Department of Conservation and Recreation

Nantasket Beach Seawall Repair and Reservation – Master Plan Services – Existing Infrastructure

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1.0 Physical Assessment of Reservation

The Nantasket Beach Reservation, located on the northern shore of southeastern Hull, MA, is a popular destination for beachgoers, walkers, joggers and others taking in the sights and sounds of the adjacent Atlantic Ocean. The Reservation, owned and operated by the Department of Conservation and Recreation (DCR), is bounded approximately by Phipps Street to the north, Hull Shore Drive and Nantasket Avenue (Route 228) to the west, the end of State Park Road to the south, and the Atlantic Ocean to the East.

The Reservation is on a long and narrow strip of land (450-500 feet wide in some locations) that separates Hull Bay and the Atlantic Ocean. The Reservation encompasses approximately 28 acres and 1.3 miles (6,800 linear feet) of beachfront. At low tide, the beach becomes a wide, expansive area that can accommodate hundreds of beachgoers. At high tide, much of the beach is presently overtaken by the ocean and beachgoers retreat to the promenade. Along most of its stretch, the seawall serves as seating for beach users along the promenade.

Field surveys and several site investigations were conducted to provide the data and information needed to assess the Reservation's physical facilities. These visits also provided insight for recommendations and improvements for consideration in the Nantasket Beach Reservation Master Plan.

Figure 1-1: Nantasket Beach Reservation with significant features

1.1 Overview

The existing infrastructure of the Nantasket Beach Reservation includes the beach, seawall, sidewalks/promenade, various buildings, parking lots and roadways. This assessment addresses the sidewalks, buildings, parking areas and roadways, as the beach and seawall are currently under rehabilitation.

Contributing to the beach's appeal is its high level of pedestrian and vehicular accessibility from adjacent, largely residential areas, and its proximity to the Boston metropolitan area. Visitors traveling by car to the Reservation will likely park in one of DCR's off-street parking lots or in parking spaces along the DCR-owned roadways. There are over 1,000 parking spaces on the Reservation, with the highest concentration at the southern end of the Reservation.

There are a total of six parking lots – five are situated adjacent to the beachfront and the sixth is an overflow lot located to the west along George Washington Boulevard. This lot is separated from Nantasket Avenue by a large condominium development. A path along the edge of the condominium parking lot could provide a more direct link from the DCR parking lot to Nantasket Avenue and the beach, which would increase the attractiveness of this underutilized lot. The on-street parking spaces are predominately found on the northern half of the Reservation. Parking is discussed further in Section 3.4.

All of the parking areas are paved with bituminous asphalt concrete and are in fair to poor condition. Areas of subgrade failure or settlement are prominent, causing severe cracking and breakup of the pavement in addition to low areas with ponding issues during rain.

Figure 1-2. Parking Lot 4 with ponding and pavement deterioration to the right.

Pedestrian access to the beachfront is encouraged with 29 crosswalks fairly evenly distributed along Nantasket Avenue and Hull Shore Drive at intersection and mid-block locations. Many of the crosswalks, however, are not at stop signs, limiting the degree to which pedestrians are protected. Also, crosswalks are narrow and the spacing of the white stripes is wide, limiting their visibility for motorists.

Sidewalks along both sides of Nantasket Avenue in the Reservation are generally in good condition. Sidewalks along the western side of Hull Shore Drive (abutting vacant Hull Redevelopment Authority property) are deteriorating and in need of improvement. The sidewalk on the eastern side of Hull Shore Drive in this location was recently reconstructed. Sidewalk construction on the Reservation varies between cement concrete and asphalt surfaces.

There is a beachfront promenade/walkway along the entire length of the Reservation, providing beach users physical and visual access to the 1.3 mile beachfront as well as to passive and active recreation opportunities (Figure 1-3). The promenade is located between the parking areas adjacent to the beach and the seawall and connects to various seating and shade areas. Accessibility to the beach from the promenade is provided via intermittent entry points in the seawall. Access to the beach from these points is provided by either a concrete stair or ramp. Many of the existing seawall entry points have been in need of improvement. For example, some of the ramps are too steep and/or are blocked by large revetment boulders. New entry stairs and ramps are being constructed during 2007. The promenade is sloped to carry runoff toward the wall which has weep hole drains to convey the water onto the beach.

Figure 1-3: Promenade along seawall with weep holes for drainage

Nantasket Avenue and Hull Shore Drive are part of the Reservation and are maintained by DCR. Overall, the roads are in good condition and the pavement shows few signs of distress. Granite curb with consistent 6" reveal separates the traveled way from cement concrete sidewalks along Nantasket Avenue. The edge of the traveled way is not as clearly defined along Hull Shore Drive, where diagonal parking exists along the seawall and sporadic pieces of curbing separate the left edge from the sidewalk.

1.2 Buildings

The Reservation includes a multitude of buildings, some of which are for public use while the others are for DCR operations. These buildings consist of the following:

Bath Houses
- Mary Jeanette Murray (MJM) Bath House
- David A. Cook Comfort Station
- Comfort Station (205 Nantasket Avenue)
- Tivoli Bath House

Landside Operations and Maintenance Buildings
- Island District Buildings
- Former Metropolitan District Commission (MDC) Police Station
- Garage Building
- Wood Store Room
- Upper Maintenance Garage and Artist Studios
- Lower Maintenance Garage (with attached Carpenter Shop)
- Lifeguard Cottage (also known as Guard House)
- Greenhouse

Other Buildings
- Bernie King Pavilion
- Carousel and Clocktower Building

Below are descriptions of DCR-owned buildings within the Nantasket Beach Reservation. Building area and physical condition descriptions are based on a 2004 Nantasket Beach Reservation Building inventory. Information regarding building inspections and renovations is derived from relevant reports and documents. In addition, a site walkover was conducted on July 26, 2007 by DCR and Berger staff.

The buildings that are open to the public consist of three bath houses, one restroom facility, and an open air pavilion. All three bath houses were undergoing renovation during the spring and summer 2007.

1.2.1 Bath Houses

1.2.1.1 Mary Jeanette Murray (MJM) Bath House

The Mary Jeanette Murray Bath House is the centerpiece of the Reservation. Built in 1930 in the Art Deco style, the MJM Bath House is one of the more architecturally significant buildings within the Reservation. The building is approximately 3,640 sq. feet in size. It is currently used as a bath house facility and community venue.

The bath house (the largest in the Reservation) is composed of a large central core, two wings, and outdoor seating and shower areas. The restroom and shower facilities are located in the wings of the building. The central core is a large open room which can be rented out for events. It is not open to the public, except during events. Currently there is no public access to the central core from the restroom and shower facilities in the wings of the building. An office located in the southeast corner of the building is used by DCR operations staff.

Figure 1-4: View of Mary Jeanette Murray Bath House from Nantasket Avenue

Shade structures (pergolas) with benches are located on the north and south side of the bath house. These are the primary shade structures for the Reservation and are heavily used by both casual visitors and as a gathering area for large groups. A volleyball court is located directly north of the bath house. A small playground with play structure is located directly to the south. A basketball court, formerly located directly north of the volleyball court, was closed recently due in part to a violent crime committed there. It has since been converted to surface parking.

In 1991, the MJM Bath House was considered inoperative due in part to the presence of lead-based paint and pigeon manure in the central core. In 1993, the building was inspected and surveyed for asbestos-containing materials. Asbestos was identified and removed following the inspection. The MJM Bath House was subsequently renovated and is now open for public use.

Figure 1-5: Gathering at the MJM Bath House pergola

The building currently has some problems with water penetration from deteriorated caulking and flashing on the roof. There is also some rust, spalling and cracking along some of the walls of the building. The windows on the ocean side require painting.

Figure 1-6: Rust and painting requirement on the southern side of the MJM bath House (left). Cracking above the window on the southern side (right).

1.2.1.2 David A. Cook Comfort Station

The David A. Cook Comfort Station is located at the northern end of the Reservation on Hull Shore Drive. The single story red brick structure was built in 1953 and is approximately 2,800 sq. feet in size. It contains public restroom and shower facilities and is in adequate condition. Additional space in the building is currently underutilized.

Figure 1-7: David A. Cook Comfort Station

1.2.1.3 Comfort Station (205 Nantasket Avenue)

The Comfort Station is across Nantasket Avenue from the beach, located on 205 Nantasket Avenue adjacent to the Clock Tower building and a privately-owned mini golf park. The structure is approximately 1,500 sq. feet in size and used as a public restroom facility. It is in seemingly good condition. The only exceptions are some problems with the one of the gas-fired heating vents and heating pipe.

Figure 1-8: Comfort Station

1.2.1.4 Tivoli Bath House

The Tivoli Bath House, located at the southern end of the Reservation, is a single story concrete structure built in 1981; it is approximately 1,475 sq. feet in size and contains restroom and shower facilities. It has been in poor condition, although was recently renovated. Just north of the Tivoli Bath House is a raised and widened portion of the promenade with a row of picnic tables.

Figure 1-9: Tivoli Bath House

1.2.2 Landside Operations and Maintenance Buildings

DCR's landside operations and maintenance buildings are located on the 3.5-acre block bounded by Wharf Avenue, Nantasket Avenue and George Washington Boulevard. The block is across Nantasket Avenue form the MJM Bath House. Some of these buildings date back to 1898. These buildings are used primarily by DCR maintenance and operations staff.

Many of these buildings require extensive maintenance. A walk-through was performed on August 26, 2007 by our team with staff from DCR.

Figure 1-10: The block of Operations and Maintenance Buildings

1.2.2.1 Island District Operations Building

The Island District Operations building is two stories high and approximately 9,000 sq. feet in size. It was originally built in 1898 and used as state police barracks. The first floor is currently used by the DCR and Massachusetts State Police as office space. The second floor is composed of several small vacant rooms and is largely unused.

Figure 1-11: Island District Operations Building

The building is heated year-round. In 1993 the building's heating system was converted to natural gas fuel. In 1997, a 1,000-gallon UST was removed from the site, along with 45 cubic yards of contaminated soil. One of the downstairs rooms is planned to be used for the storage of hazardous materials. It is not known if the paint in the building contains lead, or if some of the plaster contains asbestos.

The building is in poor condition. The roof was leaking in the past, resulting in damaged walls and ceilings. Plaster is falling in places. The roof was replaced in 1994-1995 as part of exterior renovations. Currently, there is still a leak above one of the first floor offices (supposedly due to a problem with the gutter).

Figure 1-12: Damaged wall (left) and ceiling (right) in Island District Operations Building.

The basement experiences intermittent flooding. On July 26, 2007, Mark Gershman from The Louis Berger Group, Inc. performed a quick visual inspection of the state of several deteriorated brick columns in the basement. He was accompanied by Mike Galvin and Leonard Meleger from DCR. Following is an excerpt of his report:

> *"DCR indicated that the building is currently used as a headquarters by DCR staff and from a quick observation appears to be under utilized and not fully loaded. The columns in the basement were observed to be approximately 12 inches square and comprised of mortared red bricks extending from the basement slab to the underside of the first floor timber framing. A majority of the columns have experienced deterioration of the bricks along the lower lengths of the columns (see photos below). DCR confirmed that the basement experiences flooding and standing water on a regular basis as a result of ocean storm events. No other visible distress in the columns was noted indicating that they continue to safely support the building structure above. As a result of the inspection, Berger recommends that columns be removed and replaced in kind, or with steel lally columns. This should be undertaken in the near future once the use and purpose of the building is determined by DCR. At that time other structural elements should also be inspected and appropriate repairs determined."*

Figure 1-13: Damaged support columns in basement of the Island District Operations Building.

1.2.2.2 Former Metropolitan District Commission (MDC) Police Station

The two-story Police Station building is approximately 4,000 sq. feet in size. It was built in 1904 and used as a police station by the former MDC. Currently, the building is vacant and in very poor condition.

Figure 1-14: Former Police Station

In 1993, the building was inspected and surveyed for asbestos-containing materials. Asbestos was identified in roof flashing and caulking material. In 1996, a lead-based paint inspection report found that most of the paint used on the interior of the station contains a relatively high concentration of lead. The roof is apparently tight at this time, although was leaking in the past. As a result, water damage to the walls and ceilings is wide-spread. Parts of the first floor is structurally unsound. The building has not utilities (heat, water, electricity). The area in the basement section to the west of the building was observed to be moist during the site visit on July 26, 2007. A crack was observed at the base of the outside wall out the building (to the left of the entrance door), suggesting potential structural problems.

Figure 1-15: Extensive wall and ceiling damage in former Police Station.

1.2.2.3 Garage Building

The Garage building is a 1,000 sq. feet single story garage located directly behind the former Police Station building. The garage is jointly metered for electricity with the police station. It was originally used for fire control needs. The garage is currently used for inactive storage and is in good condition.

The building's roof shingles were inspected and surveyed for asbestos-containing materials in 1993. No asbestos was found.

Figure 1-16: The Garage Building is the middle building, with the Wood Store Room (Laundry Building) in the background

1.2.2.4 Wood Store Room

The Wood Store Room (also known as the Laundry Building) is a WWII-era, single story structure of approximately 900 sq. feet. This small, rectangular building was reportedly moved to its current location and converted to a commercial laundromat. The building is individually metered for electricity and is currently used for miscellaneous storage. The building is in adequate condition.

In 1993, the building was inspected and surveyed for asbestos-containing materials. Asbestos was found on the building's floor tile and mastic.

Figure 1-17: View of lower Wood Store Room (also known as ' Laundry Building')

1.2.2.5 Upper Maintenance Garage and Artist Studios

The Upper Maintenance Garage building is a single story red brick structure built in 1900. The building is approximately 2,750 sq. feet in size. The building's interior was recently divided to provide leased space. Currently, the section of the building fronting Nantasket Avenue is leased to an art studio ('Studio at the Beach'). The remaining section of the garage is used for DCR vehicle and miscellaneous storage. The building's rear yard is used for sand/salt storage and seaweed composting. The building is in good condition.

Figure 1-18: Upper Maintenance and Artist Studio

In 1993, the building was inspected and surveyed for asbestos-containing materials. Asbestos was identified in caulking material.

A sand and salt storage pile is located on the outside of the garage (west side). Runoff from the pile flow directly into a manhole in the front of the garage. Direct runoff should be prevented as it will result in clogging of the drainage system.

