TECHNICAL REPORT H-72-2

GRAYS HARBOR ESTUARY
WASHINGTON

Report 3
WESTPORT SMALL-BOAT BASIN STUDY
Hydraulic Model Investigation

by
N. J. Brogdon, Jr.

September 1972

Sponsored by U. S. Army Engineer District, Seattle

Conducted by U. S. Army Engineer Waterways Experiment Station
Hydraulics Laboratory
Vicksburg, Mississippi

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FOREWORD

This report is the third in a series of reports to be published on the results of model tests on the Grays Harbor estuary model conducted for the U. S. Army Engineer District, Seattle. Each of these reports will describe a complete phase of model tests conducted in the model. Report 1 covers the verification and base tests phase of the model investigation.

This study was conducted at the U. S. Army Engineer Waterways Experiment Station (WES) during the period June to August 1971 under the general supervision of Messrs. H. B. Simmons, Chief of the Hydraulics Laboratory; F. A. Herrmann, Jr., Chief of the Estuaries Branch; and N. J. Brogdon, Jr., Project Engineer. This report was prepared by Mr. Brogdon with the assistance of Mr. Herrmann.

Director of WES during the course of this investigation and the preparation and publication of this report was COL Ernest D. Peixotto, CE. Technical Director was Mr. F. R. Brown.
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<td></td>
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</tbody>
</table>
CONVERSION FACTORS, BRITISH TO METRIC UNITS OF MEASUREMENT

British units of measurements used in this report can be converted to metric units as follows:

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<th>To Obtain</th>
</tr>
</thead>
<tbody>
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<td>centimeters</td>
</tr>
<tr>
<td>feet</td>
<td>0.3048</td>
<td>meters</td>
</tr>
<tr>
<td>square miles (U. S. statute)</td>
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<td>square kilometers</td>
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<tr>
<td>feet per second</td>
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<td>meters per second</td>
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<td>cubic feet per second</td>
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SUMMARY

The existing, comprehensive fixed-bed model of the Grays Harbor estuary was used to determine current velocities, surface current patterns, flushing and dispersion characteristics, and qualitative shoaling rates and patterns for four small-boat basin plans located near Westport, Wash. Data collection consisted of current velocities for plans 1 and 2, surface current pattern photographs for plans 1, 1A, and 2; qualitative shoaling rates and patterns for plans 1, 1A, and 2A; flushing rates for plans 1, 1A, 2, and 2A; and dispersion from a proposed sewage outfall for the City of Westport for plan 1.

Model test results indicate that only insignificant local changes in current velocities and surface current patterns outside the proposed basins would result from construction of any of the four small-boat basin plans. Shoaling for the plan 2 basin would be significantly less than for either plan 1 or 1A, but the shoaling rate for any of these plans would probably be moderate.

The flushing rate for either plan 1 or 1A would be much better than for either plan 2 or 2A. The flushing rates for plans 2 and 2A could be improved, however, by the addition of a channel connecting the western end of the basin to either the existing Westhaven Cove or South Bay. Waste material discharged from the proposed Westport sewage outfall would enter the proposed basin during both ebb and flood currents, but maximum concentrations in the basin would only be on the order of 0.01 percent of the initial concentration at the outfall.
1. The Port of Grays Harbor constructed the Westhaven Cove Small-Boat Basin in 1929 by dredging a natural cove. Breakwaters A and B were constructed in 1950 by the Corps of Engineers for protection of the basin; breakwater C was constructed by the Corps of Engineers in 1957. With the increased interest in sport fishing in this area and expansion of the charter boat and commercial fishing industry, this small-boat harbor no longer has the capacity to serve the ever-increasing number of boats desiring anchorage; therefore, the need for expanding this facility is urgent. The concern of the Port Authority, the Federal Government, and the public to preserve the environment of the estuarine system and the need for data to ensure a satisfactory design prompted the model study investigation of several proposed small-boat basin plans for this area. The purpose of the model study was to determine the effects of these several plans on existing current velocities and surface flow patterns, dye flushing and dispersion rates, and shoaling characteristics within the basin plans.

2. The Seattle District submitted four proposed small-boat basin plans to the U. S. Army Engineer Waterways Experiment Station (WES) for model testing. The proposed location for the small-boat basin is in South Bay, adjacent to Westhaven Cove in an existing marsh area. This location provides a safe harbor, is accessible from land, and provides easy access to the bay and open sea (plate 1).
3. Plan 1 (plate 2) provides for two 700- by 2000-ft* anchorage areas and one 1000- by 1800-ft anchorage area, connected by two 100-ft-wide bridged openings. The anchorage areas have access to South Bay through two 200-ft-wide channels. The dredged material from the anchorage areas and channels would be used to construct an airport located on the bay side of the proposed basin. The depth of the anchorage areas and channels is 21 ft mean sea level (msl). The south channel is protected by a 700-ft-long timber pile breakwater located south of the channel.

4. Plan 1A (plate 2) consists of two anchorage areas, one 700 by 2000 ft and the other 1000 by about 4100 ft. The anchorage areas are connected by a 200-ft-wide opening at the north end and a 100-ft-wide bridged opening at the south end. Access to South Bay is provided at each end of the basin through 200-ft-wide channels. The basin and entrances are protected from wave action by 4500- and 700-ft-long timber pile breakwater structures. Depth of the access channels and anchorage basins is 21 ft msl.

5. Plans 2 and 2A (plate 3) each consist of two anchorage areas, one 600 by about 2200 ft and the other 600 by about 3000 ft, with access to South Bay through two channels. Both plans provide for a 200-ft-wide by 21-ft-deep (at msl) channel at the north entrance and a south entrance channel 100 ft wide by 5 ft deep (at msl) for plan 2 but 200 ft wide by 21 ft deep (at msl) for plan 2A. This is the only difference between plans 2 and 2A. Each plan provided protection from wave action by a 1700-ft-long timber pile structure and a 400-ft-long rubble-mound structure.

The Model

6. The Grays Harbor model, constructed at the WES in 1968, reproduced approximately 230 square miles of the prototype area, including

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*A table of factors for converting British units of measurement to metric units is presented on page vii.*
the Chehalis River to South Montesano, the Pacific coast from about 7.5 miles north and south of the respective jetties, and offshore area well beyond the -60 ft contour (plate 1). For the tests reported herein, the entire model was in a fixed-bed condition. Each of the small-boat basin plans was molded in the model in removable blocks so that the desired alterations could be readily made. A description of the model and appurtenances and details of the model adjustment, model verification, and base tests are presented in Report 1* of this series and are not included herein. The model was constructed to linear scales of 1:500 horizontally and 1:100 vertically, which resulted in the following model-to-prototype scales based on the Froudian relations: velocity 1:10, time 1:50, discharge 1:500,000, volume 1:25,000,000, and slope 5:1. The salinity concentration ratio was 1:1.

