CHAPTER 21

FACTORS INFLUENCING AND LIMITING THE LOCATION OF SEWER OCEAN OUTFALLS

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A sewer outfall, or as it is commonly called and will be hereinafter termed, an ocean outfall, is customarily a pipe line extending seaward from the shore and designed to convey sewage and industrial wastes, treated or otherwise, to such a location offshore as is hoped, or expected, will prevent contamination of the nearby littoral waters, protect recreational facilities in the vicinity, and result in a disposal of the contaminating wastes without nuisance or meance to public health. Protection of aquatic life is at times the most important consideration.

Unless the cost of construction is very great or the ocean outfall rests upon a physically insecure or inadequate foundation, this method of final disposal of sewage and industrial waste is probably the most economical to be found because the ocean water and its dissolved components, together with certain microscopic and macroscopic marine life, are able to complete the destruction of even the most noxious wastes without difficulty if afforded the properly controlled opportunity. Thus, the presence of the ocean in or near the "front yard" of a municipality offers an almost irresistible temptation to dispose therein of the sewage of the community.

The term ocean outfall is, at times, applied to a sewer outlet which discharges its contents at or near high water. Scores of such outlets along the Pacific Coast empty into bays, estuaries, harbors and at river mouths. Since these have little, if any, effect upon the objective of this meeting they will be disregarded here, with the comment that they are decidedly insanitary, and further discussion directed toward outfalls which extend seaward or away from shore an appreciable distance and, in general, to a depth which does not interfere with navigation.

Principal among the functions of an ocean outfall is the discharge of contaminating waste at such a location as will prevent its return to shore in such quantity, concentration, and elapsed time as to constitute a source of contamination to the shore waters. Thus, a location for the construction of the outfall which might be otherwise satisfactory could, and many times should, be ruled out because it is unsatisfactory from a sanitary standpoint.

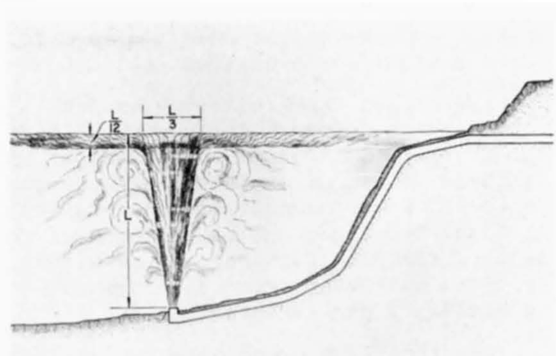
When fresh water or sewage is discharged at or near the floor of the ocean, its tendency is to rise with reasonable promptness to the surface. This is occasioned by the difference in specific gravities of the two fluids. In general, sewage may be expected to rise in an expanding column, the diameter of which at the point where the ocean surface is broken is about one-third of the length of the path from the point of discharge to the surface, and the thickness in which, as it spreads laterally over the surface, will approximate one-twelfth of the length of the rising path (Fig. 1). Factors likewise have been determined to indicate that the dilution of the fresh water or sewage with sea water will vary with the depth, direction, and velocity of the discharge at the ocean floor (Fig. 2).

Thus, one may predetermine with some degree of accuracy what will comprise the fluid mixture which, upon reaching the ocean surface, tends to spread laterally over it and which, correspondingly, will or may, be carried by the tide and wind induced currents into areas where it is not wanted.

From this it may be seen that the second series of factors to be considered are the wind currents and tidal currents because these have the controlling effect upon the time interval between the discharge of the water from the outfall pipe and its entrance in more dilute form into areas where it is undesirable. The limiting time factor from outlet to shore may be expressed as between three to ten hours, depending upon the degree of dilution, the presence or absence of large solids, and the extent of pre-treatment.

