Journal of the
BOSTON SOCIETY
of
CIVIL ENGINEERS SECTION
AMERICAN SOCIETY
of
CIVIL ENGINEERS

1848
BOSTON
SOCIETY
OF CIVIL
ENGINEERS

AMERICAN
SOCIETY OF
CIVIL
ENGINEERS
FOUNDED
1852

VOLUME 65 JULY 1978 NUMBER 2

JOURNAL OF THE

BOSTON SOCIETY
OF
CIVIL ENGINEERS SECTION

AMERICAN SOCIETY
OF
CIVIL ENGINEERS

Volume 65 **July 1978** **Number 2**

CONTENTS

PAPERS

Second-Class postage paid at Boston, Massachusetts

Published four times a year, January, April, July, and October, by the Society
80 Boylston Street, Boston, Massachusetts 02116

Subscription price $10.00 a Year (4 Copies)
$2.50 a copy
All orders must be accompanied by check
Members' subscriptions are part of their dues.

BOSTON SOCIETY OF CIVIL ENGINEERS SECTION
AMERICAN SOCIETY OF CIVIL ENGINEERS
OFFICERS 1978-1979

PRESIDENT
Howard Simpson

VICE PRESIDENTS

William S. Zoino
(Term expires 1979)

Frank E. Perkins
(Term expires 1980)

SECRETARY
Leo F. Peters

TREASURER
Saul Namyet

DIRECTORS

Edward B. Kinner
Richard J. Scranton
(Terms expire 1979)

Robert L. Meserve
Stanley C. Rossier
(Terms expire 1980)

PAST PRESIDENTS-BOARD MEMBERS
Charles A. Parthum
Bertram Berger
Charles C. Ladd

VICE PRESIDENT, WESTERN MASS. BRANCH, Thomas W. Bean

NATIONAL VICE PRESIDENT, ZONE 1, Cranston R. Rogers

NATIONAL DIRECTOR, DISTRICT 2: John J. Cusack

TECHNICAL GROUPS
COMPUTER: Salvatore G. Mazzotta, Chairman
John D. Goodrich, Clerk

CONSTRUCTION: Stephen G. Walker, Chairman
Robert C. Hoyler, Clerk

ENVIRONMENTAL: Warren H. Ringer, Chairman
Steven H. Corr, Clerk

GEOTECHNICAL: David E. Thompson, Chairman
Joseph D. Guertin, Clerk

HYDRAULICS: Richard DiBuono, Chairman
Russell C. Peterson, Clerk

STRUCTURAL: Frank B. Davis, Chairman
James M. Becker, Clerk

TRANSPORTATION: A. Russell Barnes, Jr., Chairman
Edmund J. Condon, Clerk

(Committee Chairmen are listed on inside back cover)

JOURNAL EDITOR - Edward C. Keane

EXECUTIVE DIRECTOR - Mrs. Charlotte E. Dalrymple

ADMINISTRATIVE SECRETARY - Ms. Susan Albert

JOURNAL OF THE
BOSTON SOCIETY OF CIVIL ENGINEERS SECTION
AMERICAN SOCIETY OF CIVIL ENGINEERS

Volume 65 July 1978 Number 2

UNIQUE CHALLENGES ASSOCIATED WITH MARINE STRUCTURES IN NEW ENGLAND

By
Francis C. Pierce and
Victor Calabretta[1]

Introduction

New England was one of the earliest areas of North America to be developed. Its beginnings and much of its early industrial growth can be attributed to the many fine seaports and ensuing marine related opportunities in fishing, whaling, trading and shipping, which complemented the occupations of its founders. As a result, New England's many fine seaport areas were heavily developed, and in many instances are burdened with piers, wharves and marine structures which have long outlived their usefulness and are in various stages of decay. As a consequence, development of new marine terminals in New England presents many engineering and construction problems, unique to the area, in site selection and construction. Recognition of these during initial stages of a project can greatly reduce contingencies in design and construction phases.

Design and construction of marine structures in general involve very challenging problems since we must deal with one of nature's most active energy zones. In addition, we must tread lightly in New England, since this area is in one of nature's most populated biological zones. The challenge is further complicated by the unpredictability of subaqueous and geotechnical conditions. While types of basic soil and rock materials can be ascertained fairly reliably by a review of the geologic evolution of the area, depths to suitable foundation material vary considerably over a given site primarily due to the effects of advance and retreat of glaciers. Coupled with the seemingly ever present overlying layers of soft organic silts and inorganic clays common to New England tributaries, this results in unique challenges in the design and construction of marine facilities in the region.

New England Silts

The extensive deposits of soft, highly compressible organic silt common to New England's tributaries present major problems of marine design and construction. The low shear strength and high water content of this material

---

[1] Respectively Senior Vice President, and Manager Civil Division, CE Maguire, Inc.

lead to its transformation into a near fluid upon minimal disturbance. Its high degree of compressibility makes it generally undesirable as a fill or foundation material. Even removal and disposal of this material presents a major problem due to environmental considerations which place severe restraints upon disposal, especially ocean disposal.

During the course of our work in New England, we have amassed a considerable amount of laboratory test data for various New England sites. Figures 1 through 5 present various relationships of index properties, along with settlement and strength characteristics. All samples were naturally deposited, organic silts. The organic content of the materials tested ranged from 1 to 20 percent; most samples had between 3 and 10 percent. Figure 1 presents the familiar Casagrande Plasticity Chart of Liquid Limit versus Plasticity Index. Most of the samples tested plotted near or slightly below the "A-Line".

Figure 2 presents the relationship between the natural water content and Liquid Limit. A 45 degree line (or Liquid Limit equal to Water Content) has been superimposed. This plot illustrates that the natural water content of most samples is very near, or greater than, its liquid limit, indicating the relative sensitivity of the in-situ mass.

Figures 3A and 3B present consolidation test results. While correlations are apparent between the compression index, Cc vs. liquid limit and Cc vs. water content, values may differ by a factor of two or more. Common methods for estimating Cc have been included. The reasonable correlation indicates that they could be used fairly well for estimating settlements.

Figures 4 and 5 present the results of consolidated-undrained triaxial tests in terms of total stress and effective stress respectively. Both figures indicate that the test results plot in a fairly well-defined band. There is very little cohesion apparent and the angle of internal friction appears relatively high. It must be remembered, however, that the material is below water level with very low buoyant unit weights and, consequently, low, in-situ stresses resulting in generally low shear strengths.

The combination of low strength, low in-situ confining pressures and the proximity of water content to liquid limit results in a soil often barely capable of supporting itself, let alone an imposed surcharge. One fact is consistent in all of the normally consolidated organic silts encountered to date: the soils are extremely compressible. Handling of the soil as in dredging only tends to increase the water content and void ratio, thereby further worsening the settlement characteristics. The high compressibility coupled with relatively low shear strengths make organic silt a relatively difficult material to work with.

Chemical properties of New England organic silts are generally extreme. The material is highly organic and laden with heavy metals (mercury, lead, and zinc) and oil and grease. Table 1 presents typical chemical properties of materials taken from several project sites throughout New England. Table 2 presents the results of "Shake Tests" for the material using water samples from sites previously used for ocean disposal. It can be seen that the sediments generally exceed EPA standards for ocean disposal particularly with regard to heavy metals and oil and grease. As a result, projects which require dredging and disposal of these materials generally encounter serious environmental challenges.

As a result, a major design criterion (or philosophy) in New England has been to minimize the amount of dredging and disposal involved in a marine project. The situation in New England is critical; many necessary projects to deepen major seaport channels have not been implemented; this hinders access to ports by newer, deeper draft vessels. Similarly, even where deeper main channels have been dredged, (for example, the Providence River), stringent environmental restraints have hindered private efforts to dredge fairways and berths resulting in a situation comparable to an "interstate highway without any off ramps."

The consequences to New England are severe. As examples: 1) our large import of petroleum products must arrive in older, shallower draft (and, some say, more likely to spill) tankers. 2) Many New England ports are losing their competitiveness to capture new marine trade and associated industrial development due to the inadequacy of their terminals to accommodate newer, deeper draft ships. 3) Lack of maintenance dredging is jeopardizing the continuance of existing marine commerce.

Many alternative disposal methods have been investigated including land disposal, recycling, salt marsh creation, creation of artificial islands, and containerized disposal. These methods have worked in isolated cases but generally have been found to be prohibitive in cost as a regional solution.

Our experience has met with success primarily in recycling of the material. The excessive natural water content is one of the major factors affecting the undesirable properties of the silt, and, therefore, removal of the water (by stacking temporarily in windrows, for example) enhances the utility of the material. However, considerable maintenance is required for areas reclaimed by this method.