PART II: TESTS AND RESULTS

Test Conditions

7. The model testing procedure was identical with the base test procedure except that a small-boat basin plan was installed in the model for each test. All tests were made for conditions of a mean tide (diurnal range of 8.9 ft at Westport). The total freshwater discharge passing through the harbor entrance was 11,400 cfs. The discharges at individual inflow points were: Chehalis River, 6300 cfs; Hoquiam River, 970 cfs; Wishkah River, 420 cfs; Hump tulips River, 2750 cfs; and Elk River, 960 cfs. The ocean or source salinity concentration was maintained at 33.0 ppt (total salt) throughout all tests.

Types of Data Obtained

8. Current velocity measurements at half-hour (prototype) intervals at 5 locations were made for plans 1 and 2 only. Dye samples for the basin flushing tests were obtained at surface and bottom at 22 locations for plans 1 and 1A and at 16 locations for plans 2 and 2A. Dye samples for the sewage outfall tests were obtained at the times of higher-high-water (hr 13) and lower-low-water (hr 20) slacks of the tidal current over a period of 10 tidal cycles for the flushing tests, and at selected locations in the plan 1 basin at hourly intervals over a complete tidal cycle for the outfall test. The locations of current velocity and dye sampling stations are shown in plates 4 and 5.

9. Qualitative shoaling tests were conducted for plans 1, 1A, and 2A. A mixture of 40 percent gilsonite and 60 percent water was injected into the model, and the resulting shoaling rate and patterns within each basin plan were recorded. Gilsonite is an asphaltic material with a specific gravity of about 1.035, and for these tests it was graded to pass a No. 25 standard sieve but be retained on a No. 35 sieve. Gilsonite was used to simulate the general characteristics of suspended sediment. Locations of shoal sections are shown in plate 6.
10. Surface current patterns were photographed hourly (prototype) throughout a complete tidal cycle. These photographs covered only the boat basin and Point Chehalis areas. The photographs are time-lapse exposures of confetti floating on the water surface. A bright light was flashed just before the camera lens was closed, resulting in a bright spot at approximately the end of each confetti streak which indicates the direction of flow. Surface current velocities can be determined from the photographs by measuring the lengths of the streaks and comparing the lengths with the velocity scale provided in the photographs.

Test Procedures

11. Current velocity measurements and flow patterns were confined to South Bay, the Point Chehalis vicinity, and the small-boat basins since it was believed that none of the plans would affect current velocities or patterns beyond these areas.

12. Two types of dye tests were conducted during the small-boat basin study. A flushing rate test was conducted for each of the four basin plans. For these tests the access channels were blocked off at higher-high-water slack (hr 13), and 1,000 g of powdered fluorescent dye (Pontacyl Brilliant Pink) was mixed with the water throughout the enclosed areas, as the model tide continued to operate normally. Because of uncontrollable variations in the volume behind the barriers, it was not practicable to obtain the same initial dye concentration for each plan; however, the initial concentration was about 7000 ppb for each test. At the next higher-high-water slack, the barriers in the access channels were removed, and collection of water samples was initiated and continued for 10 tidal cycles. These data are presented as a percent of initial dye concentration so comparisons of flushing rates for each plan can be easily made.

13. The second type of dye test simulated a pollutant source which would result from construction of a sewage outfall system proposed for the City of Westport. This type of dye test was made for plan 1 only. The dye release point (outfall location) is shown in plate 4.
The dye was released into the model at the proper rate (400,000 gpd) and location through a 1/8-in. copper tube connected to a glass-sided standpipe (dye reservoir) that contained dye with a density of fresh water and an initial concentration of 1,000,000 ppb. The dye was released uniformly at the -20 ft contour over a 10-cycle period at a rate equivalent to 400,000 gpd. The dye release was started at hr 0 of cycle 1 and was terminated at hr 0 of cycle 11. Water samples were obtained at the times of higher-high-water (hr 13) and lower-low-water (hr 20) slacks throughout the 10-cycle test period at 22 locations at surface and bottom (plates 93-114) and at hourly (prototype) intervals throughout cycle 5 at 9 selected locations within the basin area at middepth (plates 115 and 116).

14. The model shoaling rates or patterns in the area proposed for location of the small-boat basin could not be verified; therefore, the model results can only be analyzed in a qualitative manner. Prior to the actual basin tests, several trial tests were conducted in an effort to select a shoal material and injection procedure that would result in a sufficient quantity of material moving into and depositing in the access channels and anchorage areas and thus permit evaluation of the proposed plans. Current velocities within each basin were very small; therefore, a fine-grained, low specific gravity material (gilsonite) was ultimately selected for use as the model sediment.

15. Trial tests showed that a mixture of 40 percent gilsonite and 60 percent water introduced upstream of the south access channels and downstream of the north access channels at particular times during a tidal cycle would result in a measurable volume of gilsonite moving into and depositing within the confines of the small-boat basins. The shoaling test procedure adopted for the small-boat basin model tests was as follows: At hr 3 (weak ebb) 2000 cc of the gilsonite-water mixture was introduced above the south access channel; and at hr 6.5 (weak flood) 2000 cc was introduced below the north access channel. Each injection of the gilsonite-water mixture was accomplished over a period of 1 hr (prototype) during each of the 10 tidal cycles. After the final injection at hr 6.5 of cycle 10, the model was allowed to run until
hr 20 (lower-low-water slack) at which time the model was shut off, leaving the model flooded. The shoal patterns were then sketched, and the material deposited within the access channels and anchorage areas was retrieved and measured volumetrically. The procedure was identical in each test, with the exception of the injection location. Plans 1 and 1A had identical injection locations; however, it was necessary to move the injection locations for plan 2A in order to maintain the same distance to the access channels. The locations of the injection points for each plan are shown in plate 6.

Current Velocity Measurements

16. The results of current velocity measurements at surface, mid-depth, and bottom at five locations for plan 1 are presented in plates 7-11. One station was located in each of the basin access channels and three stations were located in the South Bay channel adjacent to the small-boat basin (plate 4). Base test data were available at the three South Bay channel locations only; therefore, only these stations will show effects of plan 1 on current velocities outside the basin. The greatest velocity changes were found to occur during ebb flow at sta 7A, located opposite the north entrance to the proposed basin. Maximum ebb velocities at all depths at this point were increased by about 1.0 to 1.5 fps, whereas maximum flood velocities were increased by only about 0.1 to 0.2 fps. Velocities at stations located south and north of the plan 1 basin were influenced very little. Maximum velocities in the north access channel to the plan 1 small-boat basin were determined to be about 1.6 fps, while those in the south access channel were about 1.0 fps.