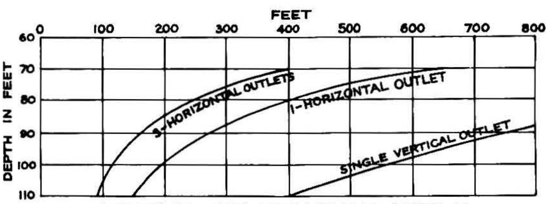
Irrespective of all other considerations those enumerated in the two paragraphs above should exercise the primary control in the location of the end of the pipe line from which the waste liquids are discharged, but from this another consideration springs. For instance.... a selected point of discharge may be such that partially treated wastes from it will travel with sufficient promptness and at sufficient concentration to adjacent shores so as to render the site objectionable. Nevertheless, the site may be utilized if the degree of treatment of the wastes prior to discharge is improved.

From this it follows that an otherwise unacceptable point of discharge may be rendered perfectly appropriate if treatment of the sewage onshore is more complete, leaving less of the work for the ocean to do; but it must be reckoned that the resulting costs for onshore construction and treatment will be materially greater and may outweigh other advantages which the site offers.



IDEALIZED SEWAGE FIELD
DISCHARGE FROM VERTICAL OUTLET

Fig. 1



RADIUS OF SEWAGE FIELD
100 C.F.S. - 1 PIPE

Fig. 2

Disregarding the possible destruction of an ocean outfall by dragging anchor flukes, sunken vessels or the like, it is probably physically possible to make a sound and permanent structure of such a pipe line almost any place. Construction may vary from the mere laying of pipe on a reasonably firm bed which apparently is, and in the past has been, undisturbed, to the resting of the line on piling at the ocean bed or above the water or excavation of a trench through solid material and the embedment of the pipe therein. Intermediate between the extremes are many combinations, and the use of many different construction materials, depending upon the diameter and length of the outfall and the forces, natural and otherwise, to which it is to be subjected.

There are two extremes offered in articulated pipe lines, one being the rigid type of structure designed to withstand all of the forces, natural and otherwise, to which it will be subjected without yielding at all, and the flexible type of structure, which may move reasonable distances laterally and vertically without leakage or rupture. Each has its place and a combination of the two may, at times, yield the most satisfactory structure.

An excellent example of the rigid type of structure is the Los Angeles City Outfall at Hyperion, wherein the reinforced concrete tubes, 100 ft. in length and 12 ft. in diameter, are set on concrete and steel piling and joined rigidly together. This outfall, only recently constructed, has not been in operation long enough to determine its permanency, but it appears to be capable of withstanding anticipated natural forces.

Two outfalls built by the Sanitation Districts of Los Angeles County at White Point are examples of the combination rigid and flexible type structures; the rigid portions of each being concreted-cased pipe laid in rock trenches from the shore some 2,000 ft. seaward, emerging thence onto the undisturbed sand floor of the ocean and laid to the end with flexible ball and socket joints at strategic intervals.

The outfall into San Francisco Bay now being constructed for the East Bay Sewerage Project by the East Bay Municipal Utility District will be critically observed as one which is moderately flexible to the end and one in which steel and rubber instead of cast iron and lead form the joints. All of these lines are of large diameter, the smallest being 60-in., the largest 12 ft.

For years the greatest weakness in articulated ocean outfall construction was found at the joints. These proved the undoing of two large diameter outfalls off the Southern California coast; one at Hyperion, and one at Santa Barbara. In each instance it was attempted to use the tongue and groove type of joint, concrete to concrete, with the annular space filled with plastic asphalt compound. Appraisal of these two lines indicated the need for a better and more secure method of connecting the pipe together and resulted in the construction of concrete pipe equipped with cast iron end rings, the rings joined to the pipe by welding to the longitudinal pipe reinforcement.