Also, the fence along the George Washington Boulevard should be repaired to improve the aesthetic appearance of the facility.

1.2.2.6 Lower Maintenance Garage (with attached Carpenter Shop)

The Lower Maintenance Garage building, built in 1900, is a single story red brick structure composed of two attached building segments (a garage and carpenter shop) and is approximately 5,000 sq. feet in size. The garage portion of the structure (the northernmost building segment) is currently used for storage of DCR maintenance vehicles and machinery. The Carpenter Shop (the southernmost building segment) is used by the DCR as space to craft benches and other furniture used on the Reservation. Both building segments are in good condition.

Figure 1-19: View of lower Maintenance Garage from Nantasket Avenue

Figure 1-20: View of lower Maintenance Garage from maintenance yard

In 1993, the building was inspected and surveyed for asbestos-containing materials. Asbestos was identified in pipe insulation.

In 1997, a 275-gallon UST was removed from the site, along with 24 cubic yards of contaminated soil.

The garage contains a floor drain without an oil/water separator which should be installed. Part of the wall requires reappointing.

1.2.2.7 Lifeguard Cottage (also known as Guard House)

The Lifeguard Cottage building is a one and one half story 780 sq. feet structure. The small building is currently used as office space by Nantasket Beach Reservation lifeguards. The building is in fair condition.

In 1993, the building was inspected and surveyed for asbestos-containing materials. Asbestos was not found.

Figure 1-21: Lifeguard Cottage

1.2.2.8 Greenhouse

The Greenhouse building is a single story 216 sq. feet structure built in 1998. It is in poor condition.

Figure 1-22: Greenhouse

1.2.3 Other Buildings

1.2.3.1 Carousel and Clock Tower Building

The Clock Tower Building and Carousel are located within the Reservation on the south side of Wharf Avenue. The Paragon Carousel is a local landmark and tourist attraction and was moved to its current location following the demolition of Paragon Park.

Figure 1-23: Clock Tower Building

Figure 1-24: Carousel and Clock Tower Building

The carousel is owned, maintained, and operated by the *Friends of the Paragon Carousel, Inc.,* although it is located on DCR land.

Figure 1-25: Detail from the inside of the historic Paragon Carousel.

The historic Clock Tower Building is owned by DCR, but is currently leased to the *Friends of the Paragon Carousel* that runs an ice cream stand out of a portion of the building. This organization also maintains a workshop in the basement and on the first floor. The second floor of the building as well as the clocktower is unused, aside from storage of some relics of Paragon Park and other items. The lease expires in 2016.

It was not known at the time of the site visit on July 26, 2007, if their was asbestos in the plaster, or lead paint. The roof supposedly does not leak, but was damaged for many years in the past. As a result, the second floor of the building has substantial ceiling and wall damage.

Figure 1-26: Extensive wall and ceiling damage on the second floor of the Clocktower Building.

Year-round utilities are operated in the basement and on the first floor, but not on the second floor. Utilities for the carousel are run through the basement of the Clocktower Building.

Some structural damage was observed on the clocktower. The facades of the two buildings require painting. The western side of the Clocktower Building facing George Washington Boulevard also could be improved aesthetically (Figure 3-28).

Figure 1-27: Possible structural damage on clocktower.

Figure 1-28: Western side of the Clocktower Building

1.2.3.2 Bernie King Pavilion

The newly renovated Bernie King Pavilion is located along the ocean front, opposite of the clocktower building. Originally built in the late nineteenth century, this 10,800 sq. feet open air facility is primarily used for seasonal concerts and dance events, and contains a privately operated concession stand. The pavilion is a popular spot for picnics during summer months, as it provides concession, seating and shade areas and allows direct visual access to the beach and ocean. On Sunday afternoons visitors come to dance to live music.

In 1999, elevated levels of lead were identified on the pavilion's exterior and interior. The facility subsequently underwent a $940,000 complete reconstruction, which was completed in 2004.

Figure 1-29: View of Bernie King Pavilion from Nantasket Avenue

Figure 1-30: Sunday afternoon dancing at the Bernie King Pavilion

1.3 User Survey

An informal user survey was conducted to gain a better understanding of visitors' use and impressions of the Reservation. The responses provided valuable background information for development of the master plan.

A total of 101 surveys were conducted on Monday July 24, Sunday July 30, and August 16, 2006. The responses are summarized below.

1.3.1 Users

Almost 90% of the users surveyed were from outside of Hull. It is assumed that many Hull residents use the town portion of the beach, rather than the DCR portion of the beach. Respondents came from areas west and south of Hull, from up to 40 miles away.

Beach User Origins

- Quincy 16%
- Boston 13%
- Hull 11%
- Weymouth 7%
- Brockton 7%
- Randolph 5%
- Milton 4%
- Needham 4%
- Abington 4%
- Braintree 3%
- Bridgewater 3%
- Whitman 3%
- Medway 2%
- Norwell 2%
- Rockland 2%
- One percent (1%) from:
  - Arlington
  - Avon
  - Canton
  - East Bridgewater
  - Franklin
  - Hingham
  - Milford
  - Newton
  - Scituate
  - Somerset
  - Stoughton
  - Walpole
  - Watertown
  - West Bridgewater.

A total of 91% of the respondents came to the beach by car. This is consistent with the finding that most of the people on the DCR beach are not from Hull. 7% of the respondents walked (Hull residents) and 2% drove a motorcycle.

Young crowds (13-25) tended to congregate at the southern ends of the beach near the Tivoli bath house, whereas families (adults with children under 18) tended to congregate at the northern ends of the beach near the Cook Comfort Station. Approximately 25% of the respondents came with children under 18 years old.

1.3.2 Beach Facilities, Maintenance and Security

Overall, beach users had relatively positive responses regarding DCR's operation of the beach and the conditions at the Reservation. Respondents generally perceived the beach facilities (i.e., bath houses) to be less clean than the beach itself. Many respondents who were not pleased with the cleanliness of the beach thought the problem stemmed more from beach users not picking up after themselves than lack of beach maintenance.

68% gave beach cleanliness either the highest or second highest rating. 90% rated it at least 3 out of a possible 5. 44% gave facility cleanliness either the highest or second highest rating. 60% rated it at least 3 out of a possible 5.

The Cook Comfort Station and the Mary Jeanette Murray Bath House received higher ratings than the Tivoli Bath House which was called out numerous times as being unacceptably dirty. The beach areas between the Mary Jeanette Murray Bath House and Wharf Street and north of the Cook Comfort Station were perceived to be the dirtiest.

Security presence received a high rating in all areas of the beach. 83% gave it either the highest or second highest rating. 91% rated it at least 3 out of a possible 5. Again, the lowest rating was given in the area around the Tivoli Bath House.

1.3.3 Beach Experience

Respondents who brought children (under 18) to the beach reported, on average, a similar beach experience as those who did not bring children. The average beach experience was about 2 out of 5.

72% of the respondents reported swimming. 28% said they did not swim. Many respondents that reported they did not go in the water to swim said they would be going in shortly (most of them "did not have a chance yet").

1.3.4 Beach Access

76% of the respondents thought there were enough beach access points. Many commented that existing access through the seawall would be adequate if ramps and stairs were improved, repaired, and cleared of large revetment boulders. Some thought the existing ramps were safer/easier to use than the stairs. Of the respondents who thought there were not enough beach access points, 47% wanted more access at the northern end of the beach, along the section of newer seawall. Of the respondents who shared additional ideas, 26% thought that the naturally occurring, smaller rocks as well as large revetment boulders were unsightly and/or presented beach access issues. The naturally occurring smaller rocks were typically described as unsightly. The large revetment boulders near beach ramps and stairs were typically described as presenting beach access issues, particularly for the elderly.

80% of respondents thought there was an adequate number of crosswalks on Nantasket Avenue. All but one of the respondents that said there were not enough crosswalks frequented a restaurant or shop at the Reservation. Several respondents complained about the misalignment of the crosswalk by the Dunkin Donuts on Nantasket Avenue.

1.3.5 Parking

Parking was often described as being convenient. 66% of the respondents gave ease of parking either the highest or second highest rating. 75% gave it at least 3 out of a possible 5. Respondents on the northern half of the beach reported more parking difficulty than those to the south. The most often cited problems with parking were "high prices" and lack of parking in lots near the Mary Jeanette Murray Bath House. Several people described parking management as the problem. Many commented that there was always a parking problem on the weekends (one must arrive very early – around 7 or 7:30am - to get a free or $3.00 space). There was less of a problem during weekdays.

64% of the respondents said they would not consider using a remote parking lot with shuttle service, even if it meant more green space within the Reservation. 18% said they would consider using a remote lot and shuttle if they were free or very inexpensive.

1.3.6 Attraction to Local Restaurants and Shops

67% of the respondents said they went or will go to a restaurant, shop, museum or other business in town while at the beach. Of the respondents that reported they went or will go to a business in town, 20% come to the beach very often during the year (at least 3 times per week during the summer months). 46% of the respondents said they would be more likely to spend more time in the commercial area if there was more to do (more restaurants/shops, etc.) and 47% of respondents said they would be more likely to come back if there were more to do. A third of the respondents who gave improvement ideas for the beach wanted more food related facilities (more beach vendors, more convenient food).

1.3.7 Beach Replenishment

66% of the respondents would support beach replenishment with sand of another color. 74% of the respondents would like a wider beach at high tide.

1.3.8 Suggestions for Additional Amenities

Respondents identified the need for the following additional amenities:

- Bath houses
- Shower related facilities
- Water fountains
- Park areas/picnic areas with benches
- Umbrella/chair rentals
- Recreational facilities
- Convenient food related facilities
- Trash cans
- Shops

1.4 Recommendations

Overall, the Nantasket Beach Reservation infrastructure is in fair-to-good condition (aside from some of the buildings). Although there are no immediate concerns for safety, the parking areas are in need of repair and rehabilitation. Further investigation and testing would be necessary to determine the extent of work necessary to properly rehabilitate the parking lots. The sidewalks are in good condition although not all areas meet current ADA accessibility guidelines. The roadways do not have any pressing physical issues that need to be addressed. Drainage and traffic issues relating to this roadway network are discussed in detail in the following sections.

Several of the DCR-owned building require extensive work if they are to be rehabilitated. It is likely that buildings such as the Clocktower Building, the Island Districts Operations building, and the Police station require extensive if not complete stripping of the inside walls and ceilings. These buildings should also be examined in detail for structural damage. Rehabilitation of the buildings will ultimately depend on the nature of its future use and the available financing mechanisms for such efforts.

2.0 Drainage System

The assessment of the existing drainage system on the Reservation was prepared by utilizing information obtained by field surveys and from record plans. Hydrologic runoff calculations were performed to analyze the hydraulic performance of the existing drainage system. Recommendations for improvements to the existing drainage system are made, along with recommendations for the suitability of various Best Management Practices (BMP's).

2.1 Existing Conditions

2.1.1 Watershed Area

The watershed area for the Nantasket Beach Reservation is approximately 30 acres in size and is bounded by the Nantasket beach to the east, Hull Bay to the west, Phipps Street to the north, and Atlantic Avenue to the south. The watershed area is comprised of mostly impervious surfaces such as roadways, large paved areas dedicated for parking, and adjacent residential and commercial developments. Stormwater runoff from these areas flow overland into the drainage system via catch basin inlets located throughout the Reservation, owned and maintained by DCR. An overview map is presented in Figure 2-3; detailed maps of the existing drainage system are attached in Appendix 2-1.

2.1.2 Drainage History

The drainage system on Nantasket Avenue, from Atlantic Hill to Bay Street was originally constructed in the early 1930's, as shown on the 1932 MDC *Reconstruction Plans of the Reservation from Atlantic Hill to Bay Street* (see Appendix 2-2 for full reference). This drainage system exists today with minor adjustments made to it over the years. The MDC plans show the construction of a main drainage line, with drainage manholes located in the Nantasket Avenue roadway at intervals of approximately every 200 feet. Catch basins are located in the gutter line on each side of the roadway.

In this assessment, the main drainage lines were divided into Drainage Lines A through F (Figure 2-3). Drainage Line A flows from Atlantic Hill northerly to Wharf Avenue. Drainage Line B begins approximately 500 feet south of Bay Street and flows southerly to Wharf Avenue. Drainage lines A and B converge at Wharf Avenue where they then flow westerly, discharging into Hull Bay (Outlet A). Main drainage lines A and B consist of vitrified clay pipe with diameters varying from 10" to 24" at the outfall. Lateral pipes from the catch basins to manholes are all 10" vitrified clay pipes.

In 1936, the MDC planned to reconstruct a portion of this system at the 24" outlet as shown on the 1936 *Plan Showing Renewal of Sewer Near Boat Pier* (see Appendix 2-2 for full reference). This plan showed the construction of approximately 80 feet of 24" reinforced concrete pipe through the seawall, discharging into Hull Bay (Outlet A).

This 24" outlet has since been replaced with a 48" reinforced concrete pipe with vertical lift tide gate at the seawall as shown in Figure 2-1. Berger did not locate any plans showing the construction of the 48" pipe and gate, but it is believed that these improvements were constructed within the last 25 years.

In 1949, the MDC designed a roadway in the alignment of the discontinued New York, New Haven and Hartford Railroad as shown in *Construction Plans for Proposed Roadway from George Washington Boulevard to Phipps Street* (see Appendix 2-2 for full reference).

Figure 2-1: Outlet A, consisting of a 48" RCP outlet with tide gate at low tide (left) and high tide (right). The tide gate is locked in a slightly open position.

These plans show the proposed construction of main drainage lines (Drainage Lines C, D and E) in the roadway with manholes located approximately every 200 or 400 feet. Like the previous drainage system that was constructed in the 1930's, this system also had 10" laterals from catch basins located in the gutter lines but the main drainage trunk consisted of reinforced concrete with diameters ranging from 12" to 18".

Drainage Line C begins approximately 700 feet north of the Nantasket Avenue and Hull Shore Drive intersection and flows southerly to an 18" outfall by George Washington Boulevard. The 18" reinforced concrete outfall (Outlet C) is shown in Figure 2-2. This drainage system still exists today with only minor adjustments made throughout its history.

