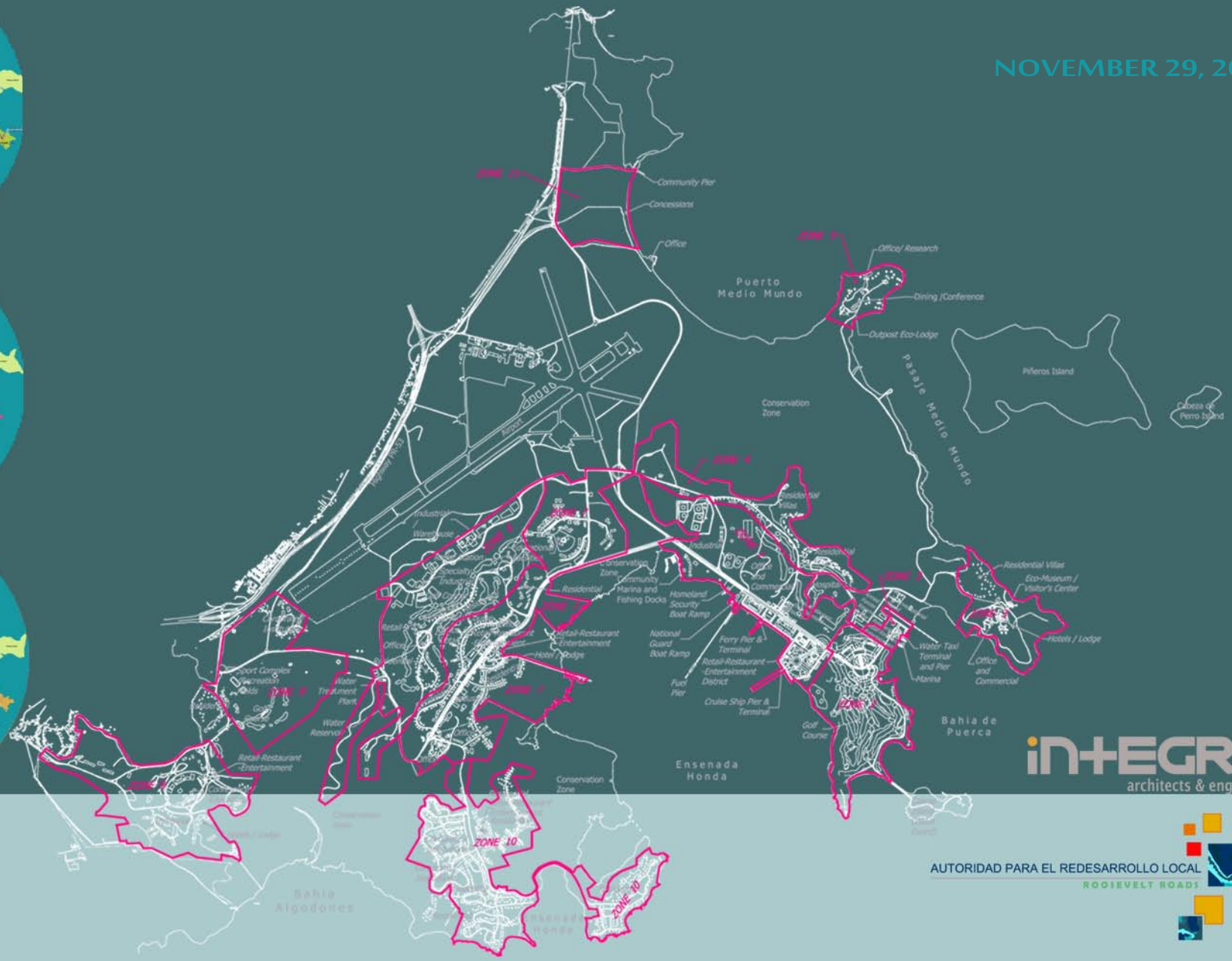
ROOSEVELT ROADS REDEVELOPMENT
INFRASTRUCTURE DESIGN GUIDELINES

NOVEMBER 29, 2012



INTEGRA architects & engineers

AUTORIDAD PARA EL REDESARROLLO LOCAL
ROOSEVELT ROADS

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1 Executive Summary and Scope of Work

Based on the assessment of the existing conditions described on the Infrastructure Master Plan for the Re-Development of the Former Naval Base Roosevelt Roads issued by Integra Design Group on April 30, 2012, **Infrastructure Design Guidelines (IDG)** have been developed to provide the design criteria and parameters for the future design and development of the sustainable utility and urban infrastructure components of the re-development. These components include: *Utility Infrastructure*: Potable Water, Wastewater and Stormwater Distribution, Electricity and Telecommunications, Solid Waste Management; *Urban Infrastructure*: Streetscape (roads, sidewalks, and mass transit), Bike Ways and Landscape.

The IDG regulate and indicate the manner in which the infrastructure development shall be carried out. Following are the main objectives of the IDG:

• To ensure compliance with the overall design vision; the Roosevelt Roads Re-use Plan, Roosevelt Roads Zoning Master Plan and align with any applicable Architectural Design Guideline or similar document published by the Roosevelt Roads Local Redevelopment Agency (LRA).

• To provide reference to standards and practices to ensure a sustainable infrastructure development - development that meets human needs for natural resources, industrial products, energy, transportation, shelter, and waste management while conserving and protecting environmental quality (indoor and outdoor) and the natural, economic and social resources essential for future development.

• To ensure that adequate information is provided at initial planning stages to allow the orderly review, assessment and approval of land development.

• To ensure that developments provide effective and economical infrastructure that service the area.

• To ensure that staged or multi-Developer projects are able to be delivered in a safe, efficient and effective manner.

• To ensure that infrastructure is planned for the full potential of the development and that unnecessary duplication or oversizing of infrastructure is avoided.

• To ensure compliance with design and construction codes; that the infrastructure will be designed and built according to all applicable local and federal design and construction codes.

1.1 Guidelines Organization

On any given capital project, stakeholders from both the public and private sectors participate in planning, scoping, funding, designing, constructing and maintaining infrastructure. *Chapter One* of the *Guidelines* provides all participants with an overview of the desirability of improved infrastructure and a general understanding of critical objectives.

Chapter Two provides an overview of how infrastructure is planned, designed and built, in collaboration with government agencies. It contains recommendations for helping the involved agencies and private utilities incorporate high performance practices into both typical and special infrastructure work. This section advocates for a more coordinated planning effort and integrated design among public agencies as well as stakeholders, helping them effectively coordinate long-term implementation across space and time.

Chapter Three is the technical component of the IDG. It sets out numerous practices organized according to the primary categories of the utility and urban infrastructure works: Potable Water, Wastewater and Stormwater Distribution, Solid Waste Management, Electricity and Telecommunications; Streetscape (roads, sidewalks), Bike Ways and Landscape.

A final section in *Chapter Four* contains best practices for construction and site management. They contain useful background information, key objectives for improved performance, and detailed technical strategies for achieving those objectives. They also explain benefits and limitations and identify opportunities for integrating multiple practices.

1.2 Abbreviations

ADS	Solid Waste Authority (Autoridad de Desperdicios Sólidos)
ANPMMD	Area Natural Protegida Medio Mundo y Daguao
AOC	Areas of Concern
ARMY	US Army
DEDC	Department of Economic Development and Commerce
DON	Department of the Navy
DRNA	Departamento de Recursos Naturales y Ambientales
DTOP	Department of Transportation and Public Works
EPA	Environmental Protection Agency (Agencia Federal de Protección Ambiental)
FCPR	Fideicomiso de Conservación de Puerto Rico
FEMA	Federal Emergency Management Agency (Agencia Federal para el Manejo de Emergencias)
FNSRR	Former Naval Station Roosevelt Roads
GPD	Gallons por day
IDG	Infrastructure Design Guidelines
JCA	Junta de Calidad Ambiental
JRTPR	PR Communications Regulatory Board
LRA	Local Redevelopment Authority, Roosevelt Roads
MSW	Municipal Solid Waste
NRHP	National Register of Historic Places (Registro Nacional de Lugares Históricos)
PB	Puerto Rico Planning Board
PPP	Public-Private Partnerships
PRASA	PR Aqueduct and Sewer Authority
PREPA	PR Electrical Power Authority
PRPA	PR Ports Authority
PT	Plan Territorial
RCRA	Resources Conservation and Recovery Act (Ley de Conservación y Recuperación de Recursos)
SFHA	Special Flood Hazard Areas (Áreas Especial de Riesgo a Inundación)
SHPO	State Historic Preservation Office (Oficina Estatal de Preservación Histórica)
SJMA	San Juan Metropolitan Area
SWMU	Solid Waste Management Units (Unidades de Manejo de Desperdicios Sólidos)
UVB	Unidades de Vivienda Básica

2 General Guiding Policies

2.1 Description of Process

The planning, design and construction of the Former Naval Base Roosevelt Roads' infrastructure projects requires extensive coordination among multiple government agencies and other entities that own, lease, operate and/or maintain utilities.

The Local Redevelopment Authority (LRA) is the government agency authorized to promote, manage and coordinate the planning and design of the Former Naval Station Roosevelt Roads (FNSRR). Under the leadership of the LRA, the Infrastructure Design Guidelines (IDG) have been prepared following consultation and liaison with multiple government agencies. Each agency was responsible for its own consultation process.

The main government agencies involved in the discussion for the development of the IDG are:

- Department of Transportation and Public Works (DTOP)
- Puerto Rico Aqueduct and Sewer Authority (PRASA)
- Puerto Rico Electrical Power Authority (PREPA)
- Puerto Rico Communications Regulatory Board (JRTPR)
- Puerto Rico Ports Authority (PRPA)

DTOP manages the transportation infrastructure – streets, bike ways, sidewalks, street signs, traffic signals and street lighting. PRASA manages the water supply distribution and wastewater system. PREPA manages the power supply system. Other agencies involved in infrastructure projects include Puerto Rico Communications Regulatory Board (JRTPR) regarding cable and telephone and Puerto Rico Ports Authority (PRPA). All of these agencies have contributed in the development of these Guidelines and will be part of the design and construction process of the infrastructure.

2.2 Design Requirements

2.2.1 Objectives

The objectives of these design requirements are as follows:

• To ensure expediency for Developers by providing clear guidelines regarding the engineering requirements;

• To ensure that new and upgraded infrastructure is of consistent standard across the various zones;

• To ensure that the works are designed such that they will fulfill the purpose for which they are intended;

• To ensure that minimum design standards are achieved and that works meet LRA's obligations;

• To ensure that community amenity will be improved through development;

• To ensure that public and employee safety during and after construction is considered; and

• To ensure that maintenance requirements are considered at the planning and design stages.

2.2.2 General

Comprehensive design criteria included in the IDG conveys engineering requirements for the internal or external delivery of design, construction and acceptance of roads, water distribution, sanitary sewer, storm sewer, electric power utilities and telecommunications infrastructure, while considering local conditions and the requirements of the LRA.

For Developers, the IDG provide the basis for expedient approvals for works built by Developers for incorporation into the infrastructure systems controlled by the LRA.

2.2.3 Compliance: Codes and Regulations

Infrastructure design and construction for the FNBRR shall be designed and built according to the Roosevelt Roads 2010 Addendum to the 2004 Reuse Plan's design principles, must comply with the 2011 Zoning Master Plan and must align with any applicable Architectural Design Guidelines or similar document published by the Roosevelt Roads LRA.

The IDG incorporate requirements identified through the review of Regulations published by the government agencies mentioned in section 2.1, model codes, local government codes and other standards and reference documents. Regulations published by government agencies include:

- PR Department of Transportation Highway Design Manual (1979), published by DTOP
- PRASA Rules and Regulations (2003 Edition), published by PRASA
- Reglamentos de la JRTPR (2007 Edition), published by JRTPR
- Manuales y Reglamentos, published by PREP
- Reglamento para la Reducción, Reutilización y el Reciclaje (2010 Edition), published by ADS

The Infrastructure shall be designed and built according to all applicable local and federal design and construction codes-The Puerto Rico Puerto Rico Building Code, 2011 edition, together with the 2009 International Building Code. All electric power distribution and metering provisions shall comply with ANSI/ASHRAE Standard 90.1-2010.

2.2.4 Sustainability

Sustainable infrastructure is essential to a sustainable society. To achieve sustainable infrastructure we need to use appropriate practices for its planning, design, construction, operation, maintenance and renewal or removal. Follow requirements issued on the Reglamento para la Reducción, Reutilización y el Reciclaje (2010 Edition), published by ADS.

2.2.5 Developers

In some cases were it is not the responsibility of the LRA to design, construct or supervise the construction of roads, water distribution, sanitary sewer, storm sewer, electric power utilities and telecommunications infrastructure for private land development, it is the

responsibility of the Developer to engage suitably qualified and experienced personnel who will carry out these functions to the satisfaction of the LRA.

Variation from Design Guidelines

Any proposal to deviate from the Infrastructure Design Guidelines at any stage of the works shall be made in writing with supporting reasons and must be approved in writing by the LRA prior to commencement of any work involving the proposed variation.

Note: Variations approved for some subdivisions or developments do not imply approval for other current or future proposals.

3 Infrastructure Design

3.1 Utility Infrastructure

3.1.1 Water Distribution

From the model results published on the Infrastructure Master Plan, in order to meet the future demands generated by the new developed areas (Zones) a direct interconnection to PRASA to an offsite water distribution system is required. This connection is available through the improvements that the Ports Authority is undergoing. The connection to the PRASA system was initially modeled considering a 12" pipe, under construction by the Puerto Rico Ports Authority (PRPA) (estimated completion at the end of year 2012) to serve the Airport located in Roosevelt Roads premises. The proposed pipe will run along Tarawa Drive, up to PRPA's property limits. From there, it will run a 10" diameter pipe along Boxer Drive, and into Leyte Drive's proposed tank. The minimum pressure at the connection point was assumed 30 psi.

As mentioned on the engineering report titled "Main Water Feeder, Fire Protection, and Sanitary System, Ceiba International Airport" prepared for the PRPA by PBS&J Caribe, LLP in the 2010 year, the Airport future water demand will be initially of550 gpm (0.79 MGD), with a future expansion up to of 1,100 gpm (1.6 MGD).

The existing PRASA infrastructure at the connection point (on State Road PR-3) is also a 12" diameter main, thus a further hydraulic analysis is recommended to verify if the PRASA system needs additional improvements to provide the water and minimum pressure required at the connection point.

New pipe locations for water distribution are shown on Figure 1. The construction of these new connections shall comply with PRASA regulations as well as with the following improvements recommendations per Zone:

Zone 1: From the hydraulic model results it was determined that the 10" and 12"Ø PVC pipes have adequate flow capacities for the expected demand of Zone 1 and the additional service for Zones 2 and a portion of Zone 3. The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades. All existing fire hydrants and pressure regulators along the Forrestal Drive shall be relocated due to the proposed widening of the road section.

A new 10" Ø PVC pipe segment with an approximate length of 350 meters shall be installed on Valley Forge Road up to Corvius Corner and Antietam Road in order to provide service to a portion of that road where new developments are expected. The existing secondary 6", 8" and 10" Ø branches that serve the Ports Area can be maintained and used to provide service for the proposed ports improvements. Minor 2" to 4 "Ø pipes should be abandoned or discarded for future use within the ports and the remaining areas.

Zone 2: From the hydraulic model results it was determined that the 10"Ø PVC pipe have flow capacities that are adequate for the expected demand of Zone 2 and the additional service for a portion of Zone 3.

The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades. No pipes substitutions will be needed, in order to maintain a minimum pressure in the system of 60 psi. All existing fire hydrants and pressure regulators along the Forrestal Drive shall be relocated due to the proposed widening of the road section. The existing secondary 6", 8" Ø shall be abandoned, because their location will interfere with the proposed zone developments. Minor 2" to 4 "Ø pipes should also be abandoned or discarded for future use.

Zone 3: From the hydraulic model results it was determined that the main 10"Ø PVC pipe branch have flow capacities that are adequate for the expected demand of this portion of Zone 3. The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

No pipes substitutions will be needed, to maintain a minimum pressure in the system of 60 psi.

All existing fire hydrants and pressure regulators along the Forrestal Drive shall be relocated due to the proposed widening of the road section.

The existing secondary 2", 4", 6" and 8" Ø shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

Zone 4: From the hydraulic model results it was determined that the 10" and 12"Ø PVC pipes have flow capacities that are adequate for the expected demand of Zone 4 and a portion of Zone 3 of 0.12 MGD. The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

No pipes substitutions will be needed, to maintain a minimum pressure in the system of 60 psi.

All existing fire hydrants along the Forrestal Drive and Antietam Road shall be relocated due to the proposed widening of the road section.

The existing secondary 6" and 8" Ø into the Tank Farm Zone, as well as the 10"Ø into the Hospital shall remain.

All other smaller pipe diameters on other areas shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

The Golf Course shall be serviced from a reclaimed water system or natural stormwater retention ponds.

Zone 5: Due to the nature of the ecological purpose of the development on this zone, no major demands are expected.

There are service options that must be incorporated into the zone, including rain water harvesting to provide the necessary water demand.

Nerveless, the installation of a 4"Ø PVC pipe along Chamberlain Road and interconnected from the existing 10" Ø PVC pipe located on Zone 3 on Antietam Road, shall be considered. This can be used to service or compliment the domestic water and fire demand cisterns inside the zone.

Zone 6: From the hydraulic model results it was determined that the 12" and 18"Ø PVC pipes have flow capacities that are adequate for the expected demand of Zone 6 of 0.63 MGD. The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

It is expected that the main distribution pipes that provides service into the Airport, will be disconnected to the Base distribution system, either by closing valves or capping ends. The Airport is currently developing their independent water distribution and connection to PRASA system.

No pipes substitutions will be needed, to maintain a minimum pressure in the system of 60 psi.

All existing fire hydrants along the Corregidor Road shall be relocated due to the proposed widening of the road section.

The existing secondary 6" and 8" Ø and other smaller pipe diameters on other areas shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

The Golf Course shall be serviced from a reclaimed water system or natural stormwater retention ponds.

Zone 7: From the hydraulic model results it was determined that the 14" Ø PVC pipe has flow capacity that is adequate for the expected demand of Zone 7 and the service for Zones 1,2,3,4 and 6 which are also interconnected the 14 Ø pipe from Langley Drive.

The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

No pipes substitutions will be needed, to maintain a minimum pressure in the system of 60 psi.

All existing fire hydrants along the Langley Drive shall be relocated due to the proposed widening of the road section.

The existing secondary 6", 8" and 10"Ø pipe portions on Kearsag Road and Lunga Pt. Road shall remain to provide service to existing and proposed facilities.

Other smaller pipe diameters on other areas shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

Zone 8: From the hydraulic model results it was determined that the 14" Ø PVC pipe has flow capacity that is adequate for the expected demand of Zone 8 and the service for Zones 9 which is also interconnected the 14 Ø pipe from Langley Drive.

The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

No pipes substitutions will be needed, in order to maintain a minimum pressure in the system of 60 psi.

There are no existing fire hydrants along the Langley Drive. New fire hydrants shall be installed on this Zone, in order to comply with government regulations.

The existing secondary 4”Ø pipe portions into Boxer Drive and into the former golf course shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

The Golf Course shall be serviced from a reclaimed water system or natural stormwater retention ponds.

Zone 9: From the hydraulic model results it was determined that the 10” and 12”Ø PVC pipe mains have flow capacity that is adequate for the expected demand of Zone 9.

The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

No pipes substitutions will be needed, in order to maintain a minimum pressure in the system of 60 psi.

All existing fire hydrants along the Bennington Road shall be relocated due to the proposed widening of the road section.

Some portions of the secondary 8”Ø pipe portions on Bairoko Street shall remain to provide service to existing and proposed facilities. Other smaller pipe diameters on other areas shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

Zone 10: From the hydraulic model results it was determined that the 10”, 12” and 14” Ø PVC pipes have flow capacities that are adequate for the expected demand of Zone 10.

The peak demands can be achieved without producing low pressures. The current system will be able to provide the capacity and pressures for the future development with only minor upgrades.

No pipes substitutions will be needed, in order to maintain a minimum pressure in the system of 60 psi.

All existing fire hydrants along the F.D.R. Drive shall be relocated due to the proposed widening of the road section.

The existing secondary 6”, 8” and 10”Ø pipe portions inside the existing residential areas shall be abandoned or discarded for future uses, because their location will interfere with the proposed zone developments.

Zone 11: Water service for this zone can be obtained from the proposed 12” Ø water main to be installed by the Ports Authority for the Airport.The installation of a 2”Ø PVC pipe interconnected to the proposed water main shall be considered. This connection will be more efficient because the closest main pipeline inside the base is located at approximately 5 kilometers at the intersection of Tarawa Drive and Forrestal Drive.

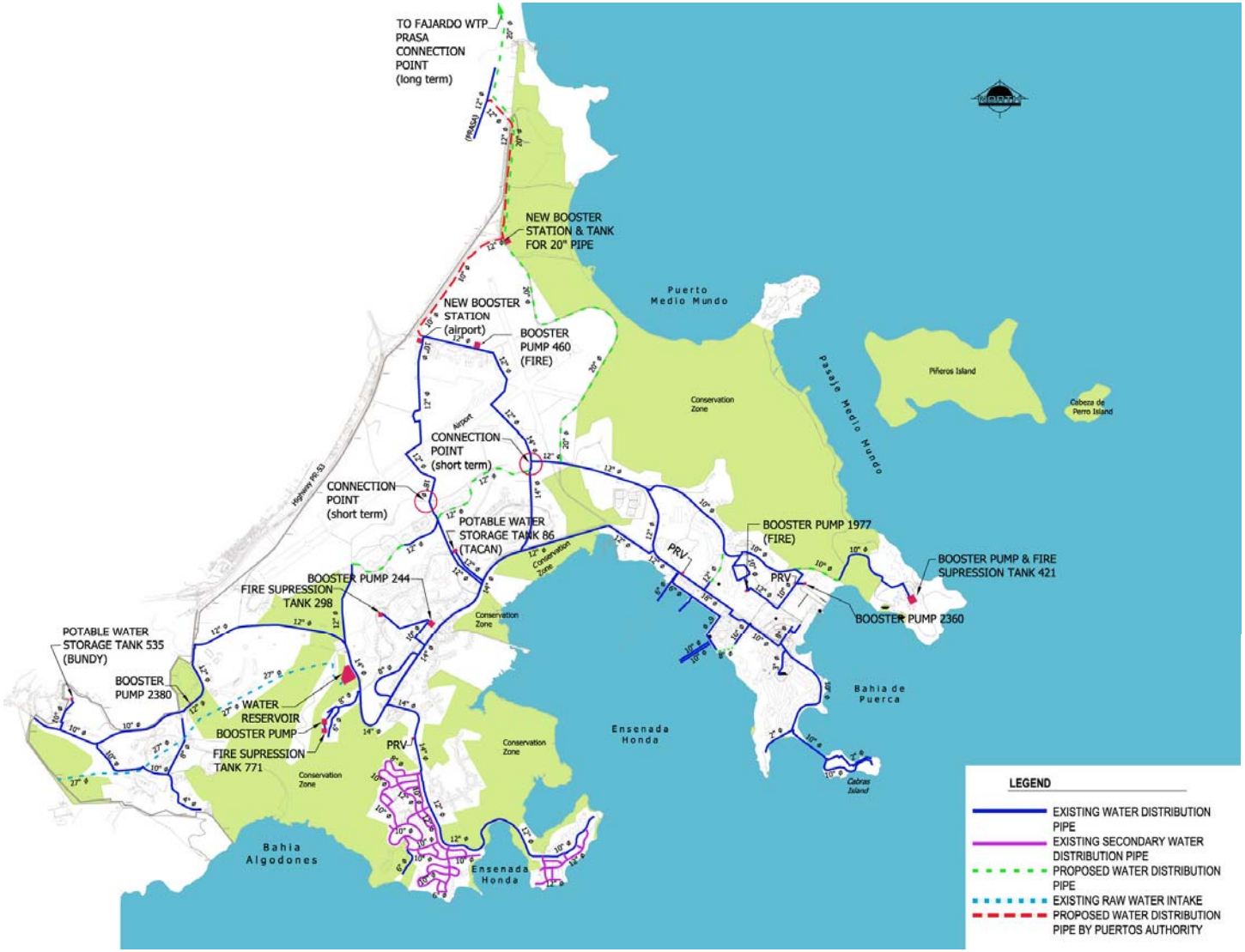


Figure 1: Proposed Water Distribution System

3.1.2 Wastewater

The findings published on the Infrastructure Master Plan on the conditions of the wastewater system and the proposed recommendations to meet future demands states that by a combination of improvements to the existing system and the provision of new pipelines, lift stations, wastewater treatment plants, connections and support systems, the future demands can be satisfied. This will be accomplished in conjunction with the support provided by the Puerto Rico Aqueduct and Sewer Authority (PRASA).

