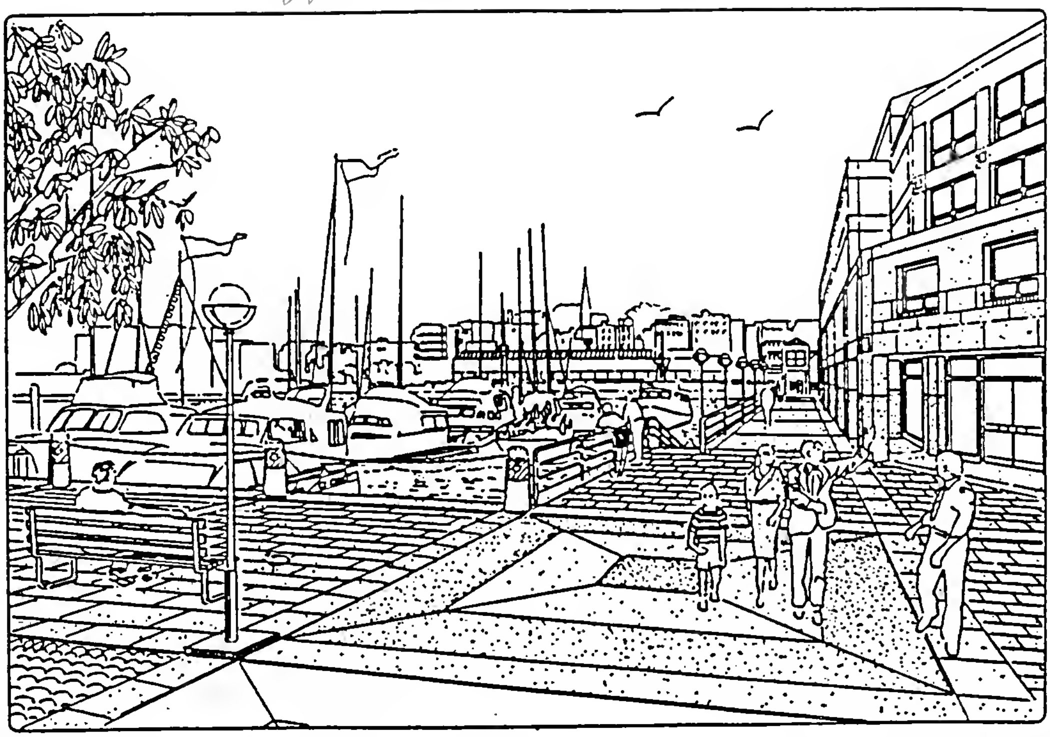
Draft Project Impact Report

TUDOR WHARF
Charlestown, MA

Appendicies & Supplement



SUBMITTED TO:
Boston Redevelopment Authority

SUBMITTED BY:
Myerson/Allen and Company, Inc.

PREPARED BY:
Fort Point Associates
300 Congress Street
Boston, MA 02210
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October, 1989

APPENDIX A
BLACK CROWNED NIGHT HERON REPORT

Lelito Environmental Consultants (LEC) was retained by Fort Point Associates to conduct an evaluation to determine the significance of Tudor Wharf to the existing heron population in Charlestown, Massachusetts (Figure 1). The Charlestown Bridge is located to the west of the site; the Charles River to the south; Constitutional Marina to the east; and, Water Street to the north. A portion of the existing building extends over the Charles River and is supported by timber pilings. These pilings currently serve as roosting and loafing sites for a locally common species of heron: the black-crowned night heron (Nycticorax nycticorax). In order to accurately assess potential impacts to this resource, a detailed investigation into the natural history, seasonal distribution, and habitat use of the black-crowned night heron in Boston Harbor, with particular emphasis on the importance of Tudor Wharf, was conducted by LEC. The following report outlines LEC's findings.

Introduction

The ecology and natural history of the black-crowned night heron (Nycticorax nycticorax) have not been researched as extensively as other species of wildlife. Current knowledge is largely limited to the original studies conducted by Gross (1923), Nobel (1938), and Noble and Wurm (1942). More contemporary investigators have been concerned with the effects of organochlorides on nest success (Custer 1983), distribution (Wolford and Erwin 1971, Custer 1982), and nest site selection (McCrimmon 1978, Davis 1986). This report will review the current knowledge of the breeding biology and resource needs of the black-crowned night heron and discuss the local distribution and habitat use of these birds in the Boston Harbor area. Special appreciation is given here to Dr. Jeremy Hatch of the Department of Biology, University of Massachusetts, for his assistance and unselfish disclosure of information.

Natural History

In order to provide a complete picture of the black-crowned night heron, a short narrative describing important aspects of the heron's natural history has been included. This information was extracted from published scientific literature and other pertinent resources.

Description

The black crowned night heron is a medium sized heron, growing to about 26 inches in length. The crown, back and shoulders of adults are black, with the remainder of the wings and tail ashy-grey. The undersides are whitish, legs are yellow and the irises are a conspicuous bright red.

Immature birds lack the black crown entirely. Their plumage is grayish-white with streaks of brown on the head and undersides, streaks and spots of rusty-brown and white on the back and dusky-brown primary feathers. Irises are brown, and legs, a pale greenish yellow.

Feeding Habits

Black crowned night herons most commonly feed in tidal creeks, the edges of ponds and swamps with standing water. They usually feed singly, often in areas several miles from the nest. They feed on a wide variety of aquatic organisms, including fish, amphibians and invertebrates.

Territoriality

Although described as being communal and having a complex social system, black-crowned night herons are highly territorial within their loosely communal aggregates. Young birds that have left the nest are reported to successfully defend their territory from intruding adults (Nobel et al. 1938). Indeed, young herons still only three weeks old, would defend their nest against adults that were not their parents (Noble and Wurm 1942). Lorenz (1938) describes the relationship between young herons and adults rather colorfully: "Such impudent youngsters are not only absolutely immune from attack, but the old birds actually seem afraid of them and will retreat whenever they see one coming." Soon after leaving the nest young herons will aggressively establish and defend territories within their natal tree. It appears that dominant birds defend perches higher in the nesting trees than submissive individuals (Nobel et al. 1938). Alliances among birds, usually siblings, to defend common areas were also noted by Nobel and his colleagues (1938). Adult birds defend vigorously the immediate location of their nest.

Nest Construction and Habitat Selection

Black-crowned night herons are colonial nesters where male and female share in nest construction activities. The male appears to be the one to collect nesting material. Although he initially participates in the actual construction of the nest, he may distribute nesting material to the female who stays in the nest and conducts most of the construction.

According to Gross (1923), nests he studied on Sandy Neck, Barnstable, Massachusetts, were typically found in trees and constructed of "cedar, oak, and especially of pitch pine." The average height of the ten nests he reported was approximately 17.5 feet above

the ground. In a more recent study of black-crowned night herons nesting in Plymouth, Massachusetts, Davis (1986) reported that nest site selection "...by black-crowned night herons and snowy egrets was a complex phenomenon that may have been influenced by (1) the time of nesting, (2) the presence of old nests, and (3) the presence of other nesting pairs."

The determinants of nest site selection and habitat quality in the inner Boston Harbor area has not been determined. Preferred nesting sites are not found in the inner Boston Harbor. The black-crowned night herons prefer to nest in areas more isolated from man's activities such as the Boston Harbor islands.

Egg Laying and Incubation

In New England, egg laying usually begins towards the middle of April and ends, typically, early June. This activity varies somewhat according to weather, food availability, habitat quality, sociality, and other variables (Custer et al. 1983, Davis 1986).

Clutch size in black-crowned night herons varies from 1-6, with 4-5 being the average (Gross 1923, Custer et al. 1983). Northern herons, predictably, have a slightly larger clutch size than southern populations (Custer et al. 1983).

Black-crowned night herons commence incubation immediately upon the laying of the first egg. This is typical of other herons as well as raptors and other groups of birds. This behavior results in the asynchronous hatching of the eggs. Therefore, the first egg to be laid is usually the first egg to hatch. Consequently, this stacks the deck in favor of the first chick with respect to growth rate and dominance over its siblings. The duration of incubation lasts approximately 22-

26 days from laying date (Gross 1923, Noble et al. 1938).

Longevity

No studies of the average or maximum longevity of black crowned night herons have been found in the literature. Eric Strauss of Tufts University suggested that average life expectancies are probably in the range of 4-8 years though some individuals probably live considerably longer.

Relationships Between Young and Adults

Once they have escaped the security of the egg (which, according to Gross (1923) is "a somewhat prolonged process"), the young are able to hold themselves upright in the nest within one day. Soon after hatching the chick commences begging for food. Black-crowned night herons feed their young regurgitated food, primarily fish. To solicit adults to regurgitate food young herons have been reported to "...seize the parent's bill nearly at right angles and [we] assume this is the typical method of receiving regurgitated food from the parent (Noble and Wurm 1942)." Hatchlings typically fledge within 4 to 6 weeks after hatching.

Breeding in First Year Birds

Breeding has been reported for first year birds by several investigators (Gross 1923, Noble et al. 1938, Custer and Davis 1982). This is interesting in that black-crowned night herons do not attain their adult plumage until after their third summer (Gross 1923). Custer and Davis (1982) collected detailed observations of a breeding pair of one year old herons, and a mixed-age breeding pair of a one and a two year old. Their findings documented the first occurrence of a pair of breeding one year old black-crowned night herons in the wild. Both nesting attempts occurred late in the season with smaller than average clutch sizes (3 eggs in

the mixed-aged pair). These findings are consistent with observations of late nesting cohorts of other species (Massey and Atwood 1981, Coulson and White 1958).

Habitat Use in Boston Harbor

Information regarding the use of Boston Harbor by black-crowned night herons is scarce (Hatch, LEC communication). What information is known is anecdotal in nature. The following information is documented by scientific publications or reports of reputable scientists.

Outer Islands

Large breeding colonies of black-crowned night herons occur on the islands of Boston Harbor; specifically, Middle Brewster, Outer Brewster, Calf Island and Spectacle Island (Hatch 1982). The herons have been known to utilize the inner harbor for feeding and roosting sites, principally during the non-breeding season; typically, late August through early April. The largest black-crowned night heron rookery, which has exceeded 300 breeding pairs, occurred on Spectacle Island. Other islands reporting breeding pairs of herons are Middle Brewster Island (20-154 pair) and Calf Island (several pair) and more recently on Outer Brewster Island (several pair) (Appendix A).

Herons begin to assemble at their breeding areas during the beginning part of April and remain there until young birds fledge in early June. The largest portion of the Boston Harbor population of black-crowned night herons migrate south beginning in August and September. A small portion of the population remain in the Boston Harbor area during the winter months. The population appeared (LEC observation) to consist principally of younger birds in their first or second winter plumage.

Inner Harbor

Specific roosting and loafing areas appear to be located within Boston Harbor, particularly in the inner harbor, during the non-breeding season: typically, late August through early April. The physical characteristics of these areas consisted, principally, of timber wharves which were abundant throughout the harbor. The herons appeared to select specific wharves for roosting sites as the birds were somewhat randomly distributed throughout the harbor. However, as yet, no information exists to maintain this observation as being characteristic of the heron.

Characteristics of Tudor Wharf

During LEC's site visit to Tudor Wharf, approximately 13 black-crowned night herons were observed roosting beneath the existing Tudor Wharf (warehouse) building. The timbers supporting this building were densely spaced, and not uniformly distributed, suggesting the construction of more than one support structure during the history of this wharf. Many of the pilings were free-standing and not performing a support function. These pilings appeared to serve as the principle roosting sites for the herons. Cross-beams, which allowed adequate space for the herons to stand, were also occupied by the birds.

At Tudor Wharf spacing between pilings was broad enough to accommodate the wing span of the herons. The absence of herons from other, more closely spaced pilings suggested that spacing may be important in the selection of this site. The Tudor Wharf site also allowed relatively unobstructed viewing in three directions; north, east, and south. This was a characteristic present on several wharves within the inner Boston Harbor.

The third characteristic of the Tudor Wharf site was the elevation of the deck in relation to the mean high water line noted on

the pilings. The distance between mean high water and the deck of the existing structure allows the herons to utilize the area throughout the entire day and not be forced to relocate according to the tide schedule.

Other Overwintering Roosting Sites

LEC conducted a visual inspection of the Inner Harbor area by boat on February 26, 1988. The purpose of this site evaluation was to determine if other areas were utilized as roosting sites within the Inner Harbor. Herons sightings were made at other locations near the confluence of the Charles and Mystic Rivers, across the river from Tudor Wharf and under the Charles River Bridge on the day of the LEC site visit.

Seasonal Distribution

Breeding Areas

Black-crowned night herons are widely distributed throughout Massachusetts during the breeding season. The majority of the herons, in the Boston Harbor area, breed on the outer islands; Middle Brewster, Outer Brewster, Calf Island and Spectacle Island (Hatch 1982, see Appendix A). These areas provide suitable nesting habitat and minimal disturbance from human activities. Although this heron is highly adapted to areas of human activity they prefer more secluded surroundings during the breeding season; early April through August. Some birds occasionally utilize the Boston Harbor area for feeding areas during the breeding season.

Roosting Areas

Black-crowned night herons are distributed throughout the Boston Harbor area during the non-breeding season. Habitats provide loafing and roosting sites for these birds primarily during periods of inactivity and during the non-breeding season (Jeremy Hatch,

LEC communication). Loafing and roosting are habits of a variety of species. The heron typically engages in these activities during resting periods, after feeding or after long periods of strenuous activity. These birds perch on trees in the natural environment, though they also utilize other structures (pilings, rock outcroppings, etc.) when available. Local ornithologists have not located the heron population within the inner portions of Boston Harbor. However, during the LEC site visit roosting areas within the harbor were observed.

Conclusion

The information contributed from this detailed investigation into the natural history, seasonal distribution, and habitat use of the black-crowned night heron, will hopefully provide sufficient guidance to the developers of Tudor Wharf. It is important to note that this wharf is not a breeding area for these herons; that, at best, it is utilized as a roosting site during the non-breeding season (late August through early April); and, that the majority of the Boston Harbor black-crowned night heron population (80%) overwinters in parts unknown outside of Boston Harbor. The unique physical characteristics of Tudor Wharf should be quantified in more detail so that the design of the alteration of these pilings might be accomplished with a minimal impact to this resource area.

Appendix B: Literature Cited

1. Gross, Alfred O. 1923. The black-crowned night heron (Nycticorax nycticorax naevius) of Sandy Neck. The Auk. 40:1-30;191-214.

2. Noble, G.K., M. Wurm, and A. Schmidt. 1938. Social behavior of the black-crowned night heron. The Auk. 55:7-40.

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4. Custer, T.W., Gary L. Hensler, and T. Earl Kaiser. 1983. Clutch size, reproductive success, and organochlorine contaminants in Atlantic coast Black-crowned night herons. The Auk. 100:699-710

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6. Custer, Thomas W. and William E. Davis, Jr. 1982. Nesting by one-year-old black-crowned night herons on Hope Island, Rhode Island. The Auk 99:784-786

7. McCrimmon, D.A., Jr. 1986. Nest site characteristics among five species of herons on the North Carolina coast. The Auk. 95:267-280.

8. Davis, William E., Jr. 1986. Effects of old nests on nest-site selection in black-crowned night herons and snowy egrets. The Wilson Bulletin. 98(2):300-303.

9. Lorenz, K.Z. 1938. A contribution to the comparative sociology of colonial nesting birds. Proceedings of the VIIIth International Ornithological Congress, Oxford, July 1934. Oxford University Press, London.

10. Massey, Barbara W. and Jonathan L. Atwood. 1981. Second-wave nesting of the California least tern: age composition and reproductive success. The Auk. 98:596-605.

11. Coulson, J.C., and E. White. 1958. The effect of age on the breeding biology of the Kittiwake (Rissa tridactyla). Ibis. 100:40-51.

APPENDIX B
CIRCULATION LIST

Draft EIR Circulation List

MEPA Unit
Executive Office of Environmental Affairs
100 Cambridge Street
Boston, MA 02201

Executive Office of Communities and Development
State Clearinghouse
100 Cambridge Street
Boston, MA 02202

Metropolitan Area Planning Council
110 Tremont Street
Boston, MA 02108

Anthony Sandonato
District Highway Engineer
District 8 Office
Massachusetts Department of Public Works
400 D Street
Boston, MA 02210

Department of Public Works
State Transportation Building
10 Park Plaza
Boston, MA 02116

Ms. Anne Meyers
Massachusetts Port Authority
State Transportation Building
10 Park Plaza
Boston, MA 02116

Mr. Adel Foz
Massachusetts Port Authority
State Transportation Building
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Environmental Review Section
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Regional Environmental Engineer
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Water Pollution Control Division
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Woburn, MA 01801

Division of Waterways Regulation
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Division of Hazardous Waste
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Boston, MA 02201

Lorraine Downey, Chair
Harborpark Advisory Committee
Department of the Environment
City Hall
Boston, MA 02201

Lorraine Downey, Director
The Environment Department
City Hall
Boston, MA 02201

Conservation Commission
c/o Department of the Environment
City Hall
Boston, MA 02201

Richard Dimino, Commissioner
Boston Transportation Department
City Hall
Boston, MA 02201

Libby Blank
Director of Planning
Boston Water and Sewer Commission
425 Summer Street
Boston, MA 02210

Regulatory Branch
Corps of Engineers
424 Trapelo Road
Waltham, MA 02254

John Burchill, Superintendant
National Park Service
Charlestown Navy Yard
Charlestown, MA 02129

Dan Curll, President
The Boston Harbor Associates
51 Sleeper Street
Boston, MA 02210

Ms. Carolyn Kiley
President, MAPVO
Bay State Cruises
20 Long Wharf
Boston, MA 02110

Constitution Marina
28 Constitution Road
Charlestown, MA 02129

Richard Johnston
Charlestown North Area Task Force
8 Prospect Street
Charlestown, MA 02129

Mr. Dennis McLaughlin, Chairman
Charlestown Neighborhood Council
26 Mt. Vernon Street
Charlestown, MA 02129

Mr. Kennth Stone
Charlestown/North Area Task Force
81 Warren Street
Charlestown, MA 02129

Ms. Kay Whelan
Charlestown Historical Society
c/o Bunker Hill Museum
Monument Square
Charlestown, MA 02129

Mr. Richard Wheeler
Constitution Museum
Charlestown Navy Yard
Charlestown, MA 02129

Commander David Cashman
USS Constitution
Charlestown Navy Yard
Charlestown, MA 02129

APPENDIX C
PREVIOUSLY ISSUED CHAPTER 91 LICENSES

2420
614

[illegible] that all
[illegible] whether
on the mortgaged premises or any interest therein or on the debt
secured by said mortgage [illegible] the party of the
second part or her representatives and that no other things
shall be done which according to the provisions of the condition
of said mortgage were to be done in the part of the mortgagor
[illegible] during the term therein mentioned
and this Indenture further witnesseth that the said party of
the second part for herself and her heirs and assigns covenants
with the said party of the first part [illegible]
ministrators and assigns, that she the said party of the second
part or her heirs or assigns, will not, prior to said fourteenth
day of September A.D. 1897 require the holder of said mortgage
[illegible] payment of the principal sum secured thereby;
that they will pay the said principal sum and the interest
[illegible] the taxes and insurance [illegible] premises and
[illegible] interest at the same rate as upon said and said
taxes and assessments for any time further than that above
[illegible] during which said principal [illegible] remain
unpaid. In witness whereof the said parties [illegible] and to
[illegible] instrument of like tenor set their hands and seals
the day and year first above written. Adelheid Wrandle
[illegible] signed and sealed
in presence of [illegible] Commonwealth of Massachusetts [illegible] Feb. 15. 1897 Then personally ap-
peared the above named [illegible] acknowledged
the foregoing instrument to be his free act and deed, before
me Charles D. [illegible] Justice of the Peace —
February 15. 1897 at eleven o'clock and sixteen minutes A.
M. Received, Entered and Examined [illegible]

Harbor and Land Comrs to The Tudor Co

Commonwealth of Massachusetts
Massachusetts Coat of Arms — — No. 1986
Whereas the Tudor Company of Boston in the County
of Suffolk and Commonwealth aforesaid has applied to
the Board of Harbor and Land Commissioners for license
to extend Tudor Wharf, so called, and [illegible] in Charles
River in the Charlestown district of the city of Boston,
and has submitted plans of the same; and whereas due
notice of said application, and of the time and place

[illegible] to the Mayor and [illegible] Board [illegible] having duly [illegible] to the [illegible] and licenses the [illegible] Company subject to the [illegible] of the Public Statutes [illegible] of all laws which are [illegible] to extend Tudor Wharf on Charles River in the Charlestown district of the city of Boston [illegible] piles [illegible] conformity with the accompanying plan No. 1986. Beginning at a point marked a on said plan at the south westerly corner of said present wharf, and in the easterly side line of Charles River Avenue, and running south-easterly in said easterly side line 80 feet to a point marked b in the harbor line established by Chapter 170 of the Acts of 1880; thence running north-easterly on said harbor line 82.05 feet to a point marked c; thence running north-westerly 81.08 feet to a point marked d in the south-easterly side line of said present wharf; thence running south-westerly in said south easterly side line 82.12 feet to a, the point of beginning. Said Company is further authorized to drive [illegible] piles within the lines of said present wharf in the locations indicated by red circles on said plan, also to use as a dock appurtenant to said extension the area within lines marked d-e, e-f, f-g, g-c, c-d, on said plan. Nothing herein contained shall be construed as authorizing the driving of piles, or doing any work outside said harbor line. This license is granted as a substitute for license No. 1983 granted to [illegible] and December 21, 1890 [illegible] The plan of said work is on file in the office of said Board, numbered 1986 and a duplicate of said plan [illegible] this license and is to be referred to as a part hereof. The amount of tide water displaced by the work hereby authorized, shall be ascertained by said Board, and compensation therefor shall be made by the said Tudor Company, its successors and assigns, by paying into the treasury of the Commonwealth thirty seven and one half (37½) cents for each cubic yard so displaced, being the amount hereby assessed by said Board, the same to be reserved as a compensation fund for the harbor of Boston. This license is [illegible] consideration of the payment into the treasury of the

[illegible] with by the [illegible] for the rights and [illegible] Commonwealth of the further sum of Five Thousand Six Hundred and Seventy dollars and sixty cents $5670.60 being the amount determined by the Governor and Council to be just and equitable therefor. Nothing in this License shall be so construed as to impair the legal rights of any person. This License shall be void unless the same and the accompanying plan are recorded within one year from the date hereof, in the Registry of Deeds for the County of Suffolk. In witness whereof said Board of Harbor and Land Commissioners have hereunto set their hands this twenty seventh day of January in the year eighteen hundred and ninety seven. Woodward Emery Chas. H. Howland Harbor and Land Commissioners Commonwealth of Massachusetts Boston Jany [illegible] 1897 Approved by the Governor and Council. Edward [illegible] Executive Clerk ——— February 15 1897 at eleven o'clock and eighteen minutes A.M. Received Entered and Examined [illegible]

Rice to Roberts

Know all Men by these Presents that I, Emma H. Rice, the mortgagee named in a certain mortgage given by William P. Davis and Alice H. Davis to me dated January 24th A.D. 1894 and recorded with Suffolk Deeds Book 2170 page 436 in consideration of One dollar and other valuable consideration paid by George H. Roberts the receipt whereof is hereby acknowledged do hereby assign transfer and set over unto the said George H. Roberts the said mortgage deed, the real estate thereby conveyed and the note and claim thereby secured. To Have and to Hold the same to the said George H. Roberts and his heirs and assigns to their own use and behoof forever, subject nevertheless to the conditions therein contained and to redemption according to law. In witness whereof I hereto set my hand and seal this second day of February A.D. 1897 Emma H. Rice and a seal Signed and sealed in presence of [illegible] Commonwealth of Massachusetts Suffolk ss Boston February 10. 1897 Then personally appeared the above named Emma H. Rice and acknowledged the foregoing instrument to be her free act & deed. Before me N. D. Kimball Justice of the Peace ——— February 15. 1897 at eleven o'clk & thirty mins A.M. Received Entered & Examined [illegible]

The Commonwealth of Massachusetts
Executive Office of Environmental Affairs
Department of Environmental Quality Engineering
Division of Wetlands and Waterways Regulation
One Winter Street, Boston 02108

RUSSELL SYLVA
Commissioner

January 5, 1988

Thorn Mead
Fort Point Associates
300 Congress Street
Boston, MA 02210

Dear Thorn,

In response to your request for information on Harbor and Land Commissioners Waterways License Numbers 1983 and 1986, the situation is as follows. License Number 1986 was written as a substitute for License Number 1983 which was then abandoned and not recorded and thus, voided. Both licenses were issued to the Tudor Company and the wording of both licenses was identical with the exception of the amount of fees assessed. No plan is on file in this office for License Number 1983 since 1986 became the valid license.

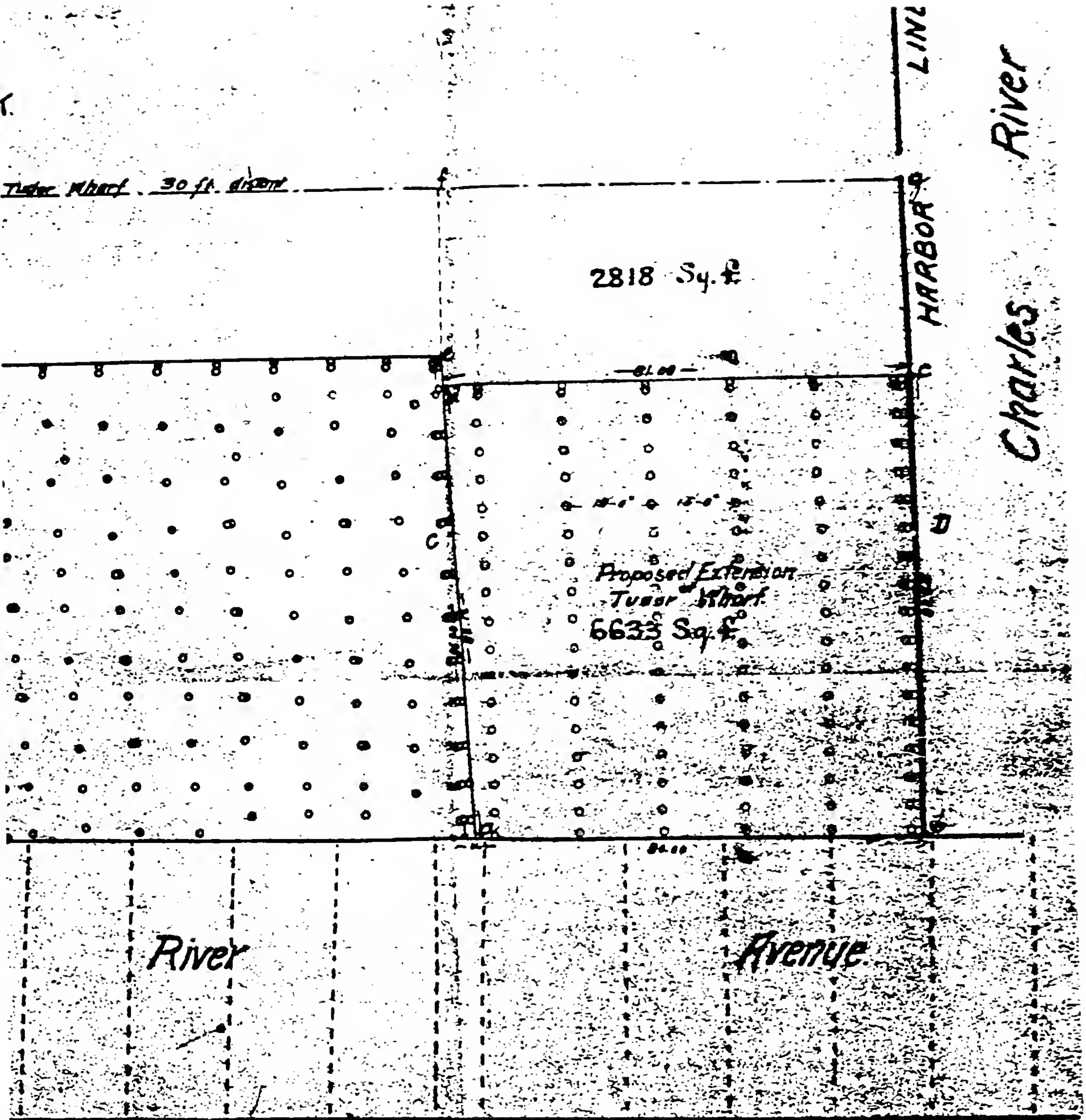
In response to your second question regarding the licensing of the Charles River Dam. I have not located any information indicating that a Waterways License was issued for dam construction. However, I do still need to check some additional sources. It has been suggested that you check with the Metropolitan District Commission legal staff in order to answer this question.

Please contact us if you have any additional questions.