Figure 2-2: Outlet C consisting of a 18" RCP outlet

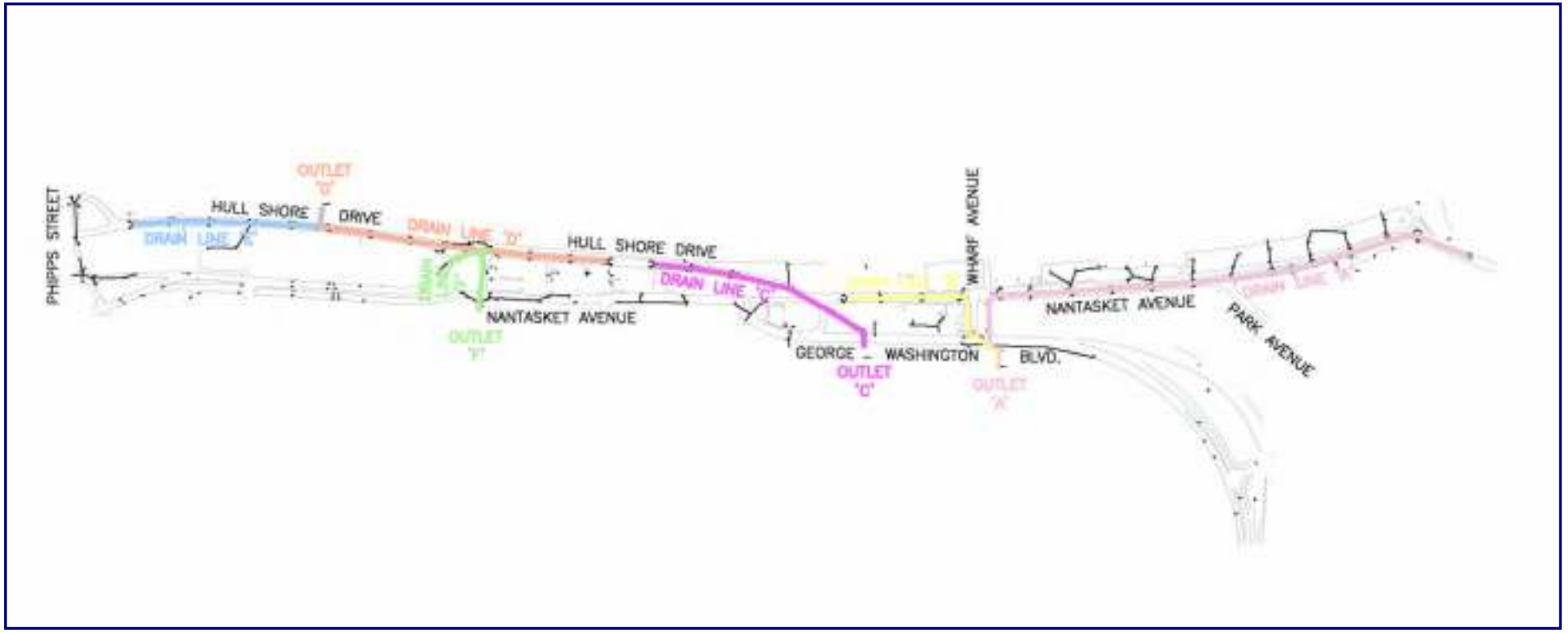


Figure 2-3: Plan with overview of drainage systems

Drainage Line D begins approximately 600 feet south of the Water Street and Hull Shore Drive intersection and flows northerly 1,600 feet to a manhole prior to discharging easterly to the beach via an 18" reinforced concrete pipe (Outlet D). Drainage Line E begins south of Phipps Street and flows 1,000 feet northerly to meet Drainage Line D at a manhole prior to discharging at Outlet D. The 18" reinforced concrete outfall (Outlet D) is shown in Figure 2-4; the outlet is filled with sediment blocking the drainage system. There were modifications made to this drainage line, particularly at the Water Street and Hull Shore Drive intersection.

Figure 2-4: Outlet D consisting of an 18" RCP outlet

In 1959, the MDC proposed a connection into Drainage Line E as shown on the July 1959 plan for *Construction of Parking Areas at George Washington Boulevard at Hull Shore Drive*" (see Appendix 2-2 for full reference). This plan shows two proposed catch basins in the parking area connected to the Hull Shore Drive roadway drainage system.

Also in 1959, the MDC proposed a connection into Drainage Line A as shown on the September 1959 plan for *Resurfacing and Reconstruction of Drainage System at South Parking Lot* (see Appendix 2-2 for full reference). This plan shows the connection of catch basins in the parking area to the Nantasket Avenue roadway drainage system.

2.2 Analysis Methodology

The stormwater analysis was conducted with two hydrologic methodologies, the Rational Method and Soil Conservation Service (SCS) approach. Bentley StormCAD, Version 5.4, utilizing the Rational Method was used to compute the stormwater flow in the drainage pipe network and model the pipe hydraulics to see if the system is properly sized for a 2-year and peak 10-year storm event. The stormwater flows at the point discharge locations for 2, 10, 25, 50 and 100-year storm frequencies were analyzed using HydroCAD, Version 7, utilizing the SCS methodology. The analysis does not take into account storm surge from the ocean entering the system, nor does it take into account tidal effects at the point discharge locations.

2.3 Analysis Results

2.3.1 Rational Method Analysis

The Rational Method analysis calculations are presented in Appendix 2-3. StormCAD models of the existing drainage system were analyzed at 2-year and 10-year design storm frequencies. The results of the modeling indicate that Drainage Lines A, C, D and E are severely deficient for 2-year and 10-year storms. Hydraulic profiles for each drainage line are presented in Appendix 2-4. The profiles show that the capacity of the storm drain system is exceeded, resulting in ponding of the roadways. Specifically, the hydraulic grade line, as shown by the heavy dashed line in the profiles in Appendix 2-4, establishes the elevations along the system to which the water level will rise. In essence, the water level will exceed the existing ground elevation resulting flooding of the roadway during storms (e.g., Figure 2-5).

Research of the record plans on the Nantasket Beach Reservation indicates that many subsequent connections were made to the original drainage system. As a result, the trunk lines are overburdened during large rain storms and capacity is quickly exceeded. Drainage Line A was constructed in Nantasket Avenue in the 1930's primarily for runoff within the roadway. During the 1960's, runoff from Parking Lots 3 and 4 were conveyed into Drainage Line A, adding nearly 5 acres of impervious ground to the watershed for Drainage Line A. Similar connections were made throughout the Reservation. Additionally, commercial and residential development along the corridor reduced the infiltration rate of the watershed, further taxing the existing drainage system.

Figure 2-5: Roadway flooding at intersection of Wharf Avenue and Nantasket Avenue

2.3.2 Soil Conservation Service Analysis

The HydroCAD Drainage Report including calculations and hydrographs is presented in Appendix 2-5. HydroCAD models of the watershed were analyzed at 2, 10, 25, 50 and 100-year design storm frequencies. This analysis provides a peak discharge flow at each Outlet, based on runoff from each of the drainage areas for Drainage Lines A to F. A summary of the results is shown in Table 2-1.

	OUTLET PIPE CAPACITY			
	OUTLET A	OUTLET C	OUTLET D	OUTLET F
PIPE SIZE	48" RCP	18" RCP	18" RCP	24" RCP
PIPE CAPACITY	65.06 CFS	6.19 CFS	4.20 CFS	12.39 CFS

	PEAK DISCHARGE FLOW (CFS) AT OUTLET				
STORM	OUTLET A	OUTLET C	OUTLET D	OUTLET F	
2-YR	29.45	9.15	7.98	4.44	
10-YR	47.48	13.92	15.27	7.32	
25-YR	60.34	17.3	20.74	9.38	
50-YR	66.75	18.97	23.52	10.41	
100-YR	76.97	21.65	28.01	12.05	CAPACITY

Table 2-1: Summary of peak discharge flows at outlets. Shaded cells indicate capacity is exceeded. These calculations apply to the low tide conditions with unimpeded flow in the drainage system.

Outlets C and D are inadequately sized for all five storm frequencies while Outlet A is adequate up to the 25-year storm. Similar to the Rational Method Analysis, the great extent of paved areas, providing little to no water infiltration and storage, contributes to the failure of the system during storm events.

2.3.3 Summary of Findings

In summary, the two types of analyses resulted in the following key findings. Findings for the drainage lines are based on the Rational Method; findings for the outlets are based on the SCS Method.

- Drainage Lines A, C, D and E: Inadequate to handle even a 2-year storm.
- Drainage Lines B and F: Adequately sized for a 10-year storm.
- Point Discharge/Outlet A: Adequately sized for flows from Drainage Lines A & B during a 25-year storm.
- Point Discharge/Outlet C: Inadequate to handle the discharge from Drainage Line C in a 2-year storm.
- Point Discharge/Outlet D: Inadequate to handle the discharge from Drainage Lines C & D in a 2-year storm.
- Point Discharge/Outlet F: Adequately sized for the flow from Drainage Lines F within the limits of the Reservation.

2.4 Recommendations

2.4.1 Proposed Near-term Actions

The assessment of the Nantasket Beach Reservation drainage system revealed various concerns relating to the efficiency of the system. It would be advisable to perform a thorough cleaning of the manholes and catch basins in the Reservation. Many of these structures were filled with silt and debris and should be maintained regularly to increase the effectiveness of the system during storms. Additionally, cleaning and improving the conditions at the outfall locations should be addressed in the short-term. At Outlet A, there is a hinged tide gate that does not operate properly due to debris and rip-rap buildup. Figure 2-1 shows the gate on the end of the 48" RCP. This has "locked" the tide gate in a slightly open position, preventing it from keeping the seawater out of the system during high tide as well as preventing it from opening fully during a storm. This malfunction will cause backup in Drainage Lines A and B, resulting in street-flooding in the vicinity of Wharf Avenue.

2.4.2 Proposed Long-Term Actions

Long-term actions are designed to improve the system to be able to handle the runoff from a 10-year storm. The focus is on Drainage Lines A, C, D, and E. Drainage Lines B and F do not require mitigation to meet this objective.

Alternative 1: Increase pipe diameter to meet 10-year storm requirements

This alternative consists of resizing the existing drainage lines to handle the flows associated with a 10-year design storm frequency. The following increases would have to be implemented to achieve this goal:

- Drainage Line A would increase to a 24" diameter from Manholes A-17 to A-12, to a 30" diameter from Manholes A-12 to A-9, and to a 36" diameter from Manholes A-9 to A-2.
- Drainage Line C would increase to an 18" diameter from Manholes C-4 to C-3, to a 21" diameter from Manholes C-3 to C-2, and to a 24" diameter from Manhole C-2 to Outlet C.
- Drainage Line D would increase to an 18" diameter from Manholes D-4 to D-3, to a 21" diameter from Manholes D-3 to D-2, to a 24" diameter from Manholes D-2 to D-1, and to a 30" diameter from Manhole D-1 to Outlet D.
- Drainage Line E would increase to an 18" diameter from Manhole E-4 to E-1, and to a 24"diameter from Manhole E-1 to D-1.

Calculations and hydraulic profiles for Alternative 1 are presented in Appendices 2-3 and 2-4, respectively.

Alternative 2: Provide underground detention chambers for parking areas

Some of the stormwater runoff from the impervious surfaces could be captured by underground detention chambers. These chambers could be built underneath parking lots and other open undeveloped area. Treating the runoff on-site would have the added environmental benefit of reducing the stormwater runoff to Hull Bay.

As part of this investigation, we conducted initial modeling to evaluate the effect of underground detention chambers on the stormwater runoff for Drainage Lines A and B. Specifically, we assumed that these chambers were sized appropriately to receive the complete runoff from a 10-year storm from Parking Areas 2, 3 and 4. Modeling shows, however, that Drainage Line A would still be too small to be able to handle the remaining stormwater runoff from streets and other impervious surfaces for a 10-year storm. The calculations and hydraulic profiles in Appendices 2-3

and 2-4 for Alternative 2 show the reduced runoff along with the resizing of the drainage lines to handle a 10-year storm. An example of underground detention chambers is presented in Figure 2-6 and 2-7.

If this alternative is to be considered further, additional modeling and design would need to be conducted to determine the feasibility of removing sufficient stormwater through adequately sized underground detention chambers, so that the replacement of existing drainage pipes can be minimized. Aside from Alternatives A and B, removal of stormwater runoff through underground chambers could also be considered for Drainage Lines C, D, and E.

Figure 2-6: Underground detention basin during construction

Figure 2-7: Parking lot after installation of underground detention basin

Alternative 3: Connect Drainage Line A to Drainage Line B

Alternative 3 is a variation of Alternative 1, resizing the pipes in Drainage Line A. The difference is a link from Drainage Line A to Drainage Line B. This connection is a 36" diameter pipe between Manhole A-5 and Manhole B-2. This connection would take advantage of the 48" pipe that leaves Manhole B-2 toward Hull Bay and would not require disturbing the carousel at Wharf Avenue, which currently sits above a 20" vitrified clay pipe carrying stormwater from Manhole A-5 to A-4. The calculations and hydraulic profiles for Alternative 3 are included in Appendices 2-3 and 2-4, respectively.

Additional Recommendations

The Nantasket Beach Reservation drainage system could incorporate various Best Management Practices (BMP's) to improve the management of the stormwater. These include avoidance of direct discharge of untreated stormwater, providing groundwater recharge by infiltration and providing Total Suspended Solids (TSS) removal. Other BMPs would consist of regular appropriate operation and maintenance activities.

Currently, untreated stormwater is discharged directly to Hull Bay (Drainage Lines A, B, C and F) and to the beach along the Atlantic (Drainage Lines D and E). This includes all of the runoff from the parking areas containing oil and other pollutants. In the case of Lines D and E, the polluted runoff drains to the sandy beach used by beachgoers. Water quality inlets could be used to separate oil and sediment as shown in Figure 2-8.

