stormwater management for the overall good of the islands.

- The rainfall values used in any document like this should be the best currently available. It's recommended that they be kept separate and footnoted so that as the more technically accurate work of WERI, NOAA, NOS, NRCS WCC, USGS, USACOE, or whoever, is released, it can be inserted as an amendment or update to the regulation (if the document does end up as the body of a regulation).
- Should the document become a regulation or referenced in regulations there will be concerns about previous plans and designs. Will such work be scrutinized under new regulations before construction begins or will it apply from some specified adoption date?
- What kind of public review will be given to proposed regulations?
- Who will review the plans and decide if they are adequate in detail and conform to the regulations? Will reviews and approvals be confined to results and not methods? If so, how will reviewers be prevented from making suggestions to the point they are absconding with the rightful role of the technical professionals working for owners?
- How will the enforcement be handled? For the CNMI, if DEQ has insufficient staff or technical expertise, then perhaps DPW-Technical Services Division would provide the service. A similar situation exists for Guam; would EPA or DPW do the reviewing?

Specific Comments:

<u>Section 4.1.</u> 1st paragraph, is desalinization a significant source? Reverse osmosis systems that treat tap water, yes, but is there much seawater treatment going on besides maybe a few hotels?

<u>Section 4.2.</u> 2nd Paragraph, last line, shouldn't 5.5.3 be 5.5.1?

5th Paragraph, last line, delete the word "organic." The organics in soil come from vegetation, not the parent rock.

<u>Section 4.3.</u> Last line: two classes, S1, S2, and S3? Or three classes?

<u>Section 4.3-4.</u> 4.3, 4th paragraph and 4.4, 2nd paragraph seem to contradict each other. I believe N & P are both responsible for eutrophication.

<u>Section 5.1-3</u> Suggested ideas that may enhance the construction section, at least in an advisory capacity if not necessarily regulatory:

- Timing of construction should strive to minimize soil exposure in the rainy season.

- Consider how erosion can be controlled in each small drainage area before planning for the whole site. It is much better to control as much as possible at the source and not let it reach the perimeter.
- Allow the least water possible to enter and exit the disturbed areas. Runoff should be diverted around excavations if possible.
- Bare earth areas should be protected in the interim by spreading mulch over them. Mulch helps protect bare soil from raindrop impacts and decreases runoff velocity, but it is not a substitute for real vegetation.
- MAINTENANCE. Aggressive maintenance of erosion and sediment control measures throughout construction is critical to their success.
- ALL workers should be educated on the importance of erosion control, not just management.

<u>Section 5.1,</u> Standard 1, should read "...generation of stormwater *runoff* and utilize..."

Standard 5, this could turn into a BIG BASIN.

Standard 10, what would this be?

<u>Section 5.2,</u> Paragraph 4, soil surveys are *not* site specific.

IMPORTANT--In reference #1, infiltration rates from TR-55 should not be quoted. Use values from the Soil Survey Manual, USDA Handbook No. 18, October 1993 (see attachment).

<u>Section 5.5.5,</u> Why are these land uses being arbitrarily selected? Actual conditions should govern. If an offsite area has not yet "built out" why should downstream developer be burdened with mitigating future offsite action by others? Upstream developers will be obliged to follow regulations too.

<u>Section 6.1.1,</u> Oddly, permits are acquired by the contractor and not by the owner. By having the owner the actual holder of the permit some action can be taken against the land in the form of legal encumbrances on the property. This is not so if a contractor with limited resources is fined; they just go out of business and the damaged landscape remains to contribute sediment, excessive runoff and the like to all who live downstream (both on the land and the receiving reef). If the landowner holds the permit and fails to follow the design or permit requirements, the government can hire a contractor to do the work and put that expense in the tax on the property.

H) NRCS has a "vertical drain" practice standard in which a hole is bored into the limestone to collect and infiltrate overflow. How will regulations on underground injection affect this practice? A copy of the current USDA NRCS Pacific Basin Conservation Practice Standard is attached.

<u>Section 6.1.2,</u> G) Again, how will regulations on underground injection affect the NRCS vertical drain practice?

<u>Appendix A,</u> "Filter Fabric" is geotextile?

Saturated hydraulic conductivity classes.

Class	Ksat (µm/s)
Very High	≥ 100
High	10-100
Moderately High	1-10
Moderately Low	0.1-1
Low	0.01-0.1
Very Low	< 0.01

Saturated hydraulic conductivity class limits in equivalent units.