Sincerely,

Lise Marx
Waterays Regulation Program

LM/sff



Plan Showing Proposed Extension of
Tudor Wharf Charlestown Mass.
Property of The Tudor Company

November 1896

Scale of Plan 16 feet to an inch
Scale of Sections 4

Henry Manley
Engineer

LIBER
3039

Commonwealth of Massachusetts

[illegible] Massachusetts [illegible]

Whereas [illegible] of Boston [illegible] of Suffolk [illegible] Edison [illegible] [illegible] in the city of Boston [illegible] [illegible] the city of Boston [illegible] [illegible] [illegible] subject to the [illegible] [illegible] [illegible] the city of Boston [illegible] [illegible]

Com. of Mass

to

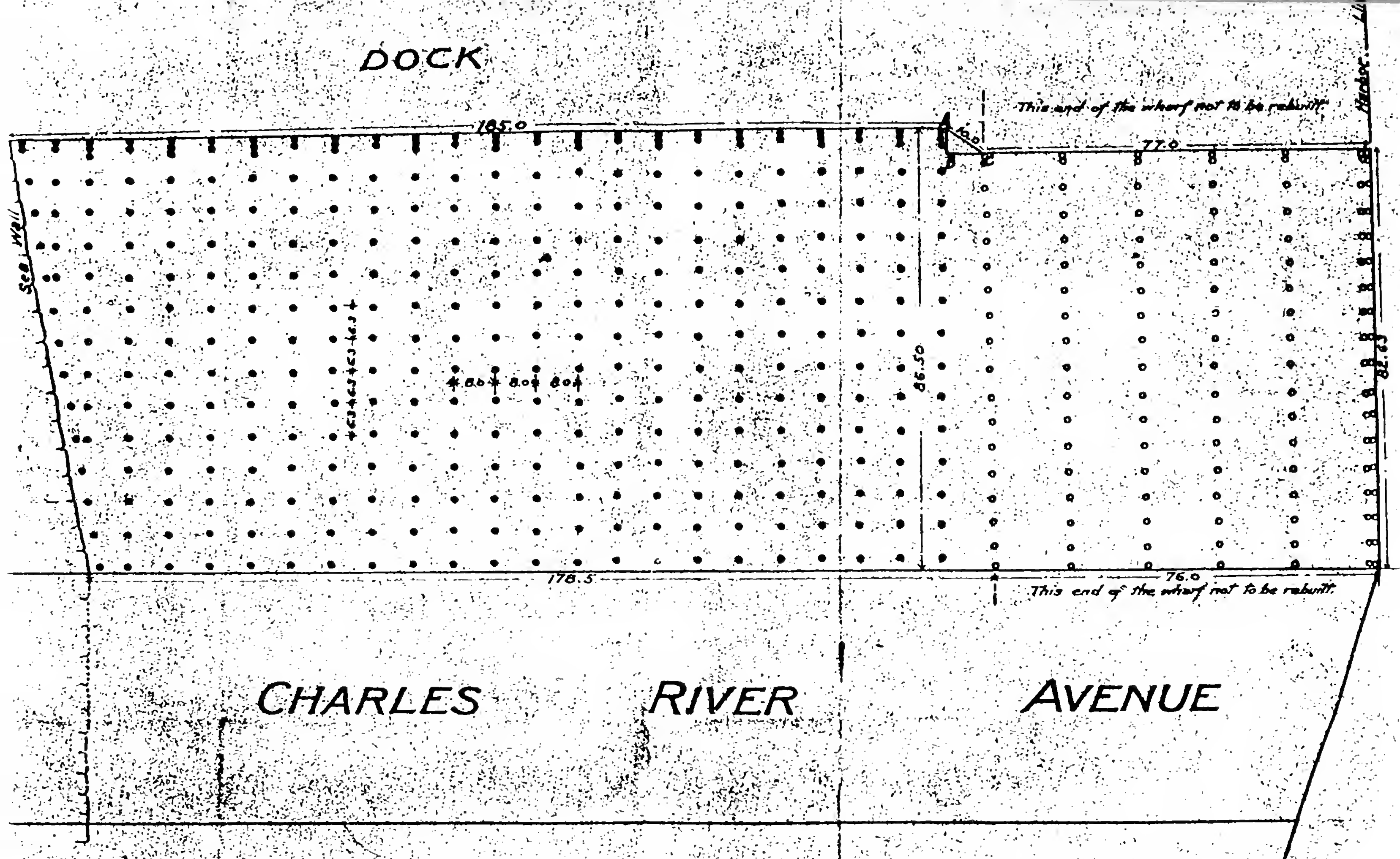
[illegible] Edison Co.

[illegible] Company is [illegible] of [illegible] Compulsion [illegible] and plan [illegible] of said work is on file in the office of [illegible] a duplicate of said [illegible] accompanied this license and is to be referred to as a part hereof. [illegible] amount of tide-water displaced by the work [illegible] shall be ascertained by said [illegible] compensation therefor [illegible] by the said [illegible] Company, its successors and assigns, by paying into the treasury of the Commonwealth [illegible] (37½) cents [illegible] cubic yard so displaced, being the amount [illegible] said Board, the amount to be [illegible] fund for [illegible] Boston [illegible] this license shall be so construed as to [illegible] the legal rights of any person. This license [illegible] unless the same and the accompanying [illegible] plans are recorded within [illegible] from the date [illegible] the registry of deeds for the county of Suffolk. [illegible] Commissioners [illegible] hands [illegible] the year [illegible] 28, 1905 at [illegible]

[illegible]

[illegible] that the New England [illegible] Company, the mortgagee named in a certain mortgage [illegible] and [illegible] 1896 and [illegible] Suffolk Deeds, [illegible] hereby acknowledge that it has received from Edward B. Bayley [illegible] the mortgagors named in said mortgage full payment and satisfaction of the [illegible] consideration [illegible] hereby cancels and discharges said mortgage and releases and quitclaims unto [illegible] may be lawfully entitled.

[illegible]
See page



PLAN OF WHARF.

Scale 16 feet to an inch.

Piles to remain shown thus ∘
Piles to be driven •

THE COMMONWEALTH OF MASSACHUSETTS MASSACHUSETTS-COAT-OF-ARMS COMMONWEALTH OF MASSACHUSETTS to TUDOR CO.

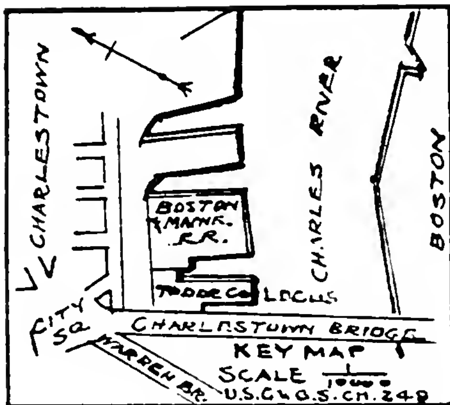
No. 2667 WHEREAS, the Tudor Company, of Boston, in the County of Suffolk, and Commonwealth aforesaid has applied to the Department of Public Works for license to repair its timber pier in Charles River at its property at Charlestown in the city of Boston, and has submitted plans of the same; and whereas due notice of said application, and of the time and place fixed for a hearing thereon, has been given, as required by law, to the Mayor and City Council of the City of Boston; NOW, said Department, having heard all parties desiring to be heard, and having fully considered said application, hereby authorizes and licenses the said The Tudor Company, subject to the provisions of the ninety-first chapter of the General Laws, and of all laws which are or may be in force applicable thereto, to repair its timber pier in Charles River at its property at Charlestown in the city of Boston, in conformity with the accompanying plan No. 2667. Thirteen piles may be driven and the necessary capping installed within the limits of an existing pier to provide for additional track support, in the location shown on said plan and in accordance with the details of construction there indicated. The plan of said work, numbered 2667, is on file in the office of said Department and duplicate of said plan accompanies this License and is to be referred to as a part hereof. Nothing in this License shall be so construed as to impair the legal rights of any person. This License shall be void unless the same and the accompanying plan are recorded within one year from the date hereof, in the Registry of Deeds for the County of Suffolk. IN WITNESS WHEREOF, said Department of Public Works have hereunto set their hands this fifth day of July, in the year nineteen hundred and forty four. H. A. Macdonald, George W. Schryver, R. L. Whipple, Department of Public Works. Approved, Richard K. Hale, Director Division of Waterways.------------- July 14, 1944. At eleven o'clock and thirty minutes A.M. Received, Entered and Examined. ------------------------

HOME OWNERS' LOAN CORP'N to HIGGINS et ux

U.S.Revenue Stamps of the amount of $6.60 were affixed to this instrument and were canceled.

Property Management No. Mass A 8885 HOME OWNERS' LOAN CORPORATION, a corporate instrumentality of the United States of America, organized and existing under and by virtue of an Act of the Congress of the United States of America, known as the Home Owners' Loan Act of 1933, as amended, having its principal office in the City of Washington District of Columbia, for consideration paid, grants to Joseph F. Higgins and Mary A. Higgins, husband and wife, as tenants by the entirety, of Cambridge, Massachusetts with QUITCLAIM COVENANTS A certain parcel of land with all buildings and structures now or hereafter standing or

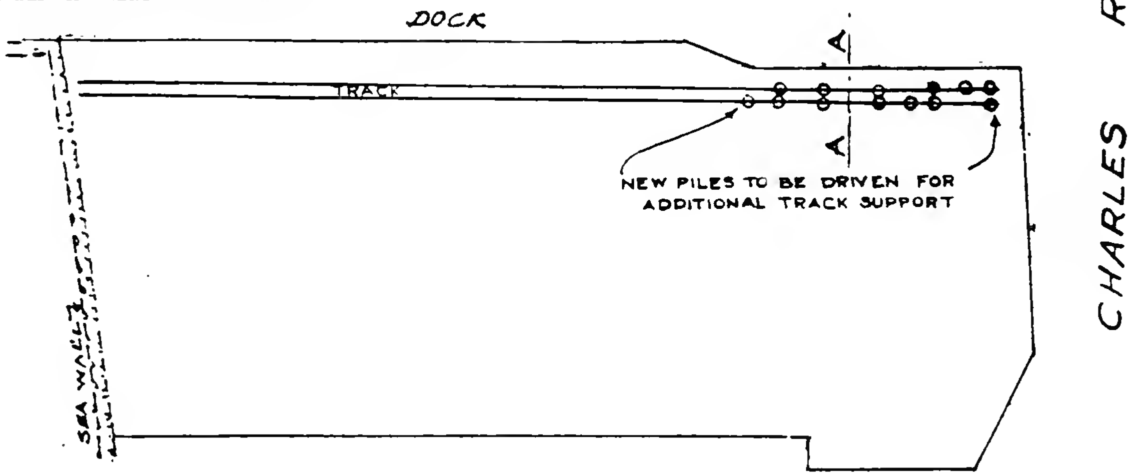
SHEET 1



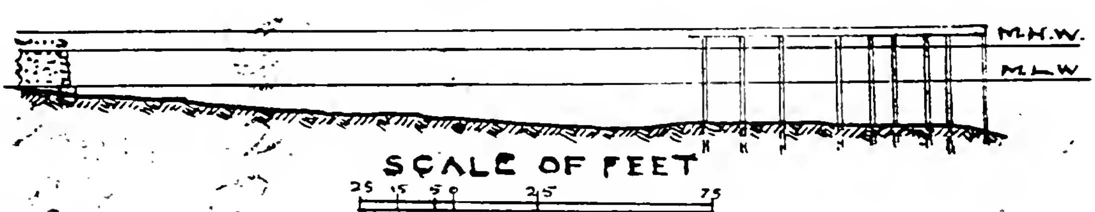
PLAN OF REPAIRS ON TIMBER PIER

SCALE OF FEET

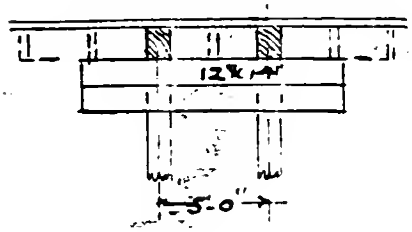
DATUM M.L.W.



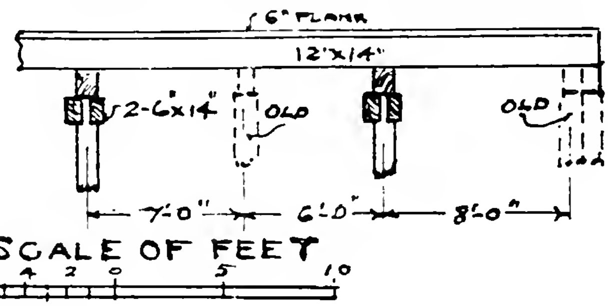
PROFILE



SECTION A-A



LONGITUDINAL SECTION



PLAN ACCOMPANYING PETITION OF

THE TUDOR COMPANY

TO REPAIR TIMBER PIER

BOSTON HARBOR

BOSTON

2667

APPROVED BY DEPARTMENT OF PUBLIC WORKS

JULY 6, 1944

[signature] COMMISSIONER OF PUBLIC WORKS

George W. Dehmer [signature] ASSOCIATE COMMISSIONERS

[signature]

[signature] DIRECTOR-DIVISION OF WATERWAYS

APPENDIX D
DREDGE SPOILS ANALYSIS

Haley & Aldrich, Inc.

Consulting
Geotechnical Engineers,
Geologists and
Hydrogeologists

58 Charles Street
Cambridge, MA 02141
617/494-1606

22 June 1988
File No. 06158-10

Myerson/Allen & Company
306 Dartmouth Street
Boston, Massachusetts 02116

Attention: Mr. David Keller

Subject: Marine Sediment Sampling and Analysis
Tudor Wharf, Charlestown, Massachusetts

Gentlemen:

In accordance with our proposal dated 25 May 1988 and your telephone request of 19 May, we have completed a program of marine sediment sampling and subsequent bulk sediment analysis (BSA) at the proposed dredge area of the Tudor Wharf Site. This work was conducted for purposes of evaluating environmental considerations associated with the construction of a 50-ft. wide by 160-ft. long boat slip dredged to El. 80.0 (NACA-Datum) immediately west of the existing Tudor Wharf Pier Building, as shown in the sketch provided by Mr. James Fay of Fort Point Associates (FPA). The approximate limits of the dredge area are shown in Figure 1.

Marine sediment sampling work included the procurement of three samples, designated BSA-1 through BSA-3, which were taken on 27 May 1988 by Guild Drilling Co., Inc., of E. Providence, Rhode Island, at the locations shown on Figure 1. Observation of sampling and determination of sample locations was observed and documented by H&A. The sampling operations consisted of advancing a decontaminated 5-ft. long by 3-in. diameter steel sampling tube to depths ranging from approximately 8 to 13 ft. (El. 78 to El. 83 NACA Datum). Two of the samples, BSA-2 and BSA-3, were taken in the intertidal zone of the mudline, while BSA-1 was obtained below mean low water level (MLW). Logs of the samples are included in Appendix A.

Branch Offices
Glastonbury, Connecticut
Portland, Maine
Bedford, New Hampshire

Affiliate
H&A of New York
Rochester, New York

Following the procurement of samples, the tubes were sealed and packed in ice for immediate transport to Clean Harbors, Inc., of Braintree, Massachusetts, a DEQE-approved analytical, laboratory for analysis. Samples BSA-1 and BSA-3 were then each composited from tubes for bulk sediment and chemical analysis. The results of these analyses are contained in Appendix B.

Based on the levels of lead (Pb) and mercury (Hg) detected from the chemical analysis, the sediment sampled at the site appears to be classified as a Category 2 dredge fill material, according to the criteria established by the DEQE Division of Water Pollution Control. It should also be noted that Polychlorinated Biphenyls (PCB's) were measured in the samples at or near detectable levels.

If you have any questions or require further information, please do not hesitate to call.

Sincerely yours,
HALEY & ALDRICH, INC.

Chris M. Erikson

Chris M. Erikson
Staff Engineer

James R. Wheeler

James Wheeler
Senior Engineer

CE:JW:aw/0315W

Enclosures

Figure 1	-	Marine Sediment Sample Location Plan
Appendix A	-	Logs of Environmental Samples Taken by Guild Drilling Co., Inc., on 27 May 1988
Appendix B	-	Results of Bulk Sediment and Chemical Analysis Conducted by Clean Harbors, Inc.

c: Fort Point Associates; Attn: Mr. James Fay

APPENDIX A

Logs of Environmental Samples taken by
Guild Drilling Co., Inc. on
27 May 1988

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1
DATE 27 May 1988
HOLE NO. BSA1
LINE & STA. See Plan
OFFSET
SURF. ELEV.

Haley & Aldrich, Inc. | ADDRESS Cambridge, Mass.
ECT NAME Dredge Samples | LOCATION Charlestown, Mass.
RT SENT TO above | PROJ. NO.
LES SENT TO Taken at Site | OUR JOB NO. 88-767

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR.
after ___ Hours	Type		3" Tube	
	Size I.D.			
after ___ Hours	Hammer Wt			BIT
	Hammer Fall			

	Date	Time
START	5/27/88	a.m. p.m.
COMPLETE	5/27/88	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN W. Dunphy
INSPECTOR
SOILS ENGR.

CATION OF BORING On Water

Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist	Strata Change Elev.	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No	Pen	Rec
								One 5 Foot 3" Environmental Sample			
								0' to 8' - Rec. 3'6"			
							8'				
								Bottom of Boring 8'			

GROUND SURFACE TO ______ USED ______ "CASING: THEN ______

Sample Type	Proportions Used	140 lb Wt. x 30" fall on 2" O.D. Sampler		SUMMARY
D=Dry C=Cored W=Washed	trace 0 to 10%	Cohesionless Density	Cohesive Consistency	Earth Boring 8'
P=Undisturbed Piston	little 10 to 20%	0-10 Loose	0-4 Soft 30 + Hard	Rock Coring
P=Test Pit A=Auger V=Vane Test	some 20 to 35%	10-30 Med. Dense	4-8 M/Stiff	Samples 1 Tube
	35 to 50%	30-50 Dense	8-15 Stiff	
		50 + Very Dense		

HOLE NO. BSA1

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1
DATE 27 May 1988
HOLE NO. BSA2
LINE & STA. See Plan
OFFSET
SURF. ELEV.

Haley & Aldrich, Inc. | ADDRESS Cambridge, Mass.
JECT NAME Dredge Samples | LOCATION Charlestown, Mass.
ORT SENT TO above | PROJ. NO.
PLES SENT TO Taken at Site | OUR JOB NO. 88-767

GROUND WATER OBSERVATIONS

after ____ Hours

after ____ Hours

	CASING	SAMPLER	CORE BAR.
Type		3" Tube	
Size I.D.			
Hammer Wt.			BIT
Hammer Fall			

	Date	Time
START	5/27/88	a.m. p.m.
COMPLETE	5/27/88	a.m. p.m.
TOTAL HRS.		

BORING FOREMAN W. Dunphy
INSPECTOR
SOILS ENGR.

OCATION OF BORING: On Water

Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler From 0-6	To 6-12	12-18	Moisture Density or Consist.	Strata Change Elev	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No	Pen	Rec
								One 5 Foot 3" Environmental Sample			
								0' to 12' - Rec. 2'6"			
							12'	Bottom of Boring 12'			

GROUND SURFACE TO ______ USED ______ "CASING: THEN ______

Sample Type
D=Dry C=Cored W=Washed
UP=Undisturbed Piston
TP=Test Pit A=Auger V=Vane Test
UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
and	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 12'
Rock Coring
Samples 1 Tube

HOLE NO BSA2

GUILD DRILLING CO., INC.

100 WATER STREET EAST PROVIDENCE, R. I.

SHEET 1 OF 1	DATE 27 May 1988
HOLE NO. BSA3	LINE & STA. See Plan
OFFSET	SURF. ELEV.

TO Haley & Aldrich, Inc. — ADDRESS Cambridge, Mass.

PROJECT NAME Dredge Samples — LOCATION Charlestown, Mass.

REPORT SENT TO above — PROJ. NO.

SAMPLES SENT TO Taken at Site — OUR JOB NO. 88-767

GROUND WATER OBSERVATIONS		CASING	SAMPLER	CORE BAR
___ after ___ Hours	Type		3" Tube	
	Size I.D.			
___ after ___ Hours	Hammer Wt			BIT
	Hammer Fall			

	Date	Time
START	5/27/88	a.m. p.m.
COMPLETE	5/27/88	a.m. p.m.
TOTAL HRS.		
BORING FOREMAN	W. Dunphy	
INSPECTOR		
SOILS ENGR.		

LOCATION OF BORING: On Water

Casing Blows per foot	Sample Depths From - To	Type of Sample	Blows per 6" on Sampler (From - To) 0-6	6-12	12-18	Moisture Density or Consist	Strata Change Elev	SOIL IDENTIFICATION Remarks include color, gradation, Type of soil etc. Rock-color, type, condition, hardness, Drilling time, seams and etc.	SAMPLE No	Pen	Rec
								One 5 Foot 3" Environmental Sample			
								0' to 13' - Rec. 3'			
							13'				
								Bottom of Boring 13'			

GROUND SURFACE TO ______ USED ______ " CASING: THEN ______

Sample Type: D=Dry C=Cored W=Washed; UP=Undisturbed Piston; TP=Test Pit A=Auger V=Vane Test; UT=Undisturbed Thinwall

Proportions Used	
trace	0 to 10%
little	10 to 20%
some	20 to 35%
	35 to 50%

140 lb Wt. x 30" fall on 2" O.D. Sampler

Cohesionless Density		Cohesive Consistency		
0-10	Loose	0-4	Soft	30 + Hard
10-30	Med. Dense	4-8	M/Stiff	
30-50	Dense	8-15	Stiff	
50 +	Very Dense	15-30	V-Stiff	

SUMMARY:
Earth Boring 13'
Rock Coring
Samples 1 Tube

HOLE NO BSA3

APPENDIX B

Results of Bulk Sediment and Chemical Analysis
Conducted by Clean Harbors Inc.

CleanHarbors
ANALYTICAL SERVICES
325 WOOD ROAD, BRAINTREE, MA 02184
(617) 849-6070

RECEIVED
JUN 14 1988
HALEY & ALDRICH, INC.

REPORT OF ANALYSIS

Haley & Aldrich, Inc.
238 Main Street
Cambridge, MA 02142

Project: Tudor Wharf - Jim Wheeler
P.O. #: 00615810

Date Received: 05/27/88
CHAS Lab #: 8805304

Attn: Mr. Kleo Taliadouros

Enclosed are the results for the sample(s) delivered to our laboratory on the date indicated above.

Should you have any questions concerning this work, please do not hesitate to contact me.

This laboratory follows quality assurance/quality control procedures outlined in EPA Publication EPA 600/4-79-019, "Handbook for Analytical Quality Control in Water and Wastewater Laboratories", March 1979, and specific QA/QC requirements of the procedures used.

The information contained in this report is, to the best of my knowledge, accurate and complete.

Per/Date: A. W. Schultheis 6/10/88
Alex W. Schultheis
Laboratory Director

nHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-1
le Type: Soil

CHAS Lab #: 8805304-01M
Date Received: 05/27/88

meter	MDL	Result	Units	Analysis Date	Method Number and Reference
nic - Total	0.094	9.43	mg/kg	06/08/88	3050/7060(c)
um - Total	7	60	mg/kg	06/08/88	3050/6010(c)
ium - Total	0.70	4.2	mg/kg	06/08/88	3050/6010(c)
mium - Total	1.4	41	mg/kg	06/08/88	3050/6010(c)
- Total	7	190	mg/kg	06/08/88	3050/6010(c)
ury - Total	0.0781	0.7236	mg/kg	06/07/88	7471(c)
nium - Total	0.141	ND	mg/kg	06/08/88	3050/7740(c)
er - Total	0.82	1.2	mg/kg	06/10/88	3050/7760(c)

s: ND = Below minimum detectable level (MDL)

Results based on sample dry weight.

anHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-3
le Type: Soil

CHAS Lab #: 8805304-02M
Date Received: 05/27/88

meter	MDL	Result	Units	Analysis Date	Method Number and Reference
nic - Total	0.127	9.83	mg/kg	06/08/88	3050/7060(c)
um - Total	10	90	mg/kg	06/08/88	3050/6010(c)
ium - Total	0.97	3.9	mg/kg	06/08/88	3050/6010(c)
mium - Total	1.9	39	mg/kg	06/08/88	3050/6010(c)
l - Total	10	250	mg/kg	06/08/88	3050/6010(c)
cury - Total	0.1083	1.176	mg/kg	06/07/88	7471(c)
nium - Total	0.190	ND	mg/kg	06/08/88	3050/7740(c)
ver - Total	1.5	ND	mg/kg	06/08/88	3050/7760(c)

es: ND = Below minimum detectable level (MDL)

Results based on sample dry weight.

anHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-1
le Type: Soil

CHAS Lab #: 8805304-01M
Date Received: 05/27/88

meter	MDL	Result	Units	Analysis Date	Method Number and Reference
l ˆil & Grease	0.072	0.201	%	06/07/88	503D(b)
l Solids	--	66.8	%	06/02/88	209F(b)

es: ND = Below minimum detectable level (MDL)

Results based on sample dry weight.

anHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-3
le Type: Soil

CHAS Lab #: 8805304-02M
Date Received: 05/27/88

meter	MDL	Result	Units	Analysis Date	Method Number and Reference
l Oil & Grease	0.088	0.138	%	06/08/88	503D(b)
l Solids	--	50.7	%	06/02/88	209F(b)

es: ND = Below minimum detectable level (MDL)

Results based on sample dry weight.

nHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-1
le Type: Soil

CHAS Lab #: 8805304-01M
Date Received: 05/27/88

SIEVE ANALYSIS

SIEVE NUMBER	OPENING SIZE in MM	WEIGHT %
--	9.5	8.1
4	4.75	10.7
10	2.0	15.3
20	0.850	17.8
40	0.425	10.5
60	0.250	18.3
100	0.150	6.8
200	0.075	4.9
Bottom Tray	<0.075	6.8

nHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-3
le Type: Soil

CHAS Lab #: 8805304-02M
Date Received: 05/27/88

SIEVE ANALYSIS

SIEVE NUMBER	OPENING SIZE in MM	WEIGHT %
--	9.5	7.3
4	4.75	11.6
10	2.00	15.1
20	0.850	19.7
40	0.425	4.6
60	0.250	8.8
100	0.150	7.6
200	0.075	8.8
Bottom Tray	<0.075	16.5

anHarbors

nt: Haley & Aldrich, Inc.
le I.D.: BSA-1
le Type: Soil

CHAS Lab #: 8805304-01M
Date Received: 05/27/88

Polychlorinated Biphenyls (PCB's)
by EPA Method 3540/8080

Extraction Date: 06/03/88
Analysis Date: 06/10/88

Parameter	MDL	Concentration	Units
PCB - Aroclor 1016	0.1	ND	mg/kg
PCB - Aroclor 1221	0.1	ND	mg/kg
PCB - Aroclor 1232	0.1	ND	mg/kg
PCB - Aroclor 1242	0.1	ND	mg/kg
PCB - Aroclor 1248	0.1	ND	mg/kg
PCB - Aroclor 1254	0.1	0.1	mg/kg
PCB - Aroclor 1260	0.1	ND	mg/kg

Notes: ND - Below minimum detectable level (MDL)
Soil/solid sample results based on sample dry weight

anHarbors

ent: Haley & Aldrich, Inc.
ple I.D.: BSA-3
ple Type: Soil

CHAS Lab #: 8805304-02M
Date Received: 05/27/88

Polychlorinated Biphenyls (PCB's)
by EPA Method 3540/8080

Extraction Date: 06/03/88
Analysis Date: 06/10/88

Parameter	MDL	Concentration	Units
PCB - Aroclor 1016	0.1	ND	mg/kg
PCB - Aroclor 1221	0.1	ND	mg/kg
PCB - Aroclor 1232	0.1	ND	mg/kg
PCB - Aroclor 1242	0.1	ND	mg/kg
PCB - Aroclor 1248	0.1	ND	mg/kg
PCB - Aroclor 1254	0.1	0.3	mg/kg
PCB - Aroclor 1260	0.1	ND	mg/kg

Notes: ND = Below minimum detectable level (MDL)
Soil/solid sample results based on sample dry weight

anHarbors

Method References

(a) "Methods for Chemical Analysis of Water and Wastes," Publication EPA-600/4-79-020, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, 1979, revised March 1983.

(b) "Standard Methods for the Examination of Water and Wastewater," 16th ed., American Public Health Association, American Water Works Association, Water Pollution Control Federation, Washington, D.C., 1985.

(c) "Test Methods for Evaluating Solid Waste: Physical/Chemical Methods," 2nd ed., U.S. Environmental Protection Agency, Office of Solid Waste and Emergency Response, Washington, D.C., July 1982.

(d) "The Determination of Polychlorinated Biphenyls in Transformer Fluid and Waste Oils," Publication EPA-600/4-81-045, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, 1981.

(e) "EPA-CLP Organic Analyses of Low and Medium Hazardous Waste Sample (Water and Soil) Procedures Revision," U.S. Environmental Protection Agency, July 1985.

(f) "Test Procedures for Analyses of Organic Pollutants," Code of Federal Regulations, Appendix A, Part 136, July 1, 1985.

(g) "Measurement of Purgeable Organic Compounds in Drinking Water by Gas Chromatography/Mass Spectrometry," Method 524, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati.

(h) "Prescribed Procedures for Measurement of Radioactivity in Drinking Water," Publication EPA-600/4-80-032, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati, August 1980.

(i) "Clean Harbors Radiological Environmental Analytical Procedures," Clean Harbors Analytical Services, Braintree, MA, October 1985.

(j) "Methods for Chlorinated Phenoxy Acid Herbicides in Industrial Effluents," MDQARL, Cincinnati, November 23, 1973.

(k) "Annual Book of Standards," Section 11: Water and Environmental Technology, Vols. 11.01-11.04, American Society for Testing and Materials, Philadelphia, 1983, 1984, 1985.

(l) "Methods for Benzidine, Chlorinated Organic Compounds, Pentachlorophenol and Pesticides in Water and Wastewater," U.S. Environmental Protection Agency, September 1978.

(m) "Methods for Organochlorine Pesticides in Industrial Effluents," MDQARL, Environmental Protection Agency, Cincinnati, November 28, 1973.

(n) "Methods for Determination of Inorganic Substances in Water and Fluvial Sediments," Techniques of Water-Resources Investigation of the U.S. Geological Survey, Book 5, Chapter A-1, U.S. Department of the Interior, 1979.