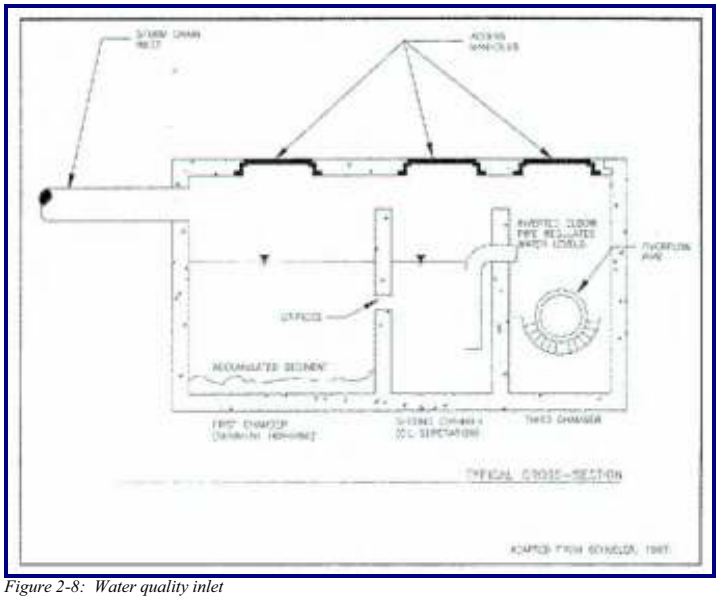


Figure 2-8: Water quality inlet

Deep sump catch basins could also be incorporated into the Nantasket Beach drainage system. These structures are low-cost options for removal of TSS and would improve the quality of the stormwater discharge. Hoods would provide additional removal of oils and debris from the storm system. These would be advisable in the parking lots, as these areas are prone to litter and spills (Figure 2-9). A typical deep sump catch basin is shown in Figure 2-10.

Figure 2-9: Litter and debris collected in catch basin

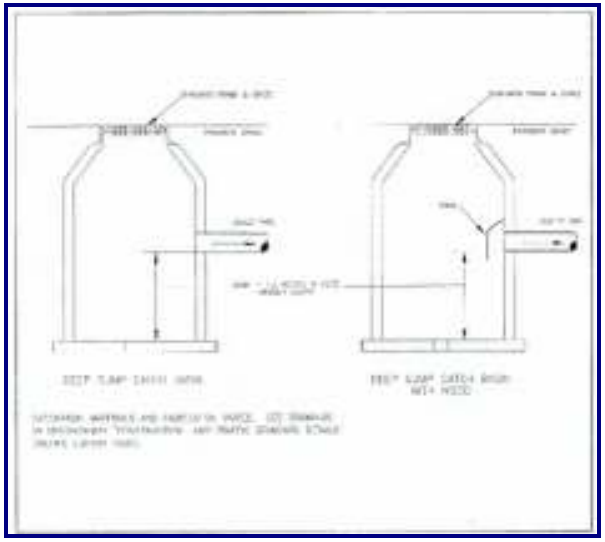


Figure 2-10: Deep sump catch basin

3.0 Traffic and Parking

The existing traffic conditions and operations were assessed along Nantasket Avenue, adjoining street system and critical intersections for the Nantasket Beach Reservation. The area of study along Nantasket Avenue is bounded approximately by Phipps Street to the north and Park Avenue to the south and the section of Hull Shore Drive between Phipps Street and George Washington Boulevard.

The traffic and parking study consisted of the following components:

- **Vehicle Traffic:** Traffic data were collected during surveys on a summer weekday and a summer weekend day. The surveys used automatic traffic recorder (ATR) and manual turning movement counts (MTM) at seven critical locations along Nantasket Avenue and Hull Shore Drive. The collected traffic data were utilized to evaluate the peak summer traffic conditions at the MTM locations.
- **Safety Assessment:** A traffic safety assessment for the Reservation was conducted based on the most recent three-year crash data available from the Massachusetts Highway Department.
- **Parking:** An inventory of on-street and parking lot spaces in the project area was prepared. Parking inventory data were used to determine the adequacy of the parking supply for both the Nantasket Beach Reservation and the commercial and residential establishments adjacent to the Reservation.
- **Pedestrian Traffic:** The pedestrian traffic was studied on a sunny weekend day in the summer at all 21 crosswalks from Water Street to the southern end of the Reservation.
- **Bicycle Traffic:** The bicycle traffic was studied in conjunction with the pedestrian traffic.

3.1 Vehicle Traffic

This section describes the principal features of the seven critical intersections in the project area. Supporting documents include peak hour traffic volumes, weekday and weekend daily traffic, and recent accident history. This information is presented herein in the form of level of service (LOS), and accident summaries.

3.1.1 Traffic Volumes

The Louis Berger Group procured the services of the firm 'Accurate Counts' to conduct and obtain manual turning movement (MTM) counts at critical locations within the project area. MTM counts were conducted for two-hour periods both in the morning (7:00 - 9:00 am) and evening (4:00 - 6:00 pm) on a weekday (Thursday August 3, 2006), and weekend midday (11:00 am – 2:00 pm, Saturday, August 5, 2006). The following seven locations were surveyed:

1) Nantasket Avenue at Phipps Street and Mountford Road
2) Hull Shore Drive Extension at Phipps Street and Manomet Avenue
3) Nantasket Avenue at Water Street and Bay Street
4) Nantasket Avenue at George Washington Boulevard
5) Nantasket Avenue at Hull Shore Drive and George Washington Boulevard
6) Nantasket Avenue at Wharf Avenue
7) Nantasket Avenue at Park Avenue

The weather on Thursday, August 3, 2006 was warm with a few clouds and wind speeds of 5 miles/hr. High tide levels occurred at 6:26 am and 6:43 pm; low tide occurred at 12:28 pm. The weather conditions on Saturday, August 5, 2006 was sunny and warm (85ºF) with wind speeds of 5 miles/hr. High tide occurred at 8:20 am and 8:31 pm; low tide occurred at 2:18 pm.

The traffic counts were used to determine the weekday morning and evening traffic volumes related to commuters, and Saturday mid-day peak hour volumes related to beachgoers (Year 2006). Figure 3-1 presents the 2006 existing peak hour volumes at the seven study area intersections along Nantasket Avenue and Hull Shore Drive.

In addition, one 72-hour directional automatic traffic recorder (ATR) count was conducted along Nantasket Avenue between Wharf Avenue and Hull Shore Drive. Table 3-1 depicts Average Daily Traffic (ADT) during both the weekday and the weekend day. Figures 3-2 to 3-5 show hourly distributions of traffic for the weekday and weekend (Saturday, Sunday and average weekend). The data reveal that this section of Nantasket Avenue carried approximately 11,000 vehicles per day (vpd) during the summer weekday, and 14,000 vpd during the summer weekend. The directional volume split indicates that Nantasket Avenue carried approximately 53% of the total daily traffic in the northerly direction on the weekday, and 56% during the weekend. Peak-period during the weekday was between 1:00 and 5:00 pm, and between 11:00 am and 5:00 pm during the weekend. Peak period hourly traffic during the weekend was in excess of 1,000 vehicles/hour, whereas on the weekday it ranged from 720 to 750 vehicles/hour.

The daily (ATR) and peak-period (MTM) traffic data collected are presented in their entirety in Appendix 3-1 of this report.

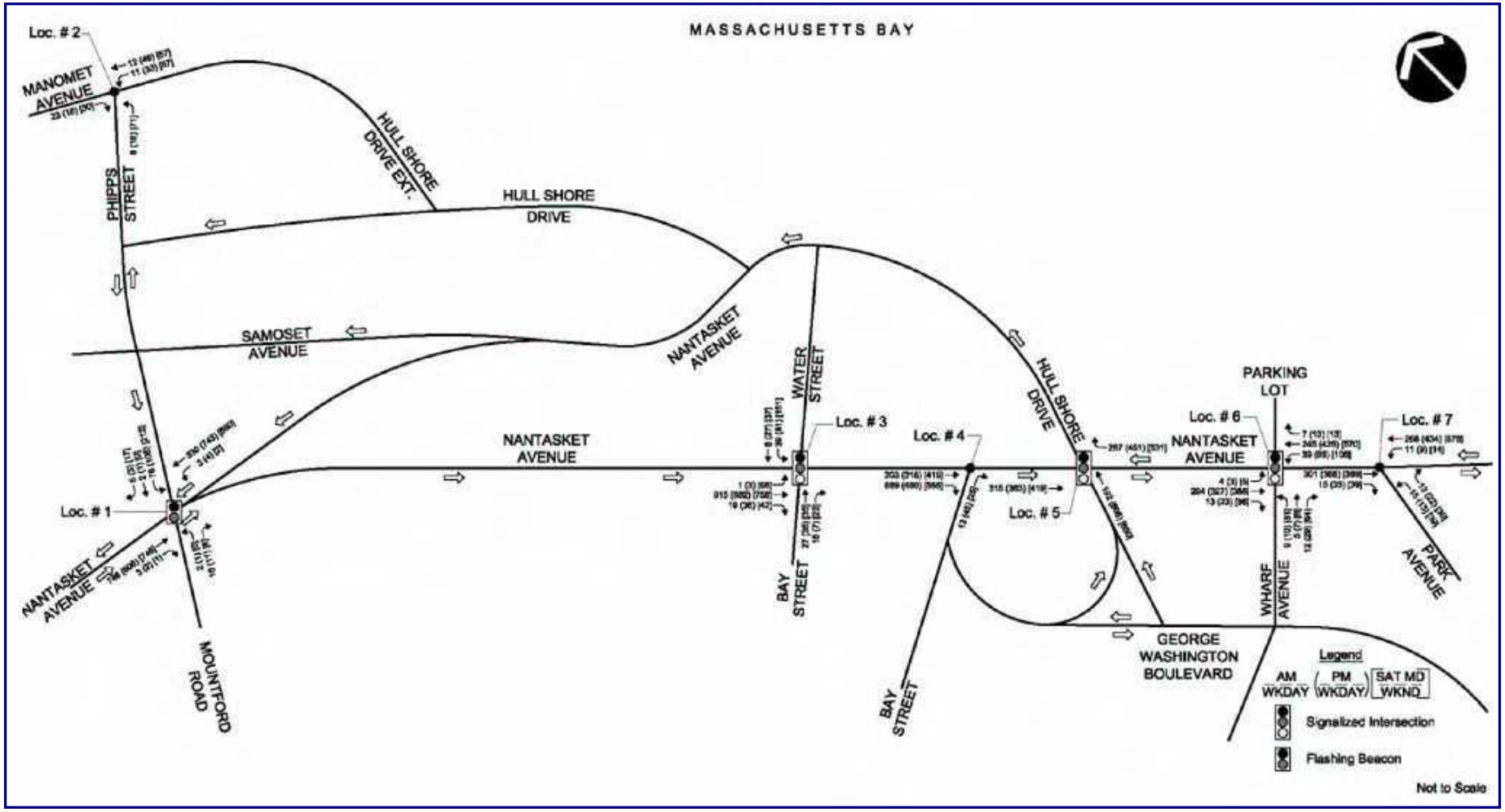
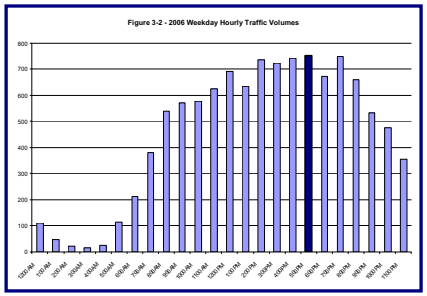


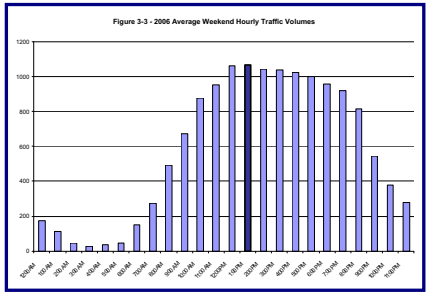
Figure 3- : Existing 2006 Peak Hourly Traffic Volumes

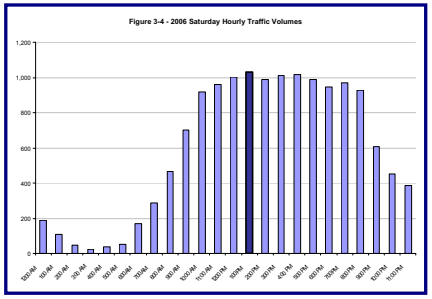
Nantasket Avenue between Wharf Avenue & Hull Shore Drive, Hull, MA

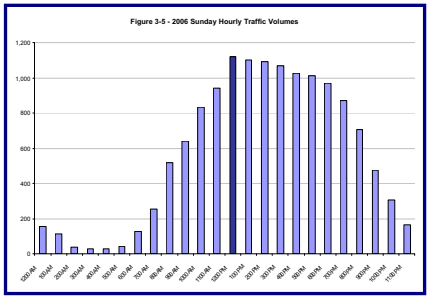
	8/4/2006		Friday	8/5/2006		Saturday	8/6/2006		Sunday	Weekend Average		
	NB	SB	Total	NB	SB	Total	NB	SB	Total	NB	SB	Total
12:00 AM	62	48	110	109	79	188	79	79	158	94	79	173
1:00 AM	32	14	46	57	54	111	59	55	114	58	55	113
2:00 AM	10	12	22	30	20	50	22	18	40	26	19	45
3:00 AM	8	7	15	15	9	24	13	15	28	14	12	26
4:00 AM	8	18	26	15	25	40	12	16	28	14	21	34
5:00 AM	43	71	114	18	36	54	21	21	42	20	29	48
6:00 AM	71	141	212	71	102	173	68	59	127	70	81	150
7:00 AM	160	221	381	148	140	288	125	131	256	137	136	272
8:00 AM	244	296	540	240	227	467	267	250	517	254	239	492
9:00 AM	259	311	570	387	317	704	336	305	641	362	311	673
10:00 AM	274	302	576	511	406	917	482	352	834	497	379	876
11:00 AM	287	337	624	596	367	963	578	365	943	587	366	953
12:00 PM	353	340	693	641	361	1,002	716	404	1,120	679	383	1061
1:00 PM	324	310	634	638	395	1,033	703	398	1,101	671	397	1067
2:00 PM	414	323	737	557	434	991	654	438	1,092	606	436	1042
3:00 PM	392	331	723	551	462	1,013	604	464	1,068	578	463	1041
4:00 PM	419	322	741	544	476	1,020	597	430	1,027	571	453	1024
5:00 PM	433	319	**752**	499	491	990	525	488	1,013	512	490	1002
6:00 PM	381	293	674	492	455	947	476	493	969	484	474	958
7:00 PM	425	324	749	512	461	973	463	407	870	488	434	922
8:00 PM	367	293	660	488	439	927	370	335	705	429	387	816
9:00 PM	282	250	532	331	277	608	258	218	476	295	248	542
10:00 PM	302	173	475	240	214	454	172	133	305	206	174	380
11:00 PM	211	144	355	176	211	387	94	74	168	135	143	278
Total	**5,761**	**5,200**	**10,961**	**7,866**	**6,458**	**14,324**	**7,694**	**5,948**	**13,642**	**7,780**	**6,203**	**13,983**

Figure 3-1: 2006 Average Daily Traffic (ADT)









3.1.2 Visual Assessment of Traffic Locations

Berger investigated each of the seven survey locations for additional traffic-related information.