From the different scenarios included in the hydraulic modeling and analysis process, it was determined that the most efficient and economical alternative for the re-development process will be the implementation of the recommendations listed below.

- Replace the existing gravity collection sewers on all main corridors, to have adequate hydraulic capacity to convey the future wastewater demands and to comply with PRASA Standards and regulations.
- Install new gravity collection sewers on portions of Zones 2, 3, 4, 6 and 8, on their respective main road corridors in order to provide a main collection system to the proposed individual developments on those areas.
- Demolish Forrestal WWTP
- Convert Bundy and Capehart WWTP's into centralized Lift Stations to handle and transfer all the wastewater generated on Zones 9 and 10.
- Develop a new lift station on Langley Drive near the intersection with FDR Drive on Zone 7 to collect all the wastewater transferred from the new lift stations on zones 9 and 10.
- Install force lines from new Bundy and Capehart Lift Stations up to the new lift station on Zone 7.
- Install force lines from new lift station on Zone 7 up to Lift Station 39 on Zone 1.
- Perform minor repairs to existing lift stations.
- Re-furbish and expand Lift Station no. 39 on Zone 1 to a maximum capacity of 3.1 MGD.
- Install a new 2,500 meters, 12" sewer forceline from Lift Station 39 on Zone 1 up to the Airport gravity sewer system at the Aviation School for PRASA service on the short term up to the year 2015.
- Install a new 10,100 meters, 12" sewer forceline from the Airport short term connection point up to the PRASA connection point at the Fajardo WWTP on the long term.
- Additional hydraulic analysis is recommended to verify the PRASA's system capacity and the necessity of the new pipelines.

See Figure 2 with the Proposed Wastewater System

Figure 2: Proposed Waste Water System

3.1.3 Stormwater

As mentioned on the assessment of the existing infrastructure, the collection and disposal systems for stormwater at Roosevelt Roads are mainly composed of a series of surface systems that transport runoff through pipe culverts, box culverts, earth ditches and channels. Due to the fact that a vast majority of those systems are located on existing road corridors, they will be affected by the improvements recommended on those corridors.

In addition to the improvements to the existing systems, there is a need to develop new stormwater infrastructure on waterfront areas where new developments are contemplated, especially on Zones 1 and 2. New stormwater infrastructure shall be designed according with PRASA regulations.

Catch Basins, Inlets Systems

The systems shall be designed following drainage regulations required by the PR Highway and Transportation Authority and shall have the hydraulic capacity for the management of 25 years frequency storm events.

As new areas are re-developed, the stormwater quality is also greatly reduced. This shall be addressed on each individual development, taking in consideration the specific physical characteristics for each future project. The following recommendation shall be implemented as part of the stormwater infrastructure development:

- Parcels or easements shall be created within the Base, in orderto provide adequate areas for developers to incorporate theirspecific quantity and quality control systems, before discharging into the stormwater infrastructure
- Develop guidelines for the design and implementation of stormwater quantity and quality mitigation measures
- Develop a stormwater management plan

The proposed redevelopment will produce an increase in stormwater runoff quantities that must be mitigated by implementing different systems such as: retention or detention ponds, underground recharge systems, pervious pavements and others. The systems shall be implemented on each individual development, by addressing the future projects' characteristics.

The proposed stormwater improvements are shown in Figure 3.

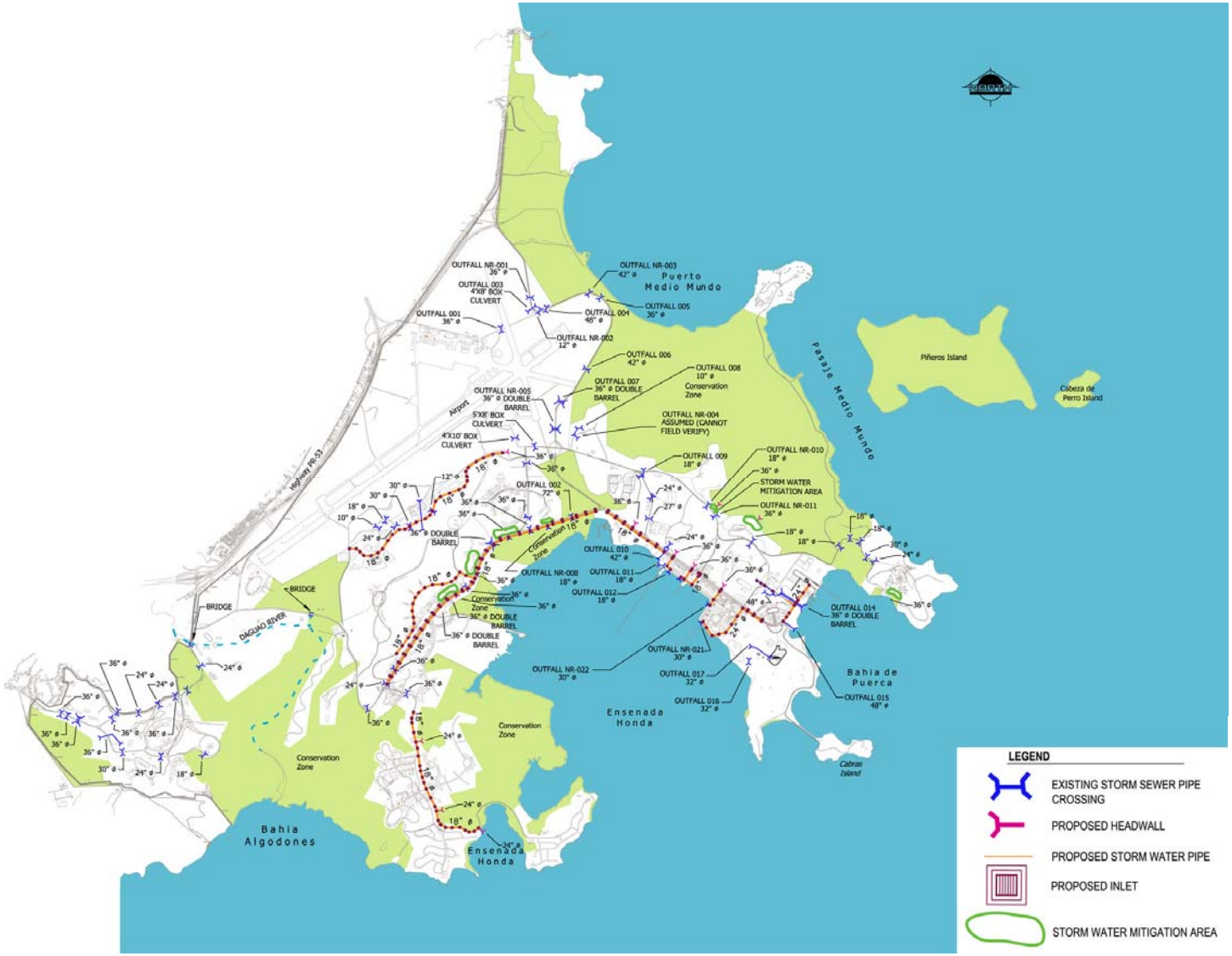


Figure 3: Proposed Storm Water System

3.1.4 Electricity and Telecommunications Systems

There is a need to perform multiple improvements on the transmission and distribution systems to provide an efficient service for the redevelopment.

Due to the fact that the proposed total load demand exceeds the current available load, it is necessary to consider the construction of a new 115 KV/38 KV transmission center. This construction requires the cession to PREPA of a parcel of land of approximately 5 acres and a new easement of 200 feet width for new 115 KV transmission lines. A suggested location of this 115 KV substation is at the South of Langley Drive at Zone 8: Sport Complex Zone. The 115 KV line must be installed on an underground easement from the PREPA Daguao Transmission Center to this new parcel in order to avoid interference with the Airport Air Right of Way.

In order to satisfy the need of the electrical load for the re-development, it is necessary to establish an electrical distribution comprised of sub-transmission voltage of 38,000 volts (38 KV) and distribution voltage 13,200 volts (13.2 KV). The use of 38,000 volts system is primarily for the industrial type loads greater than 1,500 KVA. The electrical loads at or below 1,500 KVA must be served by 13.2 KV distribution lines with private substations. The light commercial and residential electrical loads will be served by service voltages of 120/240 volts, 120/208 volts and 277/480 volts. Those services are possible through the distribution of 13.2 KV lines strategically located to serve the future loads.

The proposed Main Electrical System shall be composed of new 38 KV and 13.2 KV aerial electrical lines located on or adjacent to the main road corridors distributed throughout the Base.

There are two alternatives for the transmission and distribution systems at Langley Drive on Zones 6 and 7 and on Forrestal Drive on Zones 1 and 2. One option is to install underground transmission and distribution systems for maintaining the aesthetic look of these proposed urban and commercial areas. The other option is to install aerial transmission and distribution systems on those proposed urban and commercial areas, due to a lower installation cost when compared with underground systems. The improvements discussed here are shown on Figure 4 and 5.

All other roads on the Base will have main sub-transmission and distribution aerial electrical lines. A vast majority of the existing electrical systems will be located on the existing aerial electrical systems right of ways.

Based on the estimated electrical load per zone, substations are needed to supply the electrical need. A total of 98,313 KVA estimated electrical load is needed where is divided as follows: 39,638 KVA at 13.2 KV and 58,675 KVA at 38 KV. See diagrams below with proposed locations of new systems.

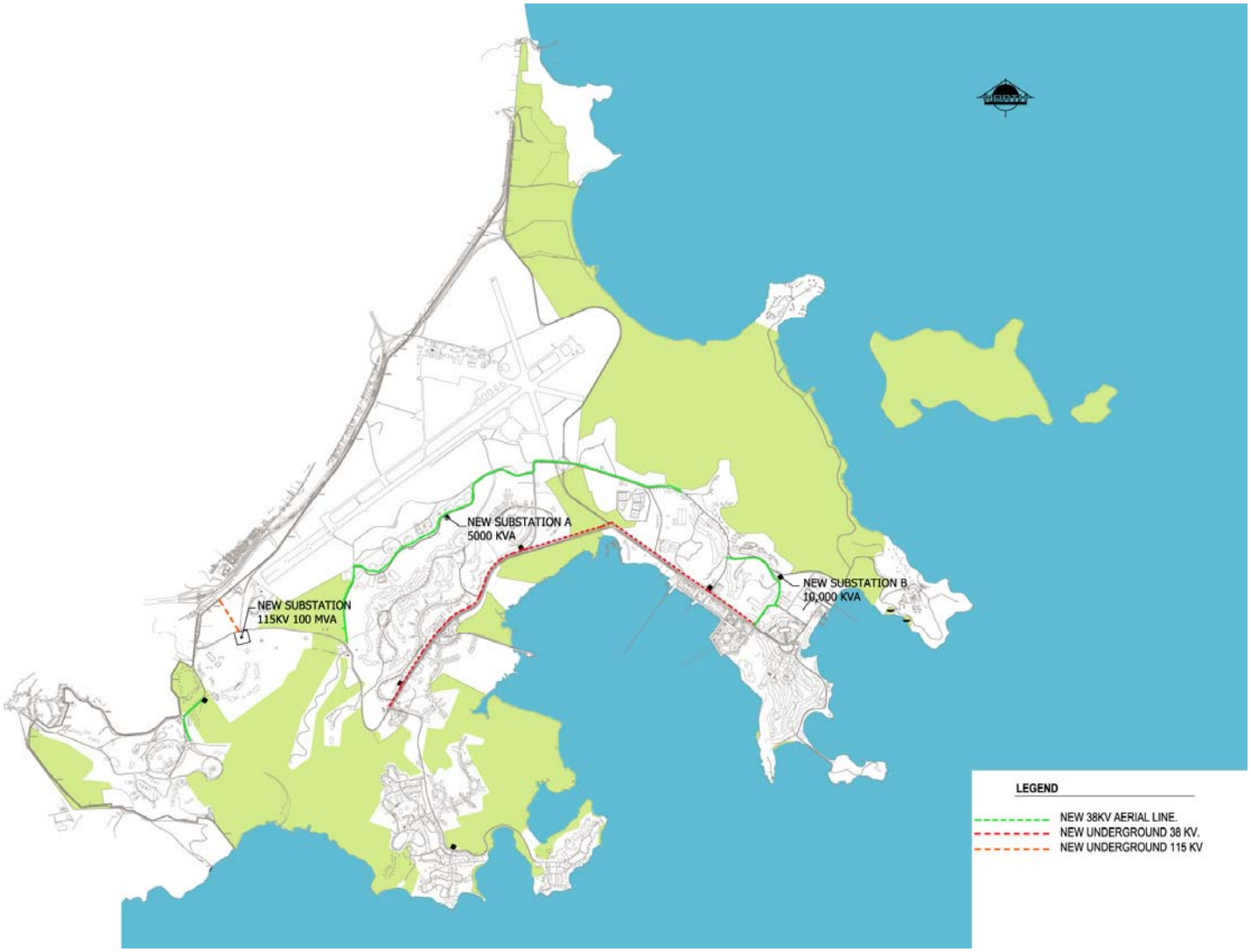


Figure 4: Proposed Electrical 38KV System

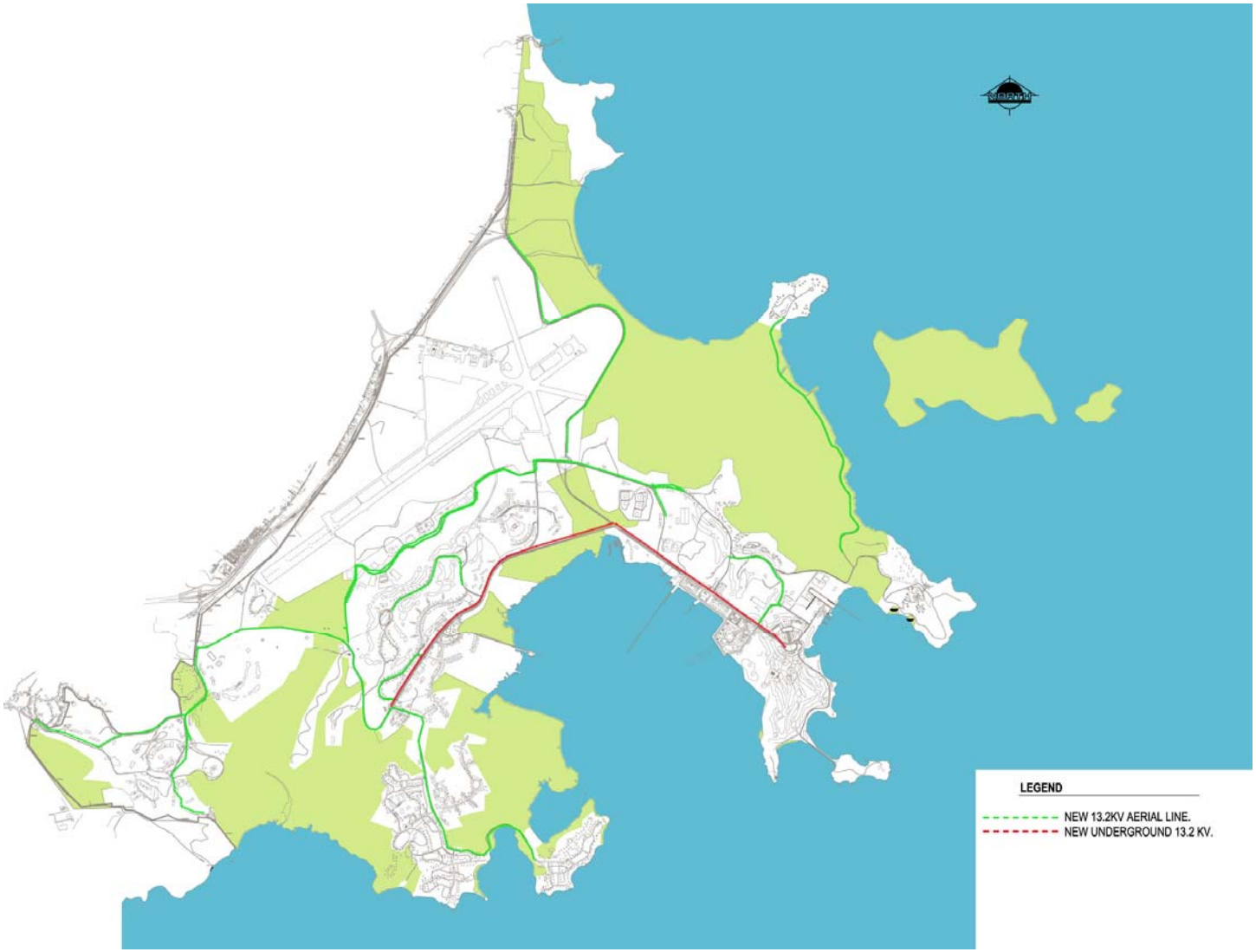


Figure 5: Proposed Electrical 13.2KV System

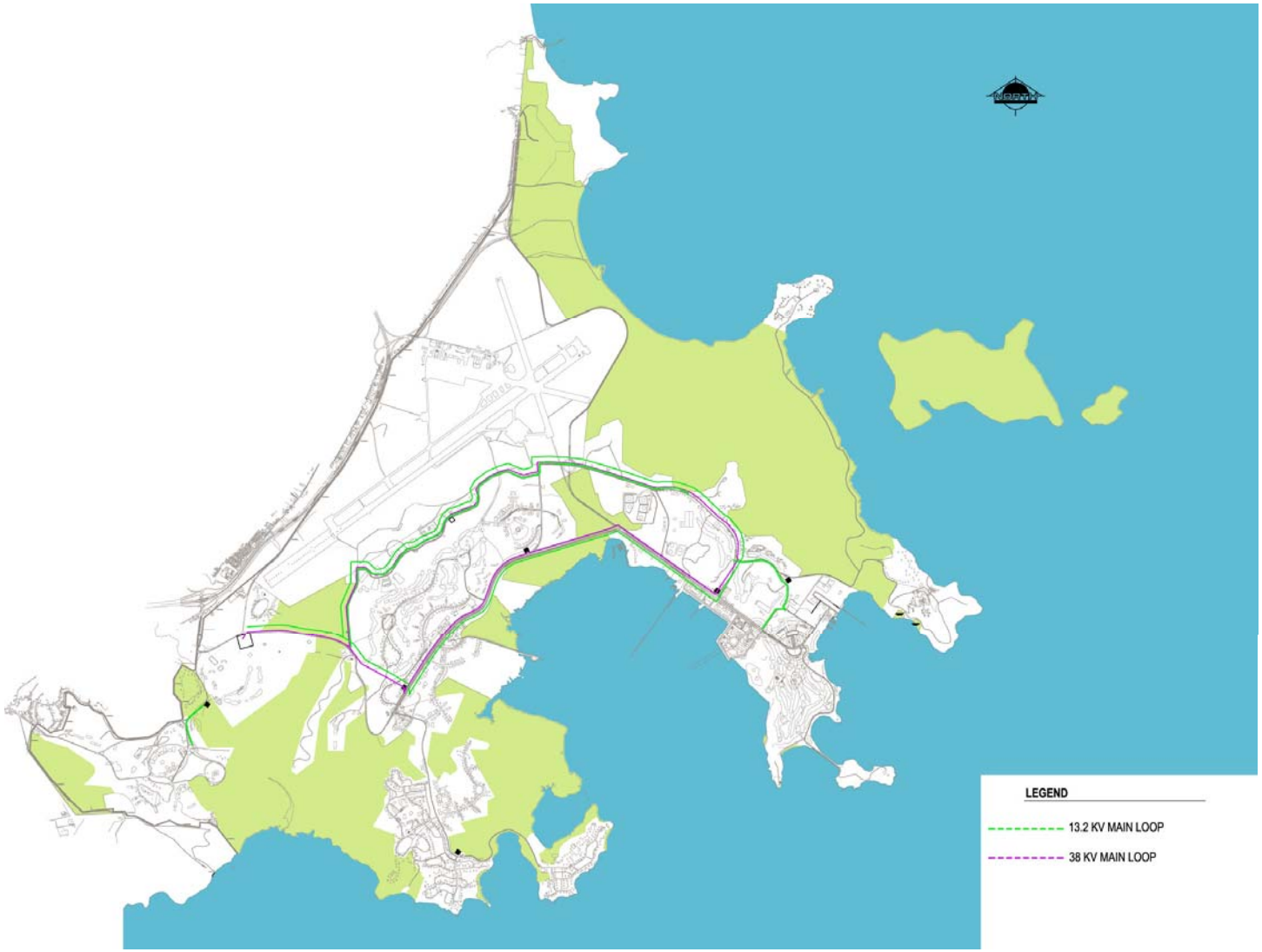


Figure 6: Proposed Electrical 13.2KV & 38KV Loop Systems

The guidelines, diagrams and drawings that follow refer to the construction guidelines of the Puerto Rico Power Authority. The system design guidelines comply with the "Reglamento de Ordenacion de la Infraestructura en el Espacio Publico", Guideline Number 22 of the "Junta de Planificacion de Puerto Rico".

Underground System

Underground system consist of primary feeders, switching units, vacuum switches, branch feeders, lateral circuits, transformers with their equipment and protective devices, secondary feeders, secondary manholes, secondary services with corresponding protection devices. Underground primary feeders system will be of three phases using four cables which will depend on the connection point given by the Authority under Jurisdiction (AUJ). Feeding Voltage will be 4,160 / 7,200 / 8,320 / 13,200 volts or any other voltage required by the Authority under Jurisdiction like / 38,000 / 115,000 volts. The Underground primary feeders will be constructed and designed to have interconnection provisions with other feeders. A coordinated design with the Authority under Jurisdiction shall be achieved first for each particular project. Primary feeders will be installed between switching units or between switching units and poles.

Conductors

a) Conductor Type: For systems that will become part of the PREPA distribution system, condutors shall be of copper, shielded, according to the latest standards as specified in standard WC7 of the AEIC, ICEA S-61-402 and S-66 -524 . The use of coaxial type cable or aluminum conductors will not be acceptable. The cable insulation shall be of crosslinked polyethylene chain retardant arborescence (cross-linked polyethylene - tree-retardant TRXLPE) or ethylene propylene rubber (EPR ethylene propylene-rubber) to 15 KV. The neutral conductor shall have a minimum insulation of at least 600 V moisture resistant (XHHW). Other types of insulations in the distribution system must be approved by PREPA. The cables shall comply with the following specifications and the latest revision of the applicable standard ICEA:

1) The conductor's strand shielding shall be extruded.
2) The insulation shall be cross-linked polyethylene - tree-retardant TRXLPE or EPR ethylene propylene-rubber with a minimum thickness of 175 mils.
3) The cables will have copper shield tape.
4) All cables shall have the following markings printed on the exterior cover:

a) Manufacturer identification
b) Type TRXLPE or EPR insulation
c) Size of conductor
d) Conductor material
e) Nominal Voltage
f) Year of manufacture

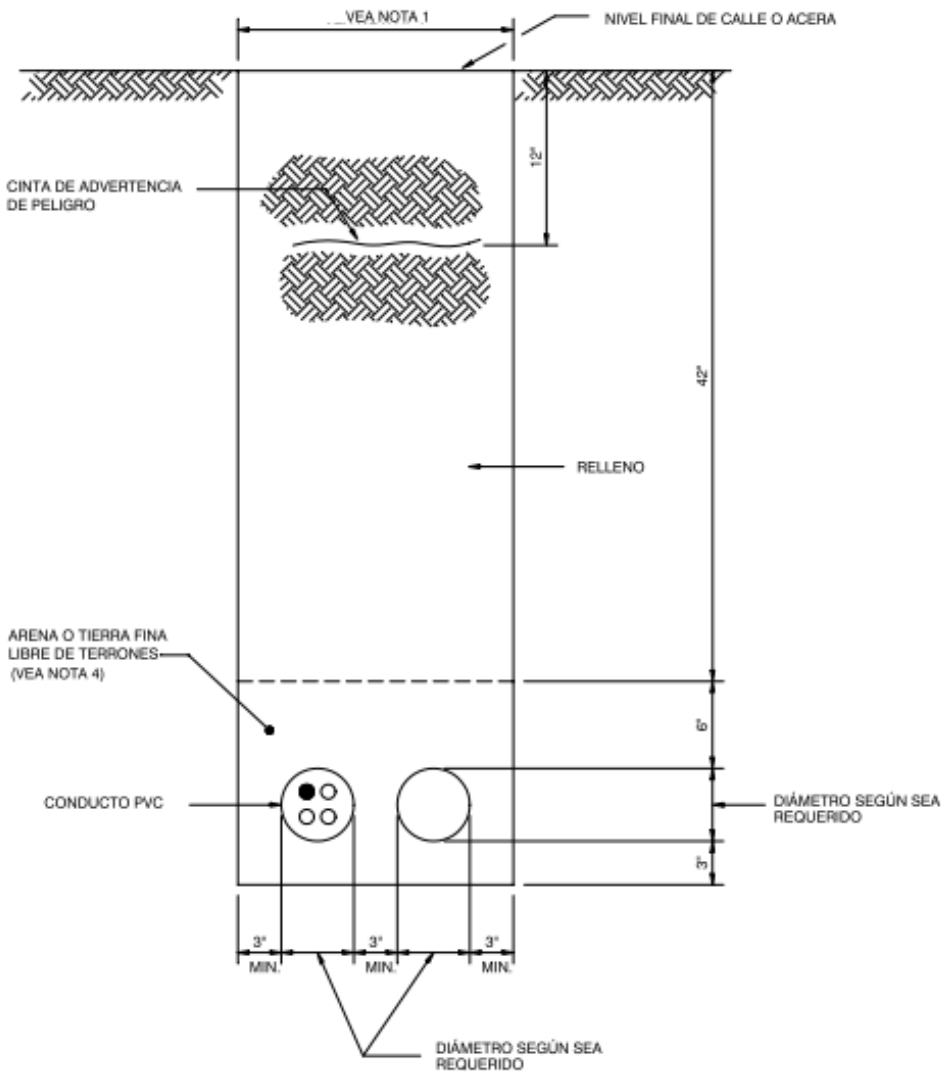
g) Insulation thickness
h) Cover Material (Jacket)

b) Wire Gauge: The designer shall coordinate with PREPA the conductor size to be used for development, in accordance with the requirements of the master plans. In any case the conductor size shall be less than 500 KCM copper. The neutral conductor (fourth line) will be insulated copper of 600 V. For three-phase feeder branches the minimum size is 4/0 AWG copper and neutral is the same caliber of the phase conductor. For circuits lateral size is calculated according to the load of the system but never less than 2 AWG copper. Table I summarizes the wire size for feeders major phase, three-phase circuits and lateral branches.
The number of ducts required in a proposed conduit addition or extension depends on the number of cables necessary to provide for the service being served. Spare conduits should be provided to consider future growth or maintenance needs.

c) Conduits:Cables will be installed in AUJ approved conduits to a minimum of 48” in depth (See Figure below). The conduits will be laid on the trench free of rocks or other object that could harm or deform the conduits. A sign band will be installed at 12” inches below finished grade. It shall be 6” inches wide, yellow with permanent continuous letters of size 11/4” x 5/8” with the words “Peligro-Peligro” repeated continuously at upper half and words “Líneas Eléctricas Debajo” at lower half.