(o) "Measurement of Trihalomethanes in Drinking Water by Gas Chromatography/Mass Spectrometry and Selected Ion Monitoring," Method 501.3, U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati.

(p) "The Analysis of Trihalomethanes in Finished Waters by the Purge and Trap Method," U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati.

(q) "The Analysis of Trihalomethanes in Drinking Water by Liquid/Liquid Extraction," U.S. Environmental Protection Agency, Environmental Monitoring and Support Laboratory, Cincinnati.

(r) "Official Methods of Analysis," Association of Official Analytical Chemists, 14th ed., 1984.

(s) "Hach Handbook of Water Analysis," Hach Chemical Company, Loveland, CO, 1979.

(t) B.M. Prichard and T.F. Gesell, "Rapid Measurement of Rn-222 Concentrations in Water with a Commercial Liquid Scintillation Counter," Health Physics, Vol. 33, 1977, pp. 577-581.

(u) "Petroleum Products and Lubricants (I): D56-D1660," Annual Book of ASTM Standards, Volume 5.01, American Society for Testing and Materials, Philadelphia, 1985.

(v) "Petroleum Products and Lubricants (III): D2981-Latest: Catalysts," Annual Book of ASTM Standards, Volume 5.03, American Society for Testing and Materials, Philadelphia, 1985.

anHarbors

QUALITY CONTROL
REPORT OF ANALYSIS

This data is submitted in conjunction with Haley & Aldrich, Inc. sample set 00615810, Tudor Wharf Soil Samples - CHAS Lab #: 8805304

anHarbors

NT: Haley & Aldrich, Inc.

LABORATORY BLANK - TRACE METALS

STION DATE: 06/07/88

PLE BATCH NO.: 8805304

ELEMENT	CONCENTRATION (mg/l)
Arsenic	0.000
Barium	0.0
Cadmium	0.00
Chromium	0.00
Lead	0.000
Mercury	0.0000
Selenium	0.0000
Silver	0.00

nHarbors

nt: Haley & Aldrich, Inc.
le Station: PCB Blank
le Type: Soil

Polychlorinated Biphenyls (PCB's)
by EPA Method 3540/8080

Extraction Date: 06/03/88
Analysis Date: 06/09/88

Parameter	MDL*	Concentration	Units
PCB - Aroclor 1016	1.0	ND	mg/kg
PCB - Aroclor 1221	1.0	ND	mg/kg
PCB - Aroclor 1232	1.0	ND	mg/kg
PCB - Aroclor 1242 ---	1.0 -----	0.9 --------	mg/kg*
PCB - Aroclor 1248	1.0	ND	mg/kg
PCB - Aroclor 1254	1.0	ND	mg/kg
PCB - Aroclor 1260	1.0	ND	mg/kg

s: ND = Below minimum detectable level (MDL)
Soil/solid sample results based on sample dry weight
* = PCB Aroclor 1242 not detected in sample

CHAIN OF CUSTODY RECORD

H & A FILE NO. [illegible]
PROJECT Tudor Wharf
H & A CONTACT Leo Taliadouros

LABORATORY Clean Harbors
ADDRESS Wood Rd. Braintree, Ma
CONTACT Alex Schultheis

DELIVERY DATE 27 May 88
DATE FINAL REPORT DUE 2 weeks
PROJECT MANAGER'S INITIALS [illegible]

H&A SAMPLE NO.	LABORATORY SAMPLE NO.	SAMPLING DATE	SAMPLING TIME	SAMPLE DEPTH	SAMPLE TYPE	VOA	ABN	METALS 8	~~PEST~~/PCB	PET. ID	O & G	Sieve Analysis			NO. OF CONTAINERS	COMMENTS (Special instructions, cautions, etc.)
BSH-1		27 May 88	1100	0-8'	Soil			X	X		X	X			1	Bulk
BSH-3		27 May 88	1200	0-13'	Soil			X	X		X	X			1	Sediment
																Analysis
			Core Samples													

I. Sampled and Relinquished by
Sign Mark Germano
Print Mark Germano
Firm H&A
Date 27 May 88 Time 1350

I. Received by
Sign
Print
Firm
Date Time

II. Relinquished by
Sign G.W. Schultheis
Print Alex Schultheis
Firm CHAS
Date 5/27/88 Time 205 PM

II. Received by
Sign
Print
Firm
Date Time

Evidence Samples tampered with? ☐ No ☐ Yes

If Yes, explain in remarks.

Client: ____
Address: ____
Client contact: ____
Telephone no.: ____

LIQUID	VOA Vial										
	Glass Bottle										
	PlasticBottle				–						
	Preservative										
	Container Volume										
SOLID	VOA Vial										
	Glass Jar										
	Plastic Jar										
	Preservative										
	Container Volume										

Note: Sample bottles supplied by lab, unless indicated.

PRESERVATION KEY: A - Sample chilled, B - Filtered, C - Acidified with ____ D - NaOH, E - NaThiosulfate F - Other

REMARKS: (Sample storage, nonstandard sample bottles)

Container 5'6" - 3" I.D. Metal Tube

APPENDIX E
TRAFFIC AND TRANSPORTATION

RUTHERFORD AVENUE AT ROUTE I RAMPS
1991 PM PEAK HOUR WITH TUDOR WHARF w/ Marina Parcel
date:05-25-1988 time:10:12:25

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	647	580	0	3	2	0.0	12.0	12.0	0
WB	635	716	0	1	3	0	12.0	12.0	0.0	0
NB	150	0	809	1	0	2	12.0	0.0	12.0	0
SB	0	0	0	0	0	0	0.0	0.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
WB	2.0%	5.0%	N	0	0	.900	0		7.0	3
NB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
SB	0.0%	0.0%	N	0	0	.900	0		7.0	0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1		*	*			*											9.3	5	A
2					*	*					*						34.5	5	A
3			*						*		*						6.2	5	A

CYCLE= 65.0

VOLUME ADJUSTMENT WORKSHEET
PART I (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	647	580	.900	0	719	644
WB	635	716	0	.900	706	796	0
NB	150	0	809	.900	167	0	899
SB	0	0	0	.900	0	0	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	TH	719	3	1.10	791	0.00	0.00
EB	RT	644	2	1.05	677	0.00	1.00
WB	LT	706	1	1.00	706	1.00	0.00
WB	TH	796	3	1.10	875	0.00	0.00
NB	LT	167	1	1.00	167	1.00	0.00
NB	RT	899	2	1.05	944	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN BEING OPPOSED	OPPOSING APPROACH VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	719	644	0	0	0	0	3	2	0
NORTHBOUND	0	0	0	0	0	0	0	0	0	0

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 ~~NO BUILD AM PEAK HOUR~~ w/PR[illegible] w/ Marina Parcel AM
date:05-25-1988 time:10:05:20

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	TH	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	6385
EB	RT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	0.850	1.000	1357
WB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
NB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	TH	2108	6385	0.33	0.34	2140	0.99	*
EB	RT	189	1357	0.14	0.75	1012	0.19	
WB	LT	222	1486	0.15	0.15	228	0.98	
WB	TH	540	4694	0.12	0.54	2529	0.21	
NB	LT	533	1516	0.35	0.36	546	0.98	
NB	RT	1330	2394	0.56	0.56	1350	0.99	*

CYCLE= 99.0 LOST=10.0 SUM V/S CRIT= 0.89 TOTAL V/C= 0.99

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	TH	0.99	0.34	99.0	24.83	2140	12.13	0.85	31.41	D	35.0	
EB	RT	0.19	0.75	99.0	2.82	1012	0.01	0.85	2.41	A	1.3	
WB	LT	0.98	0.15	99.0	31.72	228	39.49	1.00	71.21	F	7.0	
WB	TH	0.21	0.54	99.0	9.04	2529	0.01	0.85	7.69	B	6.2	
NB	LT	0.98	0.36	99.0	23.75	546	24.27	1.00	48.02	E	11.8	
NB	RT	0.99	0.56	99.0	16.10	1350	15.82	0.85	27.13	D	17.1	

DIR	Delay	LOS
EB	29.03	D
WB	26.21	D
NB	33.11	D

INTERSECTION DELAY = 30.14 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 99.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 147.6 SECONDS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 ~~NO-BUILD AM PEAK HOUR~~ With Project w/ Marina Parcel AM
date:05-25-1988 time:10:05:16

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	1725	170	0	4	1	0.0	12.0	12.0	0
WB	200	442	0	1	3	0	12.0	12.0	0.0	0
NB	480	0	1140	1	0	2	12.0	0.0	12.0	0
SB	0	0	0	0	0	0	0.0	0.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
WB	2.0%	5.0%	N	0	0	.900	0		7.0	3
NB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
SB	0.0%	0.0%	N	0	0	.900	0		7.0	0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1		*	*			*											33.2	5	A
2					*	*					*						15.2	5	A
3			*						*		*						35.7	5	A

CYCLE= 99.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	1725	170	.900	0	1917	189
WB	200	442	0	.900	222	491	0
NB	480	0	1140	.900	533	0	1267
SB	0	0	0	.900	0	0	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	TH	1917	4	1.10	2108	0.00	0.00
EB	RT	189	1	1.00	189	0.00	1.00
WB	LT	222	1	1.00	222	1.00	0.00
WB	TH	491	3	1.10	540	0.00	0.00
NB	LT	533	1	1.00	533	1.00	0.00
NB	RT	1267	2	1.05	1330	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	1917	189	0	0	0	0	4	1	0
NORTHBOUND	0	0	0	0	0	0	0	0	0	0

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 PM PEAK HOUR WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:06-20-1988 time:17:20:09

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	TH	1800	3	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	4789
EB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394
WB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
NB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	TH	786	4789	0.16	0.14	685	1.15	
EB	RT	677	2394	0.28	0.32	755	0.90	*
WB	LT	698	1486	0.47	0.53	739	0.88	*
WB	TH	871	4694	0.19	0.75	3524	0.25	
NB	LT	167	1516	0.11	0.10	145	1.15	
NB	RT	940	2394	0.39	0.70	1683	0.56	

CYCLE= 65.0 LOST=10.0 SUM V/S CRIT= 0.75 TOTAL V/C= 0.89

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	TH	1.15	0.14	65.0	21.71	685	85.45	0.85	91.09	F	23.7	55
EB	RT	0.90	0.32	65.0	16.14	755	9.54	0.85	21.82	C	8.0	13
WB	LT	0.88	0.53	65.0	10.25	739	8.30	1.00	18.55	C	6.6	12
WB	TH	0.25	0.75	65.0	1.58	3524	0.01	0.85	1.61	A	3.6	4
NB	LT	1.15	0.10	65.0	22.71	145	124.10	1.00	146.81	F	6.2	21
NB	RT	0.56	0.70	65.0	3.59	1683	0.33	0.85	3.32	A	4.8	5

DIR	Delay	LOS
EB	59.09	E
WB	9.14	B
NB	24.92	C

INTERSECTION DELAY = 31.03 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 150 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 65.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 48.1 SECONDS
for chosen cycle length 65.0
suggested timing phase 1 is 9.4 secs green, 5.0 secs yellow + red clear
suggested timing phase 2 is 34.3 secs green, 5.0 secs yellow + red clear
suggested timing phase 3 is 6.3 secs green, 5.0 secs yellow + red clear

UTHERFORD AVENUE AT ROUTE 1 RAMPS
991 PM PEAK HOUR WITH TUDOR WHARF - WITHOUT MARINA PARCEL
ate:06-20-1988 time:17:20:09

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS Version 1-7-87
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=162#3PMB GEOMETRICS=162-#3AM SIGNAL=162-#3AM
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

		VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	STREET	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	RUTHERFORD AVE	0	645	580	0	3	2	0.0	12.0	12.0	0
WB	RUTHERFORD AVE	628	713	0	1	3	0	12.0	12.0	0.0	0
NB	ROUTE 1 RAMPS	150	0	806	1	0	2	12.0	0.0	12.0	0
SB		0	0	0	0	0	0	0.0	0.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0	7.0	3
WB	2.0%	5.0%	N	0	0	.900	0	7.0	3
NB	-2.0%	5.0%	N	0	0	.900	0	7.0	3
SB	0.0%	0.0%	N	0	0	.900	0	7.0	0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1		*	*			*											9.3	5	A
2					*	*					*						34.5	5	A
3			*						*		*						6.2	5	A

CYCLE= 65.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	645	580	.900	0	717	644
WB	628	713	0	.900	698	792	0
NB	150	0	806	.900	167	0	896
SB	0	0	0	.900	0	0	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	TH	717	3	1.10	788	0.00	0.00
EB	RT	644	2	1.05	677	0.00	1.00
WB	LT	698	1	1.00	698	1.00	0.00
WB	TH	792	3	1.10	871	0.00	0.00
NB	LT	167	1	1.00	167	1.00	0.00
NB	RT	896	2	1.05	940	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	717	644	0	0	0	0	3	2	0
NORTHBOUND	0	0	0	0	0	0	0	0	0	0

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 AM PEAK HOUR WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:06-20-1988 time:17:23:55

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	TH	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	6385
EB	RT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	0.850	1.000	1357
WB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
NB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	TH	2105	6385	0.33	0.34	2139	0.98	*
EB	RT	189	1357	0.14	0.75	1012	0.19	
WB	LT	220	1486	0.15	0.15	228	0.96	
WB	TH	540	4694	0.12	0.54	2529	0.21	
NB	LT	533	1516	0.35	0.36	546	0.98	
NB	RT	1321	2394	0.55	0.56	1351	0.98	*

CYCLE= 99.1 LOST=10.0 SUM V/S CRIT= 0.88 TOTAL V/C= 0.98

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	TH	0.98	0.34	99.1	24.84	2139	11.92	0.85	31.25	D	35.0	51
EB	RT	0.19	0.75	99.1	2.83	1012	0.01	0.85	2.41	A	1.3	1
WB	LT	0.96	0.15	99.1	31.68	228	36.65	1.00	68.33	F	6.7	13
WB	TH	0.21	0.54	99.1	9.05	2529	0.01	0.85	7.70	B	6.2	6
NB	LT	0.98	0.36	99.1	23.77	546	24.24	1.00	48.02	E	11.8	22
NB	RT	0.98	0.56	99.1	15.96	1351	14.50	0.85	25.89	D	16.6	28

DIR Delay LOS
EB 28.57 D
WB 25.24 D
NB 32.26 D
INTERSECTION DELAY = 29.59 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 180 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 97.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 136.0 SECONDS
for chosen cycle length 97.0
suggested timing phase 1 is 32.5 secs green, 5.0 secs yellow + red clear
suggested timing phase 2 is 14.6 secs green, 5.0 secs yellow + red clear
suggested timing phase 3 is 34.8 secs green, 5.0 secs yellow + red clear

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 AM PEAK HOUR WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:06-20-1988 time:17:23:53

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS Version 1-7-87
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=162#3PMB GEOMETRICS=162-#3AM SIGNAL=162-#3AM
LOCATED IN CBD:N
VOLUME & GEOMETRICS

		VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	STREET	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	RUTHERFORD AVE	0	1722	170	0	4	1	0.0	12.0	12.0	0
WB	RUTHERFORD AVE	198	442	0	1	3	0	12.0	12.0	0.0	0
NB	ROUTE 1 RAMPS	480	0	1132	1	0	2	12.0	0.0	12.0	0
SB		0	0	0	0	0	0	0.0	0.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT MIN	TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
WB	2.0%	5.0%	N	0	0	.900	0		7.0	3
NB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
SB	0.0%	0.0%	N	0	0	.900	0		7.0	0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1		*	*			*											33.2	5	A
2					*	*					*						15.2	5	A
3			*						*		*						35.7	5	A

CYCLE= 99.1

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	1722	170	.900	0	1913	189
WB	198	442	0	.900	220	491	0
NB	480	0	1132	.900	533	0	1258
SB	0	0	0	.900	0	0	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	TH	1913	4	1.10	2105	0.00	0.00
EB	RT	189	1	1.00	189	0.00	1.00
WB	LT	220	1	1.00	220	1.00	0.00
WB	TH	491	3	1.10	540	0.00	0.00
NB	LT	533	1	1.00	533	1.00	0.00
NB	RT	1258	2	1.05	1321	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	1913	189	0	0	0	0	4	1	0
NORTHBOUND	0	0	0	0	0	0	0	0	0	0

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 NO BUILD PM PEAK HOUR
date:05-25-1988 time:10:09:46

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	TH	1800	3	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	4789
EB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394
WB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
NB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	TH	782	4789	0.16	0.14	674	1.16	
EB	RT	677	2394	0.28	0.32	763	0.89	*
WB	LT	678	1486	0.46	0.51	765	0.89	*
WB	TH	856	4694	0.18	0.74	3467	0.25	
NB	LT	167	1516	0.11	0.09	144	1.16	
NB	RT	922	2394	0.38	0.69	1658	0.56	

CYCLE= 60.0 LOST=10.0 SUM V/S CRIT= 0.74 TOTAL V/C= 0.89

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	TH	1.16	0.14	60.0	20.12	674	90.99	0.85	94.44	F	23.7	
EB	RT	0.89	0.32	60.0	14.75	763	8.67	0.85	19.90	C	7.3	
WB	LT	0.89	0.51	60.0	9.88	765	8.66	1.00	18.54	C	6.2	
WB	TH	0.25	0.74	60.0	1.91	3467	0.01	0.85	1.63	A	3.4	
NB	LT	1.16	0.09	60.0	20.99	144	128.92	1.00	149.92	F	8.2	
NB	RT	0.56	0.69	60.0	3.50	1658	0.32	0.85	3.25	A	4.5	

DIR	Delay	LOS
EB	59.87	E
WB	9.10	B
NB	25.71	D

INTERSECTION DELAY = 31.68 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 180 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 60.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 44.9 SECONDS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 NO BUILD PM PEAK HOUR
date:05-25-1988 time:10:0?:44

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	640	580	0	3	2	0.0	12.0	12.0	0
WB	610	700	0	1	3	0	12.0	12.0	0.0	0
NB	150	0	790	1	0	2	12.0	0.0	12.0	0
SB	0	0	0	0	0	0	0.0	0.0	0.0	0

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0	7.0	3
WB	2.0%	5.0%	N	0	0	.900	0	7.0	3
NB	-2.0%	5.0%	N	0	0	.900	0	7.0	3
SB	0.0%	0.0%	N	0	0	.900	0	7.0	0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1		*	*			*											8.4	5	A
2					*	*					*						30.9	5	A
3			*						*		*						5.7	5	A

CYCLE= 60.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	640	580	.900	0	711	644
WB	610	700	0	.900	678	778	0
NB	150	0	790	.900	167	0	878
SB	0	0	0	.900	0	0	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	TH	711	3	1.10	782	0.00	1.00
EB	RT	644	2	1.05	677	0.00	1.00
WB	LT	678	1	1.00	678	1.00	0.00
WB	TH	778	3	1.10	856	0.00	0.00
NB	LT	167	1	1.00	167	1.00	0.00
NB	RT	878	2	1.05	922	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	711	644	0	0	0	0	3	2	0
NORTHBOUND	0	0	0	0	0	0	0	0	0	0

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 NO BUILD AM PEAK HOUR
date:05-25-1988 time:10:02:37

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	TH	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	6385
EB	RT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	0.850	1.000	1357
WB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
NB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	TH	2090	6385	0.33	0.34	2152	0.97	*
EB	RT	189	1357	0.14	0.74	1009	0.19	
WB	LT	217	1486	0.15	0.15	216	1.00	
WB	TH	538	4694	0.11	0.54	2525	0.21	
NB	LT	533	1516	0.35	0.35	532	1.00	
NB	RT	1283	2394	0.54	0.55	1321	0.97	*

CYCLE= 90.0 LOST=10.0 SUM V/S CRIT= 0.86 TOTAL V/C= 0.97

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	TH	0.97	0.34	90.0	22.35	2152	9.94	0.85	27.44	D	31.5	
EB	RT	0.19	0.74	90.0	2.61	1009	0.01	0.85	2.23	A	1.2	
WB	LT	1.00	0.15	90.0	29.24	216	47.74	1.00	76.98	F	6.9	
WB	TH	0.21	0.54	90.0	8.24	2525	0.01	0.85	7.01	B	5.6	
NB	LT	1.00	0.35	90.0	22.23	532	30.58	1.00	52.81	E	12.2	
NB	RT	0.97	0.55	90.0	14.80	1321	13.61	0.85	24.15	C	15.0	

DIR	Delay	LOS
EB	25.35	D
WB	27.11	D
NB	32.56	D

INTERSECTION DELAY = 28.33 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 90.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 109.6 SECONDS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 NO BUILD AM PEAK HOUR
date:05-25-1988 time:10:02:36

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	0	1710	170	0	4	1	0.0	12.0	12.0	0
WB	195	440	0	1	3	0	12.0	12.0	0.0	0
NB	480	0	1100	1	0	2	12.0	0.0	12.0	0
SB	0	0	0	0	0	0	0.0	0.0	0.0	0

NOTE: DOUBLE LEFT TURN ON WB APPROACH ONE OF THE LEFT TURN LANES & LANE VOLUME REMOVED FROM CALC.

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
WB	2.0%	5.0%	N	0	0	.900	0		7.0	3
NB	-2.0%	5.0%	N	0	0	.900	0		7.0	3
SB	0.0%	0.0%	N	0	0	.900	0		7.0	0

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1		*	*			*											30.3	5	A
2					*	*					*						13.1	5	A
3			*						*		*						31.6	5	A

CYCLE= 90.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	0	1710	170	.900	0	1900	189
WB	195	440	0	.900	217	489	0
NB	480	0	1100	.900	533	0	1222
SB	0	0	0	.900	0	0	0

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	TH	1900	4	1.10	2090	0.00	0.00
EB	RT	189	1	1.00	189	0.00	1.00
WB	LT	217	1	1.00	217	1.00	0.00
WB	TH	489	3	1.10	538	0.00	0.00
NB	LT	533	1	1.00	533	1.00	0.00
NB	RT	1222	2	1.05	1283	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
WESTBOUND	0	1900	189	0	0	0	0	4	1	0
NORTHBOUND	0	0	0	0	0	0	0	0	0	0

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 PM PEAK HOUR WITH TUDOR WHARF w/Marina
date:05-27-1988 time:15:47:22

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
EB	TH-RT	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	0.990	1.000	6321
WB	LT	1800	2	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.920	2879
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
NB	TH	1800	2	1.033	0.976	0.990	1.000	1.000	0.900	1.000	1.000	3234
SB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
SB	TH	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	1596
SB	RT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	0.850	1.000	1357

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	449	2937	0.15	0.17	509	0.88	
EB	TH-RT	1216	6321	0.19	0.17	1096	1.11	*
WB	LT	785	2879	0.27	0.31	897	0.88	
WB	TH	1621	4694	0.35	0.31	1462	1.11	*
NB	LT	53	1486	0.04	0.12	181	0.29	
NB	TH	438	3234	0.14	0.12	395	1.11	*
SB	LT	512	1516	0.34	0.30	461	1.11	*
SB	TH	525	1596	0.33	0.30	486	1.08	
SB	RT	525	1357	0.39	0.48	648	0.81	

CYCLE=180.0 LOST=16.0 SUM V/S CRIT= 1.01 TOTAL V/C= 1.11

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.88	0.17	180.0	55.16	509	11.47	1.00	66.63	F	17.7	
EB	TH-RT	1.11	0.17	180.0	57.86	1096	58.81	0.85	99.17	F	53.3	
WB	LT	0.88	0.31	180.0	44.58	897	6.87	1.00	51.45	E	25.7	
WB	TH	1.11	0.31	180.0	49.54	1462	56.14	0.85	89.83	F	62.1	
NB	LT	0.29	0.12	180.0	54.66	181	0.26	1.00	54.92	E	2.3	
NB	TH	1.11	0.12	180.0	60.97	395	73.89	0.85	114.64	F	22.4	
SB	LT	1.11	0.30	180.0	49.97	461	70.91	1.00	120.88	F	26.1	
SB	TH	1.08	0.30	180.0	49.35	486	58.17	0.80	86.32	F	21.7	
SB	RT	0.81	0.48	180.0	30.45	648	5.34	0.71	25.58	D	13.7	

DIR	Delay	LOS
EB	90.40	F
WB	77.31	F
NB	109.23	F
SB	77.22	F

INTERSECTION DELAY = 83.32 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 100 TO 200 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 180.0 SECONDS

THE V/C RATIO CAN'T BE .95 FOR THE GIVEN CONDITIONS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 PM PEAK HOUR WITH TUDOR WHARF ~/ Marina Parcel
date:05-27-1988 time:15:47:20

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS	
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK	
EB	406	980	70	2	4	0	12.0	12.0	0.0	60	
WB	710	1400	0	2	3	0	12.0	12.0	0.0	60	
NB	50	396	0	1	2	0	12.0	13.0	0.0	26	
SB	486	499	499	1	1	1	12.0	12.0	12.0	36	← ONE LEFT TURN + VOLUME RETURNED

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.950	0		22.0	3
WB	2.0%	5.0%	N	0	0	.950	0		22.0	3
NB	2.0%	5.0%	N	0	0	.950	0		16.0	3
SB	-2.0%	5.0%	N	0	0	.950	0		16.0	4

*PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*												*		31.2	4	A
2					*	*					*						56.1	4	A
3													*	*	*		54.8	4	A
4			*						*	*							22.0	4	A

CYCLE= 180.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	406	980	70	.950	427	1032	74
WB	710	1400	0	.950	747	1474	0
NB	50	396	0	.950	53	417	0
SB	486	499	499	.950	512	525	525

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	427	2	1.05	449	1.00	0.00
EB	TH-RT	1105	4	1.10	1216	0.00	0.07
WB	LT	747	2	1.05	785	1.00	0.00
WB	TH	1474	3	1.10	1621	0.00	0.00
NB	LT	53	1	1.00	53	1.00	0.00
NB	TH	417	2	1.05	438	0.00	0.00
SB	LT	512	1	1.00	512	1.00	0.00
SB	TH	525	1	1.00	525	0.00	0.00
SB	RT	525	1	1.00	525	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	747	1474	0	0	0	0	2	3	0	0
WESTBOUND	427	1032	74	0	0	0	2	4	0	0
NORTHBOUND	512	525	525	0	0	0	1	1	1	0
SOUTHBOUND	53	417	0	0	0	0	1	2	0	0

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 AM PEAK HOUR - WITH TUDOR WHARF TRAFFIC w/Marina
date:05-25-1988 time:09:08:25

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
EB	TH-RT	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	0.993	1.000	6338
WB	LT	1800	2	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.920	2879
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
NB	TH	1800	2	1.033	0.976	0.990	1.000	1.000	0.900	1.000	1.000	3234
SB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
SB	TH-RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.940	1.000	3002

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	997	2937	0.34	0.37	1091	0.91	
EB	TH-RT	2457	6338	0.39	0.37	2354	1.04	*
WB	LT	268	2879	0.09	0.13	388	0.69	
WB	TH	660	4694	0.14	0.13	632	1.04	*
NB	LT	78	1486	0.05	0.21	310	0.25	
NB	TH	705	3234	0.22	0.21	675	1.04	*
SB	LT	553	2937	0.19	0.18	530	1.04	*
SB	TH-RT	525	3002	0.17	0.18	542	0.97	

CYCLE=153.0 LOST=16.0 SUM V/S CRIT= 0.93 TOTAL V/C= 1.04

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.91	0.37	153.0	34.78	1091	8.44	1.00	43.22	E	25.4	
EB	TH-RT	1.04	0.37	153.0	37.51	2354	26.07	0.85	54.04	E	63.4	
WB	LT	0.69	0.13	153.0	48.00	388	3.58	1.00	51.58	E	9.4	
WB	TH	1.04	0.13	153.0	50.65	632	39.90	0.85	76.97	F	23.9	
NB	LT	0.25	0.21	153.0	38.40	310	0.09	1.00	38.50	D	2.6	
NB	TH	1.04	0.21	153.0	46.53	675	38.95	0.85	72.66	F	24.8	
SB	LT	1.04	0.18	153.0	48.11	530	42.64	1.00	90.75	F	22.4	
SB	TH-RT	0.97	0.18	153.0	47.33	542	22.96	0.77	54.13	E	17.4	

DIR	Delay	LOS
EB	50.92	E
WB	69.63	F
NB	69.26	F
SB	72.92	F

INTERSECTION DELAY = 59.80 INTERSECTION LOS=E

THE CYCLE LENGTH WITHIN THE BOUNDS OF 100 TO 200 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 150.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 976.4 SECONDS
for chosen cycle length 150.0
suggested timing phase 1 is 55.6 secs green, 4.0 secs yellow + red clear
suggested timing phase 2 is 20.2 secs green, 4.0 secs yellow + red clear
suggested timing phase 3 is 27.0 secs green, 4.0 secs yellow + red clear
suggested timing phase 4 is 31.2 secs green, 4.0 secs yellow + red clear

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 AM PEAK HOUR - WITH TUDOR WHARF TRAFFIC w/Marina Parcel
date:05-25-1988 time:09:08:23

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	855	1910	100	2	4	0	12.0	12.0	0.0	60
WB	230	540	0	2	3	0	12.0	12.0	0.0	60
NB	70	604	0	1	2	0	12.0	13.0	0.0	26
SB	474	271	179	2	2	0	12.0	12.0	0.0	36

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT MIN TIME		TYPE
EB	-2.0%	5.0%	N	0	0	.900	0	22.0		3
WB	2.0%	5.0%	N	0	0	.900	0	22.0		3
NB	2.0%	5.0%	N	0	0	.900	0	16.0		3
SB	-2.0%	5.0%	N	0	0	.900	0	16.0		4

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*												*		56.8	4	A
2					*	*					*						20.6	4	A
3													*	*	*		27.6	4	A
4			*						*	*							31.9	4	A