Location 1: Nantasket Avenue at Phipps Street and Mountford Road

Phipps Street and Mountford Road intersect Nantasket Avenue to form a four-way intersection. This intersection is presently controlled by a flashing beacon and STOP signs. STOP sign controls are for Mountford Street and Phipps Street along-with 'Flashing Red' (FR) indication.

Nantasket Avenue provides one lane per direction for through and turning traffic. Mountford Street has one approach lane at the intersection. The one-way Phipps Street in the westerly direction has exclusive right and left turning lanes. The existing geometric configuration, signing, pavement markings and lane configuration at the intersection are shown in Figure 3-6.

Signing and pavement markings at the intersection are not adequate for one-way operation and do not conform to the Manual on Uniform Control Devices (MUTCD) criteria.

Figure 3-6: Location 1 (Nantasket Avenue at Phipps Street and Mountford Road)

Location 2: Hull Shore Drive Extension at Phipps Street and Manomet Avenue

Phipps Street intersects Hull Shore Drive Extension/Manomet Street to form a three-legged unsignalized intersection. Hull Shore Drive Extension and Manomet Avenue approaches are presently under STOP sign control.

The Hull Shore Drive Extension is a one-way street approaching the intersection. Phipps Street and Manomet Avenue approaches have one-travel lanes in each direction, divided by double yellow center lines (DYCL). The intersection layout, existing geometric configuration and other details are shown in Figure 3-7.

Signing for one-way operations and turn restrictions are not adequate and do not conform to MUTCD.

Figure 3-7: Location 2 (Hull Shore Drive Extension at Phipps Street and Manomet Avenue)

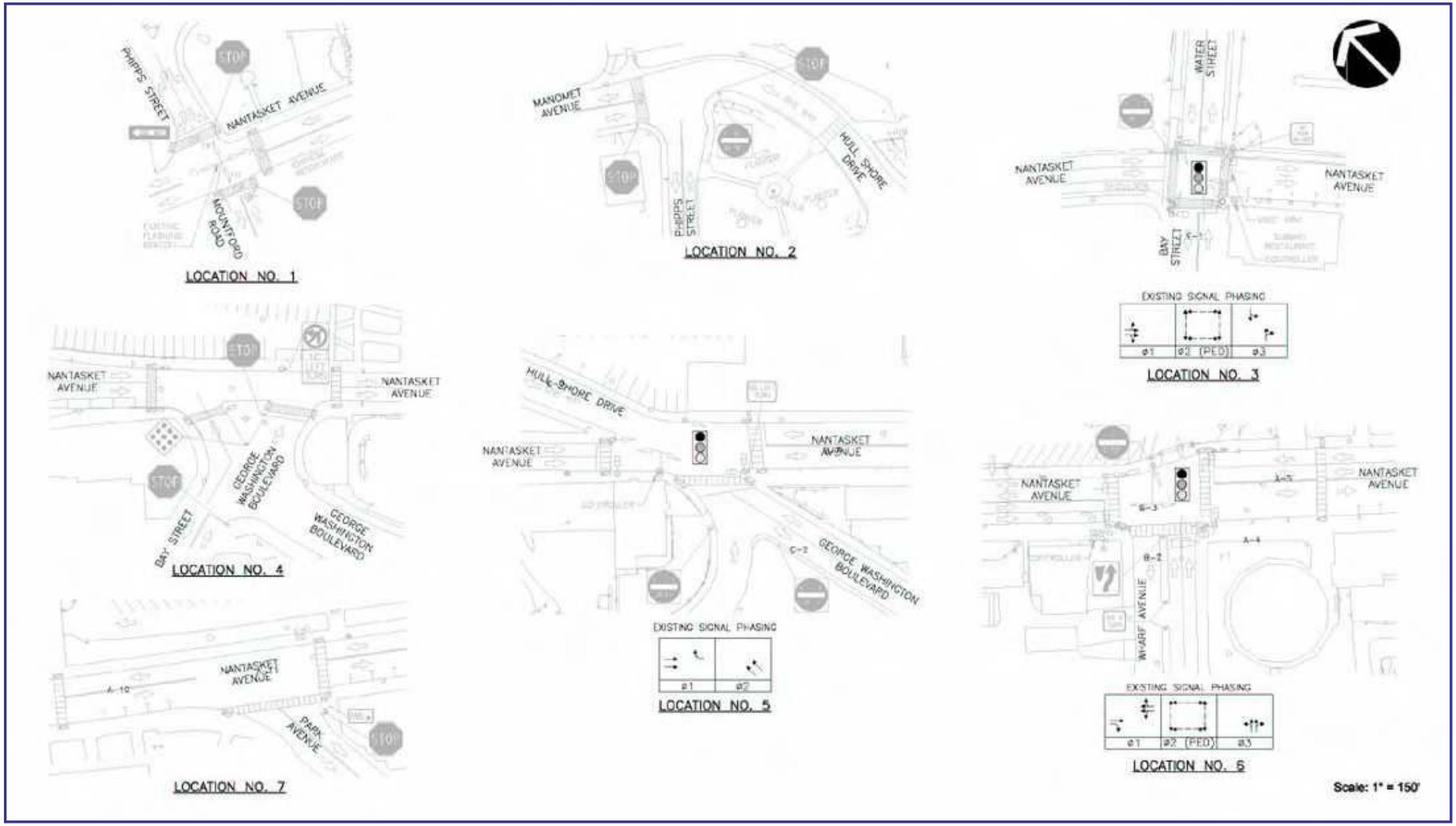


Figure 3-8: Existing Study Area Intersections – Geometry and Control

Location 3: Nantasket Avenue at Water Street and Bay Street

Bay Street and Water Street intersect Nantasket Avenue to form a four-way signalized intersection. The horizontal alignment on Nantasket Avenue, Bay Street and Water Street at this location meet at an approximate ninety degree angle.

At this location, Nantasket Avenue is one-way in the southerly direction and provides two travel lanes. Both Bay Street and Water Street provide one travel lane for through and turning traffic.

This intersection is presently controlled by a three-phase actuated traffic signal system including an exclusive pedestrian phase. Marked crosswalks are provided at all four legs of the intersection with pedestrian signal heads and push buttons. Water Street and Bay Street move concurrently in one-signal phase followed by Nantasket Avenue phase.

Existing traffic signal heads are mounted on mast arm and standard signal posts. All signal hardware appears to be old and outdated. Existing traffic control system, signal phasing, intersection geometry and lane configurations are shown in Figure 3-9.

Pavement markings are adequate at this location, but better signage is necessary for Nantasket Avenue one-way southbound operation.

Figure 3-9: Location 3 (Nantasket Avenue at Water Street and Bay Street)

Location 4: Nantasket Avenue at George Washington Boulevard

George Washington Boulevard intersects Nantasket Avenue to form a three-legged unsignalized intersection. Right turns from George Washington Boulevard onto Nantasket Avenue are presently under STOP sign control.

Nantasket Avenue is one-way in the southerly direction and provides two travel lanes at the intersection. An island is provided along George Washington Boulevard channelizing the entering and exiting traffic (Figure 3-10).

Signage for one-way operation is not adequate.

Figure 3-10: Location 4 (Nantasket Avenue at George Washington Boulevard)

Location 5: Nantasket Avenue at Hull Shore Drive and George Washington Boulevard

Hull Shore Drive and George Washington Boulevard intersect Nantasket Avenue to form a four-way signalized intersection. Nantasket Avenue is one-way in a southerly direction with two travel lanes. It is two-way in the northbound direction providing two ten-foot wide travel lanes in each direction. George Washington Boulevard is one-way in the easterly direction and provides two travel lanes. Hull Shore Drive is one-way away from the intersection.

This intersection is presently controlled by a two-phase actuated traffic signal system. Phase one serves both Nantasket Avenue northbound and southbound approaches followed by George Washington Boulevard through movements to Hull Shore Drive. Present alignment and geometry of Washington Boulevard do not allow right turns onto Nantasket Avenue. Marked crosswalks exist along all approaches and pedestrian indications are provided concurrently with the vehicular phase.

Existing traffic signal heads are mounted on mast arm and standard signal posts. A mast arm is located on the southeast corner of the intersection. The mast arm holds one two-face, three-lens signals controlling Nantasket Avenue northbound and southbound traffic. The remaining vehicle and pedestrian signal heads are mounted on standard signal posts. Existing traffic signal equipment at this location can be considered to be in fair to poor condition. Existing traffic control system, signal phasing, intersection geometry and lane configurations are shown in Figure 3-11.

Signage for one-way and turn restrictions are not adequate and does not conform to the latest edition of MUTCD.

Figure 3-11: Location 5 (Nantasket Avenue at Hull Shore Drive and George Washington Boulevard)

Location 6: Nantasket Avenue at Wharf Avenue

Wharf Avenue intersects Nantasket Avenue to form a three-way signalized intersection. Nantasket Avenue approaches have two travel lanes in each direction. Wharf Avenue is a two-way street with one travel lane in each direction. Nantasket Avenue southbound approach has a dedicated right turn lane and one general purpose lane. Currently, a driveway opening to the parking lot along the eastern side of Nantasket Avenue has been provided at the intersection opposite to Wharf Avenue. This driveway is one-way for the entering traffic only.

This intersection is presently controlled by a three-phase semi-actuated traffic signal with an exclusive pedestrian phase, and wire-loop vehicle detectors for the minor street - Wharf Avenue approach. Nantasket Avenue northbound and southbound approaches move concurrently in one signal phase followed by the phase for Wharf Avenue traffic.

Three marked crosswalks are provided across Nantasket Avenue and Wharf Avenue with pedestrian signals and push buttons.

Existing traffic signal heads are mounted on one mast arm and four regular signal posts, one in each quadrant/corner. Existing traffic control equipment at this location can be considered to be in fair to poor condition. Existing traffic control system, signal phasing, intersection geometry and lane configurations are shown in Figure 3-12.

Signage and pavement markings for the dedicated turn lanes at the intersection are not adequate and do not conform to the MUTCD criteria.

Figure 3-12: Location 6 (Nantasket Avenue at Wharf Avenue)

Location 7: Nantasket Avenue at Park Avenue

Park Avenue intersects Nantasket Avenue at an angle to form a three-way unsignalized intersection (Figure 3-13). Left and right turns from Park Avenue are under STOP sign control.

Both approaches of Nantasket Avenue and Park Avenue have one travel lane in each direction. Travel lanes along Park Avenue are separated by a single yellow lane line instead of DYCL. There is no stop bar along Wharf Avenue. There are two marked crosswalks at the intersection.

Pavement markings as described above are inadequate and do not conform to the latest edition of MUTCD.

Figure 3-13: Location 7 (Nantasket Avenue at Park Avenue)

3.1.3 Traffic Analysis for Intersection Level of Service

The base year 2006 peak hourly traffic volumes shown in Figure 3-1 were utilized to establish traffic operating conditions at the seven study intersections. Intersection capacity analyses were performed with the Saturday mid-day peak hourly traffic volumes, i.e., the 'worst case' peak hour-operations. The analyses were performed using SYNCHRO 6.0, a computer software package based on the methodology of the 2000 Highway Capacity Manual (HCM 2000).

The analyses assign a level of service (LOS) to each lane group, which is then aggregated for the approach and intersection. LOS is a qualitative measure describing operational conditions within a traffic stream, generally in terms of such service measures as speed, travel time, and freedom to maneuver. At signalized and unsignalized intersections, LOS is defined in terms of average control delay per vehicle. There are six LOS conditions designated by letters A to F, with LOS A representing the best operating condition and LOS F the worst. Each level of service is a representation of a range of operating conditions and how drivers perceive them. The LOS criteria for signalized and unsignalized intersections are summarized in Table 3-2.

Table 3-2: LOS criteria at signalized and unsignalized intersections

Level of Service	Average Delay *(seconds/vehicle)*	
	Signalized Intersections	**Unsignalized Intersections**
A	< 10	< 10
B	>10-20	>10-15
C	>20-35	>15-25
D	>35-55	>25-35
E	>55-80	>35-50
F	>80	>50

The LOS criteria for two-way stopped control (TWSC) intersections are somewhat different from the criteria for signalized intersections. This is due to the fact that a signalized intersection is designed to carry higher traffic volumes and experience greater delay than an unsignalized intersection.

Table 3-3 shows the results of capacity analyses performed for the seven study intersections, and summarizes LOS values, in addition to volume to capacity ratio, 95th % queue length and delay experienced at each approach of the intersection for the base year 2006. It also presents the overall LOS for the intersection. The table depicts the existing Saturday midday peak hour traffic operations (worst case peak hour operations). The output of the traffic analysis conducted using SYNCHRO is enclosed in Appendix 3-2 of this report. The existing LOS values and traffic operation for each intersection are discussed below.

- **Location 1: Nantasket Avenue at Phipps Street and Mountford Road.** The intersection functions at LOS C during the Saturday midday peak period. Left turns from Phipps Street are at LOS F, with excessive delay and 95% queue in excess of 580 feet. Right turns from Phipps Street, and left/right turns from Mountford Road are at LOS B with a delay of approximately 14 seconds, and minimal queue length.

- **Location 2: Hull Shore Drive Extension at Phipps Street and Manomet Avenue.** The intersection functions at LOS A, and all moves from Hull Shore Drive and Manomet Avenue under STOP sign control are at LOS B and A, respectively. Delays range between 8 and 11 seconds with minimal queue build-up.

