Commonwealth of Northern Mariana Islands – CNMI

# Low Impact Development

# Best Management Practices

# Past, Present & Future

Hawaii / Saipan / May 2018

**Derek J. Williams**

S. Jeffress Williams

Deborah Toth-Dennis

OHANA KIT
ADU & HOME
BUILDING SYSTEM

# CONTENT

## I. The Author and Organization

The author, Derek J. Williams is son of Emeritus US Scientist S. Jeffress Williams and has had a lifelong exposure to geologic processes and coastal hazards study. Mr. Williams and his organization *HawaiiADU* have been pioneering disaster resilient affordable housing and low impact prefab modular building systems in Hawaii since 2012. They design, plan, permit, build, and install pre-fabricated steel framed homes and and building structures, collaborate with general contractors and municipal building officials on improving permitting systems, and advocate for legislative and regulatory advances favoring sustainable development and widespread adoption of BMPs. Our Ohana Kit Moment Frame building system along with our efficiency and technology-oriented approach to construction are based on 3 tenets:

1. Significant challenges from climate change are imminent
2. Current residential building practices are outdated, environmentally harmful and inefficient
3. Proactive planning, strategic implementation and healthy incentives can limit the personal and environmental impacts in all cycles of development, improving the outcome and better preparing our communities for the increasingly severe changes to come.

Understanding the impact of development on local communities and native peoples is extremely important. A transparent examination of the development process should always aim for “cradle to cradle” ideal solutions even if in the end, they miss the mark. Though optimum solutions may not be immediately achievable, the closed loop nature of our islands means that ultimately all island communities will need to be far more self-sufficient in a relatively short period of 1-2 decades to thrive or even survive.

### Document Focus and Limitations

This document is intended to be a broad assessment of the most current LIDBMP resources paired with the development challenges facing CNMI, both with emphasis on current and past examples on the island of Saipan. This report is broad in scope and touches on numerous topics that in and of themselves could warrant significant additional examination. Publications such as the "CNMI and Guam storm water management manual", "Climate change and vulnerability assessment for the island of Saipan", "2016-2020 Section 309 assessment and strategy report, as well as others such as the "2017 Garapan Area Shoreline Assessment Study" should be referenced for more detailed information and localized scientific data. Implementing, incentivizing and enforcing adherence to LIDBMPs is critical to safe guarding CNMI's rare and valuable cultural and environmental assets. Ideas, approaches and technologies examined here should be independently researched in coordination with local professionals to assure proper design, implementation and operation.

**LIDBMPs Defined (Low Impact Development Best Management Practices)**

This acronym commonly represents any technique, technology, activity or approach before, during or after the planning, construction and operations of any real estate development project that improves the outcome while lessening the impact on both people and the environment.

**Contact**

This document was primarily authored by Derek J. Williams with additional research, reports and assessments conducted by Deborah Toth-Dennis and S. Jeffress Williams in coordination with the staff at Hawaii ADU and Nu House. All inquiries and correspondence should be directed to Deborah Toth-Dennis (Deborah@HawaiiADU.com – 808.292.6918) or Derek J. Williams (d@HawaiiADU.com)

## II. List of Acronyms

| | |
|---|---|
| ADU | Accessory Dwelling Unit |
| APC | Areas of Particular Concern |
| BECQ | Bureau of Environmental and Coastal Quality |
| BMPs | Best Management Practices |
| CDE | climate disruption event |
| CDI | Climate Disruption Impacts |
| CNMI | Commonwealth of the Northern Mariana Islands |
| CZA | Coastal Zone Act |
| DCRM | Division of Coastal Resources Management |
| DEQ | Division of Environmental Quality |
| DEQ | division of environmental quality |
| DPP | Department of Planning and Permitting |
| DRC | disaster recovery center |
| EIA | Environmental Impact Assessment |
| ESCP | Erosion & Sediment Control Plan |
| GIS | Geographic Information Systems |
| LEED | Leadership in Energy and Environmental Design |
| LID | Low Impact Development |
| LIDBMPs | Low impact development Best management practices |
| LOR | LID Observation Report |
| NOAA | National Oceanic and Atmospheric Administration |
| NPSP | nonpoint source pollution |
| SLC | sea level change |
| SLR | sea level rise |
| SST | sea surface temperature |
| SUSMP | Standard Urban Storm Water Mitigation Plan |
| SWE | Severe Weather Events |
| SWM | Storm Water Management |
| SWPPP | Storm Water Prevention Pollution Plan |
| VA | vulnerability assessment |
| WQR | Water Quality Rules |

## III. Executive Summary

In the Fall/Winter of 2017 our team conducted research and assessments, later visiting Saipan January 22-27, 2018 for "one on one" interviews. Our assessments focused on past, present and potential future impacts of larger scale commercial and resort development on Saipan and throughout CNMI. We met with various engineers, architects, builders, government agents, and private parties involved at different levels of real estate development to get their perspectives and ascertain LIDBMPs at current projects and those already completed. Along with those interviews, our team visited numerous build sites and *areas of particular concern* (APCs) on Saipan, observing and documenting various stages of commercial development as well as gathering examples of current climate disruption impacts including coastal erosion.

This report shares some of our findings and explores solutions from a broad spectrum, a jumping point to more comprehensive resources and information not included in the scope of this document. Saipan has some good examples and those interviewed seemed knowledgeable about common BMPs. Those with the knowledge however are unnecessarily disconnected from those responsible managing the development at various levels. Everyone interviewed from both public and private institutions showed a genuine interest and concern for the people and the environment of CNMI. Everyone interviewed however were professionals at the higher levels of planning and permitting not "boots on the ground" workers or construction site managers who are at the front line of implementing LIDBMPs during the impactful construction phase. We were not able to interview official representatives of any larger development groups and were unable to contact representatives of the resort and casino group association. It seems recent infractions and setbacks have sent a clear message that BMPs should be taken seriously. Every effort should be made to *prevent* violations before they happen rather than deal with them after the fact but regardless, all parties should be mutually invested in resolving problems as quickly and effectively as possible.

This report identifies successful LIDBMPs already successfully implemented and highlights how those can lead to repeatable positive outcomes. Basic adherence to common low-tech

NPSP mitigation techniques should be mandatory throughout the commonwealth. While there is plenty of room for more advanced technologies and techniques, the most effective way to immediately safeguard CNMI's natural health and beauty is to train, educate and require those responsible for the daily operations of construction on how, why, when and where LIDBMPs should be implemented during construction. Higher administration and corporate officers might have some influence, but at the end of the day it's the workers and managers on site that implement protocol. Construction workers should be able to recognize, implement, assemble and deploy basic BMPs and along with their foremen should receive training so all can work together to implement and adhere to best practices. Many questions will remain unanswered for years to come regarding development in CNMI but what can be done to implement LIDBMPs should be done NOW while many of these astoundingly large projects are still in the planning stages. Feedback from interviews included…

- frustration with getting foreign developers to take their professional advice seriously citing linguistic and ethical differences compounded by hubris.
- A lack of shared values with current developers who have experience building in regions with more relaxed environmental regulations or loose enforcement..
- A rift of uncertainty that too many large resort scale projects have been greenlighted without reasonably understanding how they will be built, what their impact will be, and how they should best be approached in hopes of a long-term benefit to the community
- Surprise at the current staggering scale of development in CNMI
- The few excellent permitting, EAS, building and design professionals that have chosen CNMI as their home should be supported in their role safeguarding CNMIs natural environment

## IV. Suggestions for Public Advocacy regarding LIDBMPs

1. Establish an anonymous feedback system for any stakeholder to share concerns or complaints without risk of reprisal such as a local phone number that can receive text messages and images of potential violations that can be reviewed and catalogued.
2. Gather local architects, advisors, consultants and officials together at least on an annual basis. Officials and enforcement, builders and stakeholders should meet in a neutral environment to build relationships and trust. Frustrations, challenges, successes and failures can be shared in a supportive environment.
3. Opportunities for the general public to interact with government agencies and officials responsible for all levels of monitoring the development process. These events should be coordinated as either "public" or "non-public" invitation events and would be designed to build bridges at all levels.
4. Educational opportunities targeting local developers and builders would foster positive feedback loop and sense of responsibility within the community. A permit fee or license renewal discount incentive would boost participation. Training could be mandatory for General Contractors to keep their licenses in good standing. Required training could also prepare them to take on bigger roles in the construction and development of Saipan at the resort scale. If local build professionals have skills and knowledge of value to foreign developers, then more of the development investment will stay in CNMI and the local community.

*Empowering stakeholders at all levels will only improve the chances that LIDBMPs are implemented and maintain*

## V. Introduction

Sustainable development is an elusive concept, especially in remote and isolated areas. Island chains of the South Pacific such as CNMI, Guam and Hawaii are particularly challenged to bring together all the ingredients for effective low-impact development as they also face the immediate impacts of sea level rise (SLR) and climate disruption events (CDEs). A slower percolation of information and technology due to their physical isolation are also challenges as is access to too few knowledgeable and available professionals. Experts outside of CNMI and Hawaii familiar with LIDBMPs should be encouraged and incentivized to bring their expertise to the islands.

Low impact development is critical to protecting CNMI's natural environment and the natural environment is critical to CNMI as a tourist destination which is of course integral to the fiscal health of the commonwealth. The fate of CNMIs fresh water resources are also in question and should be safeguarded at all costs. There are some very positive examples of local progress and best practices already observable in Saipan which to name a few are…

- What appears to be a well-designed and constructed "green roof" in Garapan.
- The smart design and use of stone/mesh gabions at Pau Pau Beach park.
- A centrifugal mechanical filtration device to be installed at the Coral Tree Avenue canal near micro Beach, Garapan
- Prominent promotional and education signs around the island promoting environmental stewardship and common best practices

There is a lot known about what changes are happening to Pacific Islands however trends in climate disruption are accelerating unpredictably. The low-lying western coast of Saipan from San Antonio through San Jose to Garapan and beyond San Roque will be affected by SLR increasing the risk of contamination of the reef lined bay and lower lying fresh water aquifers and brackish wetlands. According to the 2014 climate change vulnerability assessment by the climate change working group, "the villages and stakeholder resources that are located between Sasupe and Tanapag are expected to be impacted the most… Garapan and lower base should be prioritized as climate change adaption planning moves forward…"

The environmental impacts of island development are often hidden by the constant influx of air and water via oceanic and atmospheric currents. Airborne pollutants blown off islands find their way into the oceans and are no less impactful to oceanic carbon sequestration and climate change influence in the bigger picture At face value Honolulu is one of the cleanest cities in our country, in truth it is impossible to measure Honolulu's environmental footprint because pollution is washed or blown away and becomes unobservable and immeasurable. During a March 2018 storm that hit the island of Oahu, 9 million gallons of wastewater was released into Kaneohe Bay on the Windward side of Oahu in a single 24 our period. The speed of dissipation and long term hidden effects makes it difficult to know how such events will impact the natural environment. Prevention of contamination in the first place is the only way of assuring health and safety and BMPs across numerous industries and occupations is critical to prevention.