CYCLE= 153.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	855	1910	100	.900	950	2122	111
WB	230	540	0	.900	256	600	0
NB	70	604	0	.900	78	671	0
SB	474	271	179	.900	527	301	199

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	950	2	1.05	997	1.00	0.00
EB	TH-RT	2233	4	1.10	2457	0.00	0.05
WB	LT	256	2	1.05	268	1.00	0.00
WB	TH	600	3	1.10	660	0.00	0.00
NB	LT	78	1	1.00	78	1.00	0.00
NB	TH	671	2	1.05	705	0.00	0.00
SB	LT	527	2	1.05	553	1.00	0.00
SB	TH-RT	500	2	1.05	525	0.00	0.40

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	256	600	0	0	0	0	[illegible]	3	0	0
WESTBOUND	950	2122	111	0	0	0	[illegible]	4	0	0
NORTHBOUND	527	301	199	0	0	0	[illegible]	2	0	0
SOUTHBOUND	78	671	0	0	0	0	1	2	0	0

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 PM PEAK - WITH TUDOR WHARF - W/O MARINA PARCEL
date:06-20-1988 time:16:49:20

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
EB	TH-RT	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	0.990	1.000	6321
WB	LT	1800	2	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.920	2879
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1466
NB	TH	1800	2	1.033	0.976	0.990	1.000	1.000	0.900	1.000	1.000	3234
SB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
SB	TH	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	1596
SB	RT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	0.850	1.000	1357

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	443	2937	0.15	0.16	524	0.85	
EB	TH-RT	1216	6321	0.19	0.18	1127	1.08	*
WB	LT	765	2879	0.27	0.32	922	0.85	
WB	TH	1621	4694	0.35	0.32	1503	1.08	*
NB	LT	53	1466	0.04	0.11	160	0.33	
NB	TH	376	3234	0.12	0.11	348	1.08	*
SB	LT	491	1516	0.32	0.30	455	1.08	*
SB	TH	491	1596	0.31	0.30	479	1.02	
SB	RT	491	1357	0.36	0.48	649	0.76	

CYCLE=170.0 LOST=16.0 SUM V/S CRIT= 0.98 TOTAL V/C= 1.08

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.85	0.16	170.0	51.37	524	8.53	1.00	59.90	E	16.4	22
EB	TH-RT	1.08	0.18	170.0	54.01	1127	45.44	0.85	84.53	F	47.4	79
WB	LT	0.85	0.32	170.0	41.05	922	5.45	1.00	46.50	E	24.0	30
WB	TH	1.08	0.32	170.0	45.62	1503	42.69	0.85	75.06	F	54.4	93
NB	LT	0.33	0.11	170.0	53.32	160	0.45	1.00	53.77	E	2.2	3
NB	TH	1.08	0.11	170.0	58.20	348	63.45	0.85	103.40	F	17.8	32
SB	LT	1.08	0.30	170.0	46.81	455	58.22	1.00	105.03	F	22.4	44
SB	TH	1.02	0.30	170.0	45.72	479	38.48	0.79	66.25	F	17.1	26
SB	RT	0.76	0.48	170.0	27.56	649	3.53	0.69	21.55	C	12.1	12

DIR	Delay	LOS
EB	77.55	F
WB	65.74	F
NB	97.30	F
SB	64.28	F

INTERSECTION DELAY = 71.04 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 100 TO 180 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 170.0 SECONDS

THE V/C RATIO CAN'T BE .95 FOR THE GIVEN CONDITIONS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 PM PEAK - WITH TUDOR WHARF - W/O MARINA PARCEL
date:06-20-1988 time:16:49:18

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS Version 1-7-87
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=162#1PMB GEOMETRICS=162#1PMB SIGNAL=162#1PMB
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

DIR	STREET	VOLUMES LT	TH	RT	# OF LANES LT	TH	RT	LANE WIDTH LT	TH	RT	CROSS WALK
EB	RUTHERFORD AVE	401	980	70	2	4	0	12.0	12.0	0.0	60
WB	RUTHERFORD AVE	710	1400	0	2	3	0	12.0	12.0	0.0	60
NB	I-93 RAMP	50	340	0	1	2	0	12.0	13.0	0.0	26
SB	CHELSEA STREET	466	466	466	1	1	1	12.0	12.0	12.0	36

TRAFFIC & ROADWAY CONDITIONS

DIR	GRADE	%HV	ADJ PARK Y/N	MOVES	BUSES	PHF	PEDESTRIANS CROSS	BUT MIN TIME	ARR TYPE
EB	-2.0%	5.0%	N	0	0	.950	0	22.0	3
WB	2.0%	5.0%	N	0	0	.950	0	22.0	3
NB	2.0%	5.0%	N	0	0	.950	0	16.0	3
SB	-2.0%	5.0%	N	0	0	.950	0	16.0	4

PHASINGS

	EASTBOUND l	t	r	p	WESTBOUND l	t	r	p	NORTHBOUND l	t	r	p	SOUTHBOUND l	t	r	p	GREEN	Y+R	PRE/ACT
1	*	*	*												*		30.3	4	A
2					*	*					*						54.4	4	A
3													*	*	*		51.0	4	A
4			*						*	*							18.3	4	A

CYCLE= 170.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	401	980	70	.950	422	1032	74
WB	710	1400	0	.950	747	1474	0
NB	50	340	0	.950	53	358	0
SB	466	466	466	.950	491	491	491

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	V	Flt	Frt
EB	LT	422	2	1.05	443	1.00	0.00
EB	TH-RT	1105	4	1.10	1216	0.00	0.07
WB	LT	747	2	1.05	785	1.00	0.00
WB	TH	1474	3	1.10	1621	0.00	0.00
NB	LT	53	1	1.00	53	1.00	0.00
NB	TH	358	2	1.05	376	0.00	0.00
SB	LT	491	1	1.00	491	1.00	0.00
SB	TH	491	1	1.00	491	0.00	0.00
SB	RT	491	1	1.00	491	0.00	1.00

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN BEING OPPOSED	OPPOSING APPROACH VOLUMES LT	TH	RT	% OPPOSING LEFT TURN LT	TH	RT	# LANES LT	TH	RT	OPPOSING VOLUME
EASTBOUND	747	1474	0	0	0	0	2	3	0	0
WESTBOUND	422	1032	74	0	0	0	2	4	0	0
NORTHBOUND	491	491	491	0	0	0	1	1	1	0
SOUTHBOUND	53	358	0	0	0	0	1	2	0	0

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 AM PEAK HOUR - W/ TUDOR WHARF - W/O MARINA PARCEL
date:0[illegible]-20-1988 time:16:56:58

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
EB	TH-RT	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	0.993	1.000	6338
WB	LT	1800	2	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.920	2879
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
NB	TH	1800	2	1.033	0.976	0.990	1.000	1.000	0.900	1.000	1.000	3234
SB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
SB	TH-RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.940	1.000	3002

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	985	2937	0.34	0.37	1086	0.90	
EB	TH-RT	2457	6338	0.39	0.37	2365	1.04	*
WB	LT	269	2879	0.09	0.14	390	0.69	
WB	TH	660	4694	0.14	0.14	635	1.04	*
NB	LT	78	1486	0.05	0.20	304	0.26	
NB	TH	686	3234	0.21	0.20	660	1.04	*
SB	LT	553	2937	0.19	0.18	532	1.04	*
SB	TH-RT	519	3002	0.17	0.18	544	0.95	

CYCLE=151.0 LOST=16.0 SUM V/S CRIT= 0.93 TOTAL V/C= 1.04

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.90	0.37	151.0	33.91	1096	7.18	1.00	41.10	E	24.7	33
EB	TH-RT	1.04	0.37	151.0	36.82	2365	24.46	0.85	52.09	E	61.7	96
WB	LT	0.69	0.14	151.0	47.31	390	3.48	1.00	50.79	E	9.3	12
WB	TH	1.04	0.14	151.0	49.93	635	38.27	0.85	74.96	F	23.4	35
NB	LT	0.26	0.20	151.0	38.34	304	0.10	1.00	36.44	D	2.6	3
NB	TH	1.04	0.20	151.0	46.12	660	37.71	0.85	71.25	F	23.6	40
SB	LT	1.04	0.18	151.0	47.39	532	40.99	1.00	88.38	F	22.0	40
SB	TH-RT	0.95	0.18	151.0	46.51	544	20.12	0.77	50.98	E	17.0	22

DIR	Delay	LOS
EB	48.94	E
WB	57.97	F
NB	67.91	F
SB	70.27	F

INTERSECTION DELAY = 57.81 INTERSECTION LOS=E

THE CYCLE LENGTH WITHIN THE BOUNDS OF 70 TO 150 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 151.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 715.3 SECONDS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT CHELSEA STREET -
1992 AM PEAK HOUR - W/ TUDOR WHARF - W/O MARINA PARCEL
date:06-20-1992 time:12:53:50

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS Version 1-?-8?
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=162#1AM6 GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

		VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	STREET	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	RUTHERFORD AVE	844	1910	100	2	4	0	12.0	12.0	0.0	60
WB	RUTHERFORD AVE	230	540	0	2	3	0	12.0	12.0	0.0	60
NB	I-93 RAMP	70	588	0	1	2	0	12.0	12.0	0.0	26
SB	CHELSEA STREET	474	268	177	2	2	0	12.0	12.0	0.0	36

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0	22.0	3
WB	2.0%	5.0%	N	0	0	.900	0	22.0	3
NB	2.0%	5.0%	N	0	0	.900	0	16.0	3
SB	-2.0%	5.0%	N	0	0	.900	0	16.0	4

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*												*		56.4	4	A
2					*	*					*						20.4	4	A
3													*	*	*		27.4	4	A
4			*						*	*							30.8	4	A

CYCLE= 151.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	844	1910	100	.900	938	2122	111
WB	230	540	0	.900	256	600	0
NB	70	588	0	.900	78	653	0
SB	474	268	177	.900	527	298	197

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	938	2	1.05	985	1.00	0.00
EB	TH-RT	2233	4	1.10	2457	0.00	0.05
WB	LT	256	2	1.05	269	1.00	0.00
WB	TH	600	3	1.10	660	0.00	0.00
NB	LT	78	1	1.00	78	1.00	0.00
NB	TH	653	2	1.05	686	0.00	0.00
SB	LT	527	2	1.05	553	1.00	0.00
SB	TH-RT	494	2	1.05	519	0.00	0.40

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	256	600	0	0	0	0	2	3	0	0
WESTBOUND	938	2122	111	0	0	0	2	4	0	0
NORTHBOUND	527	298	197	0	0	0	2	2	[illegible]	[illegible]
SOUTHBOUND	78	653	0	0	0	0	1	2	0	0

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 NO BUILD PM PEAK HOUR
date:05-27-1988 time:13:47:20

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
EB	TH-RT	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	0.990	1.000	6321
WB	LT	1800	2	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.920	2879
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
NB	TH	1800	2	1.033	0.976	0.990	1.000	1.000	0.900	1.000	1.000	3234
SB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
SB	TH	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	1596
SB	RT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	0.850	1.000	1357

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	420	2937	0.14	0.18	530	0.79	
EB	TH-RT	1216	6321	0.19	0.18	1140	1.07	*
WB	LT	785	2879	0.27	0.32	932	0.84	
WB	TH	1621	4694	0.35	0.32	1519	1.07	*
NB	LT	53	1486	0.04	0.10	148	0.36	
NB	TH	343	3234	0.11	0.10	321	1.07	*
SB	LT	480	1516	0.32	0.30	450	1.07	*
SB	TH	480	1596	0.30	0.30	474	1.01	
SB	RT	389	1357	0.29	0.48	647	0.60	

CYCLE=160.0 LOST=16.0 SUM V/S CRIT= 0.96 TOTAL V/C= 1.07

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.79	0.18	160.0	47.67	530	5.61	1.00	53.28	E	14.6	
EB	TH-RT	1.07	0.18	160.0	50.58	1140	40.62	0.85	77.52	F	43.9	
WB	LT	0.84	0.32	160.0	38.23	932	4.97	1.00	43.20	E	22.5	
WB	TH	1.07	0.32	160.0	42.48	1519	37.83	0.85	68.26	F	50.1	
NB	LT	0.36	0.10	160.0	51.13	148	0.65	1.00	51.78	E	2.1	
NB	TH	1.07	0.10	160.0	55.17	321	60.42	0.85	92.25	F	15.4	
SB	LT	1.07	0.30	160.0	44.00	450	53.71	1.00	97.71	F	20.5	
SB	TH	1.01	0.30	160.0	43.01	474	35.37	0.78	61.40	F	15.7	
SB	RT	0.60	0.48	160.0	23.33	647	1.14	0.62	15.19	C	9.1	

DIR	Delay	LOS
EB	71.30	F
WB	60.09	F
NB	92.06	F
SB	60.98	F

INTERSECTION DELAY = 65.65 INTERSECTION LOS=F

THE CYCLE LENGTH WITHIN THE BOUNDS OF 100 TO 200 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 160.0 SECONDS

THE V/C RATIO CAN'T BE .95 FOR THE GIVEN CONDITIONS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 NO BUILD PM PEAK HOUR
date:05-27-1988 time:13:47:18

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	380	980	70	2	4	0	12.0	12.0	0.0	60
WB	710	1400	0	2	3	0	12.0	12.0	0.0	60
NB	50	310	0	1	2	0	12.0	13.0	0.0	26
SB	456	456	370	1	1	1	12.0	12.0	12.0	36

TRAFFIC & ROADWAY CONDITIONS

			ADJ	PARK			PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.950	0	22.0	3
WB	2.0%	5.0%	N	0	0	.950	0	22.0	3
NB	2.0%	5.0%	N	0	0	.950	0	16.0	3
SB	-2.0%	5.0%	N	0	0	.950	0	16.0	4

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*												*		28.8	4	A
2					*	*					*						51.8	4	A
3													*	*	*		47.5	4	A
4			*						*	*							15.9	4	A

CYCLE= 160.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	380	980	70	.950	400	1032	74
WB	710	1400	0	.950	747	1474	0
NB	50	310	0	.950	53	326	0
SB	456	456	370	.950	480	480	389

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	400	2	1.05	420	1.00	0.00
EB	TH-RT	1105	4	1.10	1216	0.00	0.07
B	LT	747	2	1.05	785	1.00	0.00
B	TH	1474	3	1.10	1621	0.00	0.00
B	LT	53	1	1.00	53	1.00	0.00
B	TH	326	2	1.05	343	0.00	0.00
B	LT	480	1	1.00	480	1.00	0.00
B	TH	480	1	1.00	480	0.00	0.00
B	RT	389	1	1.00	389	0.00	1.00

ART 3 (OPPOSING VOLUME ADJUSTMENTS)

EFT TURN	OPPOSING APPROACH									
EING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
ASTBOUND	747	1474	0	0	0	0	2	3	0	0
ESTBOUND	400	1032	74	0	0	0	2	4	0	0
RTHBOUND	480	480	389	0	0	0	1	1	1	0
UTHBOUND	53	326	0	0	0	0	1	2	0	0

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 NO BUILD AM PEAK HOUR
date:05-25-1986 time:09:04:15

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
EB	TH-RT	1800	4	1.000	0.976	1.010	1.000	1.000	0.900	0.993	1.000	6338
WB	LT	1800	2	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.920	2879
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
NB	TH	1800	2	1.033	0.976	0.990	1.000	1.000	0.900	1.000	1.000	3234
SB	LT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.920	2937
SB	TH-RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.941	1.000	3003

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	933	2937	0.32	0.38	1114	0.84	
EB	TH-RT	2457	6338	0.39	0.38	2403	1.02	*
WB	LT	268	2879	0.09	0.14	396	0.68	
WB	TH	660	4694	0.14	0.14	646	1.02	*
NB	LT	78	1486	0.05	0.19	278	0.28	
NB	TH	618	3234	0.19	0.19	605	1.02	*
SB	LT	548	2937	0.19	0.18	536	1.02	*
SB	TH-RT	502	3003	0.17	0.18	549	0.91	

CYCLE=141.0 LOST=16.0 SUM V/S CRIT= 0.91 TOTAL V/C= 1.02

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.84	0.38	141.0	30.26	1114	4.08	1.00	34.35	D	21.6	
EB	TH-RT	1.02	0.38	141.0	33.72	2403	19.44	0.85	45.18	E	55.2	
WB	LT	0.68	0.14	141.0	43.95	396	3.17	1.00	47.12	E	8.6	
WB	TH	1.02	0.14	141.0	46.37	646	33.04	0.85	67.50	F	21.4	
NB	LT	0.28	0.19	141.0	37.36	278	0.15	1.00	37.51	D	2.5	
NB	TH	1.02	0.19	141.0	43.78	605	33.99	0.85	66.10	F	20.2	
SB	LT	1.02	0.18	141.0	44.01	536	35.81	1.00	79.82	F	19.9	
SB	TH-RT	0.91	0.18	141.0	42.97	549	14.31	0.75	43.09	E	15.3	

DIR	Delay	LOS
EB	42.20	E
WB	61.61	F
NB	62.91	F
SB	62.27	F

INTERSECTION DELAY = 51.02 INTERSECTION LOS=E

THE CYCLE LENGTH WITHIN THE BOUNDS OF 100 TO 200 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 141.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 346.6 SECONDS
THE EXISTING TIMING IS OPTIMAL

RUTHERFORD AVENUE AT CHELSEA STREET -
1991 NO BUILD AM PEAK HOUR
date:05-25-1988 time:09:04:13

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	800	1910	100	2	4	0	12.0	12.0	0.0	60
WB	230	540	0	2	3	0	12.0	12.0	0.0	60
NB	70	530	0	1	2	0	12.0	13.0	0.0	26
SB	470	260	170	2	2	0	12.0	12.0	0.0	36

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS			ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT	MIN TIME	TYPE
EB	-2.0%	5.0%	N	0	0	.900	0		22.0	3
WB	2.0%	5.0%	N	0	0	.900	0		22.0	3
NB	2.0%	5.0%	N	0	0	.900	0		16.0	3
SB	-2.0%	5.0%	N	0	0	.900	0		16.0	4

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*												*		53.5	4	A
2					*	*					*						19.4	4	A
3													*	*	*		25.8	4	A
4			*						*	*							26.4	4	A

CYCLE= 141.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	800	1910	100	.900	889	2122	111
WB	230	540	0	.900	256	600	0
NB	70	530	0	.900	78	589	0
SB	470	260	170	.900	522	289	189

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	889	2	1.05	933	1.00	0.00
EB	TH-RT	2233	4	1.10	2457	0.00	0.05
WB	LT	256	2	1.05	268	1.00	0.00
WB	TH	600	3	1.10	660	0.00	0.00
NB	LT	78	1	1.00	78	1.00	0.00
NB	TH	589	2	1.05	618	0.00	0.00
SB	LT	522	2	1.05	548	1.00	0.00
SB	TH-RT	478	2	1.05	502	0.00	0.40

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	256	600	0	0	0	0	2	3	0	0
WESTBOUND	889	2122	111	0	0	0	2	4	0	0
NORTHBOUND	522	289	189	0	0	0	2	2	0	0
SOUTHBOUND	78	589	0	0	0	0	1	2	0	0

CHELSEA STREET AT WARREN STREET
1991 PM PEAK HOUR WITH TUDOR WHARF (W/ MARINA PARCEL)
date:05-25-1988 time:09:32:22

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.976	1.005	1.000	1.000	0.900	1.000	0.950	1509
EB	TH-RT	1800	2	1.000	0.976	1.005	1.000	1.000	0.900	0.984	1.000	3127
WB	LT	1800	1	1.000	0.976	0.995	1.000	1.000	0.900	1.000	0.353	556
WB	TH-RT	1800	3	1.000	0.976	0.995	1.000	1.000	0.900	0.973	1.000	4591
NB	LT-TH-RT	1800	1	1.000	0.995	0.990	1.000	1.000	0.900	0.890	0.836	1189
SB	LT-TH-RT	1800	1	1.000	0.995	0.980	1.000	1.000	0.900	0.871	0.831	1143

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
WB	85	41	1	12	1399	12	1.00	2	754	0.00
NB	85	26	1	360	83	277	0.77	1	78	0.75
SB	85	26	1	311	78	233	0.75	1	83	0.77

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
WB	3600	0.210	28.811	0.404	1.000	11.773	0.000	0.000	2.787	0.353	0.353
NB	1411	0.055	22.455	0.826	0.769	3.447	0.231	0.554	1.361	0.836	0.836
SB	1409	0.059	22.186	0.823	0.750	3.716	0.250	0.616	1.367	0.831	0.831

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	233	1509	0.11	0.11	244	0.96	*
EB	TH-RT	978	3127	0.31	0.59	1843	0.53	
WB	LT	12	556	0.02	0.48	265	0.05	
WB	TH-RT	2114	4591	0.46	0.48	2192	0.96	*
NB	LT-TH-RT	360	1189	0.30	0.30	362	0.99	*
SB	LT-TH-RT	311	1143	0.27	0.30	348	0.89	

CYCLE= 85.0 LOST= 9.0 SUM V/S CRIT= 0.87 TOTAL V/C= 0.97
FOR THE EASTBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
75 LEFT TURNS ON THE CHANGE INTERVAL AND 0 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.96	0.59	85.0	12.48	244	33.36	1.00	45.84	E	5.4	10
EB	TH-RT	0.53	0.59	85.0	7.92	1843	0.24	0.85	6.94	B	9.0	9
WB	LT	0.05	0.48	85.0	9.02	265	0.00	1.00	9.02	B	0.2	1
WB	TH-RT	0.96	0.48	85.0	16.35	2192	8.97	0.85	21.52	C	23.7	35
NB	LT-TH-RT	0.99	0.30	85.0	22.40	362	34.80	0.85	48.62	E	7.8	16
SB	LT-TH-RT	0.89	0.30	85.0	21.45	348	16.89	0.85	32.59	D	5.4	9

DIR	Delay	LOS
EB	14.43	B
WB	21.45	C
NB	48.62	E
SB	32.59	D

INTERSECTION DELAY = 22.63 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 87.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 107.6 SECONDS
for chosen cycle length 87.0
suggested timing phase 1 is 9.6 secs green, 0.0 secs yellow + red clear

CHELSEA STREET AT WARREN STREET
1991 PM PEAK HOUR WITH TUDOR WHARF (W/ MARINA PARCEL)
date:05-25-1988 time:09:32:20

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	210	750	88	1	2	0	12.0	12.0	0.0	24
WB	11	1420	310	1	3	0	12.0	12.0	0.0	24
NB	249	52	23	0	1	0	0.0	12.0	0.0	48
SB	210	10	60	0	1	0	0.0	12.0	0.0	48

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS	BUT MIN TIME	TYPE
EB	-1.0%	5.0%	N	0	0	.900	0	13.0	3
WB	1.0%	5.0%	N	0	0	.900	0	13.0	3
NB	2.0%	1.0%	N	0	0	.900	0	19.0	3
SB	4.0%	1.0%	N	0	0	.900	0	19.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*														9.5	0	A
2	*	*	*		*	*	*										40.6	5	A
3									*	*	*		*	*	*		25.9	4	A

CYCLE= 85.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	210	750	88	.900	233	833	98
WB	11	1420	310	.900	12	1578	344
NB	249	52	23	.900	277	58	26
SB	210	10	60	.900	233	11	67

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	233	1	1.00	233	1.00	0.00
EB	TH-RT	931	2	1.05	978	0.00	0.11
WB	LT	12	1	1.00	12	1.00	0.00
WB	TH-RT	1922	3	1.10	2114	0.00	0.18
NB	LT-TH-RT	360	1	1.00	360	0.77	0.07
SB	LT-TH-RT	311	1	1.00	311	0.75	0.21

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	12	1578	344	100	100	100	1	3	0	1399
WESTBOUND	233	833	98	0	81	81	1	2	0	754
NORTHBOUND	233	11	67	100	100	100	0	1	0	78
SOUTHBOUND	277	58	26	100	100	100	0	1	0	83

CHELSEA STREET AT WARREN STREET
1991 AM PEAK HOUR WITH TUDOR WHARF TRAFFIC
date:05-25-1988 time:09:25:51

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.976	1.005	1.000	1.000	0.900	1.000	0.950	1509
EB	TH-RT	1800	2	1.000	0.976	1.005	1.000	1.000	0.900	0.976	1.000	3099
WB	LT	1800	1	1.000	0.976	0.995	1.000	1.000	0.900	1.000	0.134	211
WB	TH-RT	1800	3	1.000	0.976	0.995	1.000	1.000	0.900	0.982	1.000	4633
NB	LT-TH-RT	1800	1	1.000	0.995	0.990	1.000	1.000	0.900	0.898	0.924	1323
SB	LT-TH-RT	1800	1	1.000	0.995	0.980	1.000	1.000	0.900	0.894	1.000	1413

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
WB	78	37	1	37	833	37	1.00	2	1282	0.00
NB	78	16	1	63	14	49	0.77	1	56	0.79
SB	78	16	1	267	56	211	0.79	1	14	0.77

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
WB	3600	0.356	13.719	0.074	1.000	22.855	0.000	0.000	15.210	0.134	0.134
NB	1455	0.038	13.446	0.840	0.772	2.464	0.228	0.495	1.339	0.924	0.924
SB	1427	0.010	15.275	0.866	0.792	0.635	0.208	0.206	1.299	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	256	1509	0.09	0.21	587	0.44	
EB	TH-RT	1952	3099	0.63	0.68	2109	0.93	*
WB	LT	37	211	0.17	0.47	99	0.37	
WB	TH-RT	917	4633	0.20	0.47	2174	0.42	
NB	LT-TH-RT	63	1323	0.05	0.20	270	0.23	
SB	LT-TH-RT	267	1413	0.19	0.20	288	0.93	*

CYCLE= 78.0 LOST= 9.0 SUM V/S CRIT= 0.82 TOTAL V/C= 0.93
FOR THE EASTBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
81 LEFT TURNS ON THE CHANGE INTERVAL AND 186 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.44	0.68	78.0	4.30	587	0.34	1.00	4.64	A	4.4	4
EB	TH-RT	0.93	0.68	78.0	8.17	2109	5.56	0.85	11.67	B	12.9	19
WB	LT	0.37	0.47	78.0	10.11	99	1.10	1.00	11.21	B	0.4	1
WB	TH-RT	0.42	0.47	78.0	10.41	2174	0.08	0.85	8.92	B	9.6	10
NB	LT-TH-RT	0.23	0.20	78.0	19.73	270	0.09	0.85	16.84	C	1.1	2
SB	LT-TH-RT	0.93	0.20	78.0	23.15	288	24.29	0.85	40.33	E	5.3	10

DIR	Delay	LOS
EB	10.86	B
WB	9.00	B
NB	16.84	C
SB	40.33	E

INTERSECTION DELAY = 12.71 INTERSECTION LOS=B

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 78.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 65.1 SECONDS
for chosen cycle length 78.0
suggested timing phase 1 is 16.9 secs green, 0.0 secs yellow + red clear

CHELSEA STREET AT WARREN STREET
1991 AM PEAK HOUR WITH TUDOR WHARF TRAFFIC w/ Marina Parcel
date:05-25-1988 time:09:25:49

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	230	1400	273	1	2	0	12.0	12.0	0.0	24
WB	33	660	90	1	3	0	12.0	12.0	0.0	24
NB	44	12	1	0	1	0	0.0	12.0	0.0	48
SB	190	40	10	0	1	0	0.0	12.0	0.0	48

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME	TYPE
EB	-1.0%	5.0%	N	0	0	.900	0	13.0	3
WB	1.0%	5.0%	N	0	0	.900	0	13.0	3
NB	2.0%	1.0%	N	0	0	.900	0	19.0	3
SB	4.0%	1.0%	N	0	0	.900	0	19.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*														16.5	0	A
2	*	*	*		*	*	*										36.6	5	A
3									*	*	*		*	*	*		15.9	4	A

CYCLE= 76.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	230	1400	273	.900	256	1556	303
WB	33	660	90	.900	37	733	100
NB	44	12	1	.900	49	13	1
SB	190	40	10	.900	211	44	11

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Flt	Frt
EB	LT	256	1	1.00	256	1.00	0.00
EB	TH-RT	1659	2	1.05	1952	0.00	0.16
WB	LT	37	1	1.00	37	1.00	0.00
WB	TH-RT	833	3	1.10	917	0.00	0.12
NB	LT-TH-RT	63	1	1.00	63	0.77	0.02
SB	LT-TH-RT	267	1	1.00	267	0.79	0.04

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	37	733	100	100	100	100	1	3	0	833
WESTBOUND	256	1556	303	0	69	69	1	2	0	1282
NORTHBOUND	211	44	11	100	100	100	0	1	0	56
SOUTHBOUND	49	13	1	100	100	100	0	1	0	14

CHELSEA STREET AT WARREN STREET
1991 PM PEAK HOUR WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:05-20-1988 time:17:08:40

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.976	1.005	1.000	1.000	0.900	1.000	0.950	1509
EB	TH-RT	1800	2	1.000	0.976	1.005	1.000	1.000	0.900	0.986	1.000	3132
WB	LT	1800	1	1.000	0.976	0.995	1.000	1.000	0.900	1.000	0.382	600
WB	TH-RT	1800	3	1.000	0.976	0.995	1.000	1.000	0.900	0.973	1.000	4591
NB	LT-TH-RT	1800	1	1.000	0.995	0.990	1.000	1.000	0.900	0.890	0.864	1226
SB	LT-TH-RT	1800	1	1.000	0.995	0.980	1.000	1.000	0.900	0.871	0.862	1186

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	Nc	Vo	Flto
WB	76	37	1	12	1399	12	1.00	2	728	0.00
NB	76	20	1	319	78	241	0.76	1	77	0.75
SB	76	20	1	310	77	233	0.75	1	78	0.76