17. The results of current velocity measurements for plan 2 are presented in plates 12-15. Because of the shallow depth (-5 ft msl) of the south access channel, the model velocity meters were too large to make measurements at this point. Close examination of the current direction photographs showed that maximum surface current velocities in the south access channel were on the order of 1.0 to 1.2 fps. Maximum
Current velocities in the north access channel were determined to be about 0.6 to 0.8 fps. Comparison of plan 2 and base test velocity data at the three South Bay channel stations showed that plan 2 generally increased maximum flood and ebb velocities by about the same amount at sta 8A and 8B.

**Surface Current Pattern Photographs**

18. Photo 1 shows surface current patterns at the times of maximum ebb and flood current for base test conditions. Surface current flow pattern photographs were obtained for plans 1, 1A, and 2 and are presented in photos 2-8, 9-15, and 16-22, respectively. The flow patterns as shown in these photographs indicate that each of the small-boat basin plans caused minor changes in existing surface flow patterns and directions in South Bay; however, the changes are considered insignificant and were confined to the immediate vicinity of the individual small-boat basin being tested.

**Shoaling Tests**

19. Qualitative shoaling tests were conducted for plans 1, 1A, and 2A, and the results are presented in table 1 and plate 16. For each shoaling section, table 1 presents the amount of material recovered expressed as volume, percent of total material injected into the model, and percent of total material recovered after the test. Plate 16 shows the shoaling patterns that developed in each individual small-boat basin. The locations of individual shoal sections for each plan are shown in plate 6.

20. The total shoaling volume in the anchorage areas of plan 2A was only about one-half that of plans 1 and 1A; however, the total volume in the access channels was almost equal to that retrieved from the access channels of plans 1 and 1A. In each case, the heaviest shoaling occurred in or immediately adjacent to the access channels. This shoaling pattern was almost surely a result of the incompetence of the
low current velocities to transport sediments farther back into the basins. The total amount of material deposited in the plan 2A basin was about 17 percent less than that in the plan 1 basin and about 21 percent less than that in the plan 1A basin. Since the accuracy of repeating identical shoaling tests is considered to be on the order of ±10 percent, these shoaling test results indicate that the plan 2A basin would be subject to a significantly lower shoaling rate than either plan 1 or 1A. Because of the nature of the shoaling tests for this study, it is not possible to predict the prototype shoaling rate. The test results do indicate, however, that the shoaling rate would probably be moderate.

**Flushing Tests**

21. Flushing rate tests, described in paragraph 12, were conducted for each of the four small-boat basin plans, and the resulting data are presented in plates 17-92. Tabulations of the model data from which the dye history plots were constructed are on file at the WES but are not included in this report. Water samples were collected and analyzed to determine dye concentration at 22 locations for plans 1 and 1A (plate 4) and at 16 locations for plans 2 and 2A (plate 5).

22. Dye history plots for plans 1 and 1A are presented in plates 17-38 and 39-60, respectively. Very little difference was noted between plans 1 and 1A flushing characteristics; however, an analysis of the data obtained during the tenth model tidal cycle showed that plan 1 basin flushed slightly better than plan 1A, especially at the bottom elevation. This determination was made by comparing the average percentage of initial dye concentration values during cycle 10 (last cycle of data collection) for 17 stations located within the basins and access channels. The average values calculated from cycle 10 data for the flushing tests are tabulated below:

<table>
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<tr>
<th>Elevation</th>
<th>Percent of Initial Dye Concentration</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>High-Water Slack</td>
</tr>
<tr>
<td></td>
<td>Plan 1</td>
</tr>
<tr>
<td>Surface</td>
<td>0.12</td>
</tr>
<tr>
<td>Bottom</td>
<td>0.18</td>
</tr>
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</table>
The average values calculated from percentages of initial dye concentrations occurring at cycle 10 for the southwest anchorage areas and the South Bay channel stations showed almost no difference between plans 1 and 1A. The percentage of dye remaining in these areas during either sampling period in cycle 10 was below 0.20 percent of the initial dye concentration.

23. The plan 1 basin was slightly more effective in flushing dye from the anchorage areas, probably because of the landfill proposed for the airport. The location of this land mass apparently forced or diverted a greater volume of the tidal flow through the anchorage areas during both phases of tide, whereas the timber breakwater structure in plan 1A allowed a greater percentage of the tidal flow to remain in the South Bay channel. As noted earlier, current velocities within each basin tested were of extremely low magnitude; but additional turbulence was generated in the plan 1 basin by the 100-ft-wide constriction between anchorage areas. This resulted in a significant increase in vertical mixing and a greater capacity for flushing pollutants in the basin. The piers and docks that would be constructed in the prototype were not simulated in the model for either of these plans. It is believed that the piers and docks, normal wind action, and the turbulence created by the movement of boats within the anchorage areas would increase the flushing capabilities of either basin to some degree by further increasing the vertical mixing within the basin.

24. Dye history plots for plans 2 and 2A are presented in plates 61-76 and 77-92, respectively. The same type of analysis was applied to these data as was applied to data for plans 1 and 1A. These two plans did not differ significantly in dye concentrations at stations located outside the basins. Although the differences in the surface dye concentrations within the basins for these two plans were rather small (less than 0.75 percent of initial concentration at any one station during cycle 10), concentrations for plan 2A were generally lower than those for plan 2. Much greater dye concentration differences between the two plans occurred at the bottom (as much as 36 percent of initial concentration at one station during cycle 10). Plan 2A proved to be
significantly better at flushing at this elevation zone. This was a direct result of the deeper entrance channel at the eastern end of the basin. The average percentages of initial dye concentration calculated from cycle 10 data at the 11 stations located within the basin are tabulated below:

<table>
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<th>Elevation</th>
<th>Percent of Initial Dye Concentration</th>
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<tbody>
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<td></td>
<td>High-Water Slack</td>
<td>Low-Water Slack</td>
<td></td>
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<tr>
<td>Surface</td>
<td>Plan 2</td>
<td>Plan 2A</td>
<td>Plan 2</td>
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<tr>
<td>Bottom</td>
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<td></td>
<td>9.16</td>
<td>1.73</td>
<td>9.55</td>
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At one location in the southern basin (sta B2I, bottom elevation) during testing of the plan 2 basin, the percentages of initial dye concentration at cycle 10 at high- and low-water slacks were 35.47 percent and 40.07 percent, respectively. The northern anchorage area in both plans 2 and 2A flushed significantly better than the southern anchorage area. This condition would be improved along with the overall flushing capability of either basin by providing passages for tidal flow in the form of culverts or a bridged opening at the west end of the basin. These passages should connect the two anchorage areas and should connect the proposed basin to either the existing Westhaven Cove or South Bay.