Table I - Conductor Size

Description	Phase Conductor Size	Neutral Conductor Size
Three-phase principal feeders	750 kcmil CU-15 KV 500 kcmil CU-15KV	4/0 AWG CU-600V 4/0 AWG CU-600V
Three-phase branch feeders	4/0 AWG CU-15 KV	4/0 AWG CU-600V
Lateral Circuits (monophasic or threephasic) or primary service connections	3/0 AWG CU-15 KV 2/0 AWG CU-15 KV 1/0 AWG CU-15 KV 2 AWG CU-15 KV	3/0 AWG CU-600V 2/0 AWG CU-600V 1/0 AWG CU-600V 2 AWG CU-600V



Notes:

1) Trench width as required.
2) An additional spare conduit shall be required for every cable filled conduit except in monophasic loops between transformers in residential distribution systems.
3) At street crossing, parking lots, entrances, etc. that are subject to vehicle traffic, the installed conduit shall be covered with a concrete encasement of 3” minimum.

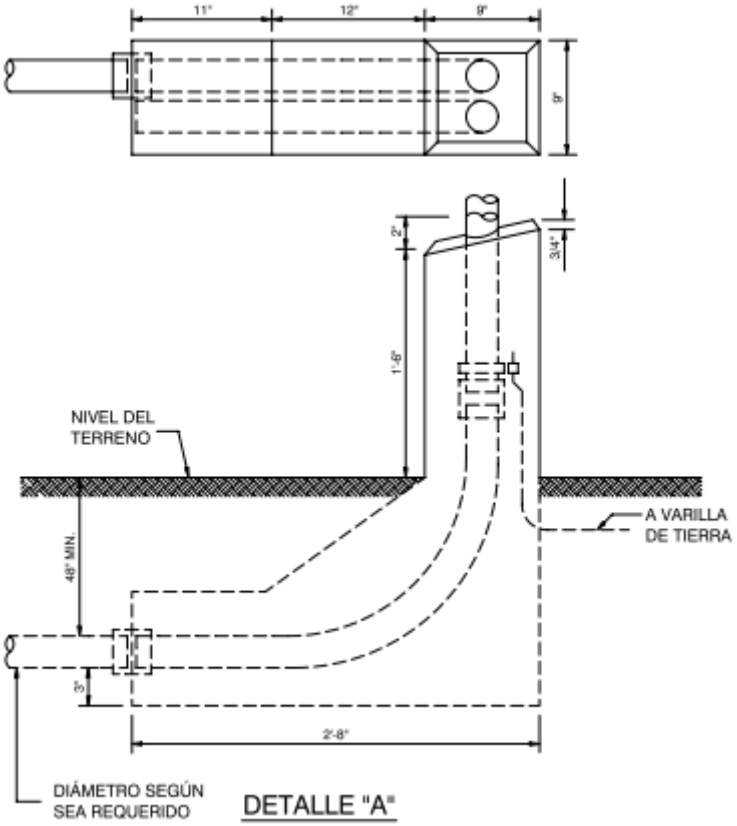
Conduits shall comply with the following specifications:

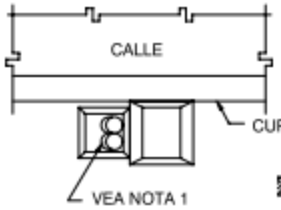
1) Shall be type Schedule 40. Type DB-60 can only be used at installations that will not be property of the AUJ.
2) Every 5’ feet intervals the conduit shall have the following details imprinted on:
    a) Diameter
    b) Type and Grade
    c) Schedule number
    d) Commercial Standard
    e) Manufacturer
3) Shall be constructed with specifications NEMA, TC2-1978 or ANSI/ASTM F 512-78.
4) Cable run will be equal or less as recommended in Table V (see below).

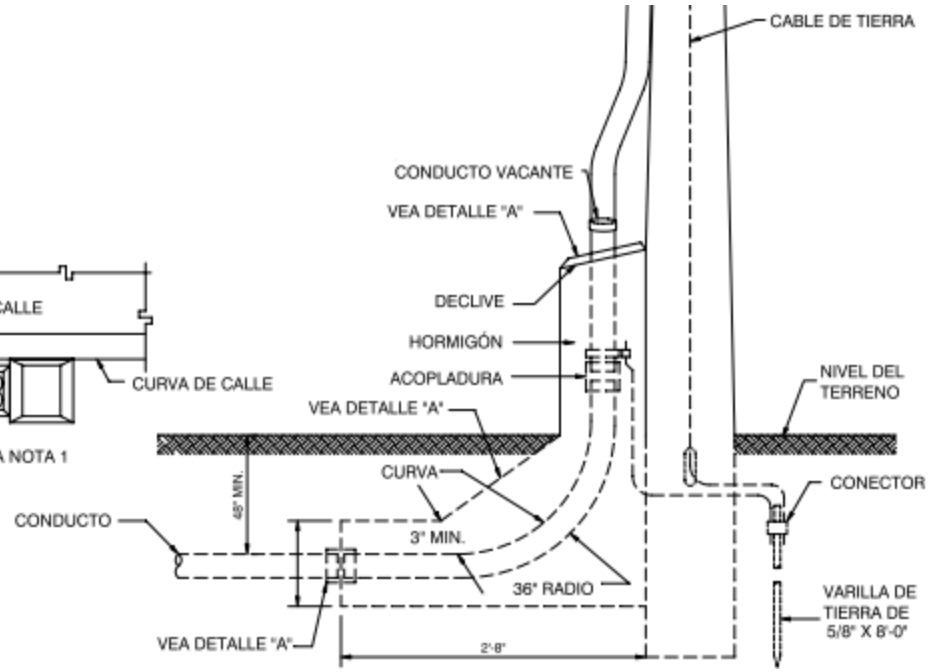
Maximum Pull Lenght for Underground Cables Table
Table V - Pulling Eye Method

Conductor 15 KV-XLP (AWG/kcmil)	Neutral 600V-XHHW (AWG/kcmil)	Conduit (Inches)	0 Bends Max (Feet)	2 Bends Max (Feet)
750	4/0	6	1166	413
500	4/0	6	1395	502
350	4/0	4	2006	589
250	4/0	4	2383	681
4/0	4/0	4	2265	716
3/0	3/0	4	2179	814
2/0	2/0	4	2071	924
1/0	1/0	3	1750	933
2	2	3	1537	784

5) Ascending conductors recommended by the AUJ will be type Rigid Galvanized. If located at less than 1 mile from sea shore it will be type schedule PVC SCH 80. These conduits will be protected using URD-4 construction details (see below):







6) Under no circumstances will primary feeders be permitted to cross residential terrains.

Electrical Protection

Underground primary feeders shall be protected on the point of connection to aerial lines with metal oxide lightning arresters for the corresponding system voltage. See table below.

Table II - Electric Protection Guidelines

System Voltage	DCV[1]-rms (en KV)	MCOV[2]-rms
2.4/4.16	3	2.55
4.16/7.2	6	5.10
4.8/8.32	6	5.10
7.62/13.2	10	8.40

Fuses shall be of nominal capacity in accordance with the requirements of the protective devices and with an interrupted capacity per PREPA standards for the specific application. In no case capacity shall be less than 8,000 amperes symmetrical. In addition, terminations shall be installed at the end points of the conductive shell to protect the cables from electrical stresses.

Resources:

- *Manual de Patrones de Distribución Soterrada*, Autoridad de Energía Eléctrica Normas y Procedimientos División de Distribución Eléctrica, January, 2000.
- Autoridad de Energía Eléctrica de Puerto Rico Directorado, *Transmisión Y Distribución. Patrones de Construcción de Líneas de Transmisión*, May, 1992.
- Autoridad de Energía Eléctrica de Puerto Rico Directorado, *Transmisión Y Distribución Patrones de Construcción de Distribución Aérea*, 1986

Due to the fact that the proposed total load demand exceeds the current available load, it is necessary to consider the construction of a new 115 KV/38 KV transmission center. This construction requires the cession to PREPA of a parcel of land of approximately 5 acres and a new easement of 200 feet width for new 115 KV transmission lines. A suggested location of this 115 KV substation is at the South of Langley Drive at Zone 8: Sport Complex Zone. The 115 KV line must be installed on an underground easement from the PREPA Daguao Transmission Center to this new parcel in order to avoid interference with the Airport Air Right of Way.

In order to satisfy the need of the electrical load for the re-development, it is necessary to establish an electrical distribution comprised of sub-transmission voltage of 38,000 volts (38 KV) and distribution voltage 13,200 volts (13.2 KV). The use of 38,000 volts system is primarily for the industrial type loads greater than 1,500 KVA. The electrical loads at or below 1,500 KVA must be served by 13.2 KV distribution lines with private substations. The light commercial and residential electrical loads will be served by service voltages of 120/240 volts, 120/208 volts and 277/480 volts. Those services are possible through the distribution of 13.2 KV lines strategically located to serve the future loads.

The proposed Main Electrical System shall be composed of new 38 KV and 13.2 KV aerial electrical lines located on or adjacent to the main road corridors distributed throughout the Base.

There are two alternatives for the transmission and distribution systems at Langley Drive on Zones 6 and 7 and on Forrestal Drive on Zones 1 and 2. One option is to install underground transmission and distribution systems for maintaining the aesthetic look of these proposed urban and commercial areas. The other option is to install aerial transmission and distribution systems on those proposed urban and commercial areas, for economic reasons.

All other roads on the Base will have main sub-transmission and distribution aerial electrical lines. A vast majority of the existing electrical systems will be located on the existing aerial electrical systems right of ways.

Based on the estimated electrical load per zone, substations are needed to supply the electrical need. A total of 98,313 KVA estimated electrical load is needed where is divided as follows: 39,638 KVA at 13.2 KV and 58,675 KVA at 38 KV:

Table 1: Total Electrical Load Per Zone

Zone	Location	Estimated Electrical Load at 13.2 KV	Estimated Electrical Load at 38 KV	Total Estimated Electrical Load per Zone
1	Port Caribe	5,569 KVA	1,820 KVA	7,389 KVA
2	Caribbean Riviera	3,477 KVA	25,835 KVA	29,312 KVA
3	El Yunque Grande	7,104 KVA	0 KVA	7,104 KVA
4	Marsh Vista	1,801 KVA	0 KVA	1,801 KVA
5	Eco-Outpost Camp	1,398 KVA	0 KVA	1,398 KVA
6	Airport Uplands	4,350 KVA	7,590 KVA	11,940 KVA
7	Main Street	7,790 KVA	12,848 KVA	20,637 KVA
8	Sports Core	3,279 KVA	0 KVA	3,279 KVA
9	Island Paradise	825 KVA	8,310 KVA	9,135 KVA
10	Capeheart	3,623 KVA	2,273 KVA	5,896 KVA
11	Ceiba Park	424 KVA	0 KVA	424 KVA
	Total:	**39,638 KVA**	**58,675 KVA**	**98,313 KVA**

New main 38 KV and 13.2 KV electrical loops for all the loads to be connected in the future, shall be considered. The electrical aerial loops would begin at the Main 115 KV Substation at Langley Drive; continue on Corregidor Road, Forrestal Drive, Antietam Road and Valley Forge Road. Then they will continue underground (if this option is selected) or aerial through Forrestal Drive and Langley Drive, until it connects again to the beginning point. See Figure 6.

Strategically we need to locate the substations in order to supply this future electrical load spread in a 25 year development period. We recommend keeping the location and increasing the parcel sizes of the India, Charlie and Delta Substations as per PREPA recommendation of a minimum parcel of 2,000 square meters. The recommended substations capacities as per the zones areas are:

- 38KV/13.2KV Substation India improved to 12,000 KVA covering zones 1 (portion) and 2.
- 38KV/13.2KV Substation Charlie improved to 7,500 KVA covering zones 1 (portion) and 7 (portion).
- 38KV/13.2KV Substation Delta improved to 12,000 KVA covering zones 6 (portion) and 7 (portion).
- New 38KV/13.2KV 5,000 KVA Substation A to serve zones 6 (portion) and 11.
- New 38KV/13.2KV 10,000 KVA Substation B to serve zones 3, 4 and 5.

- New 38KV/13.2KV Substation Coral Sea improved to 7,500 KVA, from the existing 4.16 KV and shall be converted to 13.2 KV covering zone 10.
- New 38KV/13.2KV Substation Bundy improved to 7,500 KVA, from the existing 4.16 KV and shall be converted to 13.2 KV covering zones 8 and 9. Unless it kept as a private substation for the Federal Government, then a new substation of this capacity shall be constructed in this area.

The electrical systems needed inside each individual development areas, will be a responsibility of each individual developer according to their proposed layout.

Telecommunication Systems Requirement and Demands

A new telecommunication system shall be installed for the Roosevelt Roads redevelopment in order to comply with the requirements of the "Junta Reglamentadora de Telecomunicaciones de Puerto Rico" (JRTPR or PR Telecommunications Regulatory Board).

In addition, a new system must be considered due to the increased data/communications load demand needed for the complete redevelopment.

Also a new infrastructure right of way to be transferred to the JRTPR shall be created for the installation of the new system. This right of ways shall be established along existing and proposed road corridors. JRTPR need to make sure that all telecommunications providers will have access to this infrastructure to allow for the best competitive pricing and services to the customers.

An analysis was performed to determine the data/communications load demands on the different zones. As per a study of Bank of America on Subscriber Services and Bandwidth Demand (2005) a 20 Mb/s bandwidth is required for future need.

In order for the telecommunication infrastructure to supply this need, a broadband optic fiber backbone network is required. JRTPR needs the LRA to provide the infrastructure easements and conduits installation in order that qualified providers can install the optic fiber and related equipment to create their own network for the future developments.

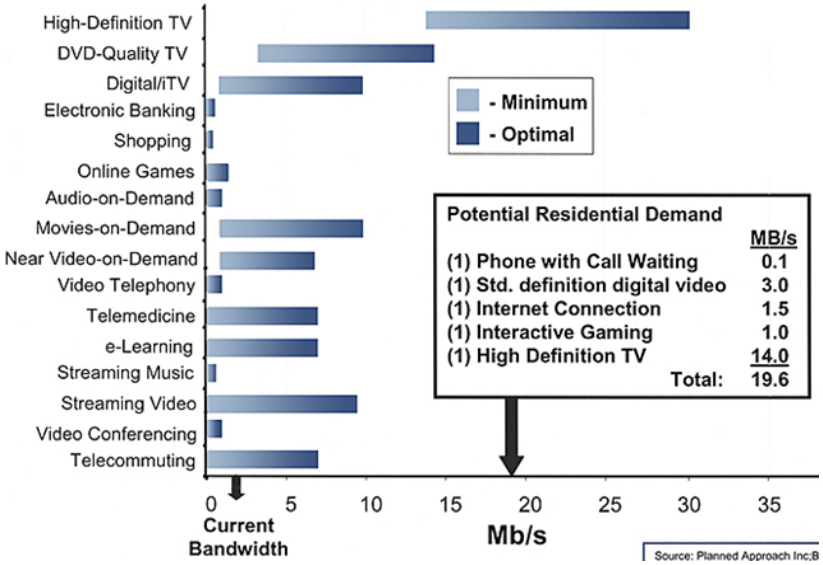


Figure 7: Subscriber Services & Bandwidth Demand (Bank of America)

A redundant underground loop with two connection points (at Gates 1 and Gate 3) for all services providers shall be installed with 10 conduits of 4 inches diameter each and 8 conduits of 2 inches diameter each. This infrastructure will connect at a Main Central Building (1,000 square meter lot size) where it is going to provide a space for each of the qualified service providers of Puerto Rico to serve the communities with high speed internet, cable tv, telephone and other services. This will be possible through the installation of fiber optics cable (installed by the providers) from the points of connection in the outside of the main gates

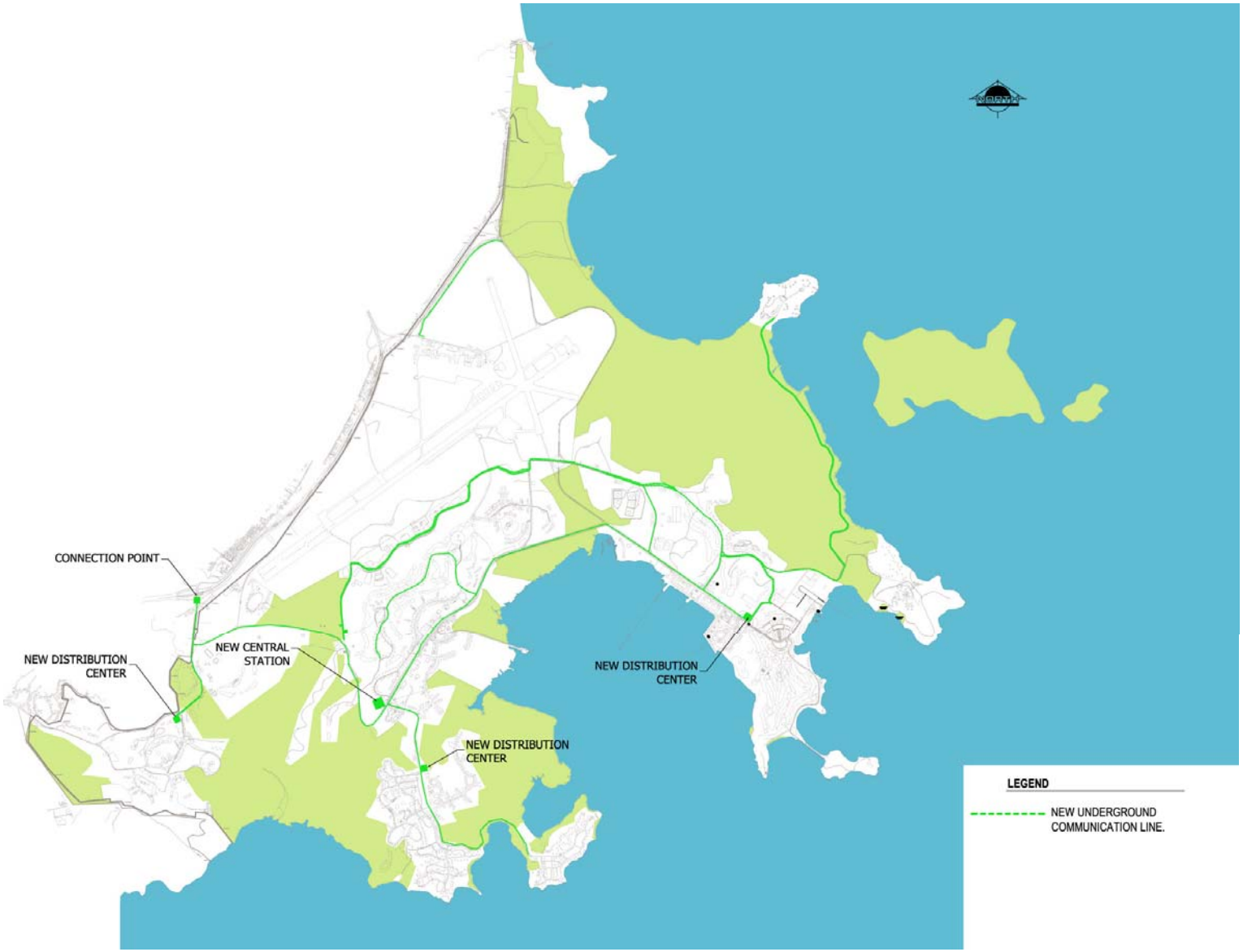


Figure 8: Proposed Telecom Distribution Map

up to the Main Central Building and then through different zones where new support facilities (approx.. 500 square meters parcel size) will be strategically located as per the need of zone's developments. With this infrastructure a fiber path redundancy is created to help ensure failure free operation in spite of fiber cuts.

The basic infrastructure consist of the preparation of the Main Central Building (approximately 1,000 square feet), underground conduits as per details in phase construction, telecommunication manholes, lot preparation for the support facilities and cession of right of way under the name of JRTPR. Any qualified telecommunication provider must use the JRTPR infrastructure to install their central equipment and cables to service the new developments.

Underground Pathways

Underground conduit structures are pathways used for placing telecommunications cable between access points such as maintenance holes (MHs), handholes (HHs), and building entrances. The number of ducts required in a proposed conduit addition or extension depends on the number of cables necessary to provide for the service being installed, expected growth, and maintenance. Cables required for growth may include facilities necessary to cutover and relieve an existing cable that is at maximum capacity. Do not attempt a detailed conduit or MH design until compiling and carefully considering all facts that might influence the final placement location. To allow ample time for preliminary plan changes, necessary investigations should be performed well in advance.
To make optimum use of the conduit structure for subsequent cable-placing operations, particular care should be given to the MH locations. A minimum number of horizontal and vertical directional changes should be allowed in the connecting duct structure. The ideal structure is essentially straight between MHs with a grade drop for water run off. The designer can ensure a structure's usefulness, regardless of reel location, by calculating the pulling tensions expected if the cable is pulled from either direction and if using the larger value for design purposes. Cable lengths should be considered when placing MHs. Additionally, it is important for the designer to recognize that bend locations and the geometry of each bend (horizontal and vertical) are important factors to be considered in the initial conduit design.

The designer designs the conduit system and specifies the types and quantities of material needed. A finished design should consist of construction plans showing the:

- Location of all existing and proposed conduit.
- Size and configuration of MHs.
- Total duct length (linear length times number of ducts) of conduit (adjacent MH wall-to-wall measurements).
- Type of conduit material.
- Special conduit fittings required.
- Conduit (ductbank) formation and depth requirements.
- Encasement specifications and materials.
- MH or cable entrances.
- Locations of any existing substructures.
- Restoration requirements.
- Required cuts (e.g., concrete, asphalt).
- Location and depth of other structures (profile).
- Traffic control plan.

When a main conduit run has two or more branches, it is possible for the total number of branch conduits (initial and estimated) to exceed the

number indicated for the main conduit run. This may be a result of using large cables in the main run as opposed to the smaller ones used in branch runs. Branch conduits may be conduits that connect to structures such as buildings, pedestals, cabinets, or poles. In the United States, branch conduits are commonly referred to as "lateral ducts" and "subsidiary ducts." Lateral ducts are typically placed from the side wall of a MH to the structure. Subsidiary ducts are extended from the end wall of a MH along with the main conduit run to feed a structure. This type of construction may be advantageous when the location of future buildings is known.