In the first open ocean outfall along the Southern California coast to show any degree of permanency, reinforced concrete pipe sections 60 in. in diameter and with a 7-in. shell thickness were equipped with mehanite cast iron end rings. The rings were welded to the longitudinal reinforcement and, for underwater connection, were so constructed that a pre-cast lead-caulking ring was driven into place from the inside of the pipe (Fig. 3). This method of joint construction has proved secure and sound in operation since 1935, but from the nature of the joint the

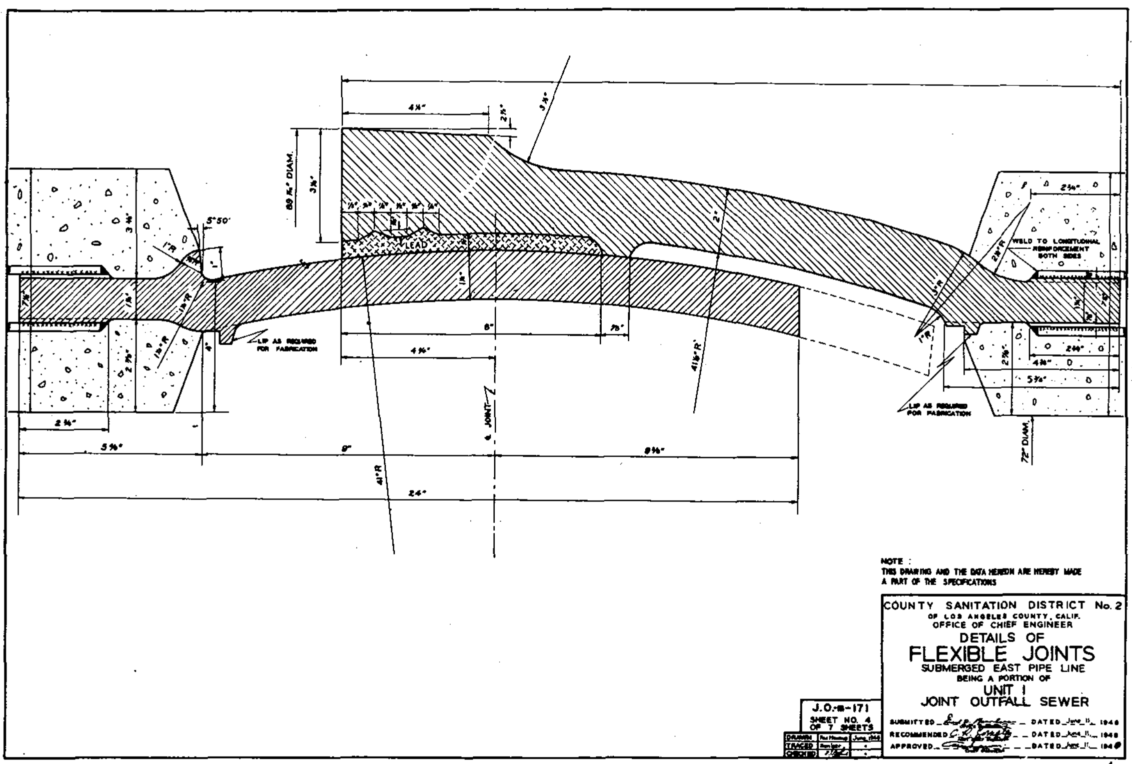


Fig. 3

interior of the line is not one smooth tube because of the annular indentations at each joint (Fig. 4). The pipe hydraulics are correspondingly influenced.

Cast iron pipe of 60 to 72-in. diameter is available but has grown increasingly difficult to obtain in the past decade and, for years during the 1940's it either could not be had at all or its delivery date set so far in the future as to discourage its use. Fortunately, there is no reason to require a sewer ocean outfall to be built of cast iron, as has been demonstrated by the use of concrete in such lines for more than the past quarter of a century. Failure has occurred in concrete outfalls but without exception those which have failed have done so for