25. The test results show quite clearly that the flushing characteristics of either the plan 1 or 1A basin are considerably better than those of either the plan 2 or 2A basin. This was expected, since there were entrance channels at either end of the plan 1 and 1A basins, whereas the entrance channels in the plan 2 and 2A basins were not located so as to generate a flow through the basins.

Dispersion Tests

26. Data resulting from a dye dispersion test simulating a proposed sewage outfall for the City of Westport, described in paragraph 13, are presented in plates 93-114. Dye dispersion data were obtained only for the plan 1 small-boat basin condition. The dye release point and
location of stations sampled are shown in plate 4. Sampling stations were identical with those for the flushing test of this plan.

27. These model data show that wastes discharged continuously from the proposed source outside the basin would enter the plan 1 small-boat basin on both the flood and ebb currents; however, the data further show strong evidence that no significant buildup of the pollutant within the basin would take place. Maximum dye concentrations within the basin generally stabilized at about 50-100 ppb (0.005-0.01 percent of the initial concentration), although this was somewhat higher than maximum concentrations observed in the South Bay channel (about 30 ppb). It must be pointed out that this test was conducted with a conservative dye (that is, it did not decay with time), and an appropriate decay rate must be applied analytically before the results can be applied to prototype conditions. At high-water slack, surface dye concentrations within the plan 1 basin were generally greater than at the bottom, while the opposite was generally true at low-water slack.

28. During the early stage of the Westport sewage outfall dye dispersion test, it was visually observed that the maximum and minimum dye concentrations within the basin did not necessarily occur at the high- (hr 13) and low-water (hr 20) slack periods. Therefore, an identical test was conducted in which dye samples at the middepth elevation at nine locations within the basin were obtained at hourly (prototype) intervals throughout cycle 5 in order to construct dye concentration history plots for a complete tidal cycle period. These dye history plots are presented in plates 115 and 116. These data show that the dye movement within the basin during a tidal cycle was more erratic than was expected and that the maximum and minimum dye concentrations occurring during a tidal cycle do not necessarily occur during the high- and low-water slack periods.
PART III: CONCLUSIONS AND RECOMMENDATIONS

29. Based on the results of tests made in the Grays Harbor model the following general conclusions have been reached:

a. None of the plans tested would have any appreciable effect on current velocities or surface current patterns outside the basins. Current velocity in the access channels would be well below that accepted for safe navigation.

b. Shoaling would occur in each of the three basins subjected to shoaling tests (plans 1, 1A, and 2A). Model data indicate that accumulation of shoal materials would occur more rapidly in the access channels than in the anchorage areas of each plan tested. Shoaling for the plan 2 basin would be about 17 and 21 percent less than that for the plan 1 and 1A basins, respectively. Although it is not possible to quantitatively predict the prototype shoaling rate, it would probably be moderate.

c. Flushing rate tests showed very little difference between the flushing characteristics of plans 1 and 1A; however, plan 1 would be slightly better in this respect. The flushing characteristics of both plans 1 and 1A were much better than for plans 2 and 2A because the entrance channels for plans 1 and 1A were essentially at opposite ends of the basin, whereas the entrance channels for plans 2 and 2A were not located so as to generate a flow through the basins. The flushing rate for plan 2A was significantly better than that for plan 2. In each plan tested, the surface flushed at a much faster rate than the bottom. The flushing characteristics of either plan 2 or 2A might be improved by providing a flow passage between the western ends of the two primary anchorage areas and a flow passage connecting the western end of the proposed basin to either the existing Westhaven Cove or South Bay. In the event plan 2 or 2A is considered for construction incorporating the additional flow passages discussed above, it is recommended that model tests be made with the flow passages installed in the model in order to accurately define their effects upon water circulation in the proposed basin, Westport Cove, and adjacent areas.

d. Waste from the proposed Westport sewage outfall would enter the plan 1 basin (and any of the other basin configurations investigated, although they were not subjected to this particular type of test) on both the flood and ebb currents; however, the maximum concentration at any location within the basin would only be on the order of 0.01 percent of the outfall concentration without applying a decay factor to the results.
Table 1
Shoaling Results of Plans 1, 1A, and 2A

<table>
<thead>
<tr>
<th>Section No.*</th>
<th>Volume of Material Retrieved, cc**</th>
<th>Percent of Total Material Retrieved</th>
<th>Percent of Total Material Injected</th>
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<td>Plan 1A</td>
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Note: Total volume of material injected was 16,000 cc.
* Sections are not identical in each plan; see plate 6 for section location.
** Average of two identical runs.
MAXIMUM EBB
HR 17

MAXIMUM FLOOD
HR 23

SURFACE CURRENT DIRECTIONS
BASE CONDITIONS
HOURS 17 AND 23
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 1

HOURS 0, 1, 2, AND 3
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 1
HOURS 4, 5, 6, AND 7

PHOTO 3
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 1
HOURS 8, 9, 10, AND 11

PHOTO 4
small boat basin study

surface current directions

plan 1

hours 12, 13, 14, and 15

photo 5
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 1
HOURS 16, 17, 18, AND 19
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 1

HOURS 20, 21, 22, AND 23

PHOTO 7
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 1

HOUR 24

PHOTO 8
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN IA

HOURS 0, 1, 2, AND 3

PHOTO 9
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 1A
HOURS 4, 5, 6, AND 7

PHOTO 10
VELOCITY SCALE

SURFACE CURRENT DIRECTIONS
PLAN 1A
HOURS 8, 9, 10, AND 11
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 1A
HOURS 12, 13, 14, AND 15

PHOTO 12
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 1A
HOURS 16, 17, 18, AND 19

PHOTO 13
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN IA
HOURS 20, 21, 22, AND 23

PHOTO 14
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN IA

HOUR 24

PHOTO 15
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 2
HOURS 0, 1, 2, AND 3

PHOTO 16
HOUR 4

HOUR 5

HOUR 6

HOUR 7

SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 2

HOURS 4, 5, 6, AND 7

PHOTO 17
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 2
HOURS 8, 9, 10, AND 11

PHOTO 18
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 2
HOURS 12, 13, 14, AND 15

PHOTO 19
SMALL BOAT BASIN STUDY

SURFACE CURRENT DIRECTIONS

PLAN 2
HOURS 16, 17, 18, AND 19

PHOTO 20
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 2
HOURS 20, 21, 22, AND 23

PHOTO 21
SMALL BOAT BASIN STUDY
SURFACE CURRENT DIRECTIONS
PLAN 2
HOUR 24

PHOTO 22
PLATE 1

MODEL LAYOUT

SCALES IN FEET

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LEGEND
- VELOCITY AND DYE STATIONS