The high cost of larger repairs and infrastructure replacements sure to be required by future legislation are also why LIDBMPs should be thoroughly implemented in every phase of the construction and development cycle especially at the planning and early dialogue stages. Now is the time for Saipan and CNMI to capture momentum towards preemptive measures. The financial consequences of shutting down construction for blatant violations might be the only way to compel developers to avoid shortcuts and insidious practices aimed at maximizing profit at the expense of the environment. With so many large development projects in the planning and early development stages, setting expectations for compliance and providing basic guidance on what is expected should be communicated to those designing, building and operating these new resort and commercial developments through a variety of materials translated into common languages pertinent to the developers themselves such as Mandarin. Guidance and communication should encompass:

I. Effective design and planning to address…
    i. landscaping, grading and channeling to moderate storm water activity, mitigate erosion and protect coasts and freshwater aquifers from tainted intrusions

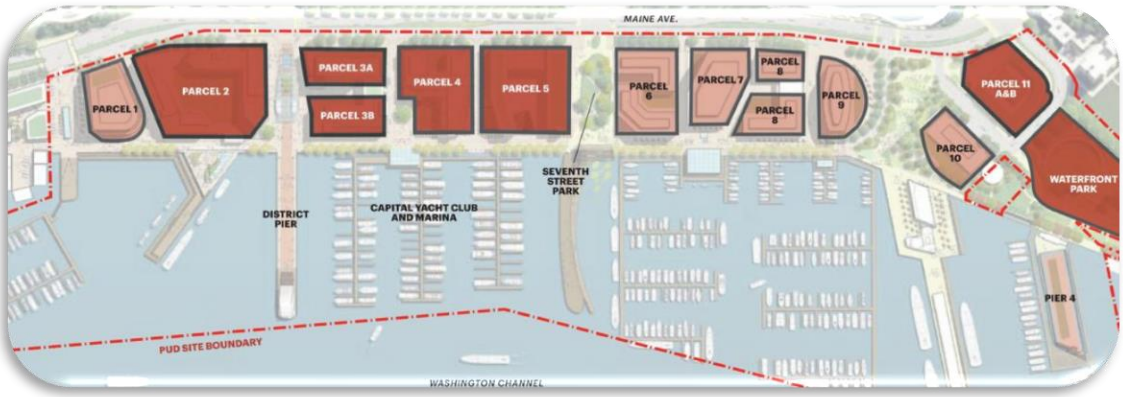
ii. equipment installations such as cisterns and catchment tanks
iii. energy efficiency gains from green roofs and on traditional roofs, reflective coatings and advanced materials to insulae and moderate temperatures
iv. Integrated renewables such as ***solar air-conditioning***
v. low-impact and long-lasting materials and construction techniques to improve resiliency from extreme weather events
vi. Best practices for sealing building envelopes to prevent damage from vectors such as termites and rodents.
vii. developments should be designed to operate assuming SLR will rise 3 meters by 2100.
viii. buffers between development and the coast should mitigate erosion and protect from the advancing ocean during extreme high tide events

II. A site-Specific CONSTRUCTION BMP plan to address…
i. Pollution from building materials and contaminates
ii. Contamination from vehicles and traffic
iii. Wind born particulate matter from the construction process
iv. Erosion and sediment transfer from exposed soil
v. Critical importance of adherence to LIDBMPs directly before and after severe weather events

CNMI's current large-scale developers may not have the best interest of CNMI at the forefront of their decision-making process *right now*. With best practices implemented and adhered to regarding design and construction, implementation and operation, the long-term impact of the current development cycle can be limited to defined outcomes within a scope of variables. Changing weather cycles and patterns being the complete unknown.

## VI. Comparison Project: The Washington DC Wharf Revitalization

Located on prime real estate in one of the most expensive cities in the nation, this project spans 27 acres of land and 50 acres of water and will feature office spaces, residential condos and apartments, hotels, restaurants, shops, entertainment, and many other amenities. The total project is valued at $2-billion. CNMIs current development cycle including a $10-billion casino resort on Rota and a $7-billion casino resort on Saipan is valued at over $20-billion or ten times that of the massive DC Project.


## VII. INCENTIVIZING ADOPTION AND ADHERENCE TO LIDBMPS

### I. Communication & Education

- **A bilingual representative** (preferably able to speak the common language of construction site managers and English) who've attended training on implementing and maintaining LIDBMPs. Individuals with this expertise should be required to be contracted by all major site developers to perform intermediary duties between the developer and local authorities tasked with monitoring best practices on a daily basis.
- **An education program** in conjunction with a local University could train permanent residents in hopes the expertise remains local. Developers could be required to pay into an education fund to setup, maintain and develop young professionals for these positions which could then be administered by the sponsoring University.
- **Easy to understand posters** should be displayed at the entrance and exits of all jobsites and trafficked work and break areas and available in language accessible to all workers.
- **Basic training for Job Site Supervisors** on how to spot, implement and maintain LIDBMPs and why strict adherence before and after major rain storm events is paramount.
- **Partner with locals in proximity to development** to help monitor, identify and track potential LID violations. The Enforcement division could then focus more on fixing problems than finding them, and development must be monitored on the weekends when public officials are off work. An anonymous information system should be established.

### II. Incentives

- **Discounts and subsidies on basic LIDBMP materials** such as bio socks, tarps and perforated mesh used for silt fences as well as stakes and other basic requirements for their installation and maintenance. CNMI could offer such materials at cost and provide a basic storage facility where builders could buy the materials for a reduced amount or they could somehow account for the purchase of such items for an annual tax deduction or other incentive.

- **Reduction of fees or other financial incentives** during any phase of the permit process with proof of exceptional adherence to LIDBMPs.
- **Awards for compliance** that could be displayed at construction sites to instill pride
- **Fostering healthy competition** between developers for "green design" bragging rights with awards and annual public announcements and/or events. HS Lee's green roof top terrace would be an excellent location for such an event and could receive the first award.
- **Subsidized advertising** and announcements for projects that adhere to standards of excellence. This might be administered by the bureau of economic development which may already administer such programs for boosting the local economy and helping smaller businesses.
- **Enhanced service or fast track of processes/inspections once they've proven adherence to LIDBMPs** , anything to save developers time and money once they have hit certain milestones or made definable improvements in their best practices.
- **Promote branding and/or artwork on dust barriers and silt fences** to motivate use and offer a positive advertising opportunity for construction companies and developers to enhance their image and build excitement during the construction phase. Simple stencils or the opportunity for local students/artists to paint/add imagery to barriers and barricades might tie their use in with the community and promote usage.

## III. Penalties and Consequences

- Financial penalties applied to the fund for pollution mitigation tarps, bio socks and other basic materials
- required to sponsor or host a LIDBMP event or somehow contribute to proactive efforts towards better future implementation
- Community service for local build teams designed to spread awareness of LIDBMPs and generate public stakeholders; a park cleanup or some activity in conjunction with a local club or philanthropic group to bring awareness to existing education signs and billboards.
-

## VIII. Barriers to Implementing LID Best Practices

### The language barrier

Based on our interview assessments language and communication are the most challenging factors in dealing with current developers. Past developers such as those responsible for the Hyatt Regency Saipan seemed to have had held the importance of best practices in high regard. Current development groups have significantly less interest in local stakeholders and seem primarily focused on autonomy and bottom line profitability.

Every effort should be made to reach the core decision makers of all major development groups so expectations for communication and compliance can be established at the highest level before any project breaks ground. Once construction begins the most effective enforcement might be to "speak softly and carry a big stick".

### A transient workforce

There is no doubt that the draw down on foreign workers due to the embattled CW-1 Visa program is having a huge impact on productivity and build costs. Honolulu is in the middle of the biggest build cycle in history and with unemployment under 2%, the great state of Hawaii has very few eligible workers to supplant those departing. Strong construction and development on the mainland US means that attracting any type of domestic workers to CNMI will be a major challenge. Those that come to CNMI to work may not envision staying and therefore do not become stakeholders in CNMI's future.

### Disempowered Apathy

CNMI's current massive development cycle might feel enormous and overwhelming. Those that lose hope and confidence in a better tomorrow often lose motivation to do their best and instill the best in others. Outreach should focus on positive outcomes and empowerment to do better. Popular media and news feeds on negative energy. Look for opportunities to spin apathy into empathy.

## IX. Categorizing LIDBMPs

LIDBPs are critical to more sustainable development and have specific applications depending on climate, weather and topography as well as many other factors. Island communities such as Hawaii and CNMI require strict adherence to particular BMPs due to the proximity with the ocean, fisheries and sensitive wetlands as well as the fragility of limited freshwater resources. While no definitive complete LIDBMP manual exists, the latest version of the "Storm Water BMP Guide for New and Redevelopment" along with the "City & County of Honolulu Storm Water Best Management Practice Manual : CONSTRUCTION" best represent the most comprehensive effort to date in categorizing and systematizing LIDBMPs relevant to pacific islands. LIDBMPs can be categorized into ***3 primary PHASES*** and ***3 sub categories*** for each phase to encompass the entire development process. Other guides tend to group all phases and their corresponding approaches into 2 primary categories : *Permanent BMPs* and *temporary BMPs.* While the "permanent/temporary" labels are effective for academics, a layman may have difficulty knowing how they relate to a specific development activity. To get BMPs implemented by the "boots on the ground" approaches should be relevant to the phases of the project itself. The sub-categories presented here are **Storm water, Non-storm water, and CE&E**. "Storm Water" deals with natural precipitation or intrusion of water focusing on NPS runoff and erosion control. "Non-storm water" addresses existing natural water features along with water introduced during development as well as contaminants that can enter the biosphere from washing and operations. This category also applies to existing water features, old and new irrigation, and concrete mixing protocol on site. An equally important third sub-category is "clean energy and efficiency". Every phase of the development cycle should incorporate energy wise practices and equipment to minimize the project's carbon footprint and are referred to as "Clean Energy and Efficiency" measures

## X. The 3 PHASES OF LIDBMP Implementation


During the *design and planning phase*, pay careful attention to existing topography and soil composition as well as existing relationships with flora, fauna, and natural water processes both stable and transitioning. All water, even that in features such as lakes and ponds may appear fixed, yet we know it is always cycling though slower than streams and rivers. During *construction*, strive for efficiency and environmental stewardship by examining material composition, milling and fabrication techniques and locations, transportation, and the total impact of operations. Off site, environmentally controlled, prefabricated manufacturing to limit site-specific environmental impacts in all phases of development and construction is a growing trend. Once site work is underway, BMPs for mitigating the substantial impact of any size construction project should be automatic. US compliant building materials sourced from Asia should be examined for safety and compliance with current health and performance standards. Utilizing compliant materials such as engineered wood and wood composites, drywall, cement board and the like is critical to limiting harmful pollutants from entering the environment during the construction phase from sawdust, off-gassing and compositional shedding. If *ongoing operations* are water-wise and energy efficient, developers and communities will benefit the most from embedded operational cost savings, slower degradation and lesser environmental impact

DESIGN & PLANNING ONGOING OPERATIONS

**Architectural landscaping a development's biosphere**

Site specific planning is absolutely critical to the long-term success of low impact development for a variety of stakeholders. Our research found that past developers of the Hyatt Regency took care and consideration to design and construct water wise landscape systems incorporating both natural and artificial features such as wetlands runoff systems, cistern storm water catchment, and designed topography to control runoff and saltwater intrusion. Paths and recreational areas are important to any development yet also a constant source of contamination & pollution from human use and traffic. The best way to mitigate pollutants from entering into ground water aquifers are to control what happens to rainwater when it lands on buildings or areas of elevated pollution. The most effective way to do this is to incorporate ***water wise systems*** into the most basic excavation and landscape planning.

*All large-scale developments should require a landscape architect familiar with the importance of topography and natural filtration systems to present a detailed plan on how storm and non-storm water from the entire property percolates into the ground or runs into local waterways along with how those processes be supported, restored, supplanted or modified to benefit the natural environment.*

Wholistic design and planning means careful consideration should be given to the entire development process and incorporated into a detailed development plan document prior to any actual construction taking place. Landscaping measures should be implemented first to help mitigate the effects of the construction itself once underway.

***The "order of execution" is of critical importance once transitioning from the design into the construction phase.***

Failure to plan effectively is the most costly and detrimental mistake. A veteran kitchen designer who works with clients designing and building new kitchens will affirm that homeowners go overbudget when the plan changes midstream of the project. Placement changes or plan alterations once construction is underway are much costlier than if the careful plan remains largely unaltered.

***Developers with the most financial stake should be made well aware of the long-term cost savings and value enhancements of LIDBMPs which can be captured in the Design and Planning phase.***

**LEED Certified architecture and design** are the most universally recognized practices, procedures and design protocol to maximize energy efficiency and minimize the overall impact of the large-scale design / build process.