Additional rehandling costs coupled with the need for a large contiguous area for dewatering the material make this a solution for a specific site rather than a regional solution. This method is currently being employed for the expansion of the Municipal Wharf Facilities at the Port of Providence, Rhode Island.

We have also had success with land reclamation by controlled placement of fill over deep layers of soft silts. In this case, the major challenge is to avoid shear failure (mudwaves) and to accurately design sculptured surcharge loads necessary to achieve the final desired finish grade after the material consolidates.

This type of construction was accomplished in the waterfront development at the U.S. Coast Guard Academy. The site for the project was underlain by deposits of soft silt in excess of 30 ft. (9m) thick. By careful placement of fill material, controlled surcharging and, in one instance, a controlled mud wave, the project was completed and final elevations after consolidation were predicted to within a tolerance of 3 inches (7.6 cm.).

Another major problem in dredging and disposal in New England arises in the deepening of main channels. Since most of New England's harbors have been developed to control depths on the order of 30-35 ft. (9-11m) MLW and it is desired to go to -40 ft. (-12 m) MLW for today's vessels, dredging here is primarily a skimming operation rather than a major excavation. Simple mathematics tells us that in dredging from Elevation -35 to Elevation -40 (-11 to -12m), even an allowed 1 foot (.3 meter) overdredge represents a 20% increase in dredge volume. This overdredge quantity, for example, on the current dredging project of the main Thames River ship channel amounts to millions of yards of excess material. A quantity comparable, for example, to the deepening of all the berths served by the channel.

Minimizing overdredge requirements could possibly leave enough room in the disposal area to complete the project; that is, to allow the berths to be dredged. The Port of Providence is currently faced with this problem, and, to date, a solution has not been found except for specific cases such as at the Providence Municipal Wharf.

While it is acknowledged that overdredging is a necessary part of the deepening operation, we, as engineers and contractors, should be seeking economical methods of minimizing this requirement, perhaps by more accurate survey methods or new post-dredge sweeping techniques.

Site Selection

The effect of glaciation on the geological features of New England's tributaries has resulted in highly unpredictable foundation conditions which call for much caution in the design and construction of marine facilities.

In Groton, Connecticut, nested boulders over bedrock resulted in some very dramatic failures during load testing of end bearing piles which had been driven to refusal. Based on past analysis, the test piles slid off the boulders during testing. Grouting and drilling were required to develop the high presumptive design loads.

Across the Thames River in New London, piles of a proposed pier at the shore end needed to penetrate a mere 10 feet (3m) below dredge depth to bedrock, while at its head, 300 feet (91m) farther into the river, pile lengths in excess of 100 feet (30m) were needed to bypass deep deposits of organic silt and reach glacial till. A similar case was encountered at a large marina in Old Saybrook, Connecticut where soft peat deposits resulted in very unusual pile driving records reflecting the very erratic firm-bottom contours. A change of as little as 10 feet (3m) in horizontal location could mean that penetration below surface of timber piles, to bypass the peat and develop capacity, could change from 20 feet (6m) to more than 50 feet (15m). Equipment and material scheduling for such field conditions poses its own challenge to the designer and contractor.

For initial site selection decisions of a proposed marine structure in New England, it is prudent, in many cases, to rely on the judgment of our forefathers. While their subsurface exploration procedures may not have been as sophisticated as today's methods, they generally were able to locate suitable sites for their pier and wharf construction. As a result, the shape of the shoreline in many of our major seaports, traces, fairly accurately, the subsurface ridges and areas of optimum foundation conditions. One lesson we learn from this is to initially treat any virgin site in a highly developed waterfront as suspect. While such a site may appear to offer advantages for new construction by virtue of reduced demolition costs, or greater flexibility in layout of the marine structure, detailed subsurface investigations could, in a majority of cases, reveal less desirable (and consequently, more costly) foundation conditions. As an example of this, we have found in Fall River, Massachusetts, evidence of third and fourth generations of pier structures at the site of its present state pier while miles of relatively virgin shoreline are available along the bank of the Taunton River. Subsequent investigations revealed extensive layers of soft, organic silts adjacent to the unused shoreline.

This same consideration caused a great deal of difficulty for a proposed extension of the Municipal Wharf in Providence, Rhode Island to expand the port's capabilities to accommodate deeper draft vessels and "roll on/roll off" ships. (Similar examples can be cited for proposed wharf extensions in Portsmouth, New Hampshire and Boston, Massachusetts.) The Providence proposal called for the extension of an existing ¾ mile (1.2km) long gravity type granite seawall approximately 1500 ft. (457 meters) farther south, thereby creating the additional required berths. The project appeared simple enough at first evaluation; upland area was available; a prototype structure (the existing seawall) was already constructed and had been tested over its estimated 75 years of existence; and extensions utilizing similar construction had already been accomplished in the past. Consequently, the project was planned and funded, based on the historical type of construction. The pilot subsurface exploration program quickly revealed why the shape of the shoreline had evolved and why developments were limited in extent. Immediately south of the existing seawall, the rock and glacial till which had served as a foundation stratum for the seawall dropped from elevation -40 ft. (-12 meters) MLW to below -100 (-30 m) MLW and in place of the till was a layer of soft, near fluid, organic silt. The structural solution developed for the new construction was an articulated pile supported structure designed to suit the site conditions, a more costly project, and a project which was considerably delayed by environmental considerations due to the unexpected dredging and disposal of a large quantity of organic silt. After a detailed analysis and evaluation of the sensitive environmental considerations, the final solution was rehabilitation of the existing wharf rather than construction of a new wharf.

Rehabilitation vs. New Construction

The trend toward rehabilitation rather than new construction appears to have merit not only for the reasons cited above, but also because it appears to be an excellent opportunity for revitalization of many blighted waterfront areas while maximizing the amount of untouched shoreline in New England and still providing the desired new terminal facilities. In many cases, this approach can also preserve the historic beauty of the 19th century New

England craftsmanship which can be seen in the granite piers and timber wharves of early whaling days. This is what was done for a project at the Mystic Seaport to provide a berth for the whaling ship Charles W. Morgan. In a majority of cases, we have found rehabilitation to be both cost effective and environmentally more acceptable than either demolition and reconstruction or new construction at a virgin site.

Rehabilitation work requires a much more broad-gauged approach both for design and construction. The designer must do considerable research into the historic performance of the existing structure and correlate its limitations with operational requirements of the new terminal. In many cases, a compromise must be considered between holding to the client's desired operational capabilities involving high costs, and accepting lesser operating capabilities and limiting the upgrading of the structure to what is basically necessary. In many cases, a benefit/cost analysis will prove to the client that a reduction in operational specifications or perhaps a revision in operational procedures is cost effective for his purposes.

An example of this was encountered in a project for Dow Chemical Company at its Gales Ferry, Connecticut, plant. The firm was using an old coaling pier for offloading, primarily liquid styrene for processing at its adjacent plant. The pier, built in the 1800's, had long outlived its design life and was in critical condition with regard to function and safety. The recommended solution was not to repair the pier, as originally had been planned, but rather to convert the structure to a specialized use. A study of terminal operations revealed that a series of mooring dolphins with an access trestle to a manifold platform would be sufficient for the primary operation at the terminal. A detailed condition survey of the pier by divers located sufficient sound piles to support the access trestle and manifold platform, and the pier was converted to a liquid cargo terminal at approximately 20% of the originally anticipated cost.

Summary

The above discussion has been presented to indicate that the marine engineer and marine contractor are faced with unique challenges by virtue of the special personality and characteristics of New England waterfront. Successful implementation of port projects in the area requires a philosophy of innovation and ingenuity. At the conceptual stages of a project, the following should be included in planning and design criteria:

1. Treat virgin sites in or near heavily developed waterfront areas as suspect until detailed studies are accomplished.
2. Consider rehabilitation over new construction.
3. Evaluate in detail operational requirements which impose stringent design criteria on the project.
4. Minimize dredging requirements.
5. Exercise caution when considering the use, or disturbance, of organic silts present at a site.

New England is at a critical stage in its marine development. On the horizon are increased fishing activity by virtue of the new 200 mile limit, offshore petroleum exploration, and the increasing economic attractiveness of waterborne transport, to name but a few. In order to serve these new possibilities, drastic upgrading of our waterfront facilities will be required. To do this in an economic and environmentally acceptable manner will require a revival of Yankee ingenuity and innovation and a thorough knowledge of the unique problems inherent in marine construction in New England.