Table 3-3: Capacity analysis summary 2006, Existing/Base condition

Location No.	Saturday Midday Peak LOS	Delay (sec)	v/c	95th % Queue Length (ft)
Loc #1: Nantasket Ave @ Phipps St & Mountford Rd - U (Flashing Beacon)				
Nantasket Avenue WB Left/Thru	A	0.1	0.00	0
Mountford Street NB Left/Right	B	14.6	0.03	2
Phipps Street SB Left	F	889.8	2.75	588
Phipps Street SB Right	B	14.0	0.05	4
Intersection	*C*		*0.64*	
Loc #2: Hull Shore Dr Ext @ Phipps St & Manomet Ave - U				
Manomet Avenue EB Right	A	8.5	0.04	3
Hull Shore Drive Extension WB Left/Thru	B	11.4	0.20	18
Phipps Street NB Left	A	7.3	0.05	4
Intersection	*A*	*9.7*	*0.17*	
Loc #3: Nantasket Ave @ Water St & Bay St - S				
Nantasket Avenue EB Left/Thru/Right	A	6.3	0.52	125
Bay Street NB Thru/Right	A	8.1	0.08	25
Water Street SB Left/Thru	A	9.8	0.44	91
Intersection	*A*	*7.1*	*0.49*	-
Loc #4: Nantasket Ave @ G Washington Blvd - U				
G Washington Boulevard NB Right	B	11.0	0.05	4
Intersection	*A*	*0.3*	*0.38*	-
Loc #5: Nantasket Ave @ G Washington Blvd & Hull Shore Drive - S				
Nantasket Avenue EB Thru	A	6.4	0.26	65
Nantasket Avenue WB Right	B	10.4	0.60	199
G Washington Boulevard NB Thru	B	12.0	0.52	104
Intersection	*A*	*10.0*	*0.63*	-
Loc #6: Nantasket Ave @ Wharf Ave & Parking Lot Driveway -S				
Nantasket Avenue EB Left/Thru	A	5.7	0.48	111
Nantasket Avenue EB Right	A	4.1	0.04	11
Nantasket Avenue WB Left/Thru/Right	A	5.6	0.49	91
Wharf Avenue NB Left/Thru/Right	A	9.1	0.28	58
Intersection	*A*	*6.0*	*0.44*	-
Loc #7: Nantasket Ave @ Park Ave - U				
Nantasket Avenue WB Left/Thru	A	0.4	0.01	1
Park Avenue NB Left/Right	C	22.6	0.32	34
Intersection	*A*	*1.9*	*0.52*	-

Notes:
S Signalized intersection
U Unsgnalized intersection

- **Location 3: Nantasket Avenue at Water Street and Bay Street.** The intersection operates at LOS A, and all major moves from Nantasket Avenue, Bay Street and Water Street are also at LOS A. Approach delays range from 6 to 11 seconds. Maximum queue is 12 feet long for the Nantasket Avenue approach.

- **Location 4: Nantasket Avenue at George Washington Boulevard.** The intersection is at LOS A, and right turns from George Washington Boulevard are at LOS B. The intersection experiences very little/minimal delay.

- **Location 5: Nantasket Avenue at Hull Shore Drive and George Washington Boulevard.** The intersection functions at LOS A. Traffic moves from Nantasket Avenue and George Washington Boulevard are at LOS B or better. George Washington Boulevard experiences the maximum delay (12 seconds) with 95% queue length greater than 100 feet.

- **Location 6: Nantasket Avenue at Wharf Avenue.** The intersection operates at LOS A, and all moves from Nantasket Avenue and Wharf Avenue are also at LOS A. Average delays on all approaches vary between 4 and 9 seconds. Maximum queue build-up is on the Nantasket Avenue northbound approach, approximately 110 feet in length.

- **Location 7: Nantasket Avenue at Park Avenue.** The intersection functions at LOS A. Park Avenue left and right turns under STOP sign control operate at LOS C with a delay of approximately 23 seconds, and a maximum queue length of 35 feet.

3.1.4 Vehicle Traffic - Summary

Traffic analyses at key intersections in the study area suggest adequate traffic operation and no major delays to be experienced.

3.1.5 Recommendations

As indicated in the existing conditions description, signing and pavement markings are inadequate and don't vonform to MUTCD. Signage and pavement markings require updating throughout the Reservation.

Existing traffic signals are old and outdated. We recommend upgrading the existing signal systems.

3.2 Safety Assessment

Accident statistics/crash data for 2002, 2003 and 2004 were collected from MassHighway for the study area (Table 3-4). MassHighway records show a total of fifty four (54) accidents occurring in the study area during the three year period investigated.

There were total of twenty two (22), fourteen (14), and eighteen (18) accidents during 2002, 2003 and 2004, respectively. The vast majority were rear-end type collisions accounting for 41% of the total crashes. Angular collisions constitute 31%, side swipe 11%, and collisions involving fixed objects at 9%. There was one head-on collision during 2002.

A good percentage of these crashes also involved personnel injuries (24%). The remaining 76% of the crashes reported were property-damage-only accidents. No fatality was reported during the 3-year period. Approximately 41% of crashes reported during the 3-year period occurred at the project area intersections, whereas the remaining 59% occurred at mid-block locations along Nantasket Avenue in the project area. Maximum number of accidents occurred at Location 5 (Nantasket Avenue at Hull Shore Drive and George Washington Boulevard). A total of six (6) crashes out of total twenty two (22) were reported at this location.

Roadway surface, adverse weather and poor light conditions were not critical factors for the crashes reported. Approximately two-third of the total crashes occurred during daylight hours, dry roadway surface conditions and in clear weather not involving rain/snow/ice.

Accident statistics and crash reports collected for the three year period are presented in their entirety in Appendix 3-3.

Table 3-4: Summary of motor vehicle crashes (2002-2004)

Nantasket Avenue btwn Park Avenue & Phipps Street
HULL, MA

Annual Crash Total by Severity

Year	Fatal	Personal Injury	Property Damage Only	Total
2002	0	7	15	22
2003	0	4	10	14
2004	0	2	16	18
Total	0	13	41	54
Percentage	0%	24%	76%	

Annual Crash Total by Type

Year	Angle	Rear-end	Fixed-Object	Head-on	Sideswipe	Pedestrian	Other	Total
2002	10	6	2	1	2	1	0	22
2003	3	7	1	0	2	0	1	14
2004	4	9	2	0	2	0	1	18
Total	17	22	5	1	6	0	2	54
Percentage	31%	41%	9%	2%	11%	0%	4%	

Number of Crashes Based on Time of Day and Conditions

Time of Day		6:00 AM - Noon:	18	6:00 PM - Midnight:	12	
		Noon - 6:00 PM:	19	Midnight - 6:00 AM:	6	
Light Condition	Daylight:	36	Dark:	18	Unknown:	0
Surface Condition	Dry:	33	Wet:	8	Snow/Ice:	3
Weather:	Clear: 35	Cloudy: 9	Rainy: 7	Snowy: 3	Other: 0	

Annual Crash by Day of the Week

Year	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday	Total
2002	3	1	1	5	3	7	2	22
2003	4	2	0	1	1	1	5	14
2004	5	2	2	2	1	1	5	18
Total	12	5	3	8	5	9	12	54
Percentage	22%	9%	6%	15%	9%	17%	22%	

Annual Crash Total by Location

Year	Intersection	Mid-Block	Total
2002	15	7	22
2003	3	11	14
2004	4	14	18
Total	22	32	54
Percentage	41%	59%	

3.3 Parking Assessment

The parking study conducted by Berger a study of the parking inventory and the parking usage.

3.3.1 Parking Inventory

Berger conducted a parking inventory for the Nantasket Reservation for both off-street parking lots and on-street parking. There are approximately 1,350 parking spaces in the Reservation. A summary is provided in Table 3-5; details are presented in Figures 3-14 to 3-17. Table 1 distinguished between designated parking lots, parking areas along the street and in undesignated spaces, and remote lots along George Washington Boulevard.

Most of the surface parking areas are adjacent to the beachfront, with the highest concentration of public parking found on the southern end of the Reservation. The largest parking lot (Lot #4) is located at the southerly end of the study area next to the MJM Bath House and has 285 marked parking spaces. An additional 47 vehicles were observed parking next to the curb along the western side of the parking lot.

Table 3-5: Summary of parking spaces for the Nantasket Beach (from south to north)

Name	Location	Spaces	Comments
Parking Lots			
Lot #4	Nantasket Ave, south of Tivoli Bathhouse	285	Additional 47 parallel unmarked spaces
Lot #3	Nantasket Ave, Tivoli Bath House to Bernie King Pavilion	136	
Lot #2	Nantasket Ave, Bernie King Pavilion to MJM Bath House	81	
Lot #1	Nantasket Ave, north of MJM Bath House	90	
DCR Lot	Between Nantasket Ave and Hull Shore Drive, south of Red Parrot Restaurant	57	
Lot near Quincy St.	Between Hull Shore Drive and Nantasket Avenue, south of Quincy Street	109	
Parking Areas			
Blocks 101-111, 201	Nantasket Ave, from south to Bernie King Pavilion	66	
Area 1	Hull Shore Drive, south of Water Street	89	
Area 5	Nantasket Ave, north of Bay Street	36	
Area 4	Nantasket Ave, north of Sagamore Terrace	21	
Area 3	North of Bay Street, west of Nantasket Ave	14	on grass
Area 2	North of Water Street	48	on grass
Hull Shore Drive	Hull Shore Drive, between Water Street and Phipps Street	50	estimate
Remote Lots			
Remote Lot 2	George Washington Blvd.	46	
Remote Lot 1	George Washington Blvd.	230	
Total Spaces		**1,358**	

Moving north there are three additional parking lots: Lot #3, Lot #2 and Lot #1 with a capacity of 136, 81 and 90 parking spaces, respectively. Another DCR parking lot is located between Nantasket Avenue and Hull Shore Drive north of George Washington Boulevard. This parking lot has 57 marked parking spaces.

Parking Area #1 provides 89 marked parking spaces along the street and is located on Hull Shore Drive north of Parking Lot #1. Parking areas #4 and #5 provide on-street parking along Nantasket Avenue between George Washington Boulevard and Water Street. These two parking areas provide 21 and 36 parking spaces, respectively. Additional marked parking spaces also exist along Nantasket Avenue between Wharf Avenue and southerly project limit. These parking areas have been identified by block as '101" to "111', and '201', and provide 66 marked on-street parking spaces in total.

An additional parking lot is located at the northerly end of the project limit located between Nantasket Avenue and Hull Shore Drive. This lot has 109 marked parking spaces, but parking was restricted due to the ongoing construction activities. People were also observed parking in two grass areas located between Water Street/Bay Street and this parking lot.

Two overflow parking lots are located on George Washington Boulevard near the southern end of the Reservation. They are separated from Nantasket Avenue by a large condominium development. The larger Remote Lot 1 has a capacity of 230 parking spaces; Remote Lot 2 has a capacity of 46 spaces.

In addition, there are approximately 50 spaces for on-street parallel parking along Hull Shore Drive between Water Street and Phipps Street. The area was under construction at the time of the survey.

3.3.2 Parking Usage

The parking usage for Parking Lots 1 to 4 was studied on Saturday of August 5, 2006 from 9:00 am to 5:00 pm, based on the assumption that a summer Saturday will provide a worst-case analysis of the parking demand and turnovers. The study was conducted on the same day as the traffic count. The capacity of the parking lots was logged on an hourly basis. The weather was warm (85ºF) and sunny.

Table 3-6 presents the number of parking spaces occupied on the four studied lots on the hourly basis between the hours of 9:00 am to 5:00 pm. Table 3-7 presents the percentage utilization of the parking areas. Figure 3-18 depicts the percentage utilization of Parking Lots 1 to 4 in a graphical form. The capacity of Lot 1 was 100% utilized between the hours of 10:00 am and 3:00 pm. Lot 2 was 100% utilized between 11:00 am to 4:00 pm. Lots 3 and 4 were at their capacity (with > 95% utilization) between 11:00 am and 1:00 pm. Usage of Lots 1 and 2 exceeded 100% utilization during the peak parking demand period (10:00 am to 4:00 pm).

3.3.3 Recommendation

Additional parking demand during the peak period can be met by increasing the attractiveness of the underutilized overflow parking lots (Remote Lots 1 and 2), located on George Washington Boulevard at the southern end of the Reservation. This can be accomplished by providing a more direct link from this parking lot to Nantasket Avenue and the beach.

Signage could be improved to inform and direct beachgoers to the Remote Lots, particularly if parking spaces are removed from the ocean front lots. This will assist in reducing traffic on Nantasket Avenue during peak summer days.