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
WB	3600	0.202	26.969	0.420	1.000	9.909	0.000	0.000	2.677	0.382	0.382
NB	1415	0.054	17.238	0.627	0.756	3.184	0.244	0.577	1.360	0.864	0.864
SB	1415	0.055	17.189	0.626	0.758	3.232	0.247	0.588	1.361	0.862	0.862

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	233	1509	0.11	0.13	276	0.84	*
EB	TH-RT	965	3132	0.31	0.61	1920	0.50	
WB	LT	12	600	0.02	0.49	291	0.04	
WB	TH-RT	2114	4591	0.46	0.49	2226	0.95	*
NB	LT-TH-RT	319	1226	0.26	0.27	329	0.97	
SB	LT-TH-RT	310	1186	0.26	0.27	319	0.97	*

CYCLE= 76.0 LOST= 9.0 SUM V/S CRIT= 0.83 TOTAL V/C= 0.94
FOR THE EASTBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
84 LEFT TURNS ON THE CHANGE INTERVAL AND 0 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.84	0.61	76.0	8.97	276	14.11	1.00	23.08	C	4.3	5
EB	TH-RT	0.50	0.61	76.0	6.25	1920	0.15	0.85	5.47	B	7.5	8
WB	LT	0.04	0.49	76.0	7.61	291	0.00	1.00	7.61	B	0.1	1
WB	TH-RT	0.95	0.49	76.0	14.19	2226	7.19	0.85	18.17	C	20.9	30
NB	LT-TH-RT	0.97	0.27	76.0	20.87	329	30.31	0.85	43.50	E	6.3	12
SB	LT-TH-RT	0.97	0.27	76.0	20.91	319	31.94	0.85	44.92	E	6.3	13

DIR	Delay	LOS
EB	8.90	B
WB	18.11	C
NB	43.50	E
SB	44.92	E

INTERSECTION DELAY = 19.47 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 76.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 71.0 SECONDS
for chosen cycle length 76.0
- suggested timing phase 1 is 8.7 secs green, 0.0 secs yellow + red clear

CHELSEA STREET AT WARREN STREET
1991 PM PEAK HOUR WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:06-20-1988 time:17:08:38

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS version 1-7-87
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=1:2#2PMB GEOMETRICS= SIGNAL=
LOCATED IN CED:Y
VOLUME & GEOMETRICS

		VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	STREET	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	CHELSEA STREET	210	750	77	1	2	0	12.0	12.0	0.0	24
WB	CHELSEA STREET	11	1420	310	1	3	0	12.0	12.0	0.0	24
NB	WARREN STREET	217	48	22	0	1	0	0.0	12.0	0.0	48
SB	WARREN STREET	210	9	60	0	1	0	0.0	12.0	0.0	48

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME	TYPE
EB	-1.0%	5.0%	N	0	0	.900	0	13.0	3
WB	1.0%	5.0%	N	0	0	.900	0	13.0	3
NB	2.0%	1.0%	N	0	0	.900	0	19.0	3
SB	4.0%	1.0%	N	0	0	.900	0	19.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*														9.7	0	A
2	*	*	*		*	*	*										36.9	5	A
3									*	*	*		*	*	*		20.4	4	A

CYCLE= 76.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	210	750	77	.900	233	833	86
WB	11	1420	310	.900	12	1578	344
NB	217	48	22	.900	241	53	24
SB	210	9	60	.900	233	10	67

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	V	Plt	Prt
EB	LT	233	1	1.00	233	1.00	0.00
EB	TH-RT	919	2	1.05	965	0.00	0.09
WB	LT	12	1	1.00	12	1.00	0.00
WB	TH-RT	1922	3	1.10	2114	0.00	0.18
NB	LT-TH-RT	319	1	1.00	319	0.76	0.08
SB	LT-TH-RT	310	1	1.00	310	0.75	0.22

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	12	1578	344	100	100	100	1	3	0	1399
WESTBOUND	233	833	86	0	79	75	1	2	0	723
NORTHBOUND	233	10	67	100	100	100	0	1	0	77
SOUTHBOUND	241	53	24	100	100	100	0	1	0	76

CHELSEA STREET AT WARREN STREET
1991 AM PEAK HOUR - WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:Mar 8 - 989 time:17:08:43

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.976	1.005	1.000	1.000	0.900	1.000	0.950	1509
EB	TH-RT	1800	2	1.000	0.976	1.005	1.000	1.000	0.900	0.975	1.000	3106
WB	LT	1800	1	1.000	0.976	0.995	1.000	1.000	0.900	1.000	0.148	232
WB	TH-RT	1800	3	1.000	0.976	0.995	1.000	1.000	0.900	0.982	1.000	4633
NB	LT-TH-RT	1800	1	1.000	0.995	0.990	1.000	1.000	0.900	0.897	0.956	1369
SB	LT-TH-RT	1800	1	1.000	0.995	0.980	1.000	1.000	0.900	0.894	1.000	1413

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
WB	73	34	1	36	833	36	1.00	2	1259	0.00
NB	73	15	1	58	14	43	0.75	1	51	0.81
SB	73	15	1	262	51	211	0.81	1	14	0.75

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
WB	3600	0.350	12.915	0.085	1.000	21.005	0.000	0.000	12.737	0.148	0.148
NB	1451	0.035	12.674	0.843	0.750	2.125	0.250	0.514	1.334	0.956	0.956
SB	1439	0.010	14.209	0.866	0.805	0.590	0.195	0.185	1.299	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	256	1509	0.09	0.21	586	0.44	
EB	TH-RT	1917	3106	0.62	0.67	2094	0.92	*
WB	LT	36	232	0.15	0.46	106	0.33	
WB	TH-RT	917	4633	0.20	0.46	2153	0.43	
NB	LT-TH-RT	58	1369	0.04	0.20	278	0.21	
SB	LT-TH-RT	262	1413	0.19	0.20	286	0.92	*

CYCLE= 73.0 LOST= 9.0 SUM V/S CRIT= 0.80 TOTAL V/C= 0.92
FOR THE EASTBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
87 LEFT TURNS ON THE CHANGE INTERVAL AND 184 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.44	0.67	73.0	4.17	586	0.34	1.00	4.52	A	4.1	4
EB	TH-RT	0.92	0.67	73.0	7.70	2094	4.99	0.85	10.79	B	13.1	17
WB	LT	0.33	0.46	73.0	9.33	108	0.66	1.00	10.05	B	0.4	1
WB	TH-RT	0.43	0.46	73.0	9.91	2153	0.09	0.85	8.50	B	7.0	9
NB	LT-TH-RT	0.21	0.20	73.0	18.41	278	0.06	0.85	15.70	C	0.9	1
SB	LT-TH-RT	0.92	0.20	73.0	21.65	286	22.77	0.85	37.75	D	4.9	9

DIR	Delay	LOS
EB	10.05	B
WB	8.55	B
NB	15.70	C
SB	37.75	D

INTERSECTION DELAY = 11.64 INTERSECTION LOS=B

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 180 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 73.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 56.0 SECONDS
for chosen cycle length 73.0
suggested timing: phase 1 is 45.5 secs green, [illegible] secs yellow + red clear

CHELSEA STREET AT WARREN STREET
1991 AM PEAK HOUR - WITH TUDOR WHARF - WITHOUT MARINA PARCEL
date:06-20-1988 time:17:02:41

1985 HCM - CHAPTER 9: SIGNALIZED - OPERATIONAL ANALYSIS Version 1-7-87
LAST DATA SET NAMES LOADED OR SAVED
VOLUME=162-#2AM GEOMETRICS=162-#2AM SIGNAL=162-#2AM
LOCATED IN CBD:Y

VOLUME & GEOMETRICS

DIR	STREET	VOLUMES LT	TH	RT	# OF LANES LT	TH	RT	LANE WIDTH LT	TH	RT	CROSS WALK
EB	CHELSEA STREET	230	1400	243	1	2	0	12.0	12.0	0.0	24
WB	CHELSEA STREET	32	660	90	1	3	0	12.0	12.0	0.0	24
NB	WARREN STREET	39	12	1	0	1	0	0.0	12.0	0.0	48
SB	WARREN STREET	190	36	10	0	1	0	0.0	12.0	0.0	45

TRAFFIC & ROADWAY CONDITIONS

DIR	GRADE	%HV	ADJ PARK Y/N	MOVES	BUSES	PHF	PEDESTRIANS CROSS BUT	MIN TIME	ARR TYPE
EB	-1.0%	5.0%	N	0	0	.900	0	13.0	3
WB	1.0%	5.0%	N	0	0	.900	0	13.0	3
NB	2.0%	1.0%	N	0	0	.900	0	19.0	3
SB	4.0%	1.0%	N	0	0	.900	0	19.0	3

PHASINGS

	EASTBOUND l	t	r	p	WESTBOUND l	t	r	p	NORTHBOUND l	t	r	p	SOUTHBOUND l	t	r	p	GREEN	Y+R	PRE/ACT
1	*	*	*														15.3	0	A
2	*	*	*		*	*	*										33.9	5	A
3									*	*	*		*	*	*		14.8	4	A

CYCLE= 73.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	230	1400	243	.900	256	1556	270
WB	32	660	90	.900	36	733	100
NB	39	12	1	.900	43	13	1
SB	190	36	10	.900	211	40	11

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	256	1	1.00	256	1.00	0.00
EB	TH-RT	1826	2	1.05	1917	0.00	0.15
WB	LT	36	1	1.00	36	1.00	0.00
WB	TH-RT	833	3	1.10	917	0.00	0.12
NB	LT-TH-RT	58	1	1.00	58	0.75	0.02
SB	LT-TH-RT	262	1	1.00	262	0.81	0.04

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN BEING OPPOSED	OPPOSING APPROACH VOLUMES LT	TH	RT	% OPPOSING LEFT TURN LT	TH	RT	# LANES LT	TH	RT	OPPOSING VOLUME
EASTBOUND	36	733	100	100	100	100	1	3	0	832
WESTBOUND	256	1556	270	0	69	69	1	2	0	1259
NORTHBOUND	211	40	11	100	100	100	0	1	0	51
SOUTHBOUND	43	13	1	100	100	100	0	1	0	14

CHELSEA STREET AT WARREN STREET
1991 NO BUILD PM PEAK HOUR
date:05-25-1988 time:09:28:27

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.976	1.005	1.000	1.000	0.900	1.000	0.950	1509
EB	TH-RT	1800	2	1.000	0.976	1.005	1.000	1.000	0.900	0.996	1.000	3164
WB	LT	1800	1	1.000	0.976	0.995	1.000	1.000	0.900	1.000	0.414	652
WB	TH-RT	1800	3	1.000	0.976	0.995	1.000	1.000	0.900	0.973	1.000	4591
NB	LT-TH-RT	1800	1	1.000	0.995	0.990	1.000	1.000	0.900	0.881	0.913	1284
SB	LT-RT	1800	1	1.000	0.995	0.980	1.000	1.000	0.900	0.870	0.868	1193

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Plto
WB	75	37	1	11	1399	11	1.00	2	675	0.00
NB	75	20	1	156	56	100	0.64	1	67	0.78
SB	75	20	1	300	67	233	0.78	1	56	0.64

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Ft	Gf	El	Fm	Flt
WB	3600	0.188	27.730	0.453	1.000	8.865	0.000	0.000	2.483	0.414	0.414
NB	1425	0.047	16.906	0.833	0.643	2.719	0.357	0.837	1.350	0.913	0.913
SB	1469	0.038	17.449	0.840	1.000	2.176	0.000	0.000	1.339	0.868	0.868

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	233	1509	0.11	0.13	282	0.83	*
EB	TH-RT	898	3164	0.28	0.62	1957	0.46	
WB	LT	11	652	0.02	0.49	318	0.03	
WB	TH-RT	2114	4591	0.46	0.49	2240	0.94	*
NB	LT-TH-RT	156	1284	0.12	0.26	336	0.46	
SB	LT-RT	300	1193	0.25	0.26	312	0.96	*

CYCLE= 75.0 LOST= 9.0 SUM V/S CRIT= 0.82 TOTAL V/C= 0.93
FOR THE EASTBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
85 LEFT TURNS ON THE CHANGE INTERVAL AND 0 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.83	0.62	75.0	8.51	282	12.44	1.00	20.94	C	4.2	5
EB	TH-RT	0.46	0.62	75.0	5.80	1957	0.13	0.85	5.03	B	6.8	7
WB	LT	0.03	0.49	75.0	7.60	318	0.00	1.00	7.60	B	0.1	1
WB	TH-RT	0.94	0.49	75.0	13.85	2240	6.68	0.85	17.46	C	20.5	29
NB	LT-TH-RT	0.46	0.26	75.0	17.68	336	0.75	0.85	15.66	C	2.4	3
SB	LT-RT	0.96	0.26	75.0	20.76	312	29.81	1.00	50.57	E	6.5	14

DIR	Delay	LOS
EB	8.31	B
WB	17.40	C
NB	15.66	C
SB	50.57	E

INTERSECTION DELAY = 17.24 INTERSECTION LOS=C

THE CYCLE LENGTH WITHIN THE BOUNDS OF 60 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 72.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 65.8 SECONDS
for chosen cycle length 72.0
suggested timing phase 1 is 8.3 secs green, 0.0 secs yellow + red clear

CHELSEA STREET AT WARREN STREET
1991 NO BUILD PM PEAK HOUR
date:05-25-1988 time:09:28:25

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	210	750	20	1	2	0	12.0	12.0	0.0	24
WB	10	1420	310	1	3	0	12.0	12.0	0.0	24
NB	90	30	20	0	1	0	0.0	12.0	0.0	48
SB	210	0	60	0	1	0	0.0	12.0	0.0	48

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME	TYPE
EB	-1.0%	5.0%	N	0	0	.900	0	13.0	3
WB	1.0%	5.0%	N	0	0	.900	0	13.0	3
NB	2.0%	1.0%	N	0	0	.900	0	19.0	3
SB	4.0%	1.0%	N	0	0	.900	0	19.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*														9.8	0	A
2	*	*	*		*	*	*										36.6	5	A
3									*	*	*		*	*	*		19.6	4	A

CYCLE= 75.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	210	750	20	.900	233	833	22
WB	10	1420	310	.900	11	1578	344
NB	90	30	20	.900	100	33	22
SB	210	0	60	.900	233	0	67

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	233	1	1.00	233	1.00	0.00
EB	TH-RT	856	2	1.05	898	0.00	0.03
WB	LT	11	1	1.00	11	1.00	0.00
WB	TH-RT	1922	3	1.10	2114	0.00	0.18
NB	LT-TH-RT	156	1	1.00	156	0.64	0.14
SB	LT-RT	300	1	1.00	300	0.78	0.22

PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	11	1578	344	100	100	100	1	3	0	1399
WESTBOUND	233	833	22	0	79	79	1	2	0	675
NORTHBOUND	233	0	67	100	100	100	0	1	0	67
SOUTHBOUND	100	33	22	100	100	100	0	1	0	56

CHELSEA STREET AT WARREN STREET
1991 NO BUILD AM PEAK HOUR
date:05-25-1988 time:09:22:46

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	LT	1800	1	1.000	0.976	1.005	1.000	1.000	0.900	1.000	0.950	1509
EB	TH-RT	1800	2	1.000	0.976	1.005	1.000	1.000	0.900	0.987	1.000	3136
WB	LT	1800	1	1.000	0.976	0.995	1.000	1.000	0.900	1.000	0.202	318
WB	TH-RT	1800	3	1.000	0.976	0.995	1.000	1.000	0.900	0.982	1.000	4633
NB	LT-TH	1800	1	1.000	0.995	0.990	1.000	1.000	0.900	1.000	1.000	1596
SB	LT-TH-RT	1800	1	1.000	0.995	0.980	1.000	1.000	0.900	0.894	1.000	1412

SUPPLEMENTAL WORKSHEET FOR LEFT-TURN ADJUSTMENT FACTOR FLT
INPUT VARIABLES

DIR	C	G	N	Va	Vm	Vlt	Plt	No	Vo	Flto
WB	60	27	1	33	833	33	1.00	2	1165	0.00
NB	60	12	1	33	11	22	0.67	1	33	0.86
SB	60	12	1	244	33	211	0.86	1	11	0.67

CALCULATIONS

DIR	Sop	Yo	Gu	Fs	Pl	Gq	Pt	Gf	El	Fm	Flt
WB	3600	0.324	10.913	0.147	1.000	15.884	0.000	0.000	7.658	0.202	0.202
NB	1434	0.023	10.749	0.854	0.667	1.145	0.333	0.467	1.317	1.000	1.000
SB	1486	0.007	11.532	0.868	0.864	0.362	0.136	0.096	1.296	1.000	1.000

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	LT	256	1509	0.09	0.21	588	0.43	
EB	TH-RT	1785	3136	0.57	0.65	2044	0.87	*
WB	LT	33	318	0.10	0.45	142	0.23	
WB	TH-RT	917	4633	0.20	0.45	2069	0.44	
NB	LT-TH	33	1596	0.02	0.20	316	0.11	
SB	LT-TH-RT	244	1412	0.17	0.20	280	0.87	*

CYCLE= 60.0 LOST= 9.0 SUM V/S CRIT= 0.74 TOTAL V/C= 0.87
FOR THE EASTBOUND PROTECTED/PERMISSIVE LEFT TURN LANE THE CAPACITY, V/S AND V/C
RATIOS HAVE ALL BEEN ADJUSTED TO REFLECT A CAPACITY FOR
106 LEFT TURNS ON THE CHANGE INTERVAL AND 173 ON THE PERMISSIVE PHASE

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	LT	0.43	0.65	60.0	3.86	588	0.34	1.00	4.20	A	3.4	3
EB	TH-RT	0.87	0.65	60.0	6.42	2044	3.24	0.85	8.21	B	9.9	13
WB	LT	0.23	0.45	60.0	7.80	142	0.16	1.00	7.96	B	0.3	1
WB	TH-RT	0.44	0.45	60.0	8.70	2069	0.10	0.85	7.49	B	7.7	8
NB	LT-TH	0.11	0.20	60.0	14.97	316	0.01	0.85	12.73	B	0.4	1
SB	LT-TH-RT	0.87	0.20	60.0	17.72	280	17.16	0.85	29.66	D	3.6	7

DIR	Delay	LOS
EB	7.71	B
WB	7.50	B
NB	12.73	B
SB	29.66	D

INTERSECTION DELAY = 9.34 INTERSECTION LOS=B

THE CYCLE LENGTH WITHIN THE BOUNDS OF 50 TO 120 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 60.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 41.2 SECONDS
for chosen cycle length 60.0
[illegible]

CHELSEA STREET AT WARREN STREET
1991 NO BUILD AM PEAK HOUR
date:05-25-1988 time:09:22:44

LAST DATA SET NAMES LOADED OR SAVED
VOLUME= GEOMETRICS= SIGNAL=
LOCATED IN CBD:Y
VOLUME & GEOMETRICS

	VOLUMES			# OF LANES			LANE WIDTH			CROSS
DIR	LT	TH	RT	LT	TH	RT	LT	TH	RT	WALK
EB	230	1400	130	1	2	0	12.0	12.0	0.0	24
WB	30	660	90	1	3	0	12.0	12.0	0.0	24
NB	20	10	0	0	1	0	0.0	12.0	0.0	48
SB	190	20	10	0	1	0	0.0	12.0	0.0	48

TRAFFIC & ROADWAY CONDITIONS

			ADJ PARK				PEDESTRIANS		ARR
DIR	GRADE	%HV	Y/N	MOVES	BUSES	PHF	CROSS BUT	MIN TIME	TYPE
EB	-1.0%	5.0%	N	0	0	.900	0	13.0	3
WB	1.0%	5.0%	N	0	0	.900	0	13.0	3
NB	2.0%	1.0%	N	0	0	.900	0	19.0	3
SB	4.0%	1.0%	N	0	0	.900	0	19.0	3

PHASINGS

	EASTBOUND				WESTBOUND				NORTHBOUND				SOUTHBOUND				GREEN	Y+R	PRE/ACT
	l	t	r	p	l	t	r	p	l	t	r	p	l	t	r	p			
1	*	*	*														12.3	0	A
2	*	*	*		*	*	*										26.8	5	A
3									*	*	*		*	*	*		11.9	4	A

CYCLE= 60.0

VOLUME ADJUSTMENT WORKSHEET
PART 1 (MOVEMENT ADJUSTMENTS)

DIR	LTV	THV	RTV	PHF	LTFR	THFR	RTFR
EB	230	1400	130	.900	256	1556	144
WB	30	660	90	.900	33	733	100
NB	20	10	0	.900	22	11	0
SB	190	20	10	.900	211	22	11

PART 2 (LANE GROUP ADJUSTMENTS)

DIR	LN GROUP	FLOW	N	LU	v	Plt	Prt
EB	LT	256	1	1.00	256	1.00	0.00
EB	TH-RT	1700	2	1.05	1785	0.00	0.08
WB	LT	33	1	1.00	33	1.00	0.00
WB	TH-RT	833	3	1.10	917	0.00	0.12
NB	LT-TH	33	1	1.00	33	0.67	0.00
SB	LT-TH-RT	244	1	1.00	244	0.86	0.05

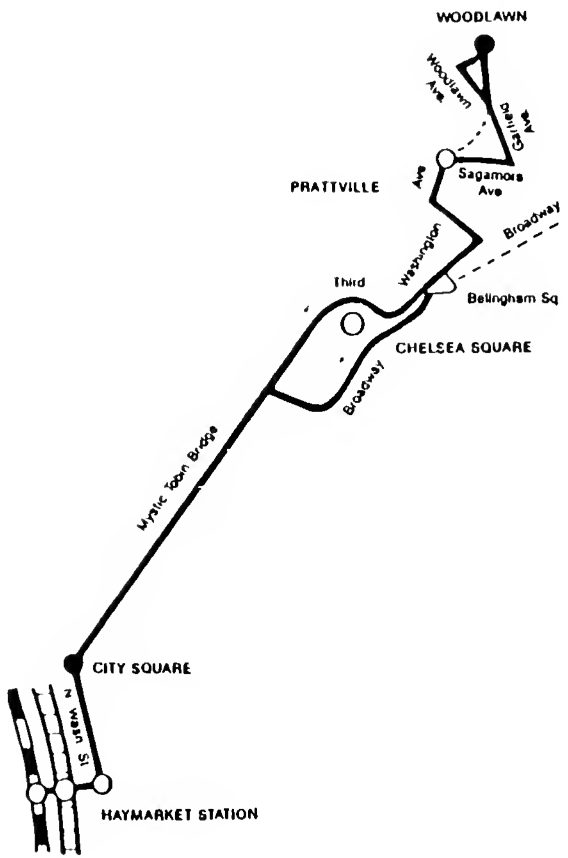
PART 3 (OPPOSING VOLUME ADJUSTMENTS)

LEFT TURN	OPPOSING APPROACH									
BEING OPPOSED	VOLUMES			% OPPOSING LEFT TURN			# LANES			OPPOSING
	LT	TH	RT	LT	TH	RT	LT	TH	RT	VOLUME
EASTBOUND	33	733	100	100	100	100	1	3	0	833
WESTBOUND	256	1556	144	0	69	69	1	2	0	1165
NORTHBOUND	211	22	11	100	100	100	0	1	0	33
SOUTHBOUND	22	11	0	100	100	100	0	1	0	11

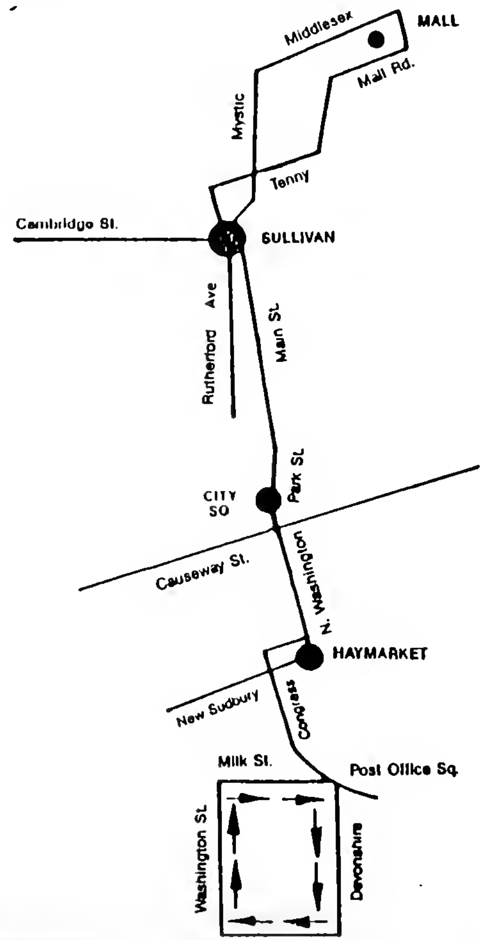
LEVEL OF SERVICE ANALYSIS

Existing Bus Routes Through City Square

111 WOODLAWN-HAYMARKET SQ.
VIA MYSTIC RIVER BRIDGE

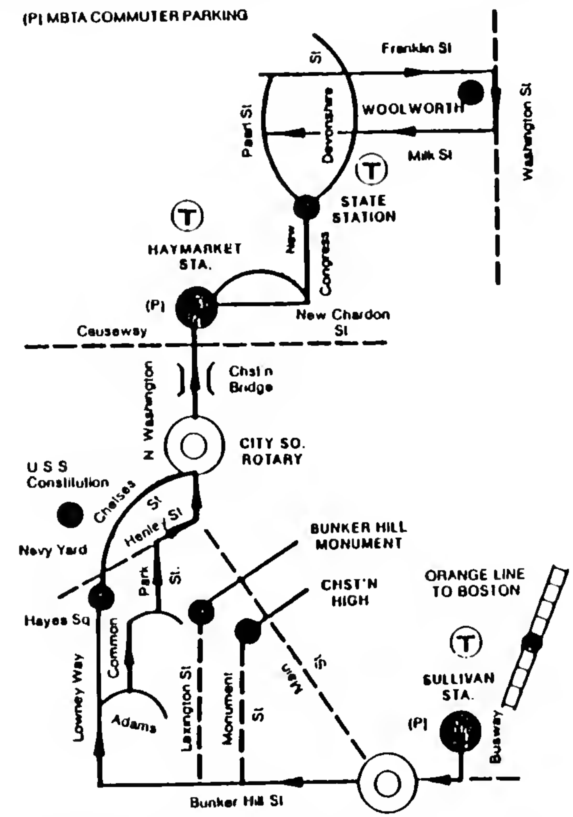


92 ASSEMBLY SQ. MALL — DOWNTOWN
VIA MAIN ST. & HAYMARKET

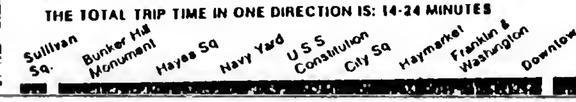


93 SULLIVAN — DOWNTOWN
VIA BUNKER HILL ST. & HAYMARKET

(P) MBTA COMMUTER PARKING



THIS DIAGRAM SHOWS THE APPROXIMATE TRAVEL TIME IN MINUTES BETWEEN STOPS, SUBJECT TO TRAFFIC CONDITIONS.
THE TOTAL TRIP TIME IN ONE DIRECTION IS: 14-24 MINUTES



NAVY YARD TRIP GENERATION - PROPOSED VS. CTPS

TOTAL =	PROPOSED (3/88)	CTPS (6/86)
OFFICE	2,054,000 s.f	2,232,000 s.f
APT/CONDO	1687 UNITS	1287 UNITS
ELDERLY HOUSING	145 UNITS	111 UNITS
RETAIL	200,000 s.f	317,000 s.f

The same trip generation assumptions were used to recalculate trips for revised development shown below:

Navy Yard Development	AM Peak Hour "ins" CTPS	AM Peak Hour "ins" PROPOSED	AM Peak Hour "outs" CTPS	AM Peak Hour "outs" PROPOSED	PM Peak Hour "ins" CTPS	PM Peak Hour "ins" PROPOSED	PM Peak Hour "outs" CTPS	PM Peak Hour "outs" PROPOSED
Apartments/Townhouses	84	111	338	442	338	442	169	221
Elderly Housing	4	5	15	19	15	19	7	10
Retail	27	17	12	8	327	206	309	195
Office	1,517	1396	286	263	220	202	1,110	1201
Marina	30		0		20		30	
Subtotal	1,662	1529	651	732	920	869	1,625	1627

TUDOR WHARF: PARKING DEMAND ACCUMULATION (with marina parcel)

Hour of Day	Office Weekday	Office Saturday	Commercial/Retail Weekday	Commercial/Retail Saturday	Restaurant Weekday	Restaurant Saturday	ACCUMULATION Weekday	ACCUMULATION Saturday
6:00 a.m.	7	0	0	0	0	0	7	0
7:00 a.m.	50	17	2	1	1	3	53	21
8:00 a.m.	157	50	4	5	3	4	164	59
9:00 a.m.	232	66	10	14	7	8	248	89
10:00 a.m.	249	66	15	22	13	11	278	99
11:00 a.m.	249	83	20	35	20	13	289	131
12:00 Noon	224	83	22	41	33	40	279	163
1:00 p.m.	224	66	23	46	46	60	293	172
2:00 p.m.	242	50	22	48	40	60	303	157
3:00 p.m.	232	33	22	48	40	60	293	141
4:00 p.m.	192	33	20	43	33	60	245	136
5:00 p.m.	117	17	18	36	46	79	181	132
6:00 p.m.	57	17	19	31	60	119	136	167
7:00 p.m.	17	17	20	29	66	126	104	171
8:00 p.m.	17	17	20	26	66	132	103	175
9:00 p.m.	7	0	14	19	66	132	88	152
10:00 p.m.	7	0	7	18	60	126	74	144
11:00 p.m.	0	0	3	6	46	113	49	119
12:00 Midnight	0	0	0	0	33	93	33	93
Peak Parking Ratio	3.00	0.50	3.80	4.00	20.00	20.00		
Percent Auto Usage	40%	80%	25%	50%	50%	100%		
Vehicle Occupancy	1.20	1.20	1.80	1.80	2.00	2.00		
Monthly Ratio	100%	100%	100%	100%	100%	100%		

TUDOR WHARF: PARKING DEMAND ACCUMULATION (without marina parcel)

	Office		Commercial/Retail		Restaurant		ACCUMULATION	
Hour of Day	Weekday	Saturday	Weekday	Saturday	Weekday	Saturday	Weekday	Saturday
6:00 a.m.	6	0	0	0	0	0	6	0
7:00 a.m.	37	12	1	1	1	3	40	16
8:00 a.m.	117	37	3	3	3	4	123	44
9:00 a.m.	173	50	7	10	7	8	186	67
10:00 a.m.	186	50	11	15	13	11	210	75
11:00 a.m.	186	62	14	24	20	13	219	99
12:00 Noon	167	62	15	28	33	40	215	129
1:00 p.m.	167	50	16	31	46	60	229	140
2:00 p.m.	180	37	15	33	40	60	235	129
3:00 p.m.	173	25	15	33	40	60	227	117
4:00 p.m.	143	25	14	29	33	60	190	114
5:00 p.m.	87	12	12	25	46	79	146	116
6:00 p.m.	43	12	13	21	60	119	115	153
7:00 p.m.	13	12	14	20	66	126	93	158
8:00 p.m.	13	12	14	18	66	132	93	163
9:00 p.m.	6	0	9	13	66	132	81	145
10:00 p.m.	6	0	5	12	60	126	70	138
11:00 p.m.	0	0	2	4	46	113	48	117
12:00 Midnight	0	0	0	0	33	93	33	93
Peak Parking Ratio	3.00	0.50	3.80	4.00	20.00	20.00		
Percent Auto Usage	40%	80%	25%	50%	50%	100%		
Vehicle Occupancy	1.20	1.20	1.80	1.80	2.00	2.00		
Monthly Ratio	100%	100%	100%	100%	100%	100%		

TUDOR WHARF: PERCENT PARKING DEMAND ACCUMULATION - DEFAULT VALUES

	Office		Commercial/Retail		Restaurant	
Hour of Day	Weekday	Saturday	Weekday	Saturday	Weekday	Saturday
6:00 a.m.	3%	0%	0%	0%	0%	0%
7:00 a.m.	20%	20%	8%	3%	2%	2%
8:00 a.m.	63%	60%	18%	10%	5%	3%
9:00 a.m.	93%	80%	42%	30%	10%	6%
10:00 a.m.	100%	80%	68%	45%	20%	8%
11:00 a.m.	100%	100%	87%	73%	30%	10%
12:00 Noon	90%	100%	97%	85%	50%	30%
1:00 p.m.	90%	80%	100%	95%	70%	45%
2:00 p.m.	97%	60%	97%	100%	60%	45%
3:00 p.m.	93%	40%	95%	100%	60%	45%
4:00 p.m.	77%	40%	87%	90%	50%	45%
5:00 p.m.	47%	20%	79%	75%	70%	60%
6:00 p.m.	23%	20%	82%	65%	90%	90%
7:00 p.m.	7%	20%	89%	60%	100%	95%
8:00 p.m.	7%	20%	87%	55%	100%	100%
9:00 p.m.	3%	0%	61%	40%	100%	100%
10:00 p.m.	3%	0%	32%	38%	90%	95%
11:00 p.m.	0%	0%	13%	13%	70%	85%
12:00 Midnight	0%	0%	0%	0%	50%	70%
DEFAULT VALUES:						
Peak Parking Ratio	3.00	0.50	3.80	4.00	20.00	20.00
Percent Auto Usage	100%	100%	100%	100%	100%	100%
Vehicle Occupancy	1.20	1.20	1.80	1.80	2.00	2.00
Monthly Ratio	100%	100%	100%	100%	100%	100%

TUDOR WHARF PARKING GENERATION

TUDOR WHARF: DEVELOPMENT COMPONENTS - GROSS LEASABLE AREA (s.f.)