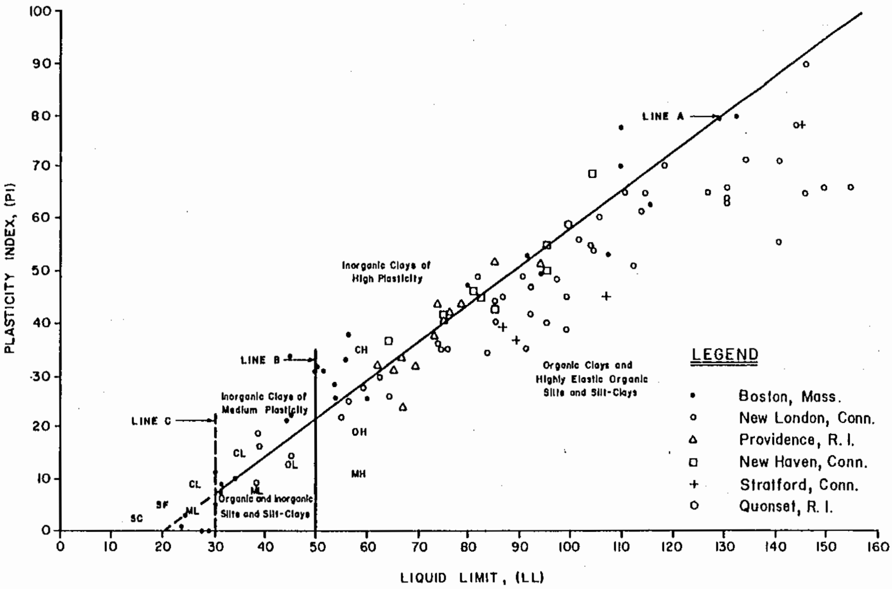


Figure 1. Plasticity Chart, Organic Silt Sediments.

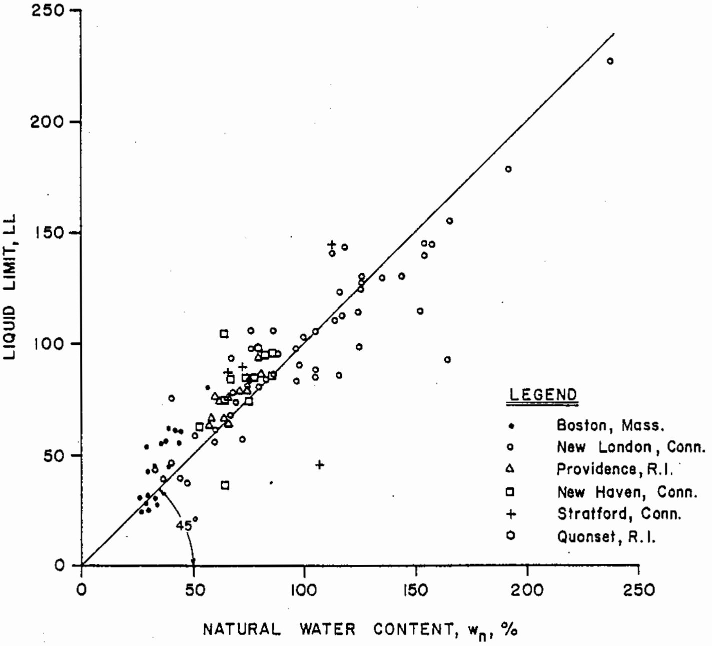


Figure 2. Liquid Limit vs. Water Content, Organic Silt Sediments.

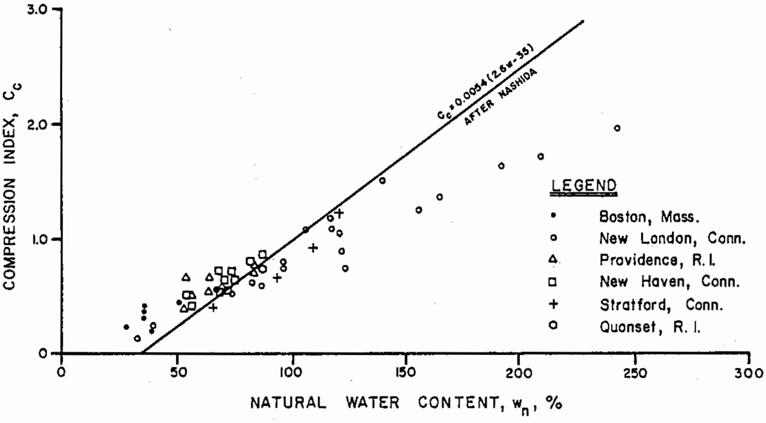


Figure 3A. Compression Index vs. Water Content, Organic Silt Sediments.

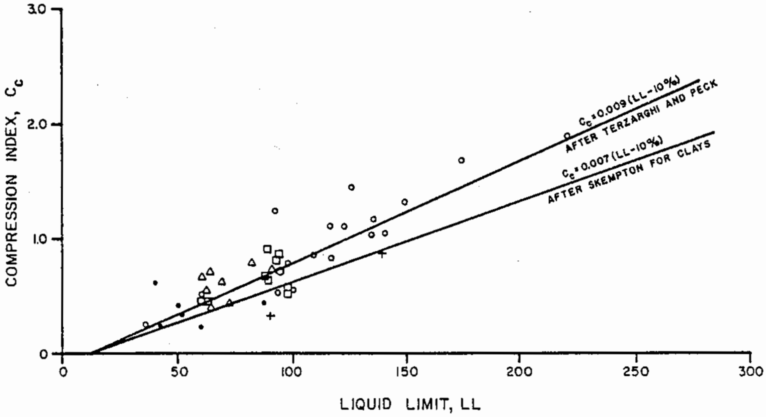


Figure 3B. Compression Index vs. Liquid Limit, Organic Silt Sediments.

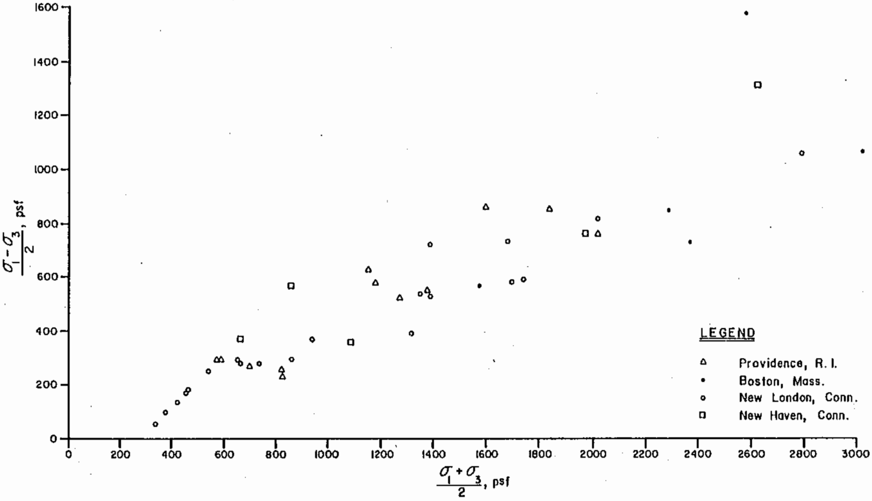


Figure 4. Triaxial Test Results, Organic Silt Sediments (Total Stress, Consolidated-Undrained).

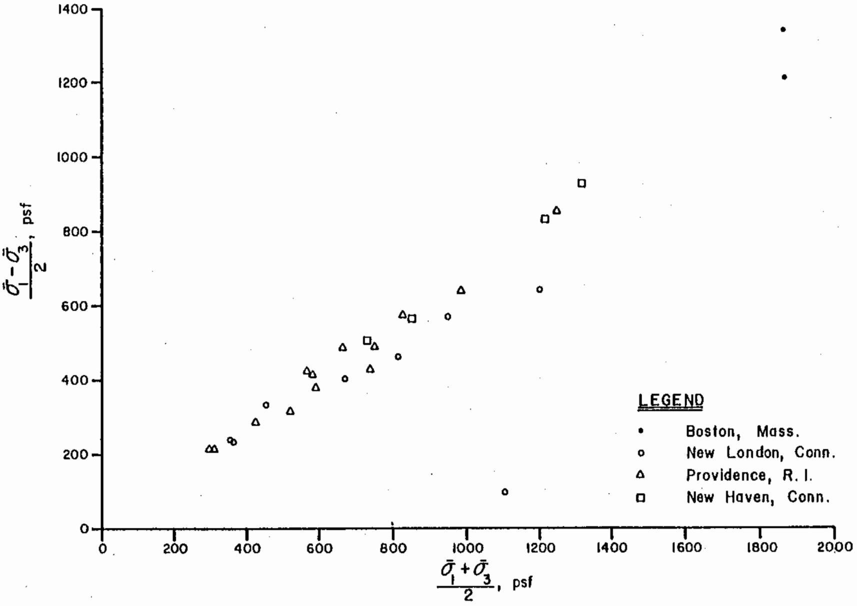


Figure 5. Triaxial Test Results, Organic Silt Sediments (Effective Stress, Consolidated Undrained).