FIGURE 8


DESIGN & PLANNING

ONGOING OPERATIONS

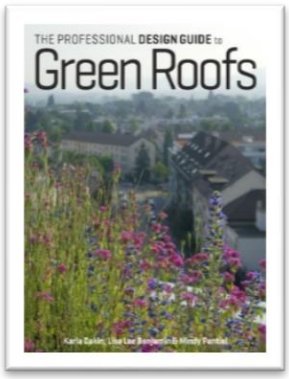
**Green Building from the Start**

The best way to mitigate the long-term impacts of building and development is to design and implement LIDBMPs from the start *within the design envelope of the building itself*. Design/Build practices once relegated to forward thinking developers are now commonplace in everyday construction throughout the developed world. The internet is an excellent resource for LIDBMPs. Though LEED certified professionals bring a high level of knowledge and expertise, a lack of access to them should not prevent developers from meeting some or all of those goals on their own. Lifecycle analysis plays a critical role in determining the true impact of a product, service or technique. CFL bulbs, for example, last a long time if continuously on with the ballast powering the mercury laden bulb the weak link. NO CFL bulbs should be used in new construction, especially on islands where proper recycling protocol is unavailable.

## Green Roofs and Rooftop Gardens

a green roof, or rooftop garden, is a vegetative layer grown on the top of the building. Green roofs provide shade and remove heat from the air through evapotranspiration, reducing temperatures of the roof surface and the surrounding air on hot summer days, the surface temperature of a green roof can be cool in the air temperature whereas the surface of a conventional rooftop can be up to 100°F or 50 the 5°C warmer green roof tops can be installed on a wide range of buildings from commercial to residential. They can comprise as little as a 2 inch covering of basic grass or lose you or as complex as a park with trees and larger plant installations.

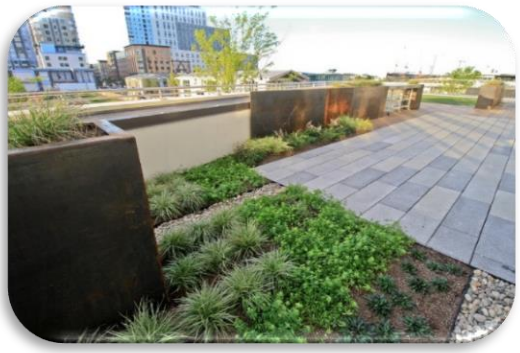
## Benefits of Green Roofs




1. **Reduced energy use** : green roofs absorb heat and insulate buildings reducing the energy needed to maintain optimum temperatures through heat and air-conditioning

2. **Improved aesthetics:** green roofs improve the view of the landscape from any visible point above the elevation of the roof. Four areas at sea level with surrounding mountains or hire perspectives this is especially pertinent.

3. **Enhanced water quality and storm water management**
   plant roots and sediment in appropriate layers reduce and slow storm water runoff while filtering pollutants from rainfall



### 4. Air pollution and greenhouse gas emissions reduction

green roofs decrease the production of associated air pollution and greenhouse gas emissions by lowering air-conditioning demand. Plants can also remove air pollutants and greenhouse gas emissions through dry the position and carbon sequestration and storage. Root systems from green roofs along with multiple layers of sediment help trap, contain, and retain various pollutants

### 5. Enhanced health and comfort

consistent temperatures and improved air quality improve indoor comfort and lower stress associated with heat waves

| Benefit | Beneficiaries | Assumption | Type | Valuation |
|---|---|---|---|---|
| Property Value | | | | |
| View onto a green roof | property owner and/or neighbors* | independent area | one-time | up to 4.5% property value (portion above green roof) |
| Recreational Garden | property owner | independent area | one-time | up to 11% property value |
| Productive Garden | property owner | occupant access, independent of area | one-time | up to 7% property value |
| Food Production | property owner | excluding labor and material cost | ongoing | $0.18-$1.85/sf per growing month |
| Sound Attenuation | property owner | affects top floor only, air traffic noise only, independent of area but assuming extensive coverage | one-time | 1.6%-4.3% property value of top floor |
| Stormwater Retention | developer, municipality | 1.05 gallons/sf retention capacity | one-time | $0.13-$4.25/sf |
| Air Quality | municipality, state | | ongoing | $210-$339/acre |
| GHG Sequestration | municipality, state | | ongoing | $11-15/acre |

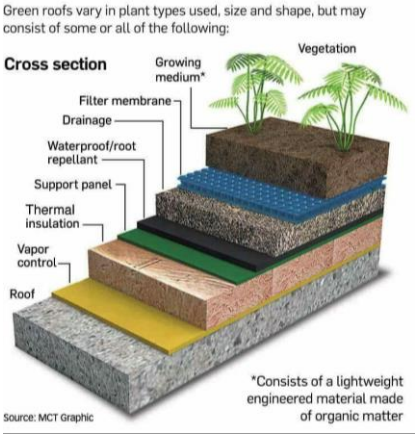
* If the green roof can be seen from at least part of the host property

### 6. Higher Property Values

green roofs have been shown to significantly in improve property value and desirability. The amount of appreciation varies tremendously from location to location but is often tied to the long-term measurable energy cost savings identified from before and after a green roof is installed. This might be harder for new construction but for existing buildings such as the HS Lee building in Garapan the benefits from energy savings should be measurable . This chart serves as an EXAMPLE ONLY of quantifiable aspects.

**What SUCCESSFUL green roofs have in common :**

- Structural engineering for additional weight
- Multiple layers of membranes to assure the integrity and longevity of the installation
- Careful design, planning and installation without cutting corners
- Proper vegetation for the desired outcome
- Properly designed runoff and drainage systems
- Proper ongoing maintenance and inspections




**Renewable Energy and Efficiency Solutions**

| GREEN ROOF SYSTEMS according FLL | SYSTEMS WITH GRANULAR DRAINAGE | | | | SYSTEMS WITH DRAINAGE PLATES | | | |
|---|---|---|---|---|---|---|---|---|
| system designation | G1 | G2 | G3 | G4 | P1 | P2 | P3 | P4 |
| typical plants | sedum herbs | sedum herbs perennials | perennials grasses shrubs | grasses shrubs trees | sedum herbs | sedum herbs perennials | perrenials grasses shrubs | grasses shrubs trees |
| extensive soil mix | 2" | 4" | - | - | 3" | 5" | - | - |
| intensive soil mix | - | - | 6" | 9" | - | - | 8" | 12" |
| separation fabric | 1/8" | 1/8" | 1/8" | 1/8" | 1/8" | 1/8" | 1/8" | 1/8" |
| granular drainage | 2" | 2" | 4" | 6" | - | - | - | - |
| drainage plate | - | - | - | - | 1" | 1-1/2" | 1-1/2" | 2-1/2" |
| drainage mat | - | - | - | - | - | - | - | - |
| protection mat | 1/4" | 1/4" | 1/4" | 1/4" | 1/4" | 1/4" | 1/4" | 1/4" |
| nominal thickness | 4" | 6" | 10" | 15" | 4" | 7" | 10" | 15" |
| dry weight | 19 lbs/ft² | 28 lbs/ft² | 45 lbs/ft² | 69 lbs/ft² | 14 lbs/ft² | 23 lbs/ft² | 34 lbs/ft² | 52 lbs/ft² |
| saturated weight | 26 lbs/ft² | 41 lbs/ft² | 70 lbs/ft² | 105 lbs/ft² | 23 lbs/ft² | 37 lbs/ft² | 57 lbs/ft² | 85 lbs/ft² |
| minimum slope | 0:12 | 0:12 | 0:12 | 0:12 | 1/4:12 | 1/4:12 | 1/4:12 | 1/4:12 |
| maximum slope | 1:12 | 1:12 | 1:12 | 1:12 | 1:12 | 1:12 | 1:12 | 1:12 |
| water retention/Year* | 50% | 60% | 70% | 80% | 50% | 60% | 70% | 80% |
| irrigation system | - | - | subsurface | subsurface | - | - | surface | surface |

Incorporating solar energy systems and other efficiency measures can both reduce the long-term impact of a development and aide its progress. CNMI sometimes faces inconsistent power supply and interruptions due to severe weather events. Batter backup systems and solar power centers could mitigate spikes in electrical use during construction and provide needed backup in the event of an outage. Installing solar PV has tremendous long-term advantages and should be required for all large-scale developments.



**Solar Air Conditioning**

For existing redevelopment or improvement Solar powered A/C systems are an ideal way to upgrade existing HVAC without more expensive and complicated solar electrical systems. This closed loop system allows compressors to be powered by either solar or grid power and can continue to operate without sun but is essentially self-sufficient during peak hours of use during the day.

DESIGN & PLANNING ONGOING OPERATIONS

STORM WATER

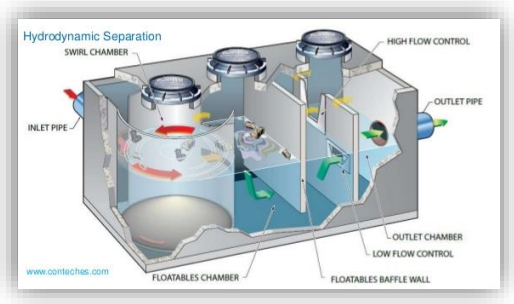
**Permeable All Weather Surfaces**

Porous yet functionally load bearing surfaces are easy to implement and versitile. also reduce solar refraction and thermal retention to lower air conditioning bills, reduce glare and add to the natural ambiance of any trafficed surface. The addition of grass, roots and sediment also helps trap pollutants from cars and machinery that would otherwise be washed away an into a drain from a non-porous surface.

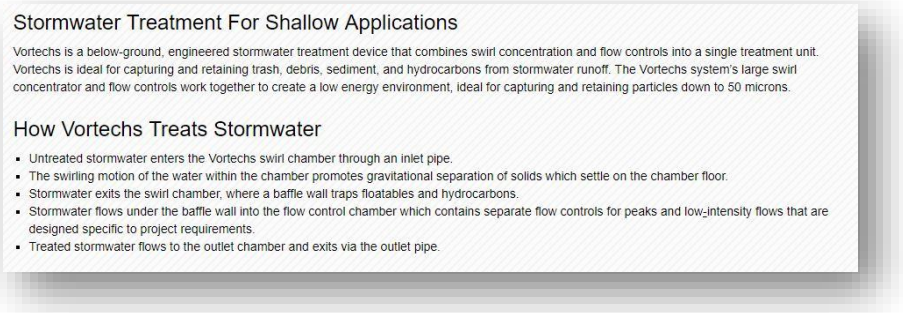
**Living Shorelines** – A hybrid mix of various natural materials (e.g., oyster reefs, artificial coral reefs, vegetation, sand, rocks) that can have the benefit of providing coastal protection and habitation enhancement.

**Gabions** – Basic engineered heavy barrier structures such as industrial size sandbags and wire mesh rock installations that secure soil, sand and sediment from erosion and/or subsidence

## Gravitational Separation Systems




CAD design and 3D modeling are producing new technologies to mitigate the effects of NPS water runoff. Stormwater clarifying devices use runoff water's energy and movement to separate water from sediment and pollutants. One such device is the Vortech storm water treatment system evidently to be installed at the coral street canal on the north side of the Imperial Pacific Resort. Through the process the water's energy is dissipated reducing the erosion potential of the subsequent runoff out of the system.