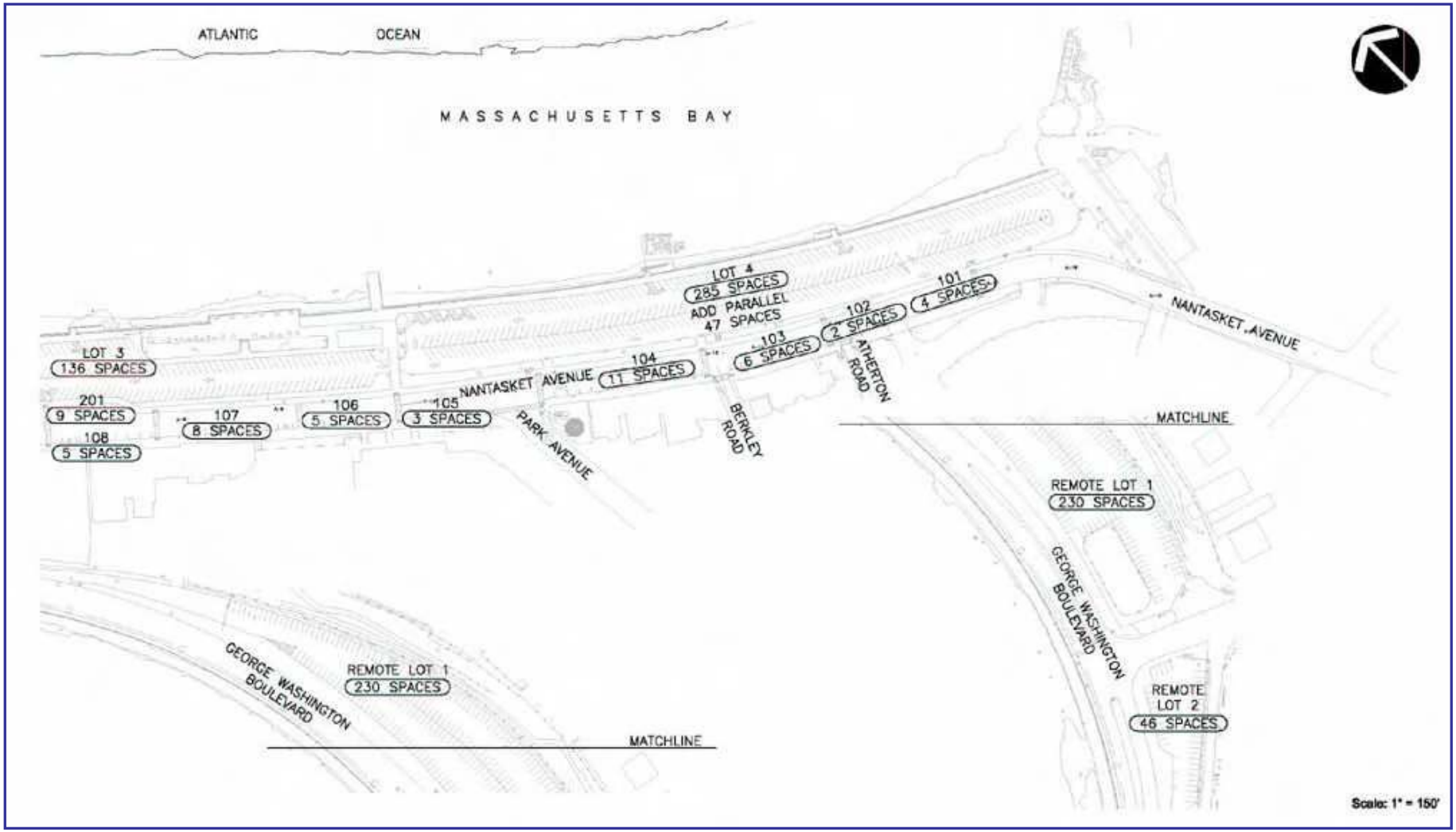


Figure 3-14: Parking Inventory – August 2006

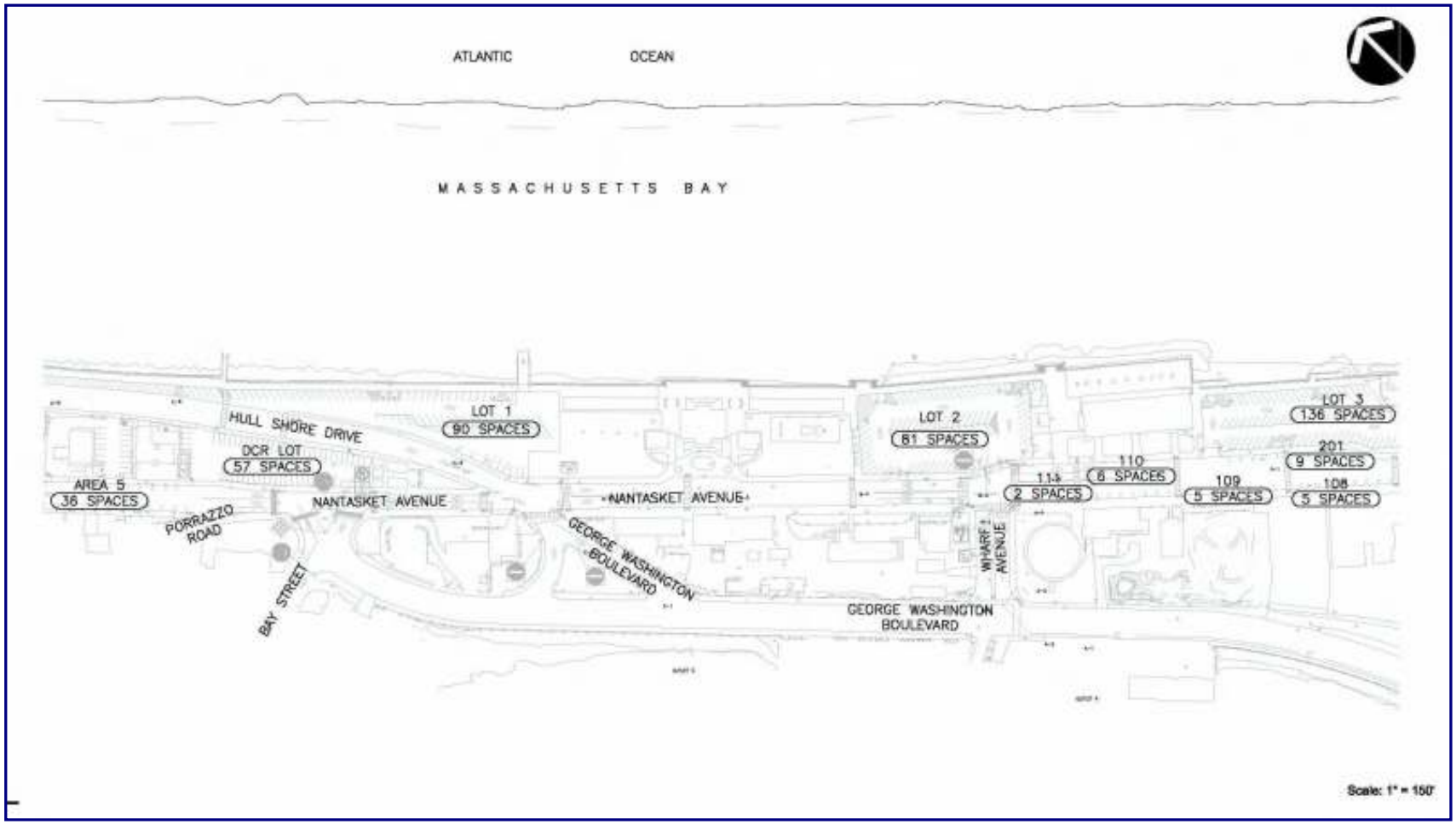


Figure 3-15: Parking Inventory – August 2006

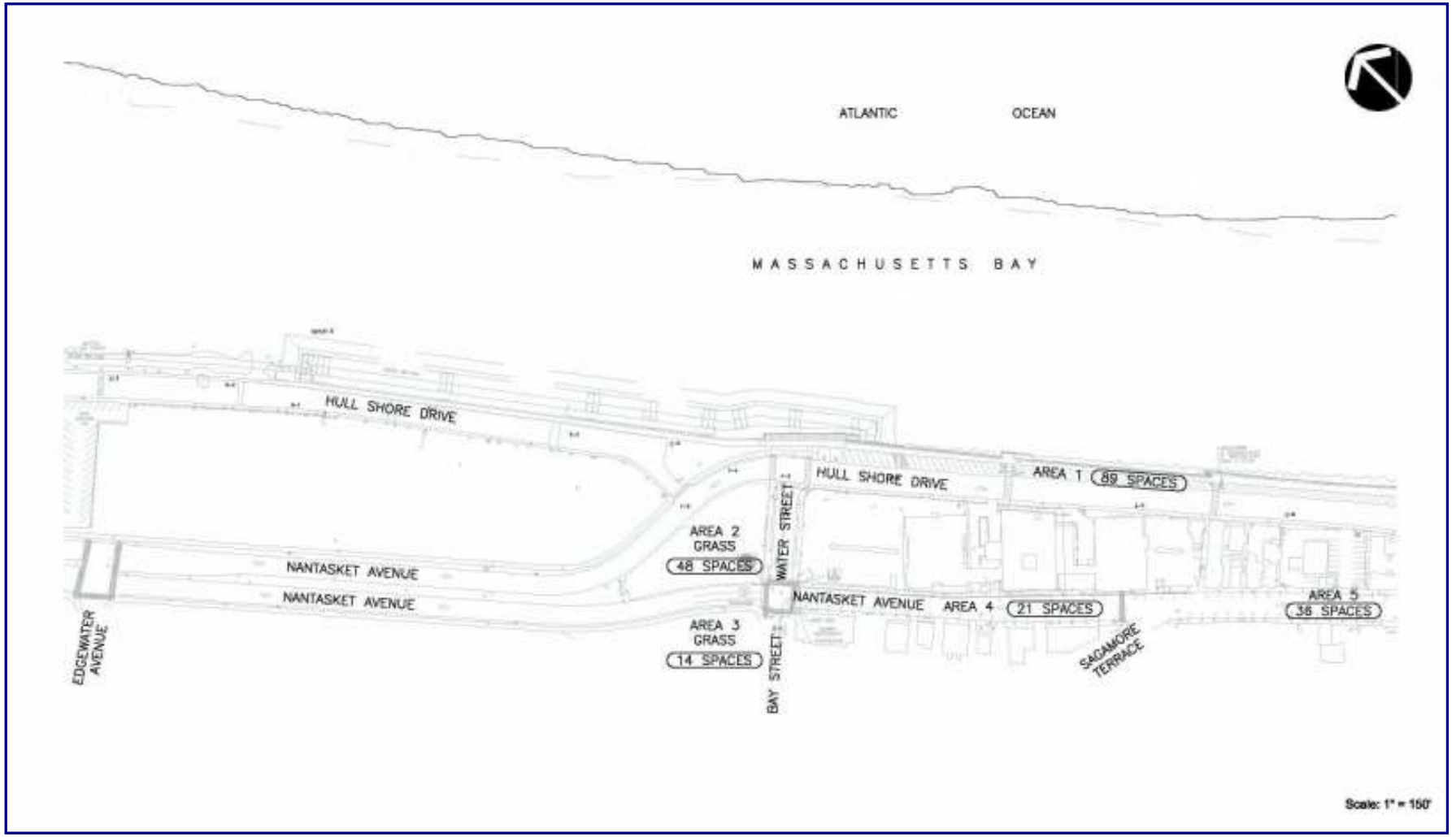


Figure 3-16: Parking Inventory – August 2006

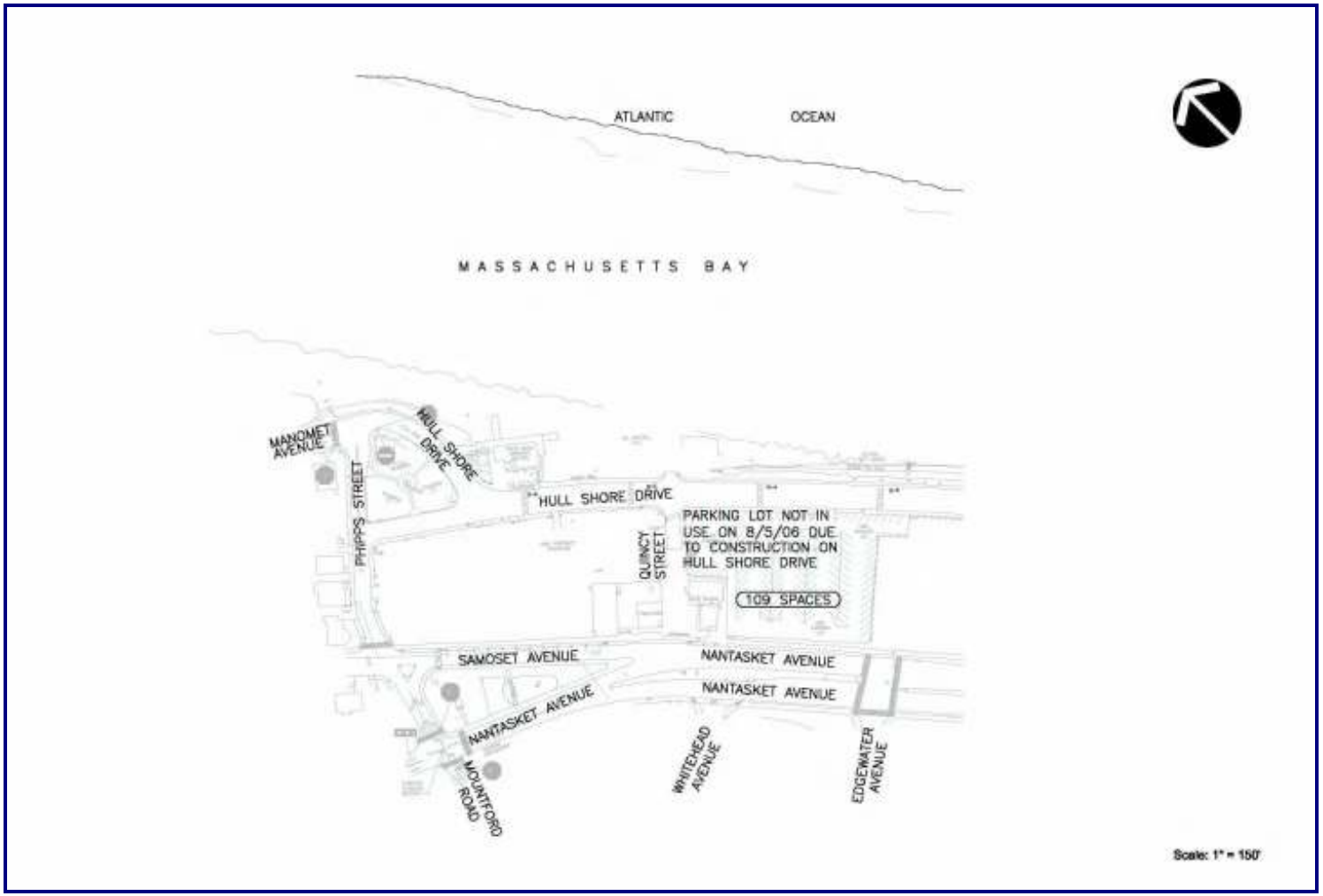


Figure 3-17: Parking Inventory – August 2006

			Time Circuit Begins								
Lot/Area	Row	Total	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
LOT 1	A	31	29	32	32	31	32	31	30	27	31
	B	18	17	19	19	20	20	18	19	14	18
	C	12	11	14	15	15	15	15	14	9	10
	D	5	2	5	5	5	7	10	7	5	4
	E	24	18	22	24	24	23	22	18	16	12
Total LOT 1		90	77	92	95	95	97	96	88	71	75
DCR LOT	A	29	9	17	27	28	28	29	29	25	28
	B	7	4	5	7	7	9	7	6	8	6
	C	21	7	6	19	23	24	25	21	23	23
Total DCR		57	20	28	53	58	61	61	56	56	57
AREA 1	A	6	5	6	6	6	6	6	6	5	5
	B	32	30	31	30	32	32	29	29	27	24
	C	28	28	28	26	29	27	27	25	27	26
	D	23	27	27	27	28	28	28	28	27	27
Total Area 1		89	90	92	89	95	93	90	88	86	82
GRASSAREA 2		48	31	24	20	24	24	31	39	43	48
GRASS AREA 3		14	1	2	4	7	11	12	14	8	4
AREA 4	A(m)	15	3	2	10	14	15	17	16	9	14
	B	6	3	2	5	6	6	6	6	4	6
Total Area 4		21	6	4	15	20	21	23	22	13	20
AREA 5	A	18	2	7	12	18	18	19	18	12	16
	B	15	1	4	13	14	12	14	14	12	14
	C	3	2	2	1	3	0	0	0	2	2
Total Area 5		36	5	13	26	35	30	33	32	26	32
LOT 2	A	8	6	7	7	8	8	8	8	8	8
	B	20	17	14	18	22	22	22	22	18	17
	C	10	10	10	11	12	11	11	11	10	8
	D	11	5	10	10	11	12	11	11	11	9
	E	16	14	16	16	16	17	17	17	17	16
	F	16	15	17	17	17	18	18	19	18	15
Total LOT 2		81	67	74	79	86	88	87	88	82	73
LOT 3	A	34	2	21	34	34	34	28	28	21	22
	B	23	13	21	23	23	22	21	15	20	18
	C	21	3	21	21	21	21	20	11	8	11
	D	58	2	20	57	56	55	51	40	25	24
Total LOT3		136	20	83	135	134	132	120	94	74	75
LOT 4	A	95	29	58	91	90	90	82	75	73	66
	B	95	19	42	98	98	97	88	75	72	62
	C	95	15	28	82	98	92	78	62	48	39
Total LOT 4		285	63	128	271	286	279	248	212	193	167
101		4	4	5	4	3	5	5	4	4	4
102		2	2	2	2	1	2	2	2	2	2
103		6	6	5	5	6	6	3	6	7	6
104		11	10	7	7	11	11	11	12	8	10
105		3	0	2	4	3	2	5	5	4	4
106		5	1	1	5	6	7	7	7	4	6
107		8	0	1	6	8	9	9	7	7	6
108		5	2	3	6	8	8	8	10	7	7
109		5	1	3	6	7	8	4	6	6	8
110		6	1	5	5	4	7	5	6	7	5
111		2	0	0	0	0	0	1	2	0	1
201		9	8	9	9	9	9	10	10	11	11
Overflow LOT 4		47			1	47	46	45	35	14	8
TOTAL		945									

Table 3-6: Parking Inventory

			Time Circuit Begins								
Lot/Area	Row	Total	9:00 AM	10:00 AM	11:00 AM	12:00 PM	1:00 PM	2:00 PM	3:00 PM	4:00 PM	5:00 PM
LOT 1	A	31	29	32	32	31	32	31	30	27	31
	B	18	17	19	19	20	20	18	19	14	18
	C	12	11	14	15	15	15	15	14	9	10
	D	5	2	5	5	5	7	10	7	5	4
	E	24	18	22	24	24	23	22	18	16	12
Total LOT 1		90	85.6%	102.2%	105.6%	105.6%	107.8%	106.7%	97.8%	78.9%	83.3%
DCR LOT	A	29	9	17	27	28	28	29	29	25	28
	B	7	4	5	7	7	9	7	6	8	6
	C	21	7	6	19	23	24	25	21	23	23
Total DCR		57	35.1%	49.1%	93.0%	101.8%	107.0%	107.0%	98.2%	98.2%	100.0%
AREA 1	A	6	5	6	6	6	6	6	6	5	5
	B	32	30	31	30	32	32	29	29	27	24
	C	28	28	28	26	29	27	27	25	27	26
	D	23	27	27	27	28	28	28	28	27	27
Total Area 1		89	101.1%	103.4%	100.0%	106.7%	104.5%	101.1%	98.9%	96.6%	92.1%
GRASSAREA 2		48	31	24	20	24	24	31	39	43	48
GRASS AREA 3		14	1	2	4	7	11	12	14	8	4
AREA 4	A(m)	15	3	2	10	14	15	17	16	9	14
	B	6	3	2	5	6	6	6	6	4	6
Total Area 4		21	28.6%	19.0%	71.4%	95.2%	100.0%	109.5%	104.8%	61.9%	95.2%
AREA 5	A	18	2	7	12	18	18	19	18	12	16
	B	15	1	4	13	14	12	14	14	12	14
	C	3	2	2	1	3	0	0	0	2	2
Total Area 5		36	13.9%	36.1%	72.2%	97.2%	83.3%	91.7%	88.9%	72.2%	88.9%
LOT 2	A	8	6	7	7	8	8	8	8	8	8
	B	20	17	14	18	22	22	22	22	18	17
	C	10	10	10	11	12	11	11	11	10	8
	D	11	5	10	10	11	12	11	11	11	9
	E	16	14	16	16	16	17	17	17	17	16
	F	16	15	17	17	17	18	18	19	18	15
Total LOT 2		81	82.7%	91.4%	97.5%	106.2%	106.8%	107.4%	108.6%	101.2%	90.1%
LOT 3	A	34	2	21	34	34	34	28	28	21	22
	B	23	13	21	23	23	22	21	15	20	18
	C	21	3	21	21	21	21	20	11	8	11
	D	58	2	20	57	56	55	51	40	25	24
Total LOT3		136	14.7%	51.5%	99.3%	98.5%	97.1%	88.2%	69.1%	54.4%	56.1%
LOT 4	A	95	29	58	91	90	90	82	75	73	66
	B	95	19	42	98	98	97	88	75	72	62
	C	95	15	28	82	98	92	78	62	48	39
Total LOT 4		285	72.1%	44.9%	95.1%	100.4%	97.9%	87.0%	74.4%	67.7%	56.8%
101		4	100.0%	125.0%	100.0%	75.0%	125.0%	125.0%	100.0%	100.0%	100.0%
102		2	100.0%	100.0%	100.0%	50.0%	100.0%	100.0%	100.0%	100.0%	100.0%
103		6	100.0%	83.3%	83.3%	100.0%	100.0%	50.0%	100.0%	116.7%	100.0%
104		11	90.9%	63.6%	63.6%	100.0%	100.0%	100.0%	109.1%	72.7%	90.9%
105		3	0.0%	66.7%	133.3%	100.0%	66.7%	166.7%	166.7%	133.3%	133.3%
106		5	20.0%	20.0%	100.0%	120.0%	140.0%	140.0%	140.0%	80.0%	120.0%
107		8	0.0%	12.5%	75.0%	100.0%	112.5%	112.5%	87.5%	87.5%	75.0%
108		5	40.0%	60.0%	120.0%	160.0%	160.0%	160.0%	200.0%	140.0%	140.0%
109		5	20.0%	60.0%	120.0%	140.0%	160.0%	80.0%	120.0%	120.0%	160.0%
110		6	16.7%	83.3%	83.3%	66.7%	116.7%	83.3%	100.0%	116.7%	83.3%
111		2	0.0%	0.0%	0.0%	0.0%	0.0%	50.0%	100.0%	0.0%	50.0%
201		9	88.9%	100.0%	100.0%	100.0%	100.0%	111.1%	111.1%	122.2%	122.2%
Overflow LOT 4		47	0.0%	0.0%	2.1%	100.0%	97.9%	95.7%	74.5%	29.8%	17.0%
TOTAL		945									

Table 3-7: Parking Usage/Turnover

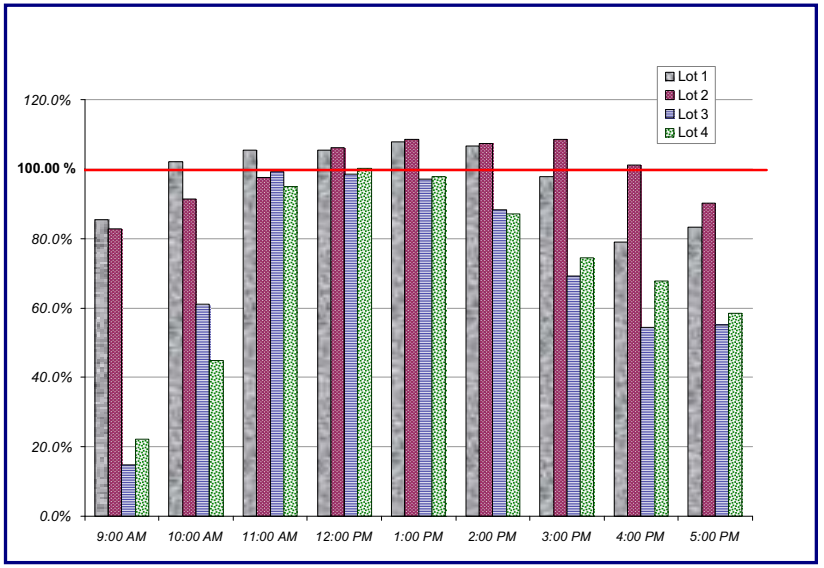


Figure 3-18: Parking turnover vs. capacity, weekend 2006

3.4 Pedestrian Traffic

3.4.1 Pedestrian Study