TABLE 1
Chemical Test Data, Organic Silt Sediments

		VOLATILE SOLIDS (%)	CHEMICAL OXYGEN DEMAND (%)	KJELDAHL NITROGEN (%)	OIL & GREASE (%)	LEAD (%)	ZINC (%)	MERCURY ppm
EPA GUIDELINES 1973		6.0	5.0	0.10	0.15	0.005	0.005	100
PROVIDENCE	average	5.7*	9.0	0.18	0.23	0.0017	0.0009*	90*
	peak	14.7	218	0.48	0.49	0.0059	0.0018*	230
FALL RIVER	average	11.6	18.0	0.32	1.10	0.061	0.0831	280
	peak	15.2	25.4	0.47	1.72	0.090	0.1394	450
MOUNT HOPE BAY	average	5.1*	—	0.19	0.11*	0.0029*	0.0095	40*
	peak	6.3	—	0.33	0.18	0.0059	0.0180	210
TAUNTON RIVER	average	8.1	—	0.29	0.42	0.0141	0.0308	277
	peak	13.2	—	0.52	0.80	0.0426	0.0728	603

*FALLS WITHIN EPA GUIDELINES

TABLE 2
Shake Test Results

	VOLATILE SOLIDS (mg/l)	TOTAL SOLIDS (g/l)	CHEMICAL OXYGEN DEMAND (mg/l)	KJELDAHL NITROGEN (mg/l)	TOTAL NITROGEN (mg/l)	OIL & GREASE (mg/l)	LEAD (μg/l)	ZINC (μg/l)	MERCURY (μg/l)	CADMIUM	HYDROGEN SULFIDE (mg/l)
NEW LONDON	822	36.6	273	2.96	12.4	10.5	5.8	16.3	0.3	0	0.28
seawater	1618	25.7	262	0.26	—	7.5	15.0	6.0	70.1	—	70.01
EPA guidelines*							8.7	24.4	0.4		
FALL RIVER							940.0	100.0	75.5		
seawater							23.0	20.0	9.0		
EPA guidelines*							35.0	30.0	14.0		
PROVIDENCE							62.0	51.0	16.0		
seawater							36.0	34.0	11.0		
EPA guidelines*							54.0	51.0	17.0		

* EPA Ocean Dumping Criteria, May 1973: The concentration of the constituent in a standard elutriate after a Shake Test should not exceed its ambient concentration in the composite water by a factor of 1.5.

WASTEWATER DISPOSAL PLANNING AND THE SOCIETAL MATRIX

By
William B. Moeller[1]

Introduction

The problem of determining an optimum engineered solution to sanitary waste disposal in an unsewered community is often very difficult. The designer is confronted with legislation from many levels of government, residents increasingly inclined to criticize and reject proposals, the need for cost control in public works; and from state and federal agencies, pressures upon client communities for decisive action. In addition to those non-engineering complications, there is the continual evolution in the state-of-the-art.(1,2) Even if not germane to a project, an engineer will likely have to field questions at public hearings about composting toilets, grey water separation, rotating biological contactors, septage treatment, sludge composting and many other subjects now increasingly on the minds of people suspicious of the engineer and his level of knowledge.

This paper presents arguments to support the proposition that additional emphasis must be directed toward optimization of design with due regard to secondary effects on the structure of society if a new system of wastewater disposal is considered. These secondary effects within a community are herein called the "societal matrix". Some examples for a community in Massachusetts will be considered by way of illustration.

No formula is proposed by which the design engineer can hope to ease the travail of completing a design study. However, it is believed that understanding the concept put forth will aid the engineer by sensitizing him to issues likely to surface during the period of public consideration of the engineer's proposal.

General Background

Our thinking on how best to dispose of nightsoil has had several stages of historical development. In medieval Europe it was often thrown into the street where it could mix with stock wastes and, everyone must have hoped, could be washed away in the runoff whenever it rained.

The privy, when it became generally adopted, was much better. Periodically the pit would have to be cleaned. The nightsoil would be loaded into a wagon which would then take it somewhere, often to a farm field, for disposal. In cities the privy became rather elaborate. Multi-storied tenements would have them arranged off the back porch at each level. The wastes would drop via wooden chutes to a hopper below.

As our society changed over to indoor plumbing, it was natural to connect

---

[1] Associate Professor and Chairman, Civil Engineering, University of Lowell, Lowell, Massachusetts.

the house sanitary drains to the storm sewer. In urban areas horses, mules, donkeys and oxen were the source of motive power, so there was already a strong waste with high solids content to be carried by the storm sewers whenever there was runoff. The contribution from households was relatively insignificant both hydraulically and as a percentage of solids that might collect during low flow.

It is noteworthy that when these early technological advances in waste disposal were taking place, most persons were unaware of the possibility of contamination and disease from human waste. Thus, it appeared logical and certainly most economical to develop a common water carriage disposal system carrying through to the end of the local storm sewer and discharging to a water course or body of water, which, unfortunately, might also serve as a source of domestic water. Some aesthetic problems developed at the end of the pipe, of course, but these were usually relatively local in scope, and part of the price of progress. As people became aware of the disease connection it was certainly easier and safer to purify the water than to correct matters at the source of pollution. Initially purification was by filtration*, later by disinfection by chlorination** as well. To attempt to clean up the flows to the combined sewers or at the outfall would have been a monumental task that, even if one hundred percent effective, would not have assured safety against disease in water supplies.

In the eighteen fifties and sixties as suburbia expanded, septic tank disposal systems proliferated. However, lack of control over siting, design, and density often resulted in high rates of failure. The result has been the evolution of a philosophy that argues for putting in sanitary sewers and treatment plants, thereby eliminating on-site problems. The current Federal Act, PL 95-217, The Clean Water Act of 1977, by the coercive influence of the massive state and federal subsidies it promises, has had the effect of making this approach a national campaign.

We have discovered that there are a few penalties that must be borne as the price of this campaign. In many cases, treated wastewater is released in such large amounts, and sufficiently burdened with nutrients that the water quality of the receiving waters deteriorates. The operation and maintenance costs of treatment plants are large and increasing.

It should be credited to the Environmental Protection Agency (EPA) that it has established an office for small flows. That office will be directing efforts at development of optimum treatment practices for single sources or small clusters of waste generating units.

One can see a pattern in the history of waste disposal: a consistent treatment of the problems by an expedient adequate to meet the immediate need for a solution, but without extensive consideration for effects beyond that.

Today, it is necessary to widen our thinking. We must plan from a more

---

*Filtration was practiced in some cases, as in Poughkeepsie, N.Y. in 1872,(3) before our awareness of the cause of water borne diseases was developed, to clarify turbid waters.

**Jersey City, N.J. in 1908 was the first municipality in the United States to use chlorine routinely to disinfect its water. Chloride of lime was the source of the chlorine.(4)

difficult perspective regarding our domestic wastewater disposal — a perspective that treats it as but one aspect of the interwoven structure of society.

The demand for prompt elimination of sources of pollution, and the availability of massive subsidies for the construction of many components of a sewerage system including a treatment facility, have generally had a strong impact upon the form of the final design. An additional influence has often been the source of the request for technical assistance. Usually it is a sewer commission or board, set up by a town in response to a rising volume of complaints about on-site waste disposal. Such a body will often phrase its request in such language as to clearly indicate that sewering of the community is to be the subject studied. The final design recommendation put forth by the consultant under these conditions becomes, more often than not, a blueprint and timetable in which is set forth the starting dates, the scope of work, and the sequence of stages of development of a sewering plan for the client community. Thus, because the designer is usually overly limited in what he is to study, the study process does not include adequate consideration of the greater societal matrix of which disposal of liquid sanitary waste is but one link.

Present Federal legislation and policy have tried to make some provision for this by requiring the "201 Facilities Plan, Step One" to consider alternatives to comprehensive sewering; and "208 Areawide Wastewater Management Studies" to clarify the problems and potentials on an integrated, regional, multi-aspect basis. The 201 studies are to be harmonious with the output of the 208 reports.(5)

Any scheme for disposal of sanitary wastes involves and generates linkages between seemingly dissimilar, unrelated aspects of the functioning of our society. Sub-systems of all different types are interrelated and interdependent in a very complex way. Sanitary waste disposal is a sub-system concerned immediately with liquid waste generation, transportation, processing or stabilization, and disposal. It is not adequate to address this subsystem in vacuum.