µm/s	m/s	m/day	in/hr	cm/hr	kg s m^{-3}	m^{3}s kg^{-1}
100.	≈ 10^{-4}	864.	14.17	36.0	1.02X10^{7}	1.02X10^{-8}
10.	≈ 10^{-5}	86.4	1.417	3.60	1.02X10^{6}	1.02X10^{-9}
1.	≈ 10^{-6}	8.64	0.1417	0.360	1.02X10^{5}	1.02X10^{-10}
0.1	≈ 10^{-7}	0.864	0.01417	0.0360	1.02X10^{4}	1.02X10^{-11}
0.01	≈ 10^{-8}	0.0864	0.001417	0.00360	1.02X10^{3}	1.02X10^{-12}

Hydraulic conductivity classes in this manual are defined in terms of vertical saturated hydraulic conductivity. Table 3-7 defines the vertical, saturated hydraulic conductivity classes. The saturated hydraulic conductivity classes in this manual have a wider range of values than the classes of either the 1951 *Soil Survey Manual* or the 1971 *Engineering Guide*. The dimensions of hydraulic conductivity vary depending on whether the hydraulic gradient and flux density have mass, weight, or volume bases. Values can be converted from one basis to another with the appropriate conversion factor. Usually, the hydraulic gradient is given on a weight basis and the flux density on a volume basis and the dimensions of K_{sat} are length per time. The correct SI units thus are meters per second.[1] Micrometers per second are also acceptable SI units and are more convenient (table 3-7). Table 3-8 gives the class limits in commonly used units.

Hydraulic conductivity does not describe the capacity of soils in their natural setting to dispose of water internally. A soil placed in a very high class may contain free water because there are restricting layers below the soil or because the soil is in a depression where water from surrounding areas accumulates faster than it can pass through the soil. The water may actually move very slowly despite a high K_{sat}.

[1] The Soil Science Society of America prefers that all quantities be expressed on a mass basis. This results in K_{sat} units of kg s m^{-3}. Other units acceptable to the society are m^3 s kg^{-1}, the result of expressing all quantities on a volume basis, and m s^{-1}, the result of expressing the hydraulic gradient on a weight basis and flux density on a volume basis.

Guidelines for K_{sat} Class Placement

Measured values of K_{sat} are available from the literature or from researchers working on the same or similar soils. If measured values are available, their geometric means should be used for class placement.

Saturated hydraulic conductivity is a fairly easy, inexpensive, and straightforward measurement. If measured values are unavailable, a project to make measurements should be considered. Field methods are the most reliable. Standard methods for measurement of K_{sat} are described in Agronomy Monograph No. 9 (Klute and Dirksen, 1986, and Amoozegar and Warrick, 1986) and in SSIR 38 (Bouma et al., 1982).

Various researchers have attempted to estimate K_{sat} based on various soil properties. These estimation methods usually use one or more of the following soil physical properties: surface area, texture, structure, bulk density, and micromorphology. The success of the individual methods varies. Often a method does fairly well in a localized area. No one method works really well for all soils. Sometimes, measurement of the predictor variables is more difficult than measurement of hydraulic conductivity. Generally, adjustments must be made for "unusual" circumstances such as high sodium concentrations, certain clay mineralogies, and the presence of coarse fragments, fragipans, and other miscellaneous features.

The method presented here is very general (Rawls and Brakensiek, 1983). It has been developed from a statistical analysis of several thousand measurements in a variety of soils. Because the method is intended for a wide application, it must be used locally with caution. The results, often, must be adjusted based on experience and local conditions.

TABLE 3-9

Criteria for Placement in Hydrologic Soil Groups

Hydrologic Soil Group	Criteria a/
A	Saturated hydraulic conductivity is *very high* or in the upper half of high and internal free water occurrence is *very deep.*
B	Saturated hydraulic conductivity is in the lower half of *high* or in the upper half of *moderately high* and free water occurrence is *deep* or *very deep.*
C	Saturated hydraulic conductivity is in the lower half of *moderately high* or in the upper half of *moderately low* and internal free water occurrence is deeper than *shallow.*
D	Saturated hydraulic conductivity is below the upper half of *moderately low*, and/or internal free water occurrence is *shallow* or *very shallow* and *transitory* through *permanent.*

[a]The criteria are guidelines only. They are based on the assumption that the minimum saturated hydraulic conductivity occurs within the uppermost 0.5 m. If the minimum occurs between 0.5 and 1 m, then saturated hydraulic conductivity for the purpose of placement is increased one class. If the minimum occurs below 1 m, then the value for the soil is based on values above 1 m using the rules as previously given.

The Green-Ampt model is an example of a model used to compute infiltration rate. The model assumes that infiltrating water uniformly wets to a depth and stops abruptly at a front. This front moves downward as infiltration proceeds. The soil above the wetting front is in the satiated wet condition throughout the wetted zone.

The equation (Rawls and Brackensick, 1983) to describe infiltration is:

$$f = Ka \left(1 + \frac{MxS}{F}\right)$$

NATURAL RESOURCES CONSERVATION SERVICE
PACIFIC BASIN AREA
CONSERVATION PRACTICE STANDARD

VERTICAL DRAIN

(Number)
CODE 630

DEFINITION

A well, pipe, pit, or bore in porous, underground strata into which drainage water can be discharged.

PURPOSE

To provide an outlet for drainage water from a surface or subsurface drainage system.

CONDITIONS WHERE PRACTICE APPLIES

This practice is applicable in locations where the underlying strata can receive, transmit, or store the design drainage flow and other drainage outlets are not available and cannot be provided at a reasonable cost. The practice is applicable only in locations where a determination has been made that it is not contrary to state laws or regulations, and that it will not cause pollution of underground waters.