LIMITS OF BASIN PLANS
See Plates 2 and 3 for details

PACIFIC

OCEAN

Movable-Bed Limits

Model Limits
NOTE: ELEVATIONS ARE IN FEET
REFERRED TO MEAN SEA LEVEL

ELEMENTS OF PLANS 1 AND 1A

SCALES IN FEET

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NOTE: ELEVATIONS ARE IN FEET
REFERRED TO MEAN SEA LEVEL

ELEMENTS OF PLANS 2 AND 2A

SCALES IN FEET

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PLATE 3
**PLAN I**

**PLAN IA**

**LEGEND**
- X DYE SAMPLING STATION
- O CURRENT VELOCITY STATION
- Δ DYE RELEASE POINT

NOTE: ELEVATIONS ARE IN FEET REFERRED TO MEAN SEA LEVEL

**LOCATION OF CURRENT VELOCITY AND DYE SAMPLING STATIONS**

**PLANS I AND IA**

**SCALES IN FEET**

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**PLATE 4**
LEGEND
X DYE SAMPLING STATION
O CURRENT VELOCITY STATION

NOTE: ELEVATIONS ARE IN FEET
REFERRED TO MEAN SEA LEVEL

LOCATION OF CURRENT VELOCITY
AND DYE SAMPLING STATIONS
PLANS 2 AND 2A

SCALES IN FEET

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MODEL TEST DATA
TIDE MEAN
FRESH-WATER DISCHARGE 11,400 CFS
SOURCE SALINITY 33.0 PPT

CURRENT VELOCITIES
PLAN I
STATION B1A
SURFACE, MIDDEPTHE AND BOTTOM

PLATE 7
MODEL TEST DATA
TIDE: MEAN
FRESH-WATER DISCHARGE: 11,400 CFS
SOURCE SALINITY: 33.0 PPT

CURRENT VELOCITIES
PLAN I
STATION B-1Q
SURFACE, MIDDEPTH AND BOTTOM

PLATE 8
SURFACE

MIDDEPTH

BOTTOM

MODEL TEST DATA
TIDE
FRESH-WATER DISCHARGE... 11,400 CFS
SOURCE SALINITY........... 33.0 PPT

CURRENT VELOCITIES
PLAN 1
STATION 7A
SURFACE, MIDDEPTH AND BOTTOM

PLATE 9
SURFACE

MIDDEPTH

BOTTOM

MODEL TEST DATA
TIDE: MEAN
FRESH-WATER DISCHARGE: 11,400 CFS
SOURCE SALINITY: 33.0 PPT

LEGEND
- - BASE TEST
--- PLAN I

CURRENT VELOCITIES
PLAN I
STATION 8A
SURFACE, MIDDEPTH AND BOTTOM

PLATE 10
MODEL TEST DATA

TIDE: MEAN
FRESH-WATER DISCHARGE: 11,400 CFS
SOURCE SALINITY: 33.0 PPT

LEGEND
--- BASE TEST
--- PLAN I

CURRENT VELOCITIES
PLAN 1
STATION 8B
SURFACE, MIDDEPTH AND BOTTOM
CURRENT VELOCITIES
PLAN 2
STATION B2A
SURFACE, MIDDEPTH AND BOTTOM

MODEL TEST DATA
TIDE MEAN
FRESH-WATER DISCHARGE 11,000 CFS
SOURCE SALINITY 33.0 PPT
MODEL TEST DATA

TIDE: MEAN
FRESH-WATER DISCHARGE: 11,400 CFS
SOURCE SALINITY: 33.0 PPT

LEGEND

- BASE TEST
- - PLAN 2

CURRENT VELOCITIES

PLAN 2
STATION 7A
SURFACE, MIDDEPTH AND BOTTOM

PLATE 13
MODEL TEST DATA

TIDE MEAN
FRESH-WATER DISCHARGE 11,400 CFS
SOURCE SALINITY 33.0 PPT

LEGEND

--- BASE TEST
--- PLAN 2

CURRENT VELOCITIES

PLAN 2

STATION B A

SURFACE, MIDDEPHT AND BOTTOM
MODEL TEST DATA

TIDE ........................................... MEAN
FRESH-WATER DISCHARGE........ 11,400 CFS
SOURCE SALINITY............... 33.0 PPT

CURRENT VELOCITIES

PLAN 2
STATION 8 B
SURFACE, MIDDEPTH AND BOTTOM

PLATE 15
SHOAL PATTERNS
PLANS 1, 1A, AND 2A

LEGEND
HEAVY
MEDIUM
LIGHT

NOTE: SEE TABLE 1 FOR VOLUMES IN INDIVIDUAL SECTION

SCALES IN FEET

PLATE 16
Plan 1
Flushing Characteristics
Station 1

Test conditions:
- Initial Conc.: 6975 PPB
- Tide Mean: 11400 CFS
- Freshwater Discharge: 11400 CFS
- Ocean Salinity (Total Salt): 33.0 PPT

Legend:
- + - Surface
TEST CONDITIONS
INITIAL CONC: 6,975 PPD
TIDE MEAN
FRESHWATER DISCHARGE 11,400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ ——— SURFACE
X ——— BOTTOM

PLAN 1 FLUSHING CHARACTERISTICS
STATION 8A
TEST CONDITIONS
INITIAL CONC: 6975 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
× --- BOTTOM

PLAN 1 FLUSHING CHARACTERISTICS
STATION 88
TEST CONDITIONS

INITIAL CONC: 6975 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ -- SURFACE
× -- BOTTOM

PLAN I
FLUSHING CHARACTERISTICS

STATION B1A
FIGURE 2.10.00

PERCENT OF INITIAL DYE CONCENTRATION

0.10

0.01

TIME IN TIDAL CYCLES

TEST CONDITIONS
INITIAL CONC: 6975 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CPS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+
SURFACE

X
BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION 818
TEST CONDITIONS
INITIAL CONC: 6975 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+----- SURFACE
X----- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION BIC
TEST CONDITIONS
INITIAL CONC:
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X ---- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION 810
PLATE 26

TEST CONDITIONS

INITIAL CONC: TIDE FRESHWATER DISCHARGE OCEAN SALINITY

6975 PFB 11400 CFS 33.0 PPT

MEAN

6975 PPB 11400 CFS 33.0 PPT

LEGEND

+ ----- SURFACE

X ----- BOTTOM

PLAN 1

FLUSHING CHARACTERISTICS

STATION 81E
TEST CONDITIONS

INITIAL CONC: 6975 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+---- SURFACE
X---- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS

STATION BIF
TEST CONDITIONS

INITIAL CONCENTRATION: 6975 PPB
TIDE MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ --- SURFACE
× --- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS

STATION 81G
TEST CONDITIONS
INITIAL CONC: 6975 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFs
OCEAN SALINITY (TOTAL SALT) 33.0 PFT

LEGEND
+--- SURFACE
x--- BOTTOM

PLAN 1 FLUSHING CHARACTERISTICS
STATION BIN
TEST CONDITIONS
INITIAL CONC: 6975 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+------ SURFACE
X------ BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION 811
TEST CONDITIONS
INITIAL CONCENTRATION  6075 PPS
TIDE MEAN 11400 CFS
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION 81J
TEST CONDITIONS

INITIAL CONC: 6975 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 FT

LEGEND

+ --- SURFACE
X --- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION B1K
PLATE 34

TEST CONDITIONS
INITIAL CONC: 6975 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ - - - TOP
X - - - BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION 81M
TEST CONDITIONS

INITIAL CONC: 6975 PPB
TIDE: MEAN FRESHWATER DISCHARGE: 11400 CF3
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+
SURFACE
X
BOTTOM

PLATE 35

FLUSHING CHARACTERISTICS

STATION BIN
TEST CONDITIONS
INITIAL CONCENTRATION 6975 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFH
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION B10
**Plan 1 Flushing Characteristics**

**Test Conditions**
- Initial Concentration: 0.01%
- Tide: Mean
- Freshwater Discharge: 11400 CFS
- Ocean Salinity (Total Salt): 33.0 PPM

**Legend**
- +—— Surface
- X—— Bottom

**Station 811**

**Time in Tidal Cycles**

**Percent of Initial Dye Concentration**

- High Water Slack
- Low Water Slack

PLATE 37
TEST CONDITIONS
INITIAL CONC. 6975 PPM
TIDE MORN
FRESHWATER DISCHARGE 11400 CFM
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+---- SURFACE
X---- BOTTOM

PLAN 1
FLUSHING CHARACTERISTICS
STATION B10
TEST CONDITIONS

INITIAL CONC: 8000 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

SURFACE

BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS

STATION 5A
TIN CLEARANCE TEST CONDITIONS

- Initial Concentration: 6000 PPB
- Tide Mean: 11400 CFM
- Freshwater Discharge: 33.0 PPT

LEGEND

+ Surface

PLAN 1B

FLUSHING CHARACTERISTICS

STATION 1
TEST CONDITIONS

INITIAL CONC: 6000 PPS
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+
SURFACE
X
BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION 7A
TEST CONDITIONS
INITIAL CONC: 6000 PPS
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CPS
OCEAN SALINITY (TOTAL SALT): 33.0 FT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION 8A
TEST CONDITIONS

INITIAL CONCENTRATION 6000 PFS
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
- --- BOTTOM

PLAN IA FLUSHING CHARACTERISTICS
STATION 88
TEST CONDITIONS

INITIAL CONCENTRATIONS
6000 PPB

FRESHWATER DISCHARGE
11400 CFS

OCEAN SALINITY (TOTAL SALT)
33.0 PPT

LEGEND

SURFACE

BOTTOM

PLAN 1A

FLUSHING CHARACTERISTICS

STATION 81A
PLATE 45

TEST CONDITIONS
INITIAL CONC: 6000 PPB
TIME MEAN 11400 CF2S
FRESHWATER DISCHARGE 33.0 PPT
OCEAN SALINITY (TOTAL SALT)

LEGEND
+ -- SURFACE
X --- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION 818
TEST CONDITIONS

INITIAL CONC: 6000 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFs
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+
SURFACE
X
BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION BIC
TEST CONDITIONS
INITIAL CONC: 6000 PPB
TIDE: MEAN FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT
LEGENDE:
+ --- SURFACE
X --- BOTTOM

PLAN IA
FLUSHING CHARACTERISTICS
STATION 810
TEST CONDITIONS

- INITIAL CONC: 6000 PPS
- TIDE: MEAN
- FRESHWATER DISCHARGE: 31,400 CF
- OCEAN SALINITY (TOTAL SALT): 33.0 PPT
- LEGEND
  - +--- SURFACE
  - X--- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS

STATION BIE
**TEST CONDITIONS**

- INITIAL CONC: 6000 PPB
- TIDE: MEAN
- FRESHWATER DISCHARGE: 11400 CF3
- OCEAN SALINITY (TOTAL SALT): 33.0 PPT

**LEGEND**

- + --- SURFACE
- x --- BOTTOM

**PLATE 1A**

FLUSHING CHARACTERISTICS

STATION 81F
TEST CONDITIONS

| INITIAL CONC: | 6000 PPB |
| TIDE | MEAN |
| FRESHWATER DISCHARGE | 11400 CFS |
| OCEAN SALINITY (TOTAL SALT) | 33.0 PPT |

LEGEND

+ --- SURFACE
× --- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION B1H
TEST CONDITIONS

INITIAL CONC: 6000 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

+ --- SURFACE
X -- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS

STATION 811
TEST CONDITIONS
INITIAL CONCENTRATION: 6000 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+ -- - SURFACE
X -- - BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION 01J

PERCENT OF INITIAL DYE CONCENTRATION
TIME IN TIDAL CYCLES

HIGH-WATER SLACK
LOW-WATER SLACK
PLATE 54

**TE9T CONDIT IONS**

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**FLUSHING CHARACTERISTICS**

**PLAN 1A**

**STATION B1K**
TEST CONDITIONS
INITIAL CONC: 6000 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF3
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION BIL
TEST CONDITIONS

INITIAL CONCENTRATION 6000 PPB
TIDE MEAN 11400 CFH
FRESHWATER DISCHARGE 33.0 PPT
OCEAN SALINITY (TOTAL SALT) 1400 CFH

PLAN 1A
FLUSHING CHARACTERISTICS
STATION B1H
TEST CONDITIONS

- INITIAL CONCENTRATION 6000 PPM
- FRESHWATER DISCHARGE 11400 CFS
- OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

- +----- SURFACE
- X----- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION BIN
PLATE 58

TEST CONDITIONS

INITIAL CONC: 6000 PPM
FREQUENT DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ ---- SURFACE
X ---- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS
STATION 810
TEST CONDITIONS

INITIAL CONCENTRATION: 6000 PPM
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFs
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ -- SURFACE
X -- BOTTOM

PLAN 1A
FLUSHING CHARACTERISTICS

STATION BIP
TEST CONDITIONS

INITIAL CONC: 6000 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11,400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ --- SURFACE

x ------ BOTTOM

FLUSHING CHARACTERISTICS

PLAN 1A

STATION 81Q
INITIAL CONC: 7056 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF3
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS
STATION 5A
TEST CONDITIONS
INITIAL CONC: 7056 PPB
TIDE MERN
FRESHWATER DISCHARGE 11400 CF9
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE

PLAN 2
FLUSHING CHARACTERISTICS
STATION 1
TEST CONDITIONS

INITIAL CONCENTRATION  7056 PPM
TIDE  MEAN
FRESHWATER DISCHARGE  11400 CF/2
OCEAN SALINITY (TOTAL SALT)  33.0 PPT

LEGEND

+ ---- SURFACE
x  ---- BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS
STATION 7A
Test Conditions

- Initial Concentration: 7056 PPB
- Tidal Mean: 11400 CFM
- Freshwater Discharge: 33.0 PFT
- Ocean Salinity (Total Salt): 33.0 PFT

Legend

- +—— Surface
- X—— Bottom

Plan 2 Flushing Characteristics

Station 00
PLAN 2 FLUSHING CHARACTERISTICS

STATION 82A

TEST CONDITIONS

INITIAL CONC 7058 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

+ + + + SURFACE
X X X X BOTTOM
TEST CONDITIONS
INITIAL CONC. 7056 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF3
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 2 FLUSHING CHARACTERISTICS
STATION 020
PLATE 68

TEST CONDITIONS

INITIAL CONC: 7056 PPM
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFM
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+---+ SURFACE
X---X BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS

STATION 82C
**Test Conditions**
- Initial Concentration: 7056 PPB
- Tide: Mean
- Freshwater Discharge: 11400 CFS
- Ocean Salinity (Total Salt): 35.0 PPT

**Legend**
- + — Surface
- X — Bottom

**Plan 2: Flushing Characteristics**

Station 820
PLATE 70

TEST CONDITIONS
INITIAL CONC. 7056 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF3
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ — SURFACE
X —— BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS
STATION B2E
TEST CONDITIONS
INITIAL CONC: 7056 PPD
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFY
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+ --- SURFACE
× --- BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS
STATION B2F
TEST CONDITIONS
INITIAL CONC: 7056 PPF
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFs
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+----- SURFACE
X----- BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS
STATION B2G
**Test Conditions**
- Initial Concentration: 7056 PPM
- Tide Mean: 11400 CFM
- Freshwater Discharge: 35.0 PPM

**Legend**
- +—— Surface
- x—— Bottom

**Plan 2**
Flush Characteristics
Station 82H
TEST CONDITIONS

- Initial Concentration: 7056 PPS
- Tide: Mean
- Freshwater Discharge: 11400 CF3
- Ocean Salinity (Total Salt): 33.0 PPT

LEGEND

- +---- Surface
- X----- Bottom

PLAN 2

FLUSHING CHARACTERISTICS

STATION 821
PLATE 75

TEST CONDITIONS:

INITIAL CONC: 7056 PPF
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

SURFACE

BOTTOM

PLAN 2
FLUSHING CHARACTERISTICS

STATION 82J
PLATE 76

HIGH-WATER SLACK

LOW-WATER SLACK

PERCENT OF INITIAL DYE CONCENTRATION

TIME IN TIDAL CYCLES

TEST CONDITIONS
INITIAL CONC: 7055 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ ----- SURFACE
X ----- BOTTOM

PLAN 2 FLUSHING CHARACTERISTICS
STATION 02K
TEST CONDITIONS
INITIAL CONC: 6894 PPB
TIDE MERN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 35.0 FT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 2A
FLUSHING CHARACTERISTICS
STATION 5A
TEST CONDITIONS
INITIAL CONCENTRATION: 6854 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CF
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+ --- SURFACE

PLAN 2A
FLUSHING CHARACTERISTICS
STATION 1
PLAN 2A FLUSHING CHARACTERISTICS

STATION 7A

TEST CONDITIONS

INITIAL CONC: 6894 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF/S
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+—+_ SURFACE
X—_/ BOTTOM

PERCENT OF INITIAL DYE CONCENTRATION

TIME IN TIDAL CYCLES

100.00
10.00
1.00
0.10
0.01
TEST CONDITIONS

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<tr>
<th>INITIAL CONC</th>
<th>TIDE</th>
<th>FRESHWATER DISCHARGE</th>
<th>OCEAN SALINITY (TOTAL SALT)</th>
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<td>6894 PPB</td>
<td>MEAN</td>
<td>11400 CFY</td>
<td>33.0 PPT</td>
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LEGEND

+ - - - SURFACE
X - - - BOTTOM

PLAN 2A FLUSHING CHARACTERISTICS

STATION 88
TEST CONDITIONS

INITIAL CONCENTRATION: 6894 PPB
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ --- SURFACE
X---- BOTTOM

PLAN 2A
FLUSHING CHARACTERISTICS

STATION 82A
PLAN 2A
FLUSHING CHARACTERISTICS
STATION 028
TEXT CONDITIONS
INITIAL CONC. 6894 PPS
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+———- SURFACE
×———- BOTTOM

PLATE 84
PLANT 2A
FLUSHING CHARACTERISTICS
STATION B2C
Test Conditions:
- Initial Conc: 6094 ppb
- Tide Mean
- Freshwater Discharge: 13400 cfs
- Ocean Salinity (Total Salt): 33.0 ppt

Legend:
- + --- Surface
- x --- Bottom

Plan 2A
Flush Characteristics
Station B2D
Plan 2A
Flushing Characteristics
Station 02E
PLAN 2A
FLUSHING CHARACTERISTICS

TEST CONDITIONS
INITIAL CONC.: 6894 PPM
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CF/3
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+---- SURFACE
X---- BOTTOM

PERCENT OF INITIAL Dye CONCENTRATION

TIME IN TIDAL CYCLES

PLATE 87
TEST CONDITIONS

INITIAL CONC: 6694 PPM
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF3
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 2A
FLUSHING CHARACTERISTICS

STATION B2G
TEST CONDITIONS

INITIAL CONC: 6894 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 FT

LEGEND

+------- SURFACE
X------- BOTTOM

PLAN 2A
FLUSHING CHARACTERISTICS
STATION 82H
TEST CONDITIONS

INITIAL CONC: 6894 PPB
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

SURFACE

BOTTOM

PLAN 2A
FLUSHING CHARACTERISTICS

STATION B2K
**TEST CONDITIONS**

- **Initial Conc.** 100,000 PPB
- **Dye Injection Rate** 400,000 GPD
- **Tide** Mean
- **Freshwater Discharge** 11,400 CF
- **Ocean Salinity (Total Salt)** 33.0 PPT

**LEGEND**

- + --- Surface
- × --- Bottom

**PLAN 1**

**Dispersion Characteristics**

**Station S**
Test Conditions:
- Initial Conc: 10000 PPB
- Dye Injection Rate: 40000 GPD
- Tide: Mean
- Freshwater Discharge: 11400 CFS
- Ocean Salinity (Total Salt): 33.0 PPT