Optimization of the proposal to develop one sub-system requires that it be looked at with due respect to the interactive points at which it is tied into the whole, through which the effect of internal change is transmitted. For example, it should be demonstrated that the interconnection between generation of liquid domestic sanitary waste and the impact upon the community water supply system have been carefully evaluated. Ignoring such a potentially significant effect while offering a supposedly optimum proposal would seriously flaw the logic of the proposal.

Because each community is unique, no universally applicable formulas can be prescribed by which the wastewater problems of a community can be cured or by which optimum facilities investments are assured.(6) This paper will merely try to offer some insights about where to look for the linkages, the interconnections, between the liquid waste disposal and other services.

The most important objective of the paper is to make the reader more aware of the importance of thinking in terms of the larger social situation when faced with a specific societal problem. Such an approach is valid whatever the problem. An interesting case for purposes of discussion exists in a community in northeastern Massachusetts. Several engineering studies have been done on its sanitary wastewater disposal problem. There is governmental pressure being put on the town by EPA and the Massachusetts Division of Water Pollution Control to build treatment facilities.

Discussion Model

The following is a simplified model of that community. The town is at present involved in an intense controversy over sewering. It offers a good model for discussion of the thesis of this paper because it seems to represent a typical situation. About twenty years ago the town consisted of several separated villages with country roads and scattered development along those country roads. (In 1950 the population was 9,000; in 1960, 15,100; in 1970, 31,400 and in 1977, 31,700). The housing densities, except in the village centers, were low, land was open; there was an abundance of it. There were, however, some problem areas even in the fifties. They weren't necessarily viewed at that time as being problem areas, at least not with as much feeling as today, but today we see by hindsight that even then they were. One of the problem areas is in the village closest to the Merrimack River. Several old mills, following the historic pattern typical throughout New England, have sewers and drains connecting directly to the river, or when not to the river, to the tributary stream upon which the mill is located. Locally generated domestic wastes are also conducted to these sewers, or to the storm sewers in the streets. Many of the homes in the area, not connected to the combined sewer, directed their wastewater to what we would frequently judge today to be an inadequate on-lot disposal system, i.e., a cesspool or small septic tank.

Another problem area in town is of more recent origin. It is in an area along a state route passing through the town center. Some of the development took place on land that was low. The not unexpected result is that improperly treated waste finds its way into the local water courses. Many of these water courses are not obvious in that area because they have been put underground in storm drains. However, where they emerge the distinctive odor of improperly treated wastewater can frequently be detected.

As development has progressed over the past years additional problem areas have arisen due to a variety of circumstances, one being the issuance of permits for on-site disposal on lots that had too high a water table for the kind of soil, and housing density, with the result that over the years the water table has been raised. Problems came about as these disposal systems became flooded. And finally there are the scattered situations where disposal systems have become obvious problems because of leach field effluent breakout. These units are located anywhere where the soil conditions are bad due to shallow bedrock or tight soil. Problems also arise from reasons not associated with lot size or regional high groundwater, such as improper design, or installation, or use.

This simplistic model of the town does not attempt to characterize all of the problem situations that face the town, but it is possible none the less to go on and use it as a means for discussing interrelationship, and to illustrate the complexity to be dealt with when trying to determine a solution or solutions for a similar community.

There are, in this example, four dissimilar situations. With such dissimilar conditions to contend with there is not likely to be a simple solution. However, it is worth considering singular solutions because they provide a basis for generating more complex solutions and serving as a base for later comparisons. One commonly pursued solution is to sewer the entire community and build whatever treatment facilities are necessary. This proposal should certainly cure the existing problems, dissimilar in origin or not. Another solution is for the town to adopt the head-in-the-sand, do-nothing approach, — evidently a least cost approach. This might well be preferred by the majority who do not have an immediate problem. Both of the approaches are extreme, and in the second case ignore state and federal statutes. Neither seems to be an optimum solution. Perhaps, however, some partial adoption of both might be a reasonable solution subject to upgrading in the future, i.e. sewer only part of the town.

Indeed, there are many more than two approaches which should be evaluated. The overall problem may involve a multitude of very different solutions; some of which at first glance appear to be uneconomical and even worse than no solution at all. Some might be not even applicable.

While the number of possible unique or unusual solutions that might be considered are many, a few of the more easily identified of these would be: (1) installation of a large sewerage system in the community with associated treatment facilities, (2) use of small area collection and treatment plants of diverse types serving a cluster of units where there is a small isolated problem, (3) the outright purchase and elimination of a waste generating unit where there is a continuous health hazard and no reasonable solution more cost effective for the community, (4) the implementation by the community of an ordinance requiring adoption of a program for periodic pumping of septic tank units so as to enhance or preserve the functioning capability of existing units, (5) municipal acquisition of on-lot systems including access and repair easements, and a municipal program for routine pumping and maintenance of all acquired systems with an appropriate annual service charge per unit, (6) support by the community health agency of installations of dry or composting waste disposal facilities, (7) education of homeowners in water use efficiency, (8) legislation banning high water consuming practices in general, or selectively in areas where there are problems, (9) the imposition of progressive water use rates which make it very uneconomical for individuals to over-consume.

Consideration of Societal Matrix

Up to this point the discussion has basically been traditional in that waste disposal problem situations and possible solutions have been the only topics considered. We should now go on to look at a second, very important complementary aspect of any such study; i.e. a consideration of linkages between the waste generating units, the proposed solutions for wastewater disposal, and the other aspects of life in the community.

The first and most obvious interrelationship arises from the fact that the origin of most wastewater is the water distribution system. The prospect of a problem in the back yard because of excessive use of water tends to make consumers very careful not to aggravate the condition. Where a community disposal system is installed, the water use per capita or per dwelling unit typically goes up rather considerably. The water consumption prior to completion of sewers is said to have suffered from "use suppression".

A study conducted by the author of conditions in a community in Rhode Island gives a clear demonstration of "use suppression". In the early 1960's water use in one of the historic village centers averaged approximately 35 to 40 gallons per capita daily. This unusually low value was the result of the severe waste disposal restrictions that the local soil conditions imposed on the on-site disposal systems of the affected population, these systems being largely replacements for the privies of an earlier era. People in the same community located only a few blocks from this particular area, and who had what one might call normal water consumption rates, consumed on the order of 100 to 130 gallons per capita daily. Plans were made to sewer the problem area. The author does not know what the current water use is in that former problem area, but it is fair to assume that it must be at least up to the regional mean of about 110 gpcd rather than the suppressed 35 to 40 gpcd to which people were formerly accustomed.

Even in those cases where there had not been a conscious effort on the part of homeowners to conserve water, there is usually a considerable percentage increase in per capita consumption when sewers are installed, partly because of subsequent installation of washers, disposals, etc., and because many things that homeowners knew were unacceptable practices in the past, such as using water to flush grease and coffee grounds and other kitchen refuse down the sink and into the house drain, now become feasible. This fact is generally considered by engineers designing systems. They do not automatically base their flows on a linear extension of water use records when planning for sanitary sewers in previously unsewered areas. (Of course, areas already on combined or obsolete sewers usually have no use suppression and so will not show such a change in consumption.) Thus, the change in opportunity for disposal of additional waste products or alternative means of disposal often brings about an additional demand for potable water from the water supply.

Industry also responds to the installation of sewers. Initially, the plants already in town at the time of the installation may show no significant change. However, once a community is sewered, industries that produce large waste-water flows are now able to come in. As a result there may be the gradual appearance of new industry with higher water consumption patterns than had been expected prior to the installation of sewers.

Another linkage between sewering and water supply is generated when provision of sewers makes construction of high density housing and industrial parks feasible. Also, when a new sewer services an area that had been, because of bedrock or water table situations, unsuitable for development with on-site disposal facilities, that land may suddenly become very developable. Thus, even with wetland zoning and other land use restrictions, a community suddenly finds an increase in its developable area as sewering takes place. The impact on water demand, as the opportunities just mentioned are developed, can be dramatic. Therefore, in a community having very limited water sources, sources which are largely already dedicated, the impact of a sewering program can be extremely traumatic. The cost of finding a water supply solution under those circumstances should be considered along with the cost of sewering.

The last statements lead us to consider yet another area of profoundly important linkage, perhaps the most important of all: implications of a liquid waste disposal scheme for a community and long term community planning. The policy statement that a community undertakes when it is making its decision on a community liquid waste disposal scheme is a statement of growth policy, and it cannot be understood as anything but that. After all, the provision or the exclusion of sanitary sewers ordains to a great extent what the immediate and long term growth potential shall be in a given part of the community.