The designer must consider all facts pertinent to the route and exercise the best judgment in each case. Ducts must be large enough for a cable or cables to be pulled through the duct. As a rule of thumb, the diameter of a duct should be at least 1.15 times the diameter of the cable, or one-half trade size larger in diameter than the diameter of the largest anticipated cable (whichever provides the greater clearance). It is the diameter of the pulling eye that is more important. Cables are normally ordered from the cable manufacturer with the pulling eye installed. If not, a core hitch is provided by the onsite crews for pulling cable.

Maintenance Hole (MH) Locations

The safety of personnel, and the general public, is a primary concern when selecting MH locations. A desirable location will:

- Provide a safe work area (WA).
- Allow for adequate traffic control when the MH is open (e.g., the placing of traffic warning devices to alert motorists of upcoming construction).
- Provide sufficient space for cable trailers, pulling trucks, etc., during construction.
- Be suitable for placing, splicing, and maintenance of cables and associated equipment.
- Not jeopardize vehicular or pedestrian traffic flow.
- Be located out of the roadway (when possible).

MHs should not be located in or near an intersection or near the point where a curve occurs in a road. Protection of the WA at these locations is difficult.

Quantity/Location

The number of MHs built into a conduit run should be kept to a minimum. When planning MH locations, the designer should:

- Document MH locations on work drawings.
- Locate MHs at junction points that permit installation of main, branch, and lateral or subsidiary ducts with minimum bending.

Factors that may impact MH location include:

- Municipal, county, state, or federal restrictions.
- Surface water drainage into the MH.
- Public and worker safety (when MH is open).
- Future street widening.
- Provisions for cable placement.

Before installing/constructing a MH, the designer should investigate each proposed location to determine subsurface conditions and/or the existence of foreign pipes or ducts. If unable to determine subsurface conditions from the existing records and field observations, or there is doubt about subsurface conditions, the designer should request a test hole be dug. The test hole should be made diagonally across the proposed site and wide enough to ensure clearance for the MH. If foreign

pipes or substructures are encountered during test hole or MH excavations, immediately investigate their ownership. It is possible that these pipes and/or substructures may be removed if they are not in use and their owner(s) grant(s) permission. If the pipes and/or substructures cannot be removed, the designer must decide whether to change the MH's location or grade.

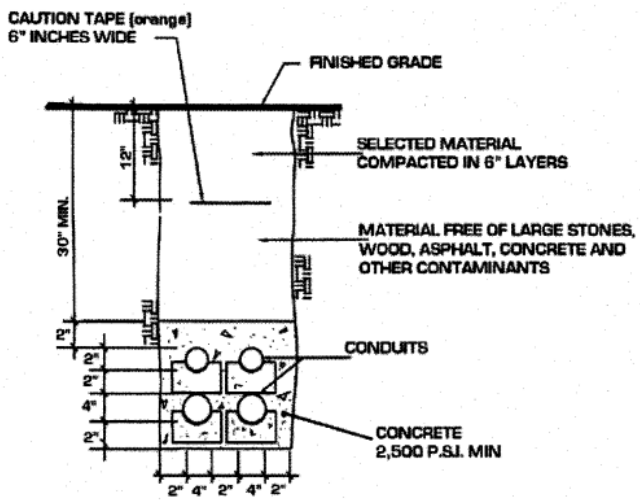
Clearances

The minimum recommended separations between telecommunications conduit systems and outside surfaces of foreign structures are:

- 75 mm (3 in) from electric light, power, or other conduits.
- 150 mm (6 in) when crossing pipes (e.g., gas, water, oil, etc.).
- 305 mm (12 in) when parallel to pipes (e.g., gas, water, oil, etc.).

For personnel safety and the protection of telecommunications equipment in the United States, the following clearances are required by the NESC:

Structure	Minimum Clearance
Power or other	75 mm (3 in) concrete foreign conduit
	102 mm (4 in) masonry
	305 mm (12 in) of well-tamped earth
Pipes	150 mm (6 in) when crossing
(gas, oil, water, etc.)	305 mm (12 in) when parallel
Power conduit terminated on poles	Separate poles, if possible. If same pole, preferably
	180 degree but not less than 90 degree



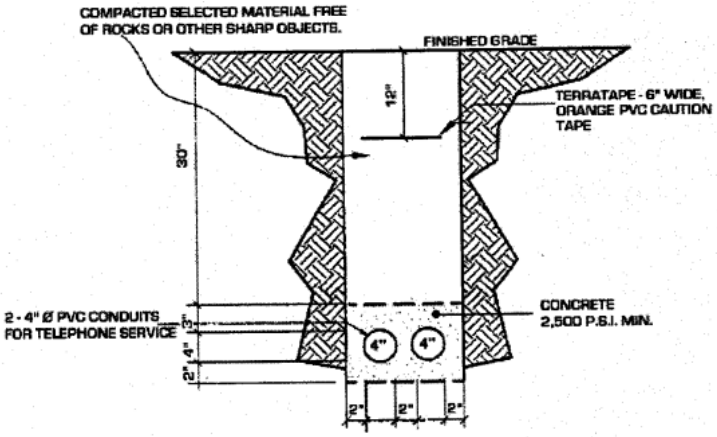
TELECOMUNICATIONS AND CABLE TELEVISION STREET CROSSING (TYPICAL)

Conduit Depth

It is the designer's responsibility to be aware of any unusual depth requirements that are established for subsurface structures. Installing conduit improperly can result in conduit deformations, sinking of the backfill, and subsequent collapse of the road surface. Conduit should be located at a sufficient depth (normally 610 to 762 mm [24 to 30 in]) below surface grade so the loads (live and dead) can be sustained by the conduit structure. Live loads have a greater effect on conduit than dead loads. Junta Reglamentadora de Telecomunicaciones de Puerto Rico (JRTPR) requires 30 inches. Following are typical trenches for JRTPR:

Conduit Formations

Design conduit formations to facilitate orderly cable racking within the MH and ensure minimal change in the formation when entering a MH. The following recommendations allow for the design of the most efficient



TELECOMUNICATIONS TRENCH AND STREET CROSSING (TYPICAL)

cable formation.

- Preferably, main conduit formations should enter the end walls of the MH at a point approximately halfway between the floor and roof.
- For wall racking considerations, design splayed ductbank entrances at the end walls rather than center placement.
- If the total number of conduits being placed is significantly less than the capacity of the terminating MH or cable entrance, conduits should enter at the lower level. The upper space should be reserved for future conduit additions.
- The conduit entrance into the MH should be sized for the ultimate number of conduits to prevent the need for future wall breakouts.

The following table lists recommended conduit formations for up to 40 conduits at the MH entrance. If more than 40 conduits are planned, special racking (center and wall) is recommended.

No. of Ducts	Using Conduit	Multiple Duct
4	2 wide by 2 high	One, 4-duct
6	3 wide by 2 high	One, 6-duct
8	4 wide by 2 high	Two, 4-duct
9	3 wide by 3 high	One, 9-duct
10 --		One, 6-duct and one, 4-duct
12	4 wide by 3 high	Two,6-duct or three, 4-duct
15 --		One, 9-duct and one, 6-duct
16	4 wide by 4 high	Four, 4-duct
18 --		Two, 9-duct

Designing Curved Conduit Sections

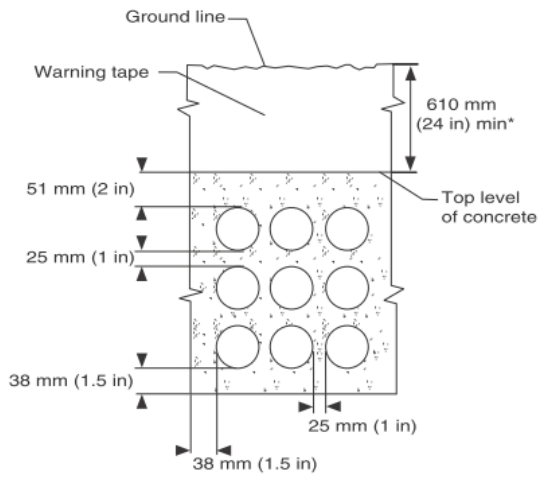
Curved section design allows conduit structure to be utilized effectively so that cable can be pulled with the least amount of tension. A curved section can be either a simple bend or an offset bend (also called a compound curve, reverse curve, double curve, or S curve). Because more tension is required to pull a cable through a curved section of duct than through a straight section of equal length, the total length will generally be reduced. The amount of reduction depends on:

- The number of bends.
- The displacement angle and radius curvature of each bend.
- Bend locations in the conduit section.

In designing curved sections, consider the following:

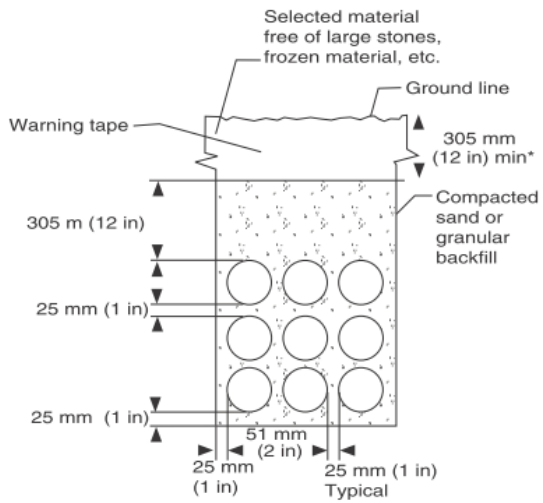
- Continuous lengths of straight individual plastic conduit can be formed into shallow curves (if a curvature radius of 12 m [40 ft] or more is used).
- Where the radius is less than 12 m (40 ft), 4.6 m (15.0 ft) radius manufactured bends must be used. If possible, the entire change in direction should be made with a single arc of 4.6 m (15.0 ft) radius.
- If using an individual conduit with a curvature radius of less than 24 m (80.0 ft), the duct must be encased in concrete. The encasement should result in 51 mm (2 in) of top cover, 25 mm (1 in) at the sides and beneath the structure.
- The arcs in an offset bend should be symmetrical.

Typical concrete-encased conduit structure



* 457 mm (18 in) permitted under driveways and sidewalks

Typical compacted fill conduit structure



* 152 mm (6 in) permitted under driveways and sidewalks

Calculating Volume of Backfill

The volume of concrete or granular backfill will vary with trench width and the degree of irregularity of the trench surface. Volumes given for each arrangement are for the minimum trench width consistent with the specified clearances. Volumes for sand or granular backfill should include an allowance for compaction. Concrete encasement will be required at bends using PVC conduit or where surface loads are in excess.

Trench Work

For all excavations deeper than 1.5 m (5.0 ft) in which a person must enter or work, Occupational Safety and Health Administration (OSHA) requires the walls be shored, sheeted, braced, or otherwise supported except when:

- Working in solid rock, hard shale, or hard slag.
- The side walls are cut to a slope of 305 mm (12 in) horizontally for each 610 mm (24 in) of rise.

Other safety precautions include:

- Shoring trenches less than 1.5 m (5.0 ft) deep if they present a hazardous work environment.
- Assigning an individual at the surface of an excavation to monitor persons working in the trench.

NOTE: The person must be in sight at all times.

Subsurface Space

The amount of subsurface space required for the conduit structure is dependent on the type, size, and number of ducts to be installed. Where sheeting or shoring is not required, the amount of required subsurface space is based on the width of the conduit formation plus the space needed for:

- Working.
- Backfill.
- Concrete encasing.

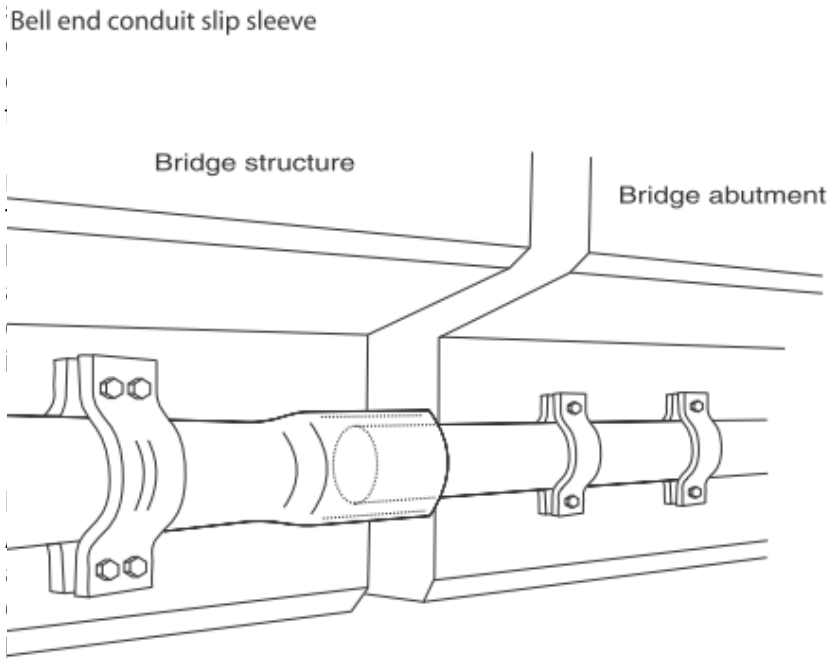
Conduit Design for Bridge Crossing

Whenever conduit must cross a bridge, always consult the AHJ regarding:

- Structural strength problems if the ducts are to be incorporated in the bridge structure.
- Obstruction of waterways if the ducts are to be attached under the bridge.
- Compensation for axial movement at each required expansion point.
- Slip sleeve requirements at a bridge abutment (see Figure 3.15) or a MH wall, if the MH is close to the bridge.

When conduit crosses a bridge, MHs built as termination points should be constructed close to the bridge ends in the approach fill. If, due to bridge length, this results in an excessively long section, it may be necessary to place pull boxes or specially designed splicing chambers of sufficient size to aid cable pulling and splicing along the span. Conduit supports are modular-type hangers designed to support and maintain the integrity of conduit systems on bridge crossings. Each bridge crossing must be individually designed to conform to local conditions and restraints imposed by the bridge site, design, and construction.

In the design phase, consult the AHJ to obtain rights-of-way and design information on load limits and expansion requirements. During temperature changes, exposed plastic conduit will change length in proportion to the magnitude of the temperature change. The conduit



procedures. MHs have multiple uses but are mainly used for underground or direct-buried plant splicing operations. They can be constructed of either concrete with steel access covers, or polyethylene with polyethylene access covers.

MHs provide accessible space in underground systems for:

- Placing and joining cables.
- Pulling cables.
- Splicing-in cable stubs.
- Load coil cases.
- Maintenance and operation equipment.
- Repeater cases (T-1, integrated services digital network [ISDN]).

MHs must be equipped with:

- A sump.

- Corrosion-resistant pulling irons.
- Cable racks (grounded per applicable electrical code or practice).
- Ladders (grounded per applicable electrical code or practice).

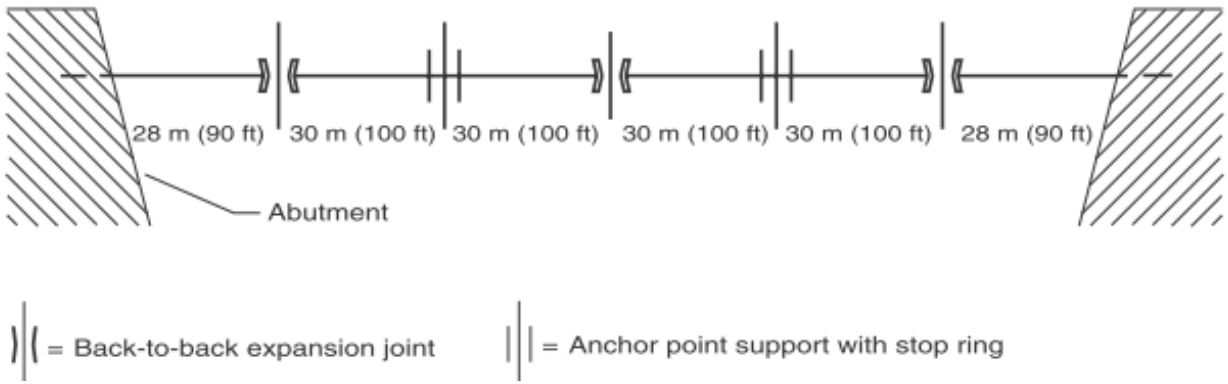
MHs should be constructed in such a way that they:

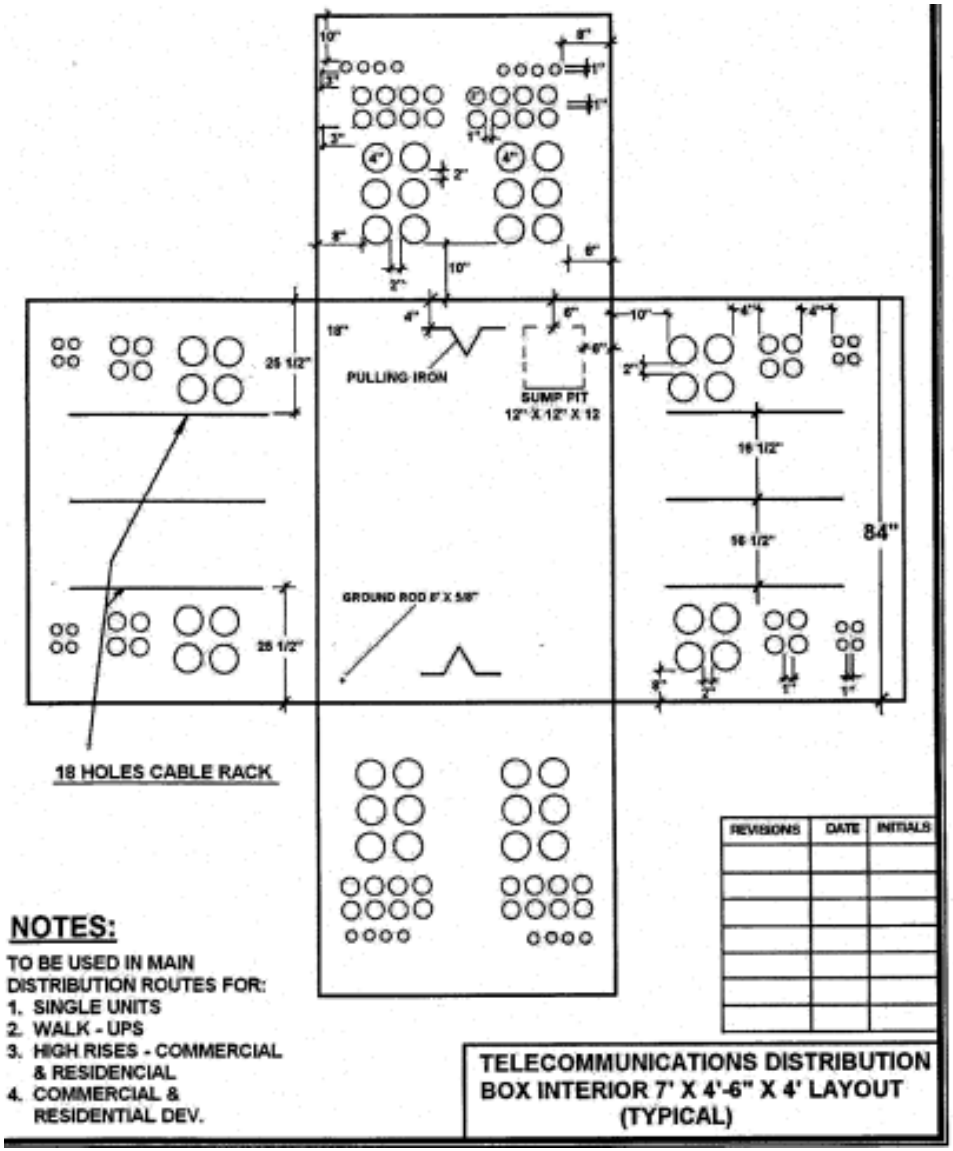
- Are capable of supporting the heaviest anticipated street traffic weight.
- Are reasonably waterproof.
- Provide sufficient racking space for the ultimate number of cables and other equipment that requires permanent anchorage.

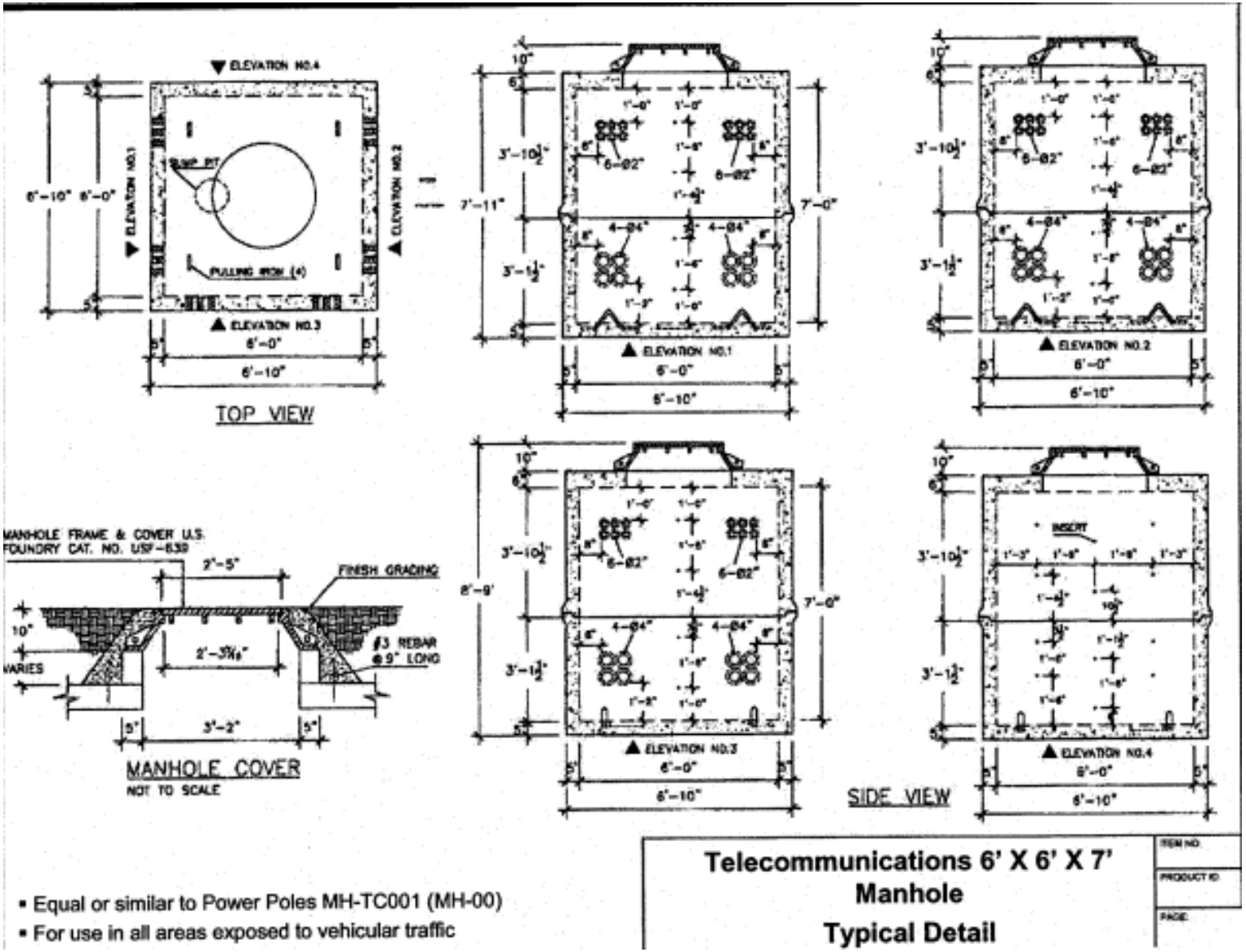
Except when needed to support telecommunications equipment, MHs should not be used as pathways for power and light conductors. For specific details, consult the NESC (or applicable safety code).