Legend:
- + --- Surface

Plan 1 Dispersion Characteristics
Station 1
TEST CONDITIONS
INITIAL CONC: 1000000 PPB
DYE INJECTION RATE: 400000 GPD
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND
+ --- SURFACE
x --- BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS
STATION 7A
TEST CONDITIONS

INITIAL CONC: 1000000 PPB
DYE INJECTION RATE 400000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

PLAN 1

DISPERSION CHARACTERISTICS

STATION BB

PLATE 97
PLATE 98

TEST CONDITIONS

INITIAL CONC: 1000000 PPB
DYE INJECTION RATE: 400000 GPD
TIDE: MEAN
FRESHWATER DISCHARGE: 11400 CPS
OCEAN SALINITY (TOTAL SALT): 35.0 PPT

LEGEND

+ - - - SURFACE
x - - - BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION B1A
TEST CONDITIONS

- INITIAL CONC: 10,000,000 PPB
- DYE INJECTION RATE: 40,000 GPD
- TIDE: MEAN
- FRESHWATER DISCHARGE: 1,140 CFS
- OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ --- SURFACE
x --- BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION BIC
TEST CONDITIONS
INITIAL CONC: 100,000 PPB
DYE INJECTION RATE 10,000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 1000 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ ——— SURFACE
X ——— BOTTOM

PLAN I
DISPERSION CHARACTERISTICS
STATION 810
TEST CONDITIONS

INITIAL CONC: 1000000 PPB
DYE INJECTION RATE: 400000 GPD
TIDE MEAN:
FRESHWATER DISCHARGE: 11400 CFS
OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

+ ---- SURFACE
X ---- BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION BIE
TEST CONDITIONS

INITIAL CONC: 1000000 PPB
DYE INJECTION RATE 400000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

+ - SURFACE
X - BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION B1F
PLATE 104

TEST CONDITIONS
INITIAL CONC 1000000 PPB
DYE INJECTION RATE 400000 GDP
TIDE MEAN
FRESHWATER DISCHARGE 11400 CPF
OCEAN SALINITY (TOTAL SALT) 33.0 FPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS
STATION BIG
TEST CONDITIONS:
- INITIAL CONC: 1000000 PPB
- DYE INJECTION RATE: 400000 GPD
- TIDE: MEAN
- FRESHWATER DISCHARGE: 11400 CFK
- OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND:
- +-------- SURFACE
- X-------- BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION B1H
TEST CONDITIONS
INITIAL CONC: 1000000 PPB
DYE INJECTION RATE 400000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 11400 CF3
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN 1 DISPERSION CHARACTERISTICS
STATION BII
TEST CONDITIONS

- INITIAL CONC: 1000000 PPM
- DYE INJECTION RATE: 400000 GPD
- TIDE: MEAN
- FRESHWATER DISCHARGE: 11400 CF3
- OCEAN SALINITY (TOTAL SALT): 33.0 PPT

LEGEND

- +: SURFACE
- X: BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION BIJ
PLAN I

DISPERSION CHARACTERISTICS

STATION 8111

TEST CONDITIONS

INITIAL CONC: 10,000,000 PPB
DYE INJECTION RATE 400,000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 11,400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

+-- SURFACE
X-- BOTTOM

PLATE 110
HIGH-WATER SLACK

LOW-WATER SLACK

DYE CONCENTRATION IN PPB

TIME IN TIDAL CYCLES

TEST CONDITIONS
INITIAL CONC 1000000 PPB
DYE INJECTION RATE 400000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 11400 CFH
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND
+ --- SURFACE
X --- BOTTOM

PLAN I
DISPERSION CHARACTERISTICS
STATION BIN
TEST CONDITIONS

INITIAL CONC: 1000000 PPB
DYE INJECTION RATE 400000 GPD
TIDE MERN
FRESHWATER DISCHARGE 11400 CF
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

LEGEND

+ --- SURFACE
X ---- BOTTOM

PLAN 1
DISPERSION CHARACTERISTICS

STATION 810
TEST CONDITIONS

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<td>Tide</td>
<td>Mean</td>
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<tr>
<td>Freshwater Discharge</td>
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<tr>
<td>Ocean Salinity (Total Salt)</td>
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LEGEND

- + - Surface
- X - Bottom

PLAN 1

DISPERSION CHARACTERISTICS

STATION 810
TEST CONDITIONS

INITIAL CONCENTRATION  1,000,000 PPB
DYE INJECTION RATE  400,000 GPD
TIDE  MEAN
FRESHWATER DISCHARGE  11,400 CFS
OCEAN SALINITY (TOTAL SALT)  33.0 PPT

MIDDEPTH
DYE CONCENTRATIONS
PLAN I (CONTINUOUS DYE RELEASE)
STATIONS BIA, BIB, BIE AND BIG
CYCLE 5
TEST CONDITIONS
INITIAL CONCENTRATION 1,000,000 PPB
DYE INJECTION RATE 400,000 GPD
TIDE MEAN
FRESHWATER DISCHARGE 11,400 CFS
OCEAN SALINITY (TOTAL SALT) 33.0 PPT

MIDDEPTH DYE CONCENTRATIONS
PLAN I (CONTINUOUS DYE RELEASE)
STATIONS BIJ, BIL, BIM, BIN AND BIQ CYCLE 5
The existing, comprehensive fixed-bed model of the Grays Harbor estuary was used to determine current velocities, surface current patterns, flushing and dispersion characteristics, and qualitative shoaling rates and patterns for four small-boat basin plans located near Westport, Wash. Data collection consisted of current velocities for plans 1 and 2, surface current pattern photographs for plans 1, 1A, and 2; qualitative shoaling rates and patterns for plans 1, 1A, and 2A; flushing rates for plans 1, 1A, 2, and 2A; and dispersion from a proposed sewage outfall for the City of Westport for plan 1.

Model test results indicate that only insignificant local changes in current velocities and surface current patterns outside the proposed basins would result from construction of any of the four small-boat basin plans. Shoaling for the plan 2 basin would be significantly less than for either plan 1 or 1A, but the shoaling rate for any of these plans would probably be moderate. The flushing rate for either plan 1 or 1A would be much better than for either plan 2 or 2A. The flushing rates for plans 2 and 2A could be improved, however, by the addition of a channel connecting the western end of the basin to either the existing Westhaven Cove or South Bay. Waste material discharged from the proposed Westport sewage outfall would enter the proposed basin during both ebb and flood currents, but maximum concentrations in the basin would only be on the order of 0.01 percent of the initial concentration at the outfall.
<table>
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