	Office	Commercial/ Retail	Restaurant	
Pier Building	60,994	5,670	6,618	
Landside Building (w/o marina parcel)	93,869	10,666	0	
Landside Building (with marina parcel)	146,631	18,286	0	
TOTAL (w/o marina parcel)	154,863	16,336	6,618	177,817
TOTAL (with marina parcel)	207,625	23,956	6,618	238,199

TUDOR WHARF: TRIP GENERATION (w/o marina parcel)

	Office (1000 sf)	Commercial (1000 sf)	Restaurant (1000 sf)	Total
Average Daily				
enter	440	286	158	884
exit	440	286	158	884
total	879	572	316	1768
Morning Peak				
enter	120	10	3	133
exit	18	4	0	23
total	138	15	3	155
Evening Peak				
enter	21	30	17	68
exit	111	31	7	150
total	133	61	24	217

TUDOR WHARF: TRIP GENERATION (with marina parcel)

	Office (1000 sf)	Commercial (1000 sf)	Restaurant (1000 sf)	Total
Average Daily				
enter	545	367	158	1070
exit	545	367	158	1070
total	1089	734	316	2140
Morning Peak				
enter	153	13	3	169
exit	23	6	0	29
total	176	19	3	198
Evening Peak				
enter	27	36	17	80
exit	141	38	7	186
total	168	74	24	266

TUDOR WHARF: TRIP GENERATION RATE ASSUMPTIONS

	ITE			CHARLESTOWN NAVY YARD			
	Employment Density	Percent Auto Trips	Vehicle Occupancy	Employment Density	Percent Auto Trips	Vehicle Occupancy	ADJUSTMENT FACTOR
Office	4.40	100.00	1.20	4.40	40.00	1.20	0.40
Commercial	na	100.00	na	na	25.00	na	0.25
Restuarant	na	100.00	na	na	50.00	na	0.50

TUDOR WHARF: ADJUSTED TRIP GENERATION RATES (w/o marina parcel)

	Office (1000 sf)	Commercial (1000 sf)	Restaurant (1000 sf)
Average Daily			
enter	2.34	17.51	23.91
exit	2.34	17.51	23.91
total	4.69	35.02	47.81
Morning Peak			
enter	0.64	0.63	0.41
exit	0.10	0.27	0.05
total	0.73	0.90	0.45
Evening Peak			
enter	0.11	1.82	2.50
exit	0.59	1.90	1.12
total	0.71	3.72	3.63

TUDOR WHARF: ADJUSTED TRIP GENERATION RATES (with marina parcel)

	Office (1000 sf)	Commercial (1000 sf)	Restaurant (1000 sf)
Average Daily			
enter	2.18	15.32	23.91
exit	2.18	15.32	23.91
total	4.37	30.63	47.81
Morning Peak			
enter	0.61	0.54	0.41
exit	0.09	0.23	0.05
total	0.71	0.77	0.45
Evening Peak			
enter	0.11	1.52	2.50
exit	0.57	1.56	1.12
total	0.67	3.09	3.63

TUDOR WHARF: ITE STANDARD TRIP GENERATION RATES (w/o marina parcel)

	Office (1000 sf)	Commercial (1000 sf)	Restaurant (1000 sf)
Average Daily			
enter	5.86	70.05	47.81
exit	5.86	70.05	47.81
total	11.72	140.09	95.62
Morning Peak			
enter	1.60	2.52	0.82
exit	0.24	1.08	0.09
total	1.84	3.61	0.91
Evening Peak			
enter	0.28	7.29	5.00
exit	1.49	7.58	2.25
total	1.77	14.87	7.25

TUDOR WHARF: ITE STANDARD TRIP GENERATION RATES (with marina parcel)

	Office (1000 sf)	Commercial (1000 sf)	Restaurant (1000 sf)
Average Daily			
enter	5.46	61.26	47.81
exit	5.46	61.26	47.81
total	10.91	122.53	95.62
Morning Peak			
enter	1.53	2.17	0.82
exit	0.23	0.93	0.09
total	1.76	3.09	0.91
Evening Peak			
enter	0.27	6.06	5.00
exit	1.42	6.31	2.25
total	1.68	12.37	7.25

TUDOR WHARF TRIP GENERATION

TUDOR WHARF: DEVELOPMENT COMPONENTS

	Office	Commercial	Restaurant	Total
Pier Building	71,760	5,670	6,618	84,048
Landside Building (w/o marina parcel)	115,680	10,666	0	126,346
Landside Building (with marina parcel)	177,750	18,286	0	196,036
TOTAL (w/o marina parcel)	187,440	16,336	6,618	210,394
TOTAL (with marina parcel)	249,510	23,956	6,618	280,084

RUTHERFORD AVENUE AT ROUTE 1 RAMPS
1991 PM PEAK HOUR WITH TUDOR WHARF
date:05-25-1988 time:10:12:27

SATURATION FLOW ADJUSTMENT WORKSHEET

DIR	LN GROUP	IDEAL	N	Fwid	Fhv	Fgr	Fpark	Fbus	Farea	Frt	Flt	s
EB	TH	1800	3	1.000	0.976	1.010	1.000	1.000	0.900	1.000	1.000	4789
EB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394
WB	LT	1800	1	1.000	0.976	0.990	1.000	1.000	0.900	1.000	0.950	1486
WB	TH	1800	3	1.000	0.976	0.990	1.000	1.000	0.900	1.000	1.000	4694
NB	LT	1800	1	1.000	0.976	1.010	1.000	1.000	0.900	1.000	0.950	1516
NB	RT	1800	2	1.000	0.976	1.010	1.000	1.000	0.900	0.750	1.000	2394

CAPACITY ANALYSIS WORKSHEET

DIR	LN GROUP	v	s	v/s	g/C	c	v/c	CRITICAL
EB	TH	791	4789	0.17	0.14	697	1.15	
EB	RT	677	2394	0.28	0.32	756	0.89	*
WB	LT	706	1486	0.47	0.53	798	0.89	*
WB	TH	875	4694	0.19	0.75	3524	0.25	
NB	LT	167	1516	0.11	0.10	145	1.15	
NB	RT	944	2394	0.39	0.70	1663	0.56	

CYCLE= 65.0 LOST=10.0 SUM V/S CRIT= 0.76 TOTAL V/C= 0.89

LEVEL OF SERVICE WORKSHEET

DIR	LN GROUP	v/c	g/C	C	d1	c	d2	PF	Delay	LOS	Avg Q	95% Q
EB	TH	1.15	0.14	65.0	21.71	697	85.92	0.85	91.48	F	23.8	
EB	RT	0.89	0.32	65.0	16.12	756	9.43	0.85	21.72	C	8.0	
WB	LT	0.89	0.53	65.0	10.37	798	9.12	1.00	19.49	C	6.8	
WB	TH	0.25	0.75	65.0	1.89	3524	0.01	0.85	1.61	A	3.6	
NB	LT	1.15	0.10	65.0	22.71	145	123.65	1.00	146.36	F	8.1	
NB	RT	0.56	0.70	65.0	3.60	1683	0.33	0.85	3.34	A	4.8	

DIR	Delay	LOS
EB	59.31	E
WB	9.59	B
NB	24.81	C

INTERSECTION DELAY = 31.20 INTERSECTION LOS=D

THE CYCLE LENGTH WITHIN THE BOUNDS OF 0 TO 0 SECONDS
WHICH MINIMIZES CRITICAL MOVEMENT DELAY IS 65.0 SECONDS

FOR A V/C RATIO OF .95 THE CYCLE SHOULD BE 49.3 SECONDS
THE EXISTING TIMING IS OPTIMAL

INDEX

Tudor Wharf

Draft Project Impact Report

October 1989

Supplement

I. GENERAL INFORMATION

1. Application Information

A. Development Team

1. Names - see attachment

2. Addresses and telephone numbers - see attachment

3. Designated contacts - see attachment

4. The development team has no current or formerly-owned developments in Boston

B. Legal Information

1. There are no legal judgments or actions pending concerning the Proposed Project. However, there will be a challenge to MDPW's pro tanto award for their taking of approximately 1500 SF.

2. The development team owns no property in Boston.

3. Site Control

a. Rapids Realty Company warehouse parcel (approximately 58,389 SF of filled and unfilled private tidelands, L.C.C.#23347, together with license rights in about 28,786 SF of adjacent Commonwealth flowed tidelands) is under control by the development team by virtue of a purchase option.

b. Charles River Avenue, a public way (approximately 12,696 SF). The project proponents plan to file for a discontinuance of that public way, and acquire control through subsequent purchase.

c. A Massachusetts Port Authority ground lease parcel (approximately 29,800 SF) for which the proponents have responded with this proposed project to a development RFP by Massport. Massport review of the proposal is underway.

2. Financial Information - Submitted under separate cover to the BRA

A. Names and addresses of all financially involved participants and bank references

B. Development Pro Forma

C. Fifteen Year Operating Pro Forma

3. Project Area

A. Metes and Bounds - See survey plan, Exhibit 5, page 51

4. Public Benefits

A. Public benefits to be provided:

1. Public access - Over an acre of open space, including a plaza and Harborpark walkways, will be open to public use 24 hours/day. The ground floor uses in the buildings will be facilities that encourage public assess. At the intersection of the Freedom Trail, Harborpark, and the Charles River Basin, Tudor Wharf will rebuild the intersection of Boston's premier pedestrian walkways.

2. Pedestrian amenities - with few services available on Boston's pedestrian paths, and particularly few amenities from the downtown to the Navy Yard, Tudor Wharf can provide some basic needed services to visitors and residents:

   a. restroom facilities
   b. food and drink refreshment
   c. tourist orientation to Charlestown, waterfront, and Boston
   d. waterfront connection under Bridge to Paul Revere Landing Park
   e. pleasant route alternative to shorten exposure to Bridge traffic

3. Water Taxi dock - as part of the expanding Boston Harbor transportation system, Tudor Wharf can provide an additional water transit link for an on-call water taxi system.

4. Dinner/Excursion boat dock - The end of Tudor Wharf provides an ideal berth a large excursion vessel. Highly visible from both the roads and walkways, and only 1/3 of a mile from North Station, this site can function as a primary or layover dock.

5. Historic ship exhibit - designated for the water area between the Wharf and the North Washington Street Bridge, the proponents propose to provide a permanent berth and support space for a suitable historic vessel. Open to the public, such vessel can be a link to the vital history of Boston's port.

6. Public boat landing and Tall Ship wharfage - for temporary layover and special event berthing on the eastern side of the Wharf.

7. Housing and Jobs Linkage contributions - Housing Linkage community contributions will range from $618,000 to $989,000. Jobs Linkage community contributions will range from $123,000. to $198,000.

8. Additional property tax revenue - Current property tax revenue is about $25,000. Upon completion, Tudor Wharf can be expected to generate over $800,000.

9. Additional permanent and construction jobs - see below

10. Additional evening, weekend, and holiday parking for area residents, visitors, and boaters - With a large parking garage only fully utilized during the weekdays by the Tudor Wharf office tenants, the garage can significantly help in meeting an evening and weekend demand for parking by neighborhood residents, recreational boaters, and tourists.

5. Employment

A. Anticipated employment levels

1. Estimated construction jobs - 200

2. Estimated permanent jobs - 900

6. Regulatory Controls and Permits

A. Zoning

1. Existing zoning requirements - The site is within a W-2 zone and the Harborpark Interim Planning Overlay District, Subdistrict D. Comprehensive rezoning is underway and draft permanent zoning has been circulated for public review and comment on June 28, 1989.

2. Zoning computations:

	Alternative #1	Alternative #2
Land Area	84,563	112,609
Watersheet	15,960	15,960
Site area	100,523	128,569
Building SF		
Landside (74')	135,600	209,820
Pier(62')	88,060	88,060
Total Development	223,660	297,880
Floor Area Ratio(FAR)	2.6	2.6
Open Space	53%	48%
Ground Plane Public Access	94%	91%
Parking Spaces	252	303
Linkage Payments	$742,000	$1,187,300

3. Anticipated requests for zoning relief - Under existing zoning, proponent would require zoning relief for uses, FAR, parapet setback, and loading docks. Proponent anticipates being granted a PDA designation, for which zoning relief of the above items would be granted under Article 6A. Additionally, an IPOD permit would be required under Article 27C. It is not yet clear what relief, if any, would be required under new proposed zoning.

B. DEP Chapter 91 License - Please refer to Section 4.0, Tidelands Licensing, pg. 89

C. Other anticipated local, state, and federal permits required with a proposed application schedule - Please refer to Section 1.5, Permit Status List, page 21

7. Community Groups

A. Community groups, abutters, owners, and displacees which may be substantially interested in or affected by the Proposed Project:

1. Community Groups
   a. Charlestown Neighborhood Council
   b. Harborpark Commission
   c. Boston Harbor Associates
   d. North Area Task Force
   e. Charlestown Preservation Society
   f. Boston Harbor Transportation Task Force

2. Abutters and Owners
   a. Massachusetts Port Authority - owner/lessor of Hoosac Pier property
   b. Bosport Docking Co. - lessee/operator of Constitution Marina
   c. Constitution Plaza Associates - owner/manager of Constitution Plaza
   d. A&S Electric Display Co. - owner of Maxwell Box building
   e. Metropolitan District Commission - owner of Paul Revere Landing Park
   f. National Park Service - Charlestown Navy Yard National Historic Park
   g. Freedom Trail Commission - Freedom Trail
   h. United States Navy - U.S.S. Constitution
   i. Raytheon Historic Foundation - owner/operator of "Whites of their Eyes"
   j. Constitution Museum - museum in the National Park
   j. Massachusetts Department of Public Works - CANA administrator
   K. Perini/Kiewit/Atkinson - CANA contractor
3. Displacees - NONE

B. List of meetings proposed and held with interested parties including the Charlestown Neighborhood Council

1. Community Groups
   a. Charlestown Neighborhood Council
      1. Housing & Development Committee - 6/28/88, preview Massport RFP
      2. Housing & Development Committee - 8/23/88, review plans
      3. Housing & Development Committee - 12/29/88, review plans

   b. Harborpark Commission
      1. 10/14/87 - presented ENF plans
      2. 11/16/88 - presented DEIR plans

   c. Boston Harbor Associates
      1. 10/1/88 - presented plans during Harbor cruise reviewing development

   d. North Area Task Force
      1. 4/22/87 - preplanning review of City Square urban design parameters
      2. attendance at multiple meetings in 88/89 regarding proposed City Square park

   e. Charlestown Preservation Society
      1. 12/4/88 - presentation of TW DEIR plans
      2. 4/5/89 - Design review committee review of DEIR plans

   f. Boston Harbor Transportation Task Force
      1. 12/6/88 - presentation of TW plans

2. Abutters and Owners

a. Massachusetts Port Authority
   1. multiple meetings in 87/88 regarding TW plans and potential inclusion of MPA parcel into the development
   2. 2/24/89 - submission of proposal to MPA for inclusion of adjacent parking lot into the Tudor Wharf project

b. Bosport Docking Co.
   1. multiple meetings during 87/88/89 concerning TW plans, maximizing water activity at Tudor Wharf, coordinating TW development, mitigating impact on marina of TW development

c. Constitution Plaza Associates
   1. multiple meetings during 87/88/89 concerning development of the Massport-owned/CPA-leased overflow parking lot proposed by proponents for inclusion into TW site.

d. A&S Electric Display Co.
   1. multiple meetings in 1989 concerning blighting impact of Maxwell Box building on City Square environs.

e. Metropolitan District Commission
   1. 12/16/87 - presentation of TW ENF plans and discussion of issues concerning pedestrian circulation along that portion of the waterfront

f. National Park Service
   1. 11/14/88 - presentation of TW DEIR plans

g. Freedom Trail Commission
   1. 11/23/88 - presentation of TW DEIR plans

h. United States Navy
   1. 11/14/88 - presentation of TW DEIR plans

i. Raytheon Historic Foundation
   1. 9/15/87 - presentation of TW ENF plans

j. Constitution Museum
   1. 11/14/88 - presentation of TW DEIR plans

k. Massachusetts Department of Public Works
   1. multiple meetings during 86/87 concerning MDPW taking for CANA, impact of CANA proposed plans on development of Rapids Furniture Warehouse site

   2. 11/3/87 - meeting regarding proposed DPW routing of pedestrian traffic during CANA, future routing, and estimated CANA schedule

l. Perini/Kiewit/Atkinson
   1. multiple meetings regarding construction coordination and cooperation between P/K/A, as CANA contractor and TW proposed construction

II. TRANSPORTATION COMPONENT

1. Please refer to Section 8.0, Traffic, Section 9.0, Parking Impacts, and Section 11.0, Construction Impacts.

2. The scope for these sections was developed by MEPA in coordination with the Boston Transportation Department. The Plan utilizes the post-CANA roadway configurations

3. Under either Article 31 or the draft of proposed new zoning, a Transportation Access Plan is not required. However, in the spirit of cooperation, the proponent submits this Plan for review, and will work with the City, it's agencies, the State, and other developers to coordinate their transportation planning for the City Square section of Charlestown.

III. ENVIRONMENTAL PROTECTION COMPONENT

1. Shadow - Please refer to Section 5.3, pages 151-154

2. Daylight - Please refer to Section 5 (Visual Impacts), page 135

3. Air Quality - Please refer to Section 11.4, page 244

4. Solid and Hazardous Wastes -
   A. Please refer to Section 11.54, page 245 for discussion of solid wastes
   B. Please refer to attached 21E Site Investigation Report for discussion of hazardous material

5. Noise - Due to roadway proximity, ambient noise levels on the site will not be materially affected. Additional evaluation ongoing.

6. Geotechnical Impact - Please refer to attached "Preliminary Geotechnical Study", .dated 24 May 1988

7. Construction Impacts - Please refer to Section 11, beginning page 233, for a discussion of the construction impacts

IV. URBAN DESIGN COMPONENT

1. A written description of the program elements and space allocation for each element can be found in Sections 2.6 and 2.7, beginning on page 47.

2. Area plans and sections can be found throughout the report; see list of exhibits immediately following table of contents.

3. Photographs of the site and neighborhood may be found on pages 13, 39, 40, 52, & 53.

4. Perspective drawings may be found in Section 5, beginning on page 135.

5. Aerial views of the area may be found on pages 13, 39, & 40.

6. Site section may be found on page 69.

7. Site plans may be found on pages 56 & 58.

8. The proposed schedule for the development of the project may be found in Section 2.8, page 71, and in Section 11.2, beginning on page 234.

9. Massing and study models are underway and will be provided under separate cover.

V. HISTORIC RESOURCES COMPONENT

1. See Sections 2.1, 2.4, 3.5, 4.6.2, and 5 for discussion of impacts on historical resources.

2. The Boston city archaeologist has assessed the archaeological resources of the entire City Square area as part of the CANA project. His review of the Tudor Wharf site reinforced the fact that the site was alternately filled and reconstructed over the years, destroying (or rearranging) any time-layered resources that may have been available.

VI. INFRASTRUCTURE SYSTEMS COMPONENT

1. Please refer to Section 10, Infrastructure, beginning on page 223.

TUDOR WHARF DEVELOPMENT TEAM
44 Charles River Avenue Boston

Developer	**Myerson/Allen & Company** 306 Dartmouth Street Boston Ma 02116 (John Allen David Keller)	247-1400
Architect/ Urban Designer/ Planner	**Childs, Bertman, Tseckares & Casendino** 306 Dartmouth Street Boston Ma 02116 (Richard Bertman. Peter Smith)	262-4354
Environmental Planner	**Fort Point Associates** 300 Congress Street Boston. Ma 02210 (Jamie Fay, Thorn Mead)	357-7044
Attorney	**DiCara, Selig, Sawyer & Holt** Three Center Plaza Boston Ma 02108 (Lawrence S DiCara. Matthew Kiefer. Sam Mygatt)	523-1800
Geotechnical Engineers, Geologists and Hydrogeologists	**Haley & Aldrich** 238 Main Street Cambridge, Ma 02142 (David Thompson, Jim Wheeler)	494-1606
Structural Engineer	**Weidlinger Associates** 44 Brattle Street Cambridge, Ma 02138 (Steven Varga)	876-9666
Mechanical Engineer Electrical Engineer Civil Engineer	**Shooshanian Engineering Assoc., Inc.** 330 Congress St Boston, Ma 02210 (Hank Eggert)	426-0110
Surveyor	**Harry R. Feldman, Inc.** 112 Shawmut Avenue Boston, Ma 02118 (Joseph L Calabro Jeff Robbins)	357-9740
Construction Consultant	**Daniel O'Connell's Sons, Inc.** 179 South Street Boston Ma 02111 (Patrick D Kelleher)	423-9569
Transportation Engineer	**Bruce Campbell & Associates** 30 Chauncy Street, Suite 701 Boston, Ma . 02111 (Georgy Bezkorovainy)	542-1199

Haley & Aldrich, Inc.

Consulting
Geotechnical Engineers,
Geologists and
Hydrogeologists

58 Charles Street
Cambridge, MA 02141
617 494 1606

18 May 1988
File No. 06158-50

Myerson/Allen & Company
306 Dartmouth Street
Boston, Massachusetts 02116

Attention: Mr. John Allen

Subject: Oil and Hazardous Material Site Evaluation
Tudor Wharf
Charlestown, Massachusetts

Gentlemen:

We are pleased to submit herewith our report entitled "Report on Oil and Hazardous Material Site Evaluation, Tudor Wharf, Charlestown, Massachusetts," prepared in accordance with our proposal dated 1 March 1988.

This report presents the results of an investigation made to evaluate the possible presence and nature of oil and hazardous materials that may exist on or beneath the ground surface at the site. The report supplements the information available from previous studies and makes recommendations concerning remedial measures that may be required prior to the proposed development.

It has been a pleasure working with you during this phase of the project, and we look forward to our continued association with you on this project.

Sincerely yours,
HALEY & ALDRICH, INC.

Suzanne E. Robert
Staff Scientist

Deborah H. Gevalt
Vice President

SER:DHG:ddc/1693h

c: J. Wheeler
D. Thompson

Branch Offices
Glastonbury, Connecticut
Portland, Maine
Bedford, New Hampshire

Affiliate
H&A of New York
Rochester, New York

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I. INTRODUCTION

1-01. GENERAL

This report presents the results of an oil and hazardous material site evaluation of the Tudor Wharf site located in Charlestown, Massachusetts. Since current plans for the proposed development include a three to four level below-grade parking garage and construction of a five-story pile supported building over the open water of Boston Harbor, the focus of this study was an evaluation of the fill and groundwater quality within the filled land portion. The portion of the Tudor Wharf development parcel outside the Tudor Wharf site limits was not included in this evaluation. The limits of the property included in this study are indicated in Figure 2.

The study summarized herein was completed concurrently with a preliminary geotechnical evaluation of the site which is summarized in our "Report on Preliminary Geotechnical Evaluation, Tudor Wharf, Charlestown, Massachusetts", dated 18 May 1988. Refer to this report for further information.

1-02. PURPOSE AND SCOPE

The purpose of this study has been to make an initial evaluation of the possible presence and nature of oil and hazardous materials which may be present on or beneath the ground surface at the site. The report supplements the information available from previous studies, and makes recommendations as to the type of remedial action that may be required for future site development. Earth excavation and dewatering will be required for below-grade construction, therefore, information on soil and groundwater quality was an important aspect of the site evaluation.

This evaluation is based upon the review of: (1) readily-available information on historical site usage and development; (2) a review of Massachusetts Department of Environmental Quality Engineering (DEQE) files for Charlestown, Massachusetts; (3) visual observations of existing site conditions; and (4) information from subsurface explorations and chemical testing designed to obtain data on soil and groundwater quality. This work was undertaken in accordance with the scope of work outlined in our proposal dated 1 March 1988.

II. BACKGROUND INFORMATION

2-01. SITE LOCATION

The site is located at 44 Charles River Avenue, south of the now discontinued Waldo Street and immediately east of the Charlestown Bridge, as shown on Figures 1 and 2 (1).* The project area is currently occupied by the Rapids Furniture warehouse and adjacent parking areas. The site is located at 44 Charles River Avenue along the east side of a cul-de-sac known as Charles River Avenue. Historically, the addresses associated with the site property have also included 36-44 Charles River Avenue (2). The limits of the property considered for this study are outlined on Figure 2 by a wide boundary line which is labeled "property line". This report does not address that portion of the proposed development parcel that lies outside the property limits.

The property is currently zoned W-2 for waterfront industries (3). Surrounding land use includes the Fulton Box Company, a box and pallet company located under the Charlestown Bridge. The Constitution Marina has been constructed to the east, along the Charles River. A paved parking lot, owned by the Commonwealth of Massachusetts Department of Public Works, is located at the intersection of Charles River Avenue and Water Street (4). A three-story brick building, used by the Boston and Maine Railroad for storage, occupies the lot east of the DPW yard (2).

2-02. SITE HISTORY AND USAGE

Information on previous site usage and historical development was obtained from a previous Haley & Aldrich, Inc. study entitled "Report on Site Conditions and History, Tudor Wharf, Charlestown, Massachusetts," dated 10 April 1987.

Site History

The village of Charlestown, known to the Native Indians as Mishawum, was officially founded in 1629 by the Spraque

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* Refer to listing of Sources of Information attached to this letter.

Brothers (5). In 1631, the Charles River was first breached between Boston and Charlestown by a bridge extending out of a small peninsula on the Charlestown side (5). By 1786, a bridge had been constructed at the present location of Charles River Avenue. By 1795, a wharf, then owned by the Austin family of Charlestown, had been built along the east side of the Charles River Bridge, on the Charlestown side (6,7).