In a community that wants to articulate clearly that it wants to grow, to acquire industry, to increase its density, good planning will promote that objective by suggesting to the community that prior to the development period it must provide for sanitary sewers, adequate water distribution systems, fire department capability, and all the other public works bases upon which the growth of the community can take place. Once the growth begins, schools and other services will also be called for.

Not uncommonly a failure to duly consider the impact of constructing wastewater disposal facilities may led to unexpected impacts upon surface and ground water sources of the community and upon the quality of these sources. An area with a high density of leach field disposal systems, pollution hazard aspects aside, experiences a significant amount of recharge of ground water. The additional ground water helps to maintain stream flow during periods of drought. Sewering may thus appreciably alter low flow characteristics of streams, and the watertable.

The field of public health in the U.S. has come a long way since the 1900's when typhoid, cholera, dysentery and other enteric water borne diseases were common throughout all of the United States and the rest of the world. Until then, contaminated wastewater all too frequently was discharged into sources of municipal water supply, and the result was tragic. It should certainly not be thought that we can go backward and be more tolerant of unsafe conditions by permitting any increase in the potential for wastewater to contaminate our surface or groundwater supplies. Unfortunately, all too often in the recent past there has seemed to be the point of view taken that we don't have to worry about these potential hazards any more because our water supplies go through treatment plants which are there to protect our health. It is only, or is largely, our inattention to the continued escape of pollutants into our aquatic environment that makes it so imperative that we have such extensive treatment facilities in so many towns. Because of the pollution loads that many water bodies carry, even treatment does not render the water aesthetically satisfactory for much of the year. Therefore, attention to the aspect called "ultimate disposal" similarly needs attention.

Implications of Sewering

To return more specifically to the given example, it is instructive to discuss relationships and potential ramifications to be considered with regard to sewering the model community. As noted earlier, community wastewater collection and treatment has been the only method of community controlled sanitary waste disposal endorsed by state and federal legislation, and thus eligible for state and federal subsidy for certain capital costs.

Sewering our model would be a very extensive public works project. One cost estimate is in the neighborhood of $47 million, or almost $1,500 per person. It should be understood that this is only the cost for sewering. It is often argued that this is really not a large capital expenditure for a community because a large portion of the funds would be provided by state and federal sources. Such an argument is specious since those funds are collected from the community in taxes, both state and federal. But even where most of the capital cost of sewering is paid for by non-local funds, there are other first costs which must be borne directly by the homeowners along the sewer lines. Among these are the tie-in costs which consist of two parts. The first is the cost of rerouting the house plumbing to the direction of the city sewer and installation and connection of the house drain from foundation to sewer. The second part of the tie-in cost is that associated with abandonment of the on-site system. In many communities it is required that abandoned tanks be pumped out and then filled with inert material. Usually an individual on a street being serviced by a sanitary sewer is not free to choose whether or not he will tie in; he is usually required to tie in by a certain date. He is, therefore, forced to expend his money for this, even if his system has been well maintained and is serviceable. The change-over costs may be several hundred dollars. (Exact values are not critical to this discussion.)

A very important question for citizens of the town to ask is who will be connected to sewers or served with sewers for the $47 million, more or less, that will have to be paid. Will it be 100% of the citizens of the community or will it be a smaller portion smaller than that, perhaps 40%, 50%, or 60% of the population? If it is much less than 100%, the cost per person served becomes considerably more. The $1,500 per capita assumed that everyone in the community would be served by the sewers. This is seldom the case no matter how densely the community is developed and how extensive the installation. If a proposed system is to serve part of a town, other questions arise: How much will it cost to extend the service later? Where will the service be extended? When will it be extended? And, what will be the cost per user?

Finally, the economic analysis must include the salvage value of systems in the ground that are to be superseded by the installation of sewers. These systems have a rather high replacement value; many of them are functional and would remain functional for many years into the future. One must therefore consider the scrapping cost which may be approximated by estimating the percentage of life-time remaining and applying it to replacement cost. The actual cash value is a function of interest rates and there are several available ways of accounting for such worth. The value of abandoned units becomes a net liability for the community because it is impossible to salvage them.

Unfortunately, the first cost of a sewer system is only part of the annual cost that must be borne by the residents of a community. Perhaps the larger part of the total cost of having wastewater disposal by sewers and a treatment plant is the continuing operation and maintenance (O & M) cost. The O & M cost is very sensitive to the cost of energy; and many treatment processes are relatively energy intensive. For example, although the volumetric proportions of solids to liquids in raw sewage is much less than 1%, sludge processing typically is responsible for approximately 50% of the O & M cost of a wastewater treatment plant.(7)

There is another cost category that is not generally included in a sewering study, but which must be considered when the plan to sewer is considered. It is the potential incremental cost for upgrading to achieve nutrient removal. Conventional treatment, that is, secondary treatment, while it removes most of the organic material from the wastewater stream, leaves the nutrients, the stimulants to aquatic plant and animal growth. All too often the reach of receiving water downstream from the point of discharge becomes a new site of pollution because of eutrification of the receiving waters. The remedy may be for the community to install tertiary, or advanced wastewater treatment facilities. Such plants are very expensive. Costs for running a treatment process of this type may equal that of the secondary treatment that is typically installed as a first phase.

One last aspect remains with regard to consideration of sewers for a community such as the one used here for an example. It must be considered as soon as one agrees that linkages through the societal fabric are of potential significance. Unfortunately, it is largely outside of local control and hard to see fully, or unequivocally, even in the best of circumstances. It is the deliberate governmental practice of utilizing large public works expenditures to carry out social-welfare economic policies. Projects provide jobs; jobs are essential in a flourishing economy. Construction of sanitary sewers and wastewater treatment facilities provide a tremendous opportunity for the implementation of this policy. For the short term it cannot be denied that these projects will indeed succeed in putting people to work. Many of the alternatives offer much less opportunity for such economic stimulation.

Summary

The need to consider the "societal matrix" when planning for sanitary waste disposal in a community has been demonstrated by means of a simplified model of a community in Massachusetts. The significance of the decisions made with regard to wastewater disposal options, especially as it related to water supply and land use planning, has been shown.

It is suggested that proper planning for domestic wastewater disposal should consider several options and combinations. These options must be considered with due regard to total cost, including operation and maintenance, and costs of septic tank abandonment if called for. Major capital costs for other municipal activities likely to be impacted should be taken into account in addition to the wastewater facilities costs. Impacted activities would certainly include water supply, zoning, retail and other business, and growth policy and land use planning.

References

1. Troyan, J.J.; Norris, O.P.; "Cost-Effectiveness of On-Site and Community Sewerage Alternatives" *Civil Engineering ASCE,* Dec. 1977, p. 84.
2. Bell, H.F.; "Reviving the Septic Tank", *Civil Engineering ASCE* Dec. 1977, p. 83.
3. Fair, G.M.; Geyer, J.C.; Okun, D.A.; *Elements of Water Supply and Wastewater Disposal;* 2nd edition, New York, John Wiley & Sons, 1971, p. 397.
4. Ibid, p. 512.
5. PL 95-217 (Federal Clean Water Act); Section 201, Section 208, U.S. Congress, Washington, D.C., 1977.
6. Borgos, M.F.; "Cost and Growth Implications of Reserve Capacity in Sewerage Facilities", *New England Water Pollution Control Association Journal* Vol. 12, No. 1, April 1978.
7. Wasserman, K.L.; "Can California Cope With Its Mounting Sludge Volumes?"; *Civil Engineering ASCE;* Feb. 1978, p. 61.

