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The Battle for Miami Beach

A coastal public works department's assertive strategy for dealing with sea level rise.

By Bruce J. Clark, SCS Engineers

Ah, Miami Beach, Fla. Ocean breezes wafting over miles of sunny beaches. High-end condos. Luxury shopping. Exciting nightlife.

Since 1915, this idyllic municipality has attracted tourists and vacationers as well as the rich and famous. Alas, two trends threaten future revenues.

Built on natural and man-made barrier islands between the Atlantic Ocean and Biscayne Bay, more than half the 18.7-square-mile community is water. On average, the municipality's 4 feet above sea level; much is at sea level.

Every year, the King Tide raises the ocean an additional 2 feet. For the last several years, seawater infiltrating drainage pipes in low-lying areas bubbled up through storm manhole covers and washed overland, flooding streets and sidewalks, lapping at the doors of homes and businesses, and generating nationwide media coverage.

Higher tides these past few years are the result of a combination of astrological events reaching their peaks within their cycles. Climate change only exacerbates these occurrences. If predictions that sea level could rise 2 feet over the next 25 years are accurate, 40% to 60% of Miami Beach is projected to flood regularly.

In 2015, the City of Miami Beach Public Works Department took the initiative to raise about 4,200 feet of asphalt streets. It's also implementing a master plan developed in 2014 to protect the homes and livelihoods of 88,000 residents and $50 million in taxes.

The plan is estimated to cost $400 million over five years and centers around a pumping system that includes stormwater treatment before discharging floodwater back into the bay. To expand the city's existing flood prevention program, the department plans to build about 20 more stormwater pump stations in addition to the 31 built since the program's inception.

Several U.S. cities including Cambridge, Mass., are exploring how global climate trends could affect local infrastructure. However, as the nation's first city to face the reality of rising sea levels, Miami Beach provides unique insight.
In the words of City Engineer Bruce Mowry, "There's no playbook for these solutions."

Keeping vehicles and people moving: roads and sidewalks
Public works initially concentrated on the island's lowest-lying areas.

In the first year, contractors upgraded stormwater utilities and raised streets and sidewalks up to an average of 2 to 3 feet above the surrounding area. Raised roads followed a comprehensive stormwater utilities retrofit before placing backfill material to the desired elevations to give place to the roads' subgrades, subbase, and base course.

The entire area up to the right-of-way line contains supplemental dedicated drainage inlets and underground piping with sealed joints. Floodwater drains off the streets and sidewalks into the newly constructed and existing stormwater pump stations.

Meanwhile, the department is engineering improved infrastructure. For example, roads that are below high-tide levels will have a minimum crown elevation of 3.7 feet when raised, a height that provides an estimated 50-year life and facilitates further elevation if necessary.

Four-step water management solution
The new pump stations consist of four primary structures: inlet detention box, submersible centrifugal or dry-mount axial flow pump, valve vault, and vortex-style solids trap.

Excess water collecting in inlets in the right of way is conveyed through underground conduits and discharged into the detention box. A concrete vault-like structure with a conventional bar rack, the box slows water flow so large debris can settle to the bottom for removal. Like a wastewater treatment plant headworks, the bar rack captures the largest pieces before they can reach and clog the pumps.

Water then flows into the main wet well, where large displacement pumps push it through the valve vault. Valves nested in the concrete vault prevent water in the downstream force main from flowing back into the facility when the pumps are off. The pumps are isolated to make maintenance more efficient.

Next, the water enters the vortex-style solids trap, a concrete structure that looks like a manhole. Centrifugal force slows the flow, enabling more suspended solids to settle out before the water discharges from a pipe into the bay. A "one-way" valve on the end of the discharge pipe prevents bay water from backing into the pipe at high tide.

Despite an aggressive anti-littering campaign and regular cleaning, debris caused one bar rack to fail.

Sumps are being installed in pump stations to prevent failures. In addition to educating various audience groups that live in or visit the area about stormwater, the city is leveraging the media attention over the last several years with messaging about how litter and waterborne pollutants affect the bay's water quality.

Given the bay's importance to the city's economy, the latter may prove quite fruitful.

Receiving water issues: no one noticed before, but now

The pump stations discharge 15,000 gpm to 80,000 gpm. Flow capacity is calculated using an estimate of tributary area served by stormwater system, sizing of supplemental collection piping, new storage chamber capacity, and operations and maintenance considerations.

Suspended sediment and contamination, particularly from *E.coli* indicating the presence of human and animal waste, are common in stormwater systems across the region, not just Miami Beach. Discharge from existing outfall pipes didn't get much attention, but the new pump stations' higher flows and velocities brought these issues to the forefront, says Public Works Engineer Carlos Tamayo.
Residents were worried about changes in water color at discharge points and the potential for additional water contamination. The city is addressing these concerns with innovative designs as well as public outreach.

As an erosion control measure for seagrass environments, the local environmental regulating agency required velocities to be reduced from 2.5 feet per second (ft/sec) to 1.4 ft/sec. The department is also working to balance lower velocities and pipe sizes in a cost-effective manner.

It's addressing pollution concerns by explaining that the system isn't moving more water than the old system; it's designed to move the same amount of water more quickly and, in fact, moves less suspended and floating debris than the existing system.

Despite an end-of-pipe dissipater that lowers energy intensity, the higher-velocity flow generates enough turbulence to disturb sediments in the shallow, near-shore discharge locations. Sediment that causes water color to change disperses by daily tidal flushing that also mitigates cumulative effects on the bay's environment.

The department points out water samples taken during seasonal flooding don't reflect all of the master plan's water quality infrastructure improvements. These improvements include treating discharge water, repairing and/or upgrading sanitary sewer pipes that can contribute contamination, and educating residents about how they can help to reduce contamination.

Over time, these upgrades along with public outreach are expected to improve conditions.

Making reliability pretty

The pump stations must be flood-proofed to ensure they function in an emergency.

To protect critical equipment, some stations located in the roadway have a 3-foot concrete block barrier.

Controls and emergency backup generators must be aesthetically pleasing, with easy access for maintenance, resistant to corrosion, and run quietly.

Elevated electrical controls on metal frames are placed above the projected flood level in each particular area, with portable generators provided to the pump stations if needed.

Public works is working with architects to develop enclosures that camouflage the machines and controls.

Overcoming construction challenges

Any large infrastructure project in the right of way faces construction challenges, and the pump stations are no different.

Traffic plans must move vehicles safely over patched excavation areas and slow drivers when dewatering discharges onto the pavement.

Underground utilities must be abandoned or relocated to accommodate new piping networks when elevating roadways. Trench excavating for utilities and structures involves sump pumps or well points that discharge to the municipal storm sewer systems or gravity drainage wells.

Next month: the solution continues

The two pump stations installed in late 2014 in the worst flooding areas along with one-way valves installed in existing gravity outfalls in those areas are keeping roads dry through the first round of King Tides. Twenty pump stations are functional, and several more are under construction or in design for less severely impacted areas.

Public works has other ideas for mitigating flooding, but they're too extensive to cover in one article. The next article will discuss how the department is prioritizing issues that have arisen, such as:

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- Changing and improving the building code so new construction follows standards that consider sea level rise adaptation
- Monitoring and reporting discharge to Miami-Dade County regulators; constituents: suspended solids, turbidity, bacteria, metals, nitrogen, and phosphorous
- Alternative power for emergency generators

The team knows they're blazing new territory by integrating new designs with proven technology. Undoubtedly, their achievements will help infrastructure managers in other coastal or low-lying areas.

Slideshow

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