By 1802, the Navy Yard had been established east of the site (5). By 1806, Frederic Tudor had established his natural ice business in the wharves adjacent to the Charles River Bridge in Charlestown (6). Between 1836 and 1850, the Boston ice trade was active in every large port in South America and the Far East (8). The Fitchburg Railroad had established a track to the Naval Shipyard along Water Street, providing rail access to the neighboring wharves by 1855 (9).

In 1874, Charlestown was annexed by the City of Boston (5). By this time, Frederic Tudor had purchased the present site property and the abutting wharf and located his office there. A railroad spur had been constructed on-site along the east dock of the warehouse (10,11). At this time, the structures on-site consisted of two buildings: a 5-story brick grist mill addressed 38 Charles River Avenue was located on the north end of the site, and a two-story brick warehouse extending over the Charles River addressed 44 Charles River Avenue (11). In 1874 Frederic Tudor operated a linseed oil mill at 22 Charles River Avenue. Ships returning from ice deliveries brought cargoes of hides, jute, dyestuffs linseed and shellac to Charlestown (12).

The 1880's saw the decline of the natural ice industry and this section of the Charlestown waterfront turned to the export of grains and provisions to the West. This conversion was concurrent with the consolidation of the adjacent wharves and the construction of the Hoosac Tunnel Docks and Elevator Co. (13).

By 1892, City drinking water had been provided to the site (14). At this time, the New England Preserving Company, part of the Tudor Company, had located at 22 Charles River Avenue in the brick building at the corner of the Water Street (14). In 1897, Frederic Tudor sold the company to Addison, Gage & Co., an ice industry rival (6,10).

In 1901, the Tudor Wharf Company (so called after the wharf, not the former owner) purchased the site for general mercantile storage (6). In 1902, the Potter-Wrightington, Inc. cereal

department and offices had located in the former grist mill located on-site at 38 Charles River Avenue (6,15). By 1912, the Charlestown Bridge was relocated to its present location. Charles River Avenue was terminated at the River's edge. By this time, sanitary sewer connections had been provided to the structures (15). By 1915, the Boston and Maine Railroad had assumed possession of the track along Water Street (16).

Potter-Wrightington remained in business at 38 Charles River Avenue until 1937. The Boston Globe leased warehouse space from them for paper storage between 1930 and 1937 (6). In 1937, the two brick structures on-site were demolished and a wood-frame warehouse structure was constructed over the existing piles in the Charles River (6,17).

Between 1932 and 1941, Jason O'Connor operated a livery boat out of the east dock side of the wharf (6). In 1944, repairs were made to the warehouse, including the addition of new piles (2,18). In 1947, the Boston Globe resumed leasing space for paper storage until 1962 (6,20).

In 1952, a one-story concrete block structure was built north of the wood-frame warehouse (19). In 1962, the wood-frame warehouse was re-sided with asbestos clad shingles and a shed was attached to the west side of the building over the River along Charles River Avenue (21). Also at this time, an oil burning furnace was installed in the concrete block building with an above ground 5,000 gallon capacity No. 2 fuel oil storage tank located between the two structures on the edge of the sea wall (22).

In 1962, the property was purchased from the Tudor Wharf Company by the Rapid Furniture Co. (6,21). At this time the Boston Globe had vacated the warehouse and the Usen Canning Warehouse leased part of the premises from the Tudor Wharf Company until 1976 (6). The I.R.S. rented the warehouse in 1979 for the storage of tax forms (23). In 1986, six natural gas-fired hot air blowers were installed in the wood-frame building (2,24).

The Rapid Furniture Company retains ownership of the property at present. During its ownership, in addition to leasing of warehouse space to other companies, the furniture company has used part of the frame structure for offices, furniture storage and retail preparation (6,24).

Local inquiries indicate no records exist of underground storage tanks in the site vicinity (2,22). Only minor petroleum releases have been reported in the site vicinity, caused by vehicle related accidents, usually resulting in a direct discharge into the Charles River or Harbor waters (25,26). The Massachusetts Department of Environmental Engineering records indicate that no confirmed sites or sites to be investigated for releases of oil and hazardous materials exist in the site vicinity (27).

III. SITE AND SUBSURFACE CONDITIONS

3-01. SITE CONDITIONS

The site was revisited on 5 May 1988 by a Haley & Aldrich, Inc. Staff Scientist, who observed the current site conditions. The site has undergone virtually no changes since the previous site visit on 19 March 1987. Two buildings are present on-site.

The older of the two buildings, a wooden frame warehouse, occupies the wharf area which extends out over the Charles River. Although the furniture warehouse is not currently in operation, small offices still exist inside the building. Heat is provided to the building by electric space heaters and six natural gas-fired hot air blowers.

Along the east dock side of this building, an abandoned railroad spur enters the building and terminates at a truck bay. The surface under the tracks within the building is constructed of an asphalt material. The floor of the truck bay is badly stained, presumably as a result of leakage from a hydraulic dumpster previously located there (28). Staining was also observed, on both occasions, along the length of the railroad spur within the building. Four paint cabinets, which were observed during our previous site visit, have been emptied of paint materials. No other evidence of spillage or storage of oil or hazardous materials was noted within this building at this time.

The second structure consists of a one-story concrete block structure. This structure was not accessible at the time of the most recent site visit. An addendum to this letter will be issued concerning the observed contents of this structure, subsequent to gaining access at a later date. Reportedly, the warehouse is being used by Warner Brothers for storage of props for a television program, and contains no oil or hazardous materials (28).

An oil burning furnace is located along the south wall of the concrete block building. An above ground fuel oil storage tank exists between the two structures on the edge of the sea wall, enclosed by concrete block walls and underlain by soil. Since the site visit of 19 March 1987, the top of the tank has been covered by corrugated metal sheets. No odors or staining were observed associated with the soil visible underneath the tank. A drainage trough exists at the base of the concrete block

enclosure along the sea wall. No oil residue was observed in this trough. The filler pipe associated with this tank is located along Charles River Avenue. No evidence of a recent release of fuel oil on the materials in the vicinity of the filler pipe was noted at the time of this site visit.

The remaining filled portions of the site are covered with asphalt material. Two storm sewer catch basins exist within the property line along the west side of the concrete block building. At the time of the site visit on 5 May 1988, both catch basins were observed as being coated by motor oil residue. Additional evidence of disposal of spent motor oil was noted by an obvious oil odor emanating from both catch basins, and discarded oil filters and one quart motor oil containers located nearby. On 5 May 1988, two Fulton Box Company trucks were observed parked in close proximity to these catch basins.

At the end of Charles River Avenue along the seawall, construction debris has been discarded, along with additional one quart motor oil containers, and auto parts. A large pile of road salt has been piled on the site at the end of Charles River Avenue. Under the wharf, scrap wood and bricks were noted, presumably remnants of demolished structures.

The Fulton Box Company remains in operation adjacent to the site under the Charlestown Bridge. At the time of the site visit, the off-site area adjacent to the Charlestown Bridge was strewn with construction and demolition debris consisting of PVC pipe, railroad ties, metal rails, scrap metal and wood. Four 55-gallon drums were being used for refuse disposal, one of which was identified as previously containing Concord grape concentrate.

A brick wall defines the eastern site boundary. An auto gas tank has been discarded against this wall. At the southeast corner of the property, twenty-three empty 55-gallon drums are being stored. These drums are reportedly props for a television program (28). Wooden debris consisting of railroad ties and pallets have also been discarded in this area of the site. A large oil stain, emanating a strong waste motor oil smell, was observed adjacent to the drums. Discarded motor oil containers were also noted in the area. The oil has been largely absorbed by sediment overlying the asphalt paved surface.

3-02. SUBSURFACE EXPLORATIONS

A preliminary subsurface exploration program was recently completed at the site during the period 28 to 31 March 1988 to obtain subsurface information for geotechnical design purposes, and to provide information on soil and groundwater quality. The program consisted of three test borings drilled from land using a truck-mounted rotary drill rig. A fourth boring was made from within the wooden frame warehouse pier structure with a portable skid rig over the Charles River. The borings were monitored in the field by H&A personnel. As-drilled locations of the borings were determined by H&A by measuring from existing site features shown on Figure 2. Ground surface elevations were determined by H&A using optical survey methods.

All four borings were advanced using 3-in. diameter casing to the specified depths. Potable water was introduced into the boring to facilitate drilling. Split-spoon samples were taken from all borings at depth intervals, typically not exceeding five feet, and at changes in soil type. For the purpose of this report, continuous samples were generally taken at two foot intervals through the surficial fill deposits. All borings were terminated in the glacial till stratum. Boring logs prepared by the boring contractor are included in Appendix A.

3-03. GROUNDWATER OBSERVATION WELLS

Groundwater observation wells were installed in completed boreholes B102, B103, and B104. The well tips were installed at depths of approximately 15 ft to 20 ft. below ground surface. The observation wells consist of 2.0 in. I.D. machine slotted PVC well screen, installed from the well point to the ground surface, to allow the observation of tidal influences on the site. The top of each observation well was sealed with cement and bentonite, and encased in a protective roadway box. Groundwater Observation Well Reports are included in Appendix B of this report. Groundwater levels measured during periodic monitoring of the observation wells for the period 29 March to 5 May 1988 are also included in Appendix B. The corresponding tide level recorded at the time of the groundwater measurements is also noted on the monitoring reports. From the groundwater data obtained at the site, it is noted that groundwater levels observed at observation wells B102(OW) and B103(OW) vary appreciably with tidal fluctuations, while the water levels observed at B104(OW) do not.

3-04. SUBSURFACE SOIL AND ROCK CONDITIONS

The subsurface explorations indicate the following general soil and rock sequence in order of increasing depth from ground surface:

- Miscellaneous Fill
- Organic Silt and Peat
- Marine Sands
- Glacial Till
- Bedrock (assumed)

Due to the complex environments responsible for the creation of these deposits, all strata may not be present at specific site locations. These strata are discussed below in order of deposition.

Bedrock

Bedrock was not encountered in any of the test borings. However, available geologic maps indicate the site is underlain by Cambridge Argillite (29).

Glacial Till

During the Pleistocene glacial period, a very dense non-stratified, unsorted material known as glacial till was deposited over the bedrock surface in the project area. The glacial till encountered at the site is typically a very dense, silty fine SAND to sandy SILT, with trace to some gravel, containing occasional cobbles and boulders. Glacial till soils were encountered at depths of 15 to 30 ft. below ground surface. Thickness of this strata was not determined since none of the test borings penetrated this layer completely.

Marine Sand

As a result of the fluctuating harbor levels, a layer of silty medium to fine SAND was found to overlie the glacial till deposits. Where encountered, this stratum ranged in thickness to up to 9.0 ft.

Organic Soils

A stratum of organic soils consisting primarily of sandy organic SILT and PEAT was found to overlie the glacial till and marine sands. The organic sandy silt generally contains shells. The salt marsh peat encountered on-site accumulated along the shore line during a slowly rising sea level. The organic silt and peat typically ranged up to 15 ft. in thickness, where encountered.

Miscellaneous Fill

The man-made layer of fill placed across the site to the present grade primarily consists of an unsorted mixture of coarse to fine sand, silt, clay, and fine gravel with varying amounts of wood, cinders, brick, slag and concrete. The thickness of this stratum varied from 5.0 to 15.0 ft., based on the most recent subsurface explorations.

Evidence of petroleum contamination was noted in the first two samples obtained from B101, which was drilled over water. The materials encountered in this boring are indicative of typical harbor bottom sediments and are not believed to be representative of the overall quality of on-site fill material.

Refer to our "Report on Preliminary Geotechnical Evaluation, Tudor Wharf, Charlestown, Massachusetts" for a more detailed description of subsurface conditions including subsurface profiles drawn in both North/South and East/West orientations across the site.

IV. CHEMICAL TESTING

4-01. LABORATORY SCREENING

In the Haley & Aldrich, Inc. laboratory, fill and soil samples were screened for the presence of detectable volatile organic compounds. This screening consisted of using an HNU Systems, Inc. PI101 photoionization analyzer to determine the presence of detectable volatile organic compounds in the headspace of the sample jars.

Using ultraviolet light, the instrument ionizes trace gases such that the positive ions created are attracted to an electrode having an applied negative potential. The current measured at this electrode is proportional to the trace gas concentration. The instrument readout provides a general indication of the presence of detectable volatile organic and inorganic compounds in parts per million (ppm). The results of these screening tests are provided in Table I of this report.

The majority of the soil samples screened did not exhibit elevated HNU readings. However, samples taken from the first 5 feet of fill from B102 (S1, S2, S3) exhibited elevated readings of 8.2, 6.4 and 18.4 parts per million (ppm) above the laboratory background level. One fill sample from B103(S5) exhibited an elevated reading of 7.5 ppm above background.

4-02. GROUNDWATER SAMPLING

A groundwater sampling program was undertaken on-site to evaluate the quality of the groundwater for environmental purposes. Samples were obtained on 13 April 1988 from each of the three monitoring wells shown on Figure 2 (B102-OW, B103-OW and B104-OW).

Before obtaining the samples from the wells, approximately ten well volumes of standing water were removed from B102-OW. Due to poor recharge rates, B103-OW and B104-OW were bailed dry five times before groundwater samples were obtained. After removal of standing water with a stainless steel bailer, a sample was obtained from the well with the bailer and immediately poured into laboratory prepared containers. Prior to bailing each well, the bailer was washed with mild detergent, then rinsed successively with tap water, distilled water, methanol and distilled water. The samples obtained were

stored in an insulated container packed with ice or in a refrigerator until delivery to the analytical laboratory. The groundwater sample submitted for priority pollutant metals analysis was filtered in the field after collection.

4-03. CHEMICAL ANALYSIS

Groundwater and selected soil samples were submitted to Alpha Analytical Laboratories for chemical analysis. The chemical analyses data and chain-of-custody records are included in Appendix C.

A. Groundwater Analyses

Groundwater samples from all three monitoring wells were submitted for testing for volatile organic compounds and total petroleum hydrocarbons by the IR method. Groundwater samples taken from B102-OW and B103-OW were also submitted for analysis for pesticides, PCBs and a petroleum scan. Additionally, groundwater samples from B103-OW were tested for acid/base neutral extractable compounds and dissolved priority pollutant metals, to obtain information on baseline groundwater quality at the site.

In general, the chemical analyses performed on the groundwater samples indicated the following:

- No volatile organic compounds were detected above the method detection limits in the groundwater samples taken on-site.

- No pesticides or PCBs were detected above the method detection limits in the groundwater samples obtained from B102-OW and B103-OW.

- A total hydrocarbon concentration of 1.3 mg/l (parts per million [ppm]) was detected in the groundwater sample taken from B104-OW. Concentrations above the method detection limit were not detected in the groundwater samples taken from B102-OW and B103-OW. No groundwater standard currently exists for total petroleum hydrocarbons, however, the current Massachusetts guidelines for oil and grease in surface waters is 15 mg/l.

- No acid/base or neutral extractable compounds were detected above the method detection limits in the groundwater sample taken from B103-OW.

- Four of the thirteen dissolved priority pollutants were detected in the groundwater sample taken from B103-OW at the following concentrations:

Copper	0.02 mg/l (parts per million [ppm])
Lead	0.07
Selenium	0.024
Zinc	0.06

U.S. EPA Drinking Water Standards and Massachusetts Class I and II Groundwater Standards for copper (1.0 ppm) and zinc (5.0 ppm) were not exceeded by the sample from B103-OW. However, the U.S. EPA Drinking Water Standards and Massachusetts Class I and Class II Groundwater Standards for selenium (0.01 ppm) and lead (0.05 ppm) were not met by the sample from B103-OW.

B. Soil Sample Analyses

Twelve soil samples obtained during the test boring program were submitted for chemical analysis to assess the quality of the fill and soil materials which underlie the site. Details pertaining to the analysis of these fill and soil samples follow.

Two substrata have been tentatively identified within the fill materials. Soils which are believed to be the most recent fill material is generally described as loose, brown to black coarse to fine sand, with cinders, brick and fine gravel, and was encountered at depths ranging from one to six feet below the ground surface at all three land borings. Underlying this top fill layer, a second fill deposit was encountered. This material is generally described as medium dense, brown medium to fine sand with silt, brick, cinders and fine gravel, and was found to range in thickness from approximately four to eight feet.

Six soil samples were selected from the top most layer of fill for chemical analysis. Sample B102(S1), which had

exhibited an elevated HNU reading of 9.8 ppm was submitted for testing for volatile organic compounds. Due to insufficient sample recovery amounts, samples S2 and S3, from B102, which also exhibited elevated HNU readings, were composited and submitted for PCB, total petroleum hydrocarbons and petroleum scan analyses. The sample taken from ground surface at B103(S1) was submitted for PCB analysis. Sample B103(S2) was submitted for acid/base neutral extractable compounds analysis. Sample B103(S3) was submitted for priority pollutant metals analysis.

Another six soil samples were selected from the lower fill material for chemical analyses. Samples S4 and S5 from B102, were composited due to insufficient sample quantity and submitted for priority pollutant metals and acid/base neutral extractable compound analyses. Sample S5 from B103 was selected based on elevated HNU reading of 7.5 ppm above the background laboratory level. Due to insufficient sample quantity, sample S5 was composited with sample S4 from B103, and submitted for volatile organic compound, total petroleum hydrocarbon and petroleum scan analyses. Soil samples S2 and S3 from B104 were observed as being darkly stained, and were selected on this basis for chemical analysis. B104(S2) was submitted for total petroleum hydrocarbon analysis. B104(S3) was submitted for volatile organic compound analysis.

Sample B103(S6A) taken from the underlying natural soil was submitted for volatile organic compound analysis. Two samples B103(S8) and B102(S11) taken from the underlying natural soil were submitted for total chloride analysis.

In general the chemical analyses of the soil samples indicated the following:

- o Volatile organic compounds were not detected at concentrations above the method detection limits in any of the soil samples submitted for this test.

- o Neither pesticides or PCBs were detected above the laboratory method detection limits in the soil samples submitted for these analyses.

- o Total petroleum hydrocarbons were detected in the soil samples at the following concentrations:

  B102(S2 & S3) 530 mg/kg (parts per million or ppm)

B103(S4 & S5)	60 mg/kg
B104(S2)	56 mg/kg

The Massachusetts Department of Environmental Engineering has established an interim policy which allows on-site disposal of soils with total petroleum hydrocarbon concentrations of up to 300 ppm. This policy applies to soils which have been affected by spills of virgin petroleum products. This interim policy may not be strictly applicable to the fill materials which will be excavated during proposed construction activities. However, the observed petroleum hydrocarbon concentrations are low relative to the current 300 ppm DEQE guideline for on-site soil disposal.

- The petroleum scan performed on B102(S2 & S3) identified No. 6 Fuel Oil as the type petroleum product present at a concentration of 2,716 mg/kg (ppm). The petroleum scan performed on B103(S4 & S5) did not identify a specific petroleum constituent.

- All thirteen of the priority pollutant metals were detected at various concentrations in the soil samples taken on-site, at the following concentrations:

	B102 (S2 & S3)	B102 (S4 & S5)	B103 (S3)
Antimony (mg/kg or ppm)	11.0	17.2	11.4
Arsenic	4.8	11.9	9.4
Beryllium	0.4	0.4	0.4
Cadmium	0.9	0.9	1.0
Chromium	10.5	13.7	7.5
Copper	28.4	13.7	45.3
Lead	88.7	31.8	150
Mercury	ND	0.19	0.29
Nickel	8.7	9.2	9.2
Selenium	ND	ND	0.3
Silver	0.06	0.11	0.6
Thallium	ND	11.2	ND
Zinc	140	49.7	59.1

The concentrations of the majority of these metals do not exceed the common range of trace chemical elements in natural soils. However, the detected concentrations of antimony and cadmium do exceed the common range for these metals (30). The common range of these elements in natural soils are as follows:

Antimony	2 - 10 ppm
Cadmium	0.01 - 0.7 ppm

No on-site disposal guidelines have been developed for these detected metals. It is anticipated that mixed fill materials such as those encountered in the borings would contain metals at or above the indicated concentrations.

- o Base/neutral extractable compounds were not detected in B102 (S4 & S5) above the method detection limits. Thirteen base/neutral extractable compounds were detected at various concentrations above the laboratory detection limits in the soil sample taken from B103. The combined total concentration of these compounds is 182,300 ppb or 182.3 ppm. These concentrations of base/neutral compounds are indicative of a incomplete combustion process, which is also suggested by the presence of cinders in the fill material (31). According to 310 CMR 19, cinders and ash are considered solid waste at this time, and may be disposed of in a licensed sanitary landfill along with construction rubble and other solid waste.

- o Two soil samples [B102(S11) and B103(S8)] were submitted for total chloride analysis. The detected concentrations for chloride were 784 mg/kg (or ppm) and 3,859 mg/kg, respectively. DEQE policy requires that soils with total chloride concentrations in excess of 250 mg/kg be disposed of at areas which drain directly into a marine environment.

V. CONCLUSIONS AND RECOMMENDATIONS

5-01. CONCLUSIONS

An oil and hazardous material site evaluation has been performed for the Tudor Wharf site in Charlestown, Massachusetts. The study included a limited number of borings, sample screening and chemical testing of soil and groundwater samples. The test borings were completed primarily for preliminary geotechnical design purposes, but were also utilized for the evaluation for the possible presence of oil and hazardous materials beneath the site. Information regarding the site conditions on 19 March 1987 was supplemented by the observations made during a 5 May 1988 site visit, a recent DEQE file review, and conduct of recent test borings and chemical testing. The scope of the recent exploration program was limited to three borings in an area of filled land totalling approximately 28,800 square feet.

A review of site history indicates the wharf was utilized for ice storage until 1897. Between 1901 and 1962, the site buildings were used for general warehousing. In 1962, the Rapid Furniture Company purchased the site and utilized part of the existing wooden frame structure for furniture preparation until 1987. The remaining warehouse space has been leased to other companies for storage, and is currently leased to Warner Brothers for prop storage. Once entry to this building is permitted, a supplementary letter concerning present site conditions will be provided.

The site is serviced by water, natural gas and municipal sewers. An above ground No. 2 fuel oil storage tank is located on-site and provides fuel to an oil burning furnace. Evidence of illegal disposal of waste motor oil was observed in two storm sewer catch basins located inside the property boundaries along Charles River Avenue. Oil staining was also observed in the eastern parking area, where an auto gas tank has also been abandoned, as well as inside the wood framed warehouse.

The fill quality on-site was observed during the conduct of the test boring program and has also been evaluated through chemical analysis. Volatile organic compounds, PCBs and pesticides were not detected in the soil samples submitted for testing. Total petroleum hydrocarbons were detected in the fill materials from all three land borings, with the highest concentration of 530 ppm detected in B102. No. 6 fuel oil was

identified as being present in this sample. The location of this boring was in the vicinity of the abandoned railroad spur. Low concentrations of the thirteen priority pollutant metals and base/neutral extractable compounds were also detected in the fill materials. In general, both the visual and chemical characteristics of the fill materials are believed to be indicative of urban land fill. The presence of low petroleum hydrocarbon concentrations, a variety of metals and certain base/neutral compounds is not unusual for this type of fill material. However, as outlined below, disposal options for excavated fill material may be limited.

No volatile organic compounds, pesticides, PCBs or acid/base neutral extractable compounds were detected in the groundwater samples taken from the site. A low concentration of total petroleum hydrocarbons was detected in the groundwater sample taken from B104(OW), below the 15 ppm oil and grease standard for surface waters in Massachusetts. Two of the thirteen priority pollutant metals were detected in the groundwater sample taken from B103(OW), in excess of the Massachusetts Class I and Class II groundwater standards for selenium and lead.

In general, the groundwater data is not indicative of a significant groundwater contamination problem. The heterogenous nature of the fill material makes an overall assessment of the fill quality difficult. However, based on the available data, it appears that localized areas of the fill are contaminated by petroleum products, and contain elevated concentrations of some metals, as would be anticipated in this type of fill material.

5-02. RECOMMENDATIONS

The oil and hazardous material evaluation conducted for the Tudor Wharf site is preliminary in nature and did not include the entire development parcel. Conclusions concerning the fill and groundwater quality have been based on testing of a limited number of samples from a few test borings. It is recommended that observations of the fill and soil characteristics be carried out during the final design studies for the development including studies for the remaining portion of the development parcel. Additional testing of both soil and groundwater would be appropriate to expand the presently available database. If dredging of the harbor bottom sediments is required,

characterization of the dredged spoil material will also be necessary.

Based on the observations made during the recent site visit, it is our opinion that the storm drains along Charles River Avenue should be cleaned out and examined for possible leakage of oil into the surrounding soils through cracks. Visual evidence of the oil stained soils at ground surface and the detected concentrations of fuel oil in some samples are indicative of localized areas of surface spillage and/or oil contamination in the fill materials. During initial phases of site development and particularly during site excavation, segregation of oil stained material and contaminated fill would be advisable.

During demolition of the on-site buildings, it will be necessary to dismantle the above ground fuel oil storage tank. It will be necessary to dispose of the empty storage tank at a state approved storage tank disposal facility. Any oil contaminated soils that may be uncovered during the tank removal will also need to be segregated for disposal. Disposal options for oily soils and excavated fill materials will vary depending on DEQE policy at the time the material is excavated. At present, we believe the fill material which contains minor amounts of cinders, ash, wood, etc. and which is not overtly contaminated by oil to be urban fill. Material which exhibits overt evidence of the oil contamination would require special handling and disposal at a landfill which will accept such materials. Zones in the fill which contain construction debris, large quantities of wood, cinders, ash, etc. would likely be classified as solid waste, and would require disposal in a DEQE approved sanitary landfill.

Due to the chloride concentrations detected in the natural soil, the excavated natural soils will need to be disposed of at a DEQE approved coastal disposal site. The chloride content of the saturated fill material may be similar to the natural soil and also require disposal at a coastal disposal site.

Because dewatering is anticipated during site excavation and foundation installation, chemical testing of groundwater was conducted to evaluate baseline groundwater quality. It is anticipated that a National Pollution Discharge Elimination System (NPDES) permit will be required for discharge of

groundwater into Boston Harbor during dewatering activities. The EPA permit application process typically requires a minimum of six months time.

5-03. LIMITATIONS

This letter has been prepared for the exclusive use of Myerson/Allen & Company, in connection with the proposed development of Tudor Wharf.

The conclusions provided by Haley & Aldrich, Inc. are based solely on the scope of work conducted and the sources and information referenced in this report. Any additional information that becomes available concerning this site should be provided to Haley & Aldrich, Inc. so that our conclusions may be reviewed and modified if necessary.

The work performed by Haley & Aldrich, Inc. is subject to the terms and conditions stated in our proposal dated 1 March 1988. This work was undertaken in accordance with generally accepted consulting engineering practices. No other warranty, express or implied, is made. The contents of this report may not be copied, provided, or otherwise communicated to any party not involved in the design, construction or financing of the subject property, in whole or in part, without the prior written consent of Haley & Aldrich, Inc.

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Haley & Aldrich, Inc.

Consulting
Geotechnical Engineers,
Geologists and
Hydrogeologists

58 Charles Street
Cambridge, MA 02141
617-494-1606

24 May 1988
File No. 06158-10

Myerson/Allen & Company
306 Dartmouth Street
Boston, Massachusetts 02116

Attention: Mr. John Allen

Subject: Preliminary Geotechnical Study
Tudor Wharf, Charlestown, MA

Gentlemen:

We are pleased to submit herewith six copies of our report entitled "Preliminary Geotechnical Evaluations, Tudor Wharf, Charlestown, Massachusetts".

This report was prepared in accordance with our proposal dated 2 March 1988, and your subsequent authorization. The scope of this study has been limited to a preliminary geotechnical evaluation of the site and construction as proposed by Childs, Bertman Tseckares & Casendino on drawings provided to us in March. Additional field explorations and engineering studies are required for design of foundations, site development and shoreline reconstruction. Please refer to Section VI for a summary of our preliminary conclusions.

It should be noted that the scope of work undertaken for <u>this report</u> does not include a site assessment for the presence of hazardous materials or oil as defined by the Massachusetts Oil and Hazardous Materials Release Prevention and Response Act (Chapter 21E). However, a Chapter 21E report is being prepared concurrently by H&A, under another contract with Myerson/Allen & Company.

Thank you for engaging us to perform this work. We look forward to working with you and other members of the design team during subsequent design and construction phases.

Branch Offices
Glastonbury, Connecticut
Portland, Maine
Bedford, New Hampshire

Affiliate
H&A of New York
Rochester, New York

If there are any questions regarding the content of this report, please do not hesitate to contact us.

Sincerely yours,
HALEY & ALDRICH, INC.

Chris M. Erikson
Staff Engineer

David E. Thompson
Executive Vice President

James R. Wheeler
Senior Engineer

CME:JRW:DET:hjs/0298W

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I. INTRODUCTION

1-01. GENERAL

This report presents a summary of preliminary subsurface explorations and foundation design recommendations for the proposed Tudor Wharf project to be constructed in Charlestown, Massachusetts. The site is located at 44 Charles River Avenue, south of the now discontinued Waldo Street and immediately east of the Charlestown Bridge, as shown on Figure 1, Project Locus. The site is currently occupied by a concrete block warehouse on shore, a one story wood frame warehouse constructed on a pier out into Boston Harbor and adjacent paved parking areas. A brick wall divides the parking area delineating the eastern property line of the Tudor Wharf parcel.

Current development plans, as presented on four drawings by Childs Bertman Tseckares & Casendino, Inc. (CBT) in March 1988, propose the construction of an on-shore six-story office structure containing three levels of underground parking. It is our understanding that four levels of below grade parking are also being considered. In addition, the development will include a five-story commercial and office building to be built over the pier into Boston Harbor, replacing the existing wood frame warehouse structure. An approximate plan of the proposed site development, superimposed over existing site features, is included as Figure 2.