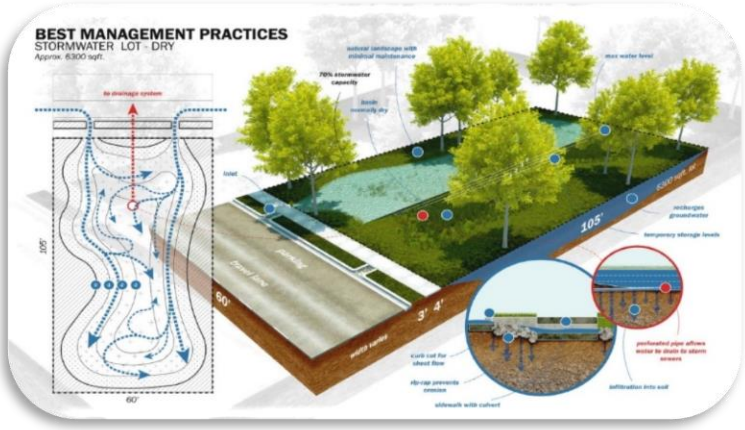
Stormwater Treatment For Shallow Applications

Vortechs is a below-ground, engineered stormwater treatment device that combines swirl concentration and flow controls into a single treatment unit. Vortechs is ideal for capturing and retaining trash, debris, sediment, and hydrocarbons from stormwater runoff. The Vortechs system's large swirl concentrator and flow controls work together to create a low energy environment, ideal for capturing and retaining particles down to 50 microns.

How Vortechs Treats Stormwater

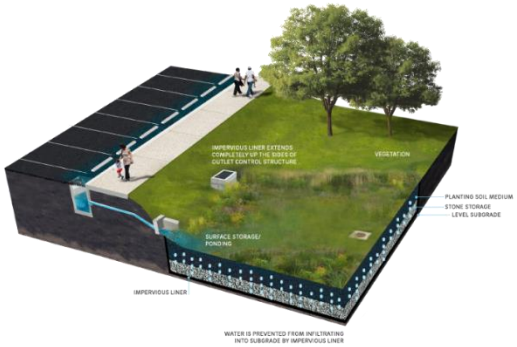
- Untreated stormwater enters the Vortechs swirl chamber through an inlet pipe.
- The swirling motion of the water within the chamber promotes gravitational separation of solids which settle on the chamber floor.
- Stormwater exits the swirl chamber, where a baffle wall traps floatables and hydrocarbons.
- Stormwater flows under the baffle wall into the flow control chamber which contains separate flow controls for peaks and low-intensity flows that are designed specific to project requirements.
- Treated stormwater flows to the outlet chamber and exits via the outlet pipe.

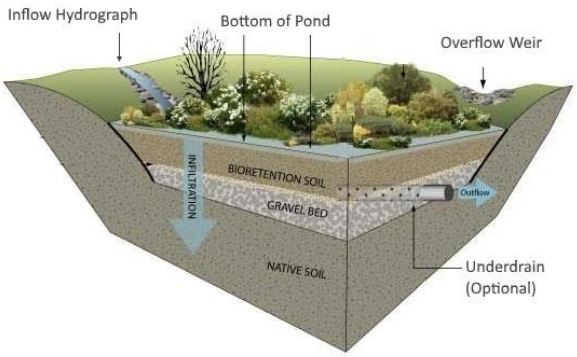
## Advanced Drainage Systems




Installation of parking lots, walkways, greenspace, or any development involving grading and excavation altering the course of water runoff and should be addressed in the planning stage. Controlling the direction, velocity and quantity of water while clarifying it is important to mitigating erosion and storm water impacts. There are a wide variety of approaches some of which have similar labels and definitions such as:

**Designed Runoff**

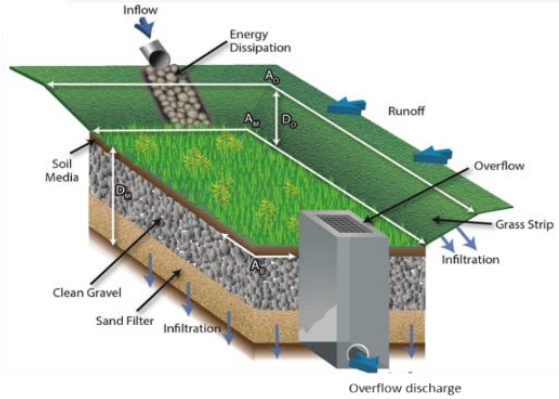


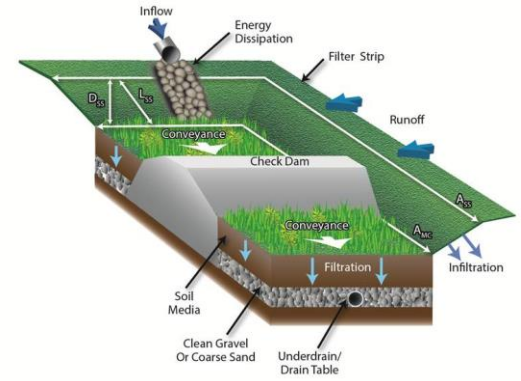



**Bio-Retention basins** collect contaminants and sediment into a "treatment area" consisting of grass buffers, sand bed, a ponding area and some form of organic or mulch layer with locally appropriate plants and soil.


**In-filtration Basins**

**Ex-filtration Basins**




**Check Dams**

**Vegetative Swales**

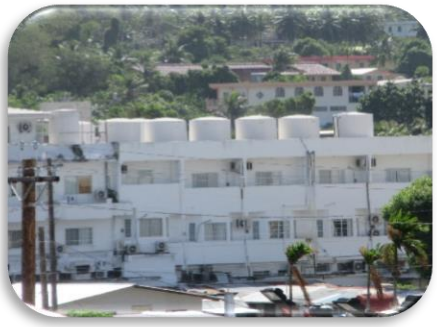
## Advanced Stormwater Treatment Facilities

Facilities such as Sherbourne in Ontario Canada utilize UV light and intelligent engineering to isolate sediment and pollutants while TrojanUVFit reactors disinfect the discharge into Lake Ontario

Waterfront Toronto

**Cisterns & Catchment Systems**

Catching water and using it for other applications is a proven method for mitigating NPS pollution and reducing the overall footprint of any size development. When water sits idyl in larger tanks, particulate matter in the water settles to the bottom and with basic filters and an effective pump design, the water can be redistributed to landscape irrigation and other non-potable uses. Regardless of the contaminanats, redistribution of catchment water to ponds and *interceptor wetlands* are an effective way to clarify stormwater discharge. The island electrical grid are more prone to blackouts and using gravity to aide pumps and water flow increases the level of water security. Elevated cisterns as seen on an apartment complex in central Garapan (pictured right) is a good way to let gravity help maintain water pressure. The other examples pictured are of are larger, resort scale complexes similar to that under the tennis courts at the Hyatt Regency in Garapan. Cistern designs integrated into the initial planning phase means that massive tanks can be strategically located on any size property out of sight yet pragmatically accessible. Periodic maintenance through a a sewer manhole type entrance allows for the tanks to be cleaned and inspected for their structural and operational integrity. Water catchment systems should not be a substitute for use reduction whenever possible. Moderating the use of water for ongoing operations through restrictive faucets and fixtures will reduce water use resort wide and mitigate the impact of guest behaviour which is out of the control of resort



management. One suggestion: Use catchment water for laundering sheets and towels on site at the resort. Grey water effluent from the laundry facility could be infinitely reusable if careful considerations are made concerning the type and composition of detergent, the amount of water required by machinery to effectively clean, and the stages of additional purification applied to the discharge after the laundry cycle and before it is reintroduced into the catchment system for use once again. Such LOOP systems are at the core concept of "cradle to cradle" thinking and if Saipan is to reach any level of long term sustainability, clarification systems with serviceable, reusable filters and natural organic cleaning processes with *natural pools* to help establish "regeneration zones" should be implemented.

DESIGN & PLANNING ONGOING OPERATIONS

NON-STORM WATER

**Grey water recycling systems**

Pump and filtration devices that take in tainted water and filter it for non-potable uses with minimal environmental impact

**Filtration ponds**

Scenic water features that designed to strategically circulate water, enhance oxygenation and propagate beneficial organisms to naturally improve water quality

**Vegetative Islands**

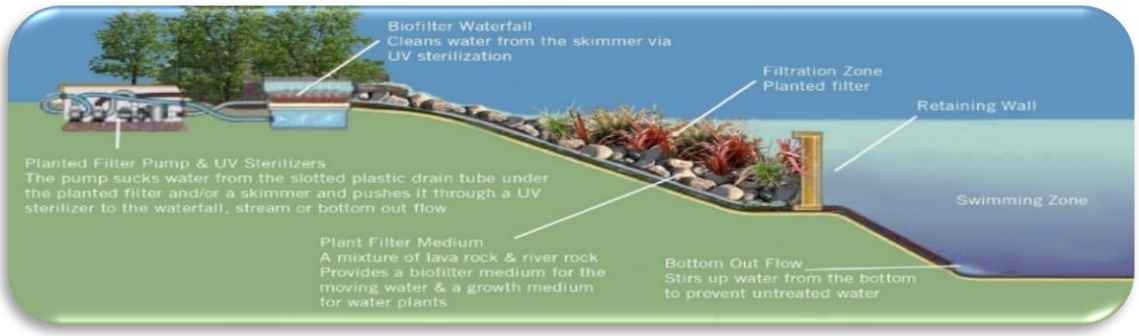
Artificial frames that incorporate Porous features allowing suitable plants to root, grow and flourish, eventually hiding a majority of the original structure

**Floating Wetlands**

Floating wetlands are designed to mimic nature and enhance water quality while limiting algae growth

**Natural Swimming Pools**

The operations, maintenance, design, chemical requirements and general ambience of pools is evolving rapidly. Unlike generic concrete pools of the past heavily chlorinated for sterility, natural pools use the most current water purification science to becaome an integrated landscape feature serving multiple functions. Such pools could readily be installed in conjunction with traditional pools to also serve as low level catchment purification systems prior to




releasing water back into the resort system or into the natural invironment in the case of flood or overflow.

Natural swimming pools would be of greater pertinence in zones above sea level where the chance for saltwater interaction is nonexistent. Having a natural pool based on freshwater vegetation and ecosystem would be jeopardized by saltwater intrusion from storm surge. Wisely, the primary vegetative purification pond at the Hyatt Regency is located some 10 feet above sea level providing both a waterfall feature that narrates the water being pumped but also allowing for the freshwater vegetation to be isolated from saltwater intrusion during king tied events. Natural ponds, pools, and vegetative purification systems are definitely pertinent where they can be protected from extensive saltwater intrusion. Given that most of the major development is at sea level or close to the ocean any such features should be carefully examined for their sustainable long-term viability.

Ground disturbing activities include:
- digging
- exposing bare soil
- heavy truck access
- construction of new structures
- grading, grubbing, stockpiling, and trenching within city right-of-way
- breaking up existing grass, concrete or asphalt
- excavation, equipment storage/staging
- demolition of existing foundations/structures

**CONSTRUCTION**

**STORM WATER**

Bio Socks, Silt fences and covered stockpiles along with dust control barriers are the low hanging fruit of BMPs that should be successfully implemented at every build site. These sometimes tedious, unexciting day to day BMPs are absolutely critical during major storm events when runoff peaks. Compliance with basic best practices often falls on the lowest level of management or site workers so it's important that training and education be as simple and effective as possible.

**Bio Socks** – utilizing permeable sacks filled with composting material to naturally filter sediment and pollutants from runoff,

**Silt Fences** – Barriers to limit the entry of sediment and pollutants into drainage systems,




**Covered Stockpiles** – covering freshly exposed soil so storm water runs of without carrying sediment with it.,

**Perimeter Dust & Noise Barriers** – basic frames often skinned with construction fabric to prevent the transport of airborne dust and pollutants

**Accountability –** The general public, builders and stakeholders should know when certain ground disturbing activities warrant careful adherence to BMPs.

**Job Site Posters** - Best practice imagery and clear instruction in a variety of accessible languages, are a valuable tool for educating the boots on the ground responsible for compliance.