PLANNING CONSIDERATIONS

WATER QUANTITY

Effect on the aquifer recharge.

Effect on the water table.

The effect on the volume of downstream flow to downstream users and uses.

WATER QUALITY

The potential hazard to ground water quality from the discharge of drainage water containing dissolved substances.

The potential for land use changes that may impair aquifer quality.

DESIGN CRITERIA

The number and size of vertical drains shall be adequate to discharge the design drainage flow into the underlying stratum or strata. The number, size, and location of the drains shall be based on a field determination of the depth, permeability, porosity, thickness, and extent of the strata.

The minimum diameter of shallow uncased wells shall be 24 in. and of deep cased wells, 4 in.

A suitable filter system, desilting basin, or other means for removing sediment from the water before it enters the well shall be provided.

Well casings shall be of adequate strength and longevity to serve planned needs.

PLANS AND SPECIFICATIONS

Plans and specifications for installing vertical drains shall be in keeping with this standard, and shall describe the requirements for properly installing the practice to achieve its intended purpose.

From: *"Brian Bearden" <brian.bearden@saipan.com>*
Date: *June 8, 2004 12:26:51 AM EDT*
To: *"Scott Horsley" <shorsley@cape.com>, <clund@guamepa.govguam.net>*
Cc: *"rclaytor" <rclaytor@horsleywitten.com>*
Subject: DEQ Comments

Hi Scott,

Here are my comments, including "important" comments I picked up on during the public meetings. Most were previously addressed during our own meetings, so there aren't that many. The edited Word document is also attached, with minor corrections regarding some CNMI stuff (but I deleted all the images so it would be easier to e-mail)

Selected public comments from Saipan Workshop notes:

1. Prescriptive design standards/sample need to be provided for small home sites, because those types of projects do not typically have a site design engineer, just some guy who drafts the basic plans for the home.

Selected public comments from Guam Workshop notes:

1. The final Phase I report should contain at least one site design example comparing “old” CNMI & Guam criteria to new, with size and cost differences.

Mine:

1. At present, most areas within the CNMI are not served by municipal/regional drainage systems. Much of the proposed design philosophy revolves around capturing a certain volume of runoff and allowing the rest to pass beyond the project site. This makes perfect sense in most places in the U.S. where a site drains to either a storm drainage system or even a stream, but so many of the sites in the CNMI drain to another property, a dirt road, or similar without any drainage system to speak of. How does a site design account for this? Some statements should be made (useless or not) that the CNMI government needs to invest in regional storm drainage infrastructure to accommodate the overflow from properly designed sites.

2. Groundwater recharge criteria does not make sense for many of the flatter regions of Saipan (and Northern Guam especially) where Karst topography prevents runoff and results in much higher recharge percentages. Or, even some of the coastal areas that are underlain by sandy soils. In other words, there are some areas where the recharge criteria could be set much higher to mimic actual runoff characteristics. How do we address this?

3. Rota and Tinian need to also be covered in the manual, with rainfall and soils maps. Rainfall values can be interpolated between Guam and Saipan data, as previously discussed. Soil maps for both islands is included in the soils survey you were provided with.

See the specific edits in the highlighted Word document.

From: "Brian Bearden" <brian.bearden@saipan.com>
To: "Scott Horsley" <shorsley@cape.com>, <clund@guamepa.govguam.net>
Sent: Wed, 9 Jun 2004 14:35:25 +1000
Subject: Re: NRCS Comments

Scott and Chris:
FYI, we sent a response to NRCS regarding the use of their "vertical drain" being a regulated underground injection well. This letter will go out today, dated June 9, 2004.

Brian

Joan B. Perry
Director, Pacific Basin Area
USDA-NRCS
FHB Building Suite 301
400 Route 8
Mongmong, GU 96910-2003
Fax: (671) 472-7288

RE: "Vertical Drain" Practice and CNMI Regulation

Dear Ms. Perry:

Thank you for your recent comments on our CNMI/Guam Stormwater Management Criteria Phase I Draft Report. In your comments, you asked a specific question regarding how CNMI and Guam Underground Injection Control (UIC) Regulations would affect the NRCS conservation practice referred to as the "vertical drain". We are taking this opportunity to directly respond to this comment for the CNMI.

This type of practice would be classified as an injection well (likely a "Class V" well) and would be regulated under the CNMI's UIC regulations. These regulations are highly restrictive, and there would be very limited circumstances under which this type of practice could be allowed, if at all. We suggest you meet with us if this is a practice that your staff intends to employ in the CNMI.

You will need to contact Guam EPA regarding their UIC regulations, however, they are likely to be very similar because of overriding federal requirements regarding the classification of such wells.

Please feel free to contact us if you wish to discuss this issue any further.

Sincerely,

John I. Castro, Jr.
Director

cc: Horsley & Witten, Inc.
Chris Lund, GEPA