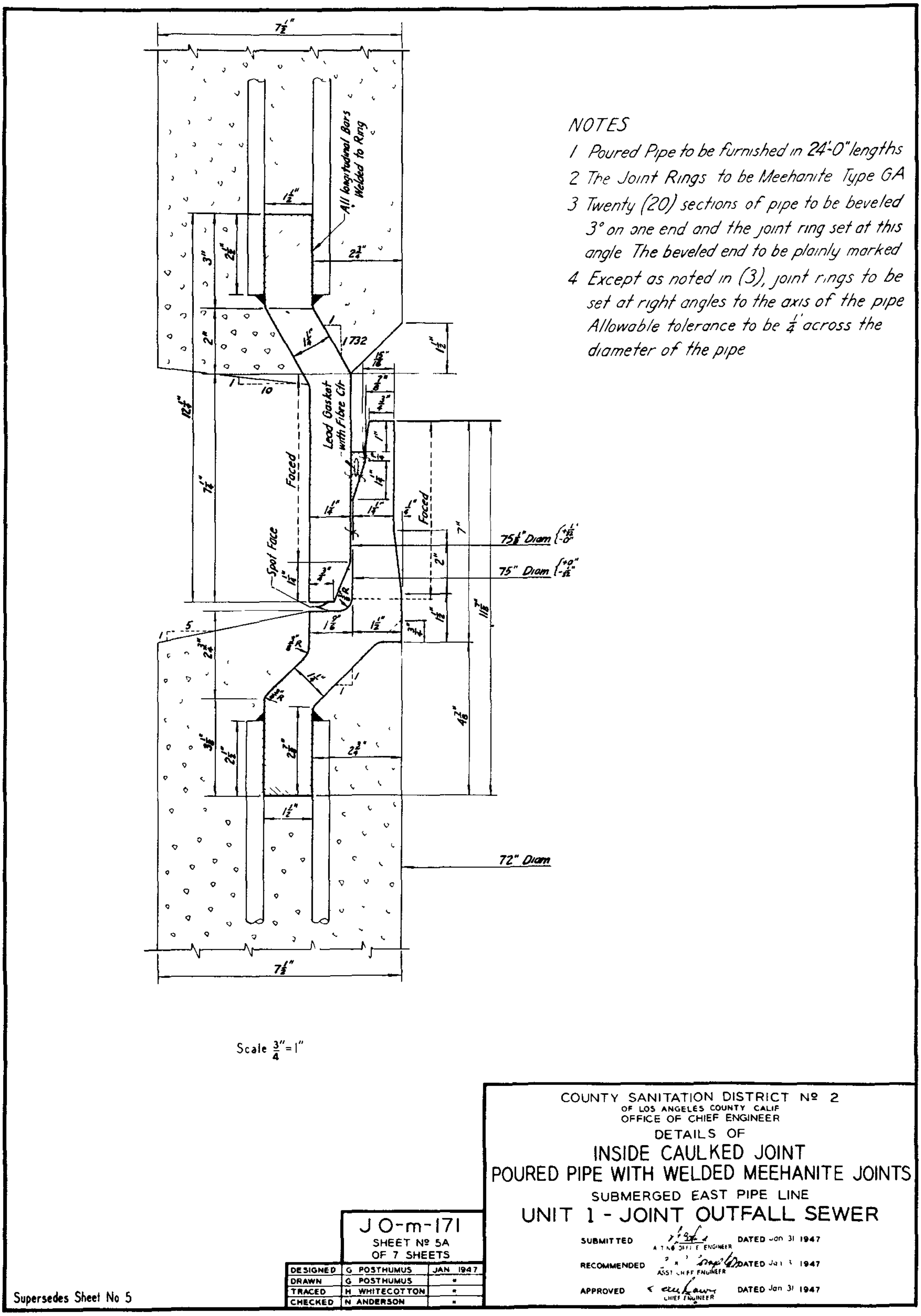

All longitudinal Bars Welded to Ring
Lead Gasket with Fibre Clr
Faced
Spot Face
75" Diam
72" Diam
Scale 3/4" = 1"
NOTES
1 Poured Pipe to be furnished in 24'-0" lengths
2 The Joint Rings to be Meehanite Type GA
3 Twenty (20) sections of pipe to be beveled 3° on one end and the joint ring set at this angle The beveled end to be plainly marked
4 Except as noted in (3), joint rings to be set at right angles to the axis of the pipe Allowable tolerance to be 1/4" across the diameter of the pipe
COUNTY SANITATION DISTRICT Nº 2
OF LOS ANGELES COUNTY CALIF
OFFICE OF CHIEF ENGINEER
DETAILS OF
INSIDE CAULKED JOINT
POURED PIPE WITH WELDED MEEHANITE JOINTS
SUBMERGED EAST PIPE LINE
UNIT 1 - JOINT OUTFALL SEWER
SUBMITTED DATED Jan 31 1947
RECOMMENDED DATED Jan 31 1947
APPROVED DATED Jan 31 1947
J O-m-171
SHEET Nº 5A
OF 7 SHEETS
DESIGNED G POSTHUMUS JAN 1947
DRAWN G POSTHUMUS
TRACED H WHITECOTTON
CHECKED N ANDERSON
Supersedes Sheet No 5