*Storm Water BMPs related specifically to construction is a vast topic not coverable in the scope of this document. For detailed information, once again, the "Honolulu Storm Water Best Management Practice Manual" should be consulted among other viable resources.*

CITY AND COUNTY OF HONOLULU
STORM WATER BEST MANAGEMENT PRACTICE MANUAL

CONSTRUCTION

**Table 3-1: Erosion Control BMPs**

| BMP# | BMP Name |
|---|---|
| EC-0 | Employee/Subcontractor Training |
| EC-1 | Scheduling |
| EC-2 | Preservation of Existing Vegetation |
| EC-3 | Hydraulic Mulch |
| EC-4 | Hydroseeding |
| EC-5 | Soil Binders |
| EC-7 | Geotextiles and Mats |
| EC-8 | Wood Mulching |
| EC-9 | Earth Dikes and Drainage Swales |
| EC-10 | Velocity Dissipation Devices |
| EC-11 | Slope Drains |
| EC-12 | Streambank Stabilization |
| EC-14 | Seeding, Planting and Sodding |
| EC-15 | Slope Roughening/Terracing |
| EC-16 | Topsoil Management |

# CONSTRUCTION

NON-STORM WATER

**Foundation Piles, elevated construction** - Deep Piles, drilled and driven into the ground for the elevated construction of homes, buildings and living spaces (including gardens) above flood zones as well as to reinforce berms, barriers and gabions to stabilize soils, sediment and sand.

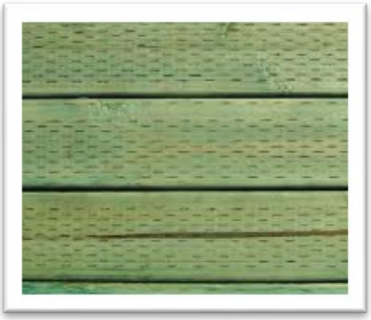
**Vehicle & Equipment Washing** – contained areas where vehicles and equipment entering and leaving construction sites can be washed of contaminants. Ideally the water is pumped, filtered and recycled from the basin.

**Vehicle Safety Inspections** –Engine and fluid checks for preventable leaks, hydraulic leaks, degraded exhaust systems responsible for excessive noise and emissions.

The United States and Europe commonly subsidize energy-efficient appliances, solar water heaters, LED lighting and energy star HVAC systems to encourage their use. While adoption may be slower since islands seem a decade+ behind the rest of North America, the island microcosm often means when things do change, they are widely adopted.

**Building Material Compliance** On a very basic level "building material compliance" is an important part of mitigating the longer-term pollution chain throughout the development process. Pollution chain refers to a process of examining any one material and the processes applied to that

material throughout the construction process to ascertain its overall environmental impact. The common use of pressure treated lumber for instance is a most basic thing to examine. Chinese lumber that has not gone through any type of a toxicity analysis may contain treatment that serves the lumber well from a durability, longevity, termite and rot resistance and cost perspective suiting the needs of the builder but may also have numerous unacceptable toxins mixed in with the treatment that when pulverized through the onsite milling and cutting process may leach into the ground from the dust and byproducts of the building process. Our teams significant building experience both in China and sourcing materials from China have given us first-hand experience with how difficult it is to account for products that have no transparency associated with their manufacturing. As in many cases, including the US prior to the EPA and the "silent Spring" lead environmental movement of the 60's and 70's, any petrochemical companies or other industries with significant amounts of toxic bi-products are always looking for secretive and innovative ways to dispose of those toxins such as incorporation into drywall, composite building materials, and other products. Those products may benefit from these toxic additions or simply serve as a disposal system to save someone money. Even if their negative impacts aren't immediately apparent, they may release their toxicity later in life due to water damage, demolition or in previous cases of some such drywall, through the off gassing of noxious fumes not easily recognized but impacting public health none the less.

**Building Materials to examine and certify**

- All pressure treated lumber AKA "Green wood"
- Drywall and MGO (Magnesium Board)
- Composite structural, sheeting and sidings (OSB, fiberboard, laminates)
- Interior & exterior epoxies, resins and fillers applied as a paste that dry hard and are sanded and coated for the desired appearance.
- Paint and coatings that may leach into the environment as a liquid during construction or throughout its normal degradation process after application.
- Roofing materials of all styles, types and applications, especially those of asphalt and petrochemical composition.

*Non-Storm Water BMPs related specifically to construction is a vast topic not coverable in the scope of this document. For detailed information, once again, the "Honolulu Storm Water Best Management Practice Manual" should be consulted among others.*

CITY AND COUNTY OF HONOLULU
STORM WATER BEST MANAGEMENT PRACTICE MANUAL

CONSTRUCTION

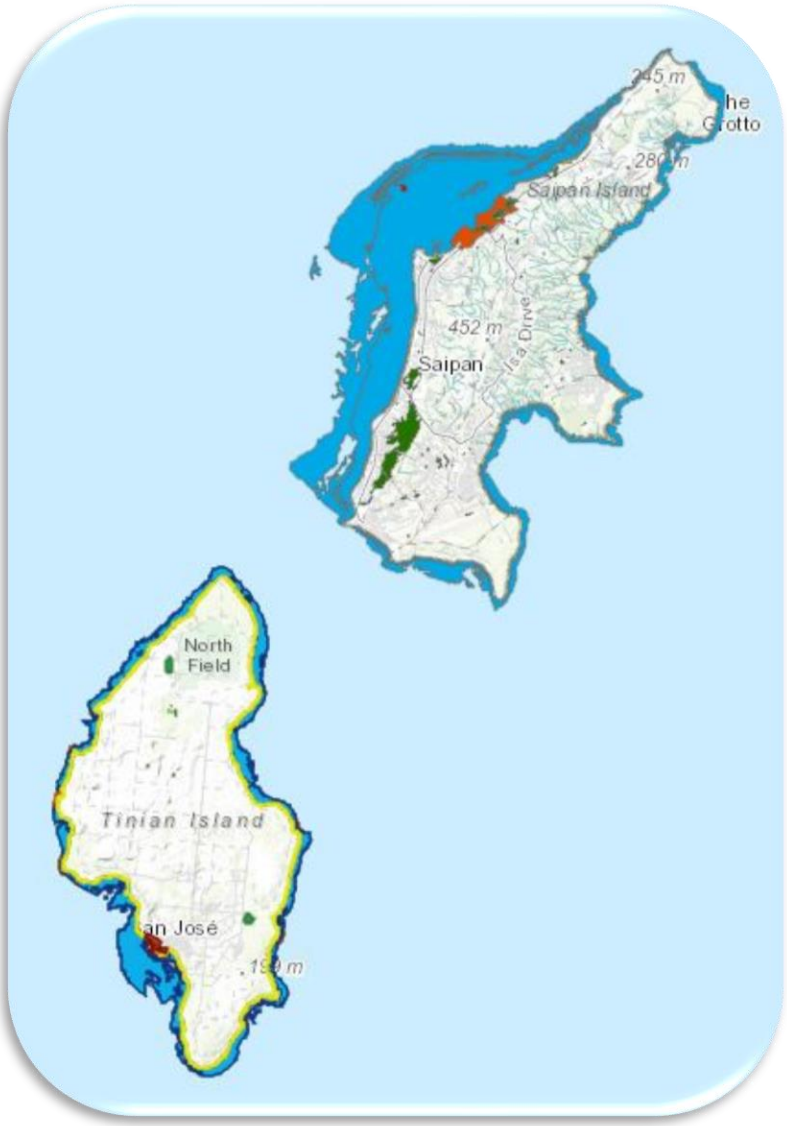
**Table 4-1: Non-Storm Water Management BMP**

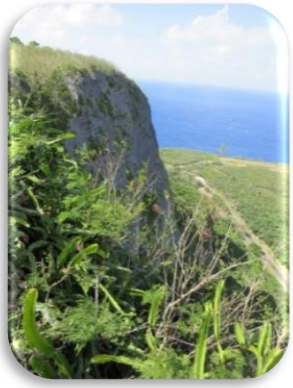
| BMP# | BMP Name |
|---|---|
| NS-1 | Water Conservation Practices |
| NS-2 | Dewatering Operations |
| NS-3 | Paving and Grinding Operations |
| NS-4 | Temporary Stream Crossing |
| NS-5 | Clear Water Diversion |
| NS-6 | Illicit Connection/Discharge |
| NS-7 | Potable Water/Irrigation |
| NS-8 | Vehicle and Equipment Cleaning |
| NS-9 | Vehicle and Equipment Fueling |
| NS-10 | Vehicle and Equipment Maintenance |
| NS-11 | Pile Driving Operations |
| NS-12 | Concrete Curing |
| NS-13 | Concrete Finishing |
| NS-14 | Material over Water |
| NS-15 | Demolition Adjacent to Water |
| NS-16 | Temporary Batch Plants |

# XI. SAIPAN'S UNIQUE ENVIRONMENTAL ASSETS

The beauty of the island's waters and natural ancient reef structures along with a unique cultural and geological history make protecting CNMI's natural beauty imperative to its vitality as a tourist destination. Active and growing tourism is an essential component for supporting and maintaining the current development cycle.

**APCs: Areas of Particular Concern – Saipan**



Areas of particular concern are places that are most vulnerable and sensitive to climate disruption, SLR and the pressures of development. Protected areas such as Managaha will be subject to increased visitation from the growing number of tourists and may experience ancillary stress from the additional resort infrastructure.

Though much of the existing reef system is not alive or is in decline, it should be protected to the greatest extent possible in hopes it will rebound. Whether living or dead the reef still hosts abundant other aquatic life. The most predominate APCs are on the west coast of the island, a coastal plain with various fresh water/salt water interaction zones. APCs along

Beach road (Rte 33) stretching from San Antonio to Garapan are most vulnerable to the consequences of development, sea level rise and increasingly intense king tides. Coastal zones North of Tanapag past Matuis are exposed to deeper water currents and increased topography which might mitigate nearshore pollution but may also exacerbate erosion. The more sensitive low-lying groundwater percolation systems and wetlands South of Garapan are most vulnerable to the effects of salt water intrusion. Developments such the Saipan Globe build site that occur on low lying level coastal projections should focus on retaining and reusing discharge and storm water. Effluent discharge between the Outer Cove Marina and Commercial Port may be swept out to sea by ocean currents but are still inside the outer reef boundary and in direct proximity to the protected areas of Managaha. Such discharge and the bay channel should be monitored for water quality and the dissipation of pollutants (Figures 13-18)

## XII. Potential Climate Change Impacts on CNMI

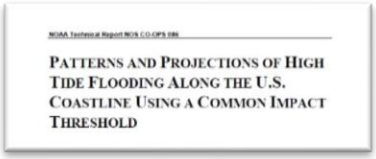
S. Jeffress Williams

The following material addresses the two DCRM priority needs discussed in the "IV Strategy to Meet Priority Needs (FY 2016-2020)" document (pages 106-132)

As discussed in Greene and Skeele (2014), *Climate Change Vulnerability Assessment for the Island of Saipan,* ongoing climate disruption globally will have many cumulative impacts to CNMI. Most will have long-term effects and impacts CNMI-wide, directly affecting both existing and future development in many significant ways by increasing risk and vulnerability, as well as impacting natural resources and processes across the region. Observations over the past several decades show that changes in weather patterns driven by climate change, are already disruptive and impacting the island economy, tourist industry, and the general quality of life. These disruptions are likely to have even greater impacts in decades ahead unless plans and regulations for adaptation and mitigation are developed, implemented, and stringently enforced to address the human causes and impacts of climate change.