The JRTPR accepted Maintenance Manhole for this application the Master Plan is the 7' x 4'-6" x 4':

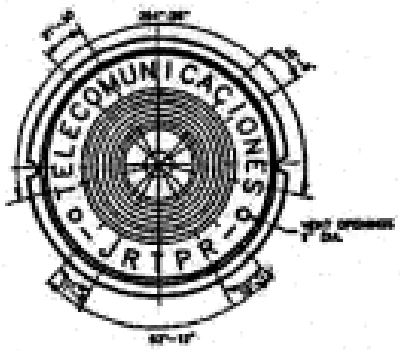
Figure 3.16: Expansion joints



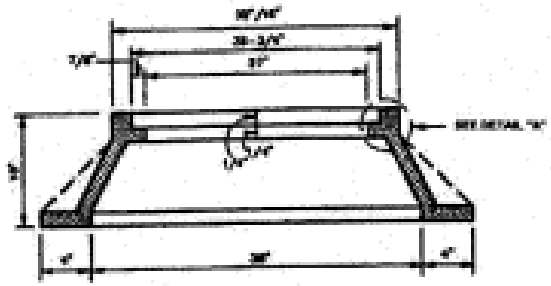

PULLING IRON
SUMP PIT
12" X 12" X 12
GROUND ROD 8' X 5/8"
25 1/2"
25 1/2"
19 1/2"
19 1/2"
84"
18 HOLES CABLE RACK
REVISIONS
DATE
INITIALS
NOTES:
TO BE USED IN MAIN DISTRIBUTION ROUTES FOR:
1. SINGLE UNITS
2. WALK - UPS
3. HIGH RISES - COMMERCIAL & RESIDENCIAL
4. COMMERCIAL & RESIDENTIAL DEV.
TELECOMMUNICATIONS DISTRIBUTION BOX INTERIOR 7' X 4'-6" X 4' LAYOUT (TYPICAL)



- Equal or similar to Power Poles MH-TC001 (MH-00)
- For use in all areas exposed to vehicular traffic

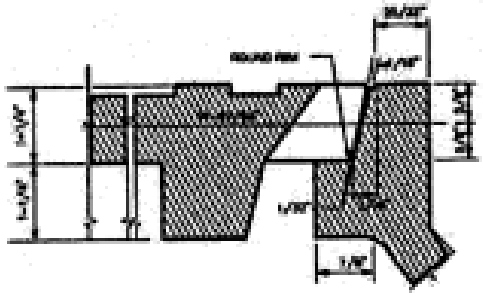


COVER TOP VIEW

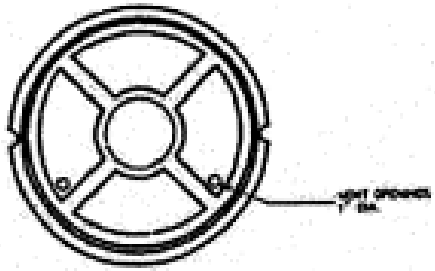


FRAME SIDE VIEW

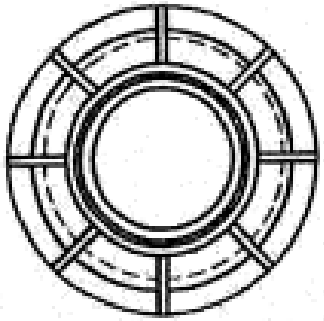
LETTERS DETAIL
(TYPICAL)



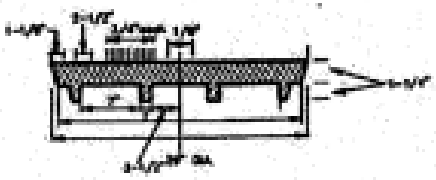
DETAIL A



COVER BOTTON VIEW



FRAME TOP VIEW



SECTION

REVISIONS	DATE	INITIALS	TELECOMMUNICATIONS MANHOLE FRAME & COVER DETAILS (TYPICAL)

Sealing Ducts

All ducts entering MH and building entrance point locations must be sealed to prevent the intrusion of liquids and gases into the MH or building. Universal duct plugs are available in a variety of sizes for use in unoccupied ducts. In those ducts where the cable has been installed, ducts can be sealed through the use of putty sealants, cementitious compounds, and hydraulic cement.

Openings, Covers, and Frames

Construct MH roof openings and necks (collars) so that they are large enough to accommodate the smallest, inside measurement of a standard MH cover frame. Collars may be constructed of brick; however, precast collars are more easily placed. If for any reason (e.g., change in grade) the vertical distance between the MH's ceiling and the street level exceeds 610 mm (24 in), use the 760 mm (30 in) frame to place permanent steps in the neck of the MH. If a MH has two or more openings, all of the openings should be the same size. At least one opening should be provided for MHs up to 3.7 m (12.0 ft) in length, two openings beyond 3.7 m (12.0 ft) in length, and three openings beyond 6 m (20 ft) in length. The number of MH openings is doubled for center-racked MH.

Select MH covers based on the environment where they are placed. For instance, a MH located beneath a traffic lane must have a cover capable of supporting the traffic's weight (e.g., type B, SB). For light loads such as grass areas, use type R.

For frames and covers, the 760 mm (30 in) size is recommended for all applications and should be specified for use with precast MHs. Although 686 mm (27 in) frames and covers are available, their use is not generally recommended. It is easier to get into and out of the 760 mm (30 in) size, especially with a blower or pump hose in the opening, and there is more room for placing apparatus into the maintenance hole.

Maintenance Hole (MH) Extension Rings

Use MH extension rings when pavement resurfacing operations necessitate the raising of MH covers. These are rings sized to mate with the existing frame and cover. They allow the opening to be raised to the new pavement level, thus allowing full access without creating a traffic hazard. Check local codes for the number limit of rings that can be used until collar or MH roof must be raised.

Handholes (HHs)

Handholes (HHs) are smaller than maintenance holes (MHs), but the covers provide full access to the entire space inside the hole. HHs are manufactured as concrete, polyethylene, or composite structures. They can be placed in the same areas that MHs are placed in. When planned for traffic areas, they must be traffic rated.

When HHs are used in an underground installation, they are used as pull-through points. HHs shall not be used as splice points. However, HHs are being used in direct-buried installations for:

- Optical fiber slack storage.
- Optical fiber splices.
- CATV splices.
- CATV taps.

HHs should:

- Facilitate cable placement.
- Have drainage provisions (e.g., drain holes, open bottom, sump-hole).
- Aid cable pulling when the bends exceed either two 90 degree bends or a total of 180 degrees, or the conduit section is so long it must be pulled in two segments.
- Meet applicable code requirements.

HHs should not be:

- Used in a main conduit system or in place of a MH.
- Larger than 1.2 m (4.0 ft) in length by 1.2 m (4.0 ft) in width by 1.2 m (4.0 ft) height.
- Used in runs of more than three, 103 mm (4 trade size) conduits.

- Shared with electrical installations other than those used for telecommunications.

Conduit entering a HH should be aligned on opposite walls at the same elevation. Some handholes are available without bottoms for drainage. When installed without bottoms, these HHs should be equipped with a 102 mm (4.0 in) layer of small rock in the bottom to prevent mud from intruding into the HH.

Resources:

- Customer-Owned Outside Plant Design Manual 2nd edition from BICSI 2001
- Reglamento para Endosos de Planos de Infraestructura y Servidumbre para Facilidades de Telecomunicaciones y Televisión por Cable. Num Reglamento Departamento de Estado 7393 del 6 de agosto de 2007.

3.1.5 Solid Waste Management

Without adequate planning rapid urbanization may lead to over-stressing of urban infrastructure services including the Municipal Solid Waste (MSW) Management. Sustainable Waste Management and appropriate Waste Management practices are essential in order to prevent urban waste from causing environmental pollution and health hazards. Therefore, developing, operating & maintaining a Solid Waste Management System is a main infrastructure component of the IDG.

Municipal solid waste (MSW) is generally defined as the wastes (other than sewage and air emissions) generated in and usually collected by a municipality. MSW is extremely variable in composition, depending on the income and lifestyle of the generators MSW includes household refuse, institutional wastes, street sweepings, commercial wastes, as well as construction and demolition debris. MSW may include paper and packaging materials; foodstuffs; vegetable matter such as yard debris; metal; rubber; textiles; and potentially hazardous materials such as batteries, electrical components, paint, bleach, and medicines. MSW may also contain varying amounts of industrial wastes from small industries, as well as dead animals and fecal matter.

The Solid Waste Management Guidelines for the FNSRR have been developed to ensure new developments in the FNSRR implement optimal waste management practices. The guidelines main focus is to promote environmental protection and protect public health, encourage best practice technologies, and ensure new developments are designed in an ecologically sustainable, consistent and practical manner with regard to solid waste management.

The guidelines address the management of solid waste from domestic and commercial premises, including general and recyclable waste. They apply to all new developments on the FNSRR and are for the use of everyone involved in the design and construction of new developments in the FNSRR, including architects, developers, engineers, consultants and builders.

The objectives of these guidelines are to:

- clearly outline the requirements for solid waste management for new developments within the FNSRR
- ensure the storage and service of solid waste in the re-development is undertaken in a manner to minimize risk to public health and the environment
- ensure new developments incorporate suitable provisions for the storage and service of solid waste appropriate and adequate to the type and volume generated
- ensure on-site storage of solid waste does not create a nuisance to occupants of the development or adjoining properties
- ensure solid waste can be safely collected with minimum disruption to traffic

- ensure recycling is provided in all new developments and encourage consideration of other waste minimization strategies
- encourage developments to incorporate best practice technologies and install waste infrastructure that is beyond the minimum requirement

Regulations

The Solid Waste Authority (ADS) is the government agency in Puerto Rico with the ministerial duty to establish and implement public policy concerning the technical, administrative and operational solid waste management. Their mission is to assess, plan and implement strategies for the sound management of solid waste in order to protect the environment, public health and conserve natural resources of Puerto Rico; in accordance with the duties and responsibilities assigned by the laws and regulations of Puerto Rico.

Solid Waste Management Systems implemented in the FNSRR should comply with federal regulations, state legislation regarding solid waste management and municipal solid waste management programs. These include, but are not limited to:

Federal Regulations:

- Resource Conservation and Recovery Act
- Clean Air Act
- Clean Water Act

State Regulations:

- Reglamento para la Reducción, Reutilización y el Reciclaje (2010 Edition), published by the ADS.

Other requirements are as follows:

- Be environmentally safe, economically viable and technologically integrated;
- Protect water resources, air and land, and does not compromise future use and availability;
- Encourage investment and employment within the public, private and community sectors.

General Requirements for All Developments

This section outlines the general waste management requirements and considerations for all new development in the FNSRR. Following this section find the specific requirements and options for each development type. Multiple sections may apply to a development, in which case the requirements of all relevant sections are applicable.

The following requirements apply to all developments:

- Storage capacity: Provide sufficient waste storage capacity to meet the needs of the development. All waste streams are required to be catered for, including general waste, recyclable waste and other development-specific waste types.

- Storage points: Provide storage points of sufficient size to accommodate the required number of bins. Multiple storage points may be required for a development. Storage points may also be used as the servicing point. Requirements for storage points differ depending on the type of development and type of bin to be used. Storage points proposed to store more than one type of bin must meet the design requirements for all bin types. Incorporate provisions for washing bins.

- Servicing points: Provide suitable provisions to allow bins to be serviced. Where a bin can be serviced from the storage point, the point must comply with the applicable design requirements for a storage point and a servicing point. Where a bin cannot be serviced from the storage point, a separate point must be provided where the bins can be moved for servicing. The servicing point must be of sufficient size to store the required number of bins requiring servicing. If more than one type of bin is to be serviced from a servicing point, the point must meet the requirements for each type of bin.

- Waste removal systems (chutes): Waste removal systems may be required for certain developments

- Vehicle Access: Adequate access and maneuvering requirements must be provided for the waste collection vehicle. Should the waste collection vehicle be required to enter the site to service the bins, the internal servicing roadways must comply with the design requirements

- User access: All storage or disposal points should be appropriately located and designed for convenient and safe access by all users.

Waste management must be considered at the design stage of a development. This is to make sure:

- sufficient waste storage capacity and appropriate waste facilities meet the needs of the development
- waste storage facilities are adequately designed to house the required waste bins
- facilities for recyclable waste are included
- there is sufficient space to allow a waste collection vehicle to service the waste bins and safely manoeuvre
- sufficient controls are incorporated to minimize the proliferation of pests, vermin and odour

Find the specific requirements and options for each development type:

Detached Dwellings

The most appropriate waste service for a detached dwelling development is wheelie bins. This is due to the volume of waste generated, adequate space at each dwelling to store and clean the bins, and the ease for residents to move bins for servicing. These are the different servicing point options for wheelie bins at detached dwellings:

- Wheelie bins stored at each detached dwelling and serviced on the curbside at the front property boundary of each dwelling
- Wheelie bins stored at each detached dwelling and serviced on the curbside at a common servicing point

Attached Dwellings and Medium Density Detached Dwellings

Waste management for attached dwellings and medium density detached dwellings is dependent on size, layout and vehicle access of the development. In all of the following options, consideration should be given to waste-carting and bin-carting distances, and the ease of moving containers around the site:

- Wheelie bins stored at each dwelling or a common storage point and serviced on the curbside.
- Wheelie bins stored at each dwelling and serviced in front of each dwelling on an internal servicing roadway.
- Wheelie bins stored at each dwelling or a common storage point and serviced from a common servicing point on an internal servicing roadway.
- Bulk bins stored at a storage point and serviced from a servicing point close to the property boundary (waste collection vehicle does not enter development)
- Bulk bins stored at a storage point and serviced from a servicing point on an internal servicing roadway.

Apartments

Waste management for apartments is dependent on the number of units, building stories, development layout and vehicle access in the development.

Developments with apartments above the third story must include a waste removal system (waste chute). Waste disposal points (hoppers) must be provided on each residential floor and the chute must discharge into bins in a waste storage room. Additional storage must be provided for recyclable waste, separate to the general waste chute. Options include a recycling waste chute, or recyclable bins in the waste storage room, an additional storage point or the waste disposal points.

The following outlines the possible waste management options for Apartments:

- Wheelie bins stored at a common storage point and serviced on the curbside at the front property boundary
- Wheelie bins stored at a common storage point and serviced from an internal servicing roadway
- Bulk bins stored at a storage point and serviced from a servicing point close to the property boundary (waste collection vehicle does not enter development).
- Bulk bins stored at a storage point and serviced from a servicing point on an internal servicing roadway.
- Ro-Ro bins (sealed and compacted) stored at a storage point and serviced from an internal servicing roadway. Smaller sized bins may be stored throughout the development and emptied into the Ro-Ro bin (main collection bin).

Commercial Premises

Waste management provisions for commercial developments must take into account general, recyclable and development-specific waste streams. Further to the waste management options outlined in this section, additional requirements for specific commercial development types have been identified.

- Wheelie bins stored at an individual tenancy or a common storage point and serviced on the curbside at the property boundary.
- Wheelie bins stored at an individual tenancy or a common storage point and serviced from an internal servicing roadway
- Bulk bins stored at a storage point and serviced from a servicing point close to the property boundary (waste collection vehicle does not enter development).
- Bulk bins stored at a storage point and serviced from a servicing point on an internal servicing roadway.
- Ro-Ro bins (sealed and compacted) stored at a storage point and serviced from an internal servicing roadway. Smaller sized bins may be stored throughout the development and emptied into the Ro-Ro bin.

Commercial Accommodation

Commercial accommodation refers to commercial development that includes a domestic or residential component, such as aged persons accommodation, community care centers, hostels, motels and resort hotels.

In addition to the general provisions outlined above, these developments may also require the following.

- For developments greater than three (3) stories, waste removal systems (Waste chute, waste disposal point, waste storage room, recyclable storage) must be provided.
- For developments with a commercial kitchen, additional storage (for waste cooking oil) may be required. Food premises include restaurants, cafés, fast food premises, nightclubs, take-away food premises and taverns. For developments where a large number of recyclables such as bottles, cans or cardboard are generated, additional recyclable storage must be provided.
- For developments where clinical or medical waste is generated, developments that generate clinical or related waste, including hospitals, medical centers and veterinary clinics please reference the Environmental Protection Agency (EPA) in the relevant industry-sector. The storage of clinical or related waste should be considered at the design stage, to ensure the development can comply with these provisions.

In addition to provisions for general and recycling waste required for all commercial operators of commercial and industrial developments that generate regulated waste must:

- maintain all documentation relating to ‘trackable waste’
- store those wastes in a manner which minimizes risk to the environment and human health
- ensure the collection of regulated wastes is by a licensed contractor
- ensure the disposal of regulated wastes is at a disposal facility licensed to receive such waste

Mixed Use

Mixed Use developments must comply with the respective requirements for the residential and commercial components of the development. Where the residential component of a mixed use development is above the third story, a waste removal system for the residential component must be provided. All mixed use developments must provide a Waste Management Plan in their development application.

It is recommended the storage and servicing of domestic and commercial waste streams are kept separate. While combined storage is permitted under the same body corporate, the servicing of the residential waste will be charged at the commercial rate.

Waste Collection and Transport

Recommended management strategies to minimize litter and clandestine dumping include:

- Encourage use of containers or bags for waste at the point of collection for each household and establishment;
- Implement a regular collection schedule with sufficient frequency to avoid accumulation of garbage;
- Use vehicles appropriate for the geographic conditions and waste types to maximize reliability of collection (e.g., compactor trucks may be appropriate for neighborhoods with wide streets and low-density trash, while smaller vehicles may be appropriate for neighborhoods with narrow streets and higher-density garbage);
- Encourage separation of recyclable materials at the point of generation, so that the collection points do not become sorting points for informal sector waste pickers;
- Cover collection and transfer vehicles along the entire route of transport to avoid windblown litter;
- Clean vehicles used for waste hauling before transportation of any goods, including compost;
- Encourage residents to put waste out at designated times and locations;

Where possible, blocking off access to dumping sites and fining illegal dumpers

Waste Management Plan (WMP)

New development proposals must include a Waste Management Plan (WMP) which outlines the proposed waste management provisions included within the development to ensure the adequate management of waste during the operational phase of the new development. The proposed development and waste management plan should comply with the requirements of this guideline. A plan should include the information outlined below:

- access routes
- truck turning movements
- loading facilities waste storage facilities size and number of garbage, recycling and organics containers to be used diversion method

- number of dwelling units in the development/total ground floor area/number of stories
- the required facilities which allow for municipal collection of waste materials. If the facilities cannot, as determined by the Developer and the General Manager, be provided, the requirements will be listed in the legal documentation concerning the development and notice shall be given to all future owners of the need to provide and maintain private collection services until such requirements are met.

Education and Signage

On-going education and signage is important to ensure people continue to use the facilities as originally intended. This is particularly relevant in tourist accommodation, where people may be unfamiliar with the waste management arrangements in the development. It is recommended that signage be installed at disposal/storage points to promote the importance of recycling and the appropriate waste types for each facility or bin. Education or signage could include:

- a one-page addition to the room directory in tourist accommodation explaining the waste management arrangements
- labelling all bins or waste disposal points (hoppers)
- instructions advising of the correct separation of general, recycling and other waste streams
- identification of potential hazards/dangers associated with using waste equipment
- signage with contact details for information on waste management in the development

Waste Management Plan Sections	Details
Introduction	Briefly describe: the development Project, purpose of the plan, structure and scope of the plan, objectives to be achieved
Definitions/references	List of references and definitions of any specific terms and acronyms.
Waste generation	Detail the scale of the development, including number of dwellings and the commercial floor area for each tenancy. List the types of waste streams likely to be generated. Provide an estimate of the volumes of waste material generated
Waste storage	Type, size and number of bins proposed at each storage point. Location, design and size of proposed storage point/s. Details and location of waste removal systems (chutes), where applicable. Storage provisions for development-specific waste types.
Waste collection/servicing	Location, design and size of servicing point/s. Nominated collection frequency for each waste type. Allocation of responsibility for waste management. Details of bin-carting and waste-carting routes and distances. Details specifying sufficient access, egress and clearance for waste collection vehicles.
Plans/figures	Adequate plans and figures to support the report and demonstrate the adequacy of the waste management provisions included in the development.

3.2 Urban Infrastructure

3.2.1 Streetscape

Road Network

The objectives of the Design of Roads requirements are as follows:

• To develop a network and alignment that balances the existing and future requirements;

• To provide a serviceable pavement for the specified lifetime with minimal maintenance;

• To ensure that staged construction methods are planned to meet the immediate, medium term and ultimate pavement and drainage design requirements;

• To provide smooth, safe, trafficable horizontal and vertical alignments, adequate sight distance with consideration being given to road classification requirements, road users and utilities.

General

Road Design shall be based on sound engineering practice following the general principles of DTOP in addition to criteria outlined within this manual. Road design plans shall be prepared in accordance with Appendix A.

Materials: Pavement

Undertake a comprehensive regime of planning, budgeting, construction, maintenance, and monitoring strategies to maximize pavement lifecycle. Develop a pavement management system to ensure that the entire roadway system is performing as well as possible at all times. Coordinate pavement management system with other citywide infrastructure planning processes to reduce disruption and coordinate construction work, redouble the value of infrastructure investments, and minimize unanticipated future work that would lead to pavement degradation.

A pavement management system is a comprehensive strategy and integrated process for operating and maintaining a city's entire roadway system. A pavement management system oversees a comprehensive regime of planning, construction, operation, maintenance and monitoring activities, including preventative
maintenance, corrective maintenance, holding maintenance, emergency maintenance, condition assessment, lifecycle cost analysis, and so on. A pavement management system is extremely beneficial because it allows stakeholders to understand and track the relationship between municipal pavement investment and
the resulting level of service. This understanding will help to optimize infrastructure investments, improve operational and maintenance techniques, and ensure long term performance of the roadway system. For best results, coordinate the pavement management system with other infrastructure planning processes, including streetscape improvement planning, utility infrastructure planning, stormwater management planning, and landscape planning

Some of the benefits include:

- Improves the durability, performance, and lifecycle of pavements.
- Decreases construction work and costs, and energy and material inputs.
- Reduces impact of construction on the environment and community.
- Optimizes the effectiveness and value of public investments in infrastructure.
- Comprehensive planning helps to minimize unanticipated future work that could lead to pavement degradation.

Technical Strategies

Develop a pavement management system to coordinate all pavement planning, construction, operations and maintenance activities. The pavement management system should encompass the following activities:

- Regular investigation of roads.
- Condition assessment and prediction of future performance.
- Selection of maintenance and rehabilitation techniques.
- Prioritization of critical maintenance and rehabilitation projects.
- Adequate budgeting for planning, design, construction, and maintenance.
- Design and construction.
- Ongoing monitoring.
- Preventative maintenance.

Develop and maintain a central database to track and integrate the following information:

- Road conditions.
- Complaints.
- Accidents.
- Community board requests.
- Maintenance needs.
- Inspection reports and evaluations.
- Condition assessments.
- Utility cut data.
- Maintenance and rehabilitation performed.

Coordinate pavement management system with other infrastructure planning processes:

- Streetscape improvement planning.
- Utility infrastructure planning and coordination.
- Integrated stormwater management planning.
- Landscape planning.

Anticipate future utility infrastructure needs and plan accordingly to minimize future pavement disturbance and to reduce long-term costs:

- Consider installing laterals and additional conduit to minimize future impact and long-term costs.
- Provide the regulatory and financial mechanisms to facilitate this process.
- Coordinate with private utilities.

Practice pavement lifecycle cost analysis:

- Identify the best value – i.e. the lowest long-term

- cost that satisfies the objective being sought – for investment expenditures. Lifecycle cost analysis accounts for environmental and social impacts and evaluates the overall long-term economic efficiency of competing alternative investment options.

Conduct routine pavement condition assessment.

- Coordinate data with utility condition assessment information.

Standardize pavement design, maintenance, and assessment methods:

- Ensure that all pavement stakeholders, including transportation agencies, private utility companies, design engineers and construction managers adhere to the same standards.
- Undertake research and development to take advantage of best available technology.

Plan and implement a preventative maintenance program:

- Preventative maintenance is a'systematic and proactive' strategy in which cost-effective treatments are made to an existing roadway system 'to preserve the system, retard future deterioration, and
- maintain or improve the functional conditions of the system.
- The goal of preventative maintenance is to maintain pavements in good condition prior to the development of structural damage, thereby slowing the rate of deterioration and extending the lifecycle of the pavement.
- Develop a preventative maintenance plan and schedule as part of the planning and design of new roads or major reconstruction.
- Integrate preventative maintenance programs with pavement condition assessment systems.
- Establish a long-term source of dedicated funding for preventative maintenance.

Optimize corrective maintenance techniques:

- Equip maintenance crews with non-destructive testing and sensing devices to locate and analyze problems promptly.
- Use mobile asphalt hole repair units capable of treating spot repairs with minimum disturbance to traffic.
- Improve restoration of utility cut trenches.
- Use trenchless technologies.
- Ensure quick response times for sending maintenance teams out to service roads.
- Consider using an overlay to extend pavement lifecycle.
- Consider employing crack sealing to prevent water infiltration.
- Consider employing rubblization – i.e. breaking down concrete into pieces and overlaying hot mix asphalt (HMA) – to rehabilitate deteriorated Portland cement concrete (PCC) pavement.
- Utilize grouting with fly ash.
- Use recycled and reclaimed materials where possible and beneficial.

Optimize additional maintenance activities:

- Emergency maintenance treatments: actions performed during or immediately following an emergency situation.
- Holding maintenance treatments: actions to prolong use of the pavement until more substantial rehabilitation takes place.
- Pavement rehabilitation treatments: periodic actions to restore initial pavement serviceability through resurfacing, overlay, etc.
- Reconstruction: removing all surface layer materials, improving base and sub-base materials as necessary, and applying a new surface.