U.S. POSTAL SERVICE

STATEMENT OF OWNERSHIP, MANAGEMENT AND CIRCULATION

(Required by 39 U.S.C. 3685)

1. TITLE OF PUBLICATION Journal of the Boston Society of Civil Engineers	2. DATE OF FILING 10/1/78

3. FREQUENCY OF ISSUE quarterly	A. NO. OF ISSUES PUBLISHED ANNUALLY @2444	B. ANNUAL SUBSCRIPTION PRICE $10.00

4. LOCATION OF KNOWN OFFICE OF PUBLICATION *(Street, City, County, State and ZIP Code) (Not printers)*
80 Boylston Street, Suite 1110, Boston, Ma 02116

5. LOCATION OF THE HEADQUARTERS OR GENERAL BUSINESS OFFICES OF THE PUBLISHERS *(Not printers)*
80 Boylston Street, Suite 1110, Boston, Ma 02116

6. NAMES AND COMPLETE ADDRESSES OF PUBLISHER, EDITOR, AND MANAGING EDITOR

PUBLISHER *(Name and Address)*
Boston Society of Civil Engineers/ASCE, 80 Boylston Street, Boston, Ma 02116

EDITOR *(Name and Address)*
Edward C. Keane, 80 Boylston Street, Boston, Ma 02116

MANAGING EDITOR *(Name and Address)*

7. OWNER *(If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding 1 percent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a partnership or other unincorporated firm, its name and address, as well as that of each individual must be given.)*

NAME	ADDRESS
Boston Society of Civil Engineers Section	80 Boylston Street, Suite 1110
ASCE	Boston, Ma 02116

8. KNOWN BONDHOLDERS, MORTGAGEES, AND OTHER SECURITY HOLDERS OWNING OR HOLDING 1 PERCENT OR MORE OF TOTAL AMOUNT OF BONDS, MORTGAGES OR OTHER SECURITIES *(If there are none, so state)*

NAME	ADDRESS
none	none

9. FOR COMPLETION BY NONPROFIT ORGANIZATIONS AUTHORIZED TO MAIL AT SPECIAL RATES *(Section 132.122, PSM)*
The purpose, function, and nonprofit status of this organization and the exempt status for Federal income tax purposes *(Check one)*

☐ HAVE NOT CHANGED DURING PRECEDING 12 MONTHS ☐ HAVE CHANGED DURING PRECEDING 12 MONTHS *(If changed, publisher must submit explanation of change with this statement.)*

10. EXTENT AND NATURE OF CIRCULATION	AVERAGE NO. COPIES EACH ISSUE DURING PRECEDING 12 MONTHS	ACTUAL NO. COPIES OF SINGLE ISSUE PUBLISHED NEAREST TO FILING DATE
A. TOTAL NO. COPIES PRINTED *(Net Press Run)*	2444	2375
B. PAID CIRCULATION 1. SALES THROUGH DEALERS AND CARRIERS, STREET VENDORS AND COUNTER SALES	none	none
2. MAIL SUBSCRIPTIONS	2239	2075
C. TOTAL PAID CIRCULATION *(Sum of 10B1 and 10B2)*	2239	2075
D. FREE DISTRIBUTION BY MAIL, CARRIER OR OTHER MEANS SAMPLES, COMPLIMENTARY, AND OTHER FREE COPIES	none	none
E. TOTAL DISTRIBUTION *(Sum of C and D)*	2239	2075
F. COPIES NOT DISTRIBUTED 1. OFFICE USE, LEFT OVER, UNACCOUNTED, SPOILED AFTER PRINTING	205	300
2. RETURNS FROM NEWS AGENTS	none	none
G. TOTAL *(Sum of E, F1 and 2—should equal net press run shown in A)*	2444	2375

11. I certify that the statements made by me above are correct and complete.	SIGNATURE AND TITLE OF EDITOR, PUBLISHER, BUSINESS MANAGER, OR OWNER X Edward C. Keane, Editor

12. FOR COMPLETION BY PUBLISHERS MAILING AT THE REGULAR RATES *(Section 132.121, Postal Service Manual)*

39 U. S. C. 3626 provides in pertinent part: "No person who would have been entitled to mail matter under former section 4359 of this title shall mail such matter at the rates provided under this subsection unless he files annually with the Postal Service a written request for permission to mail matter at such rates."

In accordance with the provisions of this statute, I hereby request permission to mail the publication named in Item 1 at the phased postage rates presently authorized by 39 U. S. C. 3626.

SIGNATURE AND TITLE OF EDITOR, PUBLISHER, BUSINESS MANAGER, OR OWNER
X Edward C. Keane, Editor

PS Form 3526 *(Page 1)*
Apr. 1976

(See instructions on reverse)

ANDERSON-NICHOLS
& Company, Inc.
A COMPREHENSIVE ENGINEERING AND MANAGEMENT SERVICE
Consulting Engineers
Boston, Massachusetts
Concord, New Hampshire
Hartford, Connecticut

CAMP DRESSER & McKEE INC.
Offices Throughout the U.S.

One Center Plaza
Boston, Massachusetts 02108

environmental engineers, scientists, planners, & management consultants
CDM

THE AUSTIN COMPANY
Designers • Engineers • Builders
★ ★ ★
General Offices: Cleveland, Ohio 44121
Offices in principal cities of North America, Europe, South America and Australia
Wellesley Hills, Mass. 02181 Tel. (617) 237-1438

ANDREW CHRISTO, Engineers
CONSULTING ENGINEERS
230 Boylston Street
Boston, Mass. 02116
Tel. 266-2525

BARNES ENGINEERING COMPANY, Inc.
Civil Engineers
411 Lexington Street
AUBURNDALE, MASS. 02166

CR
(617) 482-3440
COFFIN & RICHARDSON
Architects and Engineers
Water Supply and Wastewater Engineering
Rates and Valuations
141 Milk Street, Boston, Massachusetts 02109

CLINTON BOGERT ASSOCIATES
Consulting Engineers
Water Resource Development • Wastewater Management
Flood Control • Regional Planning • Value Engineering
Industrial Waste Treatment • Solid Waste Management
Municipal Engineering
2125 Center Avenue, Fort Lee, N.J. 07024
(201) 944-1676

Congdon, Gurney & Towle, Inc.
Engineers
53 State Street **Boston, Mass.**

BRASK & STANDLEY ENGINEERING CO.
Consulting Engineers
177 State Street, Boston
227-3170

CRANDALL DRY DOCK ENGINEERS, Inc.
Dry Docks — Piers — Waterfront Structures
Underwater Examination
21 Pottery Lane **Dedham, Mass.**

HERBERT J. ALBEE, P.E.
ASSOCIATED
ENGINEERS
ARCHITECTS
857 WASHINGTON STREET
BRAINTREE, MA. 02184
848-8117

E. D'APPOLONIA
Consulting Engineers, Inc.
Foundation Engineering
Vibrations & Soil Dynamics
Applied Mechanics
ENGINEERING OFFICES
10 Duff Road — M. R. 522B
Pittsburgh, Pa. 15235 — Chesterton, Ind. 46304
(412 - 242-5107) — (219 - 926-3814)
CORPORATE OFFICE
1177 McCully Drive, Pittsburgh, Pa. 15235

FAY, SPOFFORD & THORNDIKE, INC.
Engineering for Public Works and Industry
One Beacon Street, Boston, Mass. 02108

De Leuw, Cather & Company
Engineers
Public Transit — Traffic — Parking
Highways — Subways — Railroads
Community Planning — Urban Renewal
Municipal Works — Port Development
24 SCHOOL STREET
BOSTON, MASS. 02108

Ganteaume & McMullen
Engineers
99 Chauncy Street
BOSTON

RICHARD J. DONOVAN, INC.
ENGINEERS: Design & Construction Management
540 MAIN ST., WINCHESTER, MASS. 01890

GERAGHTY & MILLER, INC.
Consulting Ground-Water Hydrologists
Water Supply-Quality and
Pollution Problems
Regional Ground-Water Studies
Recharge-Well Design
44 Sintsink Drive East
Port Washington, N.Y. 11050
516-883-6760
Jacksonville, Fla. — Hartford, Conn.
Ponce, P. R.

E&K **EDWARDS and KELCEY**
Engineers and Consultants
470 Atlantic Ave., Boston, Mass.

GOLDBERG, ZOINO, DUNNICLIFF & ASSOCIATES, INC.
Geotechnical Consultants and Geologists
Foundations
Soil and Rock Mechanics
Geology and Geohydrology
Geotechnical Instrumentation
30 Tower Road ● Newton Upper Falls
Mass. 02164 — 617-244-4100

EUSTIS ENGINEERING CO.
Soil and Foundation Consultants
Soil Borings — Laboratory Tests
Foundation Analyses and Reports
3011 28th ST. — P. O. BOX 125
METAIRIE, LOUISIANA 70004

· WATER ·
· WASTEWATER ·
· SOLID WASTES ·
Chicago · New York · Philadelphia · Richmond · Tampa · Atlanta
GH GREELEY AND HANSEN

HALEY & ALDRICH, INC.
Consulting Geotechnical Engineers and Geologists

Soil and Rock Mechanics
Engineering Geology Engineering Geophysics
Foundation Engineering Terrain Evaluation

238 Main Street, Cambridge, Mass. 02142
617-492-6460

Haley and Ward
Civil and Sanitary Engineers
25 Fox Road - Waltham, Mass. 02154
Tel. 890-3980 Area Code 617

Testing • Inspection • Consultation
Engineering Services

The Haller Testing Laboratories
of Massachusetts, Inc.