Detailed pedestrian counts were conducted on Saturday, August 4, 2007 from 11:00 am to 2:00 pm, based on the determination that a summer Saturday will provide maximum pedestrian turnovers/demand and at the same coinciding with the worst-case peak commute period. August 4, 2007 was a nice sunny day with temperature between low to mid 80s. Low tide occurred at 10:00 am; high tide occurred at 4:13 pm. In essence it was a beautiful beach day and as a result there were plenty of beachgoers.

Pedestrian counts were conducted at twenty one (21) crosswalk locations along Nantasket Avenue and Hull Shore Drive in the project area. Locations are shown in Figure 3-19. Count data are presented in Appendix 3-4.

Pedestrian counts indicate the following (Table 3-8):

- A total of 2,867 pedestrians used the crosswalks to access the Nantasket Beach area during the three hour period.
- Maximum pedestrian activity occurred between the hour of 1:00 pm and 2:00 pm. A total of 1,183 pedestrians were observed using the 21 crosswalks within this time block.
- There were two clusters of crosswalks with higher pedestrian crossings: CW #17 to #21, connecting adjacent food and beverage businesses and beachgoers from the residential community of the Sagamore Hill to the beach. The second cluster consisted of CW #7 to #9, connecting the Bernie King Pavilion area to food and other businesses across Nantasket Avenue.
- Maximum three-hour pedestrian activity was at the mid-block crosswalk - CW #17 located along Hull Shore Drive. A total of 350 pedestrians crossed at this location. This crosswalk connects two DCR parking lots. It also receives pedestrian traffic from the Sagamore Hill community. In addition, the crosswalk was utilized by guests of the Red Parrot Restaurant.
- The adjacent crosswalk – CW #18 was also busy with 310 crossings. Much of the pedestrian traffic appears to be caused by beachgoers visiting the various food establishments on the other side of the street.
- Hourly maximum was 171 pedestrians occurred at CW #9 located along Nantasket Avenue south of Wharf Avenue. This crosswalk also had the second highest crossing (310) during the three-hour study window. The crosswalk connects the Bernie King Pavilion with the Clocktower Building, the Comfort Station, and the minigolf park.

Table 3-8: Hourly breakdown of pedestrian traffic.

Time Blocks	CW #1	CW #2	CW #3	CW #4	CW #5	CW #6	CW #7	CW #8	CW #9	CW #10	CW #11	CW #12	CW #13	CW #14	CW #15	CW #16	CW #17	CW #18	CW #19	CW #20	CW #21	Total - CW#1 to CW#21
11:00am - 12:00am	4	13	18	12	32	22	52	37	66	10	28	39	1	5	8	28	120	78	54	44	17	**688**
12:00am - 1:00pm	14	22	43	11	57	21	64	83	92	47	25	43	6	6	6	18	151	118	79	42	48	**996**
1:00pm - 2:00pm	22	16	33	31	55	34	125	79	171	64	64	25	14	3	13	2	79	114	120	71	48	**1,183**
Total : 11:00am - 2:00pm	**40**	**51**	**94**	**54**	**144**	**77**	**241**	**199**	**329**	**121**	**117**	**107**	**21**	**14**	**27**	**48**	**350**	**310**	**253**	**157**	**113**	**2,867**

3.4.2 Recommendations

- Consolidate mid-block crosswalks to reduce crossing points and thus reduce conflict points between the vehicular and pedestrian traffic.
- Consider signalizing major mid-block crosswalks: CW #9, CW #17 and CW #18 with major pedestrian activities in excess of 300 pedestrians during the three-hour period.
- Make mid-block crossings more visually distinct to the vehicular traffic. Options to be considered consists of replacing painted cross-walks with the brick crosswalks supplemented by flashing/LED warning signs, wider crosswalks, diagonal cross-hatching, etc. This will increase safety.

Figure 3-19: Station locations at crosswalks(CW) for pedestrian and bicycle counts.

3.5 Bicycle Study

Bicycles were counted on August 4, 2007 from 11:00am to 2:00pm, at the same 21 crosswalk locations along Nantasket Avenue and Hull Shore Drive in conjunction with the pedestrian counts extending from the southern end of the Reservation to Water Street. Locations are shown in Figure 3-19. Complete count data are presented in Appendix 3-4.

Bicycle counts indicate the following (Table 3-9):

- A total of 69 bicyclists (maximum) were recorded between the crosswalk location #20 and #21 during the three-hour period. Adjacent areas (CW #16 to CW #19 were also comparatively higher, suggesting bicycle traffic from the surrounding residential community of Hull.
- Bicycle traffic was higher during the hours before lunch, and the hours after lunch (i.e., before and after 12:00 am to 1:00 pm).

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Time Blocks	CW #1 and #2	CW #3 and #4	CW #5 and #6	CW #7 and #8	CW #9, #10 and #11	CW #12 and #13	CW #14 and #15	CW #16 and #17	CW #18 and #19	CW #20 and #21	Total - CW#1 to CW#21
11:00am - 12:00am	9	10	17	16	11	13	16	22	14	30	**158**
12:00am - 1:00pm	7	12	8	7	9	9	10	20	20	19	**121**
1:00pm - 2:00pm	11	12	21	15	10	15	17	17	22	20	**160**
Total : 11:00am - 2:00pm	**27**	**34**	**46**	**38**	**30**	**37**	**43**	**59**	**56**	**69**	**439**

Table 3-9: Hourly breakdown of bicycle traffic

For the entire study area, a total of 46 percent of the bicycles counted used the sidewalk while the remainder used the Hull Shore Drive and Nantasket Avenue road surfaces.