Fig. 4

reasons other than decomposition or destruction of the concrete. The combination of reinforced concrete barrel with cast iron end rings and metal to metal joints, secured by lead caulking with a certain degree of flexibility, results in a totally adequate ocean outfall if otherwise adequately designed and supported.

An ocean outfall should be designed so that it may be entered through manholes provided during construction and caulked from the inside instead of the outside of the line. The reasons for the manholes are obvious and the ability to repair a damaged joint from the inside is readily apparent when one considers the difficulties attendant upon attempting to caulk a leaky joint from the outside.

An ocean outfall flowing under pressure, and all are under pressure to some extent because of the difference in specific gravity of the two liquids, will -- unless prevented therefrom -- scour an unconsolidated foundation at a leaky joint to an extent which may cause a non-metallic joint to yield, allowing the adjacent pipe to settle, thus creating an offset in the pipe line which is practically impossible to repair (Fig. 5). This was observed in the original Hyperion pipe line and also in the one constructed at Santa Barbara. Even though the joints are of metal, care should be taken to prevent this possibility. Prevention of scouring at the joints has been successfully accomplished by piling gravel of sizes varying from 2 to 6 in. against the sides of pipe for 3 to 4 ft. beyond each edge of the joint.

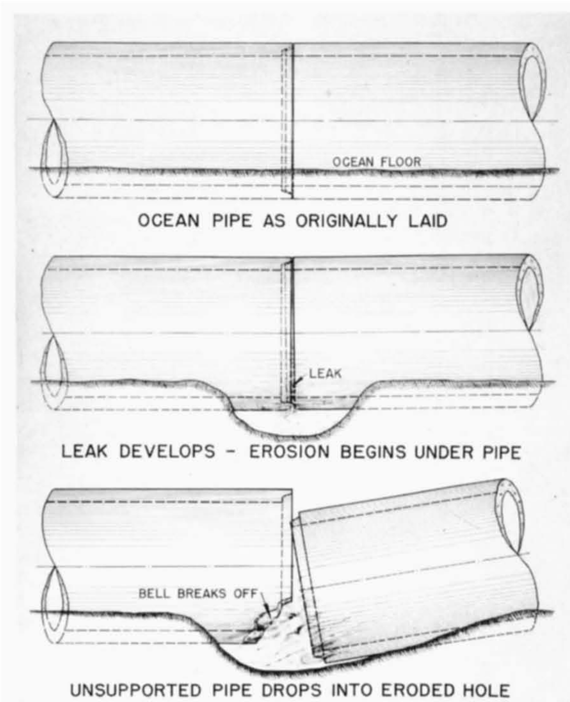


Fig. 5

Two forces will tend to scour a trench in unconsolidated material adjacent to the pipe and parallel to its long axis. One is the drag of the salt water resulting from the updraft at the outlet, and the other is the tendency for a current flowing normal to the long axis of the pipe to move seaward along a pipe line acting as a submerged weir. At times, this path, or trough, will attain such depth that the current normal to the pipe line will scour under the pipe and eventually undermine it (Fig. 6). This may be avoided by depositing rock from 2 to 6 in. in diameter from about the spring line of the pipe to the ocean floor on each side. Any scour after the rock is placed will be filled by the gravel rolling into it.