68 LAUREL STREET • WATERTOWN, MASS. 02172
TEL. AREA CODE 617 924-2321

Hardesty & Hanover
Consulting Engineers
Bridges, Special Structures
Highways & Streets
Heavy Machinery, Sewers, Pipelines
Electrical Controls, Lighting,
Soil Mechanics & Foundations
Design - Reports - Inspection
101 Park Ave. New York, N.Y. 10017

J. F. HENNESSY
Civil Engineer

BROOKLINE, MASS. 02146

4 CYPRESS STREET 566-3860

HNTB HOWARD NEEDLES TAMMEN & BERGENDOFF

Planning and design for:
Transit **Airports**
Highways **Environmental systems**
Bridges **Public and Private Buildings**
Offices in 22 cities
Suite 3050, Prudential Center,
Boston, Mass. 02199 617 267-6710

KEYES ASSOCIATES
Engineers/Planners

• Master Planning • Industrial Parks • Commercial, Office and Industrial Buildings • Manufacturing Facilities • Process Piping
• Machinery Layout • Environmental Analyses • Waterworks
• Mechanical and Electrical Engineering • Waterfront Projects
• Sewage and Industrial Wastes • Dams, Flood Control
• Highways, Bridges, Airports • Schools, Housing Projects
• Studies, Reports, Designs, Plans & Specs

• Providence, R.I. • Waltham, Mass
• Wethersfield, Ct. • Nashua, N.H.

REPORTS • DESIGN • SUPERVISION
WATER SUPPLY • SEWERAGE • DRAINAGE • SOLID WASTES
HIGHWAYS • BRIDGES • AIRPORTS
COMMERCIAL AND INDUSTRIAL BUILDINGS
WATERFRONT FACILITIES • DAMS

CE MAGUIRE, INC.
ENGINEERS · PLANNERS
PROVIDENCE RI · WALTHAM MA · NEW BRITAIN CT
NEWINGTON NH · HONOLULU HI

MAIN
CHAS. T. MAIN, INC.
Engineers

Studies, Reports • Design • Construction Management

Southeast Tower, Prudential Center, Boston, Mass. 02116, Tel. (617) 262-3200
1301 E. Morehead St., Charlotte, North Carolina 28204, Tel. (704) 375-3761

Our Services Make A World Of Difference

M&E
METCALF & EDDY
Headquarters Office
50 Staniford St., Boston, Mass. 02114
Birmingham, Chicago, New York, Oklahoma City, Palo Alto

H.W. MOORE ASSOCIATES, INC.
Consulting Engineers

Civil — Structural — Sanitary
Urban Planning and Transportation

112 SHAWMUT AVENUE Tel.
BOSTON, MASS. 02118 357-8145

New England Survey Service Inc.
William S. Crocker, Inc.
Civil Engineers and Land Surveyors
First Order Surveys
Geodetic Surveys
Photogrammetric Surveys
1220 Adams St., Lower Mills, Boston, Mass. 02124
Tel: 287-1057
287-9059

JAMES A. O'DAY, INC.

CONSULTING ENGINEERS

Civil/Structural - Rate and Appraisal Studies
Water Supply - Wastewater
Utility Management - Telecommunications

4 Park Street
Andover, Massachusetts 01810
617-470-0606

TAMS

TIPPETTS-ABBETT-McCARTHY-STRATTON
ENGINEERS AND ARCHITECTS

850 BOYLSTON STREET
BROOKLINE, MASS. 02167
(617) 731-1550

HERMAN G. PROTZE
MATERIALS TECHNOLOGIST

36 Jaconnet Street
Newton Highlands, Mass.

TESTING INSPECTION RESEARCH
DEVELOPMENT CONSULTATION

tec tibbetts engineering corp.

CONSULTING ENGINEERS
CIVIL / SANITARY / STRUCTURAL

210 DEANE STREET, NEW BEDFORD, MASS. 02746
TEL. (617) 996-5633

Maurice A. Reidy Engineers

101 Tremont Street

Boston, Massachusetts 02108

CHARLES R. VELZY
ASSOCIATES, INC.

Consulting Engineers

Air & Water Pollution Control
Water Supply - Drainage
Solid Waste Disposal
Industrial Wastes

Mineola, N.Y. *Babylon, N.Y.*
**355 Main St. Armonk N.Y. 10504*

STORCH ENGINEERS

Boston, Mass. Hempstead, N.Y.
Wethersfield, Conn. Florham Park, N.J.

WESTON & SAMPSON
ENGINEERS, INC.
10 High St.
Boston, Mass. 02110

WATER SUPPLY TREATMENT DISTRIBUTION
RATE STUDIES SUPERVISION OF TREATMENT
WATER and AIR POLLUTION STUDIES and DESIGN
INDUSTRIAL WASTE TREATMENT
SOLID WASTE PLANNING AND MANAGEMENT

SHANNON & WILSON, INC.
Geotechnical Consultants
Soil & Rock Mechanics • Seismic Response
Foundation Engineering • Instrumentation
Geology & Geophysics • Hydrogeology
Seattle • Spokane • Portland
San Francisco • Fairbanks • St. Louis

W&H

WHITMAN & HOWARD, INC.
ENGINEERS & ARCHITECTS

45 WILLIAM STREET, WELLESLEY, MASS. 02181
TEL. 617-237-5000

THE THOMPSON & LICHTNER CO., INC.

Engineers

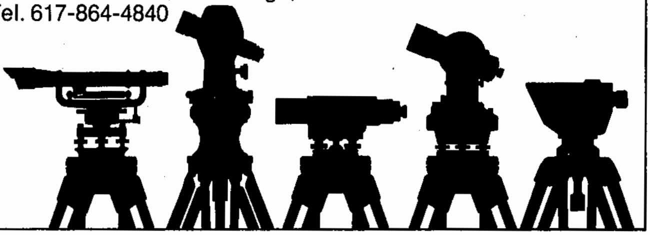
Designs and Engineering Supervision
Investigations, Testing and
Inspection of Structural Materials
Concrete, Asphalt, Soils Control

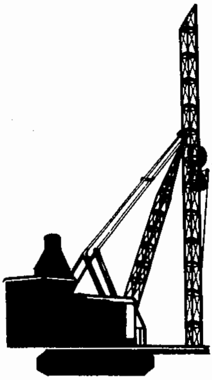
Offices and Laboratory, 8 Alton Place, Brookline 46, Mass

vtn

77 North Washington Street
Boston, Massachusetts 02114
(617) 227-6666

Engineers Architects Planners Consultants





BOSTON SOCIETY OF CIVIL ENGINEERS SECTION, ASCE

Committee Chairmen, 1978-1979

Committee	*Chairman*
ACTION PROGRAM - PROFESSIONAL PRACTICE	Rodney P. Plourde
ADVERTISING	John P. Hurney
ANNUAL MEETING	Frank E. Perkins
AUDITING	Edward B. Kinner
AWARDS	Edward B. Kinner
CONSTITUTION AND BYLAWS	Max D. Sorota
THOMAS R. CAMP FUND	Warren H. Ringer
CONTINUING EDUCATION	Ronald E. Sharpin
DISADVANTAGED YOUTH	Richard J. Scranton
EMPLOYMENT CONDITIONS	Maurice Freedman
JOHN R. FREEMAN FUND	Lee M.G. Wolman
HISTORY AND HERITAGE	H. Hobart Holly
INVESTMENT	Saul Namyet
KEY MAN	Robert M. Fitzgerald
MEMBERSHIP	Philip J. Caruso
NEWSLETTER	Leo F. Peters
NOMINATING	Charles A. Parthum
OPERATIONS MANUAL	Edward B. Kinner
PROGRAM	Frank E. Perkins
PUBLIC RELATIONS	Frank E. Perkins
PUBLICATIONS	William S. Zoino
SOCIAL AFFAIRS	Robert A. Snowber
STUDENT CHAPTERS	Roger F. Gardner
TASK FORCE, 1979 NATIONAL CONVENTION	Bertram Berger

Division Chairmen

Division	*Chairman*
ADMINISTRATIVE DIVISION	Edward B.Kinner
GENERAL TASKS DIVISION	Richard J. Scranton
PROFESSIONAL AND SOCIETY AFFAIRS DIVISION	Robert L. Meserve
TECHNICIAL DIVISION	Stanley C. Rossier

1848
BOSTON
SOCIETY
OF CIVIL
ENGINEERS

AMERICAN
SOCIETY OF
CIVIL
ENGINEERS
FOUNDED
1852