1-02. PURPOSE AND SCOPE

The objective of this study was to complete initial explorations to investigate subsurface soil and groundwater conditions at the proposed Tudor Wharf site and to develop preliminary recommendations regarding foundation support and construction of proposed structures. Recommendations on other geotechnical aspects of the project, as well as issues addressing waterfront development, are also included.

To achieve these objectives, the scope of our work included:

- A program of three test borings completed on land and one test boring completed over water to define subsurface soil and groundwater conditions.
- Field monitoring of the borings and installation of three groundwater observation wells.
- Preparation of a subsurface exploration location plan and two subsurface profiles.

- Laboratory and in-situ testing to verify field classification of soils and to determine engineering properties to aid in developing foundation design criteria.

- Completion of preliminary analysis related to geotechnical engineering aspects of foundation design and site development.

1-03. ELEVATION DATUM

To be consistent with other members of the design team, the elevations presented herein are referenced to North Area Central Artery (NACA) Project Datum , wherein El. 0.00 (NACA) is 100.00 ft. below National Geodetic Vertical Datum (NGVD), formerly USC&GS Mean Sea Level Datum of 1929.

Tide tables and bottom soundings on many site or navigation plans are referenced to Mean Low Water (MLW) Datum wherein MLW datum is 95.42 ft. above NACA Project Datum (El. 0.00 MLW = El. 95.42 NACA).

1-04. LIMITATIONS

This report has been prepared for specific applications to the proposed Tudor Wharf development in Charlestown, Massachusetts, in accordance with generally accepted geotechnical engineering practices. No other warranty, expressed or implied, is made.

The recommendations presented herein are based, in part, on information from limited subsurface explorations and on proposed development plans that are available to Haley & Aldrich, Inc. at this time. The nature and extent of variations in the subsurface conditions between explorations will not become evident until further explorations are completed and construction is undertaken. If variations appear, it will be necessary to re-evaluate the recommendations presented in this report. If changes to the design or locations of the proposed structures are made, these recommendations should be considered invalid unless confirmed in writing by Haley & Aldrich, Inc.

Access to that portion of the project east of the brick wall which forms the east property line of the Tudor Wharf paved area was unavailable during this study. Therefore, no explorations were possible in this area, and our conclusion with respect to subsurface conditions and feasible foundation construction should be considered in light of the lack of information in this area.

II. FIELD AND LABORATORY INVESTIGATIONS

2-01. PREVIOUS TEST BORINGS

A total of fifteen test borings were previously drilled within the area of the proposed development site. Logs of these borings were obtained from the following sources:

- o Drawing S-1, "Pile Plan," prepared for construction of the concrete frame Paper Storage Warehouse on-shore at Tudor Wharf by Cleverdon, Varney and Pike, Revised 14 September 1951.

- o "Geotechnical Data Report, Central Artery - North Area, Vol. II of II," prepared by Goldberg-Zoino Associates, Inc., dated May 1986.

Ten of the previously drilled fifteen borings were completed for construction of the existing warehouse and were relatively shallow, ranging in depth from 25 to 30 ft. The remaining five borings, which were compiled for the North Area Central Artery Project, were completed to greater depths ranging from 40 to 72 ft. The approximate as-drilled locations of each of these sets of borings are shown on Figure 2; copies of the individual boring logs are included in Appendix A.

2-02. RECENT TEST BORINGS

A preliminary subsurface exploration program was undertaken at the portion of the site which was accessible during the period 28 to 31 March 1988 to obtain additional subsurface information for initial project design purposes. Test Borings were completed by Carr-Dee, Corp. of Medford, Massachusetts. The program consisted of three test borings drilled from land using truck mounted rotary drilling equipment to depths approximately 56 ft. below ground surface. An additional boring was made from within the existing warehouse pier structure, over water, with a portable skid rig. This boring was conducted by opening an existing hatch in the warehouse floor and inserting drill casing down to the mudline 30 ft. below. The total depth of this boring was approximately 49 ft. below the warehouse floor. The hatch was replaced after completion of the test boring.

All borings were completed to the west of the brick wall which divides the proposed development site in the north/south direction. The land east of the brick wall was included in the development plans but was not accessible for explorations at the time of this study.

The recent borings were monitored in the field by H&A personnel. As-drilled locations of the borings were determined by H&A by taping from the existing site features shown on Figure 2. Ground surface elevations of the borings were determined by H&A using optical survey methods. All boring elevations are referenced to a standard Massachusetts Geodetic Survey Disk denoted "ARTERY 5," located in the northerly concrete sidewalk on the approach road to the Charlestown Bridge, approximately 169 ft. southeast of the centerline of Chamber Street. Boring logs prepared by the Carr-Dee Corp. are included as Appendix B and are shown graphically with the previously drilled borings on Figure 3, Subsurface Profile A-A, and Figure 4, Subsurface Profile B-B. In addition, a summary of the subsurface strata encountered and the corresponding top elevation of each strata are summarized in Table I - Summary of Subsurface Information.

Boring locations and ground surface elevations are shown on Figure 2. The locations and elevations of each boring should be considered accurate only to the degree implied by the methods used.

All four borings were advanced using a 3-in. diameter casing. Split-spoon samples were recovered from all borings at depth intervals typically not exceeding five feet and at changes in soil type. In addition, continuous samples were taken in the surficial fill deposits for Chapter 21E site assessment purposes. All borings were terminated in the glacial till stratum. It should be noted that in boring B101 a boulder was cored in the glacial till with a BX core barrel between a depth of 42.0 and 44.5 ft.

The Standard Penetration Resistance, "N," was determined at each sample level by counting the number of blows required to drive a standard split-spoon sampler (1-3/8-in. I.D., 2-in. O.D.) a distance of 18 or 24 in. into the undisturbed soil under the impact of a 140-lb. hammer free-falling 30 in. The number of blows required to advance the sampler each six inches was recorded. The "N" value is taken as the number of blows required to advance the sampler the last 12 in. of an 18-in. sampling range (or the middle 12 in. of a 24-in. sampling range).

An H&A geologist was present at the site during field explorations to:

- o Observe and document the subsurface conditions encountered.
- o Vary the depth of subsurface explorations as well as sampling location, to meet the subsurface conditions encountered.

- o Document the installation of groundwater observation wells.
- o Conduct and monitor in-situ falling head permeability tests.

As previously discussed, the project area east of the existing brick wall, which divides the site in a north-south direction, was inaccessible at the time of the exploration program and no borings could be conducted within the area. During explorations for final design, additional borings must be conducted in this area to characterize the subsurface conditions.

2-03. GROUNDWATER OBSERVATION WELLS

Groundwater observation wells were installed in completed boreholes B102, B103 and B104. The bottoms of the of the well tips were installed to depths of approximately 15 to 20 ft. below ground surface. The relationship of the well screen to the major soil strata is shown in the groundwater installation reports included as part of Appendix C.

The observation wells consist of 2.0 in. I.D. machine slotted PVC wellpoints installed from the bottom of the well to approximately ground surface. The top of each observation well was provided with a concrete/bentonite seal and was encased in a protective roadway box. Groundwater levels measured during periodic monitoring of the observation wells, between the period 29 March to 4 May 1988, are included in Appendix C. The corresponding tide level recorded at the time of the groundwater measurements is also contained in the monitoring reports.

2-04. IN-SITU PERMEABILITY TESTS

A preliminary field permeability testing program was undertaken to better evaluate the effects of a permanent underslab drainage system on the groundwater levels in the area and to assess the feasibility and type of seepage cut-off needed to construct the proposed below grade parking area. The testing program consisted of performing two falling head permeability tests in the glacial till soil in borehole B103. The location of the tests with respect to the soil stratigraphy is shown on the Subsurface Profile A-A included as Figure 3 and the field test data are included as Appendix D.

Field permeability tests were typically conducted according to the following procedure:

1. A cased borehole was advanced to the stratum to be tested and carefully cleaned out to assure that no loose soil particles were left in the hole.

2. A 2-in. O.D. split-spoon sampler was driven below the bottom of the casing to obtain a sample of the soil to verify the stratum in which the test would be performed.

3. Then, either the casing was advanced to the bottom of the zone to be tested and again completely cleaned out, or the hole was advanced to the bottom of the test zone, below the bottom of the casing, and carefully cleaned out using a 2-7/8 in. O.D. roller bit.

4. After sounding the bottom of the hole to verify that the soil was either flush with the bottom of the casing or at the desired distance below the bottom of the casing, enough Ottawa sand was poured down the casing to fill the designated test area.

5. Where the casing was flush with the bottom of the hole, the casing was extracted upward to yield the desired test zone.

6. The boreholes were then filled to the top of the casing with clear, fresh water and the distance of water level drop with time was measured and recorded.

2-05. LABORATORY TESTING

A laboratory testing program was undertaken as part of this investigation to aid in classifying the soil recovered in the borings. The tests performed included Atterberg limit determinations and grain size distribution analyses (sieve and hydrometer analyses).

All laboratory tests were performed in the H&A laboratory in general conformance with current ASTM procedures. Atterberg limit determinations and results of the grain size analyses are included as Appendix E.

III. SITE AND SUBSURFACE CONDITIONS

3-01. EXISTING SITE CONDITIONS

The Tudor Wharf site is located at 44 Charles River Avenue and is bounded on the north by the Hoosac Spur rail line along Waldo Street, on the east by a brickwall and the adjacent Hoosac Pier, on the west by Charles River Avenue and the Charlestown Bridge and extends south into Boston Harbor. The surrounding ground surface is typically flat ranging in elevation from about El. 108 to El. 110 (NACA).

The Tudor Wharf site is currently occupied by a Rapids Furniture Co. warehouse constructed partially on land and extending south on a pier over the Harbor. Portions of the site to the south and west of the warehouse structure consist of a level, asphalt paved truck loading area. This pavement is bounded to the south by a granite block seawall which runs east-west completely beneath the warehouse structure. To the east of the warehouse, an existing brick wall separates the site in a north-south direction from Waldo Street to the granite block seawall. Beyond the brick wall to the east, a relatively level asphalt paved parking area for the Constitution Marina exists.

The existing warehouse consists of a two-story high structure constructed both on land and over water. The portion of the structure built over water is of wood frame construction supported on timber piles. Plans previously obtained from Skidmore Owings & Merrill (SOM) indicate that repairs to the pile foundations, consisting of the posting and occasional replacement of damaged piles, were completed in 1944 and 1962. The condition of the pile foundation was observed and found to be in fair to poor condition. Many piles were observed to be necked down at the mudline, several were missing and some were found to be rotted at the butt. In addition, apparent fire damage was observed as many of the floor joists and piles were observed to be charred.

The land portion of the warehouse was constructed in 1952 and consists of a two-story high concrete block structure. According to foundation plans previously obtained from SOM, the structure is supported on timber (oak) piles driven to end bearing below the fill and organic soils at approximately El. 90.5 to El. 86.0 (NACA). These 15 ton capacity oak piles support both the building columns and a concrete structural floor slab.

3-02. SUBSURFACE SOIL AND ROCK CONDITIONS

The subsurface explorations indicate the following general soil and rock sequence in order of increasing depth from ground surface:

- Miscellaneous Fill
- Organic Silt and Peat
- Marine Sands
- Glacial Till
- Bedrock (Assumed)

Due to the complex geologic environments responsible for deposition of the materials, all the units may not be present at specific site locations. The units are discussed below in order of deposition and are indicated graphically on Subsurface Profiles A-A and B-B, Figures 3 and 4, respectively.

- Bedrock

  Bedrock was not encountered in any of the test borings. However, according to available geologic maps and our previous experience, bedrock in the project area is believed to consist of Cambridge Argillite, a grey slate-like mudstone of extremely variable quality.

- Glacial Till

  During an advance of the glacial ice sheet over the Boston area during the Pleistocene time period, a very dense, nonstratified, unsorted material known as glacial till was deposited over the bedrock surface in the project area. The glacial till encountered at the site typically consists of a very dense, silty fine sand to sandy silt with trace to some gravel and contains occasional cobbles and boulders.

  The top of this strata was encountered between El. 102.1 and El. 86.3 (NACA). The thickness of the glacial till strata was not determined since none of the test borings conducted were advanced into the underlying bedrock.

  The results of the two in-situ falling head permeability tests conducted in the glacial till indicate that the strata has an average permeability ranging between 4.7×10^{-5} and 9.2×10^{-6} cm/sec. Soil permeability

within this range is typical for silty glacial tills and is generally considered very low.

- Marine Sand

  As the glacial ice sheet retreated from the area, silt and sand ladened waters melting from the ice flowed into the ocean settling out to form a layer of silty medium to fine sand overlying the glacial till deposits. Where encountered, this stratum ranged in thickness of up to 9.0 ft., with the top of stratum varying from approximately El. 109.1 to El. 93.9 (NACA).

- Organic Soils

  A stratum of organic soils consisting primarily of sandy organic silt and peat was found to overlie the glacial till or marine sands. This stratum is the original harbor bottom sediments which accumulated prior to site filling. The organic silt and peat are typically soft to hard, with low strength and high compressibility. The strata ranges up to 14.5 ft. in thickness where encountered with the top of strata noted from El. 110.1 to El. 100.1 (NACA).

- Miscellaneous Fill

  With the development of the harbor area during and following the 17th century, many waterfront structures were built out into Boston Harbor. At this time, a man-made layer of fill was placed across the site to the present grade and primarily consists of an unsorted mixture of coarse to fine sand, silt, clay and fine gravel with varying amounts of wood, cinders, brick, slag and concrete. The thickness of the strata varies from 4.5 to 18.5 ft.

Refer to our report entitled "Report on Oil and Hazardous Materials Site Evaluation - Tudor Wharf, Charlestown, Massachusetts," issued concurrently with this report for further information pertaining to site history and usage.

3-03. OBSERVED WATER LEVELS

Water levels measured in boreholes upon completion of a boring may not necessarily represent the true, stabilized groundwater levels. Therefore, to monitor local subsurface water levels over an extended period of time, three observation wells were installed within the upper 15 to 20 ft. of completed borings B102, B103 and B104. Observation well installation logs and

groundwater level monitoring data are included herein as Appendix C.

It is important to note that water level readings recorded in the observation wells were made at times and under conditions stated on the groundwater monitoring reports. It is emphasized that the actual groundwater levels may differ from the observed levels and that fluctuations in the level of the groundwater may occur due to variations in tide level, season, rainfall, temperature, and other factors. Also, groundwater levels at the time of construction could differ significantly from water levels observed during this study particularly if leaking sewers are found near the site.

Water levels throughout this particular site were observed to respond to tidal fluctuations. The tidal response at a specific location depends on the permeability of the soils between the well location and the source of free water. As may be seen in the groundwater observation well data contained in Appendix C, the response to tidal action varies considerably across the site due to the complex nature of the near surface fill soils. Groundwater level data indicate that water levels at observation wells B102 and B103 vary appreciably with tidal fluctuations while water levels at B104 do not. In general however, groundwater levels at the site should be expected to reflect tide levels in Boston Harbor typically ranging from El. 96.5 (Mean Low Water - MLW) to El. 105.9 (Mean High Water - MHW).

3-04. TIDE LEVELS

The U.S. Army Corps of Engineers has developed data on observed tide levels in Boston Harbor and the predicted tide level frequency of occurrence. The following tide level frequency data are estimated by the Corps for data through August 1979:

Frequency In Years	High Tide Elevation (NACA Project Datum)
1	108.97
5	109.77
10	110.17
20	110.57
25	110.97
50	111.07
100	111.37
200	111.77

Note: El. 0.0 NACA Project Datum is 100.00 ft. below National Geodetic Vertical Datum (USC and GS Mean Sea Level Datum of 1929).

The above data are for wave free water levels. Wind-driven water and waves will add to the water levels during storm conditions.

Lowest site grades are normally set at or above El. 110.5 (NACA) in the Boston area and the lowest recommended design floor level to avoid tidal flooding is normally taken at El. 111.5 although El. 112.5 is preferred.

IV. GEOTECHNICAL CONSIDERATIONS

4-01. GENERAL

This preliminary geotechnical study assumes the project layout as shown in the Tudor Wharf plans provided by CBT and received by H&A on 22 March 1988. As further information is developed by the design team concerning building layout, structural building and column loads, bay spacing, site grading and other details, the preliminary recommendations presented herein will have to be reviewed and revised as required.

4-02. PROPOSED BUILDINGS

As indicated on Figure 2 and in the plans provided by CBT, the Tudor Wharf development will include three predominant structures: 1) an office structure with below grade parking, 2) a pier structure extending over Boston Harbor, and 3) a walkway connecting the office and pier structures. These structures are described in further detail as follows:

1. Office Structure and Below Grade Parking:
    - o A three to four level below grade parking area with a footprint approximately 185 x 285 feet to be constructed approximately 30 to 40 ft. below ground surface.
    - o An "L"-shaped six-story office building located above a majority of the underground parking area.
2. Pier Structure:
    - o A five-story building with a footprint approximately 80 x 240 feet.
    - o No below grade space is envisioned for the pier structure.
3. Walkway:
    - o A one-level corridor at approximately El. 100.0 (NACA) which connects the first level of the below grade parking area to the pier structure.
    - o The corridor portion of the walkway is approximately 12 x 100 feet long. At the end of the walkway a lobby and elevator shafts are proposed; this area is approximately 24 x 24 feet in plan.

4-03. PRELIMINARY ASSESSMENT OF FOUNDATION DESIGN AND CONSTRUCTION CONSIDERATIONS

This section of the report will concentrate on possible foundation support systems, construction impacts and foundation costs for each of the proposed major building elements of the planned development. These issues are generally determined by considering the various effects of: building geometry, typical column/wall loads and subsurface soil and groundwater conditions. For purposes of this report, building loads were estimated by H&A assuming loads in the typical range of steel or concrete construction. Each of the proposed structures, as defined previously, will be discussed separately. Our specific comments follow.

1. Office Structure and Below Grade Parking Area

Based on subsurface soil conditions presented in Figures 3 and 4, anticipated building loads and the 30 to 40 ft. excavation required for construction of the planned three of four level below grade parking garage, it is anticipated that individual spread footings bearing on the glacial till soils may be used for support of the office structure. This foundation type is recommended since the required excavation for garage construction will remove the miscellaneous fill and organic soils which are generally unsuitable as foundation bearing materials. Typical allowable bearing pressures for glacial till soils in the Boston area range between 5 and 20 tsf (tons per sq. ft.). Recommendation of an allowable bearing pressure for the glacial till will require additional analysis and subsurface explorations in combination with an evaluation of the active column loads anticipated by the structural consultant.

Excavation of the three to four level garage area will require construction of a cofferdam to retain the earth and provide a groundwater cutoff. Groundwater control is of primary concern, particularly in those areas adjacent to the harbor, where existing groundwater levels are up to 25 to 35 ft. above the lowest garage level.

Based on an evaluation of subsurface conditions and the results of in-situ permeability testing, the use of either interlocking steel sheet piling or a concrete diaphragm wall (slurry wall) constructed with adequate penetration into the glacial till soils were evaluated for use as temporary excavation support for the garage. Both of these options would theoretically provide adequate control of groundwater seepage into the excavation, however, due

to the density of the glacial till and the existence of boulders in the glacial till soils, it would be difficult, if not impossible, to drive sheeting to the required depths without damaging the sheets and adversely impacting the integrity of the wall and therefore its effectiveness as a groundwater cut-off.

Due to the depth of excavation for the proposed garage, the excavation support wall will have to be temporarily braced during construction. Temporary, high capacity tiebacks anchored into the glacial till soils are considered both economical and feasible for use on the north and west perimeter garage walls which are not adjacent to portions of Boston Harbor. The use of corner bracing, rakers and possibly cross lot bracing may have to be considered for use in providing temporary support to portions of the south and east perimeter walls where use of tiebacks is not feasible. Past experience indicates that excavation between individual members of an internally braced system (corner and cross lot bracing) is somewhat slower than excavation in an open, externally braced excavation (tiebacks).

The southernmost wall (closest to the waterfront) of the proposed underground parking area poses significant constructibility problems. In the vicinity of boring B102, the alignment of the proposed southern perimeter wall of the garage appears to pass through sections of the existing granite block seawall and within or directly adjacent to the open water of Boston Harbor. Installation of the recommended cast-in-place concrete diaphragm wall (slurry wall) would be impossible at the current proposed location without filling of this portion of the site. Filling within the tidewaters at Boston Harbor raises significant environmental and permit problems which may best be avoided.

Therefore, it is recommended that the alignment of the southern wall of the proposed garage be shifted to the north to avoid excavation of the granite block seawall and to remain beyond the tidal zone. In areas where the proposed garage is adjacent to existing seawalls, along the southern and eastern perimeter walls, a setback of approximately 15 ft. is suggested to minimize construction difficulties. This setback distance should be verified by test pit excavations which would permit direct observations of the seawall structures.

The weight of the proposed building is insufficient to resist the hydrostatic pressure that would develop below a

waterproofed pressure mat if constructed at the lowest grade level. Therefore, a slab-on-grade with a permanent underdrainage system beneath is required for hydrostatic pressure relief. A typical underdrainage system consists of a system of perforated PVC pipe placed within a layer of crushed stone. The PVC pipes are interconnected to transport the inflow of groundwater into collection pits where sump pumps are utilized to remove accumulated groundwater. Underdrain design, groundwater infiltration rates and pumpage will be determined by a number of factors including diaphram wall penetration below the lowest slab level and proximity to the harbor.

2. Pier Structure

Unlike the Office Structure, no below grade levels are anticipated for the pier structure which extends out into the harbor. Since the fill and underlying organic soils are not considered suitable for support of the proposed structure, building loads must be transferred to the natural, inorganic soils below; therefore the pier building will require a deep foundation system.

Based on waterfront construction constraints, a pile foundation system was considered as the only technically feasible foundation system. From our analysis of the subsurface information, high capacity piles driven to end bearing in the glacial till at a depth of approximately 35 to 50 ft. below the top of the existing warehouse floor (El. 114.0±) appear to be the most appropriate. These pile lengths assume piles are driven 10 ft. into the glacial till soils. However, additional borings should be conducted within the area of the proposed pier structure to more completely define the bearing strata and to allow for a better estimate of pile lengths.

Currently in the Boston area, precast-prestressed concrete piles are generally the most economical foundation element for use as end bearing piles. Maximum design loads for this pile type are 134 tons/pile (14-in. square) and 175 tons/pile (16-in. square) according to the current Massachusetts State Building Code. Precast-prestressed concrete piles are also resistance to corrosion in the salt water environment, a significant consideration for this structure.

Note that the Massachusetts State Building Code requires the completion of a pile load test for all piles with a design capacity in excess of 50 tons. Completion of such a test must be included in this project. Pile spacing and

design will be significantly impacted by requirements to transfer horizontal seismic and wind loads at the foundation level and to provide overall stability of each point of foundation support. These considerations should be studied by the structural consultant early in the design.

3. Walkway

Based on the plans provided by CBT, the proposed walkway from the office structure to the pier structure will exist one level below grade with the bottom at approximately El. 100.0. This level is within the intertidal zone range in Boston Harbor, and is about 11 ft. below the 100 year storm tide level. Therefore the walkway must be designed with consideration for waterproofing, uplift loading due to bouyant forces, hydrostatic and wave loading. The walkway will also be subject to constructibility difficulties similar to those outlined for the southern foundation wall of the proposed underground garage.

Therefore, unless the present walkway location is essential to project development, it is suggested that the walkway be relocated above grade and designed to bear on pile foundations, similar to the pier structure.

4-04. PROPOSED SITE DEVELOPMENT

During definitive planning for the various structures and site development, existing site and subsurface conditions must be considered. The site is generally comprised of filled, reclaimed land, with compressible organic soils underlying. Granite block seawalls provide shore protection at the water's edge. Within the site area structures exist which will require demolition, timber piles and previously existing utilities will be encountered during excavation. In consideration of these site characteristics, the following preliminary criteria are recommended:

A. Site Utilities and Pavements. The site, being underlain by a deposit of miscellaneous fill and organic soils, is potentially susceptible to significant ground movements and large differential surface settlements if additional surface loading occurs by raising grades or adding structural loads. If extensive filling is proposed within the area of the site, settlement may be anticipated and soil support of utilities may require surcharging or over excavation of organic soils. Further evaluation of design details for utilities and pavements in fill areas will be required.

The near surface fill and organic soils will tend to compress and settle with time. Therefore, it is recommended that pavements and final surface treatments be designed to accommodate future ground movements. Settlement estimates can be provided as more data becomes available.

B. Site Excavation and Filling. As currently proposed, extensive excavation for the proposed below grade garage is envisioned. Excavated soils will be comprised primarily of the miscellaneous fill, organic soil, marine sand and varying amounts of glacial till depending on the number of below grade levels. Buried structures including the existing warehouse foundations (oak piles and reinforced concrete pile caps), portions of the existing granite block seawall, and boulders in the glacial till soils will also be encountered during excavation. Shifting the location of the proposed south perimeter garage wall may significantly reduce excavation of sections of granite seawalls.

The majority of excavated materials are not considered suitable for use as on-site fill except as common fill under landscaped areas or other non-structural applications. Therefore, for current planning it should be assumed that excavated material will be disposed of off-site. However, reuse of excavated granite blocks for reconstruction of shore protection may be advantageous. Refer to our report on "Oil and Hazardous Materials Site Evaluation" for specific comments pertaining to off-site disposal of excavated soils.

As indicated in the previous section, the subsurface fill and organic soils will consolidate and settle if the soils are subjected to additional surface loads. Therefore, to the extent possible (considering flooding associated with storm tides), existing site grades should be maintained. If site filling greater than 1 to 2 ft. is proposed, further evaluation of anticipated movements will be required. In addition, recommendations relative to design of pavements and utility support, as well as building foundations and seawalls in these areas will require evaluation in greater detail.

C. Seawalls and Shore Protection. Preliminary visual inspection of the existing granite block seawall indicates that the wall is in relatively good condition except the area just west of the pier and near boring B102. Previous experience in the Boston Harbor area with similar seawalls indicates that these walls have a marginal factor of

safety. The potential exists for only a small change in loading to cause a wall failure. It is therefore recommended that once plans are developed for the configuration of the shore protection associated with the development that they be studied to determine the wall stability.

V. FUTURE GEOTECHNICAL STUDIES

The preceding discussions in this report have provided general geotechnical considerations and preliminary recommendations relative to the Tudor Wharf Development. Future studies will be required to collect additional subsurface information, and to develop definitive design criteria, construction techniques and final recommendations concurrent with the structural and architectural design.

Future subsurface explorations will be required at building locations or other structure locations to provide the necessary data for design studies. Additional subsurface information is particularly needed in the eastern portion of the site in the area currently occupied by the Constitution Marina parking lot which was inaccessible during the preliminary explorations. In addition, data is required to provide information to prospective contractors for their interpretation and evaluation as they prepare cost estimates. Future explorations should include test borings, test pits, and completion of in-situ and laboratory testing. Test pits will be required to determine the current location, geometry, and bearing level of the existing granite block seawalls and other shore protection elements. Such information regarding the seawall will aid in determining seawall stability and reconstruction.

The geotechnical design studies to be conducted in the future are necessary to assess the following major geotechnical issues:

- Foundation pile lengths;
- Design criteria for foundations and excavation support systems for the below grade garage;
- Design of permanent hydrostatic pressure relief systems for below grade garage;
- Stability of existing and proposed shore protection elements;
- Construction considerations related to the site work and foundation construction;
- Long and short term settlement of the miscellaneous fill and organic soil, utility support requirements;
- Temporary and permanent design soil and water loads; and

- Effects of the below grade garage construction on the adjacent Charlestown Bridge and Maxwell Box Company Building.

These studies should be conducted in coordination with design studies by other members of the project team so that the various design issues can be adequately assessed and the necessary geotechnical input provided to the project team.

VI. SUMMARY AND CONCLUSIONS

This report presents the results of our preliminary geotechnical studies for the proposed Tudor Wharf development. The studies were based on the plans for the project prepared by CBT. The recommendations presented herein are subject to modification or revision as additional field data become available and as the design evolves. The following is a summary of preliminary conclusions and recommendations developed during our studies to date.

A. Building Foundations

- The office structure should be supported on individual spread footings bearing on the glacial till soils at bearing pressures between 5 and 20 TSF.
- The excavation for the three- to four-level below-grade garage area should be supported by a concrete diaphragm (slurry) wall.
- A combination of internal and external bracing will be required to support the slurry wall depending on its final location relative to the harbor.
- A permanent underdrain system is required beneath the lowest level basement slab to relieve the hydrostatic uplift pressures.
- The alignment of the south perimeter wall of the proposed garage should be shifted north to avoid difficulties with the existing granite block wall and the tidal zone.
- The pier structure should be supported on deep, end-bearing pile foundations. Currently, precast, prestressed concrete piles are believed to be the most economical pile type for the project.
- It is recommended that the walkway connecting the office and pier structures should be relocated at grade to avoid design and construction difficulties and high costs associated with its present location.

B. Site Development

- Placement of additional fill within the site area will result in settlement of the organic soils and may effect existing or proposed utilities. Grade raises should be kept to a minimum (less than 1-2 feet).

- A significant excavation is planned for the below-grade garage area; existing foundations, portions of the granite block seawall and boulders in the glacial till will be encountered.

- With the exception of buried granite blocks which may be excavated and reused for construction of shore protection structures, excavated soils will probably be unsuitable for reuse except in landscaped areas and other non-structural application.

- Past experience with similar granite block seawalls in the Boston Harbor area indicate that these structures have been found to have a marginal factor of safety. Further analysis of the seawalls and shore protection structures should be completed from both a structural and geotechnical background.

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