It can be shown that outfalls of material proportions have no place in inner harbors or where there is serious danger of damage from anchor flukes. In any harbor where ships swing at anchor an ocean outfall is in danger, even though the pipe be plainly marked on all navigation charts. In certain natural harbors, such as San Francisco and Puget Sound, it is obvious that the bay or sound waters must be treated as open ocean in the design of ocean outfalls.

The best foundation for an open ocean outfall pipe is afforded by a trench cut in rock as far seaward as the scouring effect of waves is felt on the ocean bottom into which the pipe line is placed and embedded in tremie concrete. When a depth is reached at or beyond which the most serious storms will not disturb the ocean floor, the best foundation is said, by marine experts, to be the undisturbed ocean floor. If the latter is unconsolidated, however, precautions against longitudinal and cross scour must be observed. If rock foundation for the shoreward section of the line is not available, it should be simulated by placing the outfall pipe on a permanent pile foundation sufficiently deep so that the normal ocean bed will completely cover the pipe.

Best protection to adjacent shore waters is obtained by discharging the outfall contents into currents which are predominantly along-shore and which are seldom, if ever, directed toward points onshore such as small capes, bays, or inlets along the shore.

Excepting under the most unusual circumstances, preliminary treatment, to the extent of primary sedimentation, and the best possible dispersion or diffusion of the sewage into the sea water at the outfall outlet is advisable and will materially assist in preventing shore contamination. Careful investigation may indicate that these two factors, plus reasonably favorable currents, may entirely eliminate all trouble in this regard.

It is our opinion that at least a year of intensive study should be a prerequisite to the selection of any ocean outfall site; that the study should include a precise and accurate measurement of wind and tide induced currents during all stages of the tide in each season of the year. Additionally, the ocean floor should be thoroughly investigated to determine its consolidation and composition in order that the type of construction most appropriate to the location may be selected. These factors, coupled with existing data relating to the effect of depth, direction, quantity and velocity of discharge from the pipe outlet, should result in reasonably accurate knowledge of what may be expected from the outfall under all conditions.

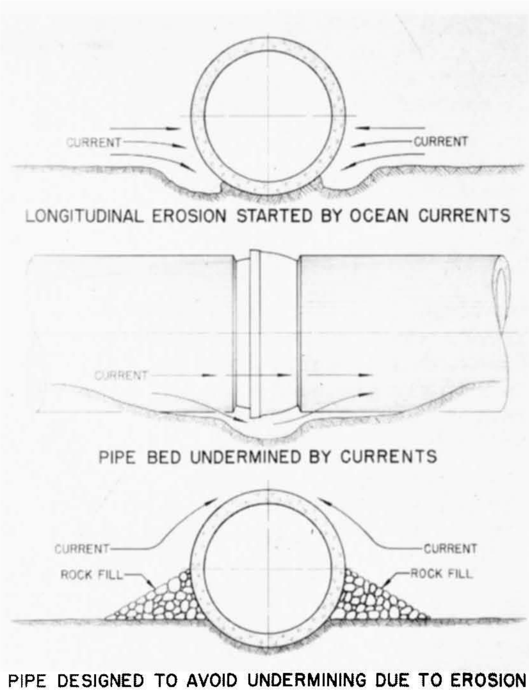


Fig. 6

One added observation about which little appears to be known, but which favorably influences the disposal of sewage into the sea, is that at depths of 100 ft. or so below the ocean surface the sea water is ordinarily not only quite cold but maintains a reasonably constant temperature throughout the year, while at the surface the temperature varies widely with the seasons. If the dispersion of the sewage into this cold sea water is carefully proportioned and controlled the rising column of mixed sewage and sea water at the point where the mixed liquor breaks the surface of the ocean will be a number of degrees colder and, consequently, of greater density than the surrounding ocean water in summer when recreational waters are most in use. The result of this is that the inertia of the rising column, having carried the mixed liquids to the ocean surface, is dissipated and the greater density of the mixed liquid causes it to plunge under the surface of the sea shortly after it begins to disperse laterally from the rising column. This phenomenon has not been carefully evaluated or rendered subject to measurement, but it is readily manifest because of the more frequent occurrence of shore contamination in the winter than in the summer.