### The Primary Impacts of Climate Disruption

- Accelerating global and local sea-level rise
- Changes to the ENSO (El Nino & La Nina phases) global and local weather patterns and cycles
- Increased typhoon/ tropical storm frequency and intensity (e.g., Typhoon Soudelor (Hanna)
- Increased storm-surge-flood elevations and storm-wave heights and energy
- Increased coastal erosion–land loss risk
- Increased areal extent and frequency of inland flooding of low-elevation areas
- Increased salt-water intrusion into limestone fresh-water aquifers
- Reduced public access to beaches, reefs (e.g., erosion, boat ramps, docks)
- Increased frequency and extent of recurrent or "nuisance" coastal "king-tide" flooding




NOAA's most recent data and projections can be found here: https://tidesandcurrents.noaa.gov/pub.html

https://tidesandcurrents.noaa.gov/publications/techrpt86_PaP_of_HTFlooding.pd

- Increased soil erosion and sediment-and debris-runoff pollution to beaches, wetlands, and coastal/nearshore regions
- Increased wetland loss and degradation
- Increased air and ocean temperatures and air-moisture content (i.e., intense/variable rainfall/drought, coral bleaching, altered turtle-gender ratios, reduced fish diversity)
- Increased ocean acidification (i.e., reef, shellfish decline)
- More highly-variable weather patterns, more intense precipitation and drought events
- Changes to coastal-nearshore-marine environments (i.e., coral reefs, mangroves, benthic habitats)
- Increasing variability of environmental and economic conditions for aquaculture diversity and production

Record-breaking weather disasters such as Hurricane Iniki (1992) in Hawaii, Hurricanes Katrina (2005) New Orleans, Sandy (2012) New York, Harvey (2017) Texas, Maria (2017) the Caribbean, and Typhoon Soudelor (Hanna) in CNMI and the western Pacific indicate trends of increased frequency and severity of major storm events. Typhoon Soudelor, a category 5 storm, was the strongest tropical cyclone of 2015 striking Saipan on August 2, 2015. Soudelor was the most intense, most damaging storm to hit CNMI in nearly three decades.

Widely accepted science continues to indicate that increases in the concentrations of greenhouse gases (e.g., carbon dioxide) in the atmosphere, primarily from the burning of fossil fuels, are the cause of the global warming conditions leading to the extreme weather events experienced in recent times. Estimates are that rainfall has increased by more than 15 percent which made the extreme rain during Hurricane Harvey which dumped more than 40 inches of rain on Houston in three days, three times more likely.

CNMI will face similar such extreme weather events being experienced across the U.S. mainland. Increases in extreme weather experienced over the past couple decades such as intense rainfall, longer droughts, more frequent and more intense storms are due to the fact that a warming atmosphere and oceans can hold more moisture and provide more energy for storm development and intensification. Higher sea levels will make typhoons, enhanced by global warming, even more destructive to CNMI.

Higher global sea levels result from the combination of the melting of land-based glaciers and ice sheets, thermal expansion of the oceans from global atmospheric warming, and changes in the power and circulation patterns of ocean currents. It is important to emphasize that when considering impacts, such as coastal hazards, global sea-level rise is simply an average. Actual relative sea-level rise is regionally and even locally specific, depending on geologic, geophysical, and oceanographic conditions.

Probabilistic projections of sea-level rise for the rest of the 21st century and beyond are not exact because we don't know exactly what future greenhouse gas emissions will be and because Earth's systems (atmosphere, continents, oceans) are inherently complex with many feedbacks, both positive and negative. Thus, current projections are best thought of as "conditional probabilities". Scientists do know, however, from actual long-term tide-gauge observations and, more recently, satellite altimetry measurements, that global sea level has risen about 21-23 cm (8-9 inches) since 1880. And since 1993, global sea level has risen about 8 cm (3 in). In addition, the rate of global sea level rise since 1993 has been faster (~3 +_0.4 mm/yr) than any period in the past almost 3000 years or longer.

Scientists are confident that sea level will continue to rise for centuries as a result of the amount of atmospheric greenhouse gases already sequestered. So, the question is not "if" sea level will continue to rise, but rather "what will be the rate of rise", "how high a rise is likely" and "when will the various rise heights occur in the future."

The best current scientific projections are that global sea level will increase by up to 1.2 m (~4 ft) by 2100. The increase, however, might be 2 m (~6 ft) or higher, depending on carbon emissions, the rate of global warming and the rate of ice-sheet melt across

Greenland and Antarctica. **For CNMI, sea-level rise will be about 0.3-0.5 m higher than the global average** because of several amplifying factors that account for the current relative-rise rate of about 4 mm/yr (3 mm global rate+ 1 mm regional subsidence rate= 4 mm/yr):

- enhanced ocean-thermal expansion
- far-field geophysical effects of ice-sheet melting across both Greenland and Antarctica
- land subsidence—a result of earthquakes (i.e., ~10 cm land drop, Guam, 1993) and long-term tectonic adjustment of volcanic bedrock, associated with tectonic subduction of the Pacific Plate on which CNMI rests

The CNMI already faces serious risks from storm-surge and recurrent-tidal-coastal flooding and coastal erosion. In the near future, higher sea levels will cause flooding and inundation to larger areas, farther inland, increase erosion and land loss, and increase littoral sediment movement along the coast, possibly increasing shoaling to the harbor and channels.

The most common type of flooding CNMI will experience likely will not come with storm surges associated with typhoons but the recurrent or "nuisance" flooding of low-lying areas during high-spring-king tides when the tides occur together with strong onshore winds. Higher sea levels will cause these king tides to happen more frequently, reach higher ground, flood larger areas, and persist for longer periods than in the past.

NOAA has reported that 2017 was the second-warmest year since record-keeping began in 1880. Second—that is—to 2016. And 17 of the 18 warmest years in history have been those since 2001. This global warmth fuels the storms, sea-level rise, and many other impacts that loom large for the CNMI region.

But while nuisance flooding will steadily increase municipal and personal losses in coming years, it is the damage that major storms such as Soudelor will do that demand serious planning. That concern should guide how CNMI manages almost everything including municipal buildings, roads, beaches and open spaces. This is best done with clear and reasonable building regulations and codes that function to protect environmental resources and property for a sustainable economy.

There are many recent publications and reports from credible sources that contain useful information applicable to CNMI issues. One such comprehensive publication, released in December 2017, by the state of Hawaii, entitled “Hawaii Sea-Level Risk Vulnerability and Adaptation Report …

https://climateadaptation.hawaii.gov/wp-content/uploads/2017/12/SLR- Report_Dec2017.pdf

addresses issues of climate-change impacts which are also germane to CNMI. The report includes a comprehensive discussion of the current science on climate change and includes recommendations for adaptation to address current and near-future impacts.


Google-Earth map of Saipan showing green-highlighted areas of highest vulnerability to flooding and erosion from a 2 m (~4 ft) projected future (~2100 AD) global sea-level rise. The small scale of the map fails to show details, but areas at greatest risk are the Garapan coast, Managaha Island, and the southwestern coastal region of Susupe and Chalan Kanoa. Many other low-elevation sandy beaches and wetlands, primarily along the west coast, as well as small pocket beaches along the east coast, are also highly vulnerable.

# XIII. ADDRESSING THE IMPACTS OF CLIMATE CHANGE, SLR AND VULNERABLE DEVELOPMENT THROUGH SCIENCE-BASED ADAPTATION PLANS & PRINCIPLES

## I. CNMI-wide Lidar elevation data collection and monitoring-mapping programs.

Access to high resolution elevation survey data, especially in the coastal zone, is critical for planning, enforcement, and observing environmental and human-caused change over time including beach profiles and observations, land erosion, runoff measurements, etc. . Lidar is an aerial mapping technology well suited to CNMI. Lidar surveys are commercially available, but existing Lidar data and future surveys may be available or requested from several federal agencies:

i. FEMA as part of their FIMP mapping program,
ii. the Army Corps of Engineers,
iii. DOI, and NOAA.

**II. Sand-inventory mapping programs to assess and quantify offshore sand sources suitable for beach nourishment/shoreline restoration.** Maintaining robust and wide beaches and dune systems is important for both coastal protection and recreational benefits. One means of mitigating beach erosion is periodic beach nourishment using high quality sand dredged offshore. This can be done by beneficial reuse when sand is dredged from navigation channels and pumped onto the beach or dredged from offshore shoals, brought ashore and pumped onto the beach to widen the berm, raise elevations, and construct *vegetated dunes*. Geologic, geophysical, biologic, and oceanographic modeling studies help characterize potential sand borrow areas and ensure that sand removal will not create adverse impacts to benthic habitats or adjacent coasts. Beach nourishment is a viable, but often temporary measure, and the long-term economic costs vs benefits require assessment.

III. **Plans for converting high-hazard areas to public open-green-space**.

a. As impacts of climate change become more pressing, some coastal areas may become so vulnerable that it makes sense to abandon development at risk and convert these areas to parks and open spaces for public use.

IV. **Coastal zone development setbacks based on erosion rates and risk factors.**

a. With sea-level rise and increased storm activity inevitable, erosion rates are likely to increase. Erosion rates should be documented as part of the monitoring program and the rates should be used to guide and establish setbacks for development. Setback time periods should be on the order of 50 years or longer (i.e., 50 yrs. x 2 m erosion= 100 ft setback) and should be adjusted as factors such as erosion rates, sea-level rise change due to climate change.

V. **Protection of public access to coastal resources.**

VI. **Restoration of eroded sandy beaches** for recreation and protection as discussed above.

a. As the coast changes, provisions are needed to ensure that the public has full access to beaches, docks, and piers.

VII. **Wetlands protection and vegetation planting restoration.**

a. Wetlands are import for both coastal protection and habitat values and should be protected. Where possible remove impediments to enable wetlands to naturally migrate landward with sea level rise.

VIII. **Use of ecosystem-compatible engineering structures and living shorelines** for coastal erosion control, stabilization, resilience, reef and wetland protection, and to reduce sediment and debris runoff pollution. Living shoreline measures are most effective when employed on low-to moderate-energy shores and often consist of a hybrid mix of various natural materials (e.g., oyster reefs, artificial coral reefs, vegetation, sand, rocks) and

can have the benefit of providing coastal protection and habitation enhancement. Fostering and maintaining resilient foliage along the shoreline and associated dunes creates an effective and visually appealing natural buffer to stabilize the shore and protect nearby wetlands.

A useful discussion of living shorelines, a hybrid mix of measures, and their potential applications, is contained on pages 21-30 in the draft final report by the Corps of Engineers, *Garapan Area Shoreline Assessment Study*, 20 October 2017.

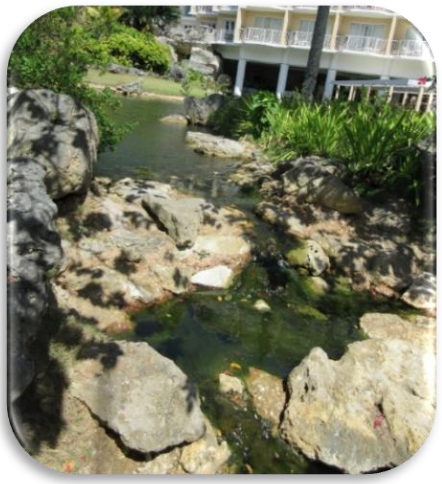
Representative pictures of the shore along the west coast showing evidence of pervasive erosion of the beach and backshore sand flat. In some areas, the shoreline has moved landward several meters annually and the beach has been lowered by about 1 meter, as shown by the exposed tree roots and umbrella bases.

These locations of obvious impact should be photographed on a regular schedule to monitor the progress of accretion. Mitigation efforts should be ongoing to prevent additional loss of these valuable coastal assets primarily utilized and accessed by the Hyatt Regency Saipan and its guests.