Use pavement management system to optimize infrastructure capital investments.

Minimize Impervious Pavement Area

Reduce impervious pavement area, where appropriate, to decrease stormwater runoff and water pollution, reduce combined sewer overflows (CSOs), decrease urban heat island effect, and improve pedestrian safety.

Technical Strategies include:

Site evaluation:

- Research site history, conduct traffic counts and accident analysis.
- Determine if road geometry is oversized or is a factor in traffic accidents.
- Consider lowering design speeds or level of service, and implementing traffic calming.
- Analyze opportunities for pavement reduction.
- Consider pedestrian criteria and streetscape amenities.
- Coordinate with area-wide bikeway initiatives.
- Coordinate with efforts to improve operation of surface mass transit.
- Discuss strategies with community board and fire department.

Develop an overall right-of-way geometry:

- Pedestrian design and traffic calming objectives.
- Bicycle planning objectives.
- Surface mass-transit operation objectives.
- Improvements to right-of-way public space, green areas, or streetscape amenities.
- Stormwater management best practices.

Reduce right-of-way impervious pavement area, where appropriate:

- Reduce vehicle lane widths, where appropriate.
- Reduce quantity of lanes, where appropriate.
- Use turning lanes and shoulders only where necessary.
- Minimize street turning radii.
- Reduce ROW parking area, where appropriate.
- Implement traffic calming measures that reduce impervious pavement.
- Increase landscaped areas by adding medians, planting strips, etc.
- Redesign impervious medians and other features with landscaping.
- Consider changes to sidewalks to reduce impervious pavement.
- Minimize the extent of unbroken expanses of impervious pavement.
- Increase landscaping within full-width sidewalk areas.
- Use pervious pavements.

Reduce impervious pavement in parking lots by up to 30% through the following changes:

- Substitute compact cars parking stalls for 30% of all spaces.
- Share parking between businesses with different peak parking demand schedules.
- Use the smallest allowable dimensions for regular parking stalls.
- Base parking lot design on average parking needs rather than peak parking needs.
- Consider using pervious pavements, especially in overflow parking areas.

Streetscape

The objective of the design guidelines for the development of the Streetscape is to design streetscapes that are conducive to walking and that optimally balance the needs of pedestrians, bicyclists, mass-transit users and automobiles. Undertake physical improvements and management measures to improve quality of life, health and safety, accessibility, connectivity, comfort, amenity and aesthetics. General guidelines include:

Evaluate pedestrian and vehicular movement:

- Evaluate future pedestrian volumes and movement.
- Evaluate future vehicular activity, conduct traffic counts, and determine needs for traffic calming or traffic management.
- Evaluate future bicycle and non-motorized vehicle traffic. Determine need for streetscape improvements to encourage active transportation.
- Anticipate future pedestrian volumes and determine appropriate level of service.
- Consider increasing pedestrian level of service, comfort and protection.
- Consider reducing automobile level of service or design speed.

Develop a master plan that incorporates some or all of the following practices:

- Area wide traffic management and traffic calming.
- Bicycling facilities.
- Surface mass transit improvements.
- Public space, street furniture and green areas.
- Security enhancements.
- Street lighting and signaling.

Sidewalks

Enhance sidewalk accessibility, continuity and connectivity:

- Plan sidewalk dimensions and layout on a district-wide scale.
- Develop a strong pedestrian orientation and character to the streetscape to encourage walking and active environments.
- Promote connectivity, continuity and accessibility.
- Provide adequately sized sidewalks:
- Determine the width of the 'through pedestrian zone', or the area that accommodates unobstructed movement between a 'furnishing zone' (the area adjacent to the street containing street furniture, trees and landscaping, light poles, signage, etc) and a 'frontage zone' (the area adjacent to storefronts that Consider traffic management measures including street direction changes, street closings, modified signal times, etc.

Signalization

Consider signalization changes to increase pedestrian safety and travel efficiency:

Evaluate existing signal timing and pedestrian level of service.

Determine if signalization changes would be beneficial and feasible.

Consider extending pedestrian crossing intervals.

Consider adjusting signal progression to calm traffic during high-pedestrian volume periods and to minimize congestion during vehicle rush hour.

Consider utilizing leading pedestrian intervals (LPI) to give pedestrians a head start in crossing prior to allowing motorists to turn.

Consider utilizing 'Barnes Dance' (all-walk phases) at high pedestrian intersections to stop all vehicles on all approaches while allowing pedestrians to cross in all directions.

Consider utilizing pedestrian detection signals – infrared systems or 'pedestrian user friendly intelligent crossing' (PUFFIN) systems – to delay signal change until remaining pedestrians clear the intersection.

Consider using audible signals to indicate crossing intervals at major intersections.
Consider using countdown signals to indicate crossing time to pedestrians.

Improve visibility and legibility of signals:
Consider increasing the size of the red signal heads (to 12 inch maximum) to improve visibility and to emphasize traffic control.
Use symbolic pedestrian walking signals instead of message-type pedestrian walking signals.

Signage

Improve signage to enhance traffic safety:

- Survey existing signage, examine accident reports, and interview community members to determine needs and goals for improved signage.
- At critical crossing areas with high pedestrian volumes or histories of accidents, utilize fluorescent signs and post reflectors to caution motorists.
- Use oversized street name signs to help orient motorists and prevent erratic driving.
- Place speed-limit signs in areas with high pedestrian volumes.

Develop wayfinding or interpretive signage:

- Use a distinct system of signage to provide useful information in urban areas for
- pedestrians, bicyclists, and vehicles. Wayfinding signage helps encourage sense of
- place and efficient pedestrian and vehicular movement.
- Provide information about major destinations, including places of cultural, historic, and geographic importance, and preferred pedestrian streets.
- Distinguish between wayfinding systems for tourists and systems for locals.
- Maintain graphic or symbolic continuity throughout wayfinding area.
- Develop innovative ways to express historic or cultural heritage.
- Imaginatively use materials, landscaping, or architectural elements to evoke understanding of a place without adding to street clutter.

Street Lighting

The objective is to achieve the most energy efficient streetlighting and signaling while maintaining a safe, uniformly lighted, and aesthetically pleasing nighttime environment.

The nighttime environment has the potential for high contrast lighting and glare due to multiple man-made light sources under the dark sky vault. Accordingly, specific lighting quality issues must be taken into account:

- Nighttime visibility, peripheral detection, adaptation.
- Security, safety, shadows, facial recognition, uniformity.
- Color appearance and contrast.
- ‘Light trespass’ is unwanted light from an adjacent source, which causes spill and glare. Light trespass causes annoyance and discomfort and may become a safety concern by impairing nighttime visibility.
- ‘Light pollution’ is a reduction in sky magnitude, or the relative visibility of the stars or darkness of the sky. It is caused by the direct loss of light up into the atmosphere and also reflected light off the earth or other surfaces.

Energy

Globally, 8% of lighting energy use is devoted to street and other exterior lighting. In terms of energy expended, street lighting has considerably less impact than lighting in the residential, service, and industrial sector.

However, it is estimated that 15 TWh are used annually for street lighting in the United States, which in itself is considerable.
Diminishing fossil fuel resources, air pollution from power plants, and the increasing cost of energy make increasing energy efficiency in streetlighting a high priority.

Materials

The embodied energy of streetlighting and signaling fixtures can be minimized by using recycled materials in poles and appurtenances, which are typically aluminum or steel. Additionally, hazardous wastes such as lead, mercury and other chemical compounds should be eliminated from lamps and ballasts.

Retrofit of Existing Fixtures

Re-lamp existing luminaries to reduce light trespass, provide more even illumination, and improve energy efficiency and sustainability:

- Attempt to reduce light trespass and pollution without increasing light fixture numbers or decreasing light levels on the ground.
- Use highest-cutoff fixtures possible while still meeting photometric requirements.
- Use flat lens lamps.
- Reduce luminance ratios to provide more even illumination.
- Install shielding devices.
- To reduce the amount of kilowatt-hours consumed, re-lamp with lamps that have high relative efficacies, and re-install luminaires with high relative efficiencies.
- Select lamps with long rated lamp life.
- Clean luminaires regularly to maintain greater efficiency.
- Replace electromagnetic ballasts with electronic ballasting, where applicable, to achieve improved lifetime lamp performance.
- Re-lamp with reduced or no-mercury lamps to minimize environmental impacts associated with disposal of hazardous material.

Installation of New Lighting Fixtures

Prevent light trespass and improve ground-level illumination:

- Consider the use of full-cutoff fixtures. If necessary – and if energy consumption is not increased – install new poles at a closer spacing to meet photometric requirements.
- Use flat-lens lamps to reduce glare.

Optimize energy performance:

To reduce the amount of kilowatt-hours consumed, select lamps with high relative efficacies, and select luminaires with high relative efficiencies and long rated lamp life.

- Select lamps with high average lamp life.
- Use electronic ballasts.
- Minimize luminaire dirt depreciation (LDD) by properly sealing and gasketing fixtures to prevent the ingress of dirt, water, and other foreign objects. Select luminaires that can be easily cleaned.
- Consider the synergy between light colored, high albedo pavement and improved light reflectance from street lights, in order to optimize energy performance.

Consider employing emerging lighting technologies:

- Consider induction lighting (60-75 lm/W, with up to 100,000 hours of life).
- Consider light-emitting diodes (LEDs) for signaling and streetlighting (see examples) Consider fluorescent lighting, which provides better color rendition and visual acuity.
- Explore possibility of installing sensors that would send a signal to a central location when the light is out to reduce maintenance costs.
- Use photocells to ensure streetlights operate only when daylight or ambient light is insufficient.
- To reduce demand on the central grid and increase emergency preparedness, consider installing photovoltaic panels on a portion of

street lighting and consider using distributed generation energy sources.

Use environmentally preferable materials and resources:

- Use a high percentage of recycled-content materials in support structures.
- Reuse materials and components where possible.
- Use low-emitting (low VOC) paints and primers on poles and appurtenances.
- Use local materials to reduce embodied energy.
- Repair and reuse damaged poles. Re-galvanize if necessary.
- Recycle unusable, damaged poles and other materials.
- Enforce proper handling and safe disposal of lamps, ballasts, and other lighting elements containing hazardous materials

3.2.2 Bike Ways

The purpose of this section is to promote bicycle transportation and to offer substantive guidance for the inclusion of bike ways in the new developments planned for the FNSRR, to help create complete streets that are safe and enjoyable for bicyclists.

A Bike Lane is defined as a portion of the roadway that has been designated by striping, signage, and pavement markings for the preferential or exclusive use of bicyclists.

Bike lanes enable bicyclists to ride at their preferred speed without interference from prevailing traffic conditions and facilitate predictable behavior and movements between bicyclists and motorists. A bike lane is distinguished from a cycle track in that it has no physical barrier (bollards, medians, raised curbs, etc.) that restricts the encroachment of motorized traffic. Conventional bike lanes run curbside when no parking is present, adjacent to parked cars on the right-hand side of the street or on the left-hand side of the street in specific situations. Bike lanes typically run in the same direction of traffic, though they may be configured in the contra-flow direction on low-traffic corridors necessary for the connectivity of a particular bicycle route.

The configuration of a bike lane requires a thorough consideration of existing traffic levels and behaviors, adequate safety buffers to protect bicyclists from parked and moving vehicles, and enforcement to prohibit motorized vehicle encroachment and double-parking. Bike Lanes may be distinguished using color, lane markings, signage, and intersection treatments.

Required Elements:

- The desirable bike lane width adjacent to a curbface is 6 feet. The desirable ridable surface adjacent to a street edge or longitudinal joint is 4 feet, witha minimum width of 3 feet. In cities where illegal parking in bike lanes is an concern, 5 foot wide bike lanes may be preferred.
- When placed adjacent to a parking lane, the desirable reach from the curb face to the edge of the bike lane (including the parking lane, bike lane, and optional buffer between them) is 14.5 feet; the absolute minimum reach is 12 feet. A bike lane next to a parking lane shall be at least 5 feet wide, unless there is a marked buffer between them. In cities where illegal parking in bike lanes is an concern, 5 feet wide bike lanes are preferred.
- The desirable bike lane width adjacent to a guardrail or other physical barrier is 2 feet wider than otherwise in order to provide a minimum shy distance from the barrier.

- Bicycle lane word and/or symbol and arrow markings shall be used to define the bike lane and designate that portion of the street for preferential use by bicyclists.
- Bike lane word, symbol, and/or arrow markings shall be placed outside of the motor vehicle tread path at intersections, driveways, and merging areas in order to minimize wear from the motor vehicle path.
- A solid white lane line marking shall be used to separate motor vehicle travel lanes from the bike lane. Most jurisdictions use a 6 to 8 inch line.
- A through bike lane shall not be positioned to the right of a right turn only lane or to the left of a left turn only lane. A bike lane may be positioned to the right of a right turn only lane if split-phase signal timing is used.
- Bike lanes should be made wider than minimum widths wherever possible to provide space for bicyclists to ride side-by-side and in comfort. Reduce bike lane width only after other street elements (e.g., travel lanes, medians, median offsets) have been reduced to their minimum dimensions. If sufficient space exists to exceed desirable widths, see buffered bike lanes. Very wide bike lanes may encourage illegal parking or motor vehicle use of the bike lane.
- When placed adjacent to parking, a solid white line marking of 4 inch width should be used between the parking lane and the bike lane to minimize encroachment of parked cars into the bike lane.
- Gutter seams, drainage inlets, and utility covers should be flush with the ground and oriented to prevent conflicts with bicycle tires.
- If sufficient space exists, separation should be provided between bike lane striping and parking boundary markings to reduce door zone conflicts. Providing a wide parking lane may offer similar benefits
- Lane striping should be dashed through high traffic merging areas.
- The desirable dimensions should be used unless other street elements (e.g., travel lanes, medians, median offsets) have been reduced to their minimum dimensions.
-

"Bike lane" signs should be located prior to the beginning of a marked bike lane to designate that portion of the street for preferential use by bicyclists.
-

On bike lanes adjacent to a curb, "No Parking" signs should be used to discourage parking within the bike lane.
- Color may be used to enhance visibility of a bike lane.

Maintenance

- Lane lines and stencil markings should be maintained to clear and legible standards.
- Bike lanes should be maintained to be free of potholes, broken glass, and other debris.
- Utility cuts should be back-filled to the same degree of smoothness as the original surface. Take care not to leave

ridges or other surface irregularities in the area where bicyclists ride.

- If chip sealing, consider providing new surfacing only to the edge of the bike lane. This results in a smoother surface for bicyclists with less debris. Sweep bike lanes clear of loose chip in the weeks following chip sealing.
- If trenching is to be done in the bike lane, the entire bike lane should be trenched so that there is not an uneven surface or longitudinal joints.

Bike Route Wayfinding

A bicycle wayfinding system consists of comprehensive signing and/or pavement markings to guide bicyclists to their destinations along preferred bicycle routes. Signs are typically placed at decision points along bicycle routes – typically at the intersection of two or more bikeways and at other key locations leading to and along bicycle routes.

Types of Signs

There are three general types of wayfinding signs:

Berkeley, CA

Chicago, IL

Oakland, CA

Signage Indicates bicyclists that they are on a designated bikeway. Make motorists aware of the bicycle route. They can include destinations and distance/time. They should be placed every ¼ to ½ mile on off-street facilities and every 2 to 3 blocks along bicycle facilities, unless another type of sign is used (e.g., within 150 ft of a turn or decision sign). Should be placed soon after turns to confirm destination(s). Pavement markings can also act as confirmation that a bicyclist is on a preferred route.

Route Types

The guidelines have identified three route categories for the FNSRR:

- Route A - Utilitarian Routes
  Connections between basic destinations or activities, daily use. The objective of these routes is to provide an alternative mode of transportation –commute- to everyday activities. Route A bike ways connect the following uses:
  - Schools
  - Work Centers
  - Institutions (Government and Civic)
  - Commercial Facilities
  - Entertainment Facilities
  - Sport Facilities
  - Inter-Nodal Hubs

- Route B - Recreational Routes
  Connections between recreational uses or scenic and nature destinations. The objective of these routes is to connect significant destinations: sport facilities, nature-oriented destinations, etc. There are two types of recreational routes:

  Low-Activity Route B (family oriented, recreational use) bike ways connect the following uses:

  - Beaches
  - Scenic Spots

- Scenic Trials
- Natural Forest
- Recreational Sport Facilities
- Recreational Civic Facilities
- Recreational Commercial Facilities

High-Activity Route B (sports oriented, mountain bike trails) bike ways connect the following uses:

- Special Open Natural Trails
- Remote Wild Nature Locations

For safety reasons this Routes should be separated and properly identified by signage.

- Route C - Combined-Shared Routes
  Combination of the above categories.

See Figure 9 for Bike Way Route locations.

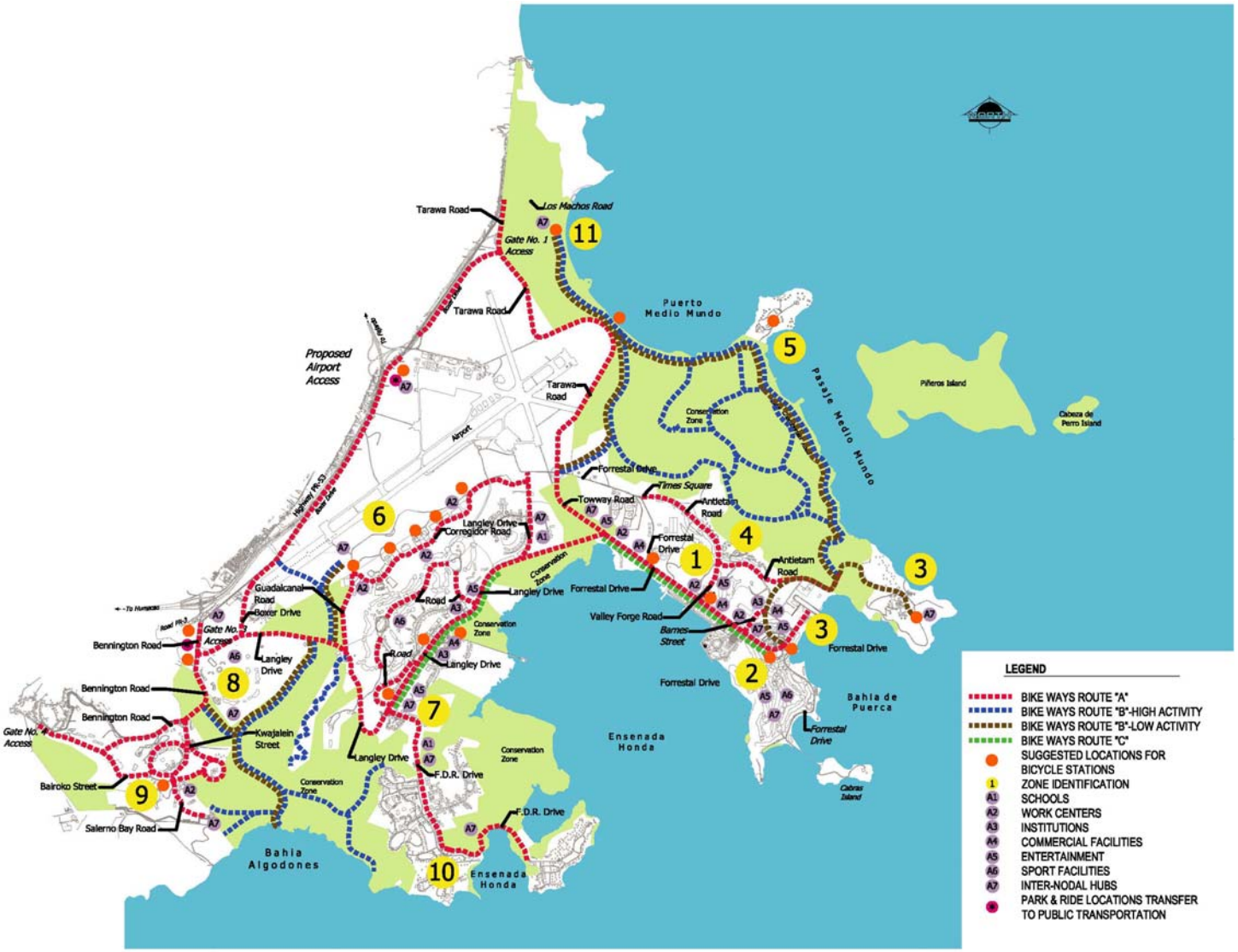


Figure 9: Bike Way Routes

3.2.3 Landscape

General considerations for landscape improvements include, to the extent possible, the conservation the existing vegetation through the development of a plan for protecting existing plant material to preserve habitat. This will minimize site disturbance, reduce capital costs for reinstallation of new plants, determine opportunities for transplanting existing planting material and eliminate invasive species to minimize long-term maintenance costs and protect preferred planting material.

In order to accomplish this the following guidelines should be followed:

Perform a site visit to survey existing vegetation:

- Evaluate health and viability of valuable species.
- Identify and record individual specimen plantings and mass plantings to be protected during design and construction.
- Identify individual plants by species, caliper and crown extent.
- Note conditions that will impact protection (grading, utilities, access routes, etc).
- Identify physical extent and density of invasive species, and determine optimal eradication technique.
- Consider potential of transplanting beneficial on-site species.
- Discuss tree and vegetation protection plans at the alignment meeting and take necessary steps to coordinate utility work to reduce impact.

Develop a tree and vegetation protection plan:

- Prepare a tree protection plan providing protection within critical root zone (12 x diameter of diameter breast height (DBH)).
- Prepare a massed planting protection plan showing limit of shrub canopy or 12 x diameter of DBH of perimeter trees, whichever is greater.
- Illustrate protection plan(s) on all relevant site plans, including the site preparation/demolition/removals plan and on the grading and site utilities plans.
- Include designated stockpile location(s) and truck access route(s).
- Indicate on plans and in specifications that protection barriers may have to be relocated and reinstalled during construction to provide temporary access.
- Require contractor to maintain protection barrier in good condition throughout the life of the contract.
- Specify that under no circumstances shall material, equipment or debris be stockpiled within the protection zones.

The main objective following guidelines outlined below which represent general principles for landscape design for the FNSRR:

- Encourage excellence in landscape design in consideration with the distinct character of this redevelopment and the natural features of the landscape.
- Preservation of existing trees, woodlots and features wherever possible.
- Diversity of plant material and naturalizing wherever possible in appropriate areas.
- Ensure integration with storm water management features.
- Preserve the heritage of such resources as archeological sites and landscapes of historical significance.
- Enhance the public perception of a proposed development in terms of aesthetic quality, comfort and convenience of pedestrians and screening of less attractive elements of the development (screening of parking, service & storage areas, privacy areas, etc.). This may be

accomplished through the use of landscaped islands and buffer planting strips.

- Contribute to the overall redevelopment image.

Additional landscape design guidelines include:

- Provide landscaping at the street-line, which contributes to the continuity of landscaping between adjacent properties.
- Maintain unobstructed visibility to building entrances, key architectural features, and signage and public spaces. Locate plant material in a manner that provides adequate site lines for both motorists and pedestrians.
- Group trees and shrubs to frame building elevations and to add visual interest to blank facades and open spaces.
- Install landscape elements that provide color and decoration, having regard for local/native vegetation.
- Install plant material to soften building elevations, maintain a pedestrian scale and provide definition to public walkways and open spaces.
- Provide landscaping to screen and buffer parking areas, open storage and other site service elements.
- Provide protection from excessive summer sun, winds, especially adjacent to outdoor areas where people congregate.
- Select plant materials that are ecologically sound, appropriate for the existing and future site conditions and suitable for the climate.
- Incorporate drought resistant plant material in order to reduce long-term maintenance requirements and conserve water (xeriscaping).
- Select native plant materials where appropriate and avoid the use of invasive plant species.

Impacts on terrestrial vegetation should be minimized by using previously developed areas and by siting new development within these areas or immediately adjacent to previously developed areas to the extent practical. Terrestrial vegetation serves to protect against soil erosion, filters and traps sediments

4 Best Practices

4.1 Construction Practices

The purpose of this section is to describe best practices for construction and site management. It contains useful background information, key objectives for improved performance and detailed technical strategies for achieving those objectives.

4.1.1 Develop and Enforce a Site Protection Plan

Develop, implement and enforce a Site Protection Plan to minimize impact of construction activity in the FNSRR.

• The works are constructed such that they fulfill the purpose for which they were intended;

• The long-term maintenance requirements are considered;

• There is no detrimental effect on other existing assets in the locality;

• The works are safe, both during and after construction; and

• The environmental impacts are minimized both during and after construction

Some Technical Strategies to achieve these objectives are:

- Illustrate site protection plan(s) on all relevant site plans: Site preparation/demolition/removals plan; grading and site utilities plans, etc.
- Clearly mark limits of construction and other relevant areas:
    - Mark clearing limits and approved work areas.
    - Identify areas of site requiring significant excavation.
    - Limit excavation and soil disturbance to minimum area necessary to perform work.
    - Establish construction access points.
    - Prevent soil compaction. Use lightest-weight machinery possible.
    - Include designated stockpile location(s) and truck access route(s).
    - Indicate on plans and in specifications that protection barriers may have to be relocated and reinstalled during construction to provide temporary access.
    - Specify that under no circumstances shall material, equipment or debris be stockpiled within the protection zones.
- Develop a Soil Erosion and Sediment Control Plan. Include the following considerations in the site protection plan:
    - Protect topsoil from compaction, erosion and disruption.
    - Protect existing trees and vegetation.
    - Protect planted areas against chemical contamination.
    - Protect new plantings.
    - Protect against invasive species.
    - Minimize sedimentation and erosion.
    - Prevent water pollution and control sources.
    - Use interim stormwater management to reduce and treat runoff.
    - Implement a waste management and recycling plan.
- Minimize noise and disruption to community.
- Properly sequence major construction activities to minimize environmental impact and community disruption.

- Use alternative contracting methods to minimize construction delays and work stoppages. Maintain transportation patterns.

Promote awareness and enforcement:

- Ensure that all disciplines respect the protection plan throughout the design and construction process.
- Require contractor to maintain protection barrier in good condition throughout the life of the contract.
- Develop special contract provisions to enforce site protection goals. Include both incentives and penalties.
- Enforce restrictions by imposing fines on contractor(s) who violate protection requirements.
- Post signage communicating site protection measures, including vehicle protocols, parking and site access, storage of waste and recyclables, storage of hazardous materials and vehicle cleaning areas.
- Conduct meetings to educate workers about site disturbance and water pollution control measures.
- Meet with contractor and/or construction manager at outset to coordinate site protection measures.
- Monitoring and Maintenance
- Conduct regular inspections and maintenance of site protection measures. Ensure that site protection markings are maintained.
- Inspect erosion and sedimentation control measures after heavy rainfalls (1/2' in less than 24 hours).
- Remove sediment from sediment traps when design capacity has been reduced by 50%.
- Periodically inspect hazardous materials containers and perform necessary maintenance.
- Monitor trees whose roots have been cut during construction for stability and health.
- Monitor disturbed soils over time to ensure stability and re-vegetation.
- Remove hazardous conditions.
- Develop and enforce a post-construction mitigation plan. Consider the use of progress payment schedules to ensure contractor compliance: Under this type of contract, money is held back from the contractor until they complete certain tasks – including landscape maintenance, site protection measures, etc. Requires monitoring to ensure compliance.
- Develop a system to impose liquidated damages on contractors that cause injury to planted areas or fail to follow protection measures.

4.1.2 Protect Existing and Future Planted Areas

With the objective to protect existing and future planted areas from soil compaction and disturbance, chemical pollution, damage from construction equipment, invasive species, and so on. Monitor and maintain vegetation protection measures.

The benefits are:

- Maintains natural infiltration and soil porosity by reducing soil disturbance and compaction.
- Reduces cost of additional planting and topsoil.
- Protects existing or new plants from construction-related contaminants that alter nutrient transfer capacity of soils and introduce toxic heavy metals. Preserves desirable vegetation and natural soil profile.
- Improves quality of life and increases property value.
- Minimizes pollution, sedimentation and erosion of receiving waters.

Technical Strategies

- Protect topsoil from compaction, erosion and disturbance:
- Protect existing topsoil or subsoil from compaction.
- Specify low ground pressure (LGP) equipment for construction operations within planted areas.

- Prohibit construction vehicles from driving or staging on future planted areas.
- If necessary, provide geotextile fabric and 12 inch gravel layer for access routes.
- Cover exposed soils immediately with erosion-control measures.
- Protect soils from chemical cleaning products and other pollutants.
- Test soils impacted by construction activity prior to planting; amend or remediate as required to meet specifications.
- Monitor disturbed soils over time to ensure stability and re-vegetation.
- Permit earthwork operations during dry weather only; soil moisture content should not exceed 20% during operations.

Minimize impact from chemical applications:

- Specify sterilants/herbicides/pesticides with short residual periods, selected specifically for the species to be eradicated and within USEPA standards of low toxicity to humans and animals. Use non-selective, non-residual herbicide, a glyphosate without surfactant if possible.
- Follow appropriate federal, state, or local environmental and health standards to assess risk when planning the use of chemical substances.
- Avoid chemical applications that can vaporize into the atmosphere, be residually absorbed by soil or plants or be leached into groundwater.
- Prohibit use of methyl bromide or other soil fumigants.
- Coordinate herbicide applications with growth characteristics of invasive species.
- Require submission of test reports, material safety data sheets, application procedures and timing of any chemical applications to vegetation.
- Specify that surrounding areas are to be protected from migration of chemical applications.
- Use biointensive integrated pest management.
- Ensure truck washing and other cleaning procedures take place away from planted areas.

Protect existing trees and vegetation:

- Discuss tree and vegetation protection plans at the alignment meeting and take necessary steps to coordinate utility work and earthwork to reduce impact.
- Implement tree and vegetation protection plans.
- Implement tree removal and transportation plans.
- Illustrate protection plan(s) on all relevant site plans, including the site preparation/demolition/removals plan and on the grading and site utilities plans.
- Remove hazardous conditions from protection zone.
- Minimize, or if possible prohibit, earthmoving within protected tree or vegetation/riparian zones.
- Protect roots of preserved trees from excavation.
- If excavation is required, hand excavate within protection zone.
- Cover exposed roots with wet burlap; reinstall native soil immediately within.

4.1.3 Protect Water Sources During Construction

Undertake conscientious construction practices to protect water sources. Implement plans for pollution prevention, chemical source control, sedimentation and erosion control, and interim stormwater management. Monitor and maintain protection of water sources

4.1.4 Implement a Waste Management and Recycling Plan

Implement a construction and demolition waste management plan for infrastructure construction to reduce the amount of waste entering the waste stream and increase recovery of recyclable materials.

5 Appendix

5.1 Appendix A

Figure 10: Road Type "A"

Road Type "A"

This is a low traffic volume road section, where pedestrian traffic is limited, due to the lack of residential or commercial facilities along its right of way, and where easement is limited due to sensitive areas on the surroundings. This road type can handle average daily traffic of up to 8,000 vehicles.

It is composed of two undivided lanes (one on each direction) and their respective shoulders. This road section shall be developed inside a maximum easement width of 15.00 meters.

Road Sections do not show bike lanes. Please refer to the Bike Ways Section for bike lane information.

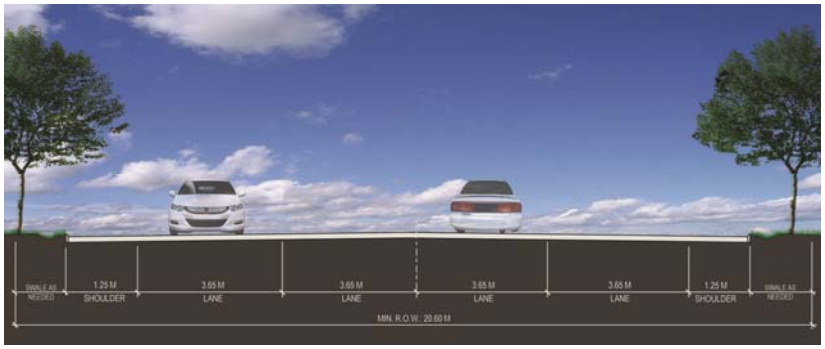


Figure 11: Road Type "B"

Road Type "B"

This is a medium to high traffic volume road section, where pedestrian traffic is limited, due to the lack of residential or commercial facilities along its right of way, and where easement is limited due to sensitive areas on the surroundings. This road type can handle average daily traffic of up to 20,000 vehicles.

It is composed of four undivided lanes (two on each direction), their respective shoulders and a bicycle lane. This road section shall be developed inside a maximum easement width of 20.60 meters.

Road Type "C"

This is a medium to high traffic volume road section, where pedestrian traffic is limited due to the lack of residential or commercial facilities

along its right of way, but easement width is not limited. In order to provide a more urban environment and to include landscaping space, a median is also considered. This road type can handle average daily traffic of up to 20,000 vehicles.

It is composed of four divided lanes (two on each direction), their respective shoulders and a bicycle lane. This road section shall be developed inside a maximum easement width of 22.00 meters

Figure 12: Road Type “C”

Road Type “D”

This is a low volume road section, where pedestrian traffic is considered, but easement width is limited. In order to provide a more urban environment and to include landscaping space, a median is also considered. This road type can handle average daily traffic of up to 8,000 vehicles.

It is composed of two divided lanes (one on each direction), planting area and sidewalks. This road section shall be developed inside a maximum easement width of 15.00 meters

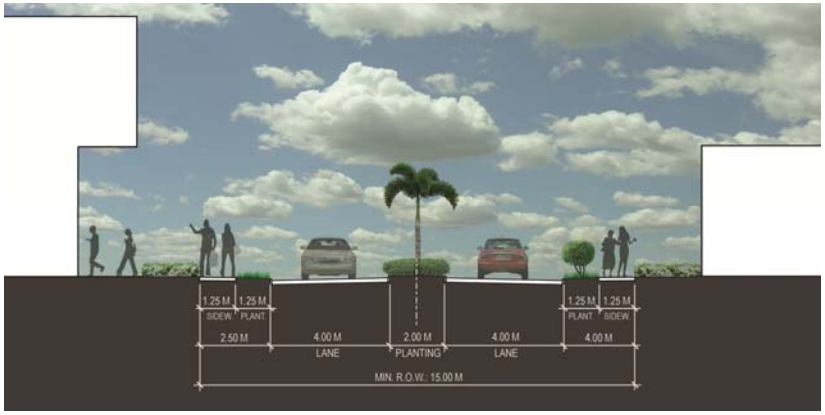


Figure 13: Road Type “D”

Road Type “E”

This is a medium to high volume road section, where pedestrian traffic is considered, and easement width is not limited. This road type can handle average daily traffic of up to 20,000 vehicles.

It is composed of four lanes (two on each direction), planting area, sidewalks and a bicycle lane. This road section shall be developed inside a maximum easement width of 22.00 meters.

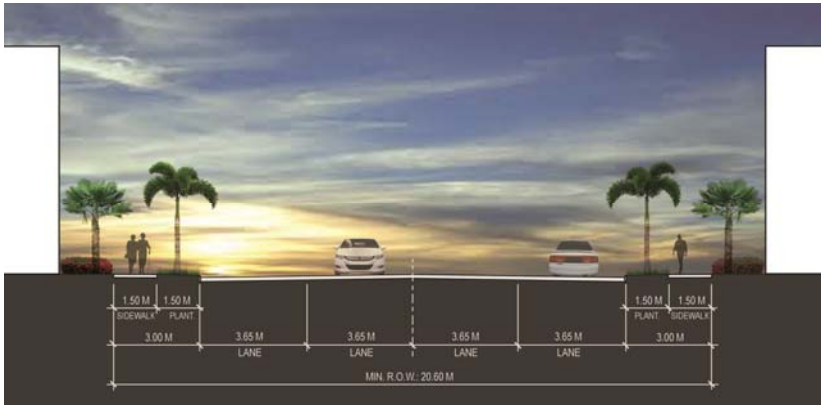


Figure 14: Road Type "E"

Road Type "F"

This is a high volume road section, where pedestrian traffic is considered, and easement width is not limited. In order to provide a more urban environment and to include landscaping space, a median is also considered. For locations where commercial activity is considered, a parking lane is provided on each side. This road type can handle average daily traffic of up to 20,000 vehicles.

It is composed of four divided lanes (two on each direction), two parking lanes (one on each direction), planting area, sidewalks, bicycle lane and a left turning lane on major intersections. This road section shall be developed inside a maximum easement width of 30.85 meters.

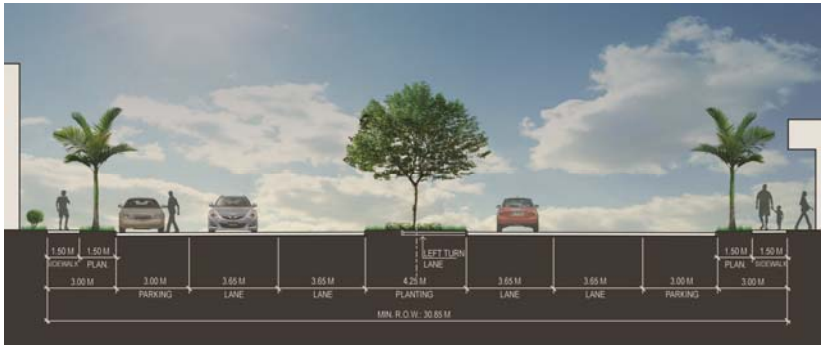


Figure 15: Road Type "F"

Road Type "G"

This is a high volume road section, where pedestrian traffic is considered, and easement width is not limited. In order to provide a more urban environment and to include landscaping space, a median is also considered. For locations where commercial activity is considered, a parking lane option is available on each side. This road type can handle average daily traffic of up to 30,000 vehicles.

It is composed of six lanes (three on each direction), two of the six lanes can be used as drop off or parking lanes as needed (one on each direction), planting area, sidewalks and a planting median that includes a left turning lane on major intersections. This road section shall be developed inside a maximum easement width of 36.00 meters.

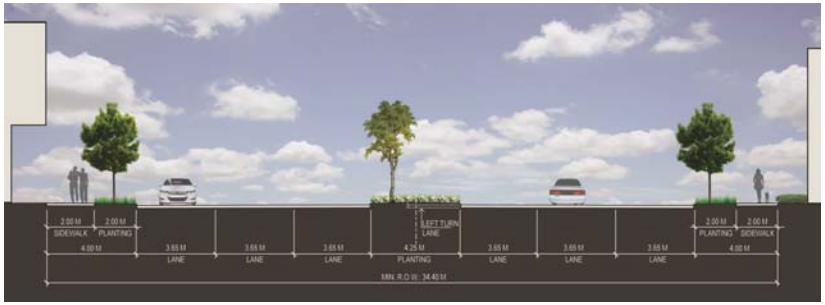


Figure 16: Road Type “G”

5.2 Appendix B

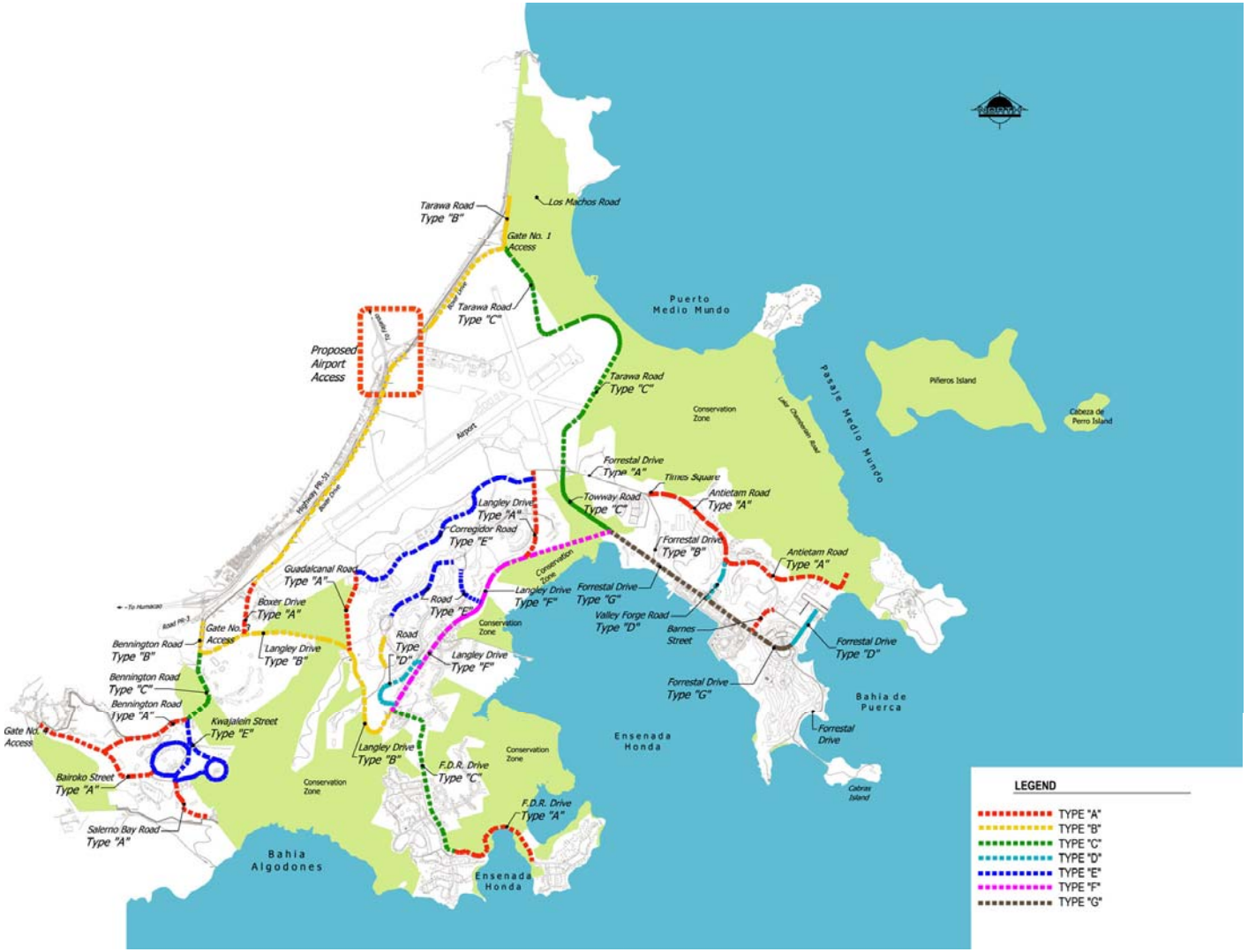


Figure17: Proposed Roads Network

5.3 Appendix C

Zone	Location	Projected Use	Development Area (Gross Square Feet)	Dev. Area (acres)	Hospital Beds	Hotel Rooms	Dwelling Units	Students	Boat Slips	Passengers / Visitors	Use Rate per Day	Water Demand (GPD)
1	Port Caribe	**Commercial Heart**										
		Retail/ Restaurants/ Entertainment Dist	200,000								300 gallons/1,000 sq. ft.	60,000
		Hospital	130,000		85						350 gallons/bed	29,750
		Office	50,000								300 gallons/1,000 sq. ft.	15,000
		Marina	25,000						400		30 gallons/boat slip	12,000
		International Cruise Terminal	150,000							1,500	10 gallons/passenger	15,000
		Industrial/ Back of House	50,000								350 gallons/1,000 sq. ft.	17,500
		National Guard Boat Ramp	9,500								300 gallons/1,000 sq. ft.	2,850
		Homeland Security Boat Ramp	2,500								300 gallons/1,000 sq. ft.	750
		Ferry Terminal	50,000							1,200	5 gallons/passenger	6,000
		Zone Total	**667,000**								**Zone Total =**	**158,850**
2	Caribbean Riviera	**Destination Anchor**										
		Casino	210,000								300 gallons/1,000 sq. ft.	63,000
		Casino Hotel	2,000,000			2,000					700 gallons/room	1,400,000
		Retail/ Restaurants/ Entertainment	200,000								300 gallons/1,000 sq. ft.	60,000
		Cabras Island (Coast Guard)	2,000								300 gallons/1,000 sq. ft.	600
		Wastewater Treatment Plant	1,000								300 gallons/1,000 sq. ft.	300
		Zone Total	**2,413,000**								**Zone Total =**	**1,523,900**
3	El Yunque Grande	**Premier Eco-Tourism Resort**										
		Hotels- "Lodge"	120,000			150					700 gallons/room	105,000
		Eco Museum/Visitor's Center	50,000								0.17 gallons/1 sq. ft.	8,500
		Office	30,000								300 gallons/1,000 sq. ft.	9,000
		Retail/ Restaurants/ Entertainment "Vill	100,000								300 gallons/1,000 sq. ft.	30,000
		Residential Villas	450,000				200				400 gallons/dwelling unit	80,000
		Marina	25,000						200		30 gallons/boat slip	6,000
		US Army Reserve/ National Guard	46,500								300 gallons/1,000 sq. ft.	13,950
		Armed Forces Reserve Center	72,000								300 gallons/1,000 sq. ft.	21,600
		Water Taxi Terminal/ Pier	20,000							600	5 gallons/passenger	3,000
		Zone Total	**913,500**								**Zone Total =**	**277,050**
4	Marsh Vista	**Golf/Country Club Amenity**										
		18 Hole Golf Course									(reclaimed water)	
		Clubhouse and Dining	35,000								300 gallons/1,000 sq. ft.	10,500
		Residential	250,000				125				400 gallons/dwelling unit	50,000
		Zone Total	**285,000**								**Zone Total =**	**60,500**
5	Eco-Outpost Camp	**Environmental Retreat**										
		Dining/ Conference	25,000								300 gallons/1,000 sq. ft.	7,500
		Lodging	100,000			100					700 gallons/room	70,000
		Office/ Research	25,000								300 gallons/1,000 sq. ft.	7,500
		Zone Total	**150,000**								**Zone Total =**	**85,000**

Figure18: Water Demand by Zone

Zone	Location	Projected Use	Development Area (Gross Square Feet)	Dev. Area (acres)	Hospital Beds	Hotel Rooms	Dwelling Units	Students	Boat Slips	Passengers / Visitors	Use Rate per Day	Water Demand (GPD)
6	Airport Uplands	**Collateral Development**										
		Airport, Government, Military	250,000								350 gallons/1,000 sq. ft.	87,500
		Industrial/ Warehouse	250,000								350 gallons/1,000 sq. ft.	87,500
		Specialty Industrial	200,000								350 gallons/1,000 sq. ft.	70,000
		Office	75,000								300 gallons/1,000 sq. ft.	22,500
		Residential	250,000				100				400 gallons/dwelling unit	40,000
		18-hole Golf Course									(reclaimed water)	
		Clubhouse	35,000								300 gallons/1,000 sq. ft.	10,500
		Radar Station	1,025								300 gallons/1,000 sq. ft.	308
		PotableWater Treatment Plant	3,800								300 gallons/1,000 sq. ft.	1,140
		Zone Total	**1,064,825**								**Zone Total =**	**319,448**
7	Main Street	**Town Center**										
		Educational Facilities/ Schools	80,000					530			30 gallons/student	15,900
		Office	100,000								300 gallons/1,000 sq. ft.	30,000
		Retail, Restaurant, Entertainment	400,000								300 gallons/1,000 sq. ft.	120,000
		Residential	1,450,000				650				400 gallons/dwelling unit	260,000
		Industrial/ Back of House / Support Serv	200,000								350 gallons/1,000 sq. ft.	70,000
		Hotel	320,000			400					700 gallons/room	280,000
		Community College	200,000					1300			30 gallons/student	39,000
		Coast Guard Pier	8,910								300 gallons/1,000 sq. ft.	2,673
		Zone Total	**2,758,910**								**Zone Total =**	**817,573**
8	Sports Core	**Community Sports**										
		9 Hole Golf Course									(reclaimed water)	
		Clubhouse	15,000								300 gallons/1,000 sq. ft.	4,500
		Retail, Restaurant, Entertainment	30,000								300 gallons/1,000 sq. ft.	9,000
		Industrial	50,000								350 gallons/1,000 sq. ft.	17,500
		Office	50,000								300 gallons/1,000 sq. ft.	15,000
		Sports Complex/ Recreation Fields	200,000	4.59							2,020 gallons/acre	9,272
		Residential	200,000				90				400 gallons/dwelling unit	36,000
		Zone Total	**545,000**								**Zone Total =**	**91,272**
9	Island Paradise	**Retreat, Conference, Learning**										
		Retail, Restaurant, Entertainment	50,000								300 gallons/1,000 sq. ft.	15,000
		Hotels	320,000			300					700 gallons/room	210,000
		Back of House / Support Services	50,000								350 gallons/1,000 sq. ft.	17,500
		Conference/ Educational	500,000								300 gallons/1,000 sq. ft.	150,000
		Zone Total	**920,000**								**Zone Total =**	**392,500**
10	Capeheart	**Residential/ Corporate**										
		Corporate/ Institutional	500,000								300 gallons/1,000 sq. ft.	150,000
		Retail, Restaurant, Entertainment	50,000								300 gallons/1,000 sq. ft.	15,000
		Residential	650,000				300				400 gallons/dwelling unit	120,000
		Zone Total	**1,200,000**								**Zone Total =**	**285,000**
11	Ceiba Park	**Gateway**										
		Concessions	10,000								300 gallons/1,000 sq. ft.	3,000
		Office	20,000								300 gallons/1,000 sq. ft.	6,000
		Pier	25,000								300 gallons/1,000 sq. ft.	7,500
		Zone Total	**55,000**								**Zone Total =**	**16,500**
											TOTAL WATER DEMAND=	**4,027,592**

Figure 19: Water Demand by Zone (cont.)

5.4 Appendix D

Location	Projected Use	Development Area (Gross Square Feet)	Dev. Area (cuerda)	Hospital Beds	Hotel Rooms	Dwelling Units	Students	Boat Slips	Passengers / Visitors	Generation Rate per Day	Wastewater Generation (GPD)
Port Caribe	**Commercial Heart**										
	Retail/ Restaurants/ Entertainment District	700,000								0.25 gallons/sq. ft.	50,000
	Hospital	130,000		85						300 gallons/bed	25,500
	Office	50,000								300 gallons/1,000 sq. ft.	15,000
	Marina	25,000						400		30 gallons/boat slip	12,000
	International Cruise Terminal	150,000							1,500	5 gallons/passenger	7,500
	Industrial/ Back of House	50,000	1.15							6000 gallons/acre	6,887
	National Guard Boat Ramp	9,500								300 gallons/1,000 sq. ft.	2,850
	Homeland Security Boat Ramp	2,500								300 gallons/1,000 sq. ft.	750
	Ferry Terminal	50,000							1,200	5 gallons/passenger	6,000
	Zone Total	**667,000**								**Zone Total =**	**126,487**
Caribbean Riviera	**Destination Anchor**										
	Casino	210,000								300 gallons/1,000 sq. ft.	63,000
	Casino Hotel	2,000,000			2,000					525 gallons/room	1,050,000
	Retail/ Restaurants/ Entertainment	700,000								0.25 gallons/sq. ft.	50,000
	Cabras Island (Coast Guard)	2,000								300 gallons/1,000 sq. ft.	600
	Wastewater Treatment Plant	1,000								300 gallons/1,000 sq. ft.	300
	Zone Total	**2,413,000**								**Zone Total =**	**1,163,900**
El Yunque Grande	**Premier Eco-Tourism Resort**										
	Hotels- "Lodge"	170,000			150					525 gallons/room	78,750
	Eco Museum/Visitor's Center	50,000								0.25 gallons/sq. ft.	12,500
	Office	30,000								300 gallons/1,000 sq. ft.	9,000
	Retail/ Restaurants/ Entertainment "Village"	100,000								0.25 gallons/sq. ft.	25,000
	Residential Villas	450,000				200				350 gallons/dwelling unit	70,000
	Marina	25,000						200		30 gallons/boat slip	6,000
	US Army Reserve/ National Guard	46,500								300 gallons/1,000 sq. ft.	13,950
	Armed Forces Reserve Center	72,000								300 gallons/1,000 sq. ft.	21,600
	Water Taxi Terminal/ Pier	20,000							600	5 gallons/passenger	3,000
	Zone Total	**913,500**								**Zone Total =**	**239,800**
Marsh Vista	**Golf/Country Club Amenity**										
	18 Hole Golf Course										
	Clubhouse and Dining	35,000								300 gallons/1,000 sq. ft.	10,500
	Residential	250,000				125				350 gallons/dwelling unit	43,750
	Zone Total	**285,000**								**Zone Total =**	**54,250**
Eco-Outpost Camp	**Environmental Retreat**										
	Dining/ Conference	25,000								300 gallons/1,000 sq. ft.	7,500
	Lodging	100,000			100					525 gallons/room	52,500
	Office/ Research	25,000								300 gallons/1,000 sq. ft.	7,500
	Zone Total	**150,000**								**Zone Total =**	**67,500**

Figure 20: Wastewater Generation by Zone

Location	Projected Use	Development Area (Gross Square Feet)	Dev. Area (acres)	Hospital Beds	Hotel Rooms	Dwelling Units	Students	Boat Slips	Passengers / Visitors	Generation Rate per Day	Wastewater Generation (GPD)
Airport Uplands	**Collateral Development**										
	Airport, Government, Military	250,000	5.74							6000 gallons/acre	34,436
	Industrial/ Warehouse	250,000	5.74							6000 gallons/acre	34,436
	Specialty Industrial	200,000	4.59							6000 gallons/acre	27,548
	Office	75,000								300 gallons/1,000 sq. ft.	22,500
	Residential	250,000				100				350 gallons/dwelling unit	35,000
	18-hole Golf Course										
	Clubhouse	35,000								300 gallons/1,000 sq. ft.	10,500
	Radar Station	1,025								300 gallons/1,000 sq. ft.	308
	PotableWater Treatment Plant	3,800								300 gallons/1,000 sq. ft.	1,140
	Zone Total	**1,064,825**								**Zone Total =**	**165,867**
Main Street	**Town Center**										
	Educational Facilities/ Schools	80,000					530			20 gallons/student	10,600
	Office	100,000								300 gallons/1,000 sq. ft.	30,000
	Retail, Restaurant, Entertainment	400,000								0.25 gallons/sq. ft.	100,000
	Residential	1,450,000				650				350 gallons/dwelling unit	227,500
	Industrial/ Back of House / Support Services	200,000	4.59							6000 gallons/acre	27,548
	Hotel	320,000			400					525 gallons/room	210,000
	Community College	200,000					1300			20 gallons/student	26,000
	Coast Guard Pier	8,910								300 gallons/1,000 sq. ft.	2,673
	Zone Total	**2,758,910**								**Zone Total =**	**634,321**
Sports Core	**Community Sports**										
	9-Hole Golf Course										
	Clubhouse	15,000								300 gallons/1,000 sq. ft.	4,500
	Retail, Restaurant, Entertainment	30,000								0.25 gallons/sq. ft.	7,500
	Industrial	50,000	1.147851							6000 gallons/acre	6,887
	Office	50,000								300 gallons/1,000 sq. ft.	15,000
	Sports Complex/ Recreation Fields	200,000	4.59							2020 gallons/acre	9,272
	Residential	200,000				90				350 gallons/dwelling unit	31,500
	Zone Total	**545,000**								**Zone Total =**	**74,659**
Island Paradise	**Retreat, Conference, Learning**										
	Retail, Restaurant, Entertainment	50,000								0.05 gallons/sq. ft.	2,500
	Hotels	320,000			300					525 gallons/room	157,500
	Back of House / Support Services	50,000	4.59							6000 gallons/acre	27,540
	Conference/ Educational	500,000								300 gallons/1,000 sq. ft.	150,000
	Zone Total	**920,000**								**Zone Total =**	**337,540**
Capeheart	**Residential/ Corporate**										
	Corporate/ Institutional	500,000								300 gallons/1,000 sq. ft.	150,000
	Retail, Restaurant, Entertainment	50,000								0.25 gallons/sq. ft.	12,500
	Residential	650,000				300				350 gallons/dwelling unit	105,000
	Zone Total	**1,200,000**								**Zone Total =**	**267,500**
Ceiba Park	**Gateway**										
	Concessions	10,000								300 gallons/1,000 sq. ft.	3,000
	Office	20,000								300 gallons/1,000 sq. ft.	6,000
	Pier	25,000								300 gallons/1,000 sq. ft.	7,500
	Zone Total	**55,000**								**Zone Total =**	**16,500**
										TOTAL WASTEWATER DISCHARGE=	**3,148,324**

Figure 21: Wastewater Generation by Zone (cont.)

5.5 Appendix E

Zone	Location	Projected Use	Development Area (Gross Square Feet)	13.2 KV	38 KV
1	Port Caribe	**Commercial Heart**			
		Retail/ Restaurants/ Entertainment District	700,000	7,700	0
		Hospital	130,000	0	1,820
		Office	50,000	690	0
		Marina	25,000	13	0
		International Cruise Terminal	150,000	1,425	0
		Industrial/ Back of House	50,000	360	0
		National Guard Boat Ramp	9,500	5	0
		Homeland Security Boat Ramp	7,500	1	0
		Ferry Terminal	50,000	375	0
		18 Hole Golf Course			
		Zone Total	**667,000**	**5,569**	**1,820**
2	Caribbean Riviera	**Destination Anchor**			
		Casino	210,000	0	2,835
		Casino Hotel	2,000,000	0	23,000
		Retail/ Restaurants/ Entertainment	200,000	2,700	0
		Cabras Island (Coast Guard)	2,000	27	0
		Waste Water Treament Plan	1,000	750	0
		Zone Total	**2,413,000**	**3,477**	**25,835**
3	El Yunque Grande	**Premier Eco-Tourism Resort**			
		Hotels- "Lodge"	120,000	960	0
		Eco Museum/Visitor's Center	50,000	675	0
		Office	30,000	414	0
		Retail/ Restaurants/ Entertainment "Village"	100,000	1,350	0
		Residential Villas - Eco-lodge	450,000	2,048	0
		Marina	25,000	13	0
		US Army Reserve/ National Guard[1]	46,500	647	0
		Armed Forces Reserve Center[1]	72,000	994	0
		Water Taxi Terminal/ Pier	20,000	10	0
		Zone Total	**913,500**	**7,104**	**0**
4	Marsh Vista	**Golf/Country Club Amenity**			
		18 Hole Golf Course		300	0
		Clubhouse and Dining	35,000	354	0
		Residential	250,000	1,148	0
		Zone Total	**285,000**	**1,801**	**0**
5	Eco Outpost Camp	**Environmental Retreat**			
		Dining/ Conference	25,000	253	0
		Lodging	100,000	800	0
		Office/ Research	25,000	345	0
		Zone Total	**150,000**	**1,398**	**0**

Figure 22: Electrical Load Demand by Zone

Zone	Location	Projected Use	Development Area (Gross Square Feet)	13.2 KV	38 KV
6	Airport Uplands	**Collateral Development**			
		Airport, Government, Military	250,000	0	3,450
		Industrial/ Warehouse	250,000	0	1,800
		Specialty Industrial	200,000	0	2,340
		Office	75,000	1,035	0
		Residential	250,000	1,148	0
		18-hole Golf Course		300	0
		Clubhouse	35,000	354	0
		Potable Water Treatment Plan	3,800	1,500	0
		Radar Station	1,025	14	0
		Zone Total	**1,064,825**	**4,350**	**7,590**
7	Main Street	**Town Center**			
		Educational Facilities/ Schools	80,000	970	0
		Office	100,000	1,380	0
		Retail, Restaurant, Entertainment	400,000	5,400	0
		Residential	1,450,000	0	6,548
		Industrial/ Back of House / Support Services	200,000	0	1,440
		Hotel	370,000	0	2,560
		Community College	200,000	90	2,000
		Coast Guard Pier	8,910	0	300
		Zone Total	**2,758,910**	**7,790**	**12,848**
8	Sports Core	**Community Sports**			
		9 Hole Golf Course		150	0
		Clubhouse	15,000	157	0
		Retail, Restaurant, Entertainment	30,000	405	0
		Industrial	50,000	360	0
		Office	50,000	690	0
		Sports Complex/ Recreation Fields	200,000	600	0
		Residential	200,000	973	0
		Zone Total	**545,000**	**3,129**	**0**
9	Island Paradise	**Retreat, Conference, Learning**			
		Retail, Restaurant, Entertainment	50,000	675	0
		Hotels	370,000	0	2,560
		Back of House / Support Services	50,000	150	0
		Conference/ Educational	500,000	0	5,750
		Zone Total	**920,000**	**825**	**8,310**
10	Capeheart	**Residential/ Corporate**			
		Corporate/ Institutional	500,000	0	2,273
		Retail, Restaurant, Entertainment	50,000	675	0
		Residential	650,000	2,948	0
		Zone Total	**1,200,000**	**3,623**	**2,273**
11	Ceiba Park	**Gateway**			
		Concessions	10,000	135	0
		Office	20,000	276	0
		Pier	25,000	13	0
		Zone Total	**55,000**	**424**	**0**
		Total Electrical Demand		**98,313**	
				39,638	**58,675**

Figure 23: Electrical Load Demand by Zone (cont.)

5.6 Appendix F: Phases

5.6.1 Phase 1

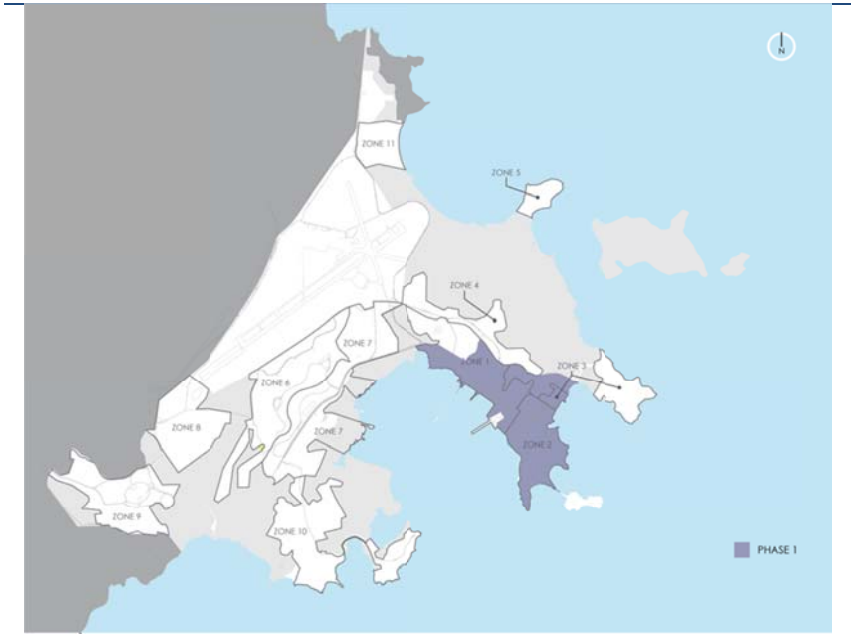


Figure 24: Redevelopment Areas for Phase 1

This initial phase involves the basic maintenance of basic infrastructure to allow for continued service to existing tenants inside Roosevelt Roads. It includes most of the proposed developments within Port Caribe (Zone 1), Caribbean Riviera (Zone 2) and some areas of El Yunque Grande (Zone 3).

Total development area considered to this phase is 3,150,000 square feet approximately.

5.6.2 Phase 2

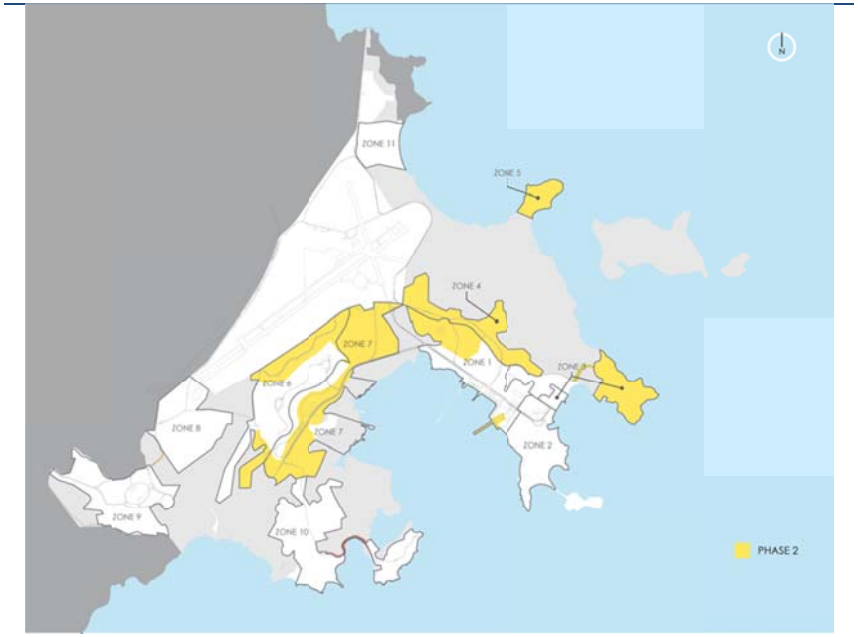


Figure 25: Redevelopment Areas for Phase 2

In order to continue the densification of the ports areas and promote redevelopment of the Main Street and surrounding areas, this second phase includes the remaining developments from Zone 1 and Zone 2 and most projects envisioned for Marsh Vista (Zone 4), Airport Uplands (Zone 6) and Main Street (Zone 7).

The aggregate redevelopment area considered for Phase 2 is approximately 3,200,000 square feet.

5.6.3 Phase 3

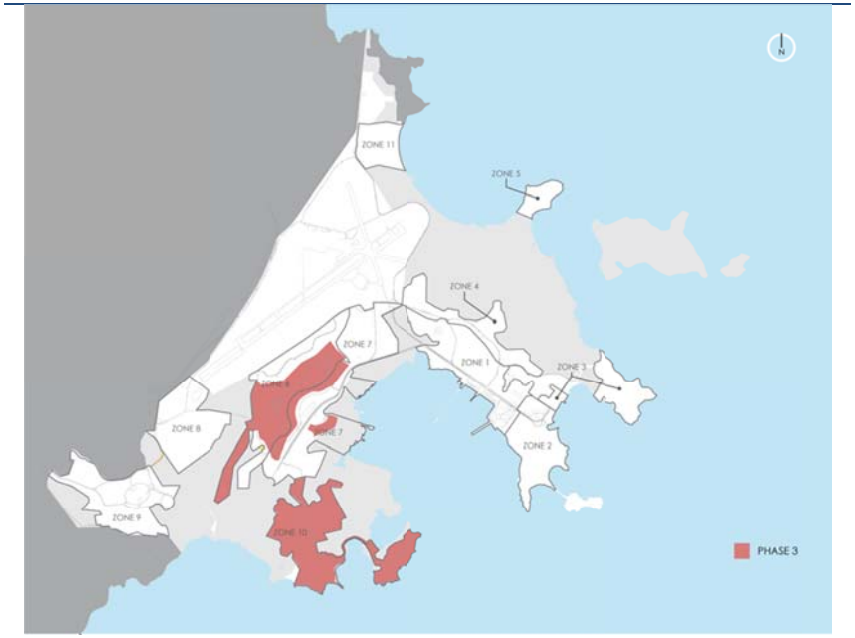


Figure 26: Redevelopment Areas for Phase 3

After the waterfront and Main Street redevelopments are performed, the next infrastructure investment will focus in providing essential improvements to allow redevelopment at the Eco-Outpost Camp (Zone 5) and the commercial area and Golf Course of the Airport Uplands (Zone 6). In addition, Phase 3 includes Capehart (Zone 10), and the Residential Area of Main Street (Zone 7).

Total Phase 3 development area is around 3,100,000 square feet.

5.6.4 Phase 4

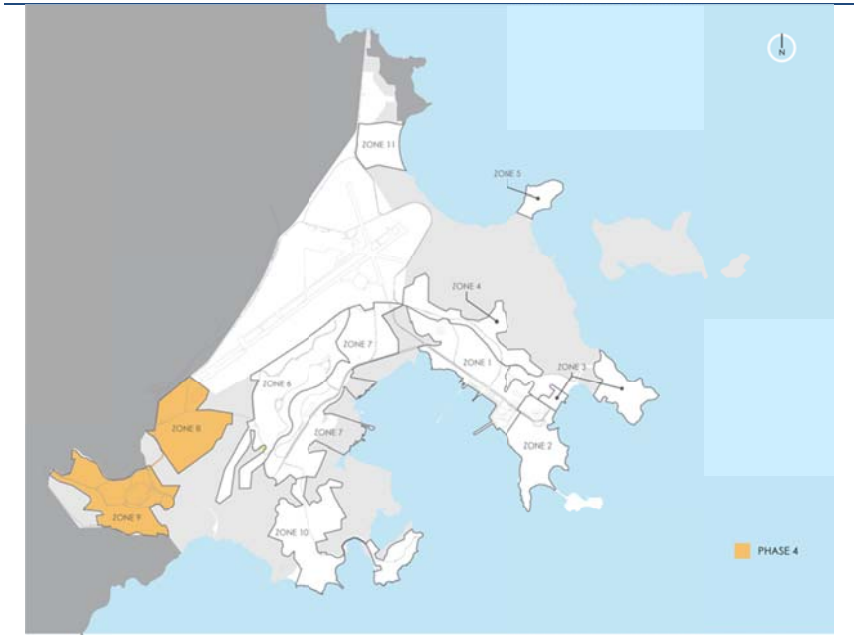


Figure 27 : Redevelopment Areas for Phase 4

The development projects considered for Phase 4 is concentrated within the Sports Core (Zone 8) and Island Paradise (Zone 9).

Phase 4 development totals approximately 1,500,000 square feet.

5.6.5 Phase 5

Figure 28: Redevelopment Areas for Phase 5

This last phase includes Ceiba Park (Zone 11).

Given the remote location of this Zone relative to the rest of the Master Plan and because of the relatively small demands and loads within this area (approximately 50,000 square feet of construction), Phase 5 of this Master Plan is considered to be best served from within the greater Ceiba municipality. Uses and demands projected for this Zone are tightly related to municipal uses and are located near public utility connection points that occur adjacent to this parcel.

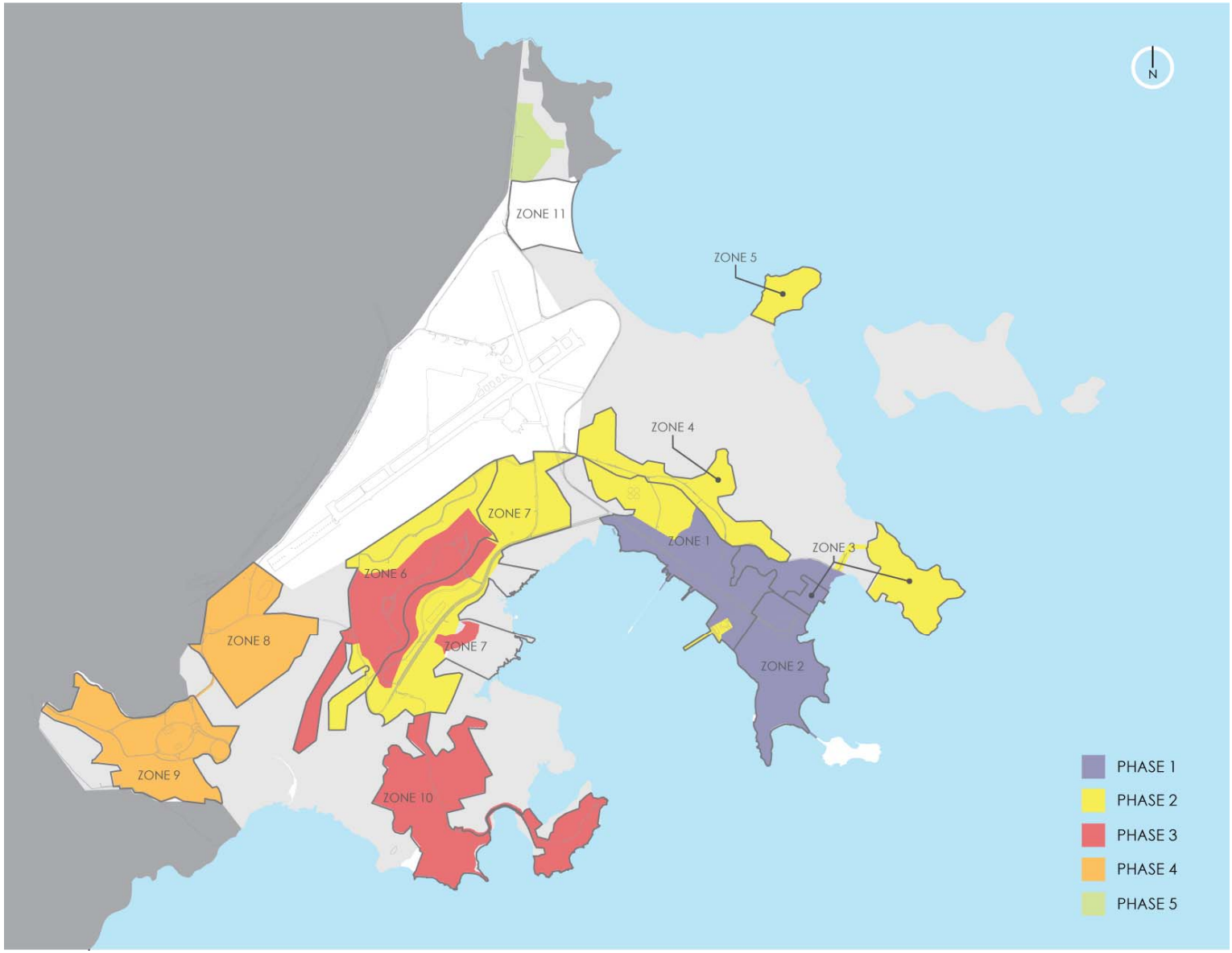


Figure 29: Infrastructure Master Plan Phasing Summary