## XIV. Local BMP LID Best Practices Then and Now

### Hyatt Regency Saipan

During our interview assessments there was significant interest in learning more about the NEWEST evolving technologies, ideas, and implementation of best practices and products for minimizing environmental impact of all phases of construction. There are some very good lessons and best practices that have been implemented locally over the past five decades of development and those examples should be studied and reproduced in their best modern example. The Hyatt in Garapan incorporated water wise practices and advanced drainage systems decades ago and should be recognized for its forward design. The Hyatt developers wisely implemented:



- Channel Runoff designed topography to control erosion and soil movement
- Artificial Filtration devices
- Natural water features and organic based filtration systems
- Rainwater catchment systems
- Permeable all-weather surfaces
- Purpose made wetlands and natural habitats
- Runoff quarantine zones for controlled storm drainage
- Living shoreline techniques for erosion control & wetlands protection

The Hyatt also installed an enormous *storm water storage tank* located below the tennis courts on the Northern ocean side edge of the property. This tank was installed

below ground level with cast concrete and appears now ready to serve a dual purpose as a massive concrete gabion to protect the resort from significant erosion.

The Hyatt is notable for its use of Natural water features and plant based natural filtration systems. The central pond and basin features various pumps and flow patterns designed to repetitively filter water through a variety of natural and artificial filtration systems. A key component to this cyclical renewal system is the large elevated artificial pond structure and waterfall hosting thickly rooted aquatic plants that capture pollutants and clarify water pumped from the lower pond. This waterfall feature overflows back into the main pond further oxygenating the water. Additional runoff channels feeding sub ponding basins with varied topography allow for sunlight to penetrate the water while it is additionally treated over and around porous surfaces with biological components. What was designed, implemented and still effectively functioning today is a human made NPS water treatment facility disguised as a natural pond and mini ecosystem. Not only does this centrally located system serve an important purpose in mitigating the ongoing environmental impact of the development, but it significantly enhances the allure, look, and feel of this fine, long standing, stable and successful resort.

**Pau Pau Beach Park**

This Beautiful (and at the time of our visit tranquil) beach access on the Northwester coast of Saipan near the hotel Kensington offers a prime example of smart design in mitigating issues related to intense runoff from major rain events as well as the effects of SLR and CDEs. The use of relatively straightforward stone and metal mesh gabions resists the pulling energy of king tide high water events while also helping filter and dissipate the energy of the storm water runoff before it reaches the beach and ocean. If left unchecked, that collected runoff would "channel" the beach and eject sand out away from the shore, compounding the already increasing effects of erosion. One question of concern for this installation is how resilient the metal webbing will be to rust and degradation from salt exposure. With heavy rocks being retained, degradation will lead to potentially expensive failure if not properly maintained. *Maintenance and inspections are critically important, and records should be kept of all engineered LIDBMP installations to monitor their effectiveness and overall condition to prevent future failure well before it happens.* Any use of metal should be over engineered, and incorporate electro galvanized, stainless steel or similarly treated metal to extend its structural life. Fixing things "after the fact" rather than doing it right the first time is vastly more expensive and time consuming. Planning,

implementation and maintenance are paramount.

**HS Lee Building Living Rooftop**

The living rooftop located adjacent the Imperial Pacific Resort hidden 4 floors up from the town energy of Garapan is a prime example of green roofs done right. While we haven't reviewed the detailed plans, it seems like it was done right and now serves as a most pertinent example of storm resilient green roofs. Every effort should be made to expose developers, designers and architects to this prime local example to get their wheels turning on how similar installations can be replicated successfully. Regular events held at the rooftop garden with permission from the owner and some sort of enticements would help to spread the knowledge and experience of this fine example. The short time we visited was enjoyable and inspiring.

Smart design choices such as an elevated and sturdy wall surrounding the installation serves a dual purpose to mitigate high winds which could damage the installation while also providing a code compliant railing for visitors. The ultra-low level of solar refraction due to the grass and vegetation along with views of the hills and sky make it an ideal location to admire and enjoy a prime green roof example.

The building owner was initially put off that the cost of the living roof, agreed to as a negotiated settlement for several infractions, would cost more than the fines themselves. Here again, it's the future dividends that should be promoted to incentivize adoption as the owner realized significant energy savings which made the higher upfront cost more than

worthwhile. The owner didn't cut corners though and even went as far as to bring in controlled planting soil from off island for the health of the new grass and to avoid weeds and pollutants that may have been present from local soil of unknown origin. Once installed the owner realized the following benefits:

- A massive increase in roof R value which along with an upgrade in compressor technology has reportedly reduced the buildings electricity costs associated with air conditioning by more than 30%. (often the case with long term investments in more sustainable technologies).
- A desirable rooftop terrace for entertaining guests and clients
- A large-scale sound absorption panel permanently affixed to the roof helping mitigate sound pollution from traffic and construction from above and below.
- A prime example of a living rooftop that will hopefully lead to many additional installations in the local community with rippling benefits to Saipan's people and natural beauty.

The long-term energy cost savings and ambience of the rooftop garden deck is already paying for itself with both financial and personal dividends as well as significantly lowered cooling costs for his building. It is recommended that similar roof top systems be installed wherever possible with high enough border walls above the roof line and effective drain systems to prevent potential damage from high speed winds and major storm events.

# XV. Local Learning Opportunities

### The Imperial Pacific Resort

From the interviews with local building professionals, the Imperial Pacific Resort has caused quite a stir in the community with repeated violations of basic construction BPs. IPR shortcomings fall into several categories. The labor practices or the impact of the CW-1 worker VISA program is not covered here for its impact yet certainly has been a factor.

### Basic Safety Violations

The scaffolding to the left with green canvas remained open during initial construction. Basic fall barriers are essential for safety. The barriers also reduce windblown contamination from foot traffic dust along the scaffolding walkways.

**Dust Barriers -** Given this entire side of the resort building is directly adjacent to a canal, any fabrication, cutting, and welding work above the ground level is subject to wind and weather that cause wind-borne construction dust and contaminates. A more logical construction plan which prioritized the exterior of the building on this particular canal side or basic dust screens would mitigate airborne pollution into the canal and adjacent neighborhoods.

The IPR builders repeatedly ignored BMPs with disregard for authority. Pumping infiltration water from the subterraneous foundation to the nearby canal would have been acceptable if they had followed proper reporting procedures to identify the water as non-contaminated naturally occurring runoff. Getting a permit for pumping would have established BPs and assured the storm water was benign and suitable to return to nature via the canal. But pumping the water in secret and without permission triggered a heftier event, one which they continued to violate by pumping after hours even after they were told to stop. The canal has since become overwhelmed with small algae and Phyto and zooplanktons feeding on elevated nitrate levels. In an effort to "sweep" the issue out to sea, someone secretly engaged in *beach excavation and unauthorized water release* by opening the stagnant waterway to the sea with heavy equipment and without permission nor expert supervision. With a little foresight the algae bloom could have been controlled or mitigated by other means such as:

1. Introducing vegetation to compensate for enriched nitrate/phosphate levels
2. Cleaning muck and sludge from the bottom of the canal basin
3. Adding approved all-natural beneficial bacteria & enzymes that consume the sludge and convert it to a nitrogen gas that simply bubbles out of the canal
4. Introducing a UV clarifier which uses ultraviolet light to kill free floating algae.
5. Introducing Barley Straw into the canal/water way via one of several forms…

**Barley Straw Bales:** Typically available loose in a mesh bag, bales of barley straw should ideally be placed in a pond several months before clarity issues are expected to occur

(around March or April, depending on your climate) as the straw must start to decompose before it releases special compounds. 1 pound of barley straw is suitable for every 1000 gallons of water and should be replaced every 4-6 months. Keep the straw well-aerated, floating it near a waterfall or stream or in shallow water. Don't leave it in the pond beyond its prime because once it decomposes long enough it reverts to a nutrient source for algae.

**Barley Pellets:** Compressed into a compact form, Barley Straw Pellets also contain the beneficial substances found in barley straw without the unsightly look of bales, pillows or pads. The pellets may also buffer pH and control alkalinity in your pond. A 6-pound bag will treat an 800-gallon pond for up to six months; a 12-pound bag will treat a 1,600-gallon pond for up to six months.

**Barley Extract:** Offering the benefits of barley straw without the mess or floating bales Barley Straw Extract contains the same beneficial substances in liquid form. Because you don't have to wait for the barley straw to decompose, it goes to work on contact. An 8-ounce container of extract treats up to 4,000 gallons for three months; a 16-ounce bottle treats up to 8,000 gallons for three months.

**Proprietary treatments such as Pond Logic's** Seasonal Defense® The power of activated barley straw with an additional punch of natural bacteria in one treatment to break down muck caused by leaves, scum and sediment. There is a myriad of similar products available featuring beneficial bacteria. Because the water in the canal will eventually make its way into the ocean, careful attention should be paid to what is introduced to counteract the algae and make sure it will not have detrimental effects to the much different salt water environment of the Bay.

Our interviews indicated local agencies were aware of the various circumstances and attempted to direct the developer toward BPs without success. The developer did not follow the advice of their local building professional and ultimately made decisions that insinuated they felt they were "above the law". Better communication, more transparency

and easier compliance with basic codes and procedures should be the goal through a LOCAL LIASON.

**The Impact RISK of unfinished development**

Driving from the South into Garapan it's impossible to miss the Imperial Pacific Resort hotel and casino which stands higher than any other structure. All stake holders should have a vested interest to see projects completed as soon as responsibly possible once they are into full development. Penalties and punishments from violations that result in significant setbacks might hurt more than help if they permanently impact the successful completion of the project. Failure to complete the current development cycle once this far along have devastating long term consequences.

Recent setbacks on the Imperial Pacific Resort have left the parent corporation with significant challenges outside of Saipan. It's publicly traded valuation has declined significantly because stock holders are concerned that the development may be in jeopardy and due to the compounding effects of other factors such as the CW-1 worker visa program, there is not a clear path to successful completion. Hopefully the total risk has been effectively diversified between the 4 primary contractors involved. The reductions in this program paired with the higher wage-earning requirements have now extended timelines, limited the labor pool and significantly raised construction costs. These perfect storms can ruin publicly traded corporations if the confidence of public investors wanes to the point that the parent company can't stop the declining valuation. The development would then

be delayed even further if the unfinished asset is sold off or shuttered which only exacerbates the project's social and environmental impact.

Unfortunately, these violations have been compounded by the human rights violations of illegal laborers that were coerced to Saipan by unscrupulous foreign agents. While the environment should stand high on the list of things to protect, human rights along with fair and ethical treatment of all people is of course, paramount.

The current inherent risks of global finance, inflation, geo-political risk, government debt and an overreliance on unsustainable stock market valuations could bring developments to a halt at any time. Once this far along, it is extremely important to complete projects as quickly as possible while safeguarding people and the environment.

# XVI. Smaller Scale Local Observations

### San Antonio Beach Front Waterpark

This waterpark development on the Southwestern shore of Saipan on/near San Antonio beach brought up several concerns

### Coastal Setbacks

This water park facility may be too close to the beach and bay. Only about 50 ft of sand separate the foundation fo the facility from the high tide mark and this means that any significant acretion would quickly impact the facility. It also means that contaminants and pollution from chlorinated water and park visitors has quick and easy access to the ocean. It's especially important in this instance to have some type of storm water treatment and/or mitigation in place such as *interceptor wetlands* and *permeable gabions*.

The concrete barriers designed to reduce the energy of stormwater runoff are solid concrete posts. While these might slow runoff they do very little to trap and/or filter pollutants. *Permeable gabions* should be utilized to allow stormwater to percolate yet trap more finer foreign contaminants.

### Unnecessary Tree Cutting

Were the trees on the beach cut by the developer? Mature tree roots secure sediment and mitigate erosion. Cut backs or removals should only occur after careful consideration and in this

case additional plantings may be helpful in preventing erosion and channeling from stormwater runoff or king tide events.

**Controlled Site access**

This site was located directly off the main road (33) yet didn't seem to have a truck access point from that road. The entrance we observed was closer to the beach from a side area accessed from a public pulloff. There was no sign of a cleaning station to mitigate dripping oil & lubricants and possible contamination from trucks and work equipment so close to the beach.

For more information on vehicular contaminants:

https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4880625/

"Heavy Metals from non-exhaust vehicle emissions in urban and motorway road dusts" National Center for Biotechnology Information

**Navy Hill Apartment Remodel – The Case for Inexpensive tarps**

The effects of drywall and plaster dust can be significant. While some materials at this site were covered, it wasn't to mitigate pollution, but to protect the materials underneath. Large amounts of drywall waste were evident and an extensive amount of white powder just outside the rooms being remodeled indicated that no attempt was made to "catch" the dust with a tarp or other ground covering. Roll off dumpsters should be used rather than piling the trash outside to be removed when convenient. In the event of such a pile, a non-permeable membrane such as a tarp should be used to capture dust and debris once the larger pieces have been removed. That same tarp can be used to more efficiently load

smaller sized waste onto a trailer or truck and the edges can then wrap around the waste pile to reduce dust and debris from blowing off during transportation. It's amazing how easy and effective a $20 blue tarp can be at helping keep sites cleaner and pollution out of the environment. Here it was evident that white dust had been washed down the street gutter to the main road for some time where it then dissipated into a nearby gully unchecked. If non-compliant drywall was used here an increased level of arsenic, lead and/or toxins would most certainly be present in the dust. Individually these types of violations appear minor but cumulatively their impacts are terribly significant.

**Suggested LIDBMP Incentives:**

1. <u>Provide free good quality "collection tarps"</u> that are long lasting themselves and have some sort of appeal other than simply their utility. (i.e. brown or silver instead of blue in color) Educate all parties about using non-porous membranes to mitigate dust and debris runoff into the environment and how excess tarp/membrane material can form a "burrito" over debris piles in the sudden event of rain.

2. <u>Cost discounts for roll off dumpster service</u> or other means of safe waste disposal that would make such BMPs more appealing to smaller local builders on tight budgets.

3. If sufficient waste disposal professionals can't meet demand perhaps small business loans or incentives to help locals start such businesses.

**Garapan Blue Coated Handicapped Ramp**

This access ramp along Beach Road in Garapan is an obvious example of why NOT to apply coatings. Though done with good intentions this is now a constant source of blue paint flakes that make their way to the nearby ocean access canal with every rain event. The source and content of coatings should always be health code compliant. When it comes to foreign building materials the compliance of exterior coatings critical. While one instance may not be critical, the cumulative environmental impact of repetitive applications is significant.

Careful consideration of why, how, when and where to apply coatings as well as the lifespan, maintenance requirements and composition of the coating are critical. Colors can be mixed into the concrete at the time of setting or applied as stains absorbed by the concrete for a longer lasting impact. Surface coatings such as epoxies and newer silicone-based variants will be more slippery when wet negating some of the safety this ramp and its railings provide.

**Saipan Globe Development Site – Tanapag**

We made an unannounced site visit to this large swath of future development from Beach Road (RTE 30) to the ocean just North of Tanapag. Though heavy equipment has begun moving in and it's obvious a large project is getting underway, the build site was scattered, and we didn't see any obvious signage indicating who was building, what they were building and who to contact with questions or concerns. All build sites should require

such information be posted in obvious and


conspicuous locations. A carefully fenced and barricaded area adjacent to the ocean at low relief perhaps at, near or maybe even slightly below sea level, had recently received a tremendous amount of fill constituting a wide variety of different compositions and colors. This prompted a few questions such as…

- Where did all this fill come from and does any of it contain pollutants?
- Should some attempt be made to cover such a large swath of loose fill if there is no concern for sediment transfer? How best to cover such a large area of open sediment?
- Was this massive effort to raise the ground part of the construction plan or an easy dumpsite for other ongoing operations that needed to displace their fill? (or both)
- What was here prior to the area being razed, compacted and now filled and most importantly was any of it wetlands and if so, could it somehow have been incorporated into the development rather than bulldozed and buried?

Areas to the left side of this image where soil had been bulldozed showed evidence of prior marsh or some type of runoff channel but in general the area seemed more arid than other parts of the island and perhaps there was little here previously worth preserving. Potential important natural features should be identified and planned for prior to aggressive site excavation and development.

## XVII. Education, Awareness, Involvement & Accountability

The time has passed to decide "how much development is too much" for CNMI. CNMI needs to be realistic about mitigating the impact of development already approved and underway while also considering the scope of future development and what a sustainable pace of growth might look like. While the government won't turn away viable projects, developers must be required to adhere to universal and common best practices found throughout the United States and much of developed world.

No punishments nor incentives will work without communication, relationships, trust, education and the morality of social and environmental stewardship. Expectations for compliance and consequences of noncompliance must be established IN WRITING in the early stages of each and every large-scale development project. If expectations and consequences are clear, concise, compelling and sufficiently understood, monitoring and enforcement during the construction phase will be easier and more effective.

**local successes, signage and engagement**


Signage that inspires and educates is important. The amount of accessible art, education and public promotion surrounding environmental stewardship is commendable. Educating all stakeholders about the sensitivity and importance of environmental assets along with how, why, when and where to stakeholders can participate is a critical component to sustainable development from the community perspective.

**Mobile Device Interactivity**

Anyone can assist with compliance in remarkable ways thanks to technology. The proliferation of social media and connectivity via Saipan's newly established 4G LTE cell services will empower the public to better engage with each other and their government. Through greater connectivity all people invested in Saipan's future can help safeguard their environment and assist the limited number of regulators in their efforts to monitor best practices across the islands. Educational signs and placards encouraging awareness and concern for safeguarding the natural environment should also encourage accountability and ***provide a path for anonymous communication*** (perhaps a telephone number for text messages and pictures) so anyone can readily report possible violations. Education, awareness and empowerment that crosses language and cultural barriers is paramount to success.


## Awareness Campaigns

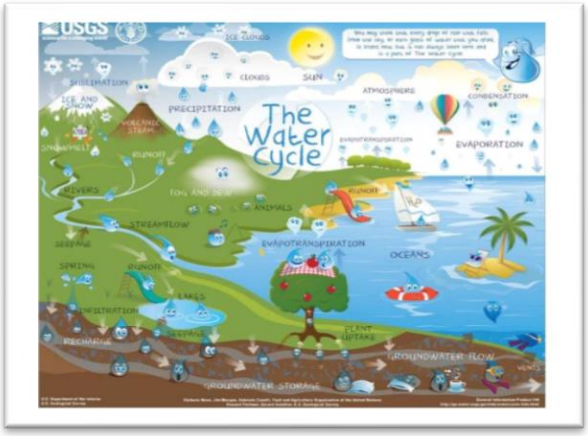






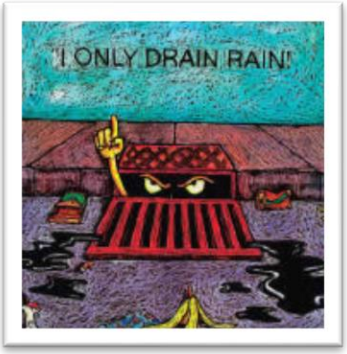
All drains to the ocean should be marked appropriately. Signs and informational plaques help all people understand their role in protecting the environment. These large billboards were erected along beach road near the bike path and were easily accessible. Such engagement is important to widespread adoption of BMPs

**Empowering youth to be stakeholders**




Educating the future citizens of CNMI and empowering them to become invested stakeholders in the future of their home and community is critical. Curious children then engage their parents and participate in community activities that promote environmental responsibility. Shared family values are contagious. Events and promotional materials such as posters, pamphlets and restaurant placemats with interactive games and activities for kids to develop future stakeholders are a great way to gain support for LIDBMPs.






**INDEX – Articles and publications**

*Assessments of Practices to Reduce Nitrogen and Phosphorus Nonpoint Source Pollution of Iowa's Surface Waters :* Dana L. Dinnes, Support Scientist USDA-ARS National Soil Tilth Laboratory Prepared for the Iowa Department of Natural Resources In Cooperation with the USDA-ARS National Soil Tilth Laboratory 2004

*Blueprint for a Clean Bay . Best Management Practices to Prevent Storm water Pollution from Construction Related Activities :* BASMAA Bay Area storm water Management Agencies Association . 2003

*California storm water Quality Association (CASQA) Best Management Practices Handbook* Construction, 2003.

*Climate Change Vulnerability Assessment for the Island of Saipan, CNMI*
January 2014 CNMI Climate Change Working Group, DCRM & Robbie Greene

*Coastal Adaptations Strategies Handbook :* National Park Service *. U.S. DoI*

*Commonwealth of the Northern Mariana Islands (CNMI) Statewide Assessment and Resource Strategy* : 2010-2015+ CNMI SWARS Council

*Rules Relating to Soil Erosion Standards and Guidelines*, April 1999 : City and County of Honolulu, Department of Planning and Permitting

Fostering Sustainable Coastal Development in the CNMI . Decision Support Tools for Enhanced Management of Shoreline Properties : CNMI DCRM

Garapan Area Shoreline Assessment Study, 20 Oct. 2017. Corps of Engineers

*"Hawaii Sea Level Rise and Vulnerability Adaptation Report"*
https://climateadaptation.hawaii.gov/wp-content/uploads/2017/12/SLR-Report_Dec2017.pdf)

*Northern Mariana Islands Tourism Master Plan 2012-2016 :* Marianas Visitors Authority
https://www.doi.gov/sites/doi.gov/files/migrated/oia/reports/upload/CNMI_Tourism_Master_Plan-

National Stormwater Best Management Practices Database. American Society of Civil Engineers, 1999. On-line: http://www.asce.org

*Overview of the City's NPDES MS4 Program : Construction Site Runoff* – DOT-HWY Annual Protect Our Water Conference : City & County of Honolulu . Nov 16, 2016

*Overview of Climate Risk Reduction in the US Pacific Islands Hazard Mitigation Planning Efforts* : Hazards, Climate and Environment Program-Anderson, Cheryl PhD . Technical Report 201103A

*Patterns and Projections of High Tide Flooding Along US Coastline using a Common Impact Threshold* : Feb 2018 : NOAA Technical Report NOS CO-OPS 086

*Pierce County Stormwater Pollution Prevention Manual: A Guide to Best Management Practices for Industries, Businesses and Homeowners*. Pierce County Public Works and Utilities. Revised March 2002. On-line:
http://www.co.pierce.wa.us/services/home/environ/water/swm/sppman/index.html

*Rules Relating to Storm Drain Standards* : DPP C&C Honolulu . Amended vs. Eff June 1, 2013

*"Standard Urban Stormwater Mitigation Plan for Los Angeles County and Cities in Los Angeles County".* State (Ca) Water Resources Control Board, October 5, 2000

*Stormwater BMP Guide for New and Redevelopment .* HNL DPP, July 2017 supporting Permit No HI S000002

*The Dark Side of Stormwater Runoff Management: Disease Vectors*
Metzger, M.E., D. F. Messer, C. L. Beitia, C. M. Myers, and V. L. Kramer, 2002

*The Transformation of Waves in Shallow Water* : Martin A. Mason Chief Engineer, Beach Erosion Board, Corps of Engineers .

*Urban Runoff: Water Quality Solutions.* American Public Works Association, Special Report #61. Berman, L., C. Hartline, N. Ryan, and J. Thorne, (1991)

**INDEX – Web Resources**

https://www.honolulu.gov/rep/site/dfmswq/dfmswq_docs/SW_BMP_Guide_REVISED_July_2017.pdf

https://www.honolulu.gov/rep/site/dfmswq/library/BMP_manual_2011-11.pdf

Juan Rodriguez
https://www.thebalancesmb.com/juan-rodriguez-844348
https://www.thebalancesmb.com/how-to-control-erosion-on-a-construction-site-844573
https://www.thebalancesmb.com/erosion-control-methods-844587
www.asce.org
www.cleanwaterhonolulu.com
www.EPA.gov
https://www.epa.gov/nps/nonpoint-source-technical-guidance-collection
http://www.stormwaterpa.org/

http://www.staradvertiser.com/2018/02/22/breaking-news/sewage-brown-water-advisories-posted-for-windward-